ROSA LUXEMBURG STIFTUNG

BY THE WAY, IT ACTUALLY WORKS

DEBUNKING RENEWABLE ENERGY MYTHS

CONTENTS

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AUD	Australian dollars
BAU	Business as usual
BNEF	Bloomberg New Energy Finance
CSP	Concentrated Solar Power (plant)
EPR	European Pressurized Reactor, Evolutionary Power Reactor
FITs	Feed-in-Tariffs
GW	Gigawatt
GSI	Global Subsidies Initiative
IEA	International Energy Agency
kW	Kilowatt
kWh	Kilowatt-hour
kWp	kilowatt peak (a measure of solar PV installed capacity)
LCOE	Levelised Cost of Electricity
MW	Megawatt
MWh	Megawatt-hour
NDCs	Nationally Determined Contributions
NPV	Net present value
ODA	Official Development Assistance
PM	Particulate Matter
PPAs	Power Purchase Agreements
PV	Photovoltaic
R&D	Research and development
SAIDI	System Average Interruption Duration Index (Germany)
SVTC	Silicon Valley Toxics Coalition
TVO	Teollisuuden Voima Oyj (Finnish nuclear power company)
UNFCCC	United Nations Framework Convention on Climate Change
USD	US dollars
WHO	World Health Organization
WTO	Word Trade Organization

RENEWABLE ENERGY IS A FUTURE CERTAINTY

After more than 20 years of negotiations, world leaders agreed in Paris in December 2015 to limit the global average temperature increase to 1.5°C above pre-industrial levels.[1] Greenhouse gas emissions are the cause of global warming and have Greenhouse gas emissions are the cause of global warming and have accumulated in the global atmosphere since the industrial revolution. However, greenhouse gasses emissions are going unchecked: we are treating the atmosphere as a common good, with everybody polluting it as they see fit and burning fossil fuels in power stations, buildings, homes, vehicles and industry.

There is very little time left to prevent the worst effects of climate change. Climate change is already causing numerous human and economic losses, and these are increasing fast.

More than half of all greenhouse gas emissions come from burning fossil fuels and this is also linked to many other negative effects. Pollutants like sulphur dioxide, nitrous oxides or small particulate matter poison the air, and their effects are felt intensely: people suffer from asthma and other diseases and are dying prematurely, especially in and near cities around the world.

Some countries and people are responsible for more emissions than others, but the effects of global climate change and local pollution are felt disproportionally by poorer women, men and children in poorer communities and countries. Sustainable development demands justice for both the present and future generations and in particular the richer countries, communities, companies and people need to reduce greenhouse gas emissions as soon as possible.

Nevertheless, the Paris goal also requires developing countries to undergo a rapid transition from fossil-fuel-based economies to renewable-energy-based economies. Indeed, in November 2016, 48 of the countries that are most vulnerable to the effects of climate change agreed to strive for '100 % domestic renewable energy production as rapidly as possible',[2] despite the fact that they delete the highlighted words count among the poorest countries in the world. Other good news is that the International Energy Agency (IEA) predicts fast growth in renewables and that costs in solar photovoltaics (PV) and onshore wind will reduce by 25 % and 15 % respectively from 2015 to 2021.[3]

The question is therefore not *whether, but how and when* we will achieve a future based on renewable energy. Doing so demands changes to be made in economic policy. The green economy has not delivered the results, as coal-fired power plants continue to be built and fossil-fuel exploration and consumption continue to be subsidised by different countries.[4] Only a small fraction of potential renewable energy has been tapped into, especially in developing countries. And, in 2016, the world already exceeded the 1°C average global warming temperature increase.

Renewable energy is the obvious choice but it is fraught with many concerns: people claim that it is too expensive, low quality, not available in sufficient quantities, that it has negative environmental effects and usurps jobs. However, in this brochure we show that these claims are myths and misconceptions. A rapid transition to renewable energy is already taking place; renewables are low-cost modern

1 This is the global aspiration in the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC). UNFCCC Decision 1/CP.21 **2** CVF (2016) **3** IEA (2016) **4** World Energy Outlook (2015) energy sources; they provide green jobs and are the sustainable and equitable choice for future energy provision; moreover, they help to avoid dangerous global climate change. Some of the developments in renewable energy are very new and this brochure aims to encourage decision makers to reconsider their long-standing views.

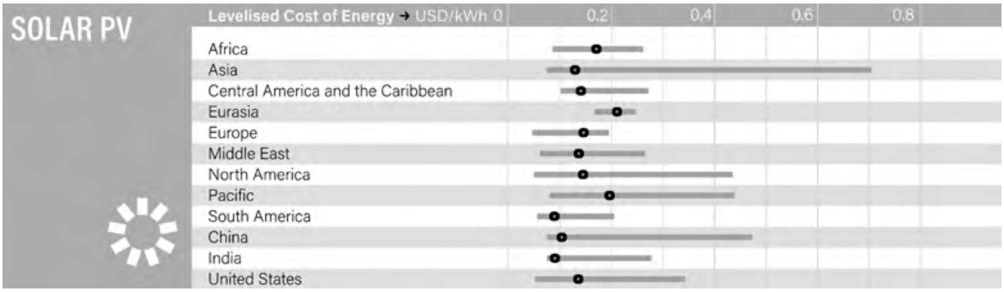
MYTH 1: RENEWABLE ENERGY IS EXPENSIVE

The main objection to rapid transformation of energy systems towards renewables has been and still is that it is too expensive, and this is particularly the case for developing countries.

But the facts are different.

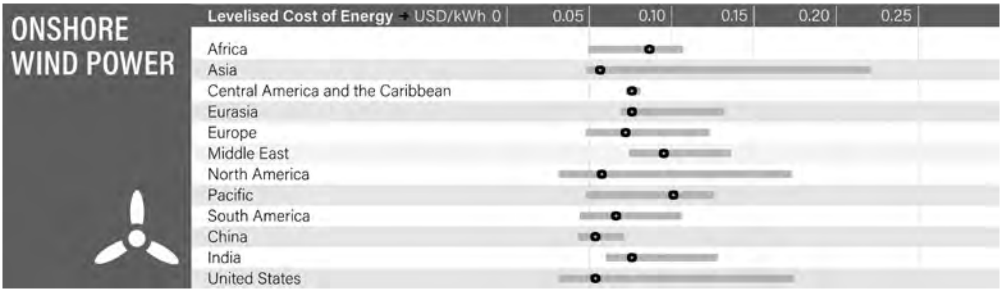
'The perception that fossil fuels are cheap and renewables are expensive is now out of date,' states Michael Liebreich, Chief Executive of Bloomberg New Energy Finance, pointing to the example of Australia.
Depending on the power sector's framework, different estimates of the cost of one kilowatt-hour (kWh) of electricity can be considered relevant for this comparison. If prices are formed at a power exchange, the price of power is determined by the price of fuel that is used. This is zero for wind and solar, and thus much lower than for conventional power plants, or bioenergy plants. However, the investment costs and other fixed costs still need to be recovered. The 'Levelised Cost of Electricity' (LCOE) is used to compare the cost of power from different sources over the lifetime of a power plant. In many situations, the LCOE for renewables is lower than for conventional power plants, but this depends on local circumstances. Figure 1 and Figure 2 show LCOEs for different for solar PV and wind respectively. These are more than competitive with new conventional power plants.

Figure 1: LCOE for Solar PV



Source: REN21 2016

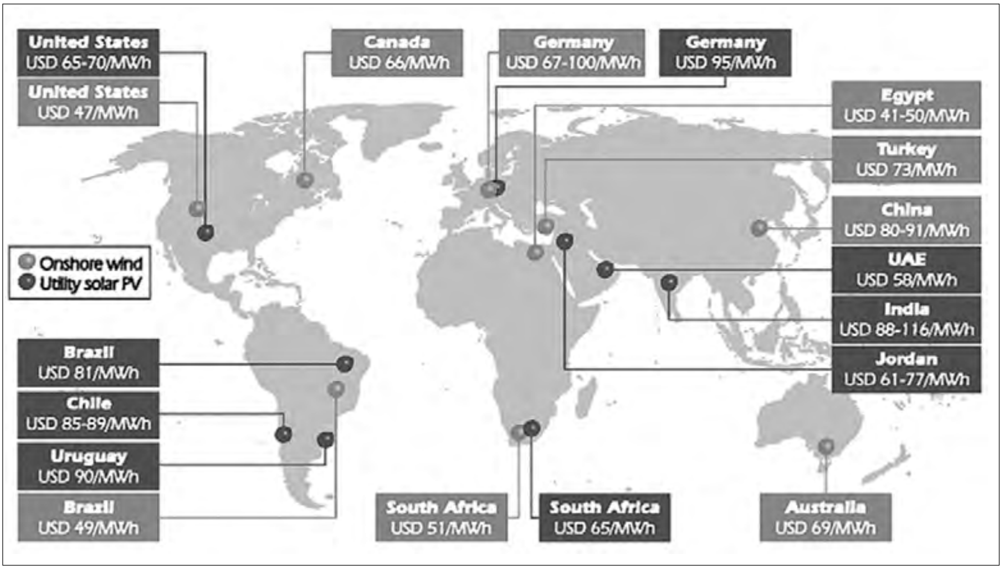
Figure 2: LCOE for Onshore Wind



Source: REN21 (2016)

Unsubsidised renewable energy is now cheaper than electricity from new-build coal and gas-fired power stations, e.g. in Australia, according to new analysis from Bloomberg New Energy Finance (BNEF).[5] BNEF modelled the cost of generating electricity in Australia from different sources. The study shows that electricity can be supplied from a new wind farm at a cost of AUD 80/MWh (USD 83/MWh), compared to AUD 143/MWh from a new coal plant or AUD 116/MWh from a new gas plant, including the cost of emissions under the carbon pricing scheme. BNEF's research shows that since 2011, the cost of wind generation has fallen by 10 % and the cost of solar photovoltaics (PV) by 29 %. By contrast, the cost of energy from new fossil-fuelled plants is high and rising.

Figure 3: Recent announced long-term contract prices for RE power (e.g. preferred bidders, PPAs or FITs) to be commissioned over 2015–2019



Source: Source: © OECD/IEA 2015, Medium-Term Renewable Energy Market Report, IEA Publishing. Licence: www.iea.org/t&c

Figure 3 shows the range of power prices for solar PV that have recently been achieved through public auctions for power purchase agreements in many countries: in many cases utilities buy power from solar farms for less than from other facilities. Even in Germany, a country with poor levels of solar radiation, auctions have been held for solar power that have resulted in power prices of €72/MWh.[6]

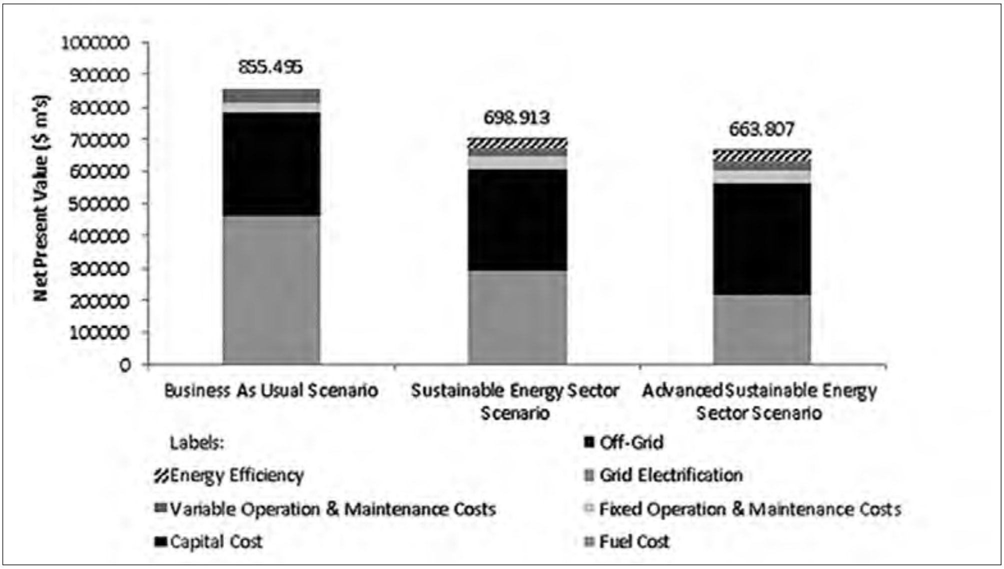
5 BNEF (2013)
6 Knight (2016)

Energy system costs

Another possible parameter is the total cost of the energy system. It is often argued that flucutating renewables require an entire 'back-up power park' and their price needs to be included in calculations (see also Myth no.3 *Renewable energy does not offer a reliable electricity supply 24 hours a day).*[7]

In addition to backup power generation, system costs include electricity transmission via the grid, power plants, converter stations and controls that keep the system running continuously. The only way to compare the costs of different energy systems is by modelling different scenarios with different energy mixes. Figure 4 presents the results of such a simulation exercise undertaken for the Mekong Region, simulating electricity system costs until 2050. The simulation found that the scenario with the highest share of renewables in its mix (96% including additional storage facilities) was the cheapest one largely due to the costs of fossil fuels.

Figure 4: How much will a Mekong electricity system in 2050 cost using 29%, 86% and 96% non-fossil fuels?



Note: Net present value of the power system costs using an 8% discount rate over the period from 2015 to 2050; the share of renewables and large hydro in 2050 in the scenarios are: business as usual – 29%; sustainable energy sector Scenario – 86%; advanced sustainable energy sector scenario – 100% renewables; Decommissioning costs were not factored into the study.
Source: own graph based on IES & MKE, 2016

7 See for example: Bloomberg (2016), World-nuclear.org (2016)

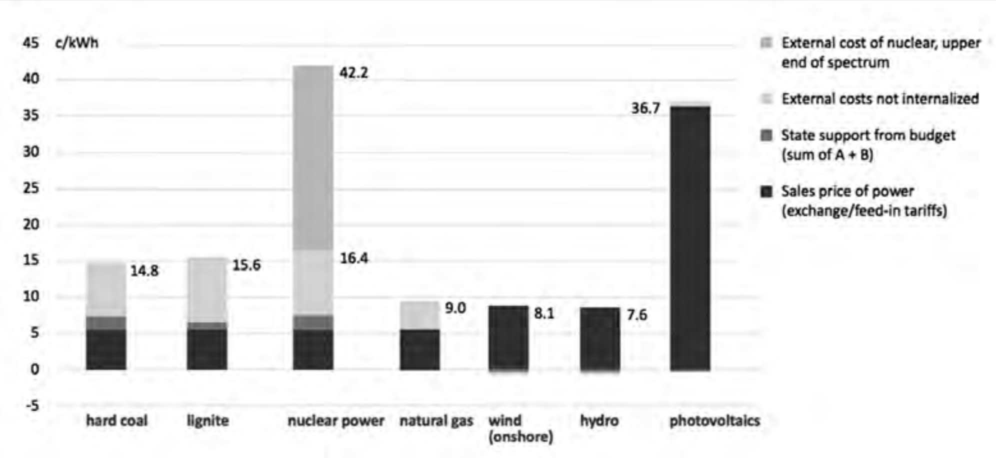
Full costs of electricity

Full costs of electricity include the system costs, externalities and state subsidies. ‘Externalities’ are the costs to human health, livelihoods and the environment; these are often not included in cost calculations of energy production. Open-pit mining and pollution from coal and other fossil fuels cause real costs to health, livelihoods and the environment but those who profit from this harm – energy producers, traders or consumers – do not pay for it. Renewable electricity becomes even more beneficial when the externalities of electricity generation with fossil fuels or nuclear energy are included in energy production prices. This is made partially possible through fees, taxes or carbon ‘cap-and-trade’, for example.

Figure 5 shows power generation costs in Germany, including LCOEs, externalities, subsidies and waste removal. It shows that, by 2012, wind power was competitive with all other conventional energy production forms.

This strongly suggests that renewables are cheaper than fossil fuels and nuclear options. In fact, renewables are increasingly becoming the cheapest source, even when only considering the LCOE and the price of the entire energy system. If externalities and subsidies are considered as well, competitiveness becomes even clearer.

Figure 5: A comparison of power generation costs to society in 2012 (Germany)



Source: BWE (2012)

Who benefits from renewables?

Fossil and nuclear energy investments are usually worth USD several hundred million and only large energy corporations can afford such investments, with the help of the financial markets. Governments often must support these with guarantees, export credits, power purchase guarantees, or production quota. For example, the most recent nuclear power project in the UK, Hinkley Point C, will cost a total of US$ 37.7 billion. One analysis found that a solar facility with storage producing the same amount of electricity would cost only US$ 18.7 billion. Even the UK government's accounting office has stated that power from Hinkley Point C will be more expensive than renewable energy. [8]
The British government has determined that power from Hinkley Point C will be subsidized by the British power consumer because its price is so much higher than the UK market price. Without that subsidy, no private financier would invest in the project. With the subsidy, the large electricity corporation EDF will build it.
In contrast, most renewable energy facilities can be financed by individuals or cooperatives. Renewables cooperatives and individuals can make a profit from the electricity that is generated. If legislators allow and foster community energy, energy production can be used by communities to increase their income and to reduce their vulnerability to increasing electricity prices. Box 1 gives an example of a community-financed renewable energy project. If a government chooses, it could still subsidise renewable energy. However, many examples from developing countries like Bangladesh or Kenya demonstrate that (micro) finance institutions can also provide support to relatively poor people to enable them to afford ownership of a power generation facility. Whether this is a solar, wind or hydro plant, this means that these people are no longer dependent on the volatile prices of fossil fuels that fluctuate on the global markets.

Box 1: Odanthurai Gram Panchayat, India.
In 2006, the Gram Panchayat (village council) of the village of Odanthurai in India set up a 350 kW wind turbine to produce its own energy and to solve the problem of its inadequate power supply and three hours of power cuts every day.[9] The Panchayat's president promoted the idea of a wind energy project under village ownership. The village's power project became the first ever to be undertaken by a local body in India. The village only requires 60 % of its production and the power surplus to be sold to the Tamil Nadu Electricity Board. Income from the project is used to repay the bank loan and this will be done within seven years. After Odanthurai became successfully self-powered, it kept going and invested in a 9 kW biomass plant in order to provide the village's drinking water pump with off-grid electricity. The biomass plant is fed with waste from a nearby sawmill and pumping costs have declined by 70 %.

8 Solar Trade Association (2015) **9** EcoIdeaz (n.d.)

MYTH 2: THERE IS NOT ENOUGH RENEWABLE FUEL TO SATISFY DEMAND

Some assert that there are not enough renewable energy resources and that fossil fuels are necessary to meet the growing energy demands, especially in developing countries.

But the facts are different.

The sun supplies most of the energy that is available to us. Solar irradiation can be converted directly into heat and power; the sun drives climate systems and therefore wind power and hydroelectricity; and the sun makes plants and trees grow, some of which we can use sustainably for energy. Direct solar irradiation that reaches the earth's surface annually constitutes more than 7,500 times the world's total annual primary energy consumption.[10]
A 'study of studies' in 2008 of the technical potential of different renewable energy technologies concluded that 'renewable energy sources can provide several times the current [global] energy supply', and that solar power is by far the largest renewable energy source, followed by wind and ocean energy.[11] There are, of course, major differences between regions and countries in terms of the technical potential of different sources of energy, with solar energy being key to Africa and much of Asia and South America, just as wind is to North America and northern Europe. Renewable energy technologies have also developed further since that study was completed in 2008.
As the potential of renewable energy is limited by technology, suitable topography and land use, it is much smaller than the theoretical potential of renewables. At the same time, the technical potential of renewables is greater than the economic potential of a number of forms of renewable energy because their competitiveness vis-à-vis other sources of power is determined by economic policies such as (carbon) taxes and market regulations. Despite this, renewable energy still has the potential to produce far more energy than needed. Moreover, a global future based on 100 % renewable energy is certainly possible, because technologies are being developed further, especially when the right economic policies are put in place.
For example, the countries in the 'Greater Mekong sub-region' have substantial potential for different forms of renewable energy,[12] especially solar power. Cambodia, Laos, Myanmar, Thailand and Vietnam have deployed very little solar and wind power generation capacity but Table 1 shows that their technical potential is close to the total power production capacity currently installed and this just takes two of many renewable energy technologies into account.
2015 was an extraordinary year for renewable energy, with the largest global capacity additions seen to date. An estimated 147,000 MW of renewable power capacity was added globally – the largest annual increase in renewable power ever seen. This is more than 1.5 times the total capacity installed in the countries of the Greater Mekong sub-region (see Table 1) – and this capacity was added in just one year. Renewables constituted an estimated 60 % of net additions to global power capacity in 2015. The boom in investment in 2015 is derived mainly from cost effectiveness and the realisation of the multiple benefits gained from using inexhaustible resources.

10 World Energy Council (2013) (Chapter 8: Solar) **11** Hoogwijk and Graus (2008) **12** ADB (2015)

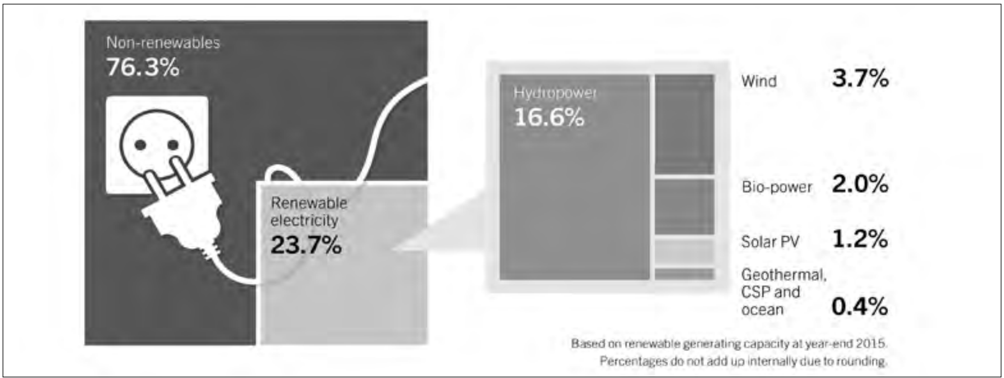
Table 1: Technical potential of renewable electricity in the Greater Mekong sub-region

In mega Watt (MW) installed capacity	Solar	Wind	Total installed capacity in 2014
Cambodia	8,074	18–72	1,400
Laos	8,812	95–379	3,400
Myanmar	26,962	86–343	4,300
Thailand	22,801	2,412–9,647	40,000
Vietnam	13,326	760–3,042	39,000
Total	79,975	3,371–13,483	88,100

Source: own table based on ADB (2015) and EIA (n.d.)

At the end of 2015, new renewable energy made up just 28.9 % of global power generation capacity and 23.7 % of global electricity production, as shown in Figure 6.[13]
Global investment in new renewable power capacity was USD 285.9 billion in 2015, i.e. more than twice the USD 130 billion allocated to new electricity generation capacity based on coal and natural gas. And, for the first time in history, annual total investment in renewable power and fuels in developing countries exceeded that in developed economies in 2015. The developing world, including China, India and Brazil, saw a total of USD 156 billion investment in renewable energy.[14]
Other developing countries now also have sizeable shares of renewables in their energy mix: for example, Uruguay where wind power meets 15.5 % of demand for electricity, and Costa Rica whose power sector is almost free from the use of fossil fuels (see Box 2). Other countries have yet to be convinced of the potential and the feasibility of a speedy transition to renewable energy (see Box 3).

Figure 6: Estimated renewable energy share of global electricity production at end of 2015



Source: REN21 2016

13 REN21 (2016) **14** REN21 (2016)

Box 2: Costa Rica produces almost all of its power without fossil fuels and aims for carbon neutrality

Costa Rica is one of the developing countries that has already deployed large amounts of renewable power capacity. It also aims for carbon neutrality.

Its electricity mainly comes from hydro and geothermal sources and wind power.[15] It has invested especially in hydropower over the past 50 years and was completing a further large hydroelectric power plant at the end of 2016 – the 'Reventazón'. In 2015, the country went for nearly 300 days without using fossil fuels for power production and a similar achievement is expected in 2016.[16]

But Costa Rica faces challenges in reaching its carbon neutrality goal because large hydropower plants can emit large amounts of greenhouse gasses (see also Myth 4). Reliance on hydropower also means that it is vulnerable to the effects of climate change so Costa Rica has been advised to gradually increase the role of geothermal, wind and solar in its power mix. In addition, transport remains almost completely dependent on fossil fuels.[17]

Box 3: Vietnam is still planning a coal-fired future but has huge renewable energy potential

Vietnam's official power development plan relies strongly on coal-fired power to supply the country's rapidly increasing demand, rising to more than 53 % of power production in 2030 when renewable power could be just under 11 %. Even by 2050, Vietnam could still be dependent on coal and gas for half of its power needs.

However, a study for the WWF shows that a renewable energy scenario is technically possible, affordable and economic.[18] From 2015 to 2050, the cumulative investment cost of the renewable energy scenario could be somewhat higher but the 'Levelised Cost of Electricity' i.e. the cost per unit of electricity would be lower for most of this period. Vietnam would not need to import coal, would mitigate climate change and drastically reduce local pollution and also gain social (health) benefits – these important advantages were not considered in the financial comparison of the various scenarios.

15 Dolezal et al. (2013) **16** Science Alert (2016) **17** OLADE (2011) **18** IES & MKE (2016)

MYTH 3: RENEWABLE ENERGY IS INTERMITTENT AND DOES NOT PROVIDE A RELIABLE SUPPLY 24 HOURS A DAY, 365 DAYS A YEAR

A common myth is that renewable energy is unreliable and that it cannot supply electricity to consumers 24 hours a day, 7 days a week for 365 days a year.

But the facts are different.

These claims are mostly raised in places with small shares of variable renewables that feed into the grid. 'Variable' refers to renewables that are linked to specific weather patterns (sun, wind, clouds, and rain/droughts).[19] Grid operators confronted with large shares of variable renewables tend to cope with the challenges very well and even gain a more secure energy supply: Germany's System Average Interruption Duration Index (SAIDI) dropped from 21.5 minutes in 2006 to 12.7 minutes in 2015,[20] whereas the renewables share increased from 12 % in 2006 to 32 % in 2015.[21] Denmark, Greece, Ireland, Portugal and Spain are further examples of countries which manage to integrate considerable shares (>20 %) of variable renewables into their systems from wind and solar power.[22]

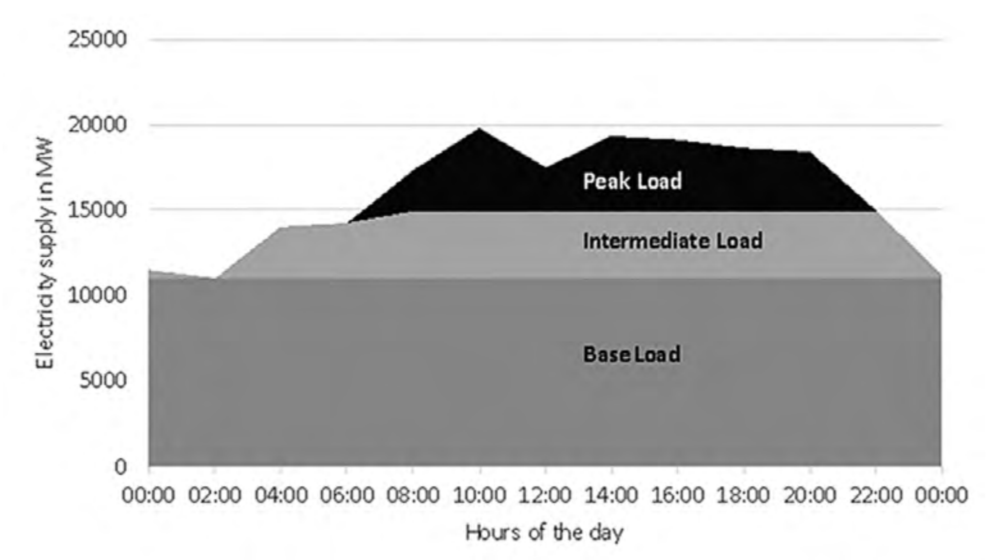
In an electricity grid, generation and demand must be balanced at all times. Coal and nuclear power plants used to provide the base electricity demand at a constant level. These 'base load' plants were designed to work at their highest efficiency when providing the same level of power at all times (Figure 7). They were complemented by adjustable power plants ('peakers') like natural gas turbines which were built to react flexibly to demand and provide additional power during times of high demand, e.g. at noon.

In the classical power system, the flexible 'peak power' plants ramp up and down following the load and making sure that power generation and consumption are balanced at all times. Modern electricity systems are structured around the supply from variable renewables. Figure 8 shows the production of electricity in Germany in 2012 and a forecast for 2020 when significantly more renewables will be installed. In both graphs, the fossil fuelled power generation follows the difference between demand and power generation from renewables. This leads to a much larger need for ramping up and down, with much stepper gradients. As Figure 8 demonstrates, this need will become stronger with higher penetration rates of fluctuating power production but this is feasible. In particular, it is a good opportunity to build up flexible power systems in countries with growing energy sectors.

In many countries, fossil fuel power plants are still required to produce electricity when electricity production from variable sources (wind and solar) is low. To match supply and demand, the power system operating system must use flexibility options: (1) demand management, (2) imports/exports, or (3) storage, as follows:

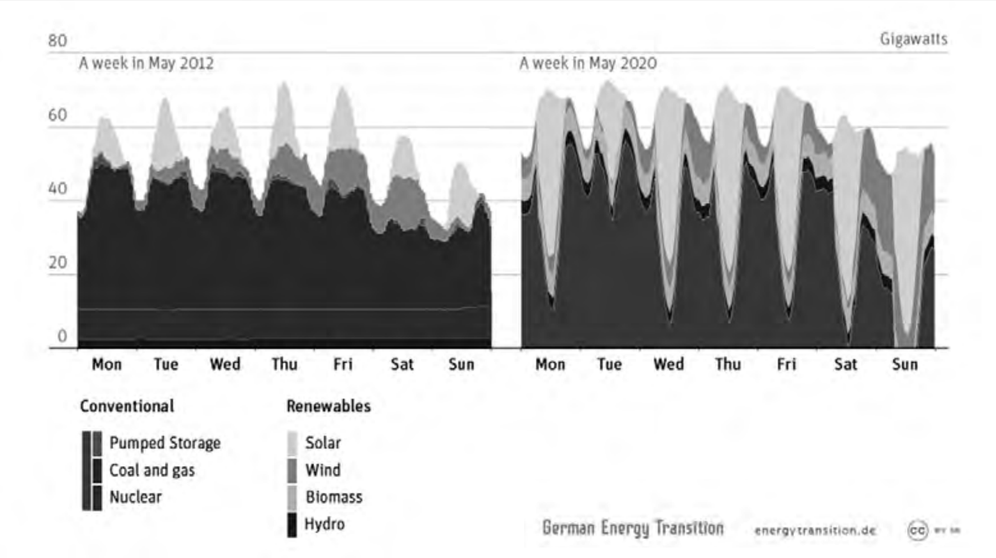
19 Sometimes renewables like wind and solar are called 'intermittent' sources. Intermittent normally refers to fossil-fuel power plants or grid infrastructure when something breaks down and a plant/grid element goes offline without warning. In contrast, variable renewables follow weather patterns known in advance. The transition from zero to full production is gradual. **20** BNetzA (2015) **21** BMWi (2015) **22** REN21 (2016); Denmark: Vattenfall (2015); Germany: BMWi (2015); Greece: Energypedia (2016); Italy: Tsagas (2016); Fitzgerald (2016); Solar Power Europe (2016)

Figure 7: Traditional power systems following demand curves



Source: own graph

Figure 8: Estimated power demand over a week in 2012 and 2020 in Germany



Source: Martinot (2015)

(1) Demand side management means moving demand to a different time, when more variable sources are available. Energy intensive industrial processes, like aluminium smelting for example, could be shifted to run when solar is available in contrast to running at night. Currently, the tariffs for industrial users are set to shift demand to fixed times. For example, industrial consumer tariffs for Vietnam are the highest from Monday to Saturday between 09:30 and 11:30 and between 17:00 and 20:00. But in future users must be encouraged to move their demand to periods with a lot of sun or wind power and form demand peaks in accordance with renewable power production. To make demand shift possible, the electricity connections of large, flexible users can be equipped with communications technology to transmit the flexible price signal.

Households and industrial users change in a modernised power system to energy 'prosumers' (producers + consumers): they produce a portion or all their power needs onsite with renewable energy technologies and can sell excess power to the national or local grid. (See also Box 4.)

(2) Import/export: The larger the area and the bigger the load and generation capacity, the better power grids are able to pick up variable sources and deliver electricity to remote consumers. If a wind front moves along a coastline, the power grid can distribute that power to all users evenly as the front passes through. This is the known as the 'balancing effect'.

(3) Storage and back-up power systems: additional demand can be covered by electricity storage. When variable supply is too high, water can be pumped into hydroelectric reservoirs ('pumped storage') and then be released again when demand is high. Biogas plants with gas storage tanks can produce power when there is peak demand. And in the future, when variable supply is at times in excess of demand, electricity will increasingly be used to charge batteries or produce hydrogen or methane gas which can produce electricity at other times.

Demand management, distributed supply from different variable sources (import/export), and storage systems are already elements of virtual power plants that are embedded in the existing larger grid – see Box 5.

Box 4: Consumers to become 'prosumers'

Producing their own energy gives businesses an opportunity to generate income from energy and not only view it as a cost factor. An onsite renewables installation increases the energy security of the production process. Additional waste streams, such as bio-waste, can be used for energy production. A series of large industrial energy users have already switched to becoming 'prosumers', these include:

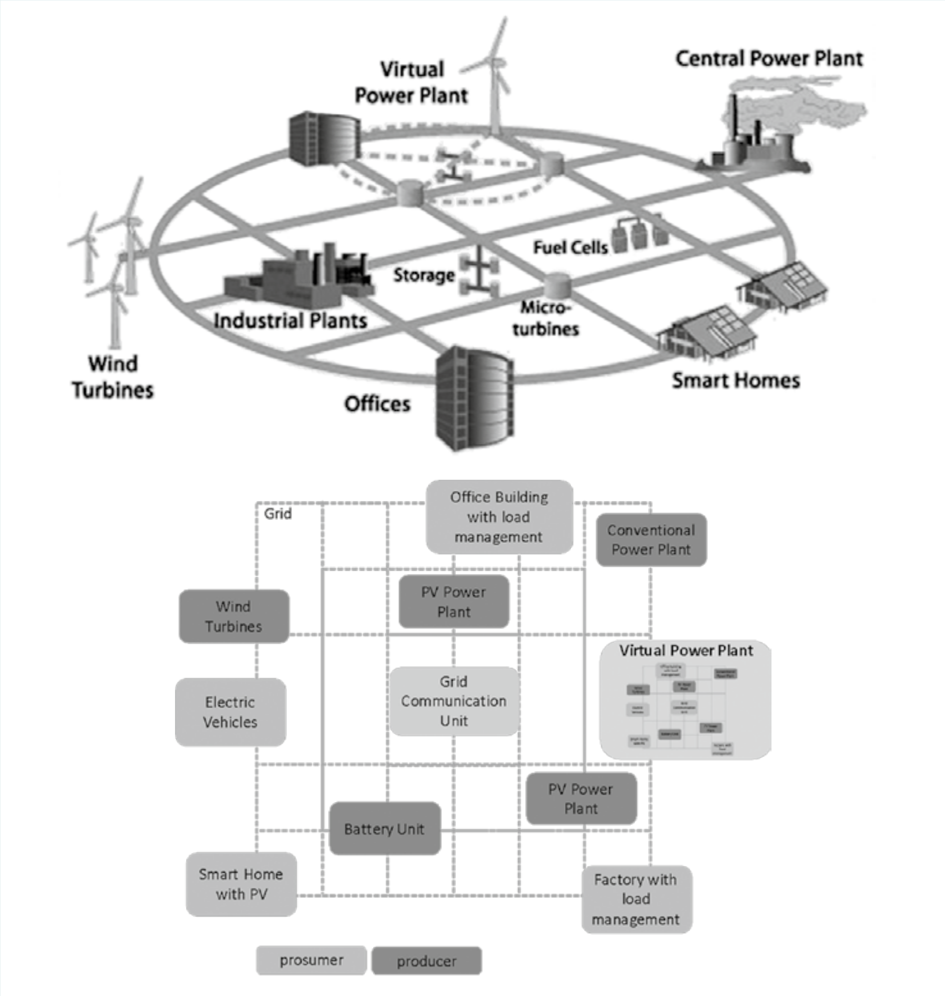
The Big C Supermarket in Di An (Binh Duong province, Vietnam) installed a 212 kW solar power plant as parking shade and uses the electricity for the supermarket.

In Cambodia, Laurelton Diamonds, a subsidiary of Tiffany & Co, has installed a 150kWp solar parking roof space for their manufacturing facility, located in the Phnom Penh Special Economic Zone (PPSEZ). The power plant supplies 15% of the factory's annual power consumption.

Box 5: Virtual power plants

A series of energy utilities already supplies their customers with 100 % renewable energy by pooling the small units that make up their system. This type of supply is referred to as virtual power plants. Virtual power plants consist of several generating installations, users and storage facilities that aggregate electricity in a controlled fashion. Like a Matryoshka doll, a virtual power plant is a smaller version of a bigger renewable energy system following the same principles (Figure 9).

Figure 9: Virtual power plant embedded in a larger smart grid



Source: own graph

MYTH 4: RENEWABLES HAVE AS MANY NEGATIVE ENVIRONMENTAL IMPACTS AS POWER GENERATED WITH FOSSIL FUELS

Some argue that renewable energy technologies have many negative environmental impacts. These include claims that renewables pollute the environment during equipment manufacturing and decommissioning, produce excessive amounts of greenhouse gasses in a similar manner to fossil fuels and that they cause climate change.

But the facts are different.

When comparing the environmental impacts of renewables with fossil fuels, it is important to consider all of the negative impacts that are caused by all forms of power. This leads to the conclusion that fossil-fuel-based energy causes more pollution and that renewables produce considerably smaller environmental risks and damage; however, renewable energy does need to be managed well.

Air pollution from fossil fuel, biomass and waste-burning power plants

The air pollutants released by fossil fuels are responsible for many human diseases and also for environmental degradation – see Figure 10. For example, in 2015 researchers from Greenpeace and Harvard University reported that coal emissions from Vietnam's power sector caused an estimated 4,300 premature deaths in 2011 and that this could rise to 25,000 deaths by 2030 if current plans for coal-power plants were to be implemented.[23]

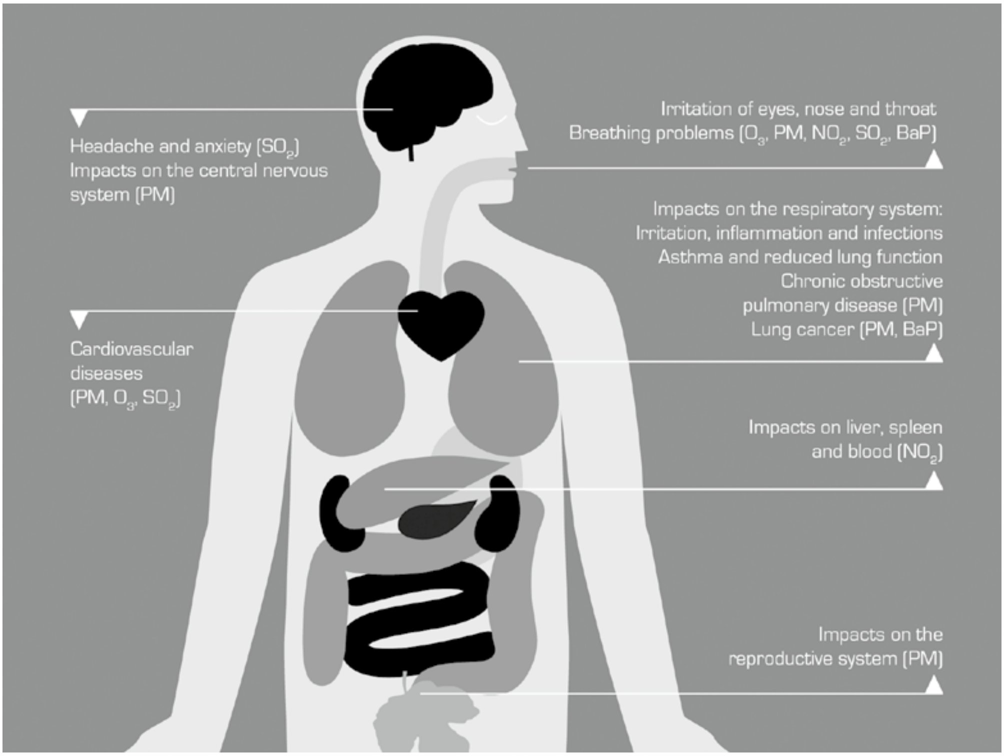
Emissions that result from the combustion of fossil fuels include:[24]

1. Carbon dioxide (CO_2): burning fossil fuels releases large amounts of CO_2 into the atmosphere. Unchecked carbon pollution leads to long-lasting changes to the climate.[25]
2. Sulphur dioxide (SO_2) causes acid rain, which is harmful to plants, and to animals that live in rivers and oceans. SO_2 also worsens respiratory illnesses and heart diseases.[26]
3. Nitrogen Dioxide (NOx) contributes to ground level ozone (O_3), which irritates and damages the lungs.[27]
4. Particulate Matter (PM) results in hazy conditions in cites and scenic areas, and, coupled with ozone, contributes to asthma and chronic bronchitis.[28]

Power generated with coal produces the largest quantities of these pollutants, but natural gas, biogas, and biomass and waste-burning power plants also produce these pollutants. Power that is generated using biogas and biomass, of course, have a smaller net result on carbon dioxide emissions assuming they are produced from waste materials.

23 Koplitz et al. (2015) **24** EIA (2016) **25** It also has an impact on society, such as increasing food prices, loss of coastal/flood-prone land and property, destruction due to extreme events, migration from heavily affected areas and loss of agriculture-based livelihoods; see also EPA (2016) **26** EIA (2016) **27** EIA (2016) **28** EIA (2016)

Figure 10: Negative health impacts of air pollution



Note: BaP = benzo(a)pyrene; NO_2 = nitrogen dioxide; O_3 = ozone; PM = particulate matter; SO_2 = sulphur dioxide.
Source: European Environment Agency (2013)[29]

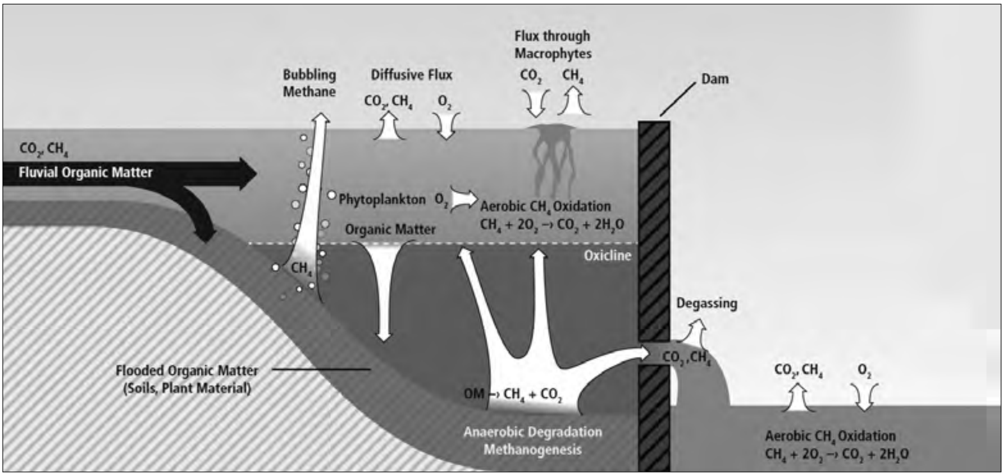
Greenhouse gas emissions from large hydropower dams

Large and medium sized hydro-electric plants are generally not categorised as renewable energy; only small hydro-plants with an installed capacity below 30 MW are commonly accepted as such.

Hydro-electric power stations with large water reservoirs, particularly those in the tropics, contribute directly to climate change. Underwater microbes feast on the organic matter that piles up in the lake sediments trapped by dams and produce methane (Figure 11).[30] Methane is 34 times more potent than CO_2 in contributing to global warming. The gas is emitted via the surface of the reservoir, at turbines and spillways and for tens of kilometres downstream.[31]

29 Ministry for the Environment New Zealand (2014) **30** Warren Cornwall (Science, 2016), Hirsch (2007) **31** International Rivers (n.d.)

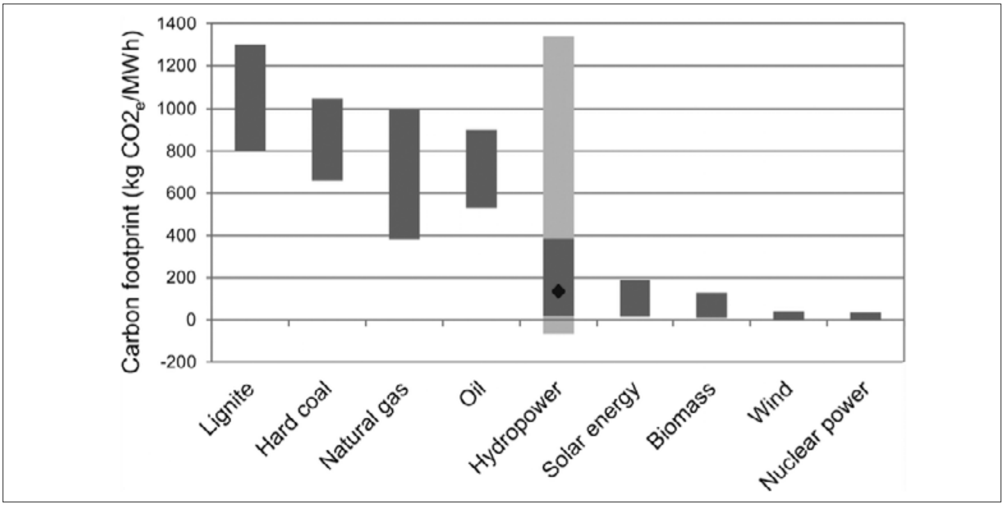
Figure 11: Carbon dioxide and methane pathways in a freshwater reservoir



Source: IPCC (2012, adapted from Guerin, 2006)

When methane production is taken into account, hydro-electric power plants in the tropics, which have large reservoirs, can have a much greater impact on global warming – relative to their generating capacity – than fossil fuel power stations that generate equivalent amounts of electricity (Figure 12).[32]

Figure 12: Carbon footprints of various energy sources.



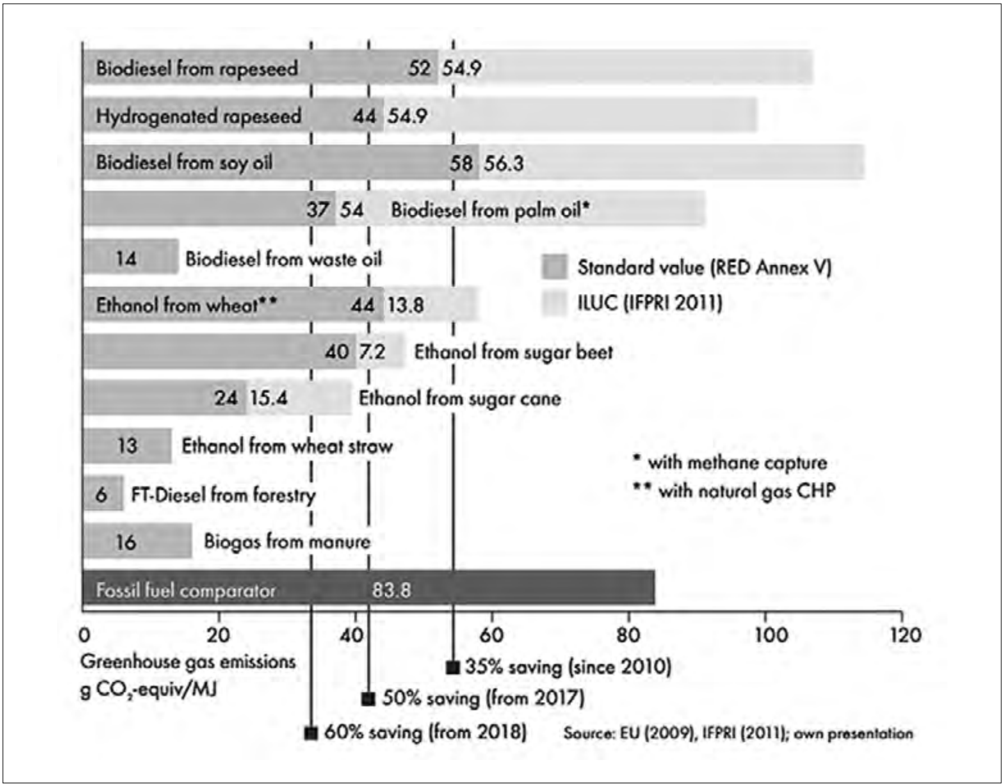
Source: Hydropower data based on Scherer & Pfister (2016) data for all other energy sources based on Turconi et al. (2013)

32 International Rivers (n.d.)

Greenhouse gas emissions from bioenergy production

Greenhouse gas emissions from bioenergy depend heavily on the land use changes caused by the feedstock. When land that is high in carbon (such as forests), is converted for bioenergy-crop production (this involves *direct* land use change), upfront emissions may cause a time lag of decades to centuries before net emission savings are achieved by the bioenergy power plant.[33] The production of bioenergy can increase food prices, which leads to the conversion of (forest) land to cropland.[34] Figure 15 shows the possible impact of *indirect* land use change effects on the carbon footprint of biofuels. The best GHG balance is from bioenergy produced from food waste, the wood industry or residues.

Figure 13: GHG emissions of biofuels including Indirect Land Use Change Effects.



Source: Shell, IFEU, IINAS (2012)

E-waste and how to reduce adverse impacts

Some renewables and their equipment use inputs and production processes need to be considered carefully. Electronic waste, for example, needs to be decommissioned with the utmost care. One example is the small amounts of heavy metals such as cadmium and lead that are used in the production of solar photovoltaic (solar PV) cells and that can cause pollution during the decommissioning of the solar modules at the end of their useful life.[35] The solar energy industry has put in place some initial mechanisms to ensure the safe production and recycling of its products: the Silicon Valley Toxics Coalition (SVTC) publishes a regular scorecard[36] of global solar module manufacturers, showing how companies perform on a series of sustainability and social justice benchmarks.[37]

Clearing forest land for a free-field solar PV park can contribute to climate change (*direct* Land Use Change). Equally, if solar PV-free field systems are built on agricultural land and displace agricultural production to forested land, there is also a negative impact (*indirect* Land Use Change). But land use changes or solar PV parks on agricultural land can be reduced through the dual use of solar PV installed on stilts such as on grazing lands for sheep, cattle or geese – see Figure 14.[38] The combination of solar PV (on stilts) with crops, such as vegetables, is known as agrivoltaic.

Figure 14: Combination of free-field PV and agriculture

Source: ENBW (n.d.)

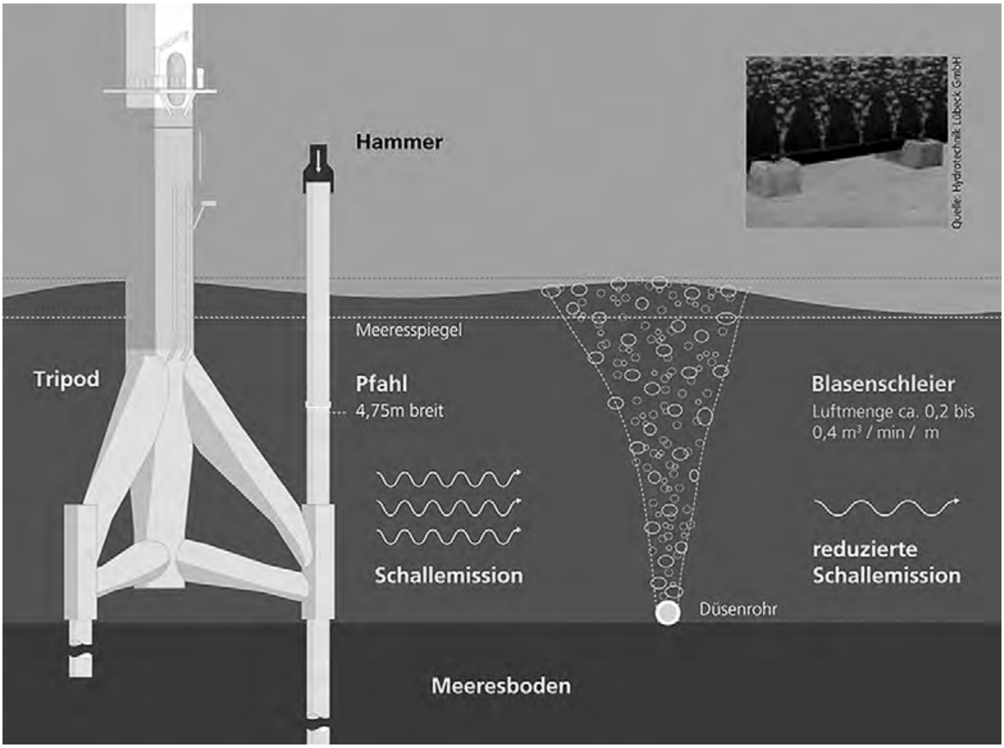
35 Environment Canada (2012) **36** SVTC (2014) **37** SVTC (n.d.)
38 The PV system can provide shade for cattle or sheep to rest underneath and because of higher soil moisture level, the shading will reduce irrigation expenses.

Environmental impact of wind power

Wind power turbines and their access roads can negatively affect national parks, protected zones or monuments; therefore, they should not be built in these areas. Rotating blades of onshore and offshore wind farms can affect some bird species and this should also be considered when granting construction permits.

During the construction period of offshore wind power plants, the drilling noises can harm ocean wildlife. To mitigate these effects, construction can take place outside of migration periods and the construction site can be sheltered with a wall of air bubbles (Figure 15).

Figure 15: Bubble curtain to minimize the effects of underwater drilling on wildlife



Source: BfN (n.d.)

MYTH 5: NUCLEAR ENERGY IS ENVIRONMENTALLY FRIENDLY

Many people believe that nuclear energy is environmentally friendly, that it is cheaper than most alternatives and is a much better low-carbon alternative than renewable energy.

But the facts are different.

The nuclear industry proclaims that nuclear power is cheap.[39] But the latest nuclear power projects, particularly in Europe, have raised concerns.

In 2005, the Finnish cabinet licenced TVO[40] to build a new unit (Unit 3)[41] at the Olkiluoto nuclear power plant, which is located in western Finland. The new unit, consisting of a first-of-its-kind 'third generation pressurized water reactor' (known as EPR) was expected to be safer, more efficient, as well as faster and cheaper to build than existing plants.[42] Initially, the main contractor was Areva NP (a joint venture between Areva and Siemens) but in 2009 Siemens sold its shareholding and pulled out of the nuclear business.[43] The construction was expected to be completed by 2009 but has been plagued by delays. The current expectation for the reactor to become operational is nine years after the original date (2018).[44] The delays have been due to lawsuits, technology failures, construction errors and miscommunication.[45] The estimated cost has risen from USD 3.6 billion to USD 9.5 billion. Currently, TVO and Areva are locked in a USD 10.5 billion legal battle over the cost overrun.[46] If the lawsuit goes against TVO, a utility company in Finland owned by shareholders, it would affect local industries in Finland. Another EPR reactor is to be constructed at the Hinkley Point C facility in the UK. An analysis by a renewable energy association found that Hinkley Point C will cost consumers USD 36.9 billion but a solar facility with electricity storage would cost British consumers just USD 18.2 billion.[47]

Over and above the construction cost of projects like Olkiluoto Unit 3 and Hinkley Point C, an additional concern is that countries will eventually have to pay the full cost of nuclear energy. This includes decommissioning and waste storage long after nuclear energy companies have moved out. Figure 5 in Myth 1 shows an estimate of the full cost of generating nuclear energy for Germany compared with other energy forms. The full cost for nuclear includes waste disposal and the risks of a nuclear accident.

Environmental concerns regarding nuclear waste

Apart from the cost, we must factor in the severe damage to the environment and human health that nuclear energy has caused in the past and will potentially cause for a further 300,000 years. According to GE Hitachi, USD 100 billion was set aside for the management and disposal of nuclear waste worldwide in 2015.[48] But it is doubtful as to whether this will be enough to deal with the long-term storage of nuclear waste.

Each year, nuclear power generation facilities worldwide produce about 10,000 truckloads of low and intermediate-level radioactive waste[49] and about 500 truckloads of

39 World Nuclear Association (2016 E) **40** Teollisuuden Voima Oyj, a Finnish nuclear power company. **41** Schneider et al. (2011) **42** Carbon Brief (2015) **43** World Nuclear News (2011 A) **44** World Nuclear News (2011 B) and The Ecologist (2015) **45** Carbon Brief (2015) **46** The Ecologist (2015) **47** Solar Trade Association (2015) **48** WNA (2016 A) **49** Intermediate level waste includes filters, steel components with reactor with a radioactivity of 4%. 90% of the volume consist of low level waste (tools, work clothing) with a radioactive content of 1% (WNA, 2016 B) **50** 3% of the waste consists of high-level waste of used nuclear fuel with a radioactive content of 95% (WNA, 2016 B) high-level radioactive waste.[50] These materials remain radioactive and dangerous to human health for thousands of years. Currently, there are two options for dealing with this poisonous load:

1. Direct disposal into a geological repository. However, no country has started storing radioactive waste on a permanent basis in a geological repository. Only the USA and Sweden have selected sites for their material after the intermediate cooling period.[51] It takes about 300,000 years for the radioactive waste to reach the same level of radioactivity as the original ore. The repositories must keep the waste safe throughout this time to prevent radioactivity from polluting the environment.
2. Reprocessing of the spent nuclear fuel. This enables partial reuse in power plants. However, it takes about 9,000 years for the radioactivity of the leftover material to decay.

Box 6 gives an example of the devastating effects of an improperly managed nuclear waste site in Russia.

Box 6: Lake Karachay – Effects of a nuclear waste disposal site

The Soviet Union used Karachay as a dumping site for radioactive waste from Mayak, a nuclear weapons factory, built in the 1940s. It is in Russia's south-west Chelyabinsk region, close to the northern border with Kazakhstan. Today, Lake Karachay is the most polluted spot on Earth.

Initially the radioactive waste from Mayak were dumped into the nearby Techa River, on which the local population depended. This method was changed to storage in rows of vats after it was found that 65 % of the local population was affected by radiation sickness. The storage facility exploded in September 1957, spewing about 70 tons of radioactive waste a mile high and the resulting dust cloud spread over 9000 square miles (over 23,000 km^2). Around 270,000 citizens and their food sources were affected. Lake Karachay was designated as a storage site since there were no outlets for the lake. This practice continued until 1967, when a severe drought dried up the lake exposing the radioactive sediments in the basin. Today, huge tracts of the region remain uninhabitable.[52]

Concerns regarding nuclear accidents

A further concern is nuclear accidents, which have been numerous throughout the history of civil nuclear energy use. The British newspaper, the Guardian, has identified 33 serious incidents and accidents at nuclear power stations since the first one recorded in 1952 at Chalk River in Ontario, Canada.[53]

An uncontrolled reaction in a nuclear reactor can potentially result in widespread contamination of air and water.[54] The three biggest nuclear accidents happened at reactors in Three Mile Island (1979) in the US,[55] Chernobyl Unit 4 (1986) in the Soviet Union and Fukushima (2011) in Japan.[56] Box 7 and Box 8 give short overviews of what occurred in Chernobyl and Fukushima.

51 Intermediate storage lasts 40-50 years, during which the material must be cooled using cooling water (WNA, 2016 A) **52** Gayle (2012) **53** The Guardian (2016) **54** EIA (2015) **55** In the Three Mile Island nuclear plant (Pennsylvania, USA), Unit 2 partially melted on 28 March 1978. **56** WNA (2016 C)

Box 7: Chernobyl 1986 – Disaster at a nuclear power plant in Europe

The Chernobyl reactor in the Soviet Union (Ukraine, near the border with Belarus) exploded on April 26, 1986, during a reactor systems test. The World Health Organization (WHO) has reported that about 200 times the radioactivity of that released by the Hiroshima and Nagasaki atomic bombs was spread across the Western Soviet Union and Europe.[57]

About 70 % of all radioactive substances released into the atmosphere during the accident fell on the territory of Belarus, which lost 23 % of its national territory to the catastrophe. The territory of the Polessye State Radiation-Ecological Reservation (1,300 km^2), the area nearest to the power plant, will remain uninhabitable due to high contamination by long-lived radioactive isotopes for tens of thousands of years.[58]

Almost 30 % of Belarussian forest land was affected by significant levels of radioactivity; over 22 % of total agricultural land was contaminated and 15 % of agricultural land was lost. Immediately after the accident, a significant increase in gamma radiation exposure was registered throughout Belarus and it was declared a zone of ecological calamity.[59]

Because of the disaster, approximately 220,000 people had to be relocated.[60] Over 1.1 million Belarussians still live in radioactively contaminated territories. Continued increases in morbidity have been observed.

Box 8: Fukushima 2011– Disaster at a nuclear power plant in Asia

In Japan, after an earthquake followed by a tsunami, the backup diesel generators needed to cool the reactors of nuclear power plant Fukushima were flooded. Overheating of fuel in the plant's operating reactor cores led to hydrogen explosions that severely damaged three reactor buildings. Fuel in these reactor cores melted and radiation released from the damaged reactors contaminated a wide area surrounding the plant and forced the evacuation of nearly half a million residents. Highly radioactive water was released into the Pacific Ocean.

In November 2011, the Japanese government determined that about 11,580 square miles (or 30,000 km^2, the surface area of Belgium) had been contaminated with long-lived radioactive caesium.[61] By 2012 around 160,000 people had been displaced due to the accident.[62] The total economic loss is estimated to be in the range of USD 130 billion.[63]

57 WHO (1995) **58** Dawe (2016) **59** Kenik (1995) **60** Union of Concerned Scientists (n.d.) **61** Starr (2016) **62** Fukushima On The Globe (n.d.); Blei (2016) **63** WNA (2016 D)

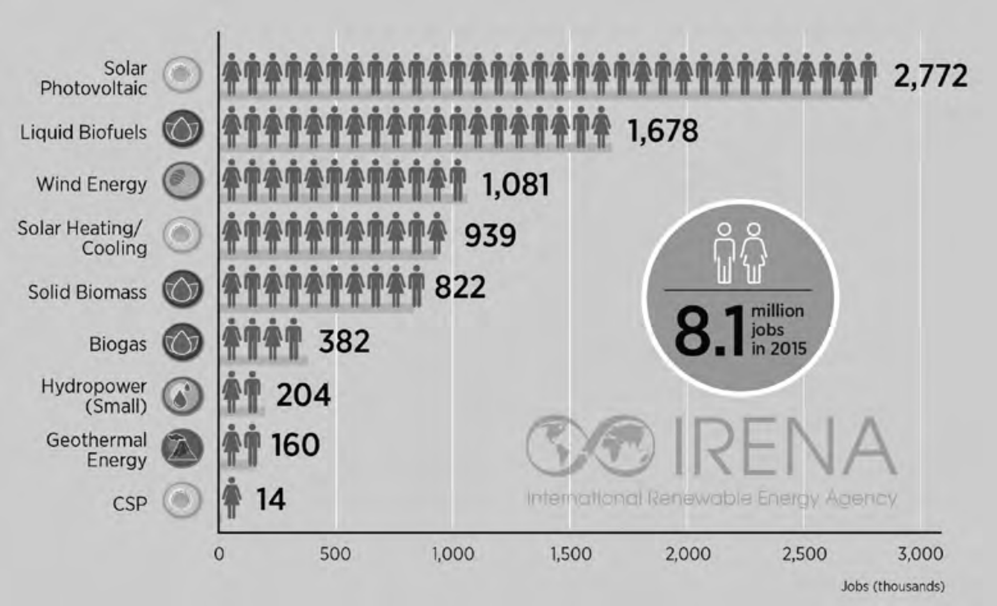
MYTH 6: TRANSITION TO RENEWABLE ENERGY COSTS JOBS

A common myth is that a transition to renewable energy costs jobs; that jobs will be lost in coal mining, oil and gas extraction, in the shipping of fossil fuels, and in pipeline, thermal power plant and transport infrastructure construction. The transition to renewable energy, it is claimed, would not match these losses with the creation of new jobs.

But the facts are different.

The total number of jobs in renewable energy increased globally by 5 % to 8.1 million in 2015,[64] which is in stark contrast to the depressed labour markets in other parts of the energy sector. There was a 3 % decrease in renewable energy employment in the EU, but over one million people were still employed in renewable energy with 355,000 renewable energy sector jobs in Germany alone. In the United States, renewable energy jobs increased by around 6 %, whereas employment in oil and gas extraction (and support activities) decreased by 18 %. In China, renewable energy employed over 3.5 million people, exceeding the 2.6 million employed in China's oil and gas sector. Bangladesh employed 127,000 people in solar PV. In addition, there are an estimated 1.3 million jobs in large hydroelectricity.[65]

Figure 16: Global renewable energy employment in 2015



Source: IRENA (2016)

64 Most of these data are from: IRENA (2016) **65** According to commonly accepted definitions, renewable energy includes small hydro with an installed capacity below 30 Megawatt (MW); it excludes large hydroelectricity.

Most jobs are in solar PV, as can be seen from Figure 16. Solar PV equipment manufacturing is predominantly in Asia and, because of import duties in the EU and USA on Chinese solar panels, China relocated some production to countries such as Brazil, India, Malaysia and Thailand in 2015. Liquid biofuel provides a lot of employment in countries such as Brazil that grow, refine and utilise biofuels on a significant scale. Many people in China, the US and Germany work in wind power, and India and Brazil now also have large and growing workforces in this sector. China, India and Germany have the largest workforces in biogas.

By comparison the coal, oil and gas industries jointly provide about 13 million jobs globally and are currently responsible for nearly four times more energy compared with renewable energy plus large hydropower.[66] Although these figures exclude some construction and jobs in coal and gas power plant operation, this data clearly suggests that a transition to renewable energy would deliver more jobs, not fewer.

This is confirmed by a study in Vietnam that compared the expected effects on employment of the official Power Development Plan up to 2030 (with its primary focus on power generated using coal), which is expected to create 260,000 jobs, and an Advanced Sustainable Energy Scenario (with a major focus on solar, biomass and wind power) that is set to deliver 700,000 additional jobs.[67] Similarly, a study in Australia on the impact of a change from 34 % to 50 % of electricity generated from renewables by 2030 also highlights net employment creation across Australia, notably from the construction and installation of solar PV.[68]

Jobs in renewable energy tend to be clean and require important skills. Data from an IRENA survey of 90 companies from 40 countries also suggests that an average 35 % of their workforce are women, whereas women only make up 20 to 25 % of the workforce in the entire energy industry, which is still dominated by fossil fuels.[69] This is promising, but not everyone from the sector would have the skills needed to find employment in the renewable energy sector. Many jobs in renewable energy are unsuitable for (former) coal miners, so re-training would be needed and alternative employment opportunities must be created.

MYTH 7: A LACK OF RENEWABLE ENERGY EXPERTISE HOLDS BACK DEPLOYMENT IN DEVELOPING COUNTRIES

Objections to early and fast deployment of renewable energy in developing countries include the myth that it is being held back by a lack of expertise. The technology is said to be too complex and too difficult for domestic companies to develop or acquire and therefore it would make developing countries dependent on foreign companies and experts. Deployment in remote, rural and poor areas, it is argued, would also fail because of lack of services for installation, repair and maintenance.

But the facts are different.

Human resources are important but need not be a major barrier to the deployment of renewable energy. With support from governments delivered by universities and technical colleges to capacity development programs, and technology exchanges between businesses, it is possible to address limitations in human resources for renewable energy development in a short period of time. For example, as soon as renewable energy was given the go ahead by the Chinese government, semi-governmental industries started producing wind energy converters, first as part of joint ventures with foreign companies and later under licencing agreements. This was accompanied by joint research projects, the establishment of numerous university degrees, as well as technical vocational skills programmes. This led China to become a leading producer of renewable energy technologies.
Many renewable energy technologies are fully developed, which means that they are being manufactured by numerous companies in different countries. Moreover, they have become affordable and are now being deployed on a very large scale. This can be said of wind power, solar PV and solar heating, biogas digesters (at different scales) and, of course, hydro-electricity generators and biomass-based boilers and power generators, as well as Concentrated Solar Power (CSP). A wealth of information on these technologies is very widely available and taught at schools and colleges in many countries of the world, and new assembly and manufacturing companies can be established using this knowledge. For example, there are 20 universities in Vietnam offering courses in renewable energy and/or research in wind power and two universities have developed renewable energy courses at bachelor and master levels.[70]
Renewable energy companies often provide direct training for their staff, distributers and prosumers. Large companies and research institutes are undertaking research and development (R&D) into some components, such as into the efficiency of solar cells and of batteries. R&D is mainly happening in developed countries, but it does also take place in developing countries. China is now a world leader in several technologies. New manufacturing processes and products may be patented so companies are also establishing production units in other countries. They are licensing local companies to use their technologies; they want to sell their products abroad and are seeking cooperation with investors and domestic companies to set up power plants. Furthermore, components of renewable energy systems are being manufactured in some developing countries even if the local deployment is still in its infancy, as illustrated by Box 9.

70 GIZ (2016)

Box 9: Trade disputes over towers for wind turbines from Vietnam

Developing countries can develop competitive renewable energy products in short periods of time, as is demonstrated by the international trade disputes over towers for wind turbines.

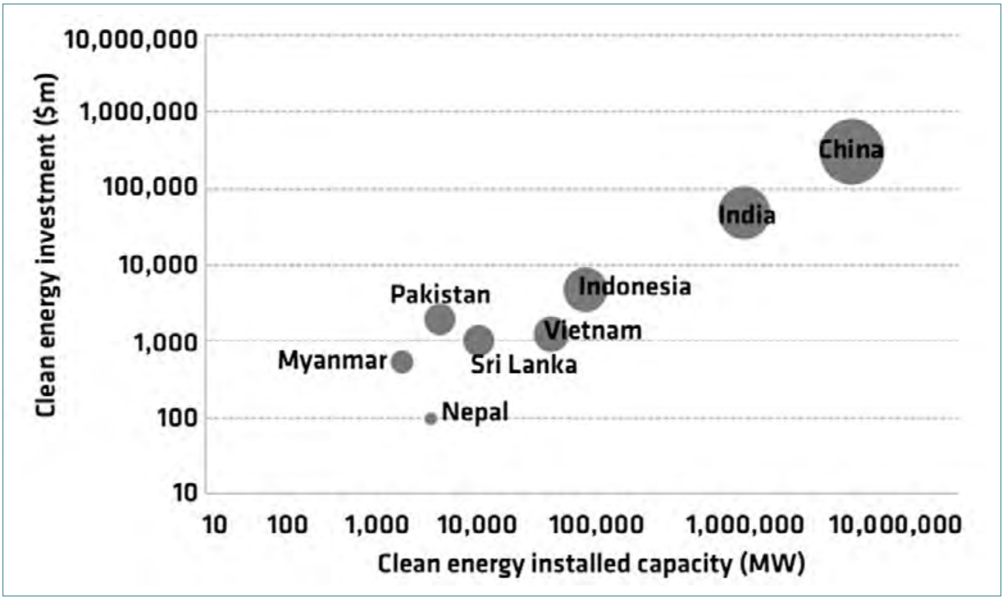
Vietnam only has a very small number of wind power parks, but companies manufacturing and exporting wind towers emerged even before any wind turbines had been erected in the country. CS Wind (Vietnam) was established in 2003 as the first such company, and it still is the main wind tower production base of CS Wind, a Korean company. UBI Tower, a Vietnamese company started building wind towers in 2010.

US manufacturers started a trade dispute in 2011, alleging that wind towers exported from Vietnam and China to the US were being sold at around two thirds of their 'normal value'.[71] The US International Trade Commission assessed the case[72] and China asked the World Trade Organization (WTO) for arbitration on imposed duties, with Vietnam as a 'third party.[73] In 2015, an 'administrative review by the US Department of Commerce of anti-dumping duties imposed on wind tower exports from Vietnam concluded that the prices of CS Wind (Vietnam) were not unfairly low, although according to the USA, Vietnam is a non-market economy, which continues to make such duties justifiable.[74]

The annual Bloomberg Climatescope Report, which assesses renewable energy markets in developing countries, found that 'Asian countries performed exceptionally well in Low-Carbon Business and Clean Energy Value Chains'.[75] Figure 17 presents the completeness of the value chains in Asia with China reaching the maximum score of the assessment.

71 Bloomberg (2011) **72** US International Trade Commission (2013) **73** WTO (2016) **74** Vietnam Breaking News (2016) **75** BNEF (2015)

Figure 17: Asia value chain completeness, compared to installed capacity and investment



Note: Larger bubbles indicate more complete value chains. China has a perfect score of 5.00 for value chains.

Source: BNEF (2015)

Making renewable energy equipment available is not the only problem: it also needs to be deployed – in the form of large power plants or boilers for industrial drying, biogas digesters, solar water heaters, and solar PV power generation units at household and community level. The reach of new technology into remote rural areas and the uptake by poor and often illiterate people has been questioned but there are many examples where capacity building has been extremely successful and has enabled widespread distribution and adoption. The examples on capacity building for spreading solar PV technology and bio-digesters in Box 10 and Box 11 illustrate this.

Box 10: Grandmothers turned solar engineers

The Indian Barefoot College proves very well that sophisticated technical knowledge can be acquired by anybody and that this can empower people and transform their lives.

Barefoot College has trained illiterate and semi-literate women, often grandmothers, from all over India and 76 other countries in solar PV technology assembly, maintenance and repair (Figure 18). Villages that are not connected to the power grid select some women who are then trained as solar engineers over a period of 6 months. They then return to serve their village and earn a regular income. This has provided at least 14,500 households with solar power. The Barefoot College also trains women in solar water heaters, solar cookers and solar-powered desalinisation of water. It has received international awards and very wide recognition for its numerous achievements.[76]

Figure 18: Barefoot College solar engineer training classroom

Source: Courtesy of Barefoot College[77]

76 Barefoot College (2016a); Top Documentary Films (2012); YouTube (2011); also: ADB (n.d.) **77** Barefoot College (2016b)

Box 11: Biogas digesters: capacities were built but support to investment still needed

Household-level bio-digesters using (notably) animal manure and producing gas for cooking, heating and lighting as well as slurry to fertilise fields have become popular in many countries. SNV has facilitated the installation of over 700,000 bio-digesters in several countries in Asia, Latin America and Africa, which now benefit an estimated 3.5 million people. This includes Cambodia's National Biodigester Programme (NBP) which has reached about 20,000 households since 2006.[78]

As is the case in other countries, NBP trains local bio-digester construction groups and provides a small subsidy to beneficiaries to reduce their investment costs but the aim is to create a market-oriented, self-financed biogas sector. This capacity building and local demand for bio-digesters creates employment and other benefits such as saving on expenditures and on cooking time, improved indoor air quality, reduced use of wood for fuel and improved fertiliser for crops.

Due to its climate change mitigation potential and social benefits, the NBP has received the 'gold standard' for carbon credits that are sold on the international carbon market.[79] This delivers a revenue stream to make it a self-sustaining programme and replaces the Official Development Assistance (ODA) subsidy on bio-digester investments. It is been involved in capacity building and the technology is now well known in many localities. However, carbon credits are low priced and complete financial independence from subsidies has proven difficult to achieve. Further growth in this technology requires continued support through (small levels of) investment: 'Governmental regulation and coordination will remain needed and carbon finance will not easily fully replace ODA and governmental financial support'.[80]

78 SNV Netherlands Development Organisation (2016a) **79** SNV Netherlands Development Organisation (2016b) **80** Buysman and Mol (2013); see also: ADB (n.d.)

MYTH 8: RENEWABLE ENERGY IS BACKWARD TECHNOLOGY

Some believe that renewable energy technology is simple, old fashioned and outdated and that it does not fit a modern and urban model of development. They argue that the renewable energy prevents developing countries from moving forward, and in cases where the technology is viewed as modern and efficient, it is said to be controlled by companies from developed countries. Critics, therefore, conclude that it is not worth investing in renewables.

But the facts are different.

Waterwheels and windmills have powered artisanal and small-scale industrial processes for two millennia, as well as drainage and irrigation systems for agriculture (see Figure 19).

Figure 19: Traditional water power use in Vietnam

Source: author's picture

The industrial revolution was first powered by trees, leading to vast deforestation, and then by fossil fuels such as coal for steam engines. Even today we use fossil fuel technologies (most of which were invented in the 19th century) for transport and electricity production. Windmills producing electricity also hail from the 19th century.
However, since the second half of the 20th century, most of these technologies have made quantum leaps in efficiency and size. These fields have seen the application of technological knowledge developed in the space and aircraft industries, not only with regards to materials, but also as part of their manufacturing processes and cybernetics. The technologies developed within these fields can be really large: the largest offshore wind turbines now have an installed capacity of 8 MW, a rotor diameter of 164 meters and a total height of 220 meters, which is as high as a 65-storey skyscraper (see Figure 20).

Figure 20: Vestas V164-8MW - the largest (offshore) wind power turbine available

Source: Courtesy of MHI Vestas Offshore Wind[81]

Turbines to capture the energy of ocean waves also use very sophisticated mechanics and advanced engineering. New materials are being invented in the 21st century and applied to all sorts of renewable energy technologies to increase efficiency and strength and to reduce costs. Modern electronics and information technology are also very much part of renewable energy development.
The first practical solar cell was developed by Bell Labs in the 1950s in the context of the 20th century space race. Tesla, also a US company, is at the technological cutting edge in terms of electric cars, battery technology and solar PV home systems, and it aims to reach mass markets. All large car companies in the world are conducting research and development and some have started the production of hybrid and all-electric cars.

81 MHI Vestas Offshore Wind (n.d.)

This trend will benefit from increasingly decentralised ('distributed') power production such as rooftop solar PV, because car batteries can be charged when supplies are high, and cars can become a power source for homes when renewable energy production is low or absent.

The integration of renewable power production, power storage and electric transport is part of a transformation that is about to happen in developed countries and that will soon affect developing countries. For example, there is a draft EU directive that will require electric vehicle charging points to be available for every new house built in Europe; and policies are being prepared in different European countries to phase out the sale of new cars with internal combustion engines from 2030.

These trends are partly driven by consumers who want cleaner and greener products and by voters and policy makers who are sending a signal to industry that influence major decisions; they no longer accept 'greenwashing' but want to see real change in investment. The international movement for 'divestment' out of fossil fuel companies[82] is supported by a wide variety of institutions, ranging from pension funds and local authorities such as German federal states[83] to churches and universities, which are moving their savings to other investments. This reinforces the signals sent to the financial markets by the 'Paris Agreement' under the UN Framework Convention on Climate Change that many of the known reserves of coal and petroleum may never be exploited; that the actual value of 'big oil' and coal mining companies, therefore, is less than it seems and that a shift to renewable energy is not only ethical but also a financially wise move to make.

The divestment movement and others are starting to have a real impact. For example, some 88 global companies have joined 'RE100' and have made a commitment to become '100 % renewable'.[84] This includes some of the largest companies in the world in sectors ranging from banking, electronics and IT to foodstuffs, cosmetics and car manufacturing. Some of the big names include: Apple, Bank of America, BMW, Coca Cola, Commerzbank, Facebook, General Motors, GoldmanSachs, Google, Johnson+Johnson, Microsoft, Nike, Philips, SwissRe, Tata Motors, Unilever and Walmart. They are making various commitments, including installing solar PV generation systems on their facilities across the world, which will provide a boost to local manufacturing, supply and installation companies and jobs in the local renewable energy industry (see also Box 4). And shareholders and the public can hold them to account to enact their promises.

Finally, as argued in the section on employment and human capacity development, the sophisticated nature of renewable technology and the fact that some patents are held by international companies do not necessarily constitute major barriers for developing countries, local industry or even for illiterate people who no longer need to remain outside of the renewable energy transition. Vietnam is exporting wind towers, even before deployment of this technology has taken off in the country itself and despite trade barriers (Box 9). Barefoot College in India demonstrates that sophisticated knowledge from all over the world can be acquired by illiterate grandmothers, if they are empowered to help transform their communities with modern, renewable energy technology (Box 10).

82 Fossil Free(n.d.) **83** 350 (2016): North Rhine Westphalia in January 2016, followed by Baden Württemberg, Berlin and Rheinland-Pfalz **84** RE100 (n.d.)

RENEWABLE ENERGY MUST BE SCALED UP RAPIDLY EVERYWHERE FOR THE BENEFIT OF ALL

Setting the record straight on renewable energy myths is important. A transformation to renewable energy is happening in many parts of the world, but it needs to happen faster, and it needs to benefit all countries, poor and disadvantaged women and men and local businesses.

The question as to *how and when* we will achieve a renewable energy future in developed and developing countries is key and we conclude that a fast and fair transition is possible through changes in economic policy and action. These changes must be real changes by governments, foreign and domestic investors, and not just 'greenwash'.

Making the transition fast and for the benefit of all means that many interests must be aligned, which is why we are challenging misconceptions with this booklet. It is crucial that the public remains aware of the fact that fossil fuels are a finite resource and that they lead to negative environmental, health, economic and social impacts: fossil fuels are the primary cause of global climate change which is threatening the foundations of human civilisation. Public awareness of the advantages and limitations of renewable energy is also important in order to reach a consensus on national policy objectives on renewable energy.

Every country will need different policy objectives, but they could include the following:

a) Provide all people and businesses with access to sustainable energy[85]
b) Create local jobs and develop local value chains including the manufacture, supply, installation, repair and maintenance of renewable energy technologies
c) Increase the ambition to reduce greenhouse gas emissions in revised Nationally Determined Contributions (NDCs). These have been submitted by all countries under the UNFCCC but are inconsistent with the overall aim of limiting average global warming to 1.5°C above pre-industrial temperatures and avoiding dangerous climate change
d) Reduce local landscape destruction and pollution, losses to local livelihoods and negative effects on health and even death due to the exploitation, transportation and use of fossil fuels
e) Reduce import dependency by lowering the use of fossil fuels, and developing energy generation technologies

A transition towards renewable energy requires key action in developing and developed countries. The actions required will also be different, but they could include the following:

1. Invest in renewable power generation projects and steadily increase investments over time
2. Enable distributed renewable power production such as solar PV on the rooftops of businesses, groups of households (neighbourhoods, villages) and individual households through 'net-metering' regulations
3. Stop investing in new coal and nuclear plants and shut down old coal-fired power plants as they reach the end of their lifespan
4. Retrain workers from the fossil fuel industry, including coal miners, and if possible offer them clean, green jobs in the renewable industry (where employment opportunities need to be created)

85 This is consistent with Sustainable Development Goal 7 - https://sustainabledevelopment.un.org/sdg7

5. Increase energy efficiency (many countries have huge potential in this regard)
6. Support independent renewable energy solutions especially in remote off-grid areas, including hybrid mini-grids

These policies and actions will bring numerous benefits to people, economies and the environment.

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