

Sustainable development through climate leadership- Opportunities for LDCs in the transition to renewable energy

By Anne Zimmer, Claire Fyson, Emily Theokritoff, Ziaul Haque and Tenzin Wangmo

The climate action and sustainable development agendas are intrinsically linked. Limiting warming to 1.5°C will require systemic change that is integrated with sustainable development; at the same time, climate change action is itself one of the sustainable development goals. Taking these linkages into account can yield important opportunities for LDCs. So-called “co-benefits” arise when climate change mitigation measures create positive synergies with sustainable development. Incorporating these co-benefits when designing NDCs and making climate finance applications could help LDCs to achieve both ambitious climate action and sustainable development.

This briefing identifies areas where such positive synergies exist, and explores the potential for a transition to a more sustainable and efficient energy system based on renewable energy to generate sustainable development co-benefits in the LDCs.

Key findings

Economic benefits: taking advantage of the renewable energy revolution

- **Energy independence:** Energy imports are a substantial burden to Least Developed Countries (LDCs) and a number of LDCs pay more for fuel imports than for education on a per capita basis. If all LDCs halved their spending on fuel imports by installing more domestic renewable energy capacity and enhancing energy efficiency, they could in total save over 7 billion USD per year in fuel import expenditures. Such savings could be used to finance necessary investments in renewable energy roll-out, or could be invested in other areas of development, e.g. in education and health.

Total spending on fuel imports by LDCs in 2017: over 15 billion USD

- **Energy access:** As shown in practice around the world, off-grid renewable energy technologies can provide opportunities to improve access to electricity even in remote areas.

Total number of people lacking access to electricity in LDCs: over half a billion people

Share of rural population in LDCs lacking access to electricity in 2016: 66%

Population lacking access to clean fuels and technologies for cooking: over 80%

Only one out of three primary schools in LDCs has an electricity connection

- **Reliability of electricity supply:** An increase in renewable power generation could improve the reliability of electricity supplies and reduce losses in revenue caused by power outages.

Over 75% of businesses in LDCs experienced power outages in 2017, resulting often in substantial revenue losses

- **Energy prices:** The costs of both on- and off-grid renewable power generation have fallen dramatically over the past decade. Solar photovoltaic (PV) module costs have dropped by 80% since 2009, and battery costs have fallen by over 70%, making off-grid options cost-competitive in currently unelectrified areas. From 2020, new solar PV and wind power installations will produce cheaper power than existing fossil fuel power plants, including the cheaper coal-fired options.

Employment benefits: sustainable job creation

- Investing in renewable energy can contribute to creating local employment opportunities in construction and installation as well as in Operations and Maintenance (O&M). The distributed nature of renewable energy technologies has great potential for job creation in rural areas.

If doubling of electricity consumption was covered by new wind and solar capacity, total job creation potential across 18 LDCs is estimated to be:

- In construction and installation: between 1.8 million and 4.3 million job years (i.e. between about 365,000 and 870,000 annual jobs building up renewable energy capacities over a period of 5 years)
- In O&M: between over 100,000 and 250,000 jobs over the lifetime of the installations

Health benefits: air pollution reduction

- **Indoor air pollution:** Renewable energy technologies provide opportunities to reduce the exposure to health damaging household air pollution.

Total number of deaths in LDCs from indoor air pollution in 2016 (estimates): over 685,000
On average, 86% of the population in LDCs does not have access to clean technologies or clean fuels for cooking

- **Outdoor air pollution:** Reducing fossil fuel combustion, e.g. from coal power plants or transportation, can reduce emissions of health damaging air pollutants.

Total number of deaths in LDCs from outdoor air pollution in 2016: over 410,000
Almost all of the population in LDCs is exposed to fine particulate matter (PM_{2.5}) concentration levels exceeding WHO¹ limits

Development benefits: synergies with Sustainable Development Goals (SDGs)

- The roll-out of a more efficient, renewables-based energy system could substantially contribute towards achieving *SDG 7 'clean, reliable and affordable energy for all'*, *SDG 3 on 'good health and well-being'*, *SDG 8 'decent work and economic prospects'*, *SDG 9 'industry, innovation, and infrastructure'* and *SDG 11 'sustainable cities and communities'*. Moreover, it could help *reduce inequality (SDG 10)*, for instance between rural and urban areas, *foster education (SDG 4)*, and *reduce gender inequality (SDG 5)*.

¹ WHO – World Health Organisation

Développer durablement par le biais d'un engagement climatique – Opportunités pour les PMA dans la transition énergétique

Par Anne Zimmer, Claire Fyson, Emily Theokritoff, Ziaul Haque et Tenzin Wangmo

Les agendas de l'action climatique et du développement durable sont intrinsèquement liés. Limiter le réchauffement à 1,5°C nécessite un changement systémique intégré au développement durable; en même temps, l'action climatique est elle-même un des objectifs du développement durable. La prise en compte de ces liens peut offrir d'importantes opportunités aux PMA. On appelle "co-bénéfices", les mesures d'atténuation au changement climatique qui créent des synergies positives avec le développement durable. L'intégration de ces co-bénéfices lors de la conception des CDN et de demandes de financements climat pourrait aider les PMA à réaliser des actions ambitieuses au niveau du climat et du développement durable.

Ce rapport met en avant les domaines dans lesquels de telles synergies existent et explore le potentiel pour une transition vers un système énergétique plus durable et efficace basé sur les énergies renouvelables afin de générer des co-bénéfices durables pour les PMA.

Conclusions clés

Avantages économiques : tirer parti de la révolution des énergies

- **Indépendance énergétique** : Les importations d'énergie représentent un fardeau considérable pour les pays les moins avancés (PMA) et un certain nombre d'entre eux paient davantage pour les importations de combustibles que pour l'éducation par habitant. Si tous les PMA réduisaient de moitié leurs dépenses d'importation de combustibles en installant davantage de capacités nationales d'énergie renouvelable et amélioreraient leur efficacité énergétique, ils pourraient économiser au total plus de 7 milliards USD en dépenses d'importation de combustibles par an. Ces économies pourraient servir à financer les investissements nécessaires au déploiement des énergies renouvelables ou être investies dans d'autres domaines de développement, comme l'éducation et la santé.

Dépenses des importations de combustibles pour les PMA en 2017: plus de 15 milliards USD

- **Accès à l'énergie** : Comme le montre les pratiques autour du monde, les énergies renouvelables hors-réseau peuvent offrir des possibilités d'améliorer l'accès à l'électricité même dans les régions reculées.

Personnes n'ayant pas accès à l'électricité dans les PMA: plus d'un demi-milliard de personnes

Population rurale dans les PMA n'ayant pas accès à l'électricité en 2016: 66%

Population n'ayant pas accès à des combustibles et aux technologies propres pour la cuisine: plus de 80%

Seule une école primaire sur trois dans les PMA a accès à l'électricité

- **Fiabilité de l'approvisionnement en électricité** : Une augmentation de la production d'énergie renouvelable pourrait améliorer la fiabilité de l'approvisionnement en électricité et réduire les pertes de revenus causées par les pannes d'électricité.

Plus des trois quarts des entreprises des PMA ont connu des pannes d'électricité en 2017, entraînant des pertes de revenus considérables

- **Prix de l'énergie** : Les coûts de la production d'énergie renouvelable pour le sur-réseau et hors-réseau ont chuté de façon spectaculaire au cours de la dernière décennie. Les coûts des modules photovoltaïques solaires ont chuté de 80 % depuis 2009 et les coûts des batteries ont chuté de plus de 70 %, rendant les options hors-réseau compétitives en termes de coûts dans les zones actuellement non électrifiées. À partir de 2020, les nouvelles installations solaires et éoliennes produiront de l'électricité à un coût plus bas que les centrales à combustibles fossiles existantes, y compris les options au charbon les moins chères.

Avantages sociaux : création d'emplois durables

- Investir dans les énergies renouvelables peut contribuer à la création d'emplois locaux pour la construction et l'installation, ainsi que pour les opérations et l'entretien. La répartition des technologies pour les énergies renouvelables offre également un grand potentiel de création d'emplois dans les zones rurales.

Si le double de la consommation d'électricité était issue des nouvelles installations éoliennes et solaires, le potentiel de création d'emplois dans les 18 PMA considérés est estimé à :

- Pour la construction et l'installation: entre 1.8 million et 4.3 million d'emplois (c'est-à-dire entre 365,000 et 870,000 emplois annuels pour le renforcement des capacités d'énergie renouvelables sur une période de 5 ans)
- Pour les opérations et l'entretien: entre plus de 100 000 et 250 000 emplois sur la durée de vie des installations

Bienfaits sur la santé: réduction de la pollution de l'air

- **Pollution de l'air intérieur** : Les énergies renouvelables offrent la possibilité de réduire l'exposition à la pollution de l'air intérieur qui est nuisible à la santé.

Décès dans les PMA en raison de la pollution de l'air intérieur en 2016: plus de 685,000

En moyenne, 86% de la population dans l'ensemble des PMA n'a pas accès à des technologies ou à des combustibles propres pour la cuisine

- **Pollution de l'air extérieur** : La réduction de l'utilisation de combustibles fossiles, par exemple dans les centrales à charbon ou le secteur du transport, peut réduire les émissions de polluants atmosphériques nocifs pour la santé.

Décès dans les PMA en raison de la pollution de l'air extérieur en 2016: plus de 410,000

Presque toute la population des PMA est exposée à des concentrations de particules fines (PM_{2,5}) supérieures aux limites de l'OMS²

Avantages de développement : Synergies avec les Objectifs de Développement Durable (ODD)

- La transition énergétique pourrait considérablement contribuer à la réalisation de l'ODD 7 « Énergie propre et d'un coût abordable », l'ODD 3 « Bonne santé et bien-être », l'ODD 8 « Travail décent et croissance économique », l'ODD 9 « Industrie, innovation et infrastructure » et l'ODD 11 « Villes et communautés durables ». De plus, cela pourrait contribuer à réduire les inégalités (ODD 10), notamment entre les zones rurales et urbaines, à promouvoir l'éducation (ODD 4) et à réduire les inégalités entre les sexes (ODD 5).

² Organisation Mondiale de la Santé

1. The urgent need for more ambitious climate action

In 2018, the Intergovernmental Panel on Climate Change (IPCC) released its groundbreaking [Special Report on Global Warming of 1.5°C](#). The report's messages are very clear: climate change poses a severe threat, with risk being lower at 1.5°C than at 2°C or higher mean temperature increases. The impacts of warming will hit the most vulnerable the hardest. However, avoiding these more severe risks is still feasible, but requires cutting global CO₂ emissions by about half by 2030, to reach net-zero by mid-century. The report has found that current Nationally Determined Contributions (NDCs), if locked in until 2030, would render 1.5°C unachievable.

To achieve such a rapid reduction in emissions, the IPCC found that rapid and far-reaching transitions of our energy, land, urban and industrial systems will be required globally. These include:

- A rapid scaling up of near-term action up to 2030. Total greenhouse gas emissions need to be reduced by about 50% by 2030 compared to today (45% below 2010 levels).
- A phase out of coal by mid-century, while renewables grow to provide over three quarters of electricity globally
- Electrification of energy use in transport, industry and buildings
- Enhanced agricultural management combined with reduced food wastage and a shift to healthier, more sustainable diets
- A steep reduction in deforestation, accompanied by conservation and restoration of natural ecosystems and land carbon stocks

Both the impacts of climate change and options for its mitigation are closely linked to sustainable development. Climate change threatens to wipe out progress already made in sustainable development and poverty eradication. Conversely, there is potential for synergies between achieving sustainable development objectives and climate change mitigation action, provided that emissions reductions policies are planned and implemented in a way that does not leave the poor and vulnerable behind. There is therefore a clear case for climate action to be made a core component of any country's sustainable development plans.

Any delay in reducing emissions through such transformations will make it costlier and more difficult to limit warming. Continuing to develop in a carbon intensive manner will lead to lock-in into high carbon development trajectories, raising the risk of stranded assets that cannot be used in a low carbon world. Instead, an early steering towards a low carbon, sustainable development pathway can prevent such lock-ins, enabling a balance between economic prosperity, social well-being and environmental protection.

Current pledges under the Paris Agreement are collectively heading for a warmer-than 3°C world³ – a level of warming that would be devastating, in particular for vulnerable populations such as those living in the LDCs. All countries need to secure faster, deeper emissions reductions to keep the 1.5°C warming limit within reach, and the IPCC's Special Report provides a clear roadmap for how to do this. This message was further amplified in the run up to the Climate Action Summit by the UN Secretary-General, António

³ <https://climateactiontracker.org/global/temperatures/>

Guterres, who called on world leaders to bring forward concrete, realistic plans for enhancing their NDCs by 2020, to be consistent with the IPCC's findings of reducing greenhouse gas emissions by 45 per cent below 2010 levels by 2030, and to net zero emissions by 2050.

While LDCs have not contributed much to historical emissions, the development pathways any country chooses – in particular for those LDCs with rapidly growing populations and energy needs – can shape future chances of mitigating dangerous climate change and thereby influence future development prospects for all countries.

This briefing outlines how the LDCs themselves can benefit from following a low carbon development trajectory, focusing on the transition to a more efficient energy system powered by renewables. Additionally, Annex 1 provides **country specific information** for all LDCs on the potential for low carbon development to generate co-benefits, and Annex 2 provides links to tools on climate change impacts at the national and regional levels.

2. Co-benefits – a way of achieving multiple socio-economic goals

Historically, countries have often perceived climate change mitigation measures to be in conflict with economic development, prioritizing economic growth over environmental or climate objectives. However, research shows that many options for reducing CO₂ emissions can yield synergies for achieving other societal objectives.⁴ These positive side effects of climate change mitigation measures are often called 'co-benefits'.

There are many different forms of co-benefits. There can be economic co-benefits such as creation of employment and increasing the quality of jobs, labour savings for households, improving livelihoods, increasing entrepreneurship opportunities, reducing expenditures on fossil fuel imports, thereby reducing susceptibility to market price volatility and stimulating innovation and technological change. Co-benefits can relate to the environment, such as improving air, water and soil quality, and protecting biodiversity. Co-benefits of climate action can also have social dimensions, including enhanced access to clean energy and reduced health impacts, as well as positive political and institutional impacts, for example improving institutional structures or enhancing cooperation between different institutions or ministries.

The way a climate policy or measure is designed, as well as the national context and circumstances, can strongly affect the impact of the policy or measure, both with regard to reducing carbon emissions as well as building resilience to potential negative side effects. Potential trade-offs, such as unwanted distributional impacts, can be avoided or lessened if policies are carefully designed and complemented by other measures (IPCC Special Report on 1.5°C, 2018).⁵

For most LDCs, energy generation from imported fossil fuels is costly and exposes electricity costs to international price fluctuations⁶. At the same time, burning fossil fuels and traditional biomass contributes to air pollution, with associated health problems, and produces over 90% of CO₂ emissions⁷. A

⁴ See e.g. Ürge-Vorsatz et al. (2014): Measuring the Co-Benefits of Climate Change Mitigation Annu. Rev. Environ. Resour. 39 549–82 Online: <http://www.annualreviews.org/doi/10.1146/annurev-environ-031312-125456>

⁵ <https://www.ipcc.ch/sr15/>

⁶ UNCTAD 2017. The Least Developed Countries Report 2017: Transformational Energy Access https://unctad.org/en/PublicationsLibrary/ldcr2017_en.pdf

⁷ Data from the PRIMAP-hist dataset, see <https://www.pik-potsdam.de/primap-live/primap-hist/>

transformation of the energy system towards increased use of sustainable renewable energy sources, such as solar PV and wind energy, combined with energy efficiency measures, can therefore come with a host of economic and social co-benefits for sustainable development, as illustrated in Figure 1.

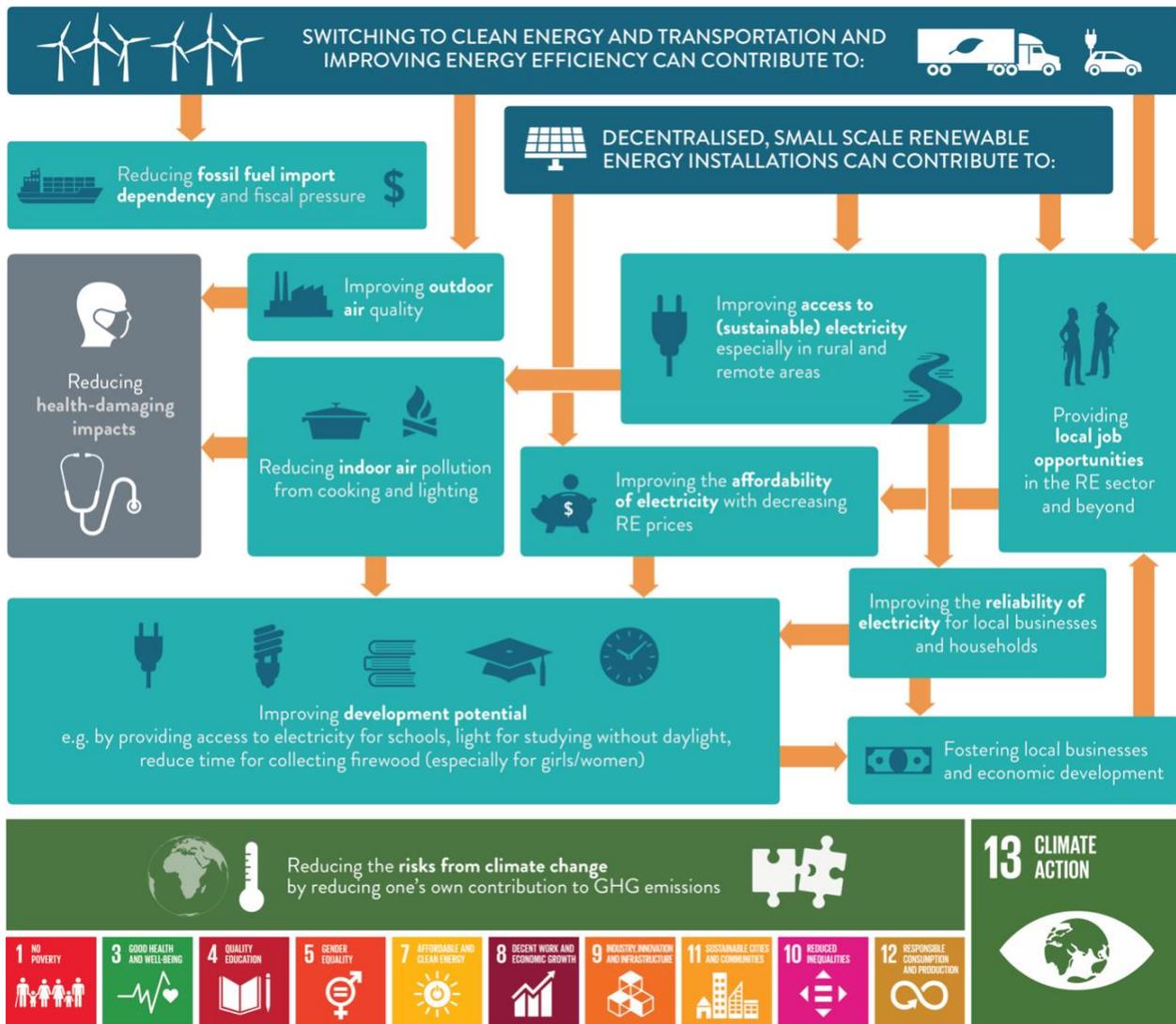


Figure 1: How the transformation of the energy system can contribute to other sustainable development objectives. Source: Climate Analytics⁸.

The importance of the energy sector for the LDCs in achieving sustainable development is reflected in the current NDCs brought forward by LDCs, all of which include the energy sector. 44 out of 47 NDCs include renewable energy targets, and 31 include targets for energy efficiency. However, only four LDC NDCs mention the co-benefits that could come with such measures.

⁸ Climate Analytics (2019). Decarbonising South and South East Asia: Shifting energy supply in South Asia and South East Asia to non-fossil fuel-based energy systems in line with the Paris Agreement long-term temperature goal and achievement of Sustainable Development Goals. <https://climateanalytics.org/media/decarbonisingasia2019-fullreport-climateanalytics.pdf>

Understanding the impact of these benefits could help LDCs to redirect domestic energy finance away from inefficient fossil fuel subsidies and mobilise private and international climate finance to fund the shift to a renewables-based energy system. While the number of climate and green financing facilities with a focus on sustainable development and climate action has been growing, a recent UNFCCC report found that the identification of co-benefits of climate action remains a key challenge in mobilising and delivering finance⁹. This briefing and accompanying country-specific data sheets (Annex 1) therefore outline the multiple socio-economic co-benefits that can arise from a transition towards renewable energy in LDCs.

Availability of international finance under the UNFCCC

The 1.5 Special Report from the IPCC (2018) states that to meet the 1.5°C target, the annual average investment needed in the energy system is around 2.4 trillion USD₂₀₁₀ between 2016 and 2035.

All LDC NDCs mention energy, 44 mention renewable energy and 31 mention energy efficiency, whereas only 22 mention clean cooking and heating. International support for the full implementation of these NDCs is critical as many targets are conditional – even though the costs of renewable energy have come down, access to finance remains a significant barrier to implementation.

Only 4 LDC NDCs mention co-benefits of mitigation. Putting a greater focus on mitigation co-benefits is therefore a **possible area for improvement in new and updated NDCs to be communicated by 2020**, as funders seek to mainstream climate change objectives into their development funding or identify benefits for sustainable development from climate finance.

Finance institutions have been increasingly focusing on sustainable development and climate action. Under the UNFCCC, finance mechanisms are available for LDCs, mainly through the Green Climate Fund (GCF) and the Global Environment Facility (GEF).

The [GCF](#) is the biggest global climate fund that supports developing countries to address climate change by shifting towards a low emission and climate resilient development. The GCF aims to allocate about half of its portfolio to mitigation, and a large share of its recent mitigation funding has been allocated to energy access and power generation¹⁰. Of the 124 projects approved by the GCF as of November 2019, 47 (38%) involve LDCs¹¹. Of these, 17 (36 %) were energy projects.

More information on GCF funding: <https://www.greenclimate.fund/gcf101>

The [GEF](#) funds are available to developing countries and countries with economies in transition to meet the objectives of the international environmental conventions and agreements.

More information on GEF funding: <https://www.thegef.org/about/funding>

⁹ UNFCCC 2018. Report of the Standing Committee on Finance to the Conference of the Parties, 23 November 2018, FCCC/CP/2018/8 https://unfccc.int/sites/default/files/resource/FCCC_CP_2018_8_0.pdf

¹⁰ 8th Report of the GCF to the Conference of Parties to the UNFCCC, 2019.

https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/tn_meetings/ea7aa7cfc8b84e709342cb7d1b2bf8d/fe7006766ab247e2b5cef9fb52ebdf72.PDF

¹¹ <https://www.greenclimate.fund/what-we-do/portfolio-dashboard>

3. Energy security – reducing fossil fuel import dependency, improving energy access and affordability

3.1 Energy independence through reducing reliance on fossil fuel imports

In 2017, LDCs spent more than 15 billion USD on importing fossil fuels such as oil products, coal and gas for energy generation. At least 12 LDCs (mostly African LDCs) spend over 5% of their total GDP on such imports, which in many cases is in a similar order of magnitude as expenditure on health care. On a per capita basis, a number of LDCs spend more on fuel imports than on education. This fuel import expenditure could be reduced by investing in renewable energy and energy efficiency. Since **renewable energy** is generated domestically, its deployment reduces the need to import fuels. More renewables would therefore reduce this economic burden and contribute to energy independence, freeing up valuable resources for investments in, for example, health (contributing to SDG 3) and education (contributing to SDG 4) as well as to invest in building up additional renewable energy infrastructure and energy efficiency measures (SDG 7 on clean energy).

Improved **energy efficiency** can also lower the need for fuel imports and facilitate the shift to renewable energy by reducing energy demand and improving the efficiency of the power supply system. This will be particularly important as demand for energy grows in the future. For example, the government of Bangladesh's energy efficiency and conservation master plan¹² anticipates that a reduction in power demand, to reach 20% below business-as-usual levels by 2030, would lead to an annual saving of BDT 135 billion (equivalent to ~1.6 billion USD, or about 1 % of GDP in 2013).

If all LDCs reduced their fuel imports by half (from 2017 levels), this could free up over 7 billion USD per year for expenditure elsewhere. Bangladesh, Myanmar, Tanzania, Ethiopia and Nepal could each save more than half a billion USD per year if they cut their fuel imports in half, according to data from 2015-2017). In terms of the proportion of total GDP, Mozambique, Togo and Mauritania have the highest saving potential, each having spent more than 8% of their GDP on fossil fuel imports in 2017 (own calculations based on WDI data, see country data tables in Section 3).

3.2 Energy Access

Energy access is currently a big challenge for many LDCs, with over half a billion people lacking electricity access in 2016 according to the World Bank's World Development Indicators (WDI). For 32 LDCs, more than 50% of the population still lives without access to electricity (Figure 2, left), despite progress in increasing in electricity access over the last two decades. For comparison, the world average was only 13% of the population without electricity access in 2016, shown by the pink line in Figure 2 (left). Rural populations have the lowest levels of electricity access – across all LDCs, around 65% of the population living in rural areas does not have access to electricity, and in 23 LDCs this number goes up to more than 80% of the population (Figure 2, right).

¹² Energy efficiency and conservation master plan up to 2030, 2016.

http://www.sreda.gov.bd/d3pbs_uploads/files/policy_2_energy_efficiency_and_conservation_master_plan_up_to_2030.pdf

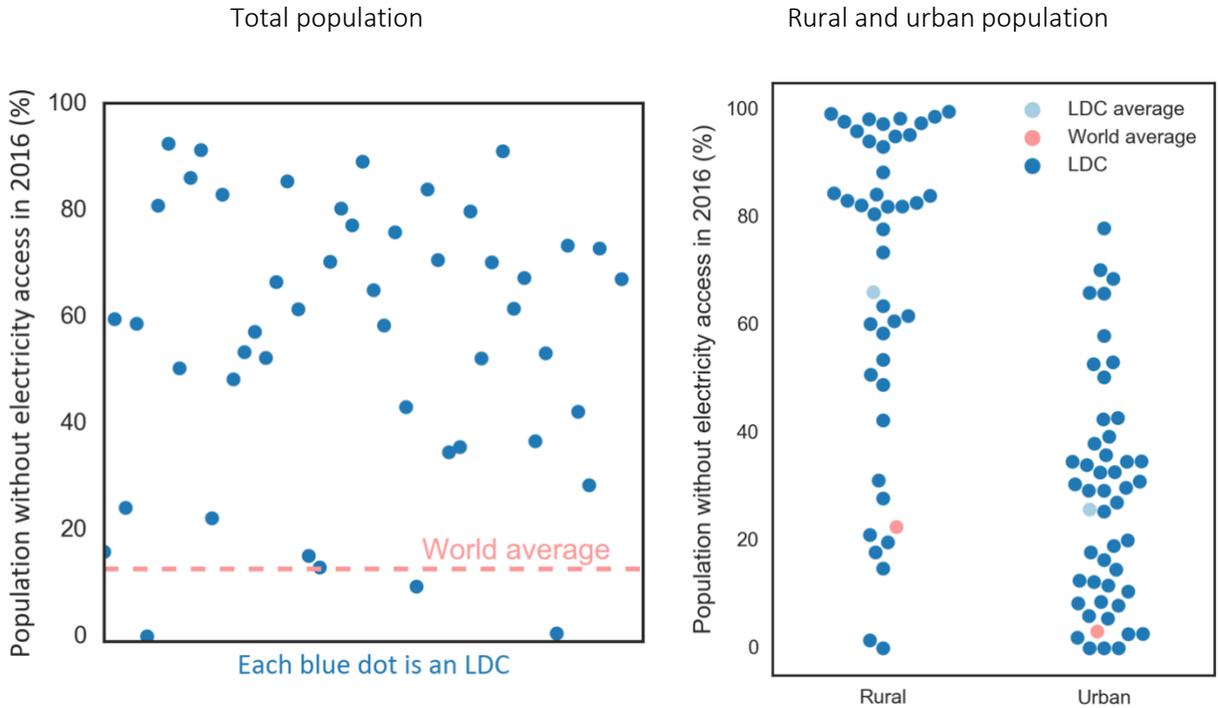
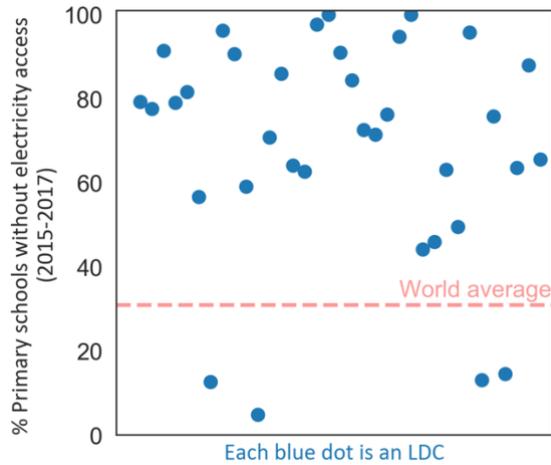


Figure 2: Population lacking access to electricity. National level (left) and differentiated by urban and rural population (right).
Source: Data from WDI.

Moreover, even households with access may have electricity for only limited hours a day. Lack of connectivity also affects education – looking at the years 2015-2017, only about a third of primary schools across LDCs reported that they have access to electricity during this time (Figure 3, left). Moreover, access to electricity, for example provided by off-grid solar home systems in remote areas, can also benefit rural households by creating the opportunity to make use of stored electricity during night time for studying, income generating activities or recreation (see also Box below on off-grid renewables for improving energy access).

Looking beyond electricity, **access to clean fuels for cooking and lighting** is also important. In most LDCs, more than 80% of the population lack access to clean fuels and technologies for cooking, often causing severe indoor air pollution (Figure 3, right). The damaging impacts of continued use of polluting fuels on health, as well as options for shifting to cleaner fuels, are explained in the section on air pollution below.

Primary schools without access to electricity



Population without access to clean fuels and technologies for cooking

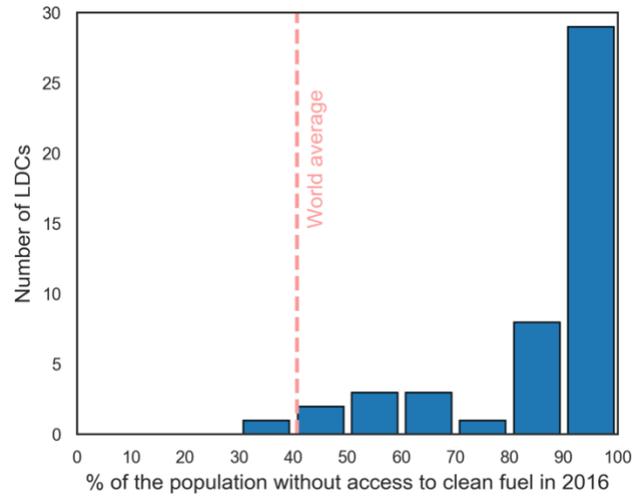


Figure 3: Left: lack of access to electricity in primary schools, source: SDG database, data for years 2015-2017. Right: lack of access to clean fuels and technologies for cooking in 2016, LDCs grouped by share without access, source: Data from WDI.

Distributed renewable power generation (for example, off-grid solar home systems and mini-grids) offers a fast and cost-effective way of providing people in rural areas with electricity in a way that can be tailored to local conditions (see Box below), which can directly contribute towards achieving SDG 7 by **improving access to electricity and clean modern technologies**. By improving energy access in off-grid areas, distributed renewables can moreover contribute to development and reduce inequality (SDG 10) by providing energy services such as lighting, cooking, cooling and also access to information technology for homes, shops, companies, and public institutions like schools (SDG 4) or healthcare facilities (SDG 3).

Off-grid renewables for improving energy access

Compared with other groups of countries, LDCs have a much less diversified energy supply (UNCTAD 2017¹³), with traditional biomass (wood, agricultural waste, dung) forming the main source of energy. Currently, most of the modern renewable energy deployed in the LDCs is hydroelectricity, for example in Bhutan and Lao People’s Democratic Republic. However, off-grid renewables such as solar home systems have become increasingly widespread in a number of countries, including some LDCs, leading to improvements in access to energy services such as lighting, cooking, appliances, heating and cooling. Distributed renewable power generation can also ameliorate local health services, provide opportunities for enhancing women’s active engagement (SDG 5 on gender equality), and create local job opportunities (IRENA 2019¹⁴) and can foster education by allowing to study without daylight (SDG 4 on education).

The last decade has seen exponential growth in the market for off-grid solar systems. In 2016, 9% of the population of Bangladesh and 6% of the population of Nepal had access to off-grid solar PV (REN21,

¹³ UNCTAD (2017): The Least Developed Countries Report 2017, Transformational Energy Access, Chapter 2. https://unctad.org/en/PublicationChapters/lcrr2017_ch2_en.pdf

¹⁴ IRENA (2019): https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Off-grid_RE_Access_2019.pdf

2019¹⁵). In African LDCs the shares are lower (3% for Uganda and Rwanda), but in many cases are growing rapidly (REN21, 2019). In Tanzania, the installed capacity of off-grid solar PV grew five-fold between 2013 and 2016; the Democratic Republic of Congo (DRC) saw sales more than triple between 2016 and 2017, while in Uganda more off-grid systems were deployed in 2017 than the number of grid connections made by utility companies and rural electrification agencies (REN21, 2018¹⁶).

Solar home systems are not the only option – mini-grids are also growing in popularity, bringing solar powered electricity to off-grid communities in Bangladesh, Myanmar and Tanzania. Afghanistan and Madagascar have even installed hydro-power based mini-grids to electrify rural mountainous communities (REN21, 2018).

Use of waste-derived biogas as a clean cooking fuel has been growing in a number of LDCs, including Bangladesh, Nepal, Ethiopia, Tanzania, Burkina Faso and Uganda (REN21, 2018), with reported benefits such as reduced workload, boosted farm productivity and reduced lighting and cooking costs (IRENA, 2017¹⁷).

3.3 Reliability of energy supply

Related to this is the **reliability** of electricity supply, especially for businesses, where more frequent power outages can inhibit economic success. In 2017, over three quarters of firms in LDCs experienced power outages – on average 10 outages per month – with those businesses affected losing on average 8% of their sales as a result. As Figure 4 shows, affected firms in some LDCs report losses of over 15% of sales due to power cuts – well above the global average. Such challenges slow down LDCs as they grow and transform their economies. An increase in renewable energy generation could provide more reliable electricity access and reduce these losses, contributing to fostering economic prospects (SDG 8).

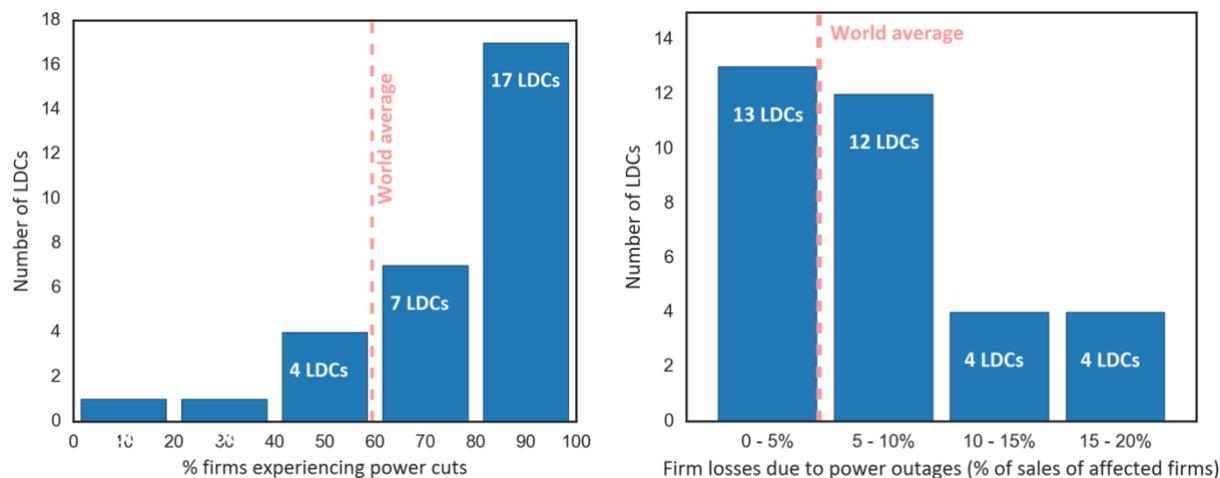


Figure 4: Indicators on the reliability of electricity supply and implications for business prospects. Left: LDCs grouped by the share of businesses that report to have been affected by power outages. Right: LDCs grouped by the reported share of value lost due to power outages (in % of sales of affected businesses). Source: Data from WDI.

¹⁵ REN21 (2019): Renewables 2019 Global Status Report: https://www.ren21.net/gsr-2019/chapters/chapter_04/chapter_04/#target_2

¹⁶ REN21 (2018): Renewables 2018 Global Status Report. http://www.ren21.net/wp-content/uploads/2018/06/17-8652_GSR2018_FullReport_web_final.pdf

¹⁷ IRENA (2017): Biogas for domestic cooking technology brief. <https://irena.org/publications/2017/Dec/Biogas-for-domestic-cooking-Technology-brief>

3.4 Affordability of energy

Between 2000 and 2017, the average global costs of electricity generated from renewable sources has declined by 25 % for onshore wind and 72 % for solar PV (see Table 1 and Climate Analytics’ [policy brief](#)). It is now commonly cheaper to deploy bioenergy, hydropower, onshore wind and solar PV projects than new fossil fuel power generation; Figure 5 illustrates how recent renewable energy projects exhibit lower costs (see Figure 5).

The International Renewable Energy Agency (IRENA) projects that from 2020 onwards new solar and wind projects are set to be even cheaper than the cost of continuing to operate existing fossil fuel power plants. More than three-quarters of new wind and solar installations coming into service around the world next year are cheaper than the fossil fuel alternatives.¹⁸ Off-grid technologies are also cost-competitive for expanding electricity access into currently unelectrified areas, with solar PV module costs having fallen by 80% since 2009 and the prices of LED lights and batteries – key components of solar home systems – have fallen by 80% and 73% respectively¹⁹. Renewables can therefore contribute to providing affordable modern energy to all (SDG 7), particularly if they are combined with highly efficient appliances, which use less energy and therefore drive costs down even further REN21, 2018²⁰.

These economic cost estimates do not even include social costs of climate impacts, health issues from air pollution and damages to the environment, e.g. from resource extraction. Such social costs are much higher for conventional energy sources than for renewable energy, meaning that **a switch to renewables has economic benefits beyond the affordability of energy.**

Costs of renewable electricity (LCOE) ²¹	Onshore wind	Solar PV
Average cost of renewable electricity in Africa (2014)	0.09 USD/kWh	0.19 USD/kWh
Average cost of renewable electricity in Asia (2014)	0.06 USD/kWh	0.16 USD/kWh
Global cost development 2000-2017 (%)	-25%	-72%

Table 1: Regional costs of onshore wind and solar PV (LCOE) and global cost development. Source: IRENA dashboard²²

¹⁸ IRENA 2019: https://www.irena.org/publications/2019/May/Renewable-power-generation-costs-in-2018?utm_source=All+IRENA+contacts&utm_campaign=46ce6f632c-EMAIL_CAMPAIGN_2019_05_21_06_13&utm_medium=email&utm_term=0_29b5801035-46ce6f632c-66498829

¹⁹ IRENA 2019: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/IRENA_Off-grid_RE_Access_2019.pdf

²⁰ REN21 (2018): Renewables 2018 Global Status Report. http://www.ren21.net/wp-content/uploads/2018/06/17-8652_GSR2018_FullReport_web_final.pdf

²¹ Levelized costs of electricity (LCOE) describe the cost per unit of electricity (e.g. one kilowatt-hour kWh), accounting for the total costs of a technology that accrue over its lifetime. LCOE allows comparing the costs of different technologies.

²² <http://resourceirena.irena.org/gateway/dashboard/?topic=3&subTopic=9>

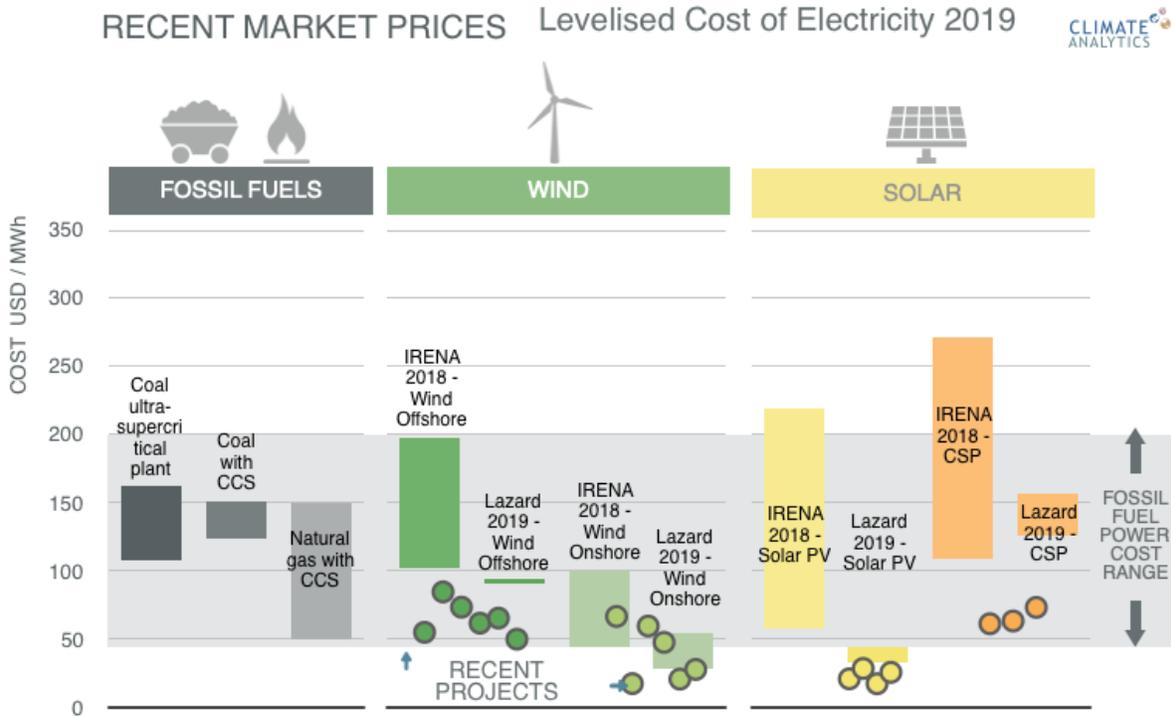


Figure 5: Comparison of cost ranges for electricity production (levelized cost of electricity - LCOE) for different renewable and non-renewable generation technologies in 2019. While the LCOE cost ranges are based on international cost ranges for already operating projects, the dots are based on recent auction results (each dot represents the lowest cost in an auction in a particular country). Sources: Calculations by Climate Analytics based on data from IRENA²³ and Lazard²⁴

A key challenge for the LDCs with regards to electricity affordability is that electricity supply can suffer from high inefficiencies, which affect overall costs. According to WDI, LDCs lost almost 16% of electricity output due to electric power transmission and distribution losses – about double the world average.²⁵ Reducing these losses would have benefits for both reducing costs and increasing the efficiency of electricity supply.

²³ IRENA (2019): Renewable Power Generation Costs in 2018.
https://www.irena.org/publications/2019/May/Renewable-power-generation-costs-in-2018?utm_source=All+IRENA+contacts&utm_campaign=46ce6f632c-EMAIL_CAMPAIGN_2019_05_21_06_13&utm_medium=email&utm_term=0_29b5801035-46ce6f632c-66498829

²⁴ Lazard (2019): Lazard’s levelized cost of energy analysis (version 13.0, Nov. 2019).
<https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf>

²⁵ World Bank World Development Indicators (Series Code EG.ELC.LOSS.ZS)
<https://databank.worldbank.org/data/reports.aspx?source=world-development-indicators#>

4. Job creation potential in renewable energy deployment

Many LDCs are currently building up new energy system infrastructure on a large scale to meet increasing energy demands. The choice of which energy sources to invest in can play a crucial role for regional and local economic development and job perspectives. With energy system infrastructure typically being built to remain for decades, decisions on newly built infrastructure need to be considered carefully to both avoid lock-in effects and stranded assets (i.e. investments that are regretted at a later stage), and to make the most of the economic development opportunities.

Investing in renewable energy can create local employment opportunities²⁶, contributing to achieving SDG 8 on decent work. Wind turbines and solar panels need to be installed and operated domestically, thus providing opportunities to foster local job creation. The distributed character of renewable energy – being spatially spread instead of concentrating on a specific region or major plant site like fossil-based power plants – could moreover enhance the local job creation potential throughout the country and especially in rural areas. Moreover, renewable energy technologies are generally considered more labour intensive compared to conventional power plants such as coal power plants. This means that more workers are needed and thus more jobs are created when investing in renewable energy technologies than in conventional power generation technologies. In order to prepare the local workforce for these tasks, investments in energy infrastructure need to go hand in hand with training of local people to develop a qualified local workforce in the renewable energy sector.²⁷

²⁶ IRENA (2019) Towards 100% Renewable Energy. https://coalition.irena.org/-/media/Files/IRENA/Coalition-for-Action/IRENA_Coalition_100percentRE_2019.pdf

²⁷ IRENA (2019) Towards 100% Renewable Energy. https://coalition.irena.org/-/media/Files/IRENA/Coalition-for-Action/IRENA_Coalition_100percentRE_2019.pdf

To provide an idea on the order of magnitude, we calculate the employment potential for LDCs for an *illustrative scenario* (see Annex 3: Methodological Note in Annex 3 for more details):

Illustrative Renewable Energy Scenario:

How many jobs would be created in LDCs if the current total electricity consumption in LDCs doubled, and if this increase was covered solely by installing new solar PV and onshore wind capacities²⁸?

We focus on two different types of jobs that have a high potential to contribute to local job creation:

- i) Jobs in construction and installation: Jobs in construction and installation of wind parks and solar PV installations accrue over the period where new renewable energy capacities are built up. This includes for example trained workers needed to install wind turbines or solar PV panels and bring them into service. As this type of work is limited in time to the duration of setting up the facilities, related jobs are measured in job years required for the construction period²⁹. The construction period for solar PV is assumed for this illustrative scenario to be roughly 1 year.
- ii) Jobs in Operation & Maintenance (O&M): O&M jobs refer to the workers that are needed to keep the installed renewable energy capacities running, e.g. by regularly checking their functioning and replacing or repairing components if needed. As these tasks are required over the full lifetime of the respective installations, these jobs can be considered permanent.

Based on employment factors that indicate the number of jobs or job years per Megawatt (MW) installed wind or solar PV capacity, we calculate the job potential in this scenario for 18 LDCs for which the necessary data is available in WDI and IRENA (see Annex 3: Methodological Note). To account for local differences in solar radiation and wind as well as differences in technical efficiency of different facilities, we show a range for our employment estimates applying an optimistic capacity factor (i.e. less additional MW renewables capacity needed to generate the required electricity) and a pessimistic capacity factor (i.e. more MW needed to generate the required electricity) for solar PV and onshore wind, respectively.

The calculation shows that, for our illustrative scenario, the estimated total job potential in O&M for all 18 LDCs considered in this example ranges from over 100,000 created jobs (high capacity factors) to over 250,000 created jobs (low capacity factors) for solar and wind together over the lifetime of the installed renewable energy facilities. For construction and installation, the total job potential for these LDCs together could range from 1.8 million job years (high capacity factors) to 4.3 million job years (low capacity factor). Assuming that the added renewable energy capacities are built up over a period of 5 years, this

²⁸ For this exemplary scenario, we assumed solar and wind each supply half of the increase in electricity needs.

²⁹ Jobs in Construction and Installation do not include jobs in manufacturing the technologies parts beforehand. These are additional jobs not considered here as manufacturing may not happen locally.

would amount to a range of about 365,000 jobs to 870,000 jobs in construction and installation each year in total over these 5 years.

Figure 6 shows the range of the estimated **job potential for O&M** over the entire lifetime of the facilities for selected LDCs for optimistic and pessimistic capacity factors assumptions. Bangladesh has the highest job potential. We estimate the O&M jobs that could be newly created over the whole lifetime of the facilities in our illustrative scenario to range from close to 24,000 jobs to over 55,000 created jobs in Bangladesh (see Figure 6). Also, Mozambique could potentially create between over 14,000 and close to 33,000 O&M jobs in our scenario. Zambia could create between about 12,500 and almost 29,000 O&M jobs, while Angola and Côte d'Ivoire could create between over 9,000 and over 20,000 O&M jobs for the lifetime of installed solar and wind installations.

Job potential in Operation & Maintenance (solar and wind combined)
for optimistic and pessimistic illustrative scenario

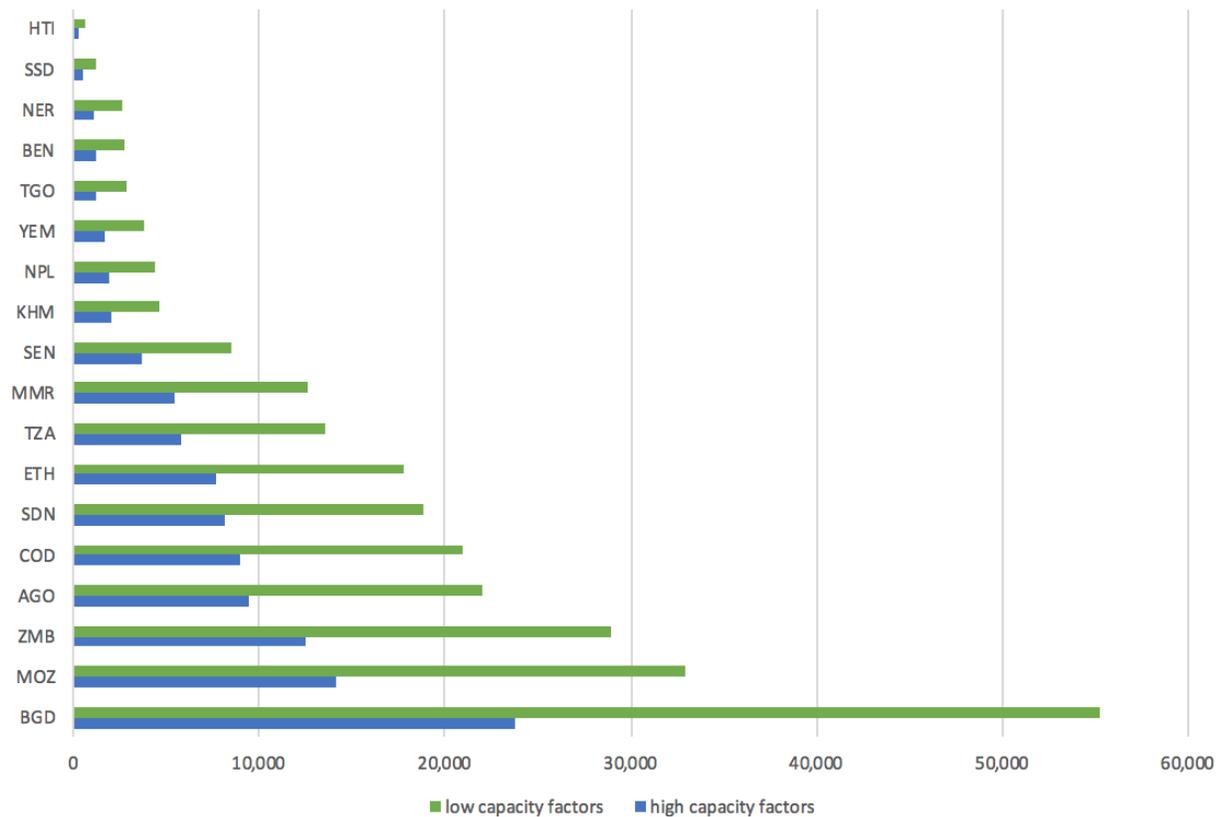


Figure 6: Job potential for illustrative scenario: jobs in O&M (solar and wind combined). Scenario: Doubling of current electricity demand fully covered by new onshore wind and solar PV capacities. Country names to the ISO codes can be found in Table 2.

For **jobs in construction and installation of renewable energy**, Figure 7 shows the range of the estimated job potential (in job years) for selected LDCs for optimistic and pessimistic capacity factor assumptions. For Bangladesh, we estimate the number of jobs years that could be newly created in our illustrative scenario to range from close to 400,00 to almost 950,000 job years. Assuming that facilities are built up over a period of 5 years this would mean a range of close to 80,000 to almost 190,000 jobs per year for this time period. For Mozambique, the job potential for construction and installation could range between

close to 240,000 and over 566,000 job years in our scenario, i.e. about between about 47,500 and over 113,000 jobs for 5 years.

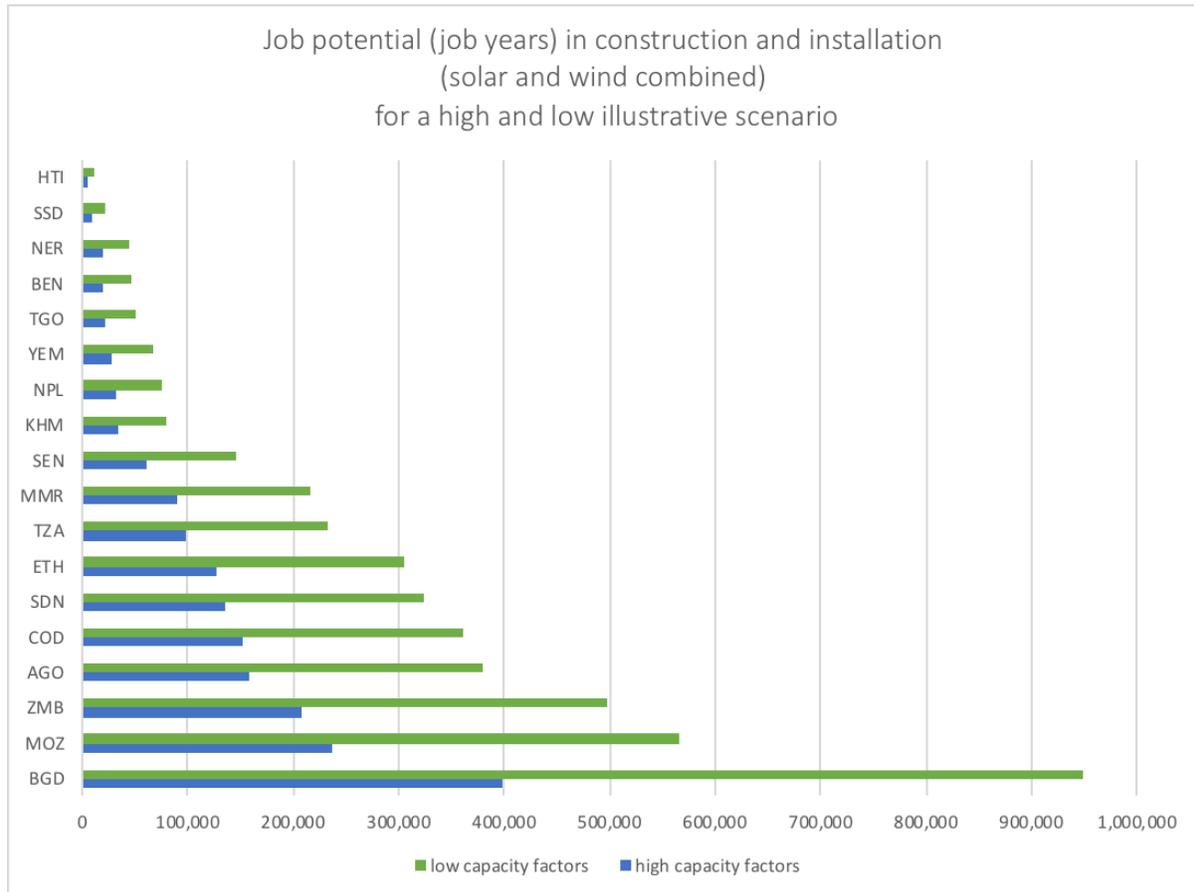


Figure 7: Job potential for illustrative scenario: Job years in Construction and Installation jobs (solar and wind combined). Scenario: Doubling of current electricity demand fully covered by new onshore wind and solar PV capacities. Country names to the ISO codes can be found in Table 2.

Our estimates are conservative given that we do not include indirect jobs created in related industries further down the supply chain. Literature indicates that these additional indirect jobs would amount to about the same order of magnitude as direct jobs.³⁰

³⁰ Ortega, M., Río, P. del Ruiz, P., & Thiel, C. (2015). Employment effects of renewable electricity deployment. A novel methodology. *Energy*, 91, 940–951.

5. Reduction of health impacts from air pollution

The WHO has designated air pollution as a “silent killer” – many are unaware of the widespread impacts that exposure to air pollution has on human health³¹. **Health-damaging air pollution** is mainly caused by use of biomass stoves for cooking, emissions from fossil fuel power plants and road transport. Decreasing the reliance on biomass and improving access to clean electricity, which can also be used for electric transport, can strongly lower this pollution and the related health damages. For LDCs, both indoor and outdoor air pollution have considerable impacts on human health and the environment. Climate change mitigation has the potential to generate numerous co-benefits also with regards to air pollution such as reduced morbidity, mortality (SDG 3 - health) and the negative impacts on agriculture (SDG 2 on food security), which could offset the costs of climate policy.³²

5.1 Indoor air pollution - reducing health impacts from cooking and lighting

High levels of indoor air pollution occur when biomass fuels (such as wood, charcoal, animal dung and agricultural residues) and coal are used for energy needs such as cooking, lighting and heating. Open fires and traditional stoves result in indoor smoke containing health-damaging pollutants such as small particles, carbon monoxide and particulate matter pollution, over-proportionately affecting children and women. In 2016, an average of 74 deaths per 100,000 inhabitants were attributed to indoor air pollution across all LDCs, compared to a world average of 51 deaths per 100,000 people (Figure 8). In absolute terms, this resulted in over 685,000 deaths due to indoor air pollution across all LDCs. On average, **86% of the population in LDCs does not have access to clean technologies or fuels for cooking** (2016, see also Figure 3, right side).

Installation of improved cook stoves can reduce the use of fossil fuel and biomass by almost 30-40% in rural households and lessen the indoor air pollution to a greater extent thus providing positive health impacts, as shown in a study evaluating a project installing 500,000 Bondhu Chula across Bangladesh.³³

³¹Schraufnagel, D. E., Balmes, J. R., Cowl, C. T., De Matteis, S., Jung, S.-H., Mortimer, K., et al. (2019). Air Pollution and Noncommunicable Diseases: A Review by the Forum of International Respiratory Societies' Environmental Committee, Part 1: The Damaging Effects of Air Pollution. *Chest*, 155(2), 409–416. <https://doi.org/10.1016/j.chest.2018.10.042>

³²Vandyck, T., Keramidas, K., Kitous, A., Spadaro, J. V., Van Dingenen, R., Holland, M., Saveyn, B., 2018. Air quality co-benefits for human health and agriculture counterbalance costs to meet Paris Agreement pledges. *Nat. Commun.* 9, 1–11. <https://doi.org/10.1038/s41467-018-06885-9>

³³ Bangladesh Institute of Development Studies (BIDS): Impacts of improved cooking stoves: Evidence relating to Bindhu Chula. http://bids.org.bd/uploads/events/almanac2018/TS-5_P-1.pdf

Crude death rate attributed to indoor air pollution in 2016

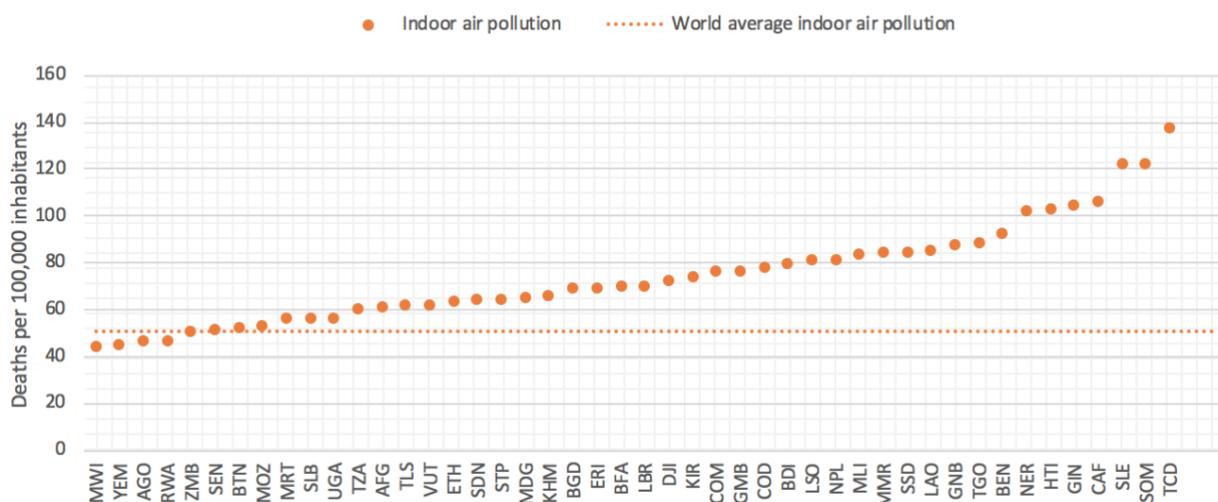


Figure 8: Crude death rate attributed to indoor air pollution in LDCs, in number of deaths per 100,000 inhabitants. Source: Data from SDG Database (based on WHO estimates). Country names to the ISO codes can be found in Table 2.

Energy efficiency and renewable energy can significantly reduce indoor air pollution and its negative health impacts. For example, improved low-emission/high-efficiency stoves are considered to be the most affordable short-term intervention, despite barriers to improved stove adoption and performance variability. There is also experimental evidence that household electrification leads to substantial improvements in indoor air quality.³⁴ Electric stoves have significantly lower levels of pollutants than biomass stoves.³⁵ Households in remote areas too isolated for grid electrification could benefit from other decentralized clean lighting technologies such as solar lamps, which can substantially reduce indoor air pollution.²⁸

5.2 Outdoor air pollution – reducing health impacts from fossil fuel combustion for power generation and transport

Globally, outdoor air pollution stemming from the power sectors is a major issue, in particular in regions that have heavily relied on coal. Coal combustion results in a range of pollutants which are accumulated in air and water, leading to a wide range of environmental and health impacts.³⁶ In addition, the transport sector is also responsible for large portions of urban air pollution, aggravating air pollution exposure.

The burden of outdoor air pollution is high for LDCs, where strong population growth along with rapid widespread urbanization and industrialization have led to dense urban centers with poor air quality. The use of old and inefficient diesel vehicles and the lack of public transport heavily contribute to this burden.

³⁴ Barron, M., Torero, M., 2017. Household electrification and indoor air pollution. J. Environ. Econ. Manage. 86, 81–92. <https://doi.org/10.1016/j.jeem.2017.07.007>

³⁵ Downward, G.S., van der Zwaag, H.P., Simons, L., Meliefste, K., Tefera, Y., Carreon, J.R., Vermeulen, R., Smit, L.A.M., 2018. Occupational exposure to indoor air pollution among bakery workers in Ethiopia; A comparison of electric and biomass cookstoves. Environ. Pollut. 233, 690–697. <https://doi.org/10.1016/j.envpol.2017.10.094>

³⁶ Munawar, M.E., 2018. Human health and environmental impacts of coal combustion and post-combustion wastes. J. Sustain. Min. 17, 87–96. <https://doi.org/10.1016/J.JSM.2017.12.007>

Data from the WDI also shows that **100% of the population in LDCs is exposed to fine particulate matter (PM_{2.5})** concentration levels exceeding WHO guidelines. In 2016, an average of 40 deaths per 100,000 inhabitants were attributed to outdoor air pollution across all LDCs. In absolute terms, over 410,000 deaths are attributed to outdoor air pollution across all LDCs (WDI 2018).

In the context of LDCs, there is great potential for leapfrogging to (decentralized) renewable energy systems, paving the way forward for sustainable development while reducing air pollution. Cost reductions of renewable energy present opportunities for the electrification of rural areas, including through off-grid and mini-grid solutions. The development of efficient, low carbon public transport networks and electrified transport options in sprawling urban centers is also required to reduce the exposure to outdoor air pollution. In fact, the electrification of the transport system can be coupled with the integration of renewables into the power grid, with electric vehicles providing flexibility to the power system by acting as a form of energy storage (IRENA, 2019³⁷).

³⁷ IRENA (2019), Innovation landscape brief: Electric-vehicle smart charging, International Renewable Energy Agency, Abu Dhabi. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_EV_smart_charging_2019.pdf?la=en&hash=E77FAB7422226D29931E8469698C709EFC13EDB2

Annexes

Annex 1: What would be the potential in my country to exploit synergies?

Clicking on the country name, you find more information on the country specific potential for co-benefits of a low carbon development.

Table 2: Links to country-specific information

ISO	Country name	Link to country information
AFG	Afghanistan	http://cobenefits.climateanalytics.org/output/AFG.html
AGO	Angola	http://cobenefits.climateanalytics.org/output/AGO.html
BDI	Burundi	http://cobenefits.climateanalytics.org/output/BDI.html
BEN	Benin	http://cobenefits.climateanalytics.org/output/BEN.html
BFA	Burkina Faso	http://cobenefits.climateanalytics.org/output/BFA.html
BGD	Bangladesh	http://cobenefits.climateanalytics.org/output/BGD.html
BTN	Bhutan	http://cobenefits.climateanalytics.org/output/BTN.html
CAF	Central African Republic	http://cobenefits.climateanalytics.org/output/CAF.html
COD	Congo, Democratic Republic of the	http://cobenefits.climateanalytics.org/output/COD.html
COM	Comoros	http://cobenefits.climateanalytics.org/output/COM.html
DJI	Djibouti	http://cobenefits.climateanalytics.org/output/DJI.html
ERI	Eritrea	http://cobenefits.climateanalytics.org/output/ERI.html
ETH	Ethiopia	http://cobenefits.climateanalytics.org/output/ETH.html
GIN	Guinea	http://cobenefits.climateanalytics.org/output/GIN.html
GMB	Gambia	http://cobenefits.climateanalytics.org/output/GMB.html
GNB	Guinea-Bissau	http://cobenefits.climateanalytics.org/output/GNB.html
HTI	Haiti	http://cobenefits.climateanalytics.org/output/HTI.html
KHM	Cambodia	http://cobenefits.climateanalytics.org/output/KHM.html
KIR	Kiribati	http://cobenefits.climateanalytics.org/output/KIR.html
LAO	Lao People's Democratic Republic	http://cobenefits.climateanalytics.org/output/LAO.html
LBR	Liberia	http://cobenefits.climateanalytics.org/output/LBR.html
LSO	Lesotho	http://cobenefits.climateanalytics.org/output/LSO.html
MDG	Madagascar	http://cobenefits.climateanalytics.org/output/MDG.html
MLI	Mali	http://cobenefits.climateanalytics.org/output/MLI.html
MMR	Myanmar	http://cobenefits.climateanalytics.org/output/MMR.html

MOZ	Mozambique	http://cobenefits.climateanalytics.org/output/MOZ.html
MRT	Mauritania	http://cobenefits.climateanalytics.org/output/MRT.html
MWI	Malawi	http://cobenefits.climateanalytics.org/output/MWI.html
NER	Niger	http://cobenefits.climateanalytics.org/output/NER.html
NPL	Nepal	http://cobenefits.climateanalytics.org/output/NPL.html
RWA	Rwanda	http://cobenefits.climateanalytics.org/output/RWA.html
SDN	Sudan	http://cobenefits.climateanalytics.org/output/SDN.html
SEN	Senegal	http://cobenefits.climateanalytics.org/output/SEN.html
SLB	Solomon Islands	http://cobenefits.climateanalytics.org/output/SLB.html
SLE	Sierra Leone	http://cobenefits.climateanalytics.org/output/SLE.html
SOM	Somalia	http://cobenefits.climateanalytics.org/output/SOM.html
SSD	South Sudan	http://cobenefits.climateanalytics.org/output/SSD.html
STP	Sao Tome and Principe	http://cobenefits.climateanalytics.org/output/STP.html
TCD	Chad	http://cobenefits.climateanalytics.org/output/TCD.html
TGO	Togo	http://cobenefits.climateanalytics.org/output/TGO.html
TLS	Timor-Leste	http://cobenefits.climateanalytics.org/output/TLS.html
TUV	Tuvalu	http://cobenefits.climateanalytics.org/output/TUV.html
TZA	Tanzania, United Republic of	http://cobenefits.climateanalytics.org/output/TZA.html
UGA	Uganda	http://cobenefits.climateanalytics.org/output/UGA.html
VUT	Vanuatu	http://cobenefits.climateanalytics.org/output/VUT.html
YEM	Yemen	http://cobenefits.climateanalytics.org/output/YEM.html
ZMB	Zambia	http://cobenefits.climateanalytics.org/output/ZMB.html

Annex 2: Why is climate change mitigation relevant for my country?

If you want to find out more about the climate impacts on a specific country, you can use our online tools:

- Global tools:
 - [Local SLR](#) allows you to compare local sea level rise at different levels of warming.
 - [Costs of inaction](#). The current round of national emission reduction pledges (Nationally Determined Contributions/NDCs) will lead to about 3°C of warming by the end of the century. This tool shows the additional economic damages Small Island Developing States (SIDS) and Least Developed Countries (LDCs) face in a 3°C world compared with 1.5°C, the limit set out in the Paris Agreement.
 - [Warming attribution calculation](#). This online tool is a resource for climate scientists which allows to relate climate impact studies to warming targets like 1.5°C and 2°C.
- Regional tools:
 - [RegioClim](#) gives non-expert users access to regional climate projections for all African countries for five climate indicators: temperature, hot extremes, precipitation, wet extremes and 5-day wet extremes. Its key feature is the ability to access projections not just at the national but also at the province level.
 - [RegioCrop](#) gives non-expert users access to crop yield projections for sub-Saharan African countries derived from state-of-the-art global crop models.
 - [Adaptation Map](#) provides an overview of adaptation actions in 11 countries in West Africa and the Member States of the Caribbean Community (CARICOM) since 2010. Its main purpose is to act as a library, fostering inter-regional learning on adaptation action. The map includes policies, strategies, programs and projects. Adaptation actions are categorised by country (regional actions are also included) and by sector.

[Tools overview page](#)

Annex 3: Methodological Note

Calculation of job creation potential based on employment factors

The calculation of the job creation potential is done in two steps:

Step 1: Deriving the capacities of newly installed solar and wind to cover the additional energy demand in our illustrative scenario

We use data on current (most recent data available) electricity demand for LDC countries for which such data is available in WDI. Based on capacity factors (see below), we calculate the capacity of solar PV and onshore wind to be newly installed for the additional electricity demand resulting from our scenario assumption, i.e. doubling current electricity demand. To account for a variation in capacity factors for wind and solar PV, we show a range, calculating the resulting MW added capacity for a pessimistic capacity factor (i.e. more MW needed to generate the required electricity) assuming a capacity factor of 10% for solar PV and 20% for onshore wind for all LDCs and an optimistic capacity factor (i.e. less MW needed to generate the required electricity) assuming a capacity factor of 25% for solar PV and 35% for onshore wind. The assumptions on optimistic and pessimistic capacity factors ranges have been derived based on observed capacity factors reported by IRENA.

Step 2: Calculating the resulting job creation potential

To obtain job potential estimates, we apply employment factors for solar PV and onshore wind provided by Rutovitz, J., Dominish, E., & Downes, J. (2015). *Calculating global energy sector jobs: 2015 Methodology Update. Prepared for Greenpeace International by the Institute for Sustainable Futures (UTS)*. These employment factors indicate the number of jobs or job years per newly installed MW of solar PV and wind, respectively and have been derived based on a set of empirical studies. Following the methodology suggested by Rutovitz et al. (2015), we multiply the technology- and job type-specific base employment factors for OECD with region-specific multipliers to account for differences in productivity. For this, we use the regional multiplier for the year 2020. *Jobs in Operation & Maintenance (O&M)* are calculated by multiplying the calculated MW newly installed capacity resulting from our illustrative scenario with the employment factor for O&M. Likewise, *jobs years in construction and installation* are calculated by multiplying the calculated MW of the newly installed capacity from our illustrative scenario with the employment factor for construction and installation. Jobs in construction and installation are non-permanent and therefore estimated in job years.

Our estimates are conservative to the regard that we do not include indirect jobs created in related industries further down the supply chain. Literature indicates that these additional indirect jobs would amount to about the same order of magnitude as direct jobs (Ortega, M., Río, P. del, Ruiz, P., & Thiel, C. (2015). *Employment effects of renewable electricity deployment. A novel methodology. Energy, 91, 940–951.*). Moreover, we do not include jobs in manufacturing of technology parts.

Data Sources

WDI (2018)

World Bank World Development Indicators

<https://datacatalog.worldbank.org/dataset/world-development-indicators>

SDG Database (2019)

<https://unstats.un.org/sdgs/indicators/database/>

IRENA 2019

Statistics: [http://www.irena.org/IRENADocuments/IRENA_RE_electricity_statistics - Query tool.xlsm](http://www.irena.org/IRENADocuments/IRENA_RE_electricity_statistics_-_Query_tool.xlsm)

Dashboard: <http://resourceirena.irena.org/gateway/dashboard/>