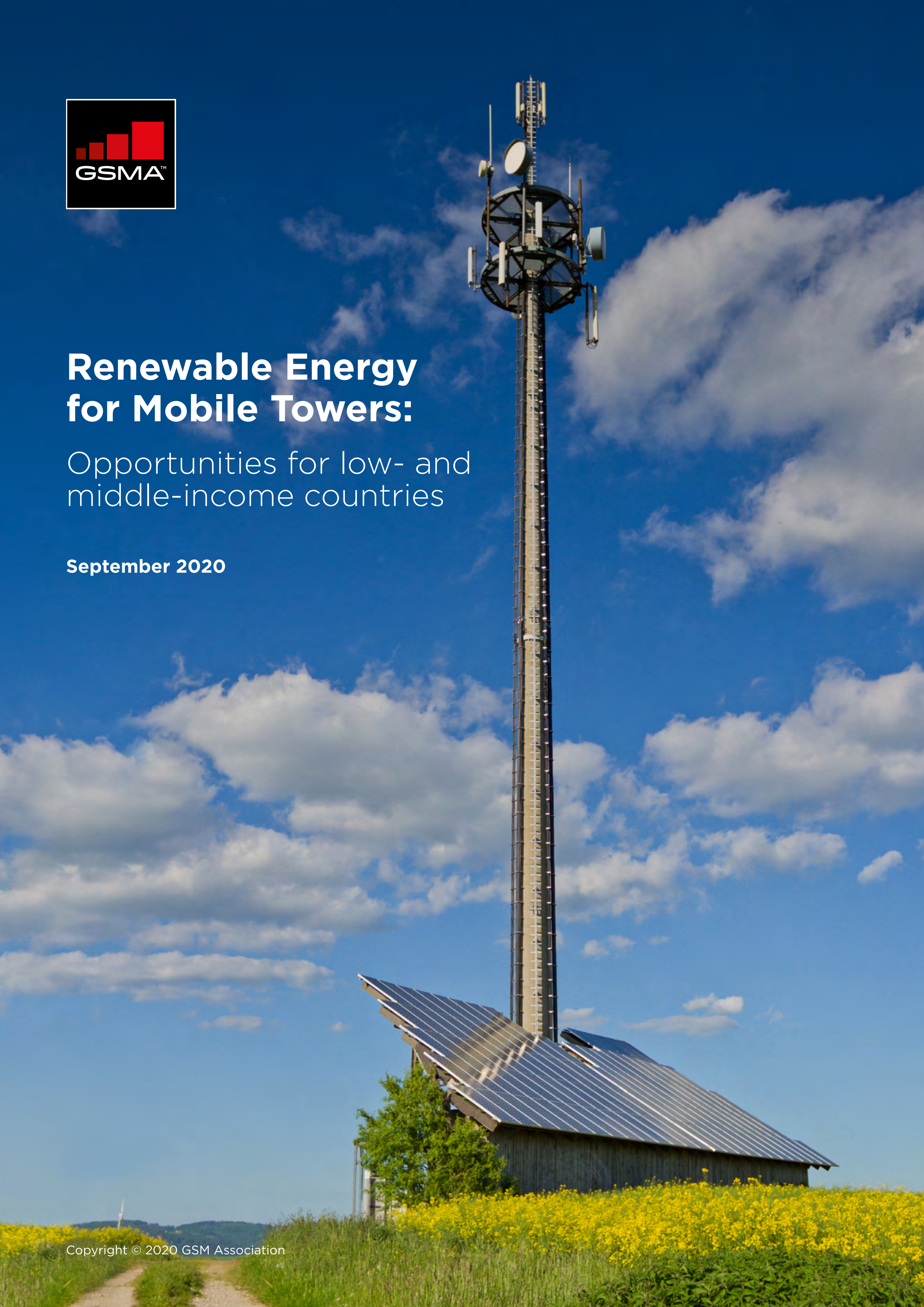

GSMA

Renewable Energy for Mobile Towers:

Opportunities for low- and middle-income countries

September 2020

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The GSMA CleanTech programme brings together the mobile industry, private and public actors in the clean technology space to unlock the power of digital technology in low- and middle-income countries as an enabler for their transition to low-carbon, climate-resilient economies. We work to catalyse the use and scale of digital solutions for sustainable natural resource management, climate resilience, circular economy and the mobile industry's switch to renewable sources, especially in off-grid sites.

The programme is supported by the UK Foreign, Commonwealth & Development Office (FCDO).

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Contents

Abbreviations

ABC	Anchor-Business-Community
AMN	Africa Mobile Networks
ATC	American Tower Corporation
C&I	Commercial and Industrial
CAF	Development Bank of Latin America
CAPEX	Capital Expenditure
CO_2e	Carbon Dioxide Equivalent
CTC	China Tower Corporation
DFI	Development Finance Institution
DRC	Democratic Republic of Congo
ESCO	Energy Service Company
ESMAP	Energy Sector Management Assistance Program
FCDO	Foreign, Commonwealth & Development Office
GeSI	Global e-Sustainability Initiative
GIS	Geographic Information Systems
IDB	Inter-American Development Bank
IPT	Internet Para Todos
ITU	International Telecommunication Union
kWh	Kilowatt Hour
LCOE	Levelised Cost of Energy
LCOS	Levelised Cost of Storage
LMICs	Low and Middle-Income Countries
MEA	Middle East and Africa
MNOs	Mobile Network Operators
NaaS	Network as a Service
OPEX	Operational Expenditure
PPAs	Power Purchase Agreements
RE	Renewable Energy
RESCOs	Renewable Energy Service Companies
RFP	Request for Proposal
SBTi	Science Based Targets Initiative
SBTs	Science-Based Targets
SDGs	Sustainable Development Goals
SHS	Solar Home System
SIDS	Small Island Developing States
SLA	Service Level Agreement
SPM	Smart Power Myanmar
SPRD	Smart Power for Rural Development
TESCO	Telecom Energy Service Company
TowerCo	Tower Company
TRAI	Telecom Regulatory Authority of India
USO	Universal Service Obligation

Executive summary

Access to mobile services, including mobile broadband, has helped unlock an array of new opportunities and services that are enhancing the livelihoods of the world's most underserved populations, spurring economic growth and enabling the mobile industry to contribute to the UN Sustainable Development Goals (SDGs). Over the last six years, the number of people subscribed to mobile services has increased rapidly, from an estimated 3.6 billion at the end of 2014 to 5.2 billion in 2020. The GSMA estimates this figure will grow by another 600 million people by 2025, and 60 per cent of new subscribers will be in Asia Pacific or Sub-Saharan Africa.[1]

In many low and middle-income countries (LMICs), access to mobile connectivity has been expedited by the expansion of mobile towers into areas either not connected to a national grid, or connected but receiving unreliable electrical power. In these locations, "off-grid" and "bad-grid" towers tend to rely on on-site diesel-powered generators for their operation, inflicting a measurable cost on the environment and the balance sheets of mobile network operators (MNOs).

In this report, we examine the scale of the off-grid and bad-grid challenge in LMICs, and evaluate how the renewable energy landscape has changed since the GSMA published its 2014 report, *Green Power for Mobile*.[2] New approaches to estimating the number of mobile towers deployed worldwide in both 2014 and 2020 have allowed us to track changes in the percentage of towers that are off-grid, bad-grid and powered by renewable energy in over 200 countries and territories.

We have found that while the number of global towers increased from four million to five million in this period, the number of those that are either off-grid or bad-grid has dropped by nearly 40 per cent, and the proportion of off-grid and bad-grid sites that run on renewable energy has nearly halved. We also estimate that the carbon dioxide equivalent (CO_2e) emissions associated with diesel-powered generators at tower sites has been reduced from 9.2 million to 7 million metric tonnes per annum.

1. GSMA (2020), The Mobile Economy.
2. GSMA (2014), Green Power for Mobile.

In many LMICs, however, the transition to renewable energy has been slow. Nearly half of all towers in Sub-Saharan Africa, and 16 per cent of towers in South and Southeast Asia, are still categorised as either off-grid or bad-grid, and over 80 per cent of these continue to run on diesel power. Furthermore, the 7 million metric tonnes of CO_2e that will be emitted from mobile towers' diesel generators will account for approximately three per cent of the industry's total emissions in 2020.[3]

Through desk research, stakeholder interviews and analyses of seven renewable energy "lighthouse" countries (see the case studies on pages 27 to 47), we provide a fresh perspective on the following global trends and barriers currently influencing the deployment of renewable energy solutions.

1. **The tower-sharing model has transformed tower ownership and how renewable energy business models are assessed and evaluated.** MNOs owned and managed close to 90 per cent of the world's mobile towers in 2014, but today 70 per cent are owned and managed by tower companies (TowerCos). Incentives and strategies for deploying renewable energy are not always aligned across these decision-making entities, a key barrier in the transition away from diesel power.

2. **Legacy and non-standardised energy contracts and lack of price benchmarking data can stunt the growth of energy service companies (ESCOs) and disincentivise TowerCo investments in renewable energy.** ESCOs have assumed an increasingly important role as specialised renewable energy suppliers and managers. However, the lack of standardisation in ESCO contracts, and the absence of price benchmarking in most countries, leaves ESCOs unable to structure their business models to achieve scale. In the meantime, MNOs and TowerCos have started to renegotiate their energy contracts, particularly "pass-through" agreements, in favour of models that incentivise energy reductions and renewable energy installations.

3. **Improved access to electricity from national grids is disincentivising investments in renewable energy, but net metering may reverse this.** Vast improvements in national electrification rates and the reliability of power grid infrastructure have changed the way towers are powered in LMICs. MNOs and TowerCos are often less inclined to deploy on-site renewable energy systems in locations that may soon be electrified. However, in some countries where access to electricity is high, MNOs are executing or exploring net metering systems — a regulated arrangement in which a company with on-site solar electricity generation capacity can receive credits for excess generation fed back to the grid.

3. GSMA (2019), 2019 Mobile Industry Impact Report: Sustainable Development Goals.

4 **Small cell sites and Anchor-Business-Community (ABC) mini-grid models have the potential to bring connectivity and electrification to rural areas, but are still not proven at scale.** In remote areas, small cell sites (low-capacity, low power-consuming towers designed to bring mobile network coverage to small pockets of the population) are considered ideal for renewable energy systems and have already been deployed successfully in LMICs. This suggests there could be an opportunity for ESCOs and MNOs to design, install and operate renewable energy-based mini-grid systems that also supply electricity to local businesses and community households. This is known as the Anchor-Business-Community (ABC) mini-grid model. Access to better data and business modelling tools on the location of unelectrified communities, and their energy needs, could help these models achieve scale.

5 **Many LMICs need enabling telecom and energy sector policies and regulatory frameworks that incentivise renewable energy.** Very few LMICs have renewable energy policies and regulations, which typically incentivise or mandate reduced diesel consumption, increased renewable energy deployments and energy-efficiency measures for tower sites. Those that do exist are often poorly enforced and not comprehensive. More policy-related dialogue is needed between the organisations that own the towers and manage the energy (MNOs, TowerCos and ESCOs) and between telecom and energy sector policymakers.

The insights drawn from our research have been used to develop recommended actions for MNOs and other ecosystem players. Recognising that the technical and financial viability of renewable energy is now well understood, the interventions we propose aim to foster cross-sector collaboration, assist the industry in overcoming the persistent barriers described above, and catalyse the deployment of renewable energy systems at an even greater scale.

1 Introduction

In recent years, significant progress has been made in ensuring that more of the world's population lives within reach of a mobile network. This development can be attributed, in part, to MNOs that have invested in tower infrastructure, and upgraded and expanded their networks.[4] Between 2015 and 2018, global 3G population coverage increased from 81 per cent to 90 per cent (equivalent to 900 million additional people covered), while 4G population coverage grew from 53 per cent to almost 80 per cent (equivalent to two billion additional people covered).[5]

In countries where access to reliable electricity from the national grid is still not universal, mobile coverage has been expanded by deploying towers in off-grid or bad-grid locations. For the purposes of this study, we define off-grid towers as those that are completely disconnected or receive no electricity from the grid, and bad-grid towers as those with over six hours of power outage per day, on average.

Over the last decade, the GSMA has helped build consensus that investments in renewable energy are not only effective at reducing mobile operators' greenhouse gas emissions and reliance on diesel fuel, but also generate cost savings that could enable the profitable expansion of mobile networks to rural and low-population density areas.[6] Although there is no single optimal green technology for mobile towers — each has unique features that can affect whether they are feasible and viable — solar is the most commonly used green technology globally. Other important renewable energy technologies include wind, biomass, battery and hybrid systems (e.g. solar plus batteries).

As MNOs implement strategies to achieve net zero greenhouse gas emissions by 2050 in line with the Paris Agreement,[7] it is critical that the industry accelerates its transition to greener and more sustainable forms of energy. To support this global effort, the GSMA's CleanTech programme has commissioned new research to better understand the global scale of this opportunity, and to identify common barriers encountered by MNOs, TowerCos, ESCOs and other important stakeholders in LMICs.

As part of this work, we have developed a new model to estimate the total number of mobile towers globally, the number of off-grid and bad-grid towers and the number of towers running on renewable energy. These estimates are summarised in the following section. Our country and regional estimates have produced a clearer picture of how the renewable energy landscape has changed between 2014 and 2020.

We also provide short case studies on the renewable energy landscape in seven "lighthouse" countries: Bangladesh, Democratic Republic of Congo (DRC), Fiji, Mali, Myanmar, Peru and Uganda. By collecting and evaluating a wide range of renewable energy-related data for over 90 LMICs, we identified these seven markets as representative of their respective regions and particularly well suited to increased adoption of renewable energy at mobile towers.

Finally, desk research and expert interviews were conducted to identify key stakeholders in the renewable energy ecosystem and to capture their perspectives on the most critical concerns, challenges, drivers and opportunities associated with the conversion of mobile towers to renewable energy sources.

A complete list of organisations engaged in our research can be found in Appendix 1, and additional details on the research methodology in Appendix 2.

4. GSMA (2018), Enabling Rural Coverage: Regulatory and policy recommendations to foster mobile broadband coverage in developing countries.
5. GSMA (2019), "Executive Summary", 2019 Mobile Industry Impact Report: Sustainable Development Goals.
6. See for instance: GSMA (2014), Green Power for Mobile.
7. Granryd, M. (16 September 2019), "Mobilising the Industry on Climate Action", GSMA Blog.

2

The renewable energy opportunity for off-grid and bad-grid towers in LMICs

To assess the extent of the opportunity to convert off-grid and bad-grid sites in LMICs to renewable energy, and how this has changed between 2014 and 2020, the GSMA has developed new data modelling techniques to estimate the total number of mobile towers, off-grid sites, bad-grid sites and green sites (those that are fully or partially powered by renewable energy) in over 200 countries and territories. This has allowed us to estimate how many towers are currently connected to reliable electricity from a national grid, how many are likely to be using diesel-powered generators (and therefore have the potential to transition to renewable energy) and the amount of CO_2e emissions from mobile tower diesel generators.

Our analysis shows that **the number of mobile towers worldwide has increased by one million, from an estimated four million in 2014 to five million in 2020.** Globally, towers were added at an annual rate (CAGR) of just over four per cent during this period, but South and Southeast Asia and Latin America outpaced this growth at 5.4 per cent and 4.6 per cent respectively (see Figure 1). In most LMICs, sustained annual growth has been driven by the expansion of 2G networks into previously disconnected (often rural) areas, as well as new investments in 3G and 4G networks. Over half of all global towers installed since 2014 are in China (487,000 net towers installed) or India (183,500).

While the total number of towers worldwide is steadily growing, the proportion of towers that are either off-grid or bad-grid is declining in every region. Globally, we estimate that the total number of off-grid sites has fallen by 33 per cent since 2014, from 297,000 to 198,000 in 2020. Over the same period, the number of bad-grid sites was nearly cut in half, dropping from 267,000 to 145,000. This trend can be explained, in part, by better access to national electricity grids. According to estimates from the Energy Sector Management Assistance Program (ESMAP), 43 countries have achieved universal electrification status in the last decade, and many other countries have made significant progress towards this goal.[8]

Today we estimate there are nearly 70,000 towers powered by renewable energy worldwide, a 45 per cent increase since 2014. India accounts for 60 per cent of this growth, adding over 12,000 renewable energy towers in this period. However, our data shows that investments in renewable energy are pervasive, with over 50 countries expanding their networks of renewable energy-powered sites by 10 per cent or more. Despite having only about three per cent of the world's towers, Sub-Saharan Africa now accounts for 14 per cent of global green sites.

Annual CO_2e emissions from diesel-powered generators at off-grid and bad-grid towers have been reduced by an estimated 2.2 million metric tonnes, from 9.2 million in 2014 to 7 million in 2020 (see Figure 2). While this estimate does not account for the emissions from national grid power, it is assumed this is significantly lower. The most dramatic improvement in emissions has been in India. Once responsible for over a third of global emissions from tower diesel generators, it now accounts for a much more modest 12 per cent. At the other end of the spectrum, Nigeria has seen emissions increase substantially. Our model estimates that 26,000 off-grid and bad-grid towers can now be found in Nigeria — more than any other country — and only three per cent of these are powered by renewable energy.

8. Energy Sector Management Assistance Program (ESMAP) (2018), Tracking SDG7: The Energy Access Progress Report 2018.

From 2014 to 2020: Key changes in the global mobile tower numbers and how they were powered, using the most recent GSMA model.

1 million
towers have been added

33% reduction
in off-grid sites

88%
of off-grid and bad-grid sites run on diesel

45% increase
in renewable energy sites

Reduction of
2.2 million metric tonnes
of CO_2e emission from diesel generators, annually

Renewable Energy for Mobile Towers: Opportunities for low- and middle-income countries

Figure 1

Compound annual growth rates (CAGRs) in total towers at the global, regional and national levels: 2014 to 2020

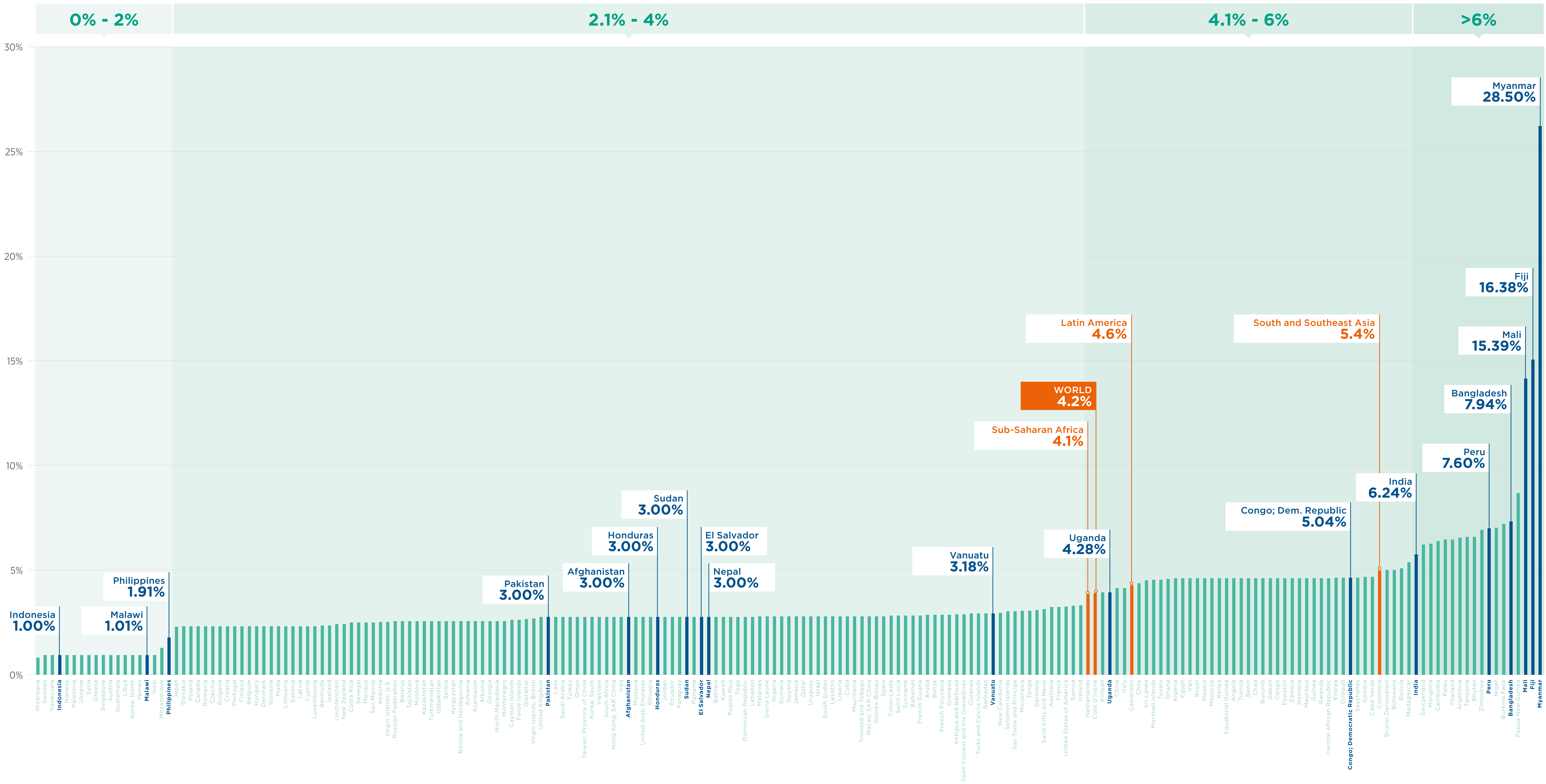
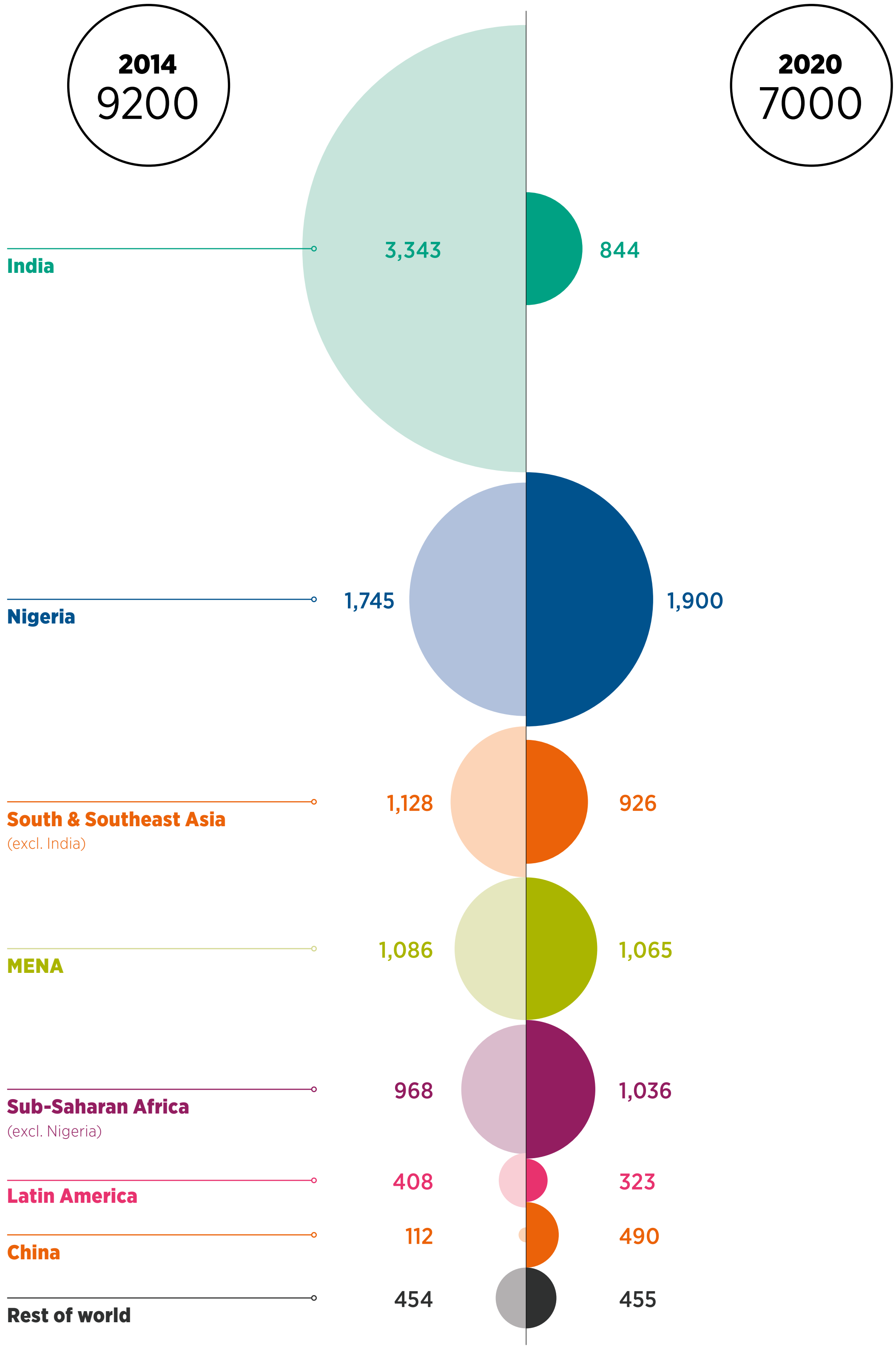


Figure 2

Estimated annual CO_2e emissions (in kilotonnes) from diesel generators at mobile towers

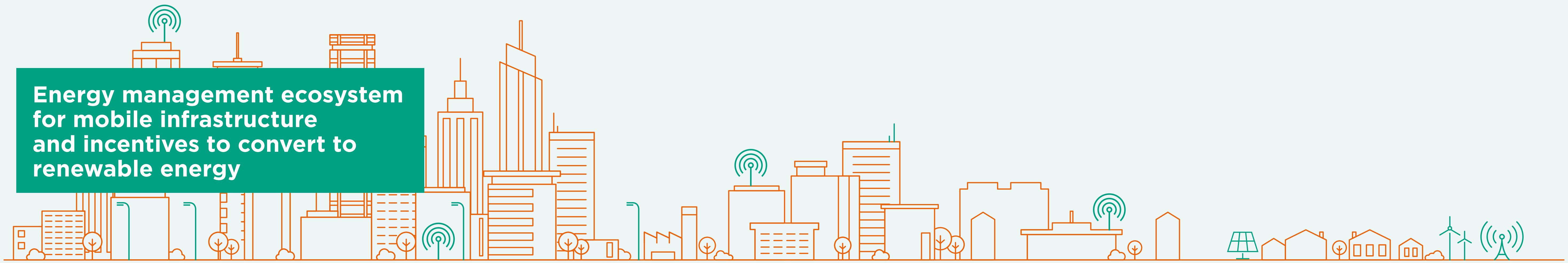


3

Energy ecosystem and incentives to convert to renewable energy

Renewable Energy for Mobile Towers: Opportunities for low- and middle-income countries

Energy management ecosystem for mobile infrastructure and incentives to convert to renewable energy



Tower Energy Management

	Good grid		Bad-grid		Off-grid	
	Incentive to use renewable energy	Key reasons to use renewable energy	Incentive to use renewable energy	Key reasons to use renewable energy	Incentive to use renewable energy	Key reasons to use renewable energy
MNOs	L	• To achieve group carbon emission targets • Use net metering to feed in to grid	M	• Reduce total cost of ownership • Use net metering to feed into grid • To achieve group carbon emission targets	H	• Reduce high energy OPEX for diesel • Lower costs for site maintenance • To achieve group carbon emission targets
TowerCos	L		L	• Reduces energy OPEX in towers with multiple tenants • Achieve TowerCo energy saving targets	M	• Diesel generators are expensive • Achieve TowerCo energy saving targets
ESCOs	L	• Use net metering to feed in to grid	M	• Use long-term contracts to generate attractive returns from renewables	H	• Use long-term contracts to generate attractive returns from renewables • ABC-mini grid to connect communities

Key stakeholders facilitating industry adoption of renewable energy

Investors and Industry Associations

- Play a critical role in facilitating the adoption of renewable energy for mobile towers
- Ex: TowerXchange, IFC, Rockefeller Foundation
- Investors/DFIs – Targeted projects/funding/grants for renewable energy adoption
- Industry associations – Peer learning forums, impact measurement, targeted support

Regulators

- Stakeholders with the most influence in the market and the strongest role in supporting renewable energy adoption
- Ex: National telco regulators and national energy regulators
- Telco regulators – Tower sharing and renewable energy adoption regulations
- Energy regulators – Net metering, tax benefits, support for national targets

KEY

- H High
- M Medium
- L Low

4

Barriers to transitioning mobile towers to renewable energy: global trends

Today there is broad consensus across the telecom industry that transitioning from off-grid or bad-grid towers to green is advantageous.[9] Even where diesel prices are low, renewable energy systems are considered cost competitive with diesel generators when the capital expenditure (CAPEX) of both options are amortised over the medium term (often four to five years), even for most off-grid and bad-grid sites. Deploying on-site solar battery systems also reduces energy-related operational expenditure (OPEX) and the challenges associated with regularly transporting diesel fuel to remote locations.

9. Based on numerous expert interviews conducted for this report.

Over the last six years, we estimate that the global telecom industry has seen a 45 per cent growth in the number of off-grid and bad-grid sites powered by renewable energy. Increased adoption of green sites in LMICs in particular have shown that tower owners and managers — MNOs, TowerCos and ESCOs — understand the technical and financial viability of renewable energy, the in-house and external expertise required and the importance of having the right mix of energy partners or vendors to deploy renewable energy systems.

Even so, we estimate that 88 per cent of the world's off-grid and bad-grid towers are still powered by non-renewable sources.[10] Based on the experiences of the lighthouse countries featured in our case studies, (pages 27–47) and the perspectives of industry experts, we have identified five high-level global trends that are slowing larger-scale deployment of renewable energy. Within these trends, we identify a range of business model barriers or misaligned incentives that sometimes exist between MNOs, TowerCos and ESCOs, as well as external barriers, or limiting factors within the broader renewable energy ecosystem.

Summary of global trends:

1. **The tower-sharing model has transformed tower ownership** and how renewable energy business models are assessed and evaluated.
2. **Legacy and non-standardised energy contracts and lack of price benchmarking data** can stunt the growth of ESCOs, and disincentivise TowerCo investments in renewable energy.
3. **Improved access to electricity from national grids** is disincentivising investments in renewable energy, but net metering may reverse this.
4. **Anchor-Business-Community (ABC) mini-grid models have not reached scale,** but have the potential to bring connectivity and electrification to rural areas, but have not reached scale.
5. There is **a lack of enabling telecom and power sector policy and regulatory frameworks** for renewable energy deployment in many LMICs.

10. GSMA research, 2020

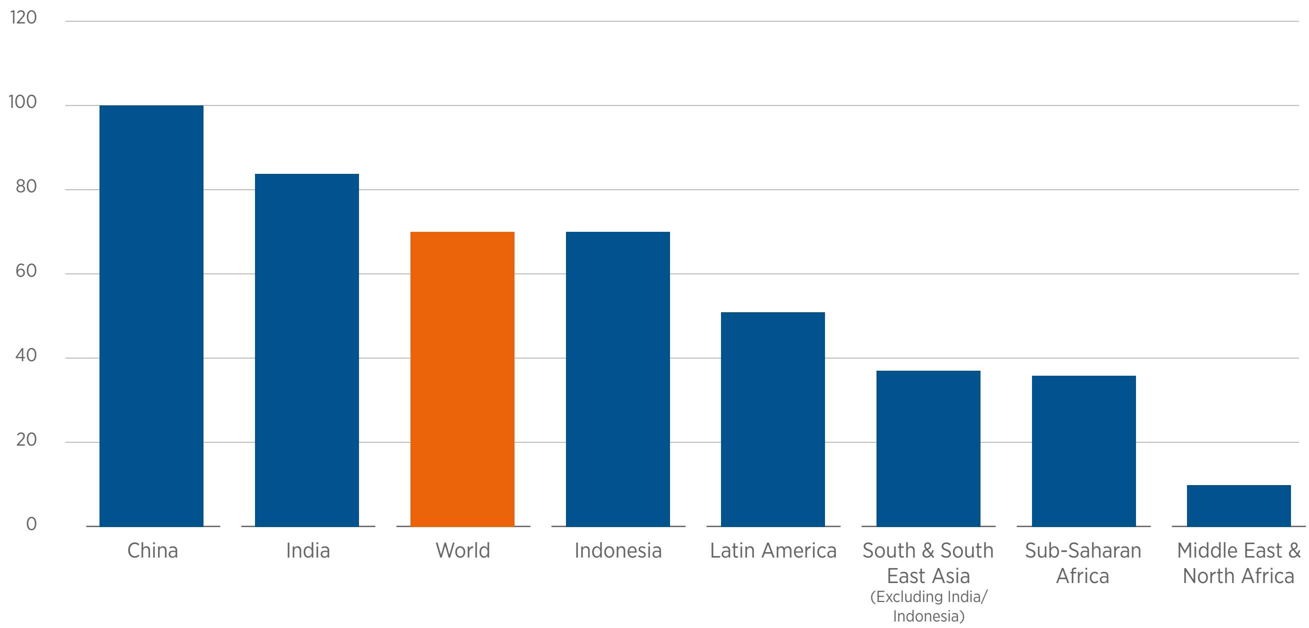
4.1 The tower-sharing model has transformed tower ownership

Just six years ago, MNOs were the primary owners of the mobile networks and tower infrastructure that helped drive widespread access to connectivity in LMICs. In 2014, the GSMA reported that up to 90 per cent of the world's towers were owned and operated by MNOs, and control of the network was seen as a part of their core business, delivering economies of scale and easy access to financing.[11] Historically, ownership and in-house management of towers have been an effective way for MNOs to expand their market share and create barriers to entry for new operators.

Since then, a major shift has occurred. Intense competition has led many MNOs to rethink the competitive advantages of tower ownership and management, with many transitioning to tower-sharing models that outsource procurement, installation, management and maintenance of tower sites to entities known as TowerCos, some of which are wholly or partly owned by MNOs. This model lightens the burden on MNO balance sheets by reducing energy-related CAPEX and OPEX[12] and diverts funds to other critical activities, such as upgrading networks to 3G, 4G or 5G. It is now estimated that only 30 per cent of the world's towers are still directly owned and operated by MNOs (see Figure 3).[13]

Figure 3

Estimated percentage of total towers owned by TowerCos in 2020



11. GSMA (2014), Green Power for Mobile.
12. Osmotherly, K. (26 October 2018), "A brief history of the global tower market", TowerXchange.
13. Osmotherly, K. (9 December 2019), "The new shape of the global telecom tower industry", TowerXchange.

Telecom regulations are enabling, and sometimes enforcing, the rapid expansion of tower sharing, with these models now mandated (in varying degrees) in over 60 LMICs. India and Indonesia were early adopters of the TowerCo model, which has also taken hold quickly in markets such as Pakistan and Bangladesh. China Tower Corporation (CTC), which is owned by the country's three MNOs, is the world's largest TowerCos with approximately 40 per cent of the world's tower sites. In Sub-Saharan Africa, TowerCos have made rapid progress in tower ownership, with market penetration across the region growing from just five per cent in 2013 to 36 per cent in 2018.[14] While the tower-sharing model is dynamic in Sub-Saharan Africa, it is not yet dominant; as of 2019, TowerCos owned and operated just over a third of mobile towers in the region.[15]

The shift in tower ownership has also changed how the business case for renewable energy is evaluated. MNOs have a favourable view of renewable energy investments for two key reasons. First, energy-related OPEX for towers is considered a cost that can (and should) be reduced to increase profitability, particularly in off-grid areas where diesel consumption is high, and where it is unlikely that towers will be connected to a national grid in the short term. MNOs in most instances view towers as a fixed and depreciating asset, and therefore tend to evaluate the business case of investing in renewable energy based strictly on the amount of energy OPEX saved.

TowerCo model is designed to be extremely capital efficient, and generally aim for a payback period of three to four years on all CAPEX investments. In many LMICs, this requirement presents a significant hurdle for renewable energy systems. In the Democratic Republic of Congo (DRC), for instance, our analysis suggests that a tower equipped with solar equipment requires a payback period of five years, compared to the four years it would take to recoup the costs of a non-solar site.[16] India is an exception due to its economies of scale, domestic manufacturing capacity and lower employment costs. Here, we estimate that the payback period for a new site with solar is 2.5 to four years, compared to two to three years for a site that runs on diesel.

In general, renewable energy solutions are only advantageous for TowerCos when the total cost of operations including CAPEX for renewable energy is more affordable than diesel equipment, there are regulatory pressures to deploy renewable energy or the OPEX required to supply diesel to towers is high.

Although MNOs are now less likely to manage how towers are powered, many are striving to influence energy decisions by committing to ambitious CO_2 emission reductions and renewable energy procurement targets. In February 2020, the industry announced new science-based targets (SBTs) for reductions in greenhouse gas emissions as a result of a collaboration between the GSMA, the International Telecommunication Union (ITU), Global e-Sustainability Initiative (GeSI) and the Science Based Targets initiative (SBTi). Twenty-nine MNOs, collectively representing 30 per cent of global mobile connections, have already committed to specific renewable energy procurement and CO_2 emission reduction targets.[17]

Orange Group, for example, is in the process of procuring or installing solar power for its off-grid and bad-grid sites in Cameroon, the DRC, Liberia, Madagascar, Mali and Sierra Leone. In some locations, renewable energy equipment will be procured directly from vendors and managed by Orange, while in others Orange will contract a TowerCos or ESCO to procure and manage its renewable energy supply. Telenor Group is taking similar approaches in Bangladesh, Myanmar, Pakistan and Thailand, as is Telefónica Group in Argentina, Brazil, Chile, Colombia, Mexico and Peru.

14. ITU News, TowerXchange Research 2019
15. TowerXchange (2019), TowerXchange Africa Dossier 2019.
16. When payback is calculated for the entire tower's CAPEX investment rather than just the solar equipment CAPEX.
17. GSMA (27 February 2020), ICT Industry Agrees Landmark Science-Based Pathway to Reach Net Zero Emissions. GSMA Press Release.

4.2 Legacy and non-standardised energy contracts and lack of price benchmarking data

As MNOs in LMICs upgrade to 3G, 4G and 5G networks, they face growing pressure on their budgets, making it increasingly popular to outsource energy investments and management to ESCOs. ESCOs have historically been engaged by MNOs to manage their diesel fuel supply and the operation of diesel generators, but in recent years they have evolved to provide renewable energy installations for tower sites. ESCO business models are favourable to renewable energy investments since contracts with MNOs and TowerCos tend to be long term (10 years or more), allowing them to depreciate renewable energy equipment over a longer period and generate attractive financial returns.

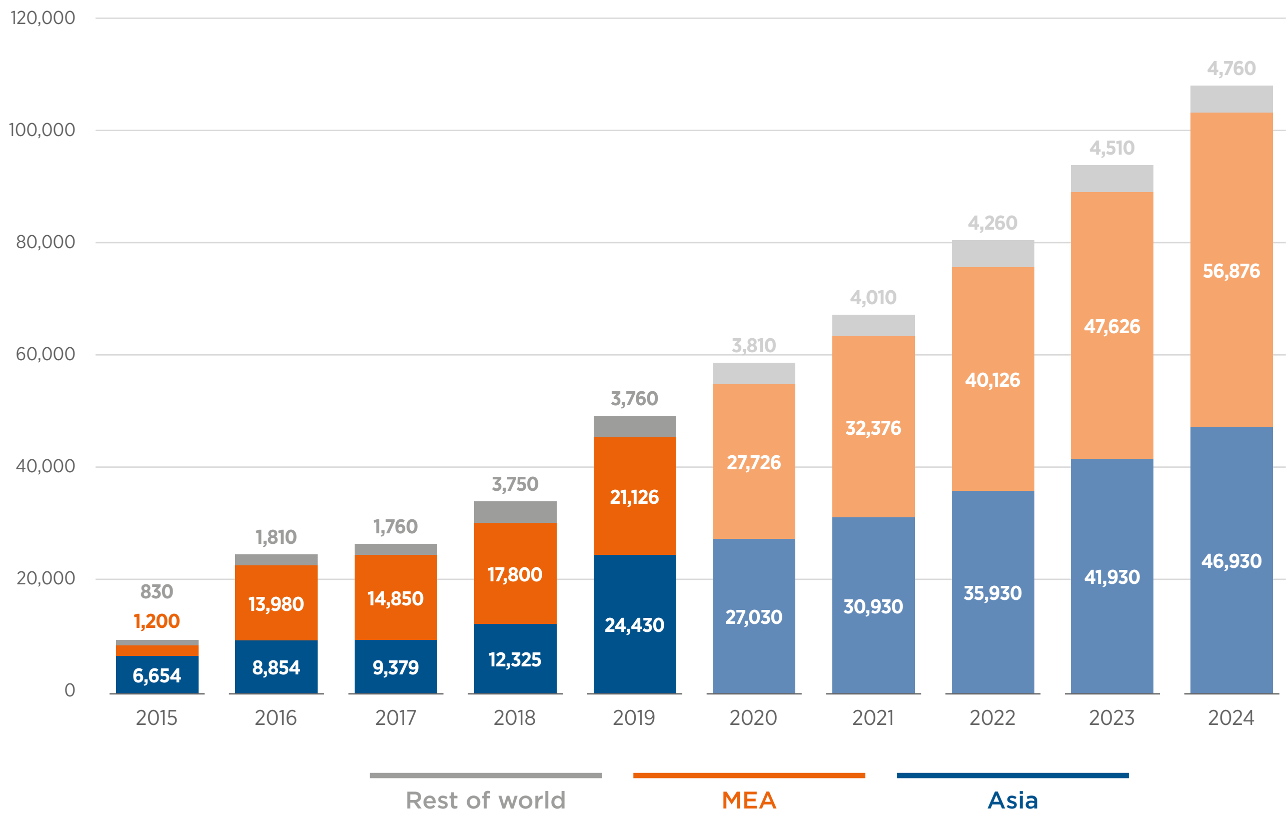
MNOs and TowerCos usually hold service-level agreements (SLAs) with ESCOs that guarantee uninterrupted power to towers over 99 per cent of the time. To achieve this, they often deploy energy-saving green solutions, such as solar battery systems, solar-diesel hybrid systems and battery-diesel hybrid systems. At the global level, a significantly higher proportion of ESCO-powered sites have renewable energy systems installed compared to towers managed directly by TowerCos.

According to TowerXchange research, ESCOs now own and operate the power systems at nearly 50,000 tower sites worldwide. Although this represents a small fraction (one per cent) of the world's total sites, it is more than a five-fold increase since 2015.[18] Asia accounted for the majority of ESCO-owned systems in 2015, but there is now an equal share in the Middle East and Africa regions (grouped together as "MEA" in Figure 4 below) following significant growth in recent years.

Figure 4

ESCO-operated telecom towers worldwide: 2015-2024 (actual and estimated)

Source: TowerXchange research, 2020



18. TowerXchange ESCO Market Study 2020

The ESCO model is relatively new to the telecom industry, and a range of payment models are still being explored, including fixed fees and guaranteed savings arrangements whereby an ESCO's payments are linked to the amount of energy OPEX an MNO or TowerCo saves (both energy savings and monetary savings).[19] The lack of standardisation in ESCO contracts, and the absence of price benchmarking in most LMICs, means ESCOs are not able to structure their business models to achieve scale. For example, there is no source of regularly updated data that could provide national or regional benchmarked prices for:

- the levelised cost of energy (LCOE) for solar battery and solar battery-diesel systems compared to the LCOE for diesel battery systems;
- the levelised cost of storage (LCOS) for battery energy storage systems;
- price per watt peak ($/Wp) of renewable energy equipment in each country, including logistics, import and customs duty, and other costs; and
- price per kilowatt hour (kWh) (all-inclusive) for supplying electricity to remote telecom towers.

MNO representatives interviewed by the GSMA acknowledged they often receive proposals and price quotations for renewable energy systems from ESCOs, but struggle to validate whether the pricing is competitive. This often means that procurement processes take longer to finalise and ESCOs experience contractual delays, which can ultimately stunt their growth and slow the deployment of renewable energy solutions.

TowerCos, on the other hand, generally charge MNOs for their energy usage in one of three ways: fixed monthly rates included in tower rental fees; payments that reflect the actual amount of energy units (kWh) used; or "pass-through" contracts whereby MNOs pay the actual costs incurred for energy on top of the site rental. The latter two models, which obligate MNOs to pay the actual cost of energy, act as a disincentive to the deployment of renewable energy.

Over the last few years, MNOs and TowerCos have renegotiated pass-through contracts in favour of models that incentivise energy reductions and renewable energy installations. However, the pass-through model still exists in many countries either in its original form or as a variation, such as in Myanmar and the DRC (see case studies). One variation of the pass-through model is "power fixed", whereby the MNO pays a fixed fee per kWh consumed for the tower based on several fee bands that are determined every quarter based on prevailing grid electricity and diesel fuel prices. In other markets, pass-through models set a base cost for energy OPEX, and any additional energy used is charged to the MNO.

19. TowerXchange ESCO Market Study 2020; GSMA research

4.3 Improved access to electricity from national grids

Many LMICs in South and Southeast Asia, and a smaller number in Sub-Saharan Africa, have seen significant improvements in national electrification rates and the reliability of power grid infrastructure. According to ESMAP estimates,[20] 43 countries have achieved universal electrification status (i.e. 100 per cent of households are connected to a central grid or an off-grid energy source) in the last decade, including Argentina, Brazil, China, Egypt, Malaysia and Thailand. Other countries, such as Bangladesh, Cambodia, Kenya, Ethiopia and Rwanda have made significant progress towards this goal.

Increases in national electrification rates have had a major impact on the way towers are powered in LMICs. In Bangladesh, for example, over 10 per cent of tower sites were located in off-grid areas in 2014, but this has dropped to just one per cent. In India, the proportion of off-grid sites fell from 36 per cent to four per cent over the same period. With electrical grids becoming ubiquitous and more reliable in many countries, MNOs and TowerCos are less inclined to deploy on-site renewable energy systems, especially for sites that are likely to be electrified in the next two years. For example, sites located three kilometres or less from an existing grid connection or in areas with significant population density.

However, in some LMICs where access to electricity is high, MNOs are executing or exploring net metering systems, a regulated arrangement in which a company with on-site solar electricity generation capacity can receive credits for excess generation that is fed back to the grid. This excess power can then be applied to offset the cost of any of the organisation's grid electricity consumption within the same or other billing periods. According to our research, over 40 LMICs already allow some form of net metering in their respective national energy policy and regulatory frameworks. In India and Bangladesh, MNOs and TowerCos such as Robi Axiata and Bharti Infratel, which collectively own several hundred solar-powered sites connected to the grid, are planning to obtain net metering contracts with their local grid utilities to optimise their solar and grid usage and further reduce energy OPEX.

Across much of Sub-Saharan Africa, where MNOs and TowerCos do not expect to receive electricity from the national grid or see significant improvement in grid reliability within the next few years, the incentive to invest in renewable energy remains high. This is also true of many small island states. Despite relatively high national electrification rates in countries like the Philippines and Indonesia, it is anticipated that around five per cent of tower sites will remain permanently off-grid due to their archipelagic geographies, which make extending central grid systems to small islands uneconomical.[21] Thousands of other islands across Southeast Asia, Pacific Islands, Indian Ocean Islands and the Caribbean are also unlikely to be connected to the national grid and will continue to depend on diesel generators, batteries and, increasingly, renewable energy to power telecom towers.

20. See: Energy Sector Management Assistance Program (ESMAP) (2018), Tracking SDG7: The Energy Access Progress Report 2018.
21. Results from GIS mapping of 91 LMICs and stakeholder interviews.

4.4 Anchor-Business-Community (ABC) mini-grid models have not reached scale

In remote areas unlikely to be connected to a national electricity grid in the near term, rural areas often gain access to mobile connectivity through "small cell sites" — low-capacity, low-power consuming sites designed to bring services to small pockets of the population. Small cell sites have also been used in high-demand urban and industrial areas to enhance the existing network with signal strength and coverage.

Small cell sites are increasingly considered ideal for renewable energy systems such as solar, as they consume less than a quarter of the energy required by larger towers. Specialised TowerCos such as Africa Mobile Networks (AMN), which describes itself as a Network-as-a-Service (NaaS) provider to MNOs, have started building small cell networks at scale in Africa. These sites are optimised for, and powered exclusively by, solar PV-battery systems with no diesel generator backup.

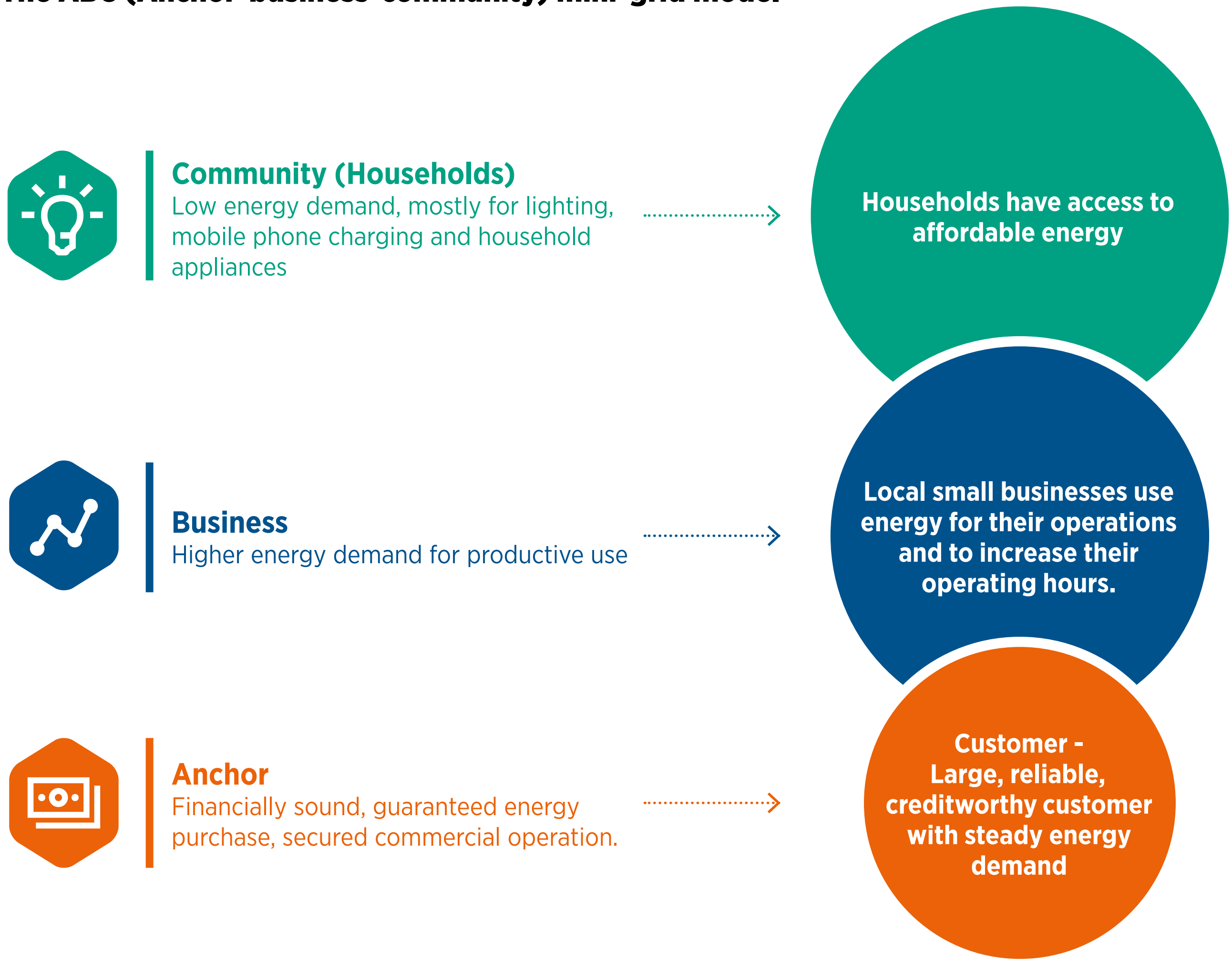
Like AMN, Telefónica set up a broadband-focused rural TowerCo in Latin America in 2019 called Internet Para Todos (IPT), in partnership with Facebook, Inter-American Development Bank (IDB) and the Development Bank of Latin America (CAF). Starting in Peru, IPT aims to provide NaaS to MNOs that want to extend mobile broadband coverage to customers in rural locations across the continent. Telefónica and IPT plan to establish over 3,600 solar-powered small cell sites in Peru as part of this initiative.

The successful deployment of small cell sites suggests that mobile towers could play a greater role in electrifying local communities where national electricity grid coverage is low.

In these off-grid locations, there is another opportunity to design, install and operate renewable energy-based mini-grid systems that supply electricity to towers with MNOs or TowerCos as the "anchor customer", but also to local businesses and community households. This is known as the Anchor-Business-Community (ABC) mini-grid model (see Figure 5).

Figure 5

The ABC (Anchor-business-community) mini-grid model[22]



The 2010 GSMA report on community power[23] first described the market opportunity of the ABC model, and the GSMA' Utilities Innovation Fund has provided grants to several grantees using this approach. However, due to a number of consistent challenges, the model has achieved mixed results and has yet to reach scale. The M4D Utilities 2016 report 'Unlocking access to utility services', highlighted that aligning the incentives of all parties involved in this model remains the main challenge.[24] Stakeholders engaged through our research indicated that they still do not have a clearly defined business model to help them evaluate the financial viability of providing power to both their towers and rural communities with low energy needs. There is a need for robust data on where the deployment of mini-grid systems could be sustainable. Such information could include: the locations of off-grid communities in relation to planned tower sites, and the current and anticipated energy requirements of these communities. Other challenges include the length of time it takes for the model to become cost effective at one site, ongoing "competition" from the expanding national grids and a variety of other hurdles related to the capacity and priorities of different stakeholder groups, including MNOs, TowerCos, ESCOs and mini-grid providers. However, there is emerging evidence that the model could work in countries such as Myanmar (page 40), and increased interest from influential organisations, including the Rockefeller Foundation, indicates that the model deserves further exploration.

22. The German Climate Technology Initiative and GIZ Promotion of Solar-Hybrid Mini-Grids (August 2016), What size shall it be? A guide to mini-grid sizing and demand forecasting.
23. GSMA (2010), Community Power: Using Mobile to Extend the Grid.
24. GSMA M4D Utilities (2016), Unlocking access to utility services: The transformational value of mobile.

4.5 Lack of enabling telecom and energy sector policies and regulatory frameworks

Renewable energy policies and regulations, which incentivise or mandate reduced diesel consumption, increased renewable energy deployments and energy efficiency measures for towers, are found in very few LMICs. Telecom and energy regulators in countries such as India, Kenya and Bangladesh, have either conducted industry consultations or included basic renewable energy measures in their national policy and regulatory frameworks. However, in many LMICs these policy measures are not comprehensive or effectively enforced. Broader renewable energy policies for the deployment of renewable energy, not specific to the telecom industry, are more common.

In addition to net metering (described in section 4.3.), there are two other types of policies that could encourage the adoption of renewable energy:

Corporate power purchase agreement (PPA) model: This model is known by various names such as 'open access' or 'group captive' in India or 'contestable consumers' in the Philippines. Under this contracting model, a commercial electricity consumer such as an MNO, aggregates energy consumption from several of its assets (towers, data centers, offices) and enters into a long-term PPA to purchase electricity from a solar plant that is setup by a solar project developer - typically at a convenient location with sufficient land availability and solar irradiance – often several hundred kilometers away from the consumer. The electricity is generated and delivered ('wheeled', and often 'banked' and distributed) to the consumer using national grid infrastructure. Telenor group, as part of its Asia-wide strategy and global goal to procure renewable energy for its operations and reduce its CO_2 emissions, is working with the government in Bangladesh on corporate PPA/procurement of solar power from project developers on 'open access' basis, although current power sector regulations do not allow such models.

Tax and duty relief on renewable energy equipment: This includes any tax or duty waivers, subsidies or exemptions for renewable energy equipment either manufactured domestically or imported from outside the country. These could include customs/import duty waivers, price concessions and tax waivers for renewable energy equipment or businesses.

Of 91 countries in Sub-Saharan Africa, Latin America, South Asia and Southeast Asia:

- 41 allow net metering
- 39 have feed-in tariffs
- 69 have some type of tax/duty relief for renewable energy equipment

India provides an example of national energy regulation that has demanded robust action from the industry. The fact that India accounts for over 60 per cent of all green sites added globally in the last six years could largely account for this regulatory framework. Examples of enabling renewable energy policies in India include:

- A green telecom initiative implemented by the Telecom Regulatory Authority of India (TRAI) that regularly tracks the number of diesel-powered and solar-powered mobile towers reported by MNOs and TowerCos.
- Corporate procurement of wind and solar power is easier in India due to the "open access" and "group captive" models built into national power sector regulations. Open access provides large energy consumers with access to the energy transmission and distribution network to obtain power from suppliers other than the local power distribution company. Group captive models allow a developer to set up a power project for the collective use of multiple industrial or commercial consumers that have at least 26 per cent equity in the project and consume at least 51 per cent of the power produced.
- Diesel subsidies were progressively eliminated in India over the last decade, making solar and other renewable energy more financially attractive for mobile towers.
- Net metering policies are allowed for commercial and industrial (C&I) customers, including MNOs and TowerCos, which encourages grid-connected, on-site, distributed solar installations. Indus Towers has already taken advantage of these policies to help make on-site solar installations more viable.
- TRAI's 2019 white paper, *Enabling 5G in India*,[25] discusses the energy efficiency of 5G networks as a key issue, confirming that energy efficiency/renewable energy will be a key policy consideration when 5G spectrum auctions are introduced in India.

In addition to the five global trends outlined above, the decision to deploy — or not deploy — renewable energy solutions can be influenced by a range of contextual factors, including local tower-sharing policies, the availability of low-cost energy from the grid, local policies and regulatory frameworks related to renewable energy, the presence and capacity of a renewable energy vendor ecosystem and the local price of diesel fuel. In addition, MNOs and TowerCos often rely on the resources and expertise of numerous other ecosystem players, such as regulators, investors, donors and renewable energy equipment providers.

In the following section, case studies on seven renewable energy "lighthouse" countries will highlight how these factors affect renewable energy deployment on a country-by-country basis.

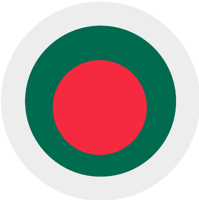
25. TRAI (February 2019), Enabling 5G in India.

5

Lighthouse country case studies

By collecting qualitative and quantitative data related to renewable energy from 91 countries, we were able to identify seven countries in Africa, Latin America, South and Southeast Asia, and Small Island Developing States in the Pacific that broadly represented the market conditions for renewable energy deployment in their respective regions. Stakeholders from each of these "lighthouse" countries were interviewed to help highlight the specific ecosystem and stakeholder dynamics that are shaping, or inhibiting, the opportunity to transition to renewable energy. While all these countries have achieved some level of success deploying renewable energy at mobile towers over the last five to six years, they differ in terms of the key factors that influenced their approach, such as tower ownership and management models, the availability of grid energy and types of stakeholders involved.

Each of the case studies uses data on tower deployment taken from our 2020 model along with specific data collected from interviews with stakeholders from each country. They also include a GIS-based map that visualises areas with renewable energy potential, using data on mobile coverage and the location of off-grid and bad-grid towers, overlapped with information on the availability of renewable energy **(see additional details in Appendix 2)**.



Bangladesh

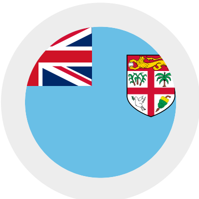
Context: Four major MNOs collectively cover about 97 per cent of the population.[26] It is one of the latest countries in South Asia to mandate tower sharing.

Potential renewable energy opportunity: With a much-improving national grid and solid net metering options, MNOs have more opportunities to deploy renewable energy solutions at their on-grid sites.

Democratic Republic of Congo (DRC)

Context: A competitive market with five MNOs, and a near-even split between the number of towers that are MNO-owned (51 per cent) and TowerCo-owned (49 per cent). National electrification rates are very low at 16 per cent. Between 2014 and 2020, the total number of tower sites increased by 35 per cent.

Potential renewable energy opportunity: With a large population living off-grid and possibly unconnected to a network, the DRC provides a good opportunity to explore using GIS-based tools to help MNOs and TowerCos identify potential sites for green towers.



Fiji

Context: There are two MNOs, and all towers are MNO-owned. Total sites have increased at an annual rate of 16.8 per cent since 2014. Electrification rate is high at 96 per cent. The main islands are completely electrified, but the outer islands are not connected to a national grid.

Potential renewable energy opportunity: ESCOs to develop a pricing model and a business plan to support MNOs with renewable energy solutions across Small Island Developing States (SIDS).

26. BTRC data on mobile phone subscribers, February 2020.

Mali

Context: Although there are four active MNOs in Mali, it is largely a duopoly between Orange Mali and Malitel. All towers in Mali are still owned and managed by MNOs.

Potential renewable energy opportunity: MNO groups' carbon emission reduction targets are strengthening the business case for local MNOs to deploy renewable energy.

Myanmar

Context: A competitive market with five MNOs and 15 TowerCos vying for market share. Roughly half the population has access to grid energy. Tower sites have increased at an annual rate of nearly 30 per cent since 2014.

Potential renewable energy opportunity: Smart Power Myanmar (SPM) is one of the few use cases for the ABC mini-grid model currently being scaled in a market, and provides an excellent learning opportunity.

Peru

Context: A steady market with 24 million unique subscribers and two dominant MNOs. Electrification rates are high, including in rural areas (87 per cent).

Potential renewable energy opportunity: Solar-powered small cell sites managed by IPT (Telefónica) provides multiple opportunities for MNOs and ESCOs to work collaboratively.

Uganda

Context: There are five MNOs in Uganda, and 80 per cent of towers are owned by one TowerCo, ATC.

Potential renewable energy opportunity: With a very low electrification rate, MNOs and TowerCos have more incentive to switch to renewable energy. They also have the option of working with ecosystem partners that provide either end-to-end renewable energy solutions or a small component of the solution.

CASE STUDY

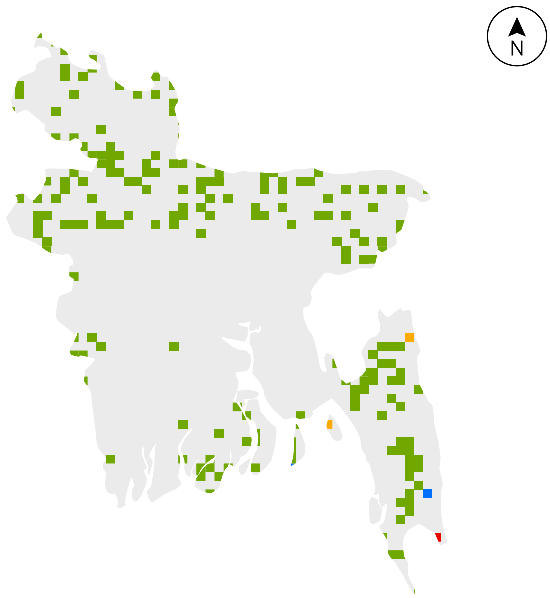
5.1 Bangladesh

BANGLADESH

Showing bad-grid and off-grid areas with/without telecom coverage set to population density and solar/wind potential above specific thresholds

OFF-GRID
- With Telecom
- Without Telecom

BAD-GRID
- With Telecom
- Without Telecom



As of 2019, Bangladesh had over 40,000 mobile towers, almost 30 per cent of which were owned and operated by TowerCos. The remaining 70 per cent of the towers were still owned and operated by MNOs. In South Asia, this is a similar ratio to Pakistan and Sri Lanka, whereas India has the highest percentage of tower ownership in the region at 84 per cent.

Over the last decade, the availability and reliability of grid electricity for mobile towers has improved significantly in Bangladesh, resulting in a large percentage of telecom towers being connected to the grid. Although the total number of off-grid sites has dropped significantly, there is still a high number of bad-grid sites in Bangladesh requiring MNOs to retain backup diesel generators at many sites.[27]

Bangladesh has very high renewable energy potential with both solar and wind resources available. According to GSMA research, almost 1,200 of Grameenphone's towers already have solar power capacity and around 700 of Robi towers owned by edotco are also operating on solar.

27. GSMA research

Key challenges

There are unique barriers to transitioning to renewable energy systems in Bangladesh. Table 1 highlights the specific barriers identified during stakeholder interviews.

Table 1

The challenges of switching to renewable energy systems in Bangladesh

Challenge		Key barrier in country
ESCO services	Not present	✓
	At a nascent stage	
No price benchmarking or standardised contracts for ESCOs		
Network expansion prioritised over CAPEX for solar energy	2G to 3G or 4G and strengthening the backbone of the network	
Energy OPEX pass-through models	Directly	✓
	The model exists indirectly	
TowerCo and MNO business models vary	No incentive to invest in solar energy	
Expanding grid	Limits incentives for off-grid/bad-grid investments	✓
Lack of net metering policy	To convert to on-grid solar initiatives	
Very high import duties and taxes	Additional costs for solar	
Limited land availability	Insufficient space for solar PV	✓
Limited access to affordable finance	Funding does not cover CAPEX for renewable energy at sites	
Lack of scale	Difficult to establish business case	

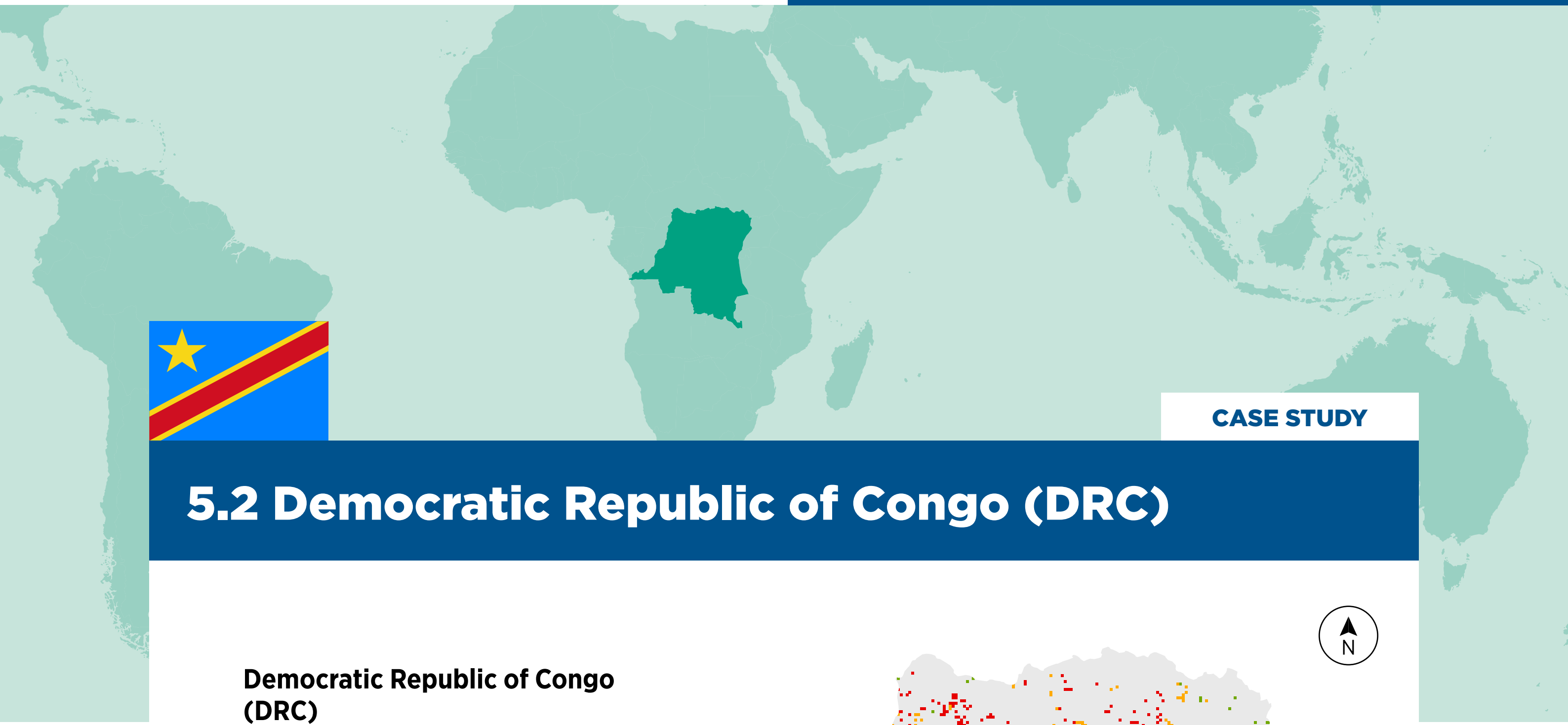
Renewable energy opportunities

Bangladesh's national electrification rate grew from 50 per cent in 2010 to 93 per cent in 2019.[28] With grid connectivity in Bangladesh improving significantly over the last decade, many towers initially equipped with renewable energy systems are now connected to the national grid. Net metering policies allow on-site solar power systems in grid-connected towers to supply excess electricity to the grid and reduce overall grid electricity consumption costs.

MNOs in Bangladesh have also been reaching out to regulators to explore the possibility of using a corporate Power Purchase Agreement (PPA) to use an off-site grid-connected solar power plant to off-set energy consumption and work towards carbon neutrality. Although the current energy policy environment does not allow corporate PPAs of this nature, this could be an opportunity for MNOs to work further with energy and telco regulators.

Since grid-connected solar power systems are proving to be significantly cheaper, MNOs are motivated to set up more grid solar solutions. Robi Axiata is planning to deploy solar at 400 of its own grid-connected sites on a net metering-based "zero billing model". Under this model, oversized 15–16 kW solar capacity would be installed, and consumption from the grid would be completely offset by excess electricity from solar (after a tower's internal consumption) that would be fed back to the grid. This would result in a monthly electricity bill of zero for the tower's grid.[29]

28. The Daily Star (26 May 2019), Power coverage reaches 93pc people in Bangladesh.
29. GSMA research, 2020



CASE STUDY

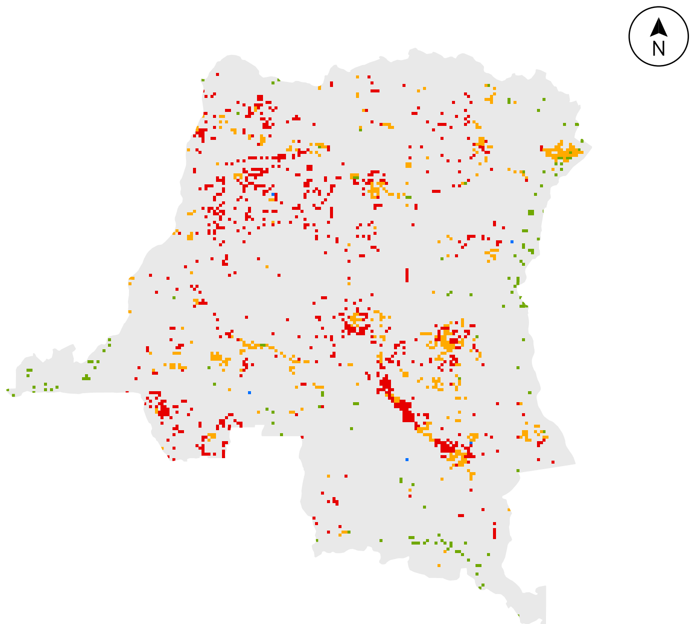
5.2 Democratic Republic of Congo (DRC)

Democratic Republic of Congo (DRC)

Showing bad-grid and off-grid areas with/without telecom coverage set to population density and solar/wind potential above specific thresholds

OFF-GRID
- With Telecom
- Without Telecom

BAD-GRID
- With Telecom
- Without Telecom



The Democratic Republic of Congo (DRC) has an estimated 4,500 mobile towers.[30] Of these, 40 per cent are owned and operated by Helios Towers, five per cent are owned by Africa Mobile Networks (AMN) and the remaining are owned and operated by MNOs.

Small cell sites in the country are powered exclusively by solar power and managed by AMN, a niche TowerCo that operates mainly in DRC (with a presence in several other countries, including Nigeria, Cameroon and Guinea-Bissau). AMN has built 235 small cell low-capacity (mostly 2G-only or 2G+3G only) towers for Orange to increase last-mile connectivity using the NaaS model. Unlike the typical TowerCo model, AMN offers both passive and active infrastructure for MNOs. All these towers are off-grid and powered by renewable energy.

30. Based on the GSMA 2020 model

Key challenges

There are unique barriers to transitioning to renewable energy systems in the DRC. Table 2 highlights the specific barriers identified during stakeholder interviews.

Table 2

The challenges of switching to renewable energy systems in the DRC

Challenge		Key barrier in country
ESCO services	Not present	
	At a nascent stage	✓
No price benchmarking or standardised contracts for ESCOs		✓
Network expansion prioritised over CAPEX for solar energy	2G to 3G or 4G and strengthening the backbone of the network	✓
Energy OPEX pass-through models	Directly	
	The model exists indirectly	✓
TowerCo and MNO business models vary	No incentive to invest in solar energy	✓
Expanding grid	Limits incentives for off-grid/bad-grid investments	
Lack of net metering policy	To convert to on-grid solar initiatives	✓
Very high import duties and taxes	Additional costs for solar	✓
Limited land availability	Insufficient space for solar PV	
Limited access to affordable finance	Funding does not cover CAPEX for renewable energy at sites	
Lack of scale	Difficult to establish business case	

Renewable energy opportunities

With a national electrification rate under 20 per cent and a low population density, a significant portion of future towers are likely to be built in off-grid and sparsely populated locations. Table 3 (below) shows national electrification rates, total population estimates, population densities and 3G population coverage in the world's six least electrified countries.

Table 3

National electrification, total population, population density and 3G coverage in countries with the lowest electrification rates

Country	National electrification (2018)[31]	Population in millions (2020)[32]	Population density (2018)[33]	3G population coverage of 2G (Q2 2020)[34]
Burundi	11%	11.8 m	435.2	40%
Chad	11.8%	16.4 m	12.3	60%
Burkina Faso	14.4%	20.9 m	72.2	65%
Niger	17.6%	24.2 m	17.7	71%
Malawi	18%	19.1 m	192.4	95%
DRC	19%	89.6 m	37.1	65%

AMN is already deploying small cell sites through its NaaS model with MNOs, which are also in the process of identifying new ESCO partners to manage the energy supply at their towers. This may soon result in the deployment of solar hybrid systems at hundreds of towers. To support these efforts, stakeholders must help address the lack of available tools and insights to develop a business model for adopting renewable energy at sites managed by and rented from TowerCos. Similarly, if business case challenges can be addressed, energy OPEX pass-through contracts between MNOs and TowerCos can be renegotiated to incentivise TowerCos to adopt renewable energy.

31. World Bank Data, Access to electricity (% of population).
32. GSMAi, 2020
33. World Bank Data, Population density (people per sq.km of land area).
34. GSMAi, 2020

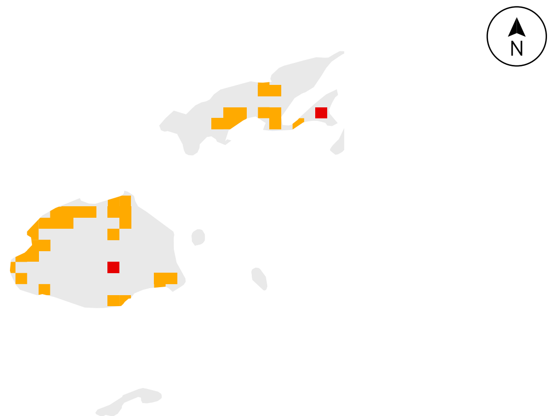
CASE STUDY

5.3 Fiji

Fiji

Showing bad-grid and off-grid areas with/without telecom coverage set to population density and solar/wind potential above specific thresholds

OFF-GRID
- With Telecom
- Without Telecom



Nearly 95 per cent of Fiji's population is covered by existing telecom infrastructure.[35] The few communities not covered by a mobile network are on islands with high volcanic activity or are too small (hamlets of less than 50 people) to make building new towers economical.[36]

There are currently no TowerCos operating in Fiji. Of the approximately 950 telecom towers in the country, just over two thirds are owned and operated by Vodafone Fiji, and the rest are owned by both Digicel Fiji. Although all MNO towers on the main island are connected to the national electricity grid, some grid-connected sites have diesel generators to help cope with weekly power outages that often last between three and four hours, but can extend to 10 to 12 hours in outer parts of the island. Since most grid electricity is generated by large-scale diesel generators, grid electricity is relatively expensive compared to neighbouring islands.

The outer islands and coastal areas in the western parts of the larger islands have high solar potential and significant wind resources available for renewable energy.[37] Fiji has higher electrification rates than most neighbouring Pacific islands, but about 20 per cent of the network connecting outer islands is still completely off-grid. As with most small island developing states, transporting diesel to small remote islands is often a challenge, and MNOs bear heavy expenses for this.[38] For this reason, Digicel Fiji has deployed solar battery-diesel hybrid systems at half of their off-grid towers, which they procured directly from renewable energy equipment vendors.[39]

35. GSMA research, 2020
36. GSMA research, 2020
37. IRENA (June 2015), Fiji: Renewable Readiness Assessment.
38. GSMA research, 2020
39. GSMA research, 2020

Key challenges

There are unique barriers to transitioning to renewable energy systems in Fiji. Table 4 highlights the specific barriers identified during stakeholder interviews.

Table 4

The challenges of switching to renewable energy systems in Fiji

Challenge		Key barrier in country
ESCO services	Not present	
	At a nascent stage	✓
No price benchmarking or standardised contracts for ESCOs		✓
Network expansion prioritised over CAPEX for solar energy	2G to 3G or 4G and strengthening the backbone of the network	✓
Energy OPEX pass-through models	Directly	
	The model exists indirectly	
TowerCo and MNO business models vary	No incentive to invest in solar energy	
Expanding grid	Limits incentives for off-grid/bad-grid investments	
Lack of net metering policy	To convert to on-grid solar initiatives	✓
Very high import duties and taxes	Additional costs for solar	
Limited land availability	Insufficient space for solar PV	
Limited access to affordable finance	Funding does not cover CAPEX for renewable energy at sites	
Lack of scale	Difficult to establish business case	✓

Renewable energy opportunities

As mentioned earlier, it is estimated that between 20 and 30 per cent of mobile towers owned and managed by MNOs in Fiji are off-grid, and only a fraction of these are currently powered by solar hybrid systems. ESCOs can use this opportunity to propose a competitive price for renewable energy solutions. MNOs in Fiji have already shown interest in contracting with ESCOs to deploy solar hybrid systems for their off-grid sites.

Solar-powered small cell sites could be a viable option in environments like Fiji (as highlighted in the case studies on DRC and Peru) or a mini- or micro-grid model that provides electricity to outer islands. Across the Pacific and Caribbean, several MNO groups are operating in multiple island states (e.g. Digicel Group, Cable and Wireless), which could provide an ESCO the opportunity to partner with an MNO to deploy renewable energy across several markets.

While there are many examples of operational community mini-grids in Fiji, none seem to involve telecom towers as an anchor customer under an ABC model. Given that the outer islands are totally off-grid, our research suggests there is a potential opportunity to explore testing this model here, as well as in other remote small island states.[40]

40. GSMA research, 2020

CASE STUDY

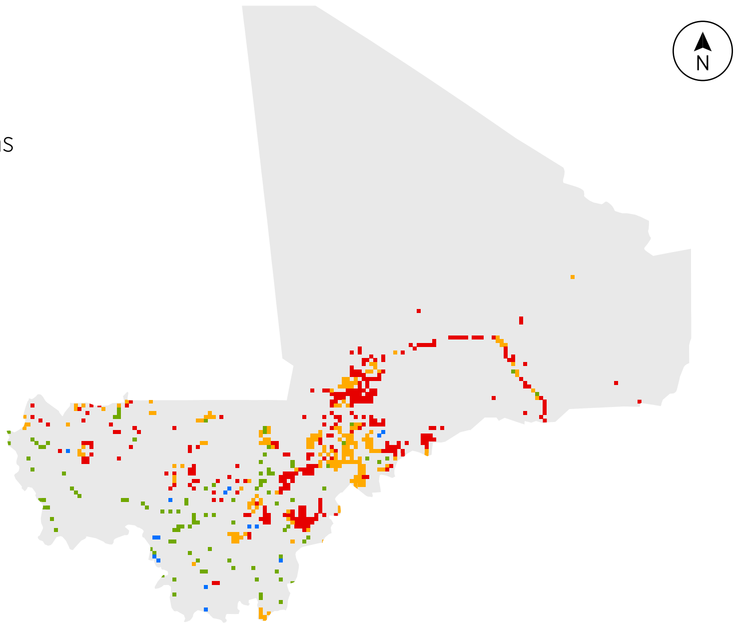
5.4 Mali

Mali

Showing bad-grid and off-grid areas with/without telecom coverage set to population density and solar/wind potential above specific thresholds

OFF-GRID
- With Telecom
- Without Telecom

BAD-GRID
- With Telecom
- Without Telecom



Mali has approximately 3,000 telecom towers, all of which are owned and managed by MNOs. Tower sharing is allowed, but there are currently no TowerCos operating in the country (a small number are exploring the business case, however) and very few MNOs share their tower sites with their peers.

With a rural electrification rate of 20 per cent,[41] the availability and reliability of grid electricity in Mali is among the worst in West Africa, and a high proportion of MNO towers are off-grid. However, Mali has very high renewable energy potential with high solar irradiance and availability of hydropower.

With energy OPEX accounting for 40 to 50 per cent of MNOs' total network OPEX, local stakeholders we interviewed feel there is a strong business case for transitioning to renewable energy. Of the 1,800 mobile towers owned by Orange Mali, almost 680 already have solar battery hybrid systems deployed.

41. IEA (2019), World Energy Outlook 2019.

Key challenges

There are unique barriers to transitioning to renewable energy systems in Mali. Table 4 highlights the specific barriers identified during stakeholder interviews.

Table 5

The challenges of switching to renewable energy systems in Mali

Challenge		Key barrier in country
ESCO services	Not present	
	At a nascent stage	✓
No price benchmarking or standardised contracts for ESCOs		✓
Network expansion prioritised over CAPEX for solar energy	2G to 3G or 4G and strengthening the backbone of the network	✓
Energy OPEX pass-through models	Directly	
	The model exists indirectly	
TowerCo and MNO business models vary	No incentive to invest in solar energy	
Expanding grid	Limits incentives for off-grid/bad-grid investments	
Lack of net metering policy	To convert to on-grid solar initiatives	✓
Very high import duties and taxes	Additional costs for solar	
Limited land availability	Insufficient space for solar PV	
Limited access to affordable finance	Funding does not cover CAPEX for renewable energy at sites	
Lack of scale	Difficult to establish business case	

Renewable energy opportunities

Given the high energy OPEX for off-grid towers, MNOs in Mali are eager to explore the opportunity to use renewable energy for their off-grid sites. Orange Mali has deployed solar-battery hybrid solutions in over 60 per cent of its off-grid sites in the country, and intends to continue this effort by exploring opportunities to transition the remainder of their off-grid sites to renewable energy. This effort will play a key role in helping Orange meet their global target to achieve net zero carbon emissions by 2040.

In a challenging market such as Mali, MNOs believe it would be in their best interest to work closely with ESCOs, creating a significant opportunity for MNOs and ESCOs to develop contracts that deliver competitive pricing for solar hybrid system deployment. Given that the ESCO model is still very new in many African markets, a price benchmarking tool for renewable energy, and a contract benchmarking process for MNOs and TowerCos to contract with ESCOs, would be two very useful tools to ease some of the growing pains with this model.

There are no ABC mini-grid models operational in Mali despite the mini-grid market having an estimated worth of over USD 200 million.[42] The deployed solar mini-grid capacity in the country has so far been based on direct procurement under a government tender, with vendors providing complete turnkey development, installation and management services.

42. African Development Bank's Green Mini Grid (GMG) Program Estimates, 2019

CASE STUDY

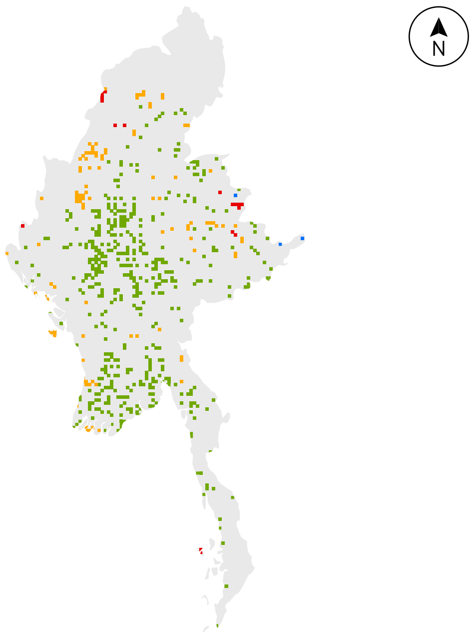
5.5 Myanmar

Myanmar

Showing bad-grid and off-grid areas with/without telecom coverage set to population density and solar/wind potential above specific thresholds

OFF-GRID
- With Telecom
- Without Telecom

BAD-GRID
- With Telecom
- Without Telecom



Over 16,500 mobile towers are deployed in Myanmar, 62 percent of which are owned and operated by TowerCos. The remaining 38 per cent of towers are still owned and operated by MNOs.

Myanmar's tower market is quite fragmented, with over 15 TowerCos operating in the country. Because Myanmar's telecom infrastructure was deployed almost entirely after 2014, all five MNOs have newer, energy-efficient towers. This makes Myanmar unique in Southeast Asia where MNOs maintain a high percentage of legacy towers with higher energy consumption.[43]

Despite recent progress in expanding access to electricity, the availability and reliability of the national grid remains low. Myanmar's rural electrification rate is approximately 30 per cent, with most of the country still relying on diesel generators, solar home systems (SHS) and renewable energy mini-grids for their power. It is estimated that almost 45 percent of towers are either in off-grid or bad-grid areas, and MNOs and TowerCos rely quite heavily on diesel generators for their power. If an off-grid site is relatively close to the existing national grid, MNOs and TowerCos do not generally switch to renewable energy if they anticipate a grid expansion in the next one to two years. Although solar battery and solar battery-diesel hybrid systems have been deployed throughout the country, renewable energy systems are estimated to be powering only 1,300 towers.

43. GSMA research, 2020

Key challenges

There are unique barriers to transitioning to renewable energy systems in Myanmar. Table 6 highlights the specific barriers identified during stakeholder interviews.

Table 6

The challenges of switching to renewable energy systems in Myanmar

Challenge		Key barrier in country
ESCO services	Not present	
	At a nascent stage	
No price benchmarking or standardised contracts for ESCOs		
Network expansion prioritised over CAPEX for solar energy	2G to 3G or 4G and strengthening the backbone of the network	
Energy OPEX pass-through models	Directly	✓
	The model exists indirectly	
TowerCo and MNO business models vary	No incentive to invest in solar energy	✓
Expanding grid	Limits incentives for off-grid/bad-grid investments	
Lack of net metering policy	To convert to on-grid solar initiatives	✓
Very high import duties and taxes	Additional costs for solar	
Limited land availability	Insufficient space for solar PV	✓
Limited access to affordable finance	Funding does not cover CAPEX for renewable energy at sites	✓
Lack of scale	Difficult to establish business case	

Renewable energy opportunities

MNOs, such as Telenor Myanmar and Ooredoo Myanmar, have been renegotiating energy OPEX pass-through contracts with TowerCos to switch to fixed-fee payments. The fee is set at a level that offers incentives to TowerCos to significantly reduce energy OPEX by deploying renewable energy systems.[44]

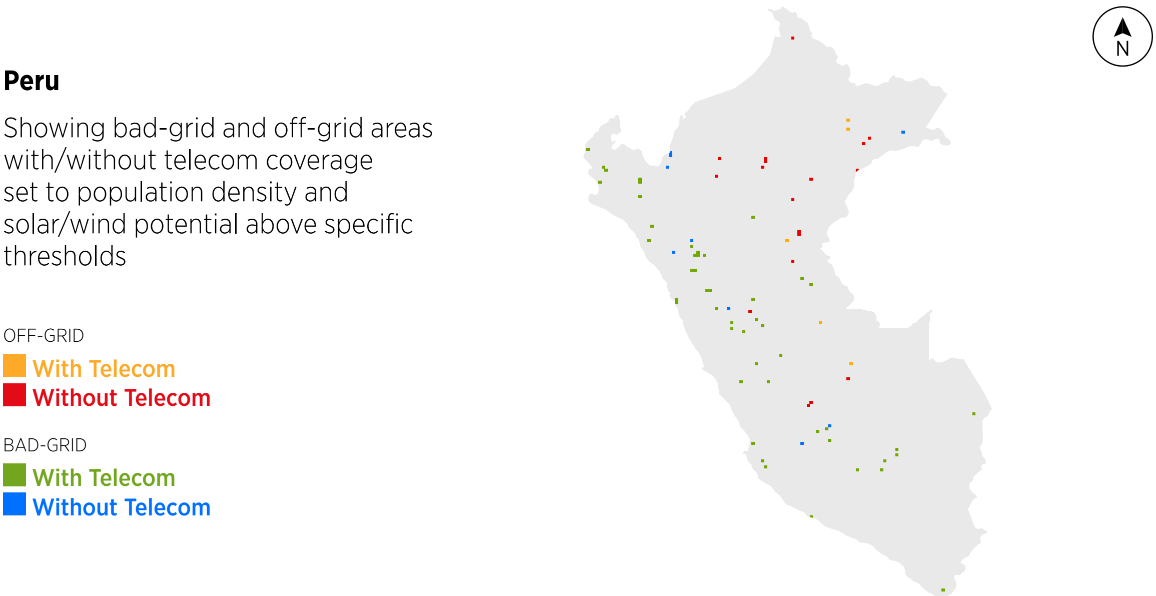
Compared to other countries in the region, Myanmar has very high availability of solar resources. High renewable energy potential and low energy consumption rate per tower supports a sound business case for renewable energy as the source for rural base stations. The emerging telecom ESCO industry in Myanmar, which is largely deploying solar battery or solar battery-diesel hybrid systems, is making significant progress. Yoma Micro Power and Voltalia, IPT Powertech are the key TESCOs operational in Myanmar, and MNOs are interested in exploring working relationships with TESCOs.

Myanmar is one of the best examples of a market that has successfully deployed mini-grids using the Anchor-Business-Community (ABC) model. Yoma Micro Power and the Rockefeller Foundation have delivered a programme called Smart Power Myanmar (SPM), which works with multiple ESCOs to provide technical and financial assistance to build renewable energy-powered rural mini-grids in off-grid areas. Yoma Micro Power procures land in a location near their anchor customer, which is often a mobile tower, where they install a renewable energy system. Power is initially supplied only to the telecom tower, but it gradually extends to neighbouring small businesses and communities, thereby completing the ABC mini-grid model. So far, 300 renewable energy systems are powering mobile towers, and 10 per cent are supplying energy to neighbouring businesses and communities. The remaining 270 will eventually follow suit, depending on local demand and technical and financial viability. Yoma Micro Power plans to scale up its solar power deployment in Myanmar to 2,000 sites by 2023.[45]

44. GSMA research
45. GSMA research

CASE STUDY

5.6 Peru



Peru has roughly 11,500 telecom towers, nearly 30 percent of which are owned and operated by TowerCos. The remaining 70 percent of towers are owned and operated by one of four MNOs. Aside from a small number of rural areas in the northern and southern parts of the country that are inhabited by indigenous peoples, grid electricity is available and reliable in most parts of Peru. The national electrification rate is approximately 95 per cent and the rural electrification rate is 87 per cent. For this reason, MNOs have a very few off-grid towers in their networks.

However, there are multiple towers in very remote locations that have been deployed through the Universal Service Fund Programme, which has a significant number of off-grid or bad-grid towers powered by diesel-battery hybrid systems, or solar hybrid systems. As mentioned earlier in this report, in 2019 Telefónica established a new broadband-focused TowerCo, Internet Para Todos (IPT), in partnership with Facebook, Inter-American Development Bank (IDB) and the Development Bank of Latin America (CAF). Starting in Peru, IPT aims to offer NaaS to MNOs that would like to extend mobile broadband services to customers in rural areas across Latin America.

Key challenges

There are unique barriers to transitioning to renewable energy systems in Peru. Table 7 highlights the specific barriers identified during stakeholder interviews.

Table 7

The challenges of switching to renewable energy systems in Peru

Challenge		Key barrier in country
ESCO services	Not present	
	At a nascent stage	✓
No price benchmarking or standardised contracts for ESCOs		✓
Network expansion prioritised over CAPEX for solar energy	2G to 3G or 4G and strengthening the backbone of the network	
Energy OPEX pass-through models	Directly	✓
	The model exists indirectly	
TowerCo and MNO business models vary	No incentive to invest in solar energy	
Expanding grid	Limits incentives for off-grid/bad-grid investments	✓
Lack of net metering policy	To convert to on-grid solar initiatives	
Very high import duties and taxes	Additional costs for solar	
Limited land availability	Insufficient space for solar PV	
Limited access to affordable finance	Funding does not cover CAPEX for renewable energy at sites	
Lack of scale	Difficult to establish business case	

Renewable energy opportunities

Peru has already introduced a net metering policy that allows on-site solar power systems installed at grid-connected telecom towers to supply excess electricity to the grid and reduce overall grid electricity consumption costs. However, a detailed cost-benefit analysis of this model is still needed to determine how to achieve scale and sustainability.

The IPT example demonstrates that solar-powered small cell sites can be a formidable option for last-mile mobile connectivity. IPT has developed a plan to deploy solar hybrid systems at over 3,600 small cell sites across Peru, primarily in off-grid or bad-grid locations, and will eventually expand this effort across Latin America. Although Telefónica directly procures and deploys solar hybrid systems itself, IPT already has working relationships with several ESCOs across Central and South America, including Enertika and Hybrico. Telefónica/IPT uses the following four models to deploy solar hybrid systems in Central and South America, including in Peru.

Different models used by Telefonica/IPT to deploy solar hybrid systems in Central and South America, including in Peru.

CAPEX model

- Investment, operation and maintenance by Telefónica/Telxius
- Examples: Peru, Colombia, Argentina and Chile

OPEX model

- Investment, operation and maintenance by ESCO
- MNO will pay a fee for the service of the tower

Energy Savings as a Service

- ESCO/vendor buys, swaps, operates and maintains the new equipment, and owns the asset
- ESCO/vendor assumes all risk and obligations
- Payback in 3+ years, contracts defined by project (max. 10 years)

Energy Efficiency Service

- Focuses on projects with payback in under three years. 80 per cent initial investment and 20 per cent divided in three payments, after verifying the savings
- Operation and maintenance by Telefónica
- Examples: Peru, Colombia, Argentina, Chile

CASE STUDY

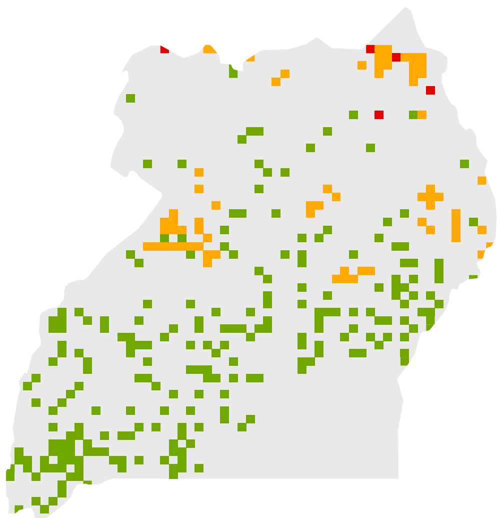
5.7 Uganda

Uganda

Showing bad-grid and off-grid areas with/without telecom coverage set to population density and solar/wind potential above specific thresholds

OFF-GRID
- With Telecom
- Without Telecom

BAD-GRID
- With Telecom
- Without Telecom



Uganda has approximately 3,800[46] telecom towers, nearly 80 per cent of which are owned and operated by one TowerCos, ATC. This is quite high compared to other markets in East Africa, such as Kenya (27 per cent of towers owned by a TowerCo), Tanzania (43 per cent) and Rwanda (66 per cent).

Compared to the rest of East Africa, Uganda has a very low national electrification rate, which was 28 percent in 2019.[47] This has resulted in a larger proportion of off-grid towers and a high number of bad-grid towers outside the capital city of Kampala. Like other countries in the region, Uganda also has very high renewable energy potential with favourable solar irradiation. Lower dependence on the national

grid in rural areas, and the fact that diesel fuel distribution is more difficult and expensive in remote locations, means that MNOs and TowerCos are motivated to explore renewable energy solutions for their off-grid and bad-grid towers. ATC already has solar hybrid systems deployed at approximately 10 per cent of its towers.

46. Based on the GSMA 2020 model
47. Mokveld, K. and von Eije S. (2018), Final Energy Report Uganda, RVO.nl.

Key challenges

There are unique barriers to transitioning to renewable energy systems in Uganda. Table 8 highlights the specific barriers identified during stakeholder interviews.

Table 8

The challenges of switching to renewable energy systems in Uganda

Challenge		Key barrier in country
ESCO services	Not present	
	At a nascent stage	✓
No price benchmarking or standardised contracts for ESCOs		✓
Network expansion prioritised over CAPEX for solar energy	2G to 3G or 4G and strengthening the backbone of the network	
Energy OPEX pass-through models	Directly	
	The model exists indirectly	✓
TowerCo and MNO business models vary	No incentive to invest in solar energy	✓
Expanding grid	Limits incentives for off-grid/bad-grid investments	
Lack of net metering policy	To convert to on-grid solar initiatives	✓
Very high import duties and taxes	Additional costs for solar	
Limited land availability	Insufficient space for solar PV	
Limited access to affordable finance	Funding does not cover CAPEX for renewable energy at sites	
Lack of scale	Difficult to establish business case	

Renewable energy opportunities

Although around 30 per cent of mobile towers in Uganda are off-grid, only around 10 per cent of all towers (350) currently have renewable energy deployment. Given the high energy OPEX cost for diesel-powered towers, and the availability of renewable energy resources in Uganda, this creates strong potential for solar hybrid systems to be used for both existing and new sites. Renegotiating existing MNO-TowerCo contracts under the energy OPEX pass-through model would also help to evaluate the business case for renewable energy transparently. With ESCO activity and energy ownership on the rise, MNOs and TowerCos could also evaluate the opportunity to use ESCOs to deploy renewable energy in off-grid and bad-grid towers.

A few pilots in Uganda have explored the ABC mini-grid model where the mobile tower is the anchor customer. An example is the 22.5 kW solar mini-grid plant in Kabunyata village, Luwero district, set up by Kirchner Solar Uganda in 2014 as part of a public-private partnership with Airtel Uganda and GIZ. The plant provided energy services to Airtel Uganda's telecom tower located in the village and 100 other customers, including local households and small businesses. Despite high potential, ABC model hasn't scaled in Uganda due to barriers mentioned in the previous section.[48]

48. Deconstructing the concept of renewable energy-based mini-grids for rural electrification in East Africa, 2016.

5.8 Summary of findings

The case studies in this report have helped highlight specific, country-level ecosystem and stakeholder dynamics that are shaping, or inhibiting, opportunities to transition to renewable energy. While no single country has been affected by all the global trends and barriers outlined in Section 4 (and summarised in Table 9, below), any combination of factors, such as tower ownership and management models, the availability and affordability of grid energy, and the types of stakeholders found in the renewable energy ecosystem, can slow or stall the deployment of renewable energy systems.

Table 9

The challenges of transitioning to renewable energy systems in seven lighthouse countries

		Myanmar	Bangladesh	DRC	Uganda	Mali	Peru	Fiji
Challenge		Southeast Asia	South Asia	Central Africa	East Africa	West Africa	Latin America	Pacific/SIDS
ESCO services	Not present		✓					
	At a nascent stage			✓	✓	✓	✓	✓
No price benchmarking or standardised contracts for ESCOs		✓		✓	✓	✓	✓	✓
Network expansion prioritised over CAPEX for solar energy	2G to 3G or 4G and strengthening the backbone of the network			✓		✓		✓
Energy OPEX pass-through models	Directly	✓	✓				✓	
	The model exists indirectly			✓	✓			
TowerCo and MNO business models vary	No incentive to invest in solar energy	✓		✓	✓			
Expanding grid	Limits incentives for off-grid/bad-grid investments		✓				✓	
Lack of net metering policy	To convert to on-grid solar initiatives	✓		✓	✓	✓		✓
Very high import duties and taxes	Additional costs for solar			✓				
Limited land availability	Insufficient space for solar PV	✓	✓					
Limited access to affordable finance	Funding does not cover CAPEX for renewable energy for sites	✓						
Lack of scale	Difficult to establish business case							✓

In the next section, insights from these seven countries and our broader research are used to provide recommendations for future action, aimed at MNOs and other renewable energy ecosystem players.

6 Opportunities to support the transition of off-grid and bad-grid mobile towers to renewable energy

Recognising that the technical and financial viability of renewable energy is now well understood, the interventions proposed in this section aim to foster cross-sector collaboration, assist the industry in overcoming the persistent barriers described in previous sections, and catalyse the deployment of renewable energy systems at an even greater scale.

Our analysis of the renewable energy landscape, global trends and barriers and broader conversations with stakeholders suggests there are five key areas in which additional support could help advance and mainstream the transition of mobile towers to renewable energy. In Figure 6, we map each of these potential opportunities against the stakeholders they would benefit, and the global trends and barriers (as outlined in Section 4) they would help to address.

Table 10

Opportunity areas mapped against stakeholder groups and global trends

Opportunity areas	Stakeholders who would find as a key engagement opportunity	The tower-sharing model has transformed tower ownership	Legacy and non-standardised energy contracts and lack of price benchmarking data	Improved access to electricity from national grids	Anchor-Business-Community (ABC) mini-grid models have not reached scale	Lack of enabling telecom and energy sector policies and regulatory frameworks
The **business case for renewable energy can be strengthened** through improved **data collection and analysis.**	• TowerCos • MNOs • Investors & Industry Associations	Most relevant	Reasonably valid		Reasonably valid	Relevant
Stakeholders should work together to s**tandardise and benchmark energy contracts between MNOs, TowerCos and ESCOs** so that they are mutually beneficial and incentivise green investments.	• ESCOs • MNOs • TowerCos • Suppliers	Relevant	Most relevant		Reasonably valid	
There is a need for **more case studies, replication guides** and **industry workshops** that can help facilitate action, improve coordination and reduce fragmentation.	• Investors & Industry Association • TowerCos • MNOs • Suppliers	Relevant	Relevant	Relevant	Relevant	Relevant
GIS-based data analysis could help develop business models to scale ABC mini-grid models and improve energy access.	• Investors & Industry Association • ESCOs • Suppliers	Reasonably valid		Reasonably valid	Most relevant	
Policy and Regulatory Dialogue and Advice.	• Regulators	Relevant	Relevant	Most relevant		Most relevant

Global trends and barriers

Legend: Most relevant / Relevant / Reasonably valid

6.1 Strengthening the business case for renewable energy with better data-driven tools

In our interviews with MNOs and other stakeholders (at both the group and country levels), it was evident that they lack the data-driven insights to allow them to build the business case for investing in renewable energy, or to strengthen their negotiations with the TowerCos that may own and manage their towers. For example, geographic information systems (GIS) — sophisticated data visualisation tools that can help MNOs gather, integrate, manage and analyse data — could address this challenge. Like the Mobile Coverage Maps produced by the GSMA's Connected Society programme,[49] GIS systems can layer datasets onto maps so that users can identify unexpected patterns and relationships, and ultimately make smarter decisions.

The types of GIS data in this tool could include:

- the locations of existing and upcoming telecom towers;
- national grid availability;
- power consumption estimates for towers and estimated energy consumption at each of these towers;
- delivered price of diesel (updated regularly based on local price data);
- distance from nearest service point/diesel reservoir to the site;
- availability of solar/green resources; and
- roads at these locations.

As additional layers, the price of renewable energy equipment in each country (with duties and taxes) and by site cost for renewable energy/hybrid systems could also be included. Some of these data sources are available in the public domain or can be purchased from specialised data sources. Country-specific details might require regular data input by local MNOs, TowerCos and ESCOs.

6.2 Standardising energy contracts and price benchmarking

It is understood that the energy OPEX pass-through model does not incentivise TowerCo investments in renewable energy and, as seen in the lighthouse countries, these contracts still exist in a direct or indirect form. MNOs in several countries are now trying to renegotiate payment agreements with TowerCos, but this can be challenging due to a lack of standardisation. Similarly, MNOs and TowerCos have found it challenging to contract ESCOs in specific markets due to the lack of price benchmarks or well-established contracting models. Tools and documents that could address this challenge include standardised energy OPEX contractual procedures (either at the national or regional level) between MNOs and TowerCos, and examples of global best practices in requests for proposals, business models and tower energy management policies.

Previous studies or on-going research conducted by key global stakeholders, such as TowerXchange and the IFC, could be a valuable resource to input into these tools. For instance, the IFC's Scaling Solar programme in Africa, and the Paris-based Terrawatt Initiative, have both developed and distributed standardised RFP procedures [50] and PPAs that have proven immensely useful in scaling the deployment of large-scale solar power stations in many developing countries of Africa and Asia. There is an opportunity for MNOs and TowerCos to work with industry-level stakeholders, such as IFC and TowerXchange, to initiate, test and implement key tools, best practice processes and templates for energy contracts.

49. GSMA Mobile Coverage Maps: https://www.mobilecoveragemaps.com/
50. Scaling Solar: https://www.scalingsolar.org/

6.3 Business models developed using data analysis tools to scale ABC mini-grid models

This report featured the Rockefeller Foundation's Smart Power Myanmar programme as a rare example of the ABC mini-grid model using a mobile tower as an anchor reaching scale. The Rockefeller Foundation's Smart Power for Rural Development (SPRD) initiative is also building GIS-based maps of tower locations and off-grid rural communities in Myanmar, and plans to expand this to Sub-Saharan Africa (Ethiopia, the DRC or Nigeria).

The GIS-based maps created for the Myanmar Smart Power Myanmar programme could provide lessons on how to identify and collect information that would help MNOs, TowerCos and ESCOs identify potential locations to implement this model, and inform a business model that could support the replication of the ABC mini grid model in other countries. Studying other examples of mobile towers used as the anchor for an ABC mini-grid model could also create much-needed knowledge to inform future experiments and deployments.

6.4 Case studies, replication guides and industry workshops

MNOs and other key stakeholders interviewed though our research highlighted the importance of peer-to-peer learning and industry benchmarking when implementing renewable energy solutions in a particular market. There is a major opportunity for industry-level organisations to promote and support engagement opportunities for MNOs, TowerCos and ESCOs.

Useful topics for all stakeholders may include:

- data analytics and insights on the effectiveness and viability of on-grid renewable energy models, such as net metered systems;
- policy and regulatory advice on on-grid renewable energy procurement;
- case studies and best practices in on-grid renewable energy procurement; and
- support for MNOs and TowerCos with renewable energy planning for future 5G network deployment.

There is a clear opportunity to establish an industry consortium, with strong support from global partners such as TowerXchange and the IFC, that offers regular opportunities for MNOs in multiple regions to engage, either virtually or in person. Creating a repository of industry best practices could be the first task of this consortium. Our stakeholder interviews highlighted that some use cases would require additional research to make this a rich and relevant repository for the industry.

6.5 Policy and regulatory dialogue and advice

Only a few LMICs have enabling policy and regulatory frameworks to promote renewable energy deployment for telecom towers. More policy-related dialogue is needed between telecom and power sector policymakers and regulators in many countries, as well as with MNOs, TowerCos, ESCOs and other stakeholders. Topics that could be useful for stakeholders include:

- Green telecom policy incentives for MNOs and TowerCos, such as discounts on licence/spectrum fees or concessional finance under Universal Service Obligation (USO) funds, to deploy/procure renewable energy for telecom towers, data centres, etc.
- Net metering policies (in countries where they do not exist) for decentralised, grid-connected, on-site solar power generation by commercial and industrial electricity consumers, including MNOs and TowerCos, and the applicability and economics of the policy for the telecom industry.
- Enabling policy and regulatory frameworks for corporate procurement/PPA of renewable energy by MNOs and TowerCos in LMICs.
- Favourable import and customs duty and taxation structures and/or incentives for local manufacturing of renewable energy equipment.

Our research on the renewable energy policy environment in 91 LMICs revealed that the policy landscape is quite diverse, yet also has the potential to support the transition of off-grid and bad-grid sites to renewable energy. However, more research and understanding of national and regional policies is needed to provide guidance to the industry on “ideal” policy environments.

6.6 Looking forward

Ambitious and urgent action, and a renewed commitment to working in partnership, will be critical to achieving the 2030 climate agenda and securing decades of development progress. Our research has created a more comprehensive picture of the shift from non-renewable to renewable energy-powered mobile towers in LMICs, as well as the common incentives, positive examples and benefits of making this transition. We are excited to see an opportunity for MNOs, TowerCos and ESCOs to review their decision making to date and consider new, mutually beneficial business models. In doing so, they will help mitigate the impact of climate change, ensure that more people have access to mobile services and support the transition to resilient, equitable and decarbonised societies in LMICs.

Appendix 1:
List of stakeholders engaged in our research

The GSMA would like to acknowledge the contributions of the organisations and stakeholders who were interviewed during the course of this research:

- **Africa Mobile Networks (AMN)**
- **African Development Bank**
- **American Tower Corporation (ATC)**
- **Caban Systems**
- **Digicel Fiji**
- **Edotco Group**
- **Foreign, Commonwealth & Development Office (FCDO), UK**
- **Grameenphone (Telenor Group)**
- **Helios Towers**
- **Huawei Technologies**
- **I-Eng Group**
- **IFC**
- **MTN Uganda**
- **Orange Group**
- **Robi Axiata**
- **Rockefeller Foundation**
- **Sagemcom**
- **Telefónica Group**
- **Telefónica Peru**
- **Telenor Group**
- **Telenor Myanmar**
- **TowerXchange**
- **TowerXchange ESCO Roundtable**
- **USAID/Power Africa**

Appendix 2: Additional Notes on the Research Methodology

GSMA would like to thank Cleantech Advisory[51] and EcoForge Advisors[52] for their collaboration on this project and for their contributions to the design, implementation, and analysis of the research.

Part I: Modelling the number of mobile towers

Our revised model estimates the total numbers of towers, as well as the numbers of towers fully or partially powered by renewable energy (green towers). This is further broken down into off-grid towers, green off-grid towers, off-grid towers solely using fossil fuel energy sources, bad-grid towers, green bad-grid towers and bad-grid towers solely using diesel power. These estimates are by country and region for 2014 and 2020. A tower is defined as a macro site, a rooftop site or a small cell; antennae in buildings and in street furniture are excluded. The model also estimates the carbon emissions from diesel consumed in the Radio Access Network (RAN), i.e. by diesel generators located on towers.

To develop the model, the GSMA used a significant amount of historical data from its Mobile Energy Efficiency and Green Power for Mobile programmes. This information is used to provide a 2014 baseline for 207 countries and territories. The information available includes the total number of towers by country, the number of off-grid towers, the number of bad-grid towers, the number of green towers and the litres of diesel consumed by on-site diesel generators, by MNO. In addition, some MNOs reported numbers of green towers in their annual reporting and this data is included in the model. Where data is unavailable, estimates are made. To help estimate the number of off-grid towers and the number of bad-grid towers, multi-variable regression techniques are used, and to assist in estimating the total number of towers, typical ratios of towers per head of population covered by mobile are used, adjusted for different mobile coverage profiles.

To help inform and validate estimates for 2020, a number of interviews were conducted with MNOs and tower companies in selected countries. In most cases, complete country data is not available, so estimates are made by first applying the ratio of total mobile connections in the country to the MNO's connections, and then multiplying this by an estimated tower-sharing factor. Additionally, tower data for some countries has been taken from MNO annual reports, as well as total tower numbers from the trade association TowerXchange. Where data is unavailable or incomplete, annual growth rate assumptions from 2014 to 2020 are applied for each country and these growth rates are flexed depending on each country's characteristics. These characteristics include whether a country is developed, in transition or developing; its degree of rural electrification; its mobile coverage by head of population, including deployment of 4G and 5G; and the extent of tower sharing in the country. RAN carbon emissions in 2020 by country are adjusted depending on changes in the numbers of green towers, off-grid towers and bad-grid towers from 2014 to 2020.

51. https://www.cleantechadvisory.co.uk/
52. https://ecoforge.in/

Part II. Identification of "lighthouse" countries

In the second phase of the project, the GSMA developed a methodology for ranking LMICs based on their readiness to scale the adoption of renewable energy for off-grid sites. A range of quantitative and qualitative data was collected and evaluated for 91 countries across Sub-Saharan Africa, Latin America, South Asia, Southeast Asia, East Asia and the Pacific Islands. The following macro-level indicators were used in this exercise:

Metric	Definition	Source
Access to Electricity- National Electrification rate	Proportion of a country's population which had access to electricity in 2018	IEA, Electricity Access Database
Renewable Energy's (Wind+ Solar) Share in Total Installed Power Generation Capacity	Installed Solar + Wind capacity as a percentage of the total installed power generation capacity of the country in 2018	IRENA Stats Database
Off-grid Solar's Share in Total Installed Power Generation Capacity	Installed Off-grid Solar capacity as a percentage of the total installed power generation capacity of the country in 2018	IRENA Stats Database
Mobile Network Coverage Ratio	Percentage of inhabitants who are within the range of a mobile cellular signal- 2015- 2018	World Bank Communications TCdata360, World Bank Development indicators database
Diesel Fuel Price	Latest Diesel fuel price per litre	Global Petrol Prices database
Telecom Tower Infrastructure Sharing Policies	Policies on infrastructure sharing being mandatory or not as of 2018	ITU Database
Policy and Regulatory Framework for Renewable Energy (Wind and Solar)	Covers policies and incentives for net metering, feed-in-tariffs, auctions & tenders, off-grid solar and RE equipment from 2019	Ren21's Renewables 2019 Global Status Report and Global Climatescope 2019
Presence of Renewable Energy Vendor Ecosystem	Looks at presence of major vendors or their distributors such as Recom, Panasonic, Luminous, Aisin etc	Websites of prominent vendors like Recom, Panasonic, Luminous etc.
Donor/Development Finance Interest in Renewable Energy Investments	Looks at renewable energy finance flows by major donors/ DFIs till 2017	IRENA Stats Database

Part III. Market opportunities and stakeholder analyses

Based on outputs from Part II, seven "lighthouse" countries — one from each region — were selected for further exploration. Each of these countries was determined to have high potential for deploying renewable energy in the near future, high potential for impact through engagement with the GSMA and representative of their region in terms of market dynamics, policy and regulatory frameworks and growth potential in the region.

For each of the seven lighthouse countries, desk research and stakeholder interviews were conducted to identify the key steps necessary to convert existing or upcoming off-grid/bad-grid sites to renewable energy- based sites. The research allowed the GSMA to identify all key stakeholders in the local ecosystem, including MNOs, tower companies, RESCOs, donors/development finance institutions, investors, commercial banks/debt providers, equipment suppliers, regulators/policymakers and mini-grid developers. Stakeholders were also asked to provide their perspectives on key concerns, challenges, drivers and opportunities to support the process of converting MNO off-grid sites to renewable energy sources. A total of 25 stakeholder interviews were completed, and a detailed list of interviewees is included in Appendix 1.

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