GREEN POWER FOR MOBILE

THE GLOBAL TELECOM TOWER ESCO MARKET

OVERVIEW OF THE GLOBAL MARKET FOR ENERGY TO TELECOM TOWERS IN OFF-GRID AND BAD-GRID AREAS

December 2014

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The report also benefited from the extensive inputs of more than 30 mobile network operators, tower infrastructure companies and energy service companies that were interviewed over the course of the study, in March and April 2014.

The findings in the report were prepared by Dalberg Global Development Advisors under the leadership of Gaurav Gupta and Vishnu Vasudev, and with support from a global team of researchers and writers including Kanishka Bhattacharya, Aurelien Chu and Ninad Kulkarni.

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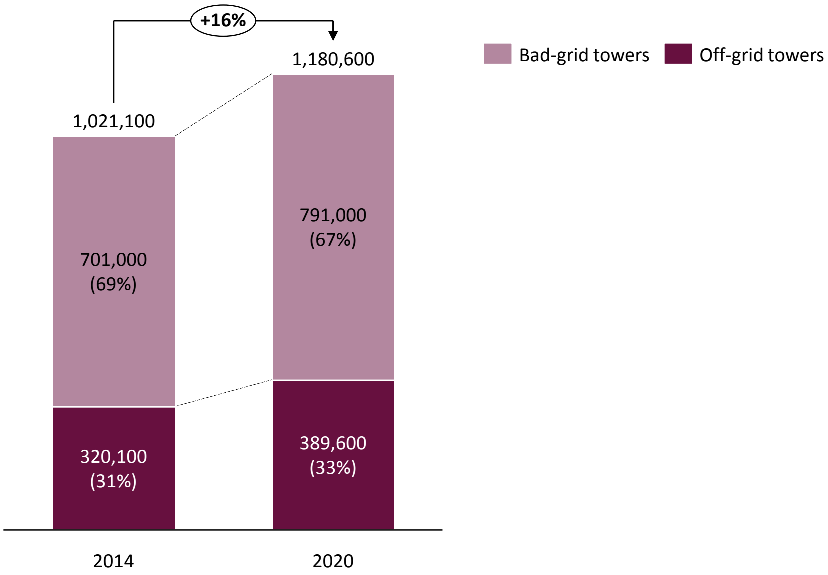
List of abbreviations

ARPU	*Average revenue per user*
Bad-grid	*Locations that are connected to the grid, but face more than six hours of power cuts per day, on average*
CAGR	*Compound annual growth rate*
CAPEX	*Capital expenditure*
ESCO	*Energy Service Company*
IESCO	*Independent Energy Service Company*
kW/kWh/kWp	*kilowatt/ kilowatt hour/ kilowatt peak*
MNO	*Mobile network operator*
MSP	*Managed Service Provider*
Off-grid	*Locations that receive zero hours of grid-electricity*
OPEX	*Operational expenditure*
PPA	*Power purchase agreement*
REC	*Renewable Energy Certificates*
TESCO	*Tower Company Energy Service Company*
TowerCo	*Tower Company*

Executive summary

By 2020, estimates indicate that the global telecom industry will deploy approximately 390,000 telecom towers that are off-grid, and 790,000 that are in bad-grid locations. This is an increase of 22% and 13%, respectively, from today.

Figure 1: Total number of off-grid and bad-grid towers
Towers (2014-2020, estimates)



Source: Dalberg Tower Estimation and Green Power Model

If these towers continue to use diesel, as is the case for more than 90% of all off-grid and bad-grid towers today:

- Diesel consumption for telecom towers will increase by 13-15% from today's levels, to over 150 million barrels per year.[1] The resulting annual cost of diesel will be over US$ 19 billion in 2020, or US$ 5 per mobile-phone user per year.
- About 45 million tons of CO_2 per year will be released, which is more than 5 million tons higher than current levels.

Conversion to more efficient, greener alternative tower power solutions, which include diesel generator-advanced battery[2] and renewable energy hybrid systems, could save the industry US$ 13-14 billion annually, even after accounting for capital expenditure (CAPEX). Adoption of these green technologies at scale also has the potential to generate approximately 40 million tons and US$ 100-500 million annually in carbon savings.[3]

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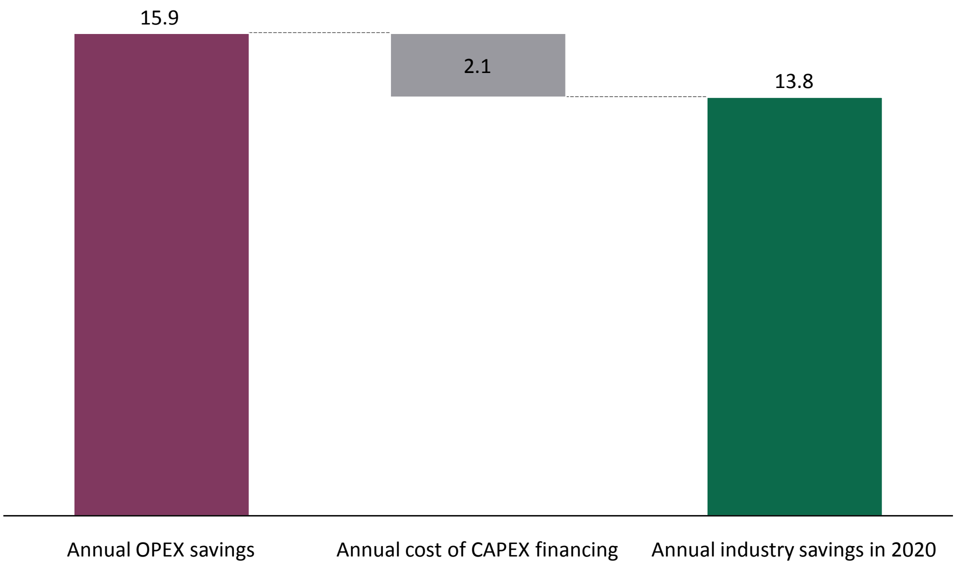
[1] Using current price of diesel, i.e. ~US$1/liter of diesel (globalpterolprices.com)
[2] The cost and specifications of Lithium Ion batteries were used in developing estimates for plant-level economics and green savings potential of the more efficient alternative tower power solutions mentioned above.
[3] Carbon prices of US$ 2 per ton of CO2 (observed in some developing countries such as India, China), and US$ 10 per ton of CO2 (observed in developed carbon markets like most of North America) were used to estimate potential for carbon savings.

Figure 2: Annual industry cost savings due to transition to green energy solutions

Billion US$ (2020)



(1) For retrofits, capex refers to additional capex required to convert to green power solutions, while for new sites capex refers to total capex required
(2) We assume that all off-grid towers under business-as-usual would deploy DG solutions at off-grid sites to ensure uptime and low capex
(3) A 10% annual cost of financing is used to develop the cost saving estimates
Source: Interviews with MNOs, TowerCos and ESCOs (March-April 2014); Desk research; Dalberg Tower Estimation and Green Power Model (2014); Dalberg analysis

A crucial driver of the conversion to greener alternatives will be Energy Service Companies (ESCOs) that provide energy to towers owned by Mobile Network Operators (MNOs) and dedicated Tower Companies (TowerCos).

- Many MNOs across the world, especially in Asia and Africa, are in the process of selling of their tower assets, including the energy infrastructure, to third-party structures. This trend, brought on by a strong imperative to cut network deployment and operating costs, is expected to intensify in the next six years.
- In a rapidly evolving tower energy landscape, that requires a high degree of customization across multiple tower sites and specific technical expertise, MNOs are not best-positioned to drive energy efficiency. Moreover, MNOs have an incentive to reduce complexity of non-revenue generating operations like power, in order to focus on revenue-generating parts of their business
- MNOs place a priority on expanding networks and upgrading technology of active equipment.[4] With finite funds for CAPEX, MNOs will always favor investments in active radio equipment over investments in energy solutions.

There are two types of ESCOs in the market today, each facing specific challenges related to the transition of the industry to greener tower energy solutions:

- *TowerCo ESCOs (TESCOs):* These are TowerCos that generate and provide electricity to their MNO tenants at telecom tower sites. TESCOs typically bundle their energy services with other standard functions of dedicated TowerCos (e.g. site

[4] Core radio equipment (including equipment) that is responsible for broadcasting mobile phone signals to users. Passive infrastructure, on the other hand, includes the non-electronic equipment including the tower itself, energy infrastructure, etc.

security, monitoring of active equipment and upgrade of passive infrastructure), and charge an all-inclusive fixed monthly fee for all rendered services.

Critically, TESCOs own, operate, and bear all operating costs for the tower's energy assets. Because energy generation and provision can constitute up to 60% of all annual operating expenses, TESCOs are incentivized to continuously seek long-term opportunities for energy efficiency, energy cost reduction, and cost predictability.
Their primary challenge is that historically, contracts between TowerCos and MNOs were structured in a way that provided TowerCos no commercial or business incentives to prioritize energy cost reductions and energy efficiency, i.e. they had incentives to be TESCOs.[5] While the contracts have now reversed, inertia remains that works against greater adoption green and renewable energy solutions, even though on paper they promise substantial cost reductions.

- *Independent ESCOs (IESCOs):* These are dedicated or pure-play energy companies that own and operate energy assets at power telecom tower sites. IESCOs derive revenues from selling energy to MNOs as well as dedicated TowerCos,[6] and share similar incentives as TESCOs to reduce energy costs by upgrading energy assets.

  Financing new energy generation assets, especially through debt financing at viable interest rates is the primary challenge facing IESCOs today. The small size and low asset base of existing IESCOs and those looking to enter IESCO market, has proved particularly limiting when banks evaluate funding applications. In addition, banks often have an incomplete understanding and experience of IESCO business models, and often lack effective frameworks to assess funding needs and requirements.

As the drive to decrease telecom tower energy costs gathers momentum over time, TESCOs are expected to develop appropriate contract management structures in their dealings with MNOs, which would offer clear incentives for energy efficiency, innovation and cost reductions.
This transition is already underway in key markets. For example, in India, TowerCos, which currently comprise about 60% of the total market of 400k telecom towers, have switched from almost universally deployed 'pass-through' models to fixed-fee contracts with their MNO tenants, all in the past 2-3 years.

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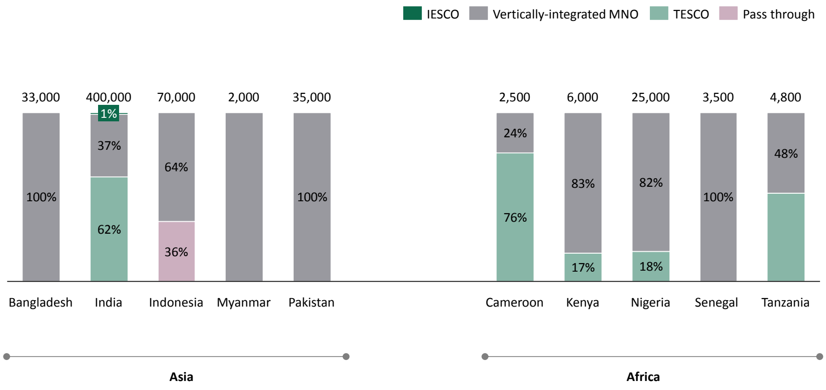
[5] This is changing rapidly as will be shown in the report. Pass-through models are now changing almost universally to fixed-fee contracts in which MNOs pay an all-inclusive monthly rental to TowerCos for all tower-related services.
[6] These are defined as TowerCos that outsource energy generation to IESCOs in order to focus purely on infrastructure management and increasing tenancies.

Figure 3: Estimated share of the TESCO market in key countries in Asia and Africa

Percentage of total tower estate



Source: GSMA Country Assessments (2013); TowerXchange (2013); Dalberg analysis

The role of IESCOs in providing additional impetus for adoption of green energy solutions is unclear and will depend primarily on two factors:

- *Funding opportunities:* Their capacity to attract funding in order to win and service large contracts from MNOs and/or TowerCos, typically for hundreds or thousands of towers at once.

- *Value proposition to TowerCos and MNOs:* Their ability to remain at the very edge of technological innovation and cost-effectiveness, so that dedicated TowerCos, in particular, are incentivized to outsource their tower energy assets and generation responsibilities to IESCOs, since employing a dedicated power company would expectedly be more efficient than deploying in-house resources.

This market can be accelerated by providing the following major forms of support:

Banking and finance support: Commercially attractive financing mechanisms are a must, given the high CAPEX requirements. Key needs include low collateral requirements, construction financing and longer repayment timelines of at least 7 years. To bring this into effect, it will be important to develop greater capacity within personnel to assess ESCO business models for funding.

Entry of large ESCO players: Large players (Cummins Power, Caterpillar, SunEdison, etc.) will bring the ability to scale aggressively through their enhanced asset bases, existing relationships with commercial lenders and focus on innovation and product development.

Conducive policy and regulatory environment: Local policymakers and regulatory bodies require training and policy development assistance on key issues such as the deployment of renewable-energy certificates (RECs) for green energy use at telecom towers, elimination of diesel subsidies, and tax and tariff rebates in order to incentivize renewable energy use at telecom towers.

Market intelligence and knowledge sharing: Greater data collection and effective information sharing is another important intervention that can help accelerate the market. In particular, there is a need to disseminate key financial information that would assist in making risk and return judgements for those looking to invest in or execute energy provision for off-grid and bad-grid telecom towers.

1. Introduction

Why are we talking about the energy needs of the telecom industry?

In early 2014, for the first time, the number of mobile phone subscriptions in the world exceeded the global population.[7] There are now over 7 billion active mobile phone connections in the world, and this number continues to grow. Despite achieving this high-water mark, almost 3.5 billion people in the world still remain without mobile phone handsets (the number of active connections in the world typically outnumber the number of unique mobile phone users by a ratio of approximately 2). This highlights a significant growth opportunity for the industry in the next six years.

Research from GSMA indicates that that future mobile subscriber growth will be concentrated in developing countries in Africa and Asia among populations that are currently 'unconnected'[8] to mobile phone networks. These populations, estimated to grow to approximately 2 billion by 2020,[9] overwhelmingly inhabit rural areas where access to electricity is patchy and unreliable at best. To illustrate, 30-40% of rural populations in developing countries lack access to grid-based electricity. This includes almost 600 million in Sub-Saharan Africa alone and another 600-625 million in Asia (about 300-350 million of whom are in India). Therefore, over the next six years, as Mobile Network Operators (MNOs) and Tower Companies (TowerCos) stretch networks into ever more remote locations to achieve universal coverage, the existing base of off-grid and bad-grid telecom towers is expected to grow substantially at about 16% annually.[10] Ensuring that these towers have continuous and sufficient access to non-grid electricity is the clear industry priority; to do so in a cost-effective and commercially sustainable manner is the main challenge.

Why would adoption of green and renewable energy solutions help?

Analysis indicates that energy costs already account for approximately 30% of network operating costs for a large MNO, and upwards of 60% for a TowerCo. The high costs are due to an overdependence on diesel-generator-based solutions to supplement or replace grid-based electricity at off-grid and bad-grid tower sites—almost 90% of these sites use diesel-generators.[11] Against a backdrop of rising global oil and energy prices there is a clear commercial imperative for MNOs and TowerCos to explore and seriously consider alternative solutions that use green and renewable energy, several of which are already producing electricity at a cheaper cost than diesel-generators.

Additionally, unless the routine practice of using diesel-generators does not change, the forecasted network expansion will be increasingly carbon intensive. Emissions from the global telecom industry are expected to grow at a compounded annual growth rate (CAGR) of 4.8%, from 151 million tons (Mt) CO_2 in 2002 to reach 349 Mt CO_2 in 2020 (see Figure 4). The majority of the

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[7] The number of mobile phone subscriptions in April 2014 was approximately 7.015 billion, according to the GSMA Intelligence website (www.gsmaintelligence.com). The number of unique mobile subscribers, which provides a clearer picture of the number of independent mobile phone users in the world, is much lower, at approximately 3.5 billion.

[8] Globally there remains a share of the population without access to a mobile network–the (as of yet) 'unconnected' population. In addition, there will always be a share of the population within an area of coverage who are not mobile subscribers for other reasons. For example, within the youth, elderly, disabled, incarcerated or unemployed demographics, mobile subscriber penetration is likely to be lower than the overall average.

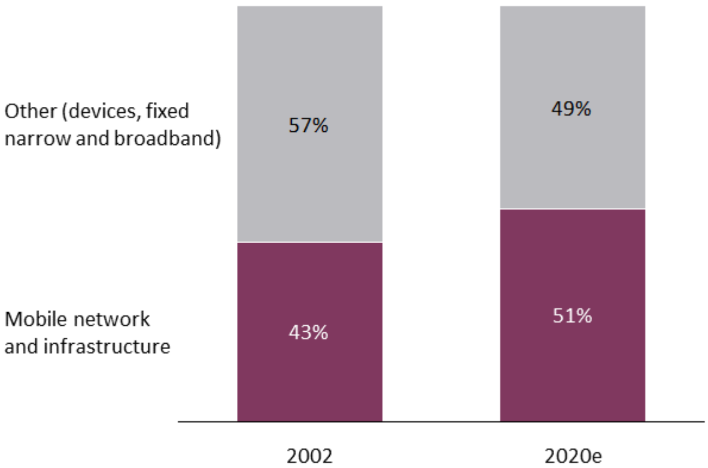
[9] GSMA (December 2012)

[10] Off-grid implies the telecom towers is either completely disconnected from the grid, or receives no electricity from the grid. Towers that face more than six hours of power outage per day, on average, are classified as bad-grid.

[11] GSMA research.

increase will be due to the expansion of mobile phone networks, and in particular, due to increased use of diesel at telecom tower sites. Overhauling standard practices and systematically adopting green and renewable energy solutions in all off-grid and bad-grid towers, has the potential to reduce the industry's carbon footprint by up to 5 million tons of CO_2 annually.[12]

Figure 4: Global telecoms footprint (infrastructure and devices)
Percentage of global telecom emissions (2002-20)



Source: "SMART 2020: Enabling the low carbon economy in the information age", The Climate Group and Global e-Sustainability Initiative (2008); Dalberg research

However, uncertainty exists over the true scale of the benefits that green and renewable energy solutions can offer. In addition, there are several barriers that currently hinder their uptake. At the same time, there is a growing recognition from the industry that some mature green and renewable energy technologies, most of which are solar-based, are approaching or have already approached commercial viability. This has injected renewed momentum to the greening imperative.

What are the study's objectives?

Given the significant scope and potential for the industry from the adoption of lower-cost, green and renewable energy solutions, **one primary objective of this report is to illustrate the commercial rationale and the environmental imperative for the mobile phone industry to deploy green and renewable energy solutions at off-grid and bad-grid telecom tower sites.** Many of these alternative energy solutions are already cheaper than diesel-generator-only tower energy solutions, as we show later in the report.

In addition to demonstrating the green potential in the industry, the report's **other main goal is to critically examine the landscape of tower energy suppliers, and specifically, provide a perspective on the role and viability of the Energy Service Company, or outsourced-generation model in initiating and accelerating this transition to green and renewable energy technologies.**

In the following sections, the report will first summarize the energy challenge for the industry by predicting the demand for non-grid-based electricity from telecom tower sites over the next six years. Then it will provide an overview of the landscape of

[12] Dalberg analysis.

energy providers, including clearly defining and segmenting ESCOs and presenting a high-level discussion of key business model elements. The report will also summarize trends and issues in the supply of energy to telecom towers, including an examination of plant-level economics of different energy solutions, and provide forecasts on the potential of green power. In conclusion, it will examine key barriers and opportunities for the industry transition to green and renewable energy solutions at telecom tower sites.

What is the scope?

This report is focused on energy consumption of mobile phone towers in off-grid and bad-grid locations. To be able to provide coverage for a user of a mobile handset, a mobile tower needs to be close enough to the customer to be able to receive and send signals. In many cases, customers are located in areas that do not have any grid electricity; towers in these locations need to use supplemental electricity, which historically has come from diesel-powered generators.

Demand estimates: Our market-sizing estimates will focus on assessing telecom towers in rural areas that suffer from no or poor access to electricity, between now and 2020 (i.e. over the next four to six years). The overarching assumption we hold to be true is that any additional towers in urban areas are likely to be grid-connected and will therefore be outside of the purview of this report. (See annex for the detailed methodology and approach used to develop our estimates.)

Geographic scope: The report will aim to provide a global view of the mobile phone industry, with particular granularity on the developing world (Africa and Asia), where access to grid-based electricity is most constrained. Many of our insights and trends are based on interviews and discussions with key industry stakeholders across 10 focus countries that account for approximately 60-70% of the global rural population without reliable access to electricity.

Figure 5: Key indicators for 10 focus countries[13]

Country	Population	Population density	Coverage	Mobile Penetration	Electrification
	(million)	*(# per km^2)*	*(% of population)*	*(% of population)*	*(% of population)*
Bangladesh	149	1,174	89%	63%	60%
Cameroon	20	45	68%	60%	54%
India	1,200	411	73%	69%	75%
Indonesia	240	135	65%	113%	73%
Kenya	41	74	95%	70%	19%
Myanmar	48	80	11%	10%	49%
Nigeria	158	180	72%	66%	48%
Pakistan	174	229	36%	68%	69%
Senegal	12.5	69	86%	82%	57%
Tanzania	45	52	76%	55%	15%

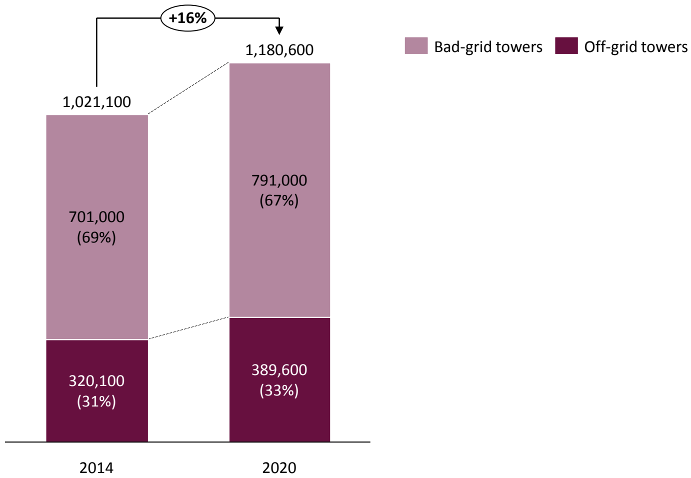
[13] Represents latest available real data from independent data sources were used as a reference for the Dalberg Tower Estimation and Green Power Model

1. Energy demand at telecom towers: What is the challenge?

By 2020, estimates indicate that the global telecom industry will deploy approximately 390,000 telecom towers that are off-grid, and 790,000 that are in bad-grid locations. This is an increase of 22% and 13%, respectively, from today. Currently there are around 1 million off-grid and bad-grid telecom towers in the world in total. These are expected to increase by 16-17% to 1.2 million till 2020.[14] About 70% of these million towers are in areas that can be classified as bad-grid (less than 18 hours of reliable grid access).

Figure 6: Total number of off-grid and bad-grid towers

Towers (2014-2020, estimates)



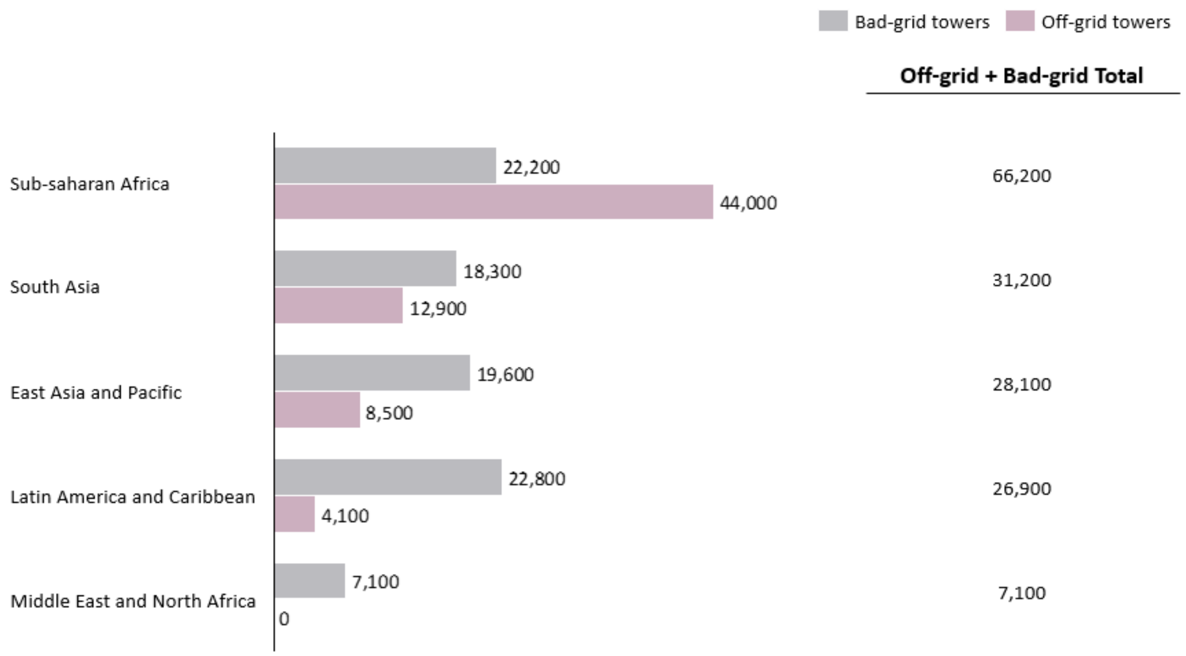
Source: Dalberg Tower Estimation and Green Power Model

The global split of off-grid to bad-grid towers is not expected to change significantly in the next six years. Overall, an additional 70,000 off-grid and 90,000 bad-grid towers are expected to be deployed between 2014 and 2020. As shown in Figure 7, Africa and Asia will together account for almost 80% of this projected growth, with the remainder largely coming from Latin American countries.

[14] Dalberg Tower Estimation and Green Power Model

Figure 7: Additional off-grid and bad-grid towers by region

Number of towers (2014-2020)

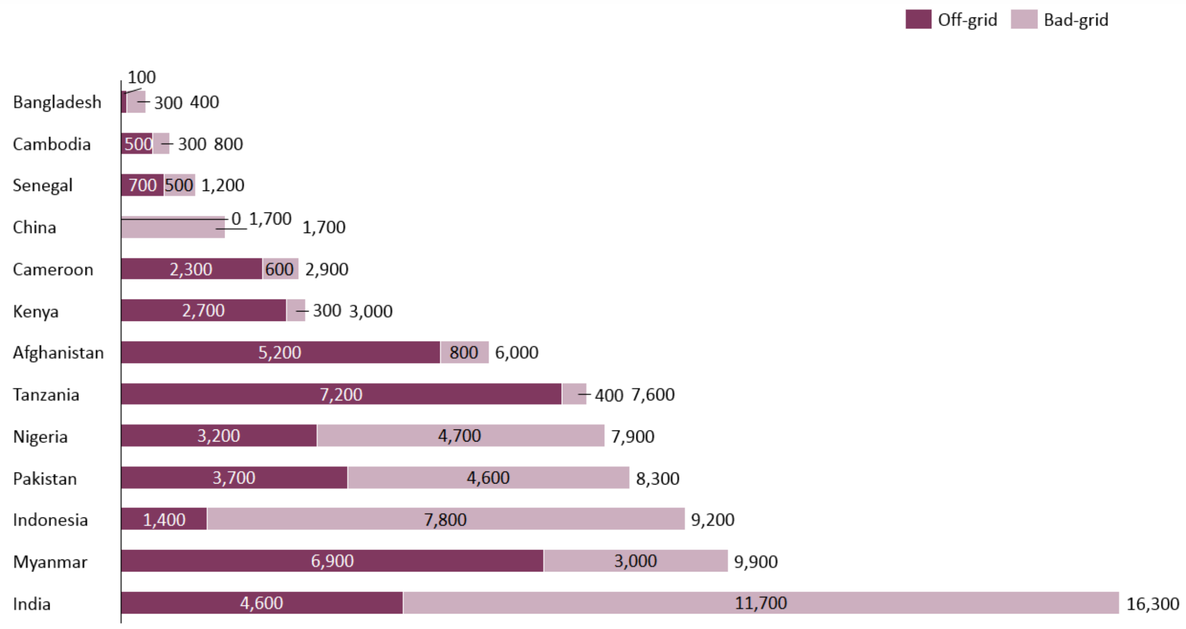


Source: Dalberg Tower Estimation and Green Power Model

At the country level, India alone will be responsible for about 10% of the global in off-grid and bad-grid towers and about 30% of the increase in Asia, with an estimated 16,500 deployments (in addition to its existing base of over 230,000 off-grid and bad-grid towers) till 2020. Indonesia, Pakistan and Myanmar are other countries in Asia that are expected to add a substantial number of off-grid and bad-grid towers in the same time period, approximately 10,000, 8,000 and 4,000 towers, respectively.

In Africa, it's most populous country, Nigeria, tops the list, with an estimated 8,000 additional deployments in off-grid and bad-grid regions, independently accounting for about 12% of the continent's total growth. Tanzania and Kenya, will be the other large growth markets in Africa. Countries such as Mozambique, Botswana, South Africa, Namibia and Angola are also likely to see significant tower deployment by 2020. On-going conflicts and severe infrastructural challenges will limit the expansion of coverage in some countries, such as Sudan and the Democratic Republic of Congo, although both countries have a large population not covered by a mobile network.

Figure 8: Growth in the number of off-grid and bad-grid towers for key countries in Africa and Asia
Number of towers (2014-20)



Source: Dalberg Tower Estimation and Green Power Model

The major driver of the estimated growth in off-grid and bad-grid towers is the expected expansion of mobile networks into rural regions in Africa and Asia, large parts of which face limited access to reliable electricity.

Rural network expansion

In most countries in Asia and Africa, network growth and hence tower growth, will be restricted to semi-urban and rural areas. Based on interviews with sector stakeholders, almost all the 10 focus countries[15] in the study have between 95-100% population coverage in urban regions. With these urban markets almost completely saturated, MNOs have been compelled to expand into semi-urban and rural areas to add new customers.

Rural connectivity to mobile-phone networks, on the other hand, has significant scope for improvement. In sub-Saharan Africa, estimates indicate that around 30% of the rural population is not covered by any mobile network.[16] In India, rural penetration is estimated to be between 30-40% only,[17] implying about 200 million people without mobile phone access in one country alone. The impetus to improve rural coverage over the next six years will be driven by rising rural incomes and increased rural demand for mobile phone services, especially as income-enhancement applications of mobile services continue to proliferate. In addition, in most developing countries, MNOs are required to fulfil universal coverage obligations meant specifically to ensure mobile-phone access even in those rural regions that have a limited commercial incentive. For example, in India, MNOs are mandated by the government to provide up to 90% coverage in metros and 50% coverage in the rest of the country. Failure to do so can result in termination of the MNO's spectrum license.

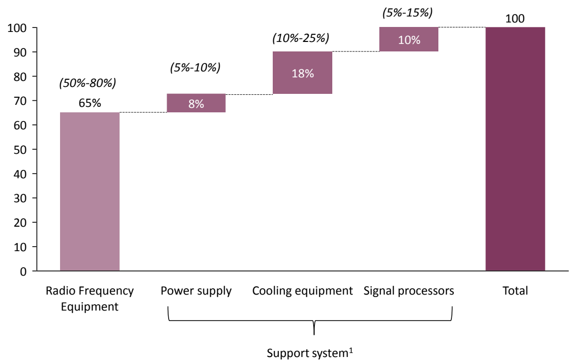
[15] Focus countries – Bangladesh, Cameroon, Ethiopia, India, Indonesia, Kenya, Myanmar, Nigeria, Pakistan, Senegal and Tanzania
[16] Dalberg analysis
[17] India Mobile Landscape 2013 – Telecomwatch

It should be noted that some coverage growth and intensification is expected to occur in urban areas. First, the penetration of new data services—i.e. 3G and 4G services—has increased network traffic, and second, with increasing levels of urbanization in key developing markets will necessitate network upgrades. However, the demand for higher-intensity, higher-quality coverage in urban areas is expected to be met through tower-sharing and technological improvements in Base Transceiver Stations (BTSs),[18] rather than by deploying new tower sites.[19] Space and cost constraints as well as new safety regulations around proximity of towers to residential areas are two important reasons why MNOs and TowerCos will seek to invest in tower-sharing rather than new tower deployments, as explained in interviews.

Poor electrification levels

Telecom towers require 24/7 access to electricity in order for the installed 'active' (i.e. electronic) equipment to function and for mobile phone users to be able to use their phones.[20] Active components, comprising BTSs (the primary radio equipment), an air conditioner (if required) and antennas and lighting, are the largest energy consumers at a tower site. As shown in Figure 9, within an individual mobile phone tower, the BTS can account for approximately 50-80% of total energy consumption. On average, interviews indicate that telecom tower with one BTS installed would require between 0.8-1.5 kWh of electricity per day. That daily consumption rises to 2.5 to 6 kWh per day for sites with up to 3 tenants (i.e. 3 installed BTSs).

Figure 9: Breakdown of energy consumption at a tower site with an outdoor BTS requiring cooling
Share of total tower energy consumption



(1) From the power consumption point of view, the elements of a base station can be divided into two groups: radio frequency equipment (that includes power amplifiers transceivers), and support system, which includes AC/DC power conversion modules, air conditioning elements, and analog and digital signal processors.
Source: Conte, Alberto, "Power consumption of base stations", Alcatel-Lucent Labs France (2012); Dalberg analysis

Historically, populations in developing countries, in particular within rural regions, have suffered from poor access to electricity. As can be surmised from Figure 10, large parts of rural areas in the developing world do not have quality access to electricity.

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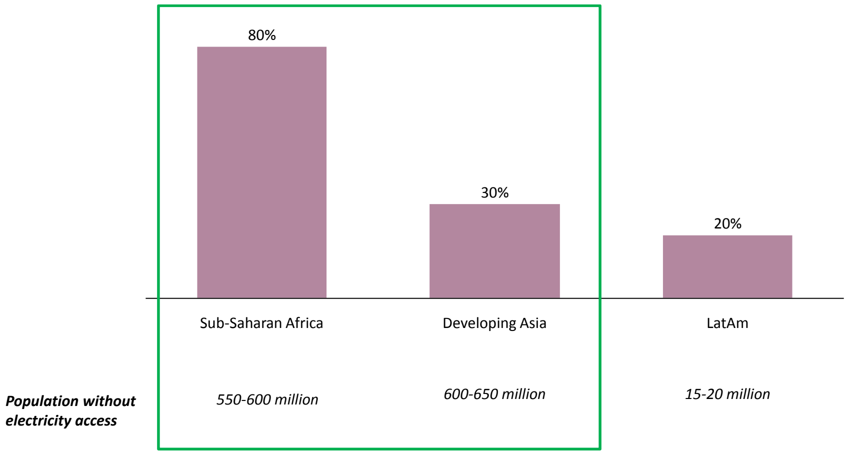
[18] BTSs are the primary radio equipment at a tower site that is responsible for generating the majority of the demand for electricity.
[19] Interviews with Tower Industry stakeholders (March-April 2014)
[20] The core radio equipment that is responsible for broadcasting mobile phone signals to users. Passive infrastructure, on the other hand, includes the non-electronic equipment including the tower itself, energy infrastructure, etc.

Figure 10: Rural under-electrification rates in developing regions

% of rural population that has no access to electricity (2011)



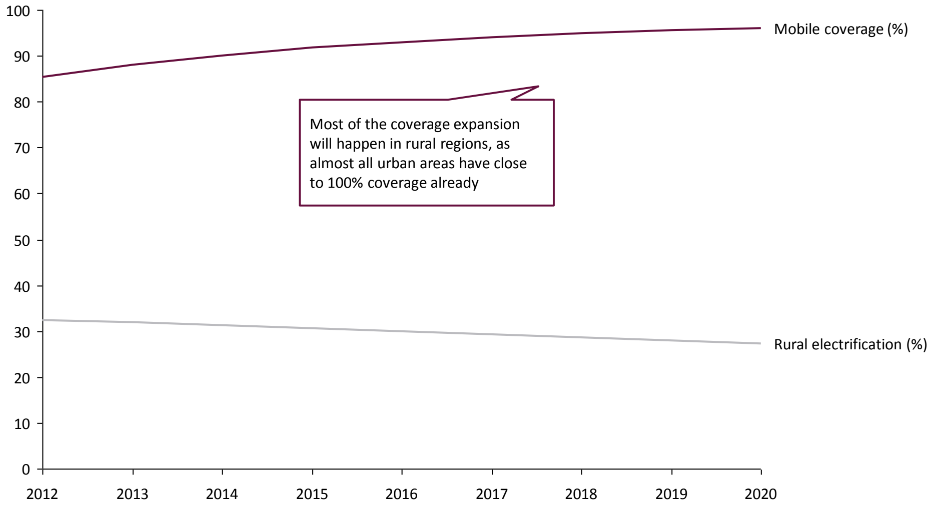
Source: IEA, World Energy Outlook (2011); Dalberg analysis

Telecom towers in these areas with unreliable electric grids face the constant threat of downtime i.e. when BTSs go offline due to lack of electricity access. The cost of downtime is prohibitively high for MNOs. Towers in these areas require additional or backup power to make up for the lack of grid-based electricity, and to ensure uptime.

While most governments do have plans to expand their national electric grid over the next six years, the rate of grid expansion will be outpaced by the projected growth in mobile network coverage, as illustrated in Figure 11. Furthermore, a grid connection does not automatically guarantee effective and consistent access to the grid. The situation is further exacerbated because most tower growth will be concentrated in underpenetrated rural and semi-urban regions that are usually severely electricity-deficient.

Figure 11: Growth in mobile coverage vs electrification rates for India - Illustrative

Percentage of population covered (2012-20)



Source: GSMAi database; IEA World Energy Outlook; Dalberg analysis

As a result, operators' demand for non-grid electricity is expected to grow. By 2020, all off-grid and bad-grid towers globally are expected to require 7.2 TWh of non-grid electricity and consume almost 150 million barrels of diesel a year.[21]

[21] Assuming 1.5 kW power requirement for a telecom site and 2.3 liters of diesel consumed per hour; 1 barrel = 119 liters

1. Major players and business models

Prior to discussing the telecom tower energy landscape (See Section 4), it is important to introduce the major players and develop a solid understanding of the business models that prevail in the industry.

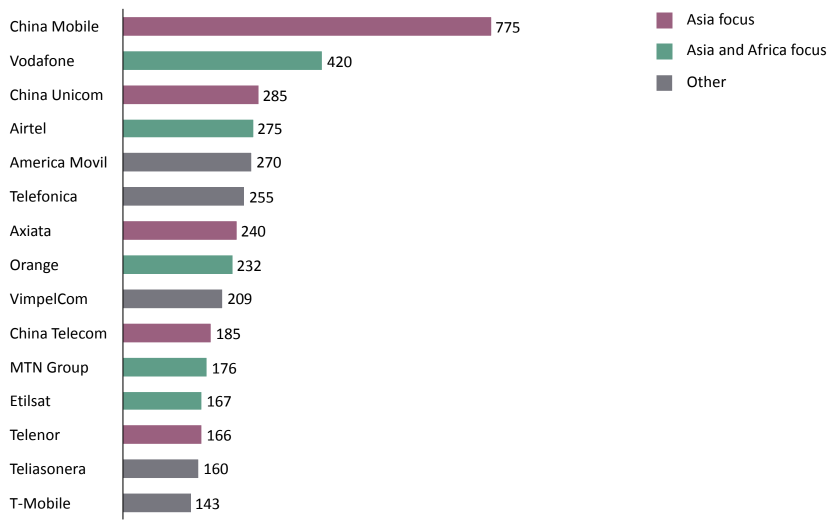
Major players

There are two primary decision makers in the global telecom tower energy landscape: Mobile Network Operators (MNOs) and Tower Companies (TowerCos).

Mobile Network Operators (MNOs)

MNOs are the primary owners of the vast mobile networks and infrastructure that pass on wireless signals to mobile phone users in a country. The lucrative core business of an MNO—its control over a national mobile network—leads to economies of scale and easy access to financing. This then allows the MNO to fund the construction and operation of mobile network infrastructure (including telecom towers), either through direct ownership or through other parties. Until about five years ago, MNO maintained ownership of all active and passive infrastructures at telecom tower sites as a means of driving market share and erecting high barriers of entry for new players.

Figure 12: Top 15 MNOs in the world and their key focus markets
Millions of subscribers



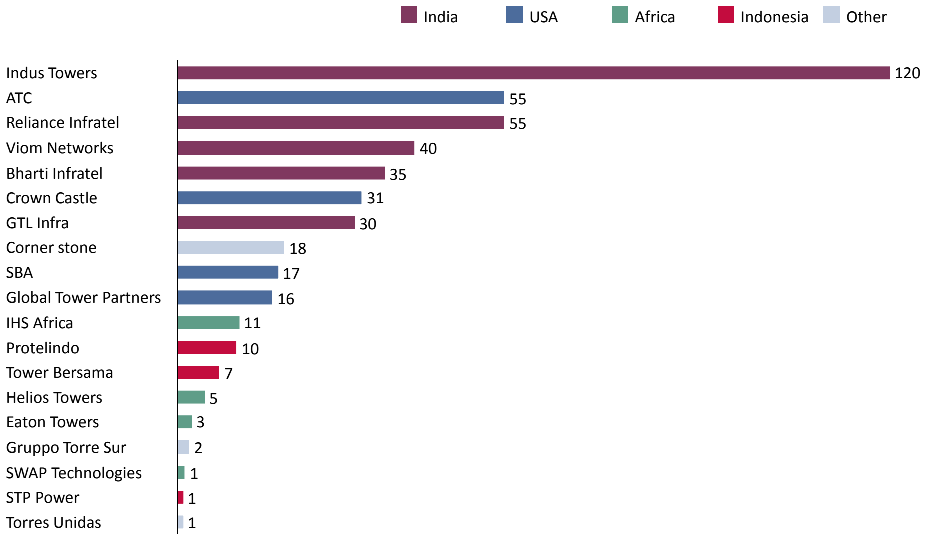
Source: International Telecommunications Union; MNO websites; Dalberg research

Tower Companies (TowerCos)

Tower-sharing is the practice of outsourcing the procurement, installation, management and maintenance of all passive infrastructures at telecom tower sites to entities known as TowerCos. TowerCos were initially created by MNOs in order to separate out the capital intensive telecom infrastructure component of their business from the consumer-facing service orientated business.

Figure 13: International telecom tower companies – TowerCos

Number of towers in thousands

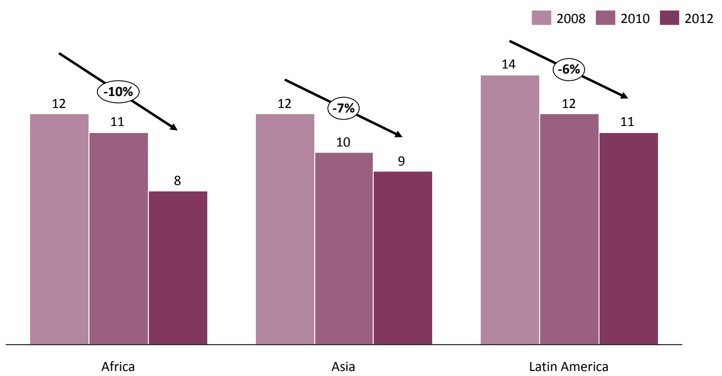


Source: "Hybrid Energy for Telecom Towers", Saviva Research (2013); TowerXchange estimates (in particular for Africa) - www.towerxchange.com; Individual company websites; Dalberg research and analysis

MNOs viewed the transition to tower-sharing as an imperative to secure the future sustainability of their business. Most importantly, TowerCos enabled MNOs to reduce and stabilize the inflating costs of network deployment and growth in light of sharply falling global average revenues per user (ARPUs) and a resulting margin squeeze.

Figure 14: International average revenue per user (ARPU) per month

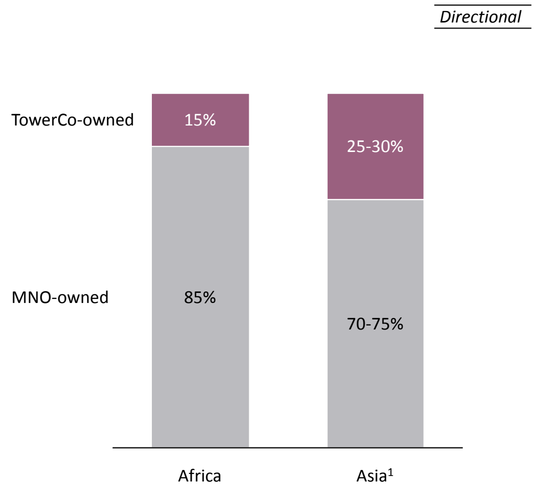
US$/month (2008-12)



Source: Saviva Research Review (2013); GSMA; Dalberg research

MNOs have traditionally been the main decision-makers in matters related to energy generation at telecom tower sites, while TowerCos have primarily been reactive forces. In the past five years, however, TowerCos have begun to occupy a more central role. This has been driven by the growth of tower-sharing model globally, which transfers ownership of telecom tower assets, including all energy generation equipment to TowerCos. Figure 15 shows the extent of tower-sharing models in Africa and Asia.

Figure 15: Estimated share of ownership of telecom towers in Africa and Asia



(1) Ownership share in Asia was estimated based on bottom-up information for the following countries: India, China, Indonesia, Pakistan, Bangladesh and Myanmar
Source: GSMA Country Assessments (2013); TowerXchange (2013); Dalberg analysis

Clearly, Asia is more advanced with 25-30% of its current tower estate in key countries already having adopted tower-sharing business models. This has occurred primarily because large mobile phone markets such as India and Indonesia, collectively home to almost 470k towers, were early adopters. In India, TowerCos own approximately 60% of all telecom towers already; while in Indonesia they own about 40% of the approximate 70,000 towers in the country. China remains an anomaly in Asia, since the three largest MNOs—China Mobile, China Unicom and China Telecom—have thus far retained independent ownership of towers. However, recent media reports have indicated that a comprehensive shift toward tower-sharing is imminent in the country. Earlier this year, the three national MNOs have started talks on setting up a joint-venture indigenous TowerCo, to allow for infrastructure-sharing at telecom tower sites. Accordingly, a further 500,000 towers from China are likely to transition to the tower-sharing business model by the end of 2014.[22] This alone would increase the share of TowerCo-owned towers in Asia to almost 50%.

Tower-sharing is more nascent in the African continent. Less than 20% of the current tower estate, or about 25,000 towers are owned and operated by TowerCos. But, change is likely to occur rapidly. According to industry estimates, a further 40,000-42,000 towers in Africa are likely to transfer from MNO-captive to TowerCo-owned and operated, by the end of 2014, increasing their share across Africa to almost 40%.

The choices that MNOs and TowerCos make with regard to key issues such as self-generation and management of tower energy versus outsourcing to dedicated power companies, defining incentive structures and sharing risk between the contracting entities, etc., have a substantial impact on the structure and nature of the business models that are deployed in the sector. These are discussed below.

[22] "China telecoms operators see plenty to gain in sharing infrastructure", South China Morning Post (May 2014); Dalberg research

Tower energy business models

The main prevailing business models in the telecom tower infrastructure industry are defined and differentiated according to how **ownership of energy assets** as well as the **costs of energy generation** are shared between energy buyers and sellers. Ownership of assets signifies not only incurring substantial upfront capital investment, but also the attendant risks that could potentially diminish the value of that investment, such as inefficiency, damage and obsolescence. Asset owners have the power to upgrade or replace energy assets. This responsibility determines ability and incentives to switch to renewable energy solutions.

Energy operations costs refer collectively to the recurring costs associated with generating electricity at telecom tower sites. In off-grid and bad-grid tower sites, the primary component of plant-level energy operations costs is expenditure on diesel fuel, accounting for almost 80% of the total. Other important cost items include maintenance, repairs and replacements, e.g. engine replacements for the diesel generator, etc.

Figure 16: Business models deployed at telecom tower sites

ESCO business models

Model	Energy buyer	Energy seller	Energy asset ownership	Energy operations costs	Incentive to reduce energy costs
1 TowerCo ESCO	MNO	TowerCo	TowerCo	TowerCo	Medium - High
2 Independent ESCO	TowerCo/MNO	3rd Party	3rd Party	3rd Party	High
3 Vertically-integrated MNO	MNO	MNO	MNO	MNO	Limited
4 TowerCo pass-through	MNO	TowerCo	TowerCo	MNO	None

Source: Interviews with MNOs, TowerCos and ESCOs (March-April 2013); Dalberg analysis

Figure 16 illustrates four main business models currently deployed in the industry. The first two are termed **ESCO business models** and represent the primary focus of this report. In the third overarching model, **vertically-integrated MNOs** cater to their own power needs. In the fourth and final model, MNOs outsource energy asset ownership, but TowerCos **pass-through** all energy operating costs to partner MNOs.

A more detailed description of the four business models and the resulting incentives is found below.

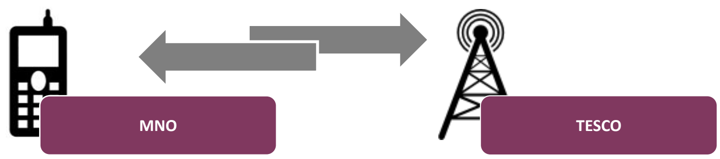
ESCO business models

In the context of the telecom tower infrastructure industry, the Energy Service Company business model refers to the unique way in which energy asset ownership and energy operations costs are structured and shared between buyers and sellers of energy at telecom tower sites, so that the seller has a clear and substantial profit motive to focus on energy efficiency and reduce energy costs. Specifically then, ESCOs are entities that own, install, operate, maintain and bear all of the costs of energy infrastructure at a telecom tower site, providing electricity to an independent buyer (either an MNO or a dedicated TowerCo[23]) for a fee. [24]

ESCO business models may be further bifurcated into two important categories: TowerCo ESCOs (TESCOs) and Independent ESCOs (IESCOs).

TESCOs: These are entities that generate and provide electricity to their MNO tenants at telecom tower sites, generally for a fixed monthly fee. TESCOs typically bundle their energy services with other standard functions of dedicated TowerCos e.g. site security, monitoring of active equipment, upgrade of passive infrastructure, etc. This effectively means that TESCOs are able to offer a comprehensive value proposition to MNOs for the complete set of telecom tower related activities and responsibilities. Contracts between MNOs and TESCOs reflect this value proposition. TESCOs receive all-inclusive fixed monthly payments from MNOs for their services. All operational risks, in particular the risk of downtime, i.e. the amount of time per month that the telecom tower is offline, are borne by the TESCO. Most TowerCos globally are required to deliver 99.95% to 99.99% uptime or Service Level Agreement (SLA) in a month to their MNO tenants. This effectively translates to anywhere between 4-21 minutes of downtime per month. As can be imagined, this high level of performance is difficult to produce continuously, especially when telecom towers are in rural regions and suffer an unreliable access to electricity.[25]

Figure 17: Illustration of the TESCO business model



	MNO	TESCO
Energy role	Mandate	Facilitate and execute
Key responsibilities	• Lease tower infrastructure/services from TowerCo for a monthly rental per a long-term contract • Reimburse 100% of the cost of generation, including any fluctuations in prices	• Set up and bear all capital costs for passive infrastructure including energy infrastructure • Pass-through all energy costs to the MNO • Provide tenancy and energy to MNOs for a fixed monthly fee • Bear all downtime risks/penalties

Source: Interviews with MNOs, TowerCos and ESCOs (March-April 2014); Dalberg research

Critical to their function as TESCOs, these entities own, operate, and bear all operating costs for the tower's energy assets. Because energy generation and provision can constitute up to 60% of all annual operating expenses, TESCOs are incentivized

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[23] These are defined as TowerCos that outsource energy generation to IESCOs in order to focus purely on infrastructure management and increasing tenancies.

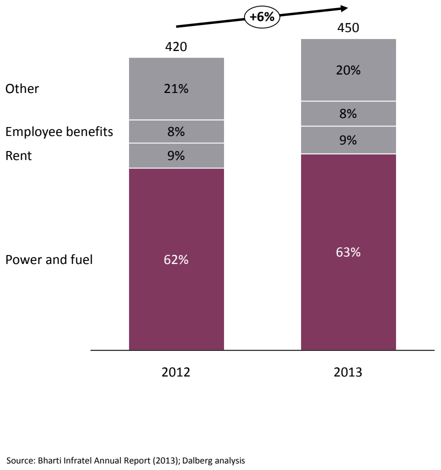
[24] This definition of an ESCO is inspired from but not entirely identical to the meanings ascribed to the term by other institutions, including The World Energy Council, the European Commission's Institute for Energy and Transport, the Lawrence Berkeley National Laboratory, and NAESCO.

[25] Indus Towers website

to continuously seek long-term opportunities for energy efficiency, energy cost reduction, and cost predictability, even though provision may not be the core activity of the company.

Figure 18: Share of a TowerCo's annual operating costs from energy and fuel expenses

Million US$ (2012-13)



Examples of TESCOs

Helios Towers Africa operates in Ghana, Tanzania and the Democratic Republic of Congo and boasts nearly 5,000 towers. Helios Towers leases sites to interested telecoms, remaining in control of tower and energy assets and operations. The company was founded in 2005 and claims to be both the first and largest independent Tower Company in the continent to date. Customers include Tigo, Bharti Airtel, Vodafone, MTN, Africell, Kasapa, as well as various television and radio channels and non-telecom actors. A Nigerian sister company currently owns and operates upwards of 1,000 towers in the country, for a wide customer list including MTN Nigeria, Airtel, Etisalat, Globacom, and Visafone.

IHS Africa is an African TowerCo that owns and operates 3,500 towers in a TESCO model and further manages another 4,750 in a Managed Service Provider (MSP) model in Cote D'Ivoire, Cameroon, Nigeria, Zambia and Rwanda. Founded in 2001, the company offers three different contracts: Build-to-Suit (TESCO model), Buy-Lease-Back (TESCO model) and Manage with License to Lease (MSP model).[1]or right with the text, and make this red box narrower.

IESCOs: These are dedicated or pure-play energy companies that own and operate energy assets that power telecom tower sites. IESCOs derive revenues from selling energy to the buyers—MNOs and dedicated TowerCos—and share similar drivers and motivators as TESCOs to upgrade assets and reduce energy costs.

There are two potential avenues or channels for IESCOs to gain market share in the telecom tower industry. In the first channel, MNOs decide to directly outsource energy infrastructure and operations of their towers to IESCOs. IESCOs own and install the energy assets, and bear all operating costs. MNOs must pay an energy fee to partner IESCOs in lieu of their energy generation services.

Contracts between MNOs and IESCOs can be of three types: fixed-fee, power-purchase agreements (PPAs) and energy savings. Pros and cons of each contract type are explored in Figure 19.

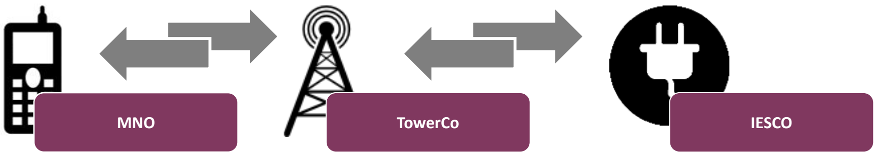
Figure 19: Comparison of different IESCO contract types

Contract type	Brief description	Pros and cons
Fixed Monthly Fee Agreement	$\text{Price} = \$X \text{ per month}$ • Fee is constant and independent of usage	+ Simple contract; likely to be easily accepted by MNOs and dedicated TowerCos + Non-variable cash flows easy to use to prepare budgets, source funding etc. – No penalties for MNOs and TowerCos for excessive electricity consumption
Power Purchase Agreement (PPA)	$\text{Price} = \frac{\$X}{\text{kWh}} * \text{KwH consumed}$ • Per kWh rate is fixed, and MNO is billed for the units of electricity it consumes	+ MNOs/TowerCos charged according to their consumption of electricity, incentivizing them to also focus on energy efficiency – Difficult to estimate/agree on a long-term per kWh rate; risk of cost fluctuations falls in the IESCO – Unstable cash flows for all parties as consumption may vary over time
Energy Savings Agreement (ESA)	$\text{Price} = X\% * (\text{Cost}^{t-1} - \text{Cost}^{t})$ • MNOs pay based on a portion of verified energy cost "savings" that is benchmarked to a "notional" status quo	+ Clear value proposition (can only save buyer money) – Challenging to identify actual OPEX savings based only on a notional base case – If the energy requirement in a site increases, recalculation of benefits is needed, which is complicated

Source: www.gsma.com; Dalberg research and analysis

In the second channel, in Figure 20, dedicated TowerCos buy electricity from IESCOs, allowing them to focus on revenue-generating efforts such as building out their tower base, and garnering additional tenants for existing towers. As shown in Figure 20, MNOs outsource all activities and responsibilities related to tower deployment and operations to TowerCos, who then further outsource all energy generation activities, e.g. the ownership, deployment and operations of all energy assets, to IESCOs. As far as the IESCO is concerned, the TowerCo is the energy buyer. Contract arrangements between IESCOs and dedicated TowerCos follow the same pattern as those for IESCOs and MNOs discussed above.

Figure 20: Illustration of IESCO business model in which the TowerCo is the primary energy buyer



	MNO	TowerCo	IESCO
Energy role	Mandate	Facilitate	Execute
Key responsibilities	• Lease tower infrastructure/services from TowerCo for a monthly rental	• Set up and bear all costs for passive infrastructure **excluding** energy • Provide tenancy and energy to MNOs, typically for a fixed monthly fee • Outsource energy generation to dedicated power company	• Set up and bear all costs for energy infrastructure • Bear all energy operations costs • Provide energy to TowerCos, typically for a fixed monthly fee • Bear all downtime risks/penalties

Source: Interviews with MNOs, TowerCos and ESCOs (March-April 2014); Dalberg research

Examples of IESCOs

OMC: Omnigrid Micropower Company (OMC) is a Mumbai-based IESCO with 10 plants powering up to 40 towers in India. The 3-year-old company, with under 50 employees, sets up power plants which are based on a variety of renewable energy sources (with a strong bias towards solar). These power plants can power 2-4 telecom towers as well as rural households. The company diversifies its revenues by providing power to telecom users as well as supplying a variety of rentable charged lanterns, fans and chargers for use by retail consumers. The company's main client is Bharti Infratel.

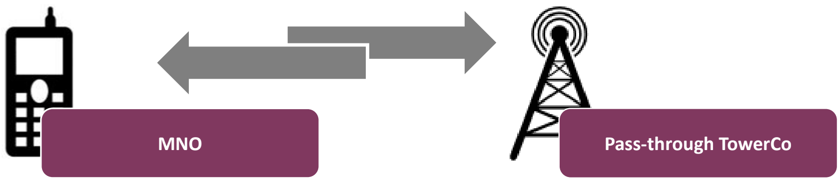
Applied Solar Technologies (AST): AST is a New Delhi-based IESCO that provides power to 1,000 towers in India. This 6-year-old company with approximately 100 employees installs, operates and owns solar and solar-diesel generator hybrid assets for clients including Bharti Infratel, Indus Tower, and Idea. Media reports indicated that the company has received funding from the IFC and OPIC in order to extend its operations to 10,000 towers by 2015.

Non-ESCO business models

Vertically-integrated MNOs: This refers to the traditional model of an MNO as a single firm controlling all aspects of network deployment, operations and growth, including energy generation. This business model flourished during the initial stages of the global mobile phone revolution, but has diminished in importance due to the advent of tower-sharing models.

Pass-through TowerCos: In this model, MNO's are tenants to a TowerCo's infrastructure—i.e. the energy assets are completely owned by the TowerCo—but are contractually bound to reimburse all energy-related expenditures. An illustration of this model is provided in Figure 21.

Figure 21: Illustration of a pass-through TowerCo business model



	MNO	Pass-through TowerCo
Energy role	Mandate	Facilitate and execute
Key responsibilities	• Lease tower infrastructure/services from TowerCo for a monthly rental per a long-term contract • Reimburse 100% of the cost of generation, including any fluctuations in prices	• Set up and bear all capital costs for passive infrastructure including energy infrastructure • Pass-through all energy costs to the MNO • Provide tenancy and energy to MNOs for a fixed monthly fee • Bear all downtime risks/penalties

Source: Interviews with MNOs, TowerCos and ESCOs (March-April 2014); Dalberg research

This arrangement was common in the first stages of the transition to tower-sharing. At the time, contracts between TowerCos and MNOs were designed to minimize all energy-generation-related risks for TowerCos and to ensure predictable cash flows for them. MNOs, who are the primary consumers of energy at telecom tower sites via their BTSs, agreed at the time to reimburse all energy expenditure of the TowerCo as per consumption, over and above other fixed rental charges.

2. Energy supply landscape and trends

Market share of business models

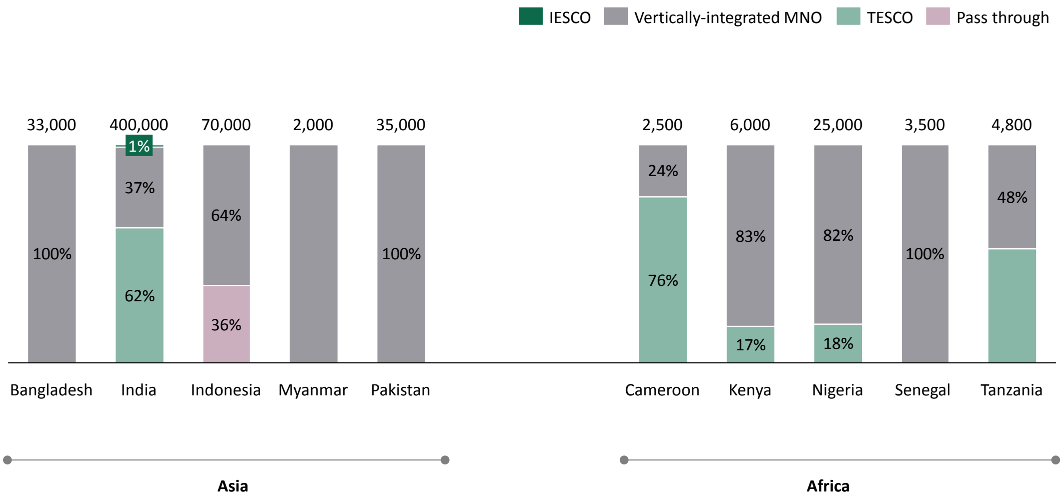
Vertically-integrated MNOs continue to dominate the energy supply landscape in telecom towers in Asia and Africa. TESCO models are on the rise.

In about six of the ten countries of focus in this study, vertically-integrated MNOs retain a majority share of the telecom tower energy landscape. However, the static picture shown in Figure 22 is more a result of obsolete industry priorities and structures, which tends to underplay key emerging trends.

Most important amongst these trends is the industry transition to TESCO models. In most developing mobile phone markets this has happened in two stages. In the first stage, MNOs transfer tower assets to TowerCos and adopt pass-through energy models. In the second stage, pass-through models are dropped in favor of fixed price energy models, or TESCO business models that incentivize energy cost reductions.

Figure 22: Current market share of different tower energy business models in key African and Asian mobile-phone markets

% of total towers (2012-13)



Source: GSMA Country Assessments (2013); TowerXchange (2013); Dalberg analysis

In Asia, India is the most advanced TESCO market. Tower-sharing and pass-through models emerged in India about five years ago, earlier than in most other developing countries. The transition to TESCO models has mainly occurred in the last two-three years as MNOs increasingly prioritized reduction of energy costs. For example, even in early 2013, less than 10% of TowerCo-managed towers were under the TESCO model.[26] Currently, all towers owned by TowerCos, which is about two-thirds of the total domestic estate, operate under the TESCO model. Over the next six years, practically all telecom towers in India are expected to adopt the TESCO business model. Among other focus countries in Asia, Bangladesh and Myanmar are

[26] Saviva Research 2013

high-growth markets. Growth of the TESCO model in Myanmar is expected to be especially quick with its mobile sector opening up to international investment in the past year. Interviews and research suggests that in the next two years alone an additional 10,000 towers will be brought online, all under the TESCO model. In Bangladesh, major operators like Bharti Airtel (with above 4,000 towers) are planning to outsource tower energy provision to TESCOs in the next one-two years.

In Indonesia, although tower-sharing is expected to increase, it is unclear whether pass-through energy models will be abandoned. Interviews indicate that the country's telecom towers have a generally high-level of electricity access, which favors pass-through contracts.

In Africa, growth of the tower-sharing model has largely progressed hand-in-hand with the TESCO model mainly because most MNOs and TowerCos have chosen to skip the intermediate pass-through stage. The only exception is American Tower Company (ATC), which has made use of the power pass through clause in Ghana, Uganda and South Africa. Current TESCO market share in Africa is at 10-15% (which is the same as the share of the TowerCo market). The TESCO market share is expected to rise to almost 40% of the total tower market by the end 2014 alone, and to almost 50% by 2015.[27] Cameroon and Tanzania are the most penetrated markets in the continent with almost 75% and 50% of their respective tower estate now owned and managed under the TESCO model. Nigeria, however, has the most number of towers in Africa—around 5k towers—under this model.

Globally, IESCO share of the current market is marginal, and their presence has been primarily limited to India. OMC and AST are the two largest pure-play IESCOs; they operate mainly in India and are responsible for energy generation and management at approximately 4-5k towers in the country (less than 1% of the domestic tower estate).
However, it should be noted that the industry also includes ESCO-like entities known as Managed Service Providers. These are companies that engage in energy operations and management without ownership of the underlying assets. Such activity can serve as a valuable intermediary point for companies building brand and revenues in order to transition further down the road into a full-blown ESCO.

[27] www.towerxchange.com

Due to the difficulty of ESCOs to achieve significant scale due to obstacles in financing and contracting, providing ESCO-like services while avoiding the inherent risk exposure, can be a strong step towards building a company's client base and developing experience and connections. In the long run however, it is precisely the ESCO's risk exposure through energy asset ownership that aligns incentives in the direction of long-term energy sustainability. Examples of major MSPs operating in Asia and Africa are provided in Box 3.

Landscape and trends of tower energy solutions

The unfortunate legacy of the first phase of the global mobile phone revolution is the proliferation of highly inefficient, costly and wasteful energy solutions for telecom tower sites, particularly those sites that suffer from unreliable access to electricity. More than 95% of tower sites in off-grid and bad-grid regions have usually used power from over-sized diesel generators—typically 15 kVA or higher—to supplement grid-based power.

A major reason for the deployment of these inefficient solutions was that when the majority of these sites were activated nearly 10-12 years ago, MNOs were responsible for deploying all energy equipment. Their sole focus was on ensuring uptime, and they assumed that diesel was the only effective power source that could help them achieve that, in the absence of grid-based electricity.

This was largely true, since renewable energy sources including solar were neither easily available nor economically viable. Not only were the diesel-based solutions well-known to MNOs, easy-to-implement, and fairly reliable and robust even in harsh environments, but most importantly, their low CAPEX requirements relative to known renewable energy alternatives, served to further sweeten their value proposition to key industry players. **Plant-level energy costs for off-grid and bad-grid telecom tower sites, driven by dependence on diesel, have become the largest cost item for MNOs and TowerCos.** They can

Box 3: Examples of MSPs

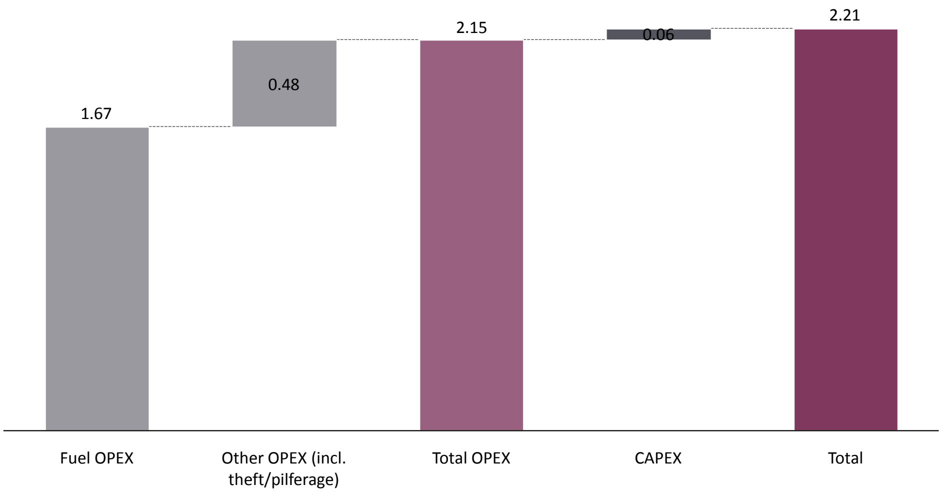
Ericsson is a global managed service provider and the largest mobile telecommunications vendor in the world, with a yearly revenue of over US$35 billion in 2012. The company installs and upgrades telecom towers or equipment, including energy assets, for a variety of clients in Asia and Africa. It also provides maintenance contracts, consulting services, impact assessments, and even energy management. It is purely, however, a CAPEX model.

Cummins Power is a global managed service provider and energy product vendor. The group provides diesel generator sets and a variety of other energy products as well as engines and miscellaneous components to industrial buyers such as telecom actors. The company provides O&M contracts to clients in Asia and Africa that include power management, 95% uptime guarantees, and repair parts servicing.

account for up to 30% of a large MNO's network operating costs and more than 60% for a large TowerCo. Diesel remains critical as either the primary or backup energy source for every mobile tower, and continues to be the largest cost component at a telecom tower site. The average telecom tower in a location that is completely off-grid (zero hours of active grid connectivity) would require the diesel generator (DG) to run for close to 24 hours to maintain uptime. Accordingly, current estimates indicate that at a retail price of about US$1 per liter, diesel costs alone can account for almost 70-80% of the total cost of generation at a telecom tower, as shown in Figure 23. The fully-loaded cost of generation of electricity at off-grid towers, which includes the implicit cost of fuel theft and pilferage, can rise up to US$2.21 per kWh or approximately 10 to 20 times the price of grid electricity in most countries in Africa and Asia.

Figure 23: Cost of generation at a typical off-grid tower with 24-hours DG[28]

US$/kWh (2014)



Note: All energy cost estimates are made keeping in mind a time period of 7 years.
Source: Dalberg Tower Estimation and Green Potential Model; Interviews with MNOs, TowerCos and ESCOs (March-April 2014); Dalberg analysis

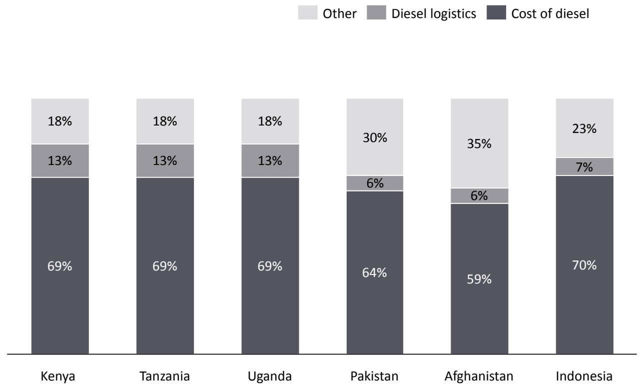
Data collected by GSMA from countries in Asia and Africa reinforce the importance of diesel costs as a part of overall operating expenses. Operators and TowerCos in the countries shown in

Figure 24 (next page) indicated that fuel and logistics costs accounted for up to 80% of annual operating expenses at a telecom tower site.

[28] Please see the annex for detailed discussion and assumptions for plant-level economics.

Figure 24: Operating cost of telecom towers by country (off-grid)[1]

Percentage of annual operating expenditure



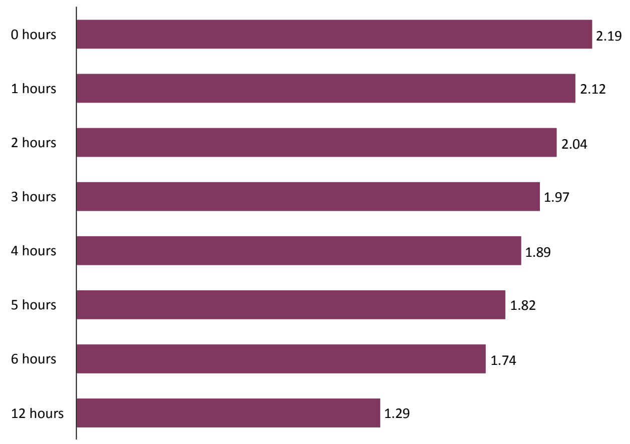
Note: Based on real data collected by GSMA through primary interviews with MNOs, energy providers etc.
Source: GSMA market analysis reports for 12 countries; Dalberg analysis

Expenditure on diesel and subsequently the cost of generation in off-grid and bad-grid telecom towers will depend on four important factors:

- Hours of grid-access: With energy prices from the grid that are up to 10 to 20 times cheaper than from diesel, the economics of towers with grid access are significantly more attractive than those without. For every additional hour of access to grid-based electricity up to 12 hours of grid access, the cost of generation at the telecom tower reduces by 3-5% (see
-
- Figure 25), by reducing the amount of time a diesel generator is required to run.

Figure 25: Sensitivity of the cost of generation to increasing hours of access to grid electricity

Cost of generation in US$/kWh



Source: Interviews with MNOs, TowerCos and ESCOs (March-April 2014); Desk research; Dalberg Tower Estimation and Green Power Model (2014); Dalberg analysis

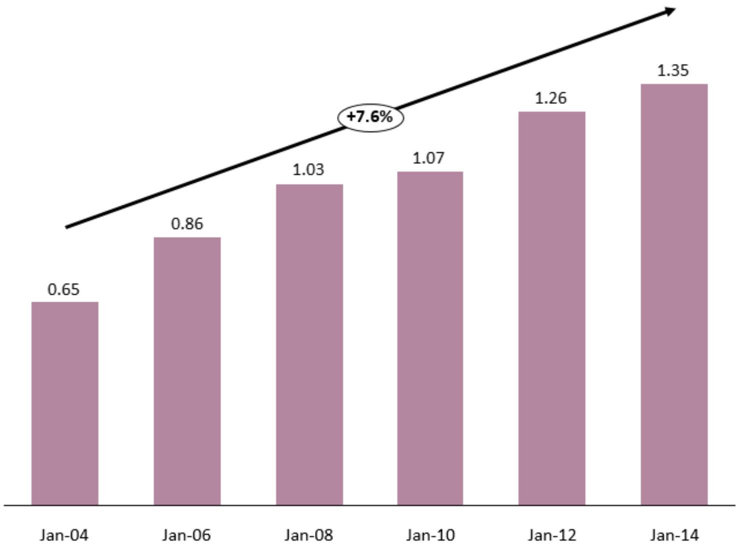
- **Price of diesel:** Clearly, given that almost 80% of annual operating comes from fuel expenses, the price of diesel is a critical driver of the cost of generation. Estimates indicate that a 1% rise in its price will cause the cost of generation at an off-grid tower to rise by the same amount.

  From a cost-cutting perspective, the high burden of diesel costs does not bode well for the future, for MNOs. As shown in Figure 26, the retail price of diesel has been growing at approximately 8% annually for the last decade. In certain countries such as India and Nigeria, the rise in diesel prices has been sharper, driven by the rollback of vast subsidies that were placing a large fiscal burden within these economies.

  Not only are costs rising, but in addition, monthly fluctuations in prices occur based on the rise and fall of crude oil prices. This has created costs of hedging risk in the short-term and broader financial uncertainty in the long-term.

Figure 26: Retail price of diesel in the world

Current US$ per liter (2004-14)



Source: World Bank Database on global retail prices of diesel; www.globalpetrolprices.com; Dalberg analysis

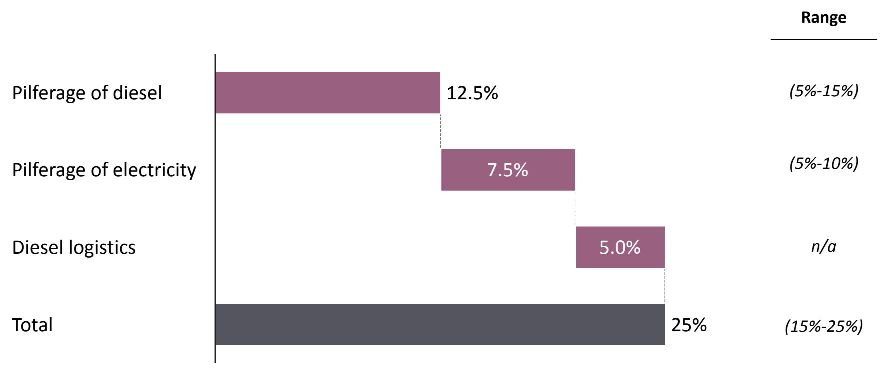
- **Load:** The plant-level economics discussed above assumes single tenancy, which means only one BTS per tower, to keep calculations simple and broadly applicable. The corresponding load or peak demand is assumed to be about 1.5kW [29]. Given that the main loads (or drivers of total energy demand) at a tower are the BTS, and—if needed—the air conditioner, clearly the energy demand from multiple tenants would be significantly higher, and generally weakens the case for transition to renewable energy. Improvements in energy efficiency, such as more efficient BTS or energy management systems, can significantly reduce the amount of energy required, and are currently being explored by MNOs and TowerCos.

[29] Load was assumed based on inputs from interviews.

- **Indirect diesel costs:** Costs such as pilferage of fuel or electricity and transportation further add an equivalent of 25% to the price of diesel as shown in Figure 27, but are typically difficult to attribute to get a fully loaded cost of diesel.

Figure 27: Indirect costs of diesel

Percentage of annual diesel cost



Source: Source: Interviews with MNOs, TowerCos and ESCOs (March-April 2013); Dalberg analysis

The industry implications for continued adoption and usage of diesel-generator-only energy solutions at off-grid and bad-grid towers, as is the case for more than 95% of the current estate, are quite serious. First, it will cost the global telecom industry more than US$ 18 billion in 2020 alone, from the consumption of more than 150 million barrels of diesel,[30] which represents a growth of about 15% in diesel consumption from today's levels. This would amount to approximately US$ 2-2.5 per mobile-phone user per year in 2020. Second, it would release about 45 million tons of CO_2 in 2020, which is about 5 million tons higher than current levels of carbon emissions.

Consequently, there is an increasingly strong rationale for MNOs to reduce their exposure to diesel and diesel related costs in the future, particularly with diesel prices expected to increase in the short term. Among the alternative technologies available, the use of green and renewable energy solutions, which include diesel-generator and advanced battery solutions, and solar, diesel-generator and advanced battery solutions, have been explored and found most viable by MNOs and TowerCos in most parts of the world.

These specific alternative telecom tower energy solutions are already cheaper than their diesel-generator-only counterparts. The alternative solutions that pair diesel generators in conjunction with advanced batteries like Lithium Ion batteries, can reduce diesel consumption at off-grid and bad-grid tower sites by up 40%-50%, according to interviews. Although diesel usage is not completely eliminated, there is a significant reduction in fuel consumption, which drives economic savings and provides a healthy "green contribution" driven by lower CO_2 emissions.

The use of solar technology at individual tower sites can reduce and virtually eliminate diesel usage from off-grid and bad-grid tower sites. However, feasibility of solar and its adoption at tower sites depends critically on on-the-ground factors such as tower placement (i.e., ability to have a south-facing tower with sufficient exposure to sun and availability of sufficient open land around

[30] Using current price of diesel, i.e. ~US$1/liter of diesel (globalpterolprices.com)

the tower), the daily availability of sufficient hours of sunshine, etc. In addition, even today, solar solutions typically do not have the capacity to support high loads i.e. more than two tenants, or 2 BTS, per site (equating to an approximate load of 2.5-3.5 kW).[31]

Although there is no single optimal technology for the telecom sector, thus far, solar has been the most common renewable energy technology used in green pilot sites across the world. While solar is clearly the most mature technology in the telecom tower space, it should be noted that all renewable solutions have different factors that may influence their feasibility and viability. Other important renewable energy technologies that have been experimented with include biomass and wind.

Figure 28: Characteristics of prominent renewable energy solutions, when combined with diesel

	Solar	Biomass	Solar-Wind
Maximum power output	3-5 kW	20-40 kW output	3-4.5 kW (Solar) 4-5 kW (Wind)
Potential DGRH reduction[32]	90-100%	75-90%	70-75%
Towers supported	1 tower (1-2 BTSs)	Multiple (7-10 BTSs)	1 tower (1-2 BTSs)
Maturity of tower solution	Highly mature; highest adoption (~4000 towers)	Mature; low adoption at towers	In pilot stage
Tower-specific requirements	• Panels need to slope toward the equator, with an azimuth angle[33] for sufficient exposure to sunlight • 4-6 sq.m./kWp of area • Insolation >5 kWh/m2/day	• 300-500 kg of feedstock required per day per plant • Sufficient space for generator • Operational staff	• Solar insolation and wind speed should be complementary through the year • Wind speed greater than 4.5-5 m/s
Advantages	• Minimal maintenance (maintenance involves periodic cleaning of panels) • Generation costs expected to decline significantly • Insolation requirement accessible in large parts of Africa and Asia	• Uses same generator as diesel, increasing ease of retro-fitting • High potential to power nearby communities • Low CAPEX	• Most countries in Africa and Asia have sufficient solar insolation • Large parts of Africa are well-suited for wind-based generation

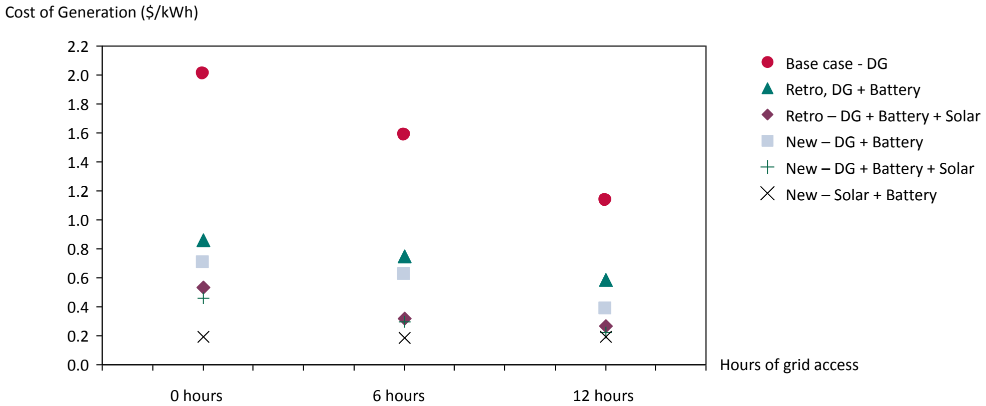
[31] Interviews with MNOs, TowerCos and ESCOs (March-April 2014)
[32] Based on estimated power output and maximum power generating time.
[33] An azimuth is an angular measurement in a spherical coordinate system. The vector from an observer (origin) to a point of interest is projected perpendicularly onto a reference plane; the angle between the projected vector and a reference vector on the reference plane is called the azimuth. (www.wikipedia.com)

			• Low maintenance required for both solar and wind
Disadvantages	• South-facing requirement limits the number of towers at which solution is feasible • Hours of operation limited by hours of sunlight (~6 hours per day) • High CAPEX	• Current technology can only run for 10-12 hours per day • Need for trained technicians • No viable solution (business model) for a single tower	• Wind speed requirement is high and likely to require towers in excess of 50 m in height, which will raise CAPEX

The analysis shown in Figure 29 shows the cost of generation of these efficient, alternative power solutions at off-grid and bad-grid towers in comparison to the diesel-generator-only solution. As can be seen, the greener alternatives are substantially cheaper. For example, in off-grid sites, retro-fitting the standard base case with advanced batteries can reduce the cost of generation by 50%-60%, primarily driven by a reduction in diesel consumption. Diesel run time reduces from close to 24 hours to approximately 12 hours due to the retro-fitting of advanced battery systems. Adding solar PVs to the alternative power solution, reduces the generator runtime even further to approximately 6 hours per day, on average, and decreases the cost of generation by an additional 15-20%.

Figure 29: Comparison of the cost of generation of different solutions according to differential grid access

US$/kWh

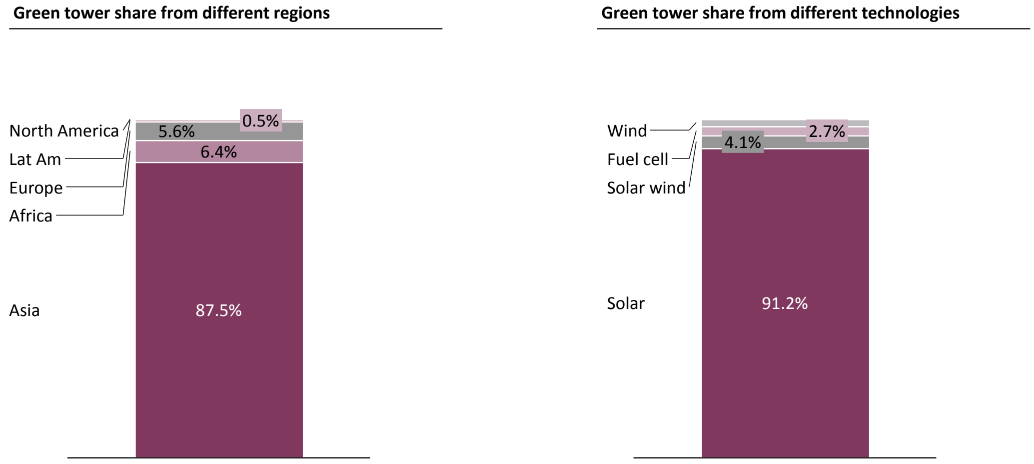


Source: Dalberg Tower Estimation and Green Potential Model; Dalberg analysis

In the last 10 years, despite growing interest from the industry, levels of adoption of green and renewable energy solutions have remained low. Only approximately 40,000 "green" sites exist in the world today. In addition, an estimated 26,000 diesel-generator and battery hybrid power solutions have been deployed in telecom tower sites globally. As shown in Figure 30, the most advanced green telecom market current exists in Asia, with close to 90% of global green deployments. China and India account for the majority of green towers in Asia. Based on current evidence, solar is the most viable renewable energy technology for deployment in telecom towers.

Figure 30: Global distribution of green and hybrid telecom tower sites

Number of green and hybrid sites

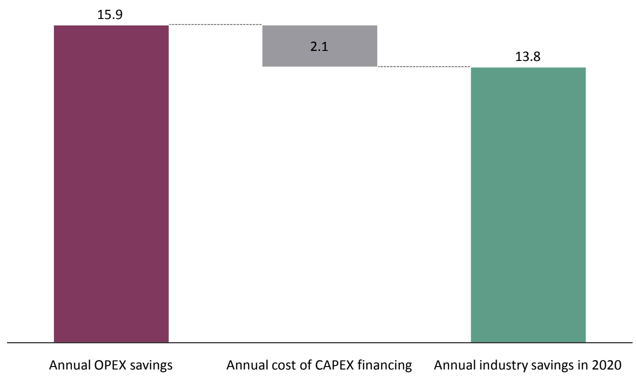


Source: Green Deployment Tracker (www.gsma.com); Dalberg analsyis

Conversion to more efficient, greener alternative tower power solutions, which include diesel generator-advanced battery[34] and renewable energy hybrid systems, could save the industry US$ 13-14 billion annually, even after accounting for CAPEX financing. Adoption of these green technologies at scale also has the potential to save approximately 40 million tons of CO_2 annually, representing US$ 100-500 million[35] in yearly carbon savings.

Figure 31: Annual industry cost savings due to transition green energy solutions

Billion US$ (2020)



(1) For retrofits, capex refers to additional capex required to convert to green power solutions, while for new sites capex refers to total capex required
(2) We assume that all off-grid towers under business-as-usual would deploy DG solutions at off-grid sites to ensure uptime and low capex
(3) A 10% annual cost of financing is used to develop the cost saving estimates
Source: Interviews with MNOs, TowerCos and ESCOs (March-April 2014); Desk research; Dalberg Tower Estimation and Green Power Model (2014); Dalberg analysis

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[34] The cost and specifications of Lithium Ion batteries were used in developing estimates for plant-level economics and green savings potential of the more efficient alternative tower power solutions mentioned above.

[35] Carbon prices of US$ 2 per ton of CO_2 (observed in some developing countries such as India, China), and US$ 10 per ton of CO_2 (observed in developed carbon markets like most of North America) were used to estimate potential for carbon savings.

3. Barriers and opportunities

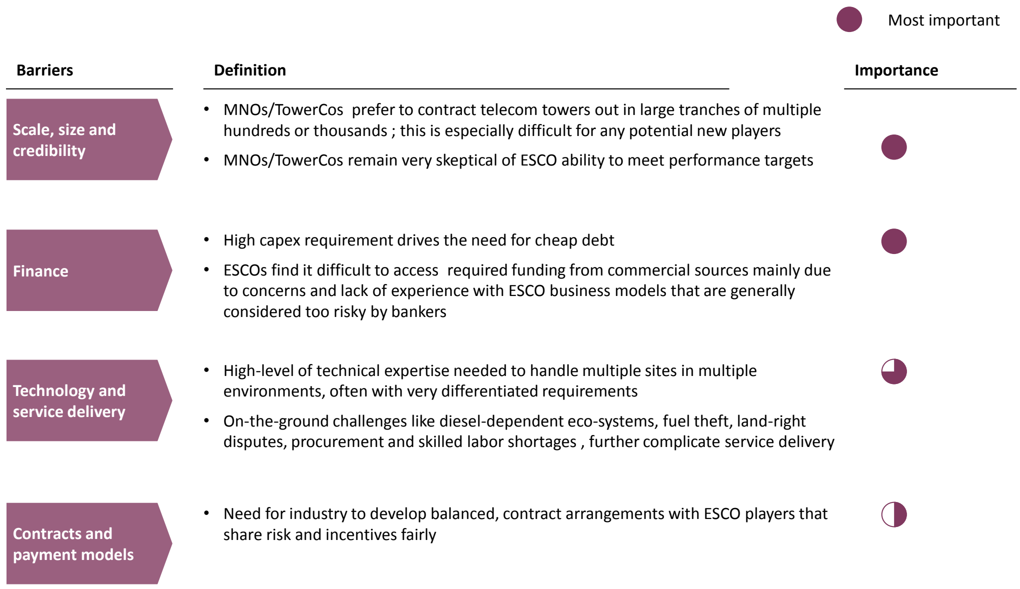
Who can drive the transition to green and renewable energy adoption?

The growth of ESCOs will be a crucial driver for the conversion to green and renewable energy alternatives providing energy to MNOs and dedicated TowerCos. MNOs will find it difficult to lead the transition efforts for the following three reasons:

- **MNOs are focused on selling off all tower infrastructures:** As explained above, many MNOs across the world, especially in Asia and Africa, are in the process of selling of their tower assets, including the energy infrastructure, to third-party structures. This trend, brought on by a strong imperative to cut network deployment and operating costs, is expected to intensify in the next six years.
- **High degree of customization/complexity at the tower level:** In a rapidly evolving tower energy landscape that requires a high degree of customization across multiple tower sites and geographies, as well as specific technical expertise, MNOs are not best-positioned to drive energy efficiency. Moreover, MNOs have an incentive to reduce complexity of non-revenue generating operations like power, in order to focus on revenue-generating parts of their business, which primarily revolve around servicing customers. They are reluctant to embrace green and renewable energy solutions that add to operational complexity, even though they may help to reduce costs in the long term.
- **Financing priorities:** MNOs place a priority on network expansion and technology upgrade of active equipment. With a limited pool of CAPEX, MNOs will always favor investments in active radio equipment over investments in energy solutions. Therefore they tend to ignore the very real cost-saving potential of green and renewable energy solutions, especially as their expectation of payback—three to four years—is quite long by industry standards. ESCOs are better placed to invest in long-term assets and amortize them over time in order to reap the full benefits of reduced costs.

Each of the two types of ESCOs—TESCOs and IESCOs—face challenges related to the transition of the industry to greener tower energy solutions. The critical barriers are discussed below. It should be noted that while the commentary and analysis considers both TESCOs as well as IESCOs, the primary focus will be on the latter, since the market environment and barriers are particularly severe for them.

Figure 32: Overview of major barriers



Source: Dalberg analysis

Among the major challenges to the growth and scale of ESCO business models, two were established as most critical during interviews with stakeholders: (1) challenges related to scale, size and credibility of ESCO players, and (2) finding access to sufficient quantities cheap debt, primarily to fund the CAPEX needed to deploy energy infrastructure at telecom tower sites. Other important barriers included technology and on-the-ground challenges to service delivery, and developing appropriate contracts and payment models.

These barriers are interlinked and often reinforce each other. For example, financing issues are a reflection of the small size, scale and lack of track record and perceived riskiness of ESCOs, in particular IESCOs. Lack of access to capital also makes it difficult to launch large-scale operations, which inhibits relationships with MNOs. Weak relationships with MNOs and unfavorable contracts gives ESCOs a poor reputation among providers of capital, further reinforcing the cycle.

ESCO business models are responsive to different conditions in regulatory environments, industrial makeup, and local telecom ecosystems in different countries. First, government approaches to stimulating and/or regulating renewable energy sectors, the telecom sector, and the convergence of the two, can have a contribution to the success of ESCO models. Certain policies, such as India's mandated 5% energy efficiency increase in telecom towers, Indonesia's obligatory tower-sharing, or Kenya's financing mechanisms for green telecom projects, are important support for TESCOs and IESCOs.

Second, the existing infrastructure, market saturation of telecom providers, industry growth, and competitive landscape within a country will no doubt have a significant impact on the nature of the energy end-users. Also, the contract terms and deployment scale they are comfortable with, and the level of maturity these MNOs or TowerCos will expect from energy providers.

For example, countries like Tanzania or Myanmar, where mobile penetration is much lower, MNOs are looking for mass tower rollouts in untested areas over a relatively short period of time. TESCOs are best-suited to these environments. Alternatively, in more mature markets like India, industry priorities have already begun to shift from further deployment to curbing energy operating expenses. In such an environment, MNOs as well as dedicated TowerCos may be more orientated toward experimentation in business models in order to upgrade their existing energy infrastructure at tower sites in the quickest and most cost-effective manner. IESCOs are bound to have greater opportunities in such countries.

Differences in local ecosystems complicate the implementation challenges which ESCOs face in the field. The labor market for skilled technicians, the supply market for energy equipment and spare parts, population density, the quality of transportation infrastructure and the strength of local policing action must all be considered.

On the whole, TESCOs are inherently better-equipped to navigate most of the major barriers. For IESCOs, the overarching challenge is that this is an industry with very high entry barriers. It is difficult to start small and grow gradually to scale over time. MNOs and TowerCo mindsets regarding IESCOs—that the small, start-ups would be unable to achieve the levels of performance required—are yet to change. These misgivings may not be completely unfounded, although the presence of several large MSP players, which resemble IESCOs in practically all activities save for ownership of the energy assets. Companies such as Cummins Power Solutions, which has over 50,000 towers in Africa, would seem to indicate that the required capabilities already exist in the market.

Figure 33: Differential impact of barriers on TESCOs and IESCOs

● ◢ ○ Increasing intensity of barriers

Barriers	TESCO	IESCO	Key Differences
Scale, size and credibility	✓ ◔	◕	Most TESCOs share good relationships with MNOs because of their existing size and scale, as well as the familiarity of their business model , relative to the IESCO business model.
Finance	✓ ◑	●	TESCOs benefit from lower CAPEX to asset ratios, making them less risky bets for financial backers. Their business models are more widely accepted by creditors and investors.
Technology and service delivery	◑	◑	IESCOs with dedicated energy business models are better suited to deal with technological challenges. TESCOs are better equipped to combat on-the-ground challenges to implementation and delivery.
Contracts and payment models	✓ ◔	◑	TESCO contracts typically have much less risk exposure and are for longer terms than IESCO, because of the tower rental agreement and the multiple tenants TESCOs have per tower unit.

Source: Dalberg analysis

These pre-existing mindsets about capabilities aside, MNOs and TowerCos would prefer to contract out their towers in large tranches of multiple hundreds or thousands, rather than in smaller batches. In the classic case of "chicken-and-egg", IESCOs are prevented from achieving scale, primarily because no scaled IESCO player currently exists.

The ability to deliver a comprehensive set of telecom tower related services, namely the procurement, installation, ownership, operation and maintenance of *all* passive infrastructure (and not just energy), in particular at scale, is the primary edge that TESCOs have over IESCOs in the market. As a result, at least over the next six years TESCOs are expected to outperform IESCOs, and extend their share of the global market. Below, further detail is provided on each of the important barriers mentioned.

Scale, size and credibility

IESCOs must establish and maintain strong business relationships with MNOs and dedicated TowerCos in order to capture and build market share. In this, they are encumbered in two important and related ways. Not only must IESCOs offer sufficient experience to persuade MNOs and, increasingly, TowerCos of their ability to provide continuous electricity coverage at telecom tower sites (99.7% uptime),[36] but they must do so at scale.

First, IESCOs must prove their credibility and capabilities to MNOs and dedicated TowerCos—that they possess the necessary technical expertise, technological resources, critical aftersales service capabilities in order to ensure continuous electricity coverage at telecom tower sites. This is particularly difficult for IESCOs because traditionally they have been pigeonholed by MNOs and TowerCos as small start-ups or "system integrators" or renewable energy-focused companies, with unclear and unproven technical and project management capabilities. Their nascence in the sector—virtually no IESCO currently exists in Africa, and only two, AST and OMC in India, have any kind of scale to speak to in Asia—and resulting lack of experience also counts heavily against IESCOs.

Secondly, MNOs as well as dedicated TowerCos seeking to outsource energy infrastructure and operations, look for partners that can operate at scale across multiple countries, and sometimes even continents. Providing contracts on a tower by tower basis to small ESCOs is expensive and unwieldy for MNOs and dedicated TowerCos. Moreover, success on a limited size does not guarantee scalability of the solutions and business model. Most MNOs and TowerCos felt during interviews that in order to generate credibility with stakeholders, ESCOs would need to develop the capability of deploying large numbers of towers, in the range of 500-1000 sites at the very least.

Access to finance

Obtaining third-party financing in order to invest CAPEX into energy generation remains the primary need for all ESCO business models to scale. The cost and availability of capital has a great impact on the capability of an ESCO to mobilize funding at a reasonable cost and bring efficiency in operational costs. The telecom sector is the second most capital intensive

[36] 99.7% uptime denotes, on average, the active radio equipment on the telecom tower i.e. the BTS, antennae, etc., may be offline ("downtime") for no more than 26 hours each year, on average. Any additional downtime, over and above 26 hours per year would trigger stringent penalties for the energy contractor (TESCO or IESCO).

industry (after power), and so any business model putting energy generation as a core activity is hugely dependent on favorable financing terms, particularly for debt financing.

Given their small size and low asset base, access to commercial sources of finance has proven particularly limiting for IESCOs. In contrast, TESCO ownership of both tower and energy assets makes them more familiar and less risky for MNOs, financial institutions and investors alike. They are able to court commercial creditors more effectively, enabling them to scale in partnership with MNOs, who are incentivized to sell off their tower assets – tower and energy assets – in bulk.

For most IESCOs and companies looking to develop IESCO business models, the most pressing need is debt financing to support either growth or working capital needs. These companies have faced challenges accessing debt because of four major reasons:

- **Quality of fixed assets considered acceptable collateral by lenders:** Most IESCO or companies looking to develop IESCO business models tend to lack fixed assets (namely, property) that are considered acceptable collateral by most commercial financial institutions. Lenders are especially wary about accepting renewable energy assets such as PV panels, wind turbines, etc. as collateral as they remain unaware and uncertain regarding product risk, lifetime, resale opportunities, etc. Even when a secondary or second-hand market exists, renewable energy assets generally have low recovery values and high recovery costs, adding to their perceived risk-potential.

- **Tenure of financing is typically too short for IESCO needs:** Most IESCOs, look for long-term financing products—typically of a 7-10 year tenure—mainly due to difficulties involved in setting up and operating in the sector. Moreover, the longer tenure enables ESCOs to effectively realize the full cost-savings potential of green and renewable energy solutions. However, banking institutions conventionally provide loans for a maximum of three to five years and most IESCOs lack the ability to repay these investments in that timeframe.

- **Lack of a sufficient financing history:** Financial institutions have eligibility criteria that include the need for companies to have a sufficient number of years (usually three) of positive cash flows, presence of a credit history, and proven profitability. While some TESCOs can provide the necessary credentials, most IESCOs suffer from a genuine lack of track record and performance history to satisfy bankers.

  Ironically, a historical lack of funding to IESCOs in particular constrains opportunities for future funding. The dearth of prominent examples of successful IESCOs further constrains their access to finance, as most financial institutions would prefer to wait-and-watch how markets evolve, restricting debt for both enterprises that have been operating in the sector for a long time as well as relatively new entrants.

  The major blockage from mainstream financial institutions is that they lack project assessment frameworks to evaluate and adjudicate ESCOs quickly and effectively. Most financial institutions do not have a dedicated framework or team for assessing IESCO projects, in particular those that use renewable energy as a core component of their business and technology value proposition. Instead commercial financial institutions tend to rely on their standard SME financing teams to evaluate these investments. These teams rely on traditional assessment models that fail to capture aspects, risks and incentives unique to the telecom tower energy sector and are not directly applicable to these projects. This challenge is even further complicated because often IESCOs (and ESCOs) use renewable energy technology that bankers have rudimentary knowledge and experience of, at best.

- **Cost of loan may be out of range for IESCOs:** Standard financing products on the market are difficult to access for most IESCOs. As illustration, IESCOs in India cited the cost of standard debt products—13-18% annually—to be too high. They would prefer, in the ideal scenario, to have interest rates in range of 7-8%. IESCOs face challenges accessing these debt instruments because they are not in a position to service the payments at interest rates charged to them.

- **Project assessment framework mismatched to IESCO enterprises:** Most financial institutions do not have a dedicated framework or team for assessing IESCO projects, in particular those that use renewable energy as a core component of their business and technology value proposition.

Technology and service delivery

The implementation of efficient power solutions at telecom tower sites is constrained by a set of challenges, as the industry at large attempts to displace an older and more established energy paradigm: resistance from stakeholders that are invested in the current technology, risks associated with theft and pilferage of diesel and energy assets, and key technological challenges. All these challenges are found in some form in the telecom industry today, and currently impede the adoption of the IESCO business models, in particular, at scale.

- **Presence of stakeholders invested in the diesel supply-chain:** The large-scale use of diesel in off-grid and bad-grid sites has led to the development of and dependence on entire ecosystems of diesel providers, transporters, wholesalers and other actors. This existing group of ground-level intermediaries stands to lose economically due to the proposed transition to alternative solutions that will reduce diesel consumption. They have a strong incentive for supply chains to remain broken and for the use of more diesel in telecom tower sites.

- These intermediary-related challenges have caused significant unanticipated consequences at pilots, which include theft of renewable energy equipment and disruption of supply of electricity to the telecom tower. Not only do ESCOs have to uncover these informal, but complex and long standing industry dynamics, but they must engage substantively with these intermediaries and develop innovative means of incorporating them into the renewable energy value proposition.

  Clearly, the solution involves active stakeholder interaction, understanding of local dynamics, and the installation of high-quality monitoring and alarm systems, which TESCOs, given their experience and longer track record in the field, are better suited to execute.

- **Pilferage and other security risks:** Indirect or hidden costs associated tower operations, primarily related to the use of diesel can often be difficult to fully attribute or estimate with any accuracy, and may be systematically under-estimated by the industry. These hidden costs, including theft and pilferage of diesel, misuse of electricity, variations in diesel transportation costs, can add up to approximately 15-40%, on average, to the nominal price of diesel. Fuel theft is a major issue in Sub-Saharan Africa and South Asia, where it can rise as high as 20-30% of the total diesel inputs. Considering that even ESCOs will rely primarily on diesel-hybrid solutions, these costs will not be eliminated entirely for TESCOs and IESCOs.

A TESCO with a standardized monitoring system applied across all its towers, and an IESCO that can integrate its monitoring system with the towers' equipment are best placed to scale effectively in such settings. IESCOs may have an edge when it comes to dedicating human resources to tracking irregularities and solving theft cases. IESCOs also have stronger incentives to reduce diesel dependency, which minimizes exposure to this risk.

- **Need for multiple technological power solutions and technical expertise, customized to specific local needs:** Because different sites have different energy potentials (sunlight, wind strength, biofuel access, etc.) a large-scale ESCO business model must offer a full panoply of energy solutions and aftersales servicing. This exacerbates all of the previous challenges because the ESCO must be able to tap into a labor and equipment market for each of its solutions, identify and manage the different technologies that pertain to different sites, and oversee a diversified energy portfolio across different geographies, regulatory regimes, and customer markets.

  In addition, ESCO personnel must be capable of installing, operating, monitoring, and repairing energy assets at scale at once. They must be capable of operating in the local context, and so will generally be drawn from the local labor pool, adding strong geographic variability to the difficulty of accessing human capital. The ability to hire, train, and retain competent individuals will impact the ability of the ESCO to provide. An IESCO focusing solely on energy assets will generally have a team that is entirely focused around energy delivery, giving it less overhead, more management attention, and a greater recruitment and training focus on energy technicians. TESCOs will need to form dedicated energy asset operations teams in order to compete.

Contracts and payment models

The primary challenge for TESCOs arises from their history and record as pass-through TowerCos that had limited or no incentives at all to reduce energy costs. This history has led to an odd inertia in the market that works against the transition to green and renewable energy solution, even though on paper they promise substantial cost reductions.

Even so, contracts between MNOs and TowerCos have evolved to TESCO arrangements in the past two to three years. The increased value proposition of TESCOs and the ease of taking on tenants, increase the chance of the TESCO maintaining long-term contracts and paying back its investors and creditors, reducing the need for extra risk-sharing or variable fee structures.

For IESCOs, the challenge lies in developing a contractual relationship with the energy buyer that effectively and equitably shares risk and reward. Fixed-fee contracts are simple from the perspective of the energy buyer, but fail to adequately capture the risk of excessive electricity consumption. While PPAs are safer for energy sellers in that buyers are charged on their actual consumption of electricity, it remains fairly difficult to estimate and agree on the per kWh price. Energy savings agreements are particularly challenging because they require significant trust, transparency and credibility from both buyers and sellers to operationalize successfully.

In addition to the nature of the contract and the specific payment model, the time period of the contract is very important. IESCOs, whose primary value proposition of zero CAPEX requirements from the buyer, need a long-term contracts of at least 5-10 years, with room for frequent and periodic renegotiations to account for potential energy price increases or increases in the demand for electricity at the tower level. Without the 5-10 year contract, which IESCOs need to be profitable, banks will be less likely to finance the company, which further increases its already high financing costs.

Going forward, as economic incentives in the industry are clarified, and the drive to decrease telecom tower energy costs gathers more momentum, TESCOs are expected to drive home their structural advantages over IESCOs and lead the transition to green and renewable energy adoption in the industry. Specifically, in the next six years MNOs will implement appropriate contract management structures in their dealings with TowerCos that would offer clear incentives for energy efficiency, innovation and most importantly cost reductions, and thereby for the transition to green and renewable energy.

It is less certain how IESCOs will fare. Their ability to provide additional impetus for the adoption of alternative energy solutions will depend primarily on two factors:

- **Funding opportunities:** Their capacity to attract funding in order to win and service large contracts from MNOs and/or TowerCos, typically for hundreds or thousands of towers at once.

- **Value proposition to TowerCos and MNOs:** Their ability to remain at the very edge of technological innovation and cost-effectiveness. Dedicated TowerCos, in particular, are then incentivized to outsource their tower energy assets and generate responsibilities to IESCOs, since employing a dedicated power company would be more efficient than deploying in-house resources. Importantly, linked to the IESCO value proposition will be its ability to provide services at a large scale (1000 towers at least). IESCOs that can offer to take over a meaningful share, if not all of an MNOs or TowerCos energy generation and management, and do so at scale (not just for small pilots) will be favoured for partnerships.

Drivers of the green transition

The discussion below is not mean to be an exhaustive synthesis of all activities and conditions necessary to accelerate the adoption of green and renewable energy technologies in the market. The discussion below simply highlights some important and fundamental interventions that can unlock growth by targeting the main sources of inertia in the market.

Banking and finance support: Commercially attractive financing mechanisms are a must, given the high CAPEX requirements. Key needs include:[37]

[37] "IFC Energy Service Company Market Analysis", IFC (June 2011).

- Low collateral requirements based on long-term contracts with MNOs and TowerCos who are well-capitalized and therefore considered creditworthy
- Construction financing
- Longer repayment timelines of at least 7 years, etc.

MNOs and TowerCos could help support the emergence of this type of financing segment offering a clear perspective on their energy outsourcing plans (e.g. 1,000 sites over 2 years). This would not only likely attract larger players to enter into the sector (e.g. Caterpillar, Cummins Power), but also allow smaller IESCOs to organize their scale up with “bankable” contracts.
Very importantly, commercial lenders at the local level require greater access to information and training to overcome their lack of awareness on the savings potential of the projects, which typically results in higher interest rates and capital costs.

Entry of large ESCO players: Thus far it appears that the telecom tower energy market has passed below the radar of the large, global power sector companies. These large players will bring the ability to scale aggressively through their enhanced asset bases, existing relationships with commercial lenders and focus on innovation and product development.

Conducive policy and regulatory environment: Local policymakers and regulatory bodies require training and policy development assistance on key issues such as the deployment of renewable-energy certificates (RECs) for green energy use at telecom towers, elimination of diesel subsidies, and tax and tariff rebates in order to incentivize renewable energy use at telecom towers.

Market intelligence and knowledge sharing: Greater data collection and effective information sharing is another important intervention that can help accelerate the market. In particular, there is a need to disseminate key financial information that would assist in making risk and return judgements for those looking to invest in or execute energy provision for off-grid and bad-grid telecom towers.

Annex

Methodology for market model

The **"Dalberg Tower Estimation and Green Power Model"** estimates the current and future number of off-grid and bad-grid towers globally. In addition, it also estimates the potential OPEX savings and investment requirement to convert these tower sites to green power. In this section, we explain the underlying architecture, key assumptions and data sources for the model.

Model architecture

The model uses percentage mobile coverage (by population) as a basis to model the number of off-grid and bad-grid towers and relies on a detailed assessment of plant level economics to estimate the potential for green power. There are four main building blocks:

1. Percentage mobile coverage (by population): denotes the percentage of the total population which is covered by a mobile signal. This population may or may not be currently using a mobile phone, but the coverage is directly dependent on the presence of a mobile tower in the vicinity. Coverage was projected up to 2020.

2. Population Density: the population density for urban and rural regions gives an indication of how densely populated the country is. This influences the number of towers needed to cover the population with a mobile network. For example, in a sparsely populated country a large number of towers will be required to provide coverage to the population (which would be spread out over a larger area).

3. Percentage electrification: refers to the percentage of the total population which is connected to the grid. This was also split by rural and urban populations. The electrification levels of the population was used as a proxy for the electrification status of the towers. Further, assumptions made are explained below.

4. Site level economics: A detailed analysis of the economics of various power solutions (solar + battery, DG + solar + battery, DG + battery etc.) were carried out for three scenarios; off-grid sites, sites with six hours of grid-based electricity and sites with 12 hours of grid-based electricity. The solution with the lowest cost of generation ($/kwh) was considered the optimal solution for each scenario. This solution was then used to calculate estimated cost savings and investment required.

We have highlighted the key assumptions, data sources and calculation for each step below:

Percentage Mobile Coverage

	Focus countries	Global estimates
Assumptions	• If total coverage >85%, urban coverage is 100%; if total coverage <85%, urban coverage is 80%	• Based on the enabling environment, countries will follow one out of three standardized growth curves for coverage

	Focus countries	Global estimates
	• For regions where coverage is 100%, tower growth is driven by growth in population	• The enabling environment depends on growth in mobile penetration, growth in GDP, EODB rankings, competition in the telecom industry and universal service obligations • *Assumptions for focus countries also apply*
Data sources	• GSMAi database for 2009 coverage • Interviews with MNOs, TowerCos and experts in each country used to determine current and 2020 levels of coverage	• GSMAi database for 2009 coverage, mobile penetration • World Bank database for GDP growth • ITU • EODB business rankings
Calculations	• The overall growth in mobile coverage is modelled using a decaying growth rate function	• Countries were assigned a score based on the drivers mentioned above • Based on the overall score, countries were classified intro three categories based on speed of expected growth in coverage • Standardized coverage curves were applied based on the category

Population Density

	Focus countries	Global estimates
Assumptions	• For focus countries, urban population density is the same as regional averages (except for India and China, for which data is available) • In urban regions, the range of a telecom tower is 5 sq. km. • In rural regions, the range of a telecom tower is 25 sq. km.	• Urban regions occupy 5% of a country's land area • In urban regions, the range of a telecom tower is 5 sq. km. • In rural regions, the range of a telecom tower is 25 sq. km.
Data sources	• World Bank Database for area • United Nations World Urbanization Prospects for current and future population • Urban population density from www.demographia.com	• World Bank Database for area • United Nations World Urbanization Prospects for current and future population

	Focus countries	Global estimates
Calculations	• Based on coverage, calculate urban and rural populations yet to be covered by mobile • Use population density to calculate corresponding area to be covered • Calculate number of towers required based on tower range	• *Same approach as for focus countries*

<u>Percentage electrification</u>

	Focus countries	Global estimates
Assumptions	• The electrification status of telecom towers is the same as the electrification status of the population • In rural regions, all towers are either in bad-grid or off-grid • All urban regions, which do not yet have coverage are bad-grid regions • Electrification will grow as per historical trends for each country	• The electrification status of telecom towers is the same as the electrification status of the population • In rural regions, if electrification is >70%, only half the towers which are not off-grid are bad-grid; if electrification <70%, then all towers which are not off-grid are bad-grid • In urban regions, 30% of all towers are bad-grid • Regional averages used for expected growth in electrification
Data sources	• World Energy Outlook 2013, IEA	• World Energy Outlook 2013, IEA
Calculations	• Number of off-grid and bad-grid towers are calculated by applying the above assumptions to the number of towers calculated after the previous step	• *Same approach as for focus countries*

<u>Site level economics</u>

Detailed site level economics were developed for multiple scenarios based on the following dimensions:

- New sites vs retrofits at existing sites
- Hours of grid electricity available (ex: 0 hours, 6 hours, 12 hours)
- Power configuration used (DG only, DG + battery, DG + battery + solar etc.)

Sample assumptions for one case have been explained below.

Assumptions for new, off-grid, DG + battery + solar

	Parameters	Assumption
Overall	Site Load *(KWh)*	*1.5*
	Rate of interest *(%)*	*10%*
	General and Administrative expenses *($)*	*2,600*
	Time period of interest *(years)*	*7*
DG	Capacity *(KW)*	*10*
	Operating load *(%)*	*50%*
	Run time (*hours/day)*	*4*
	Fuel consumption *(liters/hour)*	*1.8*
	Diesel price *($/liter)*	*1.08*
	Capex *($)*	*2700*
	Annual maintenance *(% of capex/year)*	*10%*
	4 year engine overhaul *(% of capex)*	*25%*
	7 year generator and switching system overhaul *(% of capex)*	*20%*
	Pilferage (*% of fuel cost)*	*15%*
	Lifetime *(years)*	*10*
Battery	Type	*Li ion*
	Capex *($/KWh)*	*500*
	Hours of use per cycle *(hours/day)*	*8*
	Lifetime *(# of cycles)*	*2500*
	Depth of discharge (*%)*	*80%*
	Voltage *(Volts)*	*48*
Solar	Capacity *(KW)*	*6*
	Efficiency *(%)*	*90%*
	Hours of sunlight (*hours)*	*6*
	Capex *($/watt)*	*0.8*
	Installation cost *($)*	*2000*
	Annual maintenance *(% of capex/year)*	*1%*
	% of battery charge coming from solar *(%)*	*-*
	Lifetime *(years)*	*15*

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About GSMA

GSMA represents the interests of mobile operators worldwide. Spanning more than 220 countries, GSMA unites nearly 800 of the world's mobile operators with 250 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and Internet companies, as well as organisations in industry sectors such as financial services, healthcare, media, transport and utilities. GSMA also produces industry-leading events such as Mobile World Congress and Mobile Asia Expo.

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Mobile for Development brings together our mobile operator members, the wider mobile industry and the development community to drive commercial mobile services for underserved people in emerging markets. We identify opportunities for social and economic impact and stimulate the development of scalable, life-enhancing mobile services.

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About the GSMA Green Power for Mobile Programme

Green Power for Mobile works to extend the coverage, reduce the cost and minimise the environmental impact of mobile networks by championing renewable energy.

Whilst it continues to serve mobile network operators globally, the programme will place key focus on a number of target markets in Africa and Asia including Indonesia, Bangladesh, Pakistan, Afghanistan, Nigeria, Ghana, Kenya, Tanzania, Uganda, Senegal and Cameroon. With Project Managers based in each of these regions, GPM is well-positioned to engage with the industry and address the requirements of these markets.

For more information on the GSMA's Green Power for Mobile Programme, please contact us on greenpower@gsma.com

http://www.gsma.com/mobilefordevelopment/programmes/green-power-for-mobile