



Mitigating ICT-Related Carbon Emissions: Using Renewable Energy to Power Base Stations in Africa's Mobile Telecommunications Sector

Author: Isabelle Gross

Initiative Overview

Although the ICT sector contributes only about 2% of global greenhouse gas (GHG) emissions¹, this is growing. One of the fastest-growing segments has been telecommunications: making up about one-third of the ICT sector's global carbon footprint². And within telecommunications, no market has been growing faster than that in Africa: by 2011, the number of African mobile subscribers had passed the symbolic half-a-billion mark³. Continued high growth is anticipated, with average penetration rate for the continent still only 41% compared to 76% globally⁴.

Such growth comes at an environmental cost. The adoption of mobile communication services in Africa means rollout of tens of thousands of base stations running on fossil fuels because so many parts of the continent lack reliable electricity supply. In DRC Congo, for example, 90% of Vodacom's base stations are powered solely by diesel generators, and across Africa, 90% of all base stations have a diesel generator either as the sole or backup source of power⁵. The number of off-grid, fossil-fuelled base stations is likely to rise steeply – with an estimated 75,000 being built per year in developing countries – since growth is particularly focused on rural areas: those least able to connect to the electricity grid⁶. The GSM Association thus forecasts there will be 640,000 off-grid base stations across the world by 2012⁷.

Estimates of carbon footprint per mobile subscriber are certainly coming down as technology develops: first-generation networks produce around six times the CO₂ of third-generation networks⁸. Published figures vary quite considerably, in part depending on how much of the mobile lifecycle is included. One study reports 55kg of CO₂ per subscriber per year from operational outputs (and a further 13kg for mobile and base station manufacture)⁹. Multiplied up, that would suggest an annual carbon footprint for the African mobile telecommunications sector of 27.5 million metric tonnes of

¹ Garnter (2007) Gartner estimates ICT industry accounts for 2 percent of global CO₂ emissions, Gartner, Stamford, CN <http://www.gartner.com/it/page.jsp?id=503867>

² ITU (2010) *Climate Change, ICTs and Regulation*, GSR 2010 discussion paper, International Telecommunication Union, Geneva <http://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR10/documents/GSR10-paper5.pdf>

³ Nakaweesi, D. (2010) Africa mobile phone users hit 500 million, *The Monitor*, 15 Nov <http://allafrica.com/stories/201011150298.html>

⁴ ITU (2010a) *The World in 2010: ICT Facts & Figures*, International Telecommunication Union, Geneva

⁵ Gerbier, E. (2010) *The Green Technology Programme*, Vodafone http://www.vodafone.com/content/dam/vodafone/about/sustainability/vodafone_greentechnologyprogramme.pdf and Vodafone (2010) *Vodafone Green Technology Demo*, Vodafone

⁶ Milosevic, F. (2011) *ICT Carbon Credit Programme (ICCP) for Telecom Operators*, presentation at Innovation Africa Digital Summit, Mombasa, 22-24 March <http://www.extensia-ltd.com/pagedocuments/4/6/fritz-milosevic-nedbank-capital-presentation/tab/32>

⁷ Taverner, D. (n.d.) *Green Power for Mobile: Extending Mobile Beyond the Grid*, GSM Association, London

⁸ TRAI (2011) *Consultation Paper on Green Telecommunications*, Telecom Regulatory Authority of India, New Delhi <http://www.ccaoi.in/UI/links/fwresearch/conceltation%20paper%203.pdf>

⁹ Singhal, P. (2005) *Life Cycle Environmental Issues of Mobile Phones*, Nokia, Espoo http://ec.europa.eu/environment/ipp/pdf/nokia_mobile_05_04.pdf

Mobile operator MTN provides figures for a selected list of African countries that are far below this: averaging 4.25kg CO₂ per subscriber per year, but it is unclear what this includes: the African countries within its Carbon Disclosure Project Report are South Africa, Nigeria, Ghana, Uganda and Cameroon. These show variations from South Africa where the average annual emission of CO₂ per mobile subscriber is reported as 0.29kg to Nigeria where the figure jumps to 6.9kg.

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carbon dioxide, of which between 60% and 80% is estimated to come from running the base station network¹⁰.

Leading telecoms operators working in Africa have pledged to reduce their CO₂ emissions. The Vodafone group has said for example that it would cut its emissions per network node in emerging markets by 20% by 2015 (from the 2010/11 baseline)¹¹. The main approach to be used is renewable energy, and this case study therefore looks at renewable energy sources (solar and wind energy mainly) to power base stations in rural areas as an alternative to diesel generators. It uses examples of African mobile operators that have already successfully deployed such solutions on their networks.

Application Description

A base station (BTS: base transceiver station in full) is a tower or mast mounted with telecommunication equipment (e.g. antenna, radio receiver and transmitter at the top of the mast as shown in Figure 1) that enables the transmission of mobile signals (voice and data). At the bottom of each tower, there is a shelter with additional transmission equipment, air-conditioning, battery racks and – for those that are off-grid or with unreliable electricity supply – in a separate room, the diesel generator. The electricity consumption of a BTS is on average divided as follows: transmitters: 54%, air-conditioning: 35%, other equipment: 11%¹². A typical BTS with a 4.8kW site load for example will consume 34 litres of diesel per day. On a yearly basis, this equates to more than 12,000 litres of diesel with an operating cost that can be double or triple that of an on-grid BTS according to the price of oil. In terms of emissions, this translates into an annual carbon footprint around 33.3 tonnes of CO₂¹³. The deployment of green energy solutions consists in replacing (partially or totally) the diesel generator by solar panels or a wind turbine as the main power supply of the BTS: see, for example, Figure 2.

Figure 1: Standard Mobile Base Station



Formal Drivers and Objectives/Purpose for ICT Usage

The drivers to roll out renewable energy-powered BTS are of two kinds, financial and environmental. At the mobile operator's group level¹⁴, the emphasis is on climate change mitigation initiatives. Almost all mobile operators¹⁵ have pledged to reduce the carbon footprint of their operations

¹⁰ Singhal (*ibid.*) and Vodafone (2010) *Vodafone Green Technology Demo*, Vodafone

¹¹ Vodafone (2011) *Minimising our Carbon Footprint*, Vodafone

http://www.vodafone.com/content/index/about/sustainability/eco-efficiency/minimising_our_carbonfootprint.html

¹² Author's own calculation based on data provided by mobile operator based in West Africa.

¹³ Author's own calculation based on data provided by mobile operator based in West Africa, and given each litre of diesel produces 2.68kg of CO₂ (Davies, T.W. (n.d.) *Calculation of CO₂ Emissions*, University of Exeter, UK).

¹⁴ Many mobile operations in the developing world, including many in Africa, are owned by large global telecommunications companies with group level headquarters – where all strategic decisions are made – in the global North. Examples include the Vodafone Group, Orange/FT, Telefonica, Millicom International, and MTN.

¹⁵ The example of Vodafone was given above. Orange/FT is similarly committed to reduce its CO₂ footprint by 20% by 2020 on the basis of a 2006 baseline: Pike, A. (2010) *How to evolve your radio network in an energy efficient way*, workshop presentation, Bath, UK, 22-23 April

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worldwide as part of broader corporate social and environmental responsibility strategies. These, in turn, are mainly driven by a mix of legislative and consumer pressures in industrialised country markets. With conversion of fossil-fuelled generators to solar/wind power in Africa helping reduce carbon footprints, these actions therefore contribute to the responsibility agenda.

At the country's operational level, the introduction of renewable energy solutions to power BTS enables operators to realise substantial savings on operating costs because they no longer incur the recurrent costs associated with the purchase and supply of diesel to power their BTS. It is not always clear which one of the two drivers – environmental or financial – matters more for mobile operators since the two become intertwined around the same strategy. One thing one can say is that environmental drivers come largely from outside the global South: in African countries, for example, there is rarely any regulatory framework on climate change issues, and mobile users' awareness on this topic remains very low.

Stakeholders

In Africa, most of the green energy-powered BTS projects are driven by mobile operators in partnership with renewable energy equipment manufacturers and solution providers. In Kenya, mobile operator Safaricom has worked with US-based wind power solutions provider Bergey at its BTS site in Laisamis located 200 miles North of Nairobi¹⁶. Mobile operator, Orange Côte d'Ivoire's solar base stations are powered by solar panels from manufacturer Tenesol¹⁷. On some projects, radio network equipment manufacturers (Ericsson, Huawei) and the GSM Association (as a funding and adviser partner) have also been involved. Public stakeholders (e.g. Ministry of Energy or telecoms regulators, let alone NGOs or consumer groups) are usually not involved in this type of project.

Impact: Cost and Benefits

When analysing the costs and benefits of implementing renewable energy solutions to power base stations, mobile operators look at capital expenditure (CAPEX) and operating expenditure (OPEX) and how long it will take (payback period) to recoup CAPEX by making OPEX savings. A study for mobile operator MTN on running 10 BTS in Uganda on solar energy indicates an average CAPEX around US\$49,000 per BTS, annual savings of the order of US\$15,000 and an average payback period of around three years, though with the latter figures varying depending on the price of diesel¹⁸. In Mozambique mobile operator Mcel has been replacing diesel generators with 100% solar powered systems on some of its sites. Up to 2010, it reports annual OPEX savings of US\$405,000, with a CAPEX payback of around 12 months per site¹⁹.

Some mobile operators extend the calculation of green energy benefits to include CO₂ reduction levels, thus linking their projects direct to climate change mitigation. The Mcel initiative just noted reports an overall annual saving over 5,000 tonnes of CO₂ by turning to solar power on several of its base stations. MTC, Namibia's largest mobile operator, swapped its diesel generator for a dual solar-wind power system in one pilot BTS which provides an annual saving of 4.58 tonnes CO₂ per year²⁰.

¹⁶ Bergey (2008) *Laisamis, Kenya*, Bergey Windpower, Norman, OK http://www.bergey.com/posts/2010/8/24/laisamis_kenya

¹⁷ Tenesol (n.d.) *Off-Grid – Telecom*, Tenesol, La Tour de Salvagny <http://www.tenesol.fr/fr/references/grid-telecom-orange-cote-divoire>

¹⁸ GSMA (2010) *MTN Uganda – Feasibility Study*, GSM Association, London http://gsmworld.com/documents/gpfm_mtn_feasibilitystudy_pages.pdf. Note that the actual load – i.e. the total energy consumption of the individual base station – will also affect the payback period.

¹⁹ GSMA (2010a) *Global Mobile Award Winners 2010*, GSM Association, London http://www.globalmobileawards.com/gma11_oldcontent/history_from_backup/history/winners_2010.htm#cat_id15

²⁰ Milosevic (*ibid.*)

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According to the GSM Association's green energy tracker²¹ at the time of writing there were 666 renewable energy powered base stations in Africa. Almost all were solar-powered, though with a few running on wind, solar-wind hybrid, fuel cell or bio-fuel energy. African green BTS represent around 6% of the green base stations deployed worldwide (by far the largest number – more than 60% – are in China). African mobile operators have only just begun the process of swapping existing diesel-powered BTS and rolling out new BTS powered by renewable energy sources. So far out of the 55 African countries only eleven have green energy BTS, and the 666 base stations are a tiny proportion of the many tens of thousands that exist across the continent²².

Evaluation: Failure or Success

When evaluating green BTS, there are not many failures as such but some projects did not work out as well as expected because they were either over- or under-dimensioned with regards to the power load of the BTS or did not have the correct meteorological data (particularly important for the implementation of wind-powered BTS). Mobile operators are gaining more knowledge and experience with each new project they implement and therefore there will be fewer technical glitches as time goes by.

As an example, by mid-2011, mobile operator Orange Côte d'Ivoire had rolled out 104 BTS sites powered by solar energy, mainly in rural areas (see Figure 2). It planned to roll out ten additional solar-powered sites per year until 2015, at which point renewable BTS would represent 15% of its total number of base stations²³.

Overall, the small proportion of green BTS within the total – well under 1% and possibly closer to 0.2% if GSMA figures are correct – means only a limited contribution to carbon mitigation; particularly considering the rapidity with which new BTS – including off-grid BTS – are being built. However, they do represent some contribution, with a verdict that something is better than nothing. If a significant dent is to be made in the telecommunications sector's CO₂ emissions, then there will need to be a significant scaling up; something that will likely require involvement of other stakeholders including government, consumer groups, and international organisations.

Figure 2: Solar powered BTS – Côte d'Ivoire



²¹ GSMA (2011) *Deployment Tracker*, GSM Association, London <http://apps.wirelessintelligence.com/green-power/tracker/>

²² GSMA (2011: *ibid.*). As examples of numbers of base stations, Vodacom – with a 58% market share – had roughly 10,000 base stations in operation in South Africa in 2010: Vodacom (2010) *Vodacom Annual Report 2010*, Vodacom, Midrand, South Africa http://vodacom.investoreports.com/vodacom_ar_2010/business-overview/technology-and-resources/; there were reported to be around 20,000 base stations in Nigeria in 2011: Nkanga, E. (2011) Nigeria, ICT devt will contribute to GDP growth, says minister, *This Day*, 1 Sept <http://allafrica.com/stories/201109010866.html>; and Mobinil – with a 43% market share – had 6,500 base stations in Egypt in 2008: Balancing Act (2008) Mobinil launches 3G services in Egypt, *Balancing Act*, 421, Sept. By comparison, India had an estimated 250,000-340,000 in 2010: Shah, B. (2010) *Cellular Base Stations*, Indian Institute of Forest Management, Bhopal, India & Chadha, M. (2010) Solar power cellphone towers in India to reduce 5 million tons CO₂ emissions, *Clean Technica*, 24 March. On that basis, one may estimate the total number of BTS in Africa in mid-2011 to be 150,000-350,000.

²³ The author's own conversation with a representative of mobile operator Orange Côte d'Ivoire.

Enablers/Critical Success Factors

A **positive cost/benefit equation** has been central to the roll-out of green BTS that has so far occurred. The financial aspects have been noted above, and the benefit side of the equation is further strengthened by the positive environmental reporting that telecoms firms can lay claim to as a result of their renewable energy investments.

One key to the extent of carbon mitigation is **choice of technology**. For example, using solar power in combination with a diesel generator for a hybrid system requires a lower level of capital investment but provides lower CO₂ savings (GSMA estimates 2,685 of these in addition to 10,245 green BTS worldwide in 2011)²⁴. By contrast, a fully-green system using a combination of solar- and wind-based battery charging (a mix used by operators to guarantee 24/7 uptime since neither solar nor wind are 100% available) would minimise operating costs and maximise emissions reductions, but cost much more for capital investment.

Constraints/Challenges

As is perhaps reflected in the relatively limited extent of green BTS roll-out, the programme faces a number of important challenges:

- **Technical complexity and expertise constraints** create difficulties for the mobile operators²⁵. Most African telecoms engineers are familiar with BTS powered by diesel generators because this is what they have been working with since the launch of mobile telephony. There is much less expertise available on renewable energy solutions in all areas: planning, implementation and maintenance.
- A number of renewable energy technologies face **generation challenges**. For instance – and somewhat ironically given the connection to climate change – there are meteorological limitations. By and large – in much of Africa – these do not relate to sunshine and solar power but to the right level of wind (not too much, not too little) for wind-powered system. In South Africa for example, only the southern coastline is well suited for wind power. Côte d'Ivoire has rather limited suitable sites compared to Senegal²⁶. In addition, long-term availability of fuel sources for alternative technologies may be problematic. In 2006/07, Ericsson, MTN and the GSM Association undertook a bio-fuel pilot in Nigeria that established the operational feasibility of using it as an energy source for standard base stations. However, the pilot – and ideas of future expansion – was terminated because of the lack of bio-fuel availability within the country²⁷.
- **Eligibility constraints** mean that not all base stations are suitable for renewable energy systems: those with high loads (i.e. high power requirements) would need an unviably large space of solar panels (which generate relatively small amounts of electricity per panel), particularly where space is limited as in urban areas; and would require an unviably large investment cost, particularly as such stations would typically need multiple types of renewable energy.
- An emergent challenge has been that of **theft**. There have been problems with siphoning diesel from traditional off-grid BTS, but theft of solar panels, wind generators and batteries is also an issue²⁸. For one African mobile operator, this had reached such proportions they were considering not rolling out any more solar-powered BTS.
- **Financing** the capital cost of green BTS is a further obstacle. Most renewable energy projects are financed entirely by mobile operators from their own internal funds. Not all operators in Africa necessarily have plentiful supplies of capital for investment in green projects. Even those with

²⁴ GSMA (2011: *ibid.*)

²⁵ Milosevic (*ibid.*)

²⁶ The author's own conversation with a representative of mobile operator Orange Côte d'Ivoire.

²⁷ ITRealms (2008) GSMA says Nigeria lacks biofuel feedstocks, *ITRealms Online*, 29 Oct

<http://itrealm.blogspot.com/2008/10/gsma-says-nigeria-lacks-biofuel.html>

²⁸ Milosevic (*ibid.*)

capital still have to choose between competing infrastructure investments. So for example why would a mobile operator invest in renewable energy projects (offering a long term saving) when more 3G base stations are needed (increasing revenue prospects in the short term)?

- Beside financial considerations – and reflected in their financial decision-making – the **mindset** of mobile operators remains the biggest challenge. They have a negative perception about the reliability of renewable energy solutions (e.g. the BTS will go down if there is no wind!) compared to the old and well-known diesel solutions and a risk aversion to technologies that they have yet to completely master.

Recommendations/Lessons Learned

For most African countries, the central issue is resolution of the chronic deficit in electricity production. However, this is not an excuse to put aside the issue of climate change. Mobile operators – at the heart of the telecommunications success story in Africa – have shown some interest by piloting projects that reduce carbon emissions and enable them to operate in a more environmentally sustainable way. But the scale of deployment of green BTS in Africa is yet too small to have any significant impact on climate change. The challenge that lies ahead of them is to scale up to a level where these new technologies will have a real climate impact.

Identifying pressure points will be important in understanding what will drive the operators to take more widespread action. As noted, the main environmental pressures have so far come from outside Africa, and there needs to be more effort to identify and build local environmental drivers. One impact of this absence has been a disjuncture between the global and the local: carbon mitigation is a top-down strategy coming from group level headquarters in the global North; by contrast national operational priorities are often for network expansion, with green BTS having to fight their case alongside many other priorities. With the environmental agenda being seen as top-down and externally-driven, this has limited the participation of local stakeholders – employees, customers, government, civil society – in a debate about ICTs and climate change.

Greater sharing of knowledge and expertise is required. The GSM Association has been an important clearinghouse, but there still seems to be too little known within national operators in Africa about the specifics of planning and implementing green BTS solutions. This partly explains the very limited percentage of BTS in Africa converted to renewable energy; and Africa's small share of global green BTS. Greater sharing of information and knowledge – including sharing between operators and renewable energy suppliers – may also slowly help to change operators' mindsets, and make green BTS more of a norm rather than an exception.

A **greater variety of funding sources** is needed; particularly dedicated sources where operators are not faced with the opportunity costs that often, to them, look like "be bigger or be greener". Government incentives for renewable energy could help; as could tapping into broader initiatives. For example, in 2011, South Africa's Nedbank Capital launched a carbon credit-related initiative for African telecom operators²⁹. It allowed the operators to access global carbon credit markets (without having to understand the complexities of those markets and regulations), and thus earn additional income from providing renewable power sources for their base stations. It is possible that public-private partnerships might have some role to play, but direct action by government can also help. Again in 2011, the Senegalese government announced it would use its ICT universal access fund to invest in energy saving projects³⁰. Although not directly linked to base station power, it is clear that the potential exists to use universal access funds in this manner.

²⁹ Milosevic (*ibid.*)

³⁰ Dabo, B. (2011) Fonds de soutien de l'énergie du Plan Takkal, *Reussir*, 5 Mar <http://www.reussirbusiness.com/12763-FONDS-DE-SOUTIEN-DE-L-ENERGIE-DU.html>

Data Sources & Further Information

Isabelle Gross, Balancing Act, igross@balancingact-africa.com

Data for this case study was gathered by the author through contacts with mobile operators in Africa, and as part of writing an earlier paper in 2011: *Energy for Cellular Base Stations in Africa* - <http://www.balancingact-africa.com/reports/telecoms-and-interne/energy-for-cellular>

Another source of further information are the Green Power for Mobile reports produced by the GSM Association: http://www.gsma.com/our-work/mobile_planet/green_power_for_mobile/resources.htm

EDITORS:

Richard Heeks
Angelica Valeria Ospina

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The **Climate Change, Innovation and ICTs** project is an initiative led by the Centre for Development Informatics (CDI) of the University of Manchester, UK, with funding support from Canada's International Development Research Centre (IDRC). Further information about the project and related resources can be found at: <http://www.niccd.org>



2012