giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

IRENA International Renewable Energy Agency

TURNING THE URBAN RAIL SYSTEM GREEN

NEW DELHI, INDIA

Operation of the Delhi metro system requires massive electricity consumption

Cities can pursue renewable energy deployment in urban settings through public ownership of utilities and other entities that deliver basic services such as water provision or transportation. Steering such entities to boost their renewable energy use can inspire others, not just in one city but in the surrounding country or region.

Successful solar deployment has spurred plans for a renewable-powered metro system

The government-owned Delhi Metro Rail Corporation (DMRC) provides one such example. In 2014, DMRC started to harness the solar energy potential of its metro station rooftops by inviting bids from private developers through a tendering process. By March 2017, it had commissioned an installed capacity of 20 MW peak (MW_p) of solar energy on the roofs of metro stations, depots and other office buildings through power purchase agreements (PPA); (DMRC, 2017a). In addition, DMRC has signed a power purchase agreement with the state government of Madhya Pradesh to procure 24% of the electricity generated from the Rewa Ultra Mega Solar Project (Government of India, 2017).

The success of solar deployment and procurement, and in particular the fact that these sources cost less than buying power from conventional distribution utilities, has inspired DMRC to develop more ambitious plans. These would allow the company to run the entire metro system in a climate-neutral fashion by 2021.

The challenge of powering urban transport

The Delhi Metro Rail Corporation Ltd. (DMRC) was established in 1995 as a government-owned company with equal equity participation of the Government of New Delhi and the Government of India (DMRC, 2018). Having started operations in 2002, it is India's first modern metro system. Today, it is the 13th largest metro system in the world with 288 kilometres of track and 208 stations, of which more than 100 are elevated with most of them suitable for solar PV (DMRC, 2018). It caters up to 3.3 million passengers daily (DMRC, 2016a).

The operation of the metro system requires a huge amount of electricity. Between 2015 and 2016, the metro consumed more than 700 million kWh, sufficient to meet the annual electricity requirements of over 700 000 people in India (DMRC, 2016b). This number is based on per capita consumption of approximately 1 000 kWh/person. DMRC has traditionally purchased the electricity from distribution utilities for Rs 6 to 7 per kWh (around USD 0.08 to 0.09 per kWh).[1] The price has historically increased by between 3% and 5% each year in the last decade. By contrast, rooftop solar developers are offering electricity at a flat rate of around Rs 5 to 6 per kWh for 25 years. The abundance of roof space and the rapidly falling cost of technology have provided the opportunity for DMRC to secure lower electricity prices over the long-term.

Dehli has the 13th largest metro system in the world, with 288 kilometres of track and 208 stations

1 The exchange rate used throughout this report is INR 1.00 = USD 0.01544, based on an average exchange rate for 2017 (January–October), www.oanda.com/currency/average

Actions taken

The Delhi Metro Rail Corporation identified the business models, key partnerships and external expertise required to support the pilot phase and subsequent scaling-up of a renewable energy-powered metro system. Putting in place a 2 MWp solar rooftop plant under a RESCO model showcased the financial feasibility of expanding the model across the entire metro rail system.

Solar applications piloted at metro stations

DMRC initially piloted rooftop photovoltaic (PV) power plants on three sites. The pilot projects were used to carry out three key activities:

Identifying a business model. The pilot projects used a renewable energy service company (RESCO) business model. This model involves DMRC purchasing electricity through a PPA directly from a developer (the so-called RESCO) who invests in, owns and operates the plant. To choose the RESCO, DMRC invited bids from private developers through a tendering process. In their bids, developers offered prices for the electricity generated over the next 25 years from rooftop plants on DMRC's buildings. The RESCO model was preferred because it allows the renewable energy equipment to be owned, operated and maintained by the solar developer rather than by DMRC themselves.

Shareholder engagement and leadership/commitment. The Government of New Delhi and the central government, as equal shareholders of the DMRC, encouraged the piloting of solar applications inter alia through their representation on DMRC's management board. As a government entity, DMRC was able to establish contacts with another government-owned entity, the Solar Energy Corporation of India (SECI), which organised, prepared, announced and evaluated the tenders on behalf of DMRC. The central government subsidised 15% of the capital costs as part of its ongoing promotion of rooftop solar (MNRE, 2017).

Capacity development. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) provided technical support and detailed feasibility studies to DMRC for three sites, identifying a potential capacity of 2 MW_p (GIZ, 2018). The potential considers detailed shading analysis on building roofs such as shadow from outdoor AC units, telecom antennas, water tanks etc. GIZ also supported capacity building efforts among DMRC officials on how to realise the rooftop PV potential.

The 2 MW_p installed under the pilot project became the largest roof top plant in New Delhi operated under the RESCO model. Private developers were offering a price of approximately Rs 5.5 to 6.5 per kWh (USD 0.085 to 0.10 per kWh), fixed for 25 years. These prices are generally found to be cheaper than the current and future electricity prices of distribution utilities.

The Delhi Metro by 2017 had commissioned solar rooftop systems with 20 megwatts-peak capacity

Scaling up and outreach

The pilot intervention showed that the application of solar PV is a cost-competitive business opportunity for DMRC, with savings accruing from day one of the project. Also, the experience and knowledge gained throughout the pilot helped DMRC develop more ambitious plans for the further deployment of solar PV. Organising auctions directly, DMRC commissioned 20 MWp of solar rooftop systems across its metro network by 2017 (DMRC, 2017b). This incorporates the National Capital Territory region including parts of Haryana and Uttar Pradesh, where some solar systems are installed.

By 2021, DMRC plans to turn the Delhi Metro into a completely climate-neutral entity, by raising cumulative solar PV capacity to 50 MWp (Delhi Metro Rail, 2017) and procuring power from utility-scale solar park projects. Delhi Metro became one of the off-takers from the Rewa Solar Park in the state of Madhya Pradesh, located nearly 800 kilometres outside the city's boundaries (Mondal, 2017).

DMRC is involved in sharing experiences and awareness-raising initiatives to motivate metro operators in other municipalities to undertake similar efforts. More than 150 representatives from railways and metro rail corporations participated in a January 2015 workshop organised by DMRC in partnership with GIZ, the Institution of Engineering and Technology (IET UK) and the Institution of Railway Electrical Engineers (IREE); (DWHI, 2015).

The pilot projects used a renewable energy service company (RESCO) business model

Results to date

The activities of DMRC show that the application of solar PV is not only feasible but even profitable for metropolitan rail authorities. Electricity prices offered by solar PV developers are lower than current and expected future electricity prices of distribution utilities, leading to financial savings for DMRC.

Other co-benefits include job creation. A study led by the Natural Resources Defense Council (NRDC, 2014) identifies 33.75 full time equivalent jobs per MW over the 25-year lifetime of a generic rooftop solar photovoltaic plant. In 2016, strong growth in solar PV installations boosted employment in India to 121 000 jobs in the solar rooftop sector, 17% higher than in 2015 (IRENA, 2017). The project will also result in GHG emissions savings of approximately 70 000 tonnes of CO_2 (tCO_2) per year once 50 MW of installed solar power capacity is in place.

The success of pilot interventions has inspired DMRC to formulate more ambitious plans for the future. DMRC has been also advising other metro corporations to help replicate its efforts and up-scale solar PV in the transport sector in Indian cities. These include the Chennai Metro Rail Project. The replicability potential is significant, as about a dozen large Indian cities are currently designing their own metro rail systems and some are considering Delhi's model.

Lessons for other cities

Secure buy-in from public shareholders. The Government of New Delhi and the central government both hold seats on the DMRC management board. Their support has been essential in carrying the plans of the rail corporation forward. DMRC was thereby able to use its shareholders to connect with organisations that helped the implementation of pilot interventions, among them GIZ and the Solar Energy Corporation of India (SECI). With subsidies from the national government, SECI conducted a tender in early 2013 to select a developer of rooftop solar plants, including for the Delhi Metro Rail. (SECI, n.d.). The role of the city-level government consisted mainly of supporting public utilities through its shares, while its convening power also helped DMRC mobilise a network of stakeholders.

Develop the necessary technical capacity. The DMRC benefitted from the support of the GIZ and SECI to implement pilot interventions and develop the necessary in-house expertise and knowledge. SECI organised the initial auctions while GIZ provided training to DMRC´s staff and helped to structure the project through background studies. Public utilities and cities often face similar technical constraints when piloting solar applications. Bringing in the technical expertise for pilot intervention with a view to scale up renewable energy provision independently is thus a crucial first step. The choice of business model can reduce the technical challenges in this regard. In this case, the RESCO model that was used gave the responsibility to operate the plants to the developer, which focused on the core business of power generation.

Build on the success of pilots. DMRC first implemented pilot interventions whose success served to formulate a comprehensive solar policy. The underlying idea behind this approach was to create a convincing case to spur further efforts. Indeed, the profitability of the first solar applications helped DMRC in its strategy to place solar energy at the forefront of its energy plan. After the first rooftop plant was inaugurated in 2014, DMRC launched its ambitious plan to achieve 20 MW of rooftop solar by 2017/2018. Currently, DMRC is pursuing even more ambitious plans, aiming to run the entire metro system on a climate-neutral basis by 2021.

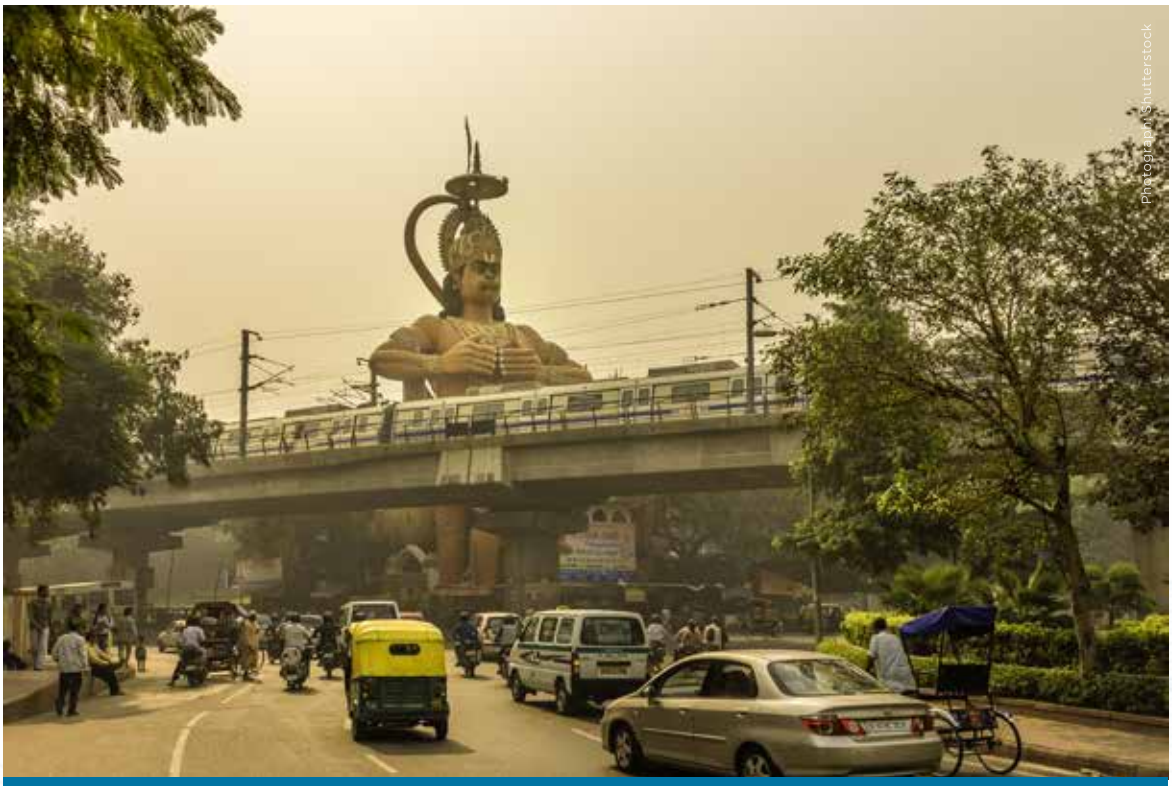
National and municipal governments encouraged collaboration on solar deployment

Higher-level policy support. For cities and municipal public utilities, efforts have to be co-ordinated with regional and national levels of government to achieve results. In India, the central government identified the development of solar energy technologies as one of the eight National Missions for climate protection in 2008. As a result, the government launched the "Jawaharlal Nehru National Solar Mission" (JNNSM) which aims to develop and deploy 100 GW of solar energy by 2022 (Government of India, 2015; MNRE, n.d.). Rooftop solar systems are envisioned to make up roughly 40% of the targeted capacity. The plans of DMRC are directly aligned to the solar mission of the national government, and this is one reason DMRC was able to secure buy-in from its public shareholders.

Impact summary	
Capacity installed so far	20 MWp
Plans: Capacity installed by 2021	50 MWp
Capital subsidy	15% of capital cost*
Electricity price (by private developers)	Rs 5.5 to 6.5/kWh (USD 0.085–0.10/kWh)
Financial savings since project launch	Approx. Rs 1/kWh (USD 0.015/kWh) at least
Expected GHG emission savings with 50 MW of installed solar power capacity	70 000 tCO_2 per year

Source GIZ India (2016).

* Initial projects received a 30% subsidy, later capacity received 15% (as indicated here). Future capacity will receive no subsidy.



Photograph: © shutterstock

A national solar mission aims to deploy 100 gigawatts by 2022

References

DMRC (2017a), *Delhi Metro becomes first ever Metro to get Green Certification for all its major Buildings – Achieves the Target of generating 20 MW Solar Power by 2017*, Delhi Metro Rail Company, www.delhimetrorail.com/press_reldetails.aspx?id=2Dt8jWU1N2clld, accessed July 2017.

DMRC (2017b), *Renewable Energy*, Delhi Metro Rail Company, 31 March 2017, www.delhimetrorail.com/renewable.html, accessed April 2018.

DMRC (2016a), *Over 33 lakh passengers travel by Delhi metro on 17th August 9; highest ridership records set so far this month out of top 10*, Delhi Metro Rail Company, www.delhimetrorail.com/press_reldetails.aspx?id=ziW90Fh2LBwlld, accessed April 2018.

DMRC (2016b), *DMRC Sustainability Report 2015–2016*, Delhi Metro Rail Company, www.delhimetrorail.com/otherdocuments/Sustainability-Report.pdf, accessed August 2018.

DWHI (2015), *GIZ organises workshop to promote solar energy in metro and rail transport sector in India*, German Centre for Research and Innovation, Delhi, January 2015, www.dwih.in/content/giz-organises-workshop-promote-solar-energy-metro-and-rail-transport-sector-india.

GIZ (2016), *Climate Change Mitigation: India invests in Solar Energy*. *Train of the Delhi Metro Rail*, image, www.giz.de/en/workingwithgiz/35868.html.

GIZ India (2016), *Cleaning of PV Panels*, image, accessed November 2016.

GIZ (2018), Email communication with Sandeep Goel, GIZ India Activity manager for the detailed feasibility studies for three project sites in 2013, 8 September 2017.

Government of India (2017), *Power Purchase Agreement for Rewa Ultra Mega Solar Power Project signed*, Press Information Bureau, http://pib.nic.in/newsite/PrintRelease.aspx?relid=161084, accessed 23 April 2017.

Government of India (2015), *Revision of cumulative targets under National Solar Mission from 20,000 MW by 2021–22 to 1,00,000 MW*, Press Information Bureau, 17 June 2015, http://pib.nic.in/newsite/PrintRelease.aspx?relid=122566.

IRENA (2017), *Renewable Energy and Jobs – Annual Review 2017,* International Renewable Energy Agency, Abu Dhabi, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/May/IRENA_RE_Jobs_Annual_Review_2017.pdf.

MNRE (2017), *National Solar Mission – An Appraisal. 28th Report*, Standing Committee on Energy (2016–17), Ministry of New and Renewable Energy, Sixteenth Lok Sabha, p. 29, http://164.100.47.193/lsscommittee/Energy/16_Energy_28.pdf, accessed April 2018.

MNRE (n.d.), *Towards Building SOLAR INDIA*, Jawaharlal Nehru National Solar Mission, www.mnre.gov.in/file-manager/UserFiles/mission_document_JNNSM.pdf, accessed November 2016.

Mondal, D. (2017), "Delhi metro signs power purchase agreement with Madhya Pradesh for Rewa project," The Economic Times, 17 April 2017, https://energy.economictimes.indiatimes.com/news/renewable/delhi-metro-signs-power-purchase-agreement-with-madhya-pradesh-for-rewa-project/58225878.

NRDC and CEEW (2014), *Making Use of the Roof: Employment generation from Hero MotoCorp's 80 KW Rooftop Solar Project in Haryana India*, Issue Paper, NRDC International India, Natural Resources Defense Council and Council on Energy, Environment and Water, August 2015, www.nrdc.org/sites/default/files/renewable-energy-solar-jobs-hero-IP.pdf.

SECI (n.d.), *SECI and DMRC sign MoU*, www.seci.gov.in/upload/files/what_new/news/568e5b8553e48PressreleaseDMRCMoU.pdf, accessed April 2018.

Acknowledgements

This case study was prepared in co-ordination with the German Agency for International Co-operation (GIZ), under the guidance of Rabia Ferroukhi (IRENA). Content was authored by Joerg Gaebler, Sandeep Goel and Robert Kirchner (GIZ). IRENA colleagues Laura El-Katiri, Jinlei Feng, Ghislaine Kieffer, Verena Ommer, Michael Renner also provided valuable input.