Case Study

Delhi Metro Rail Corporation

October 2010
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Executive Summary

The Delhi Metro started with an 8.5 kilometre link from Shahdara to Tis Hazari in December 2002. It has since extended to 152 kilometres, catering to almost 15 lakh people. Over the past eight years, it has proved to be the backbone of the public transport system in the capital.

A large number of people have shifted from private vehicles, buses and autos to metro for daily travel for several reasons. First, auto rickshaws are not reliable despite laws requiring the use of metres, and travel by bus is time consuming. Second, private vehicles are expensive due to fuel costs and difficult to use due to limited car parking space. Finally, travelling by metro avoids being stuck in traffic for long hours thus saving both time and energy.

The Delhi metro has been praised for its cleanliness and punctuality. The train design is up-to-date - with air-conditioning facilities and power outlets in each compartment.

Urban transport experts say that the metro’s signalling and safety provisions are the best in the world. The system provides intercom facilities for the passengers to speak to the driver in case of an emergency. Continuous automatic train control (CATC) is used to ensure a safe system. The rail corridor (surface and elevated rail) uses Automatic Train Protection (ATP) and an Automatic Train Stop system. The metro corridor (the subway section) is built on an Automated Train Operation (ATO) system. Today, the metro runs at a maximum speed of 50 kilometres per hour.

A well-trained maintenance staff ensures that commuters abide by station rules. Public urination, spitting, drinking and eating are strictly prohibited and security staff are authorised to fine violators. A new law enforcement body, the Delhi Metro Police, has been set up to specifically deal with law and order issues on the metro.

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1 Automatic Train Control is a system of automated rail features: ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision). ATP keeps trains a safe distance apart. It has a control unit for each block which receives data from the blocks ahead, converts it into a speed limit for the block it controls and sends the speed limit data to the track. The train picks up the data using the codes transmitted along the track. The transmission system can track circuits, loops or beacons (balises) located along the track. The data received by the ATP control unit is usually limited to indicating that a train is in the block or the speed limit currently imposed in the block. This data is sent to the ATS computer where it is compared with the timetable to determine if the train is running according to schedule or is late or early. To adjust the train’s timing, the ATS can send commands to the ATO spots located along the track.
DMRC is the proud implementing agency of a social sector project which has benefited a wide section of the state’s economy. A rail based system like the metro has a good carrying capacity and is non-polluting to the environment. It only uses one-fifth energy per passenger-km compared to a road based system. Moreover it is fast, reliable, safe and comfortable for the commuters.

**Background**

**The Making of the Metro**

The history of metro planning in Delhi dates back to the 1970s. The Central Road Research Institute (CRRI) undertook the first exhaustive study on traffic and travel characteristics of Delhi in 1969-70. After examining several alternatives, CRRI recommended a Mass Rapid Transit system for Delhi. At a later stage, the Metropolitan Transport Team (MTT) and Ministry of Railways reviewed the recommendation, made a few modifications, and prepared a plan to construct the system. The system envisioned was to be 36 kilometres of underground corridors aligned on two axes - North-South and East-West corridors - and 96 kilometres of surface rail corridors. This was the beginning of Metropolitan Transport Project.

CRRI’s study on Delhi’s travel needs stood alone until 1981. Further transport projection was assigned to Town & Country Planning Organisation. The body planned to construct a 58 kilometre underground and 195 kilometre surface corridor. The Delhi Development Authority (DDA) also prepared a perspective plan for Delhi (MPD-2001) in 1984, suggesting a multi modal transport system comprised of 200 kilometres of a Light Rail Transit System, 10 kilometres of Tramway, an extension to surface rail system, and extensive road networks.

Due to rapid growth, especially along the western and eastern parts of the city, a study group was appointed by the Ministry of Railways, Government of India to recommend a precise alignment for the East-West corridor and in 1987, a Task Force was appointed for assessing the choice of exact construction technology.

RITES, a government enterprise that works on railway engineering projects, prepared a feasibility report and suggested an Integrated Multi Modal Mass Rapid Transport System to be comprised of Rail corridors, Metro corridors and bus services. The final plan was to construct sections and implement them in a sequence based on passenger kilometre carried per kilometre length of each section.
The Delhi Metro Rail Corporation Limited was registered in May 1995 under the Companies Act, 1956. It has equal equity participation of the Government of India and the Government of the National Capital Territory of Delhi. DMRC became the special purpose organisation vested with powers to execute the metro project that would involve many technical complexities, in a difficult urban environment, to be completed within a limited timeframe.

**New Delhi over time**

Delhi has experienced a huge growth in population over the last few decades— from 57 lakh in 1981, to 162 lakh in 2006 and is poised to reach 190 lakh by the year 2011. In turn, the number of motor vehicles is increasing at a rate of 6.21 per annum, bringing the number of motor vehicles in Delhi to more than that of Mumbai, Calcutta, and Chennai combined. This has resulted in extreme road congestion, slowing of road movement, increases in road accidents, fuel wastage and environmental pollution— motorized vehicles alone are contributing to about two thirds of the atmospheric pollution. Moreover, it has resulted in a chaotic situation where the average number of persons killed per day due to motor vehicle accidents has increased to 5 and injuries to 13. As a result, there is a clear need to provide an efficient mass transport system to prevent future deterioration of the situation.

### TRANSPORT IN DELHI

<table>
<thead>
<tr>
<th>Population growth</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1833-1,20,000 people</td>
<td>5 fatal accidents everyday</td>
</tr>
<tr>
<td>1936-6,00,000 people</td>
<td>3 major accident injuries everyday</td>
</tr>
<tr>
<td>1991-93,70,000 people and 18,12,967 vehicles</td>
<td>Buses—main source of road accidents</td>
</tr>
<tr>
<td>2015-209,00,000 people</td>
<td>Main source of pollution: vehicular 64%</td>
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<tr>
<td></td>
<td>70% of pollution contributed by 2 wheelers</td>
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<tr>
<td></td>
<td>Vehicle population of Delhi higher than cumulative vehicle population of Mumbai, Kolkata and Chennai</td>
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</tbody>
</table>

Today, the Delhi Metro Rail Corporation Ltd. has completed a 65.10 kilometres route in Phase-I and 121 kms in Phase –II.

The DMRC aims to cover the entire city with a metro network by the year 2021 and provide world class services in terms providing commuters with a safe, reliable, punctual, comfortable and affordable mode of transportation. It promises to maintain full transparency in all decisions and transactions. It guarantees that metro construction will not inconvenience or endanger public life nor lead to ecological or environmental degradation.

**Key Features**

- December 2002- 65.10 km phase-I between Shahdara and Tis Hazari. The metro was built at the cost of 10,571 crore.
- October 2010- 124.63 km phase-II
- To be completed by 2021- Phase-III and phase-IV will add another 115.59 km and 108.50 km respectively
- Total length of Delhi Metro is projected to be 413.1 km. At present it is 95.53 km.

**Objective**

To provide a safe, reliable, comfortable, low-cost and environmentally friendly mass transport system for the city of Delhi. It aims to operate on sound commercial lines obviating the need for Government support.

**Working Design**

A passenger travelling from Moolchand to Sarita Vihar shares her metro ride experience:

“...I had to pay a visit to my aunt in Sarita Vihar so I decided to take an auto from my residence in Safdarjung Enclave to go to Moolchand metro station because it is the direct route to my destination. The staff at the ticket counter was helpful in giving me directions to the correct platform and I had to wait for about 5 minutes to board the train. The ticket cost me 15 rupees and a token was given to me which I had to flash at the ticket gate. What I noticed was a lady security guard sitting next to me and when asked, she too was very helpful in telling me that Sarita Vihar was only 5 stations away. There were around 10 seats reserved for senior citizens and disabled persons. The announcements were clear and there was a digital display...
board to let us know which station we were at. I had a comfortable 20 minute ride without delays. I found the metro extremely useful for covering long distances in the city...”

Construction of Delhi Metro
The construction of the first phase of Delhi Metro was during 1995-96 to 2004-05 and second phase from 2005-06 to 2010-11. In 2004, the total cost of the Delhi Metro for both phases was estimated to be Rs 64,060 and Rs 80,260 million respectively. Phases III and IV will cover the rest of Delhi and also stretch to some areas in the neighbouring states. By 2015, new areas will be brought onto the metro map and more people will have access to the MRTS network.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Corridors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shahdara-Barwala (22 kms)</td>
<td></td>
<td>Vishwa Vidhyalaya-Jahangirpuri (6.36 kms)</td>
</tr>
<tr>
<td>Vishwa Vidhyalaya-central secretariat (11 kms)</td>
<td>Central Secretariat-Qutub Minar (10.87 kms)</td>
<td></td>
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<tr>
<td>Barakhamba road-Dwarka (22.8 kms)</td>
<td>Shadhi-Dilshad Garden (3.09kms)</td>
<td></td>
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<tr>
<td>Barakhamba road-Indraprashtha (2.8 kms)</td>
<td>Indraprastha-New Ashok Nagar (8.07 kms)</td>
<td></td>
</tr>
<tr>
<td>Extension into Dwarka sub city (6.5 kms)</td>
<td>Yamuna Bank-Anand Vihar ISBT</td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td>(6.16 kms)</td>
<td>Kirti Nagar-Mundka (18.47 kms)</td>
</tr>
<tr>
<td>----------------</td>
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<tr>
<td><strong>Investment</strong></td>
<td><strong>Rs 6406 crores</strong></td>
<td><strong>Rs 8026 crores</strong></td>
</tr>
<tr>
<td><strong>Phase III</strong></td>
<td><strong>Phase IV</strong></td>
<td></td>
</tr>
<tr>
<td>Rangpuri to Shahbad Mohammadpur</td>
<td>Jahangirpuri to Sagarpar West</td>
<td></td>
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<tr>
<td>Barwala to Bawana</td>
<td>Narela to Najafgarh</td>
<td></td>
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<tr>
<td>Jahangirpuri to Okhla Industrial Area Phase I</td>
<td>Anithera Mod to Gurgaon</td>
<td></td>
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<tr>
<td>Shahbad Mohammadpur to Najafgarh</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date and Year</th>
<th>Route</th>
<th>Length (km)</th>
<th>Average riders</th>
<th>daily riders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 24, 2002</td>
<td>Shahdara - Tis Hazari</td>
<td>8.5</td>
<td>30,000</td>
<td></td>
</tr>
<tr>
<td>Oct 03, 2003</td>
<td>Tis Hazari - Inderlok</td>
<td>4.7</td>
<td>80,000</td>
<td></td>
</tr>
<tr>
<td>Mar 31, 2004</td>
<td>Inderlok - Rithala</td>
<td>8.8</td>
<td>1.2 lakh</td>
<td></td>
</tr>
<tr>
<td>Dec 19, 2004</td>
<td>DU - Kashmere gate</td>
<td>4.3</td>
<td>1.3 lakh</td>
<td></td>
</tr>
<tr>
<td>Jul 02, 2005</td>
<td>Kashmere gate – central sec</td>
<td>4.0</td>
<td>2.6 lakh</td>
<td></td>
</tr>
<tr>
<td>Dec 30, 2005</td>
<td>Barakhamba-Dwarka</td>
<td>22.8</td>
<td>4.2 lakh</td>
<td></td>
</tr>
<tr>
<td>Mar 31, 2006</td>
<td>Dwarka-Dwarka subcity</td>
<td>6.0</td>
<td>4.6 lakh</td>
<td></td>
</tr>
<tr>
<td>Nov 11, 2006</td>
<td>Barakhamba-Indraprashta</td>
<td>3.0</td>
<td>5.2 lakh</td>
<td></td>
</tr>
</tbody>
</table>
June 03, 2008 | Shahdara-Dilshad garden | 3.1 | 7.5 lakh  
Feb 03, 2009 | DU-Jehangirpuri | 6.4 | 7.5 lakh  
May 10, 2009 | Indraprastha-Yamuna Bank | 2.1 | 8.4 lakh  
Nov 12, 2009 | Yamuna Bank-Noida city centre | 13.1 | 8.9 lakh  
Jan 06, 2010 | Yamuna Bank-Anand Vihar | 6.3 | 9.3 lakh  
April 02, 2010 | Inderlok-Mundka | 15.1 | 10.1 lakh  
Jun 21, 2010 | Qutub Minar-Huda city center | 14.5 | 10.5 lakh  
Sep 03, 2010 | Central sec-Qutub Minar | 12.5 | 12.7 lakh  
Oct 03, 2010 | Central sec-Sarita Vihar | 15.0 | 14.7 lakh  

Source: The Times of India, November 3, 2010

Methodology
With the objective of documenting good practices for the Governance Knowledge Centre (GKC), the OneWorld Foundation (OWFI) team carried out desk research on Delhi Metro Rail Corporation (DMRC) taking from online and government provided sources.

The research team undertook a citizens’ survey to study the advantages and disadvantages of the metro. Women and senior citizens were particularly targeted for surveys. Questions were structured around efficiency, safety, convenience and affordability. Interviews were carried out with twenty five regular commuters, ten senior citizens and fifteen women at the end of October 2010.

Data Analysis
The following are the results of the citizen’s survey - a 50 person sample, collected at Hauz Khas Metro Station, South Delhi. Out of the 50 commuters surveyed, nearly half identified themselves as daily commuters.
Nearly half of the commuters surveyed said that they used public buses prior to the metro. The remaining half of the commuters used their own vehicles or autos, almost split equally between the two.

The majority of commuters are smart card users and benefit from the 10 percent discount on recharge and travel. They can easily avoid the queue at the ticket counter and head towards the security check, thus saving valuable time.
Depending on the route, commuters have to pay a minimum of 8 rupees and a maximum of 30 rupees for metro. It is comparatively much cheaper than auto whereby the minimum fare is 20 and 6.5 is added to every kilometre travelled. Travelling by bus can be a problem as it is very time consuming to cover long distances. Commuters praised the Delhi Metro for its efficiency – pointing to a less than 15 minute to wait for and board a train at any given time.

*Figure B suggests that commuters find the Delhi Metro affordable*

*Figure C suggests that the Delhi metro is reliable in adhering to time schedules.*
Regular and audible announcements are said to be made at the station to inform commuters about the arrival time of the train and the location of the platform. Information is also provided once boarded on the train. Some passengers suggested that the DMRC include emergency instructions in their announcements.

Passengers have expressed a concern with the congestion on the metro especially during peak hours and have recommended adding more coaches. At present, they are four to six coaches per train and 15 lakh commuters travel on the metro every day.

When asked if anyone has lost their belongings, only one person said he had lost his phone in the train but had not reported it to the maintenance staff. Notices explaining what steps must be taken if belongings are lost are posted throughout stations. For further security, commuters noted that there are CCTVs in all stations and security guards who patrol in and around the stations.

Although Phase I and Phase II are complete, some passengers have mentioned that all corridors are yet to be connected. For example, if a person has to commute from Safdarjung Enclave to Sarita Vihar. She has to take an auto from Safdarjung to Moolchand station first.

Female commuters told surveyors that the metro has made travel within the city easy and safe. Earlier, many females feared for their security while travelling in a crowded train, but with the reserved compartment, they can confidently commute long distances without depending on anyone to accompany them. There are also female security guards stationed in all coaches to prevent people from violating rules. Males who try to board the reserved coach will be penalized by the authority and fined 200 rupees. In fact, there have been instances where prompt action has been taken against violators. Senior citizens suggested that coaches also be reserved for them.
Figure E suggests that the majority of females travelling by metro feel safe while doing so.

Commuters noted that staff members on duty are helpful. Notices and instructions on code of conduct and general information about the metro are displayed in every station in both Hindi and English.

**Stakeholders**

According to the Chief Public Relations Officer, DMRC, the metro model is unique because 60 percent of the project cost is financed by the Government of Japan through Japan International Co-operation Agency (JICA) while the remaining is funded by the Government of India and Delhi government. The following is a list of all stakeholders.
<table>
<thead>
<tr>
<th><strong>Owners</strong></th>
<th>Delhi government &amp; central government</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major Funding Agency</strong></td>
<td>Japan International Cooperation Agency</td>
</tr>
<tr>
<td><strong>Employees</strong></td>
<td>Core Leadership Team</td>
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<tr>
<td></td>
<td>Project &amp; Operational Staff</td>
</tr>
<tr>
<td></td>
<td>Maintenance &amp; Construction Team</td>
</tr>
<tr>
<td><strong>Customers</strong></td>
<td>Citizens of Delhi</td>
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<tr>
<td><strong>Government</strong></td>
<td>Municipal Authorities</td>
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<tr>
<td></td>
<td>Law Enforcement Agencies</td>
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<td></td>
<td>Urban Development Organisation</td>
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<td></td>
<td>Other ancillary government agencies</td>
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<tr>
<td><strong>Partners</strong></td>
<td>Overseas Technology Partner</td>
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<tr>
<td></td>
<td>Various construction &amp; infrastructure companies</td>
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<tr>
<td><strong>Suppliers</strong></td>
<td>Manpower &amp; sub-contracting</td>
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<td></td>
<td>Machinery &amp; component manufacturing</td>
</tr>
<tr>
<td></td>
<td>Maintenance contracting</td>
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<tr>
<td><strong>Community</strong></td>
<td>Media agencies (opinion influencers)</td>
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<td></td>
<td>International fraternity</td>
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<tr>
<td></td>
<td>Social organisations (NGOs)</td>
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</tbody>
</table>
Lessons Learned

The following are the lessons learned from the DMRC experience that should be considered for replication in other cities.

Delhi is a populated city and the number of motor vehicles is expected to go up to 35 lakh by 2011 which only suggests further road congestion and pollution. In this context, a metro system is a necessary alternative for daily commuters.

The number of passengers on the Delhi metro has greatly increased since its launch - from a mere 20,000 commuters at its outset, it has grown to one million commuters and is expected to double by the end of the year (2010). The Central Road Research Institute did a survey of 12,000 metro commuters between Shahdara and Tis Hazari in 2007 and found out that one-third of two wheeler owners were metro users and by 2009, the figure had doubled to two-thirds. A similar trend was seen amongst car owners. The reasons for preferring metro to the other types of transport were:

- 23.27 percent of commuters preferred travelling by metro to avoid traffic jams
- 15.97 percent of commuters found it the most comfortable way to travel
- 8.38 percent of commuters opted for safety reasons
- 5.14 percent of commuters opted for metro to avoid parking problems

The Delhi metro offers all the benefits of a typical public transport system plus a few added aspects that make it stand out as a unique, cutting-edge model.

One of the basic benefits is the metro’s ability to decongest roads. Metro commuters can avoid traffic during peak hours and do not have to worry about parking their vehicles. For daily commuters, the metro provides better mobility and cost savings. On average, commuters spent a minimum of 2400 rupees on fuel and 400 rupees for parking per month. In contrast, metro tickets cost between 8 and 30 rupees, depending on the route.

The following are advantages that are unique to the Delhi Metro model.

Fare Setting

The fare structure is determined by a Fare Fixation Committee as prescribed in the Delhi Metro Operations and Maintenance Act, 2002. The committee is headed by a serving or retired judge of the High Court and has very senior representatives of the central and state governments at his disposal.
Reserved Coach for Women

Women prefer to take the metro as they find it safer than travelling in autos or buses. In every train, there is a compartment reserved for women. Enacted on October 26, 2010, a 200 rupee fine will be given to male passengers who sit in reserved coaches.

Convenient Facilities

Metro commuters have benefitted from the following customer friendly services:

- Token dispensation machines in busy stations
- Metro citizen forums that familiarise metro commuters with system functioning
- 24 hour online customer care cell for speedy redressal of public queries and complaints
- Personal assistance for physically challenged persons to help them in boarding and deboarding the train, both at the entry and the exit of the metro station (when informed in advance)
- Ticketing and passenger control are through Automatic Fare Collection System, which was introduced to the country for the first time.
- Entries and exits to metro stations are controlled by flap-doors operated by 'smart-cards' and contact less tokens.
- An adequate number of escalators have been installed in all metro stations.
- In addition to the 120 feeder buses, 300 air conditioned CNG buses provide comfortable connectivity to metro stations. There is also a radio taxi service available for commuters.

Human Resource Management

Staff council meetings are held on a weekly and monthly basis to discuss day-to-day affairs; staff members are encouraged to make suggestions and recommendations for improvement. Competency building workshops are organised to educate staff members in time management, team building and motivational techniques for their personal and professional development.

Building Expertise

The Delhi Metro Training School, established in 2002, is the only specialised training institute in South Asia in metro operations and maintenance technology. It imparted training to the metro maintenance and operations staff and was certified by the International Organization for Standardization (ISO) for maintaining standards in Quality Management Systems in training.
Savings
The Delhi metro is estimated to free up a large amount of funds that can be reinvested in other public projects. Below is the estimated savings that the metro will induce.

1. Removal of 610 buses from New Delhi - Rs 89 crores
2. Reduction in private vehicles - Rs 324 crores
3. Reduction in traffic congestion - Rs 503 crores from savings in operating cost of vehicles
4. Reduction in number of accidents - Rs 151 crores in terms of less damage to vehicles and medical and insurance expenses
5. Reduction in fuel consumption - Rs 366.92 crores
6. Savings in investment in road infrastructure - Rs 165 crores

Security Measures
Security guards and controllers are stationed at every platform and inside the trains to avoid problems from occurring and to ensure that commuters follow the code of conduct. They are authorised to penalise commuters that violate Delhimetro rules and regulations. Thus far, 3000 violators have been fined for offences such as spitting, squatting, fighting and destroying metro property.

DMRC has made the following provisions to ensure the safety of its passengers:

- Increased the number of dog squads (inside the metro)
- Strengthened the bomb disposal teams
- Increased the supply of bomb blankets
- Additional door frame metal detectors on the Metro system
- Procurement of power search lights called dragon lights and TETRA radio sets
- Baggage scanners for automatic scanning of luggage
- Installed 3000 lose circuit TV (CCTV) cameras at the stations apart from the cameras inside the trains.

Environmentally Friendly
DMRC has been awarded from the Ministry of Power for adopting special measures to reduce energy consumption. These measures include efficient use of energy in the management of station and tunnel lighting, use of solar energy in parking lots, and optimal use of air conditioning in trains and stations. The metro prevents approximately 28,800 tonnes of carbon dioxide emissions per year.
The Delhi Metro is the world’s first railway project to be registered by the United Nations Framework Convention on Climate Change under the Clean Development Mechanism. It has claimed carbon credits, amounting to Rs 1.2 crore annually, for the use of a regenerative braking system. When a train brakes, the kinetic energy released is able to start a machine known as converter-inverter. This machine acts as an electricity generator, which supplies electrical energy back to the overhead electricity lines. The regenerated electrical energy that is supplied back to the overhead lines is used by other accelerating trains. This technique has helped to reduce the electricity requirement by 30 percent. To date, it has saved 1,12,500 megawatts of power and has prevented the emission of 90,000 tonnes of carbon dioxide. Each time the metro saves power, it receives carbon credits and the money available from sale of carbon credits can be used for operational costs, training staff, and research and development.

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Research was carried out by OneWorld Foundation India (OWFI), Governance Knowledge Centre (GKC) team.

Documentation was created by Research Associate, Attrika Hazarika

For further information, please contact Naimur Rahman, Director, OWFI, at owsa@oneworld.net
Appendix B – Interview Questionnaire

Mr Anuj Dayal, Chief Public Relations Officer
1. What makes the DMRC unique?
2. How is the fare structure determined? What remains to be addressed or achieved?
3. What role, if any, does Delhi Metro play in sustainable urban development?
4. What are the funding sources?
5. What were the challenges faced during implementing this project?

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