HOW SUSTAINABLE IS THE 21ST CENTURY MASS TRANSIT RAILWAY?

Mr TC Chew
Projects Director
MTR Corporation

1. INTRODUCTION

The world in the 21^{st} century is under pressure of increasingly expensive energy, material costs and rapid depletion of natural resources as well as environmental challenges. This leads to a growing concern for "sustainability". Individuals and enterprises can no longer ignore or deny their responsibilities to address the issue seriously. In the context of this paper, "sustainability" is defined as meeting the needs of the present without overly compromising the ability of future generations to meet their needs.

The MTR Corporation, as one of the major transport operators in Hong Kong, acknowledges the urgency for action and proactively seeks ways to realize "sustainable development" for our railway infrastructure systems and operation. Having five new railway extension projects in its agenda in the coming decade, MTR is taking concrete measures to reduce the carbon footprint of the railway and to ensure the effective use of resources. This paper discusses the actions that have been and will be taken and highlights the challenges encountered.

2. CARBON-CREDITING RAIL TRANSPORT

Rail-based transport is often regarded as a "green transport" as it delivers the best energy optimization across public transport sector modes. It reduces private vehicle trips by providing mass transport service and improves fuel efficiency by relieving road congestion. Moreover, it serves as a land-use multiplier by allowing compact land use that enables alternatives for social, environmental or economic purposes.

In recent years, there has been encouraging progress in controlling the carbon footprint of road base vehicle transportation. Advancement in technology has made possible reduction in fuel consumption and in exhaust emission control from road vehicles. Electric vehicles are becoming more popular and a number of cities have launched plan and policy to encourage wider adoption of electric vehicles.

While road transport has made significant progress in enhancing sustainability, railway operators, equipment suppliers and system developers have also innovated in various areas and put forward its carbon-saving agenda. In 2006, the MTR Corporation issued its Climate Change Policy in recognition of the necessity to take immediate actions so as to operate effectively and efficiently in the significantly changed environments. The Policy aims at working towards a positive impact on the global environment and one of the key actions is to reduce direct carbon emissions in a targeted and continuous fashion.

3. SUSTAINABILITY THROUGH SUPPLY CHAIN AND ASSET LIFE CYCLE MANAGEMENT

The demand for sustainability can no longer be satisfied with short term and uncoordinated activities. Thorough consideration ought to be given throughout the life cycle of railway construction and operation. It is therefore essential to promote the sustainability mindset from the start of the asset life cycle, that is from the procurement stage forward. This is achieved by practices as green procurement, which injects the requirements for sustainable development into the supply chain. Manufacturers are encouraged to deploy the best technology solutions for satisfying the requirements concerning sustainability, through, for instance, the choice of materials, improvement in energy efficiency and design flexibility etc.

Higher standards and expectations are set for the choice of materials at an affordable cost. Adoption of materials that can be reused or recycled at the end of asset life is desired. For rolling stock, for instance, manufacturers have been exploring the use of materials with low embodied energy and low carbon footprints. With improvement in materials, overall vehicle recyclability target of as high as 90% can be achieved. In particular, the adoption of renewable primary products such as compounds from cork and stainless steel for vehicle floor can bring about significant lower carbon footprint per train compared to conventional plywood floor and gives almost 100% recyclability rate.

Energy efficiency is another important criterion in the selection of products as it directly affects energy consumption throughout the asset life cycle. Taking rolling stock as an example again, significant improvement has been made in train propulsion traction control over the years, resulting in notable enhancement in energy efficiency. Moreover, manufacturers have emphasized the light-weight design of trains as well since the weight of the vehicles would affect the demand for traction power. Adoption of aluminium carbody with thin wall profile and lighter materials for windows and front masks are few of the means to lower the vehicle weight. The standards and specifications must be reviewed to minimize overly demanding criteria which lead to un-economical application of material.

With the changing demand in the modern world, system or equipment upgrade or modification is common in an asset's life cycle. Flexibility embedded in system and equipment design is therefore an important consideration. Products are preferably designed in such a way that allows easy upgrade and modular replacement of components if needed.

By partnering with the supply side and encouraging better practices, railway operators, including MTR, are building their long-term sustainable future. Such supply chain and asset life cycle management also collectively promotes society's broader sustainable development.

4. SUSTAINABILITY THROUGH CONTROL OF RESOURCES CONSUMPTION

Apart from emphasizing sustainability at the start of the supply chain, it is equally important to address the issue at the railway's construction and operation stages, during which the control of resources consumption is essential. MTR proactively investigates better design and functionality, application of innovative construction technologies and materials, energy efficiencies and the maintenance of the railway for realizing responsible using of resources.

On the civil side, efforts have been made in optimizing the size of the railway infrastructure, including station box, viaducts and tunnels etc, in order to limit the volume of concrete used, scale of excavation and spoil disposal. In deciding the construction methods, the environmental and sustainability issues are taken into consideration as well.

On the E&M side, with the rapid development in technology, various initiatives for reducing resources consumption, especially energy consumption, have evolved over the years. Examples of initiatives that have been or will be implemented by MTR are as follows:

i) Environmental control system

- **Water-cooled air conditioning system**

  Fresh Water Cooling Towers are used for implementing water-cooled air conditioning system where appropriate. This leads to significant energy saving as heat dissipation through evaporation cooling is more energy efficient than air cooled condenser.

- **District cooling system**

  District cooling is another approach to be adopted for energy saving. This cooling method is more efficient due to bulk production of cooling. It saves energy as well as construction of separate cooling plants. The Kai Tak District Cooling Scheme is being considered for the stations in the area under the Shatin to Central Link project.

- **Energy saving free cooling mode**

  The specially designed free cooling mode allows the station to be naturally ventilated and cooled suitable weather conditions and hence reduces energy consumption.

ii) Lighting system

- **Light Emitting Diode (LED) lighting**

  LED lighting brings lower energy cost in lighting generation and longer life than conventional fluorescent lamp. Each HB-LED light has an estimated life cycle of 50,000 hours, therefore achieving saving on the traditional fluorescent light tube waste. Its close resemblance to natural daylight, which enhances the travel environment, is another attractive benefit. The pilot programme for this “green” lighting in rail stations has been implemented in Choi Hung Station.

- **Lighting control**

  By dividing the public areas into zones for lighting control, the lights can be switched flexibly on demand and reduces energy consumption.

- **Solar photovoltaic panels**

  With the installation of solar photovoltaic panels, power can be generated from solar energy at extremely low operating costs. These panels have been adopted for remote installations like Ngong Ping 360 wind monitoring systems and Government Projects, such as Kennedy Town Swimming Pool Re-provisioning and EPD Monitoring Station at Sai Ying Pun Community Centre entrusted under the West Island Line Project.

iii) Lifts and escalators

- **Elimination of home landing of lifts**

  For lifts in railway stations, the home landing function can be suppressed such that the lifts can stop at the last served floor. This minimizes lift travel with empty car.

- **Automatic control of car lights and ventilation fans**

  Turning off car lights and ventilation fans for long idled lifts can save lighting and ventilation fans energy when the lift is not receiving any service call for a certain period

- **Standby mode for group control of lift bank**

  During non-peak hours, the usage rate of the lifts is low. Energy saving can be achieved by automatically putting certain lifts out of service during non-peak hours.

- **Lift power generation feature**

  Energy consumption can be reduced by introducing the lift power generation feature of lifts, which uses the unbalance load between lift car and counter weight to generate power during downward operation.

- **Adoption of variable frequency drive**

  Using variable frequency drive for lifts, escalators and moving walkways for soft start can minimise heavy start up current. For escalator and moving walking, this also allows the equipment to change to crawling speed automatically in case of long idle period.

- **Adoption of traction lifts**

  Traction lifts instead of hydraulic lifts are adopted as far as possible. This is favourable for energy saving as traction lifts achieve better energy efficiency than hydraulic lifts.

iv) Power supply system

- **Single high voltage transmission and distribution system**

  The 33 kV power supply network is used to transmit and distribute traction and station loads to reduce transmission loss. With such system design, the 11kV power network is eliminated. This has been adopted since the Tseung Kwan O Line project and will be adopted in most of the new projects.

- **Wayside traction energy storage**

  The regenerative braking energy from rolling stock can be stored by wayside energy storage devices such as super-capacitors. This allows the regenerative braking energy to be stored and consumed by other rolling stock instead of being dissipated by resistors.

v) Overhead line system

- **Overhead rigid conductor rail**

  As the electrical resistance of overhead rigid conductor rail is lower than the conventional catenary system, the adoption of rigid conductor rail can enhance the energy efficiency of the overhead line system. This will be implemented in suitable sections of the new railway lines.

- **Silver copper contact wire**

  The electrical resistance of silver copper contact wire is lower than that of other types of contact wire, such as tin copper as used in the Mainland. To reduce energy wastage, silver copper contact wire will be adopted for most of the new railway projects.

vi) Main Control System

- **Time scheduling**

  The Main Control System controls and monitors various electrical and mechanical systems in the stations. By implementing the time scheduling function in the Main Control System, devices like signage, advertising panels and PIDS boards etc can be switched off automatically when suitable in order to conserve energy.

vii) Rolling stock

- **Regenerative brake**

The regenerative brake enables the transmission of regenerative braking energy from the rolling stock to the overhead line for consumption by other trains. The provision of regenerative brake can also minimize the brake pad or block wear. This has been adopted for previous projects like Tseung Kwan O Line and West Rail Projects and will be adopted for all new rolling stock.

- **Weight management**

  Reduction in the weight of rolling stock can contribute to reduction in the traction power needed to drive the vehicles. Hence, rolling stock manufacturers are required to submit a weight management plan for their rolling stock as part of the System Engineering Management process. This has been adopted for previous and new projects including Tseung Kwan O Line and West Island Line and will be adopted for other future projects.

- **Power electronics equipment**

  Reliable, high efficiency and low loss Insulated Gate Bipolar Transistor (IGBT) power semiconductors are adopted for traction control. The power electronic equipment also saves weight due to lighter and compact size components. This has been adopted for previous and current new projects.

- **Permanent magnet motor**

  Permanent magnet synchronous motors with higher energy efficiency can be adopted. This will be explored and considered for future projects.

viii) Signalling system

- **Automatic door open/close**

  The implementation of automatic train door open/close function can enable train operation to adhere closely to the timetable and reduce non-productive dwell time. It also avoids tight running to catch up with delay and allows more coasting to save energy.

- **Automatic train regulation**

  Different train running profiles are implemented for peak and off-peak hours. This increases the amount of coasting during off-peak hours and hence achieves energy saving.

5. CARBON FOOTPRINT CONTROL

On top of all the technical measures for achieving sustainable development, MTR has seen a need to improve the management and reporting systems and to set more specific emissions reduction targets. Hence, MTR is attempting to devise a carbon footprint tracking system for its railway projects. This carbon assessment initiative introduces a carbon management protocol model for the design, construction and operation of rail systems. It covers the entire life cycle of railway projects, both the embodied carbon and the carbon emitted during the provision of service. In the preliminary and high level assessment of the North South Line of the Shatin to Central Link, for example, it has been found that the major contribution of construction carbon emission is from embedded carbon in building material, which accounts to around 95% of the total emission, and station operation and traction carbon emission together contribute to around 98% of operation carbon footprint. The assessment can facilitate the identification of de-carbonisation opportunities by predicting and measuring embedded carbon in building a rail line during the design stage.

The implementation of the carbon assessment initiative is currently at a preliminary stage and the model of carbon footprint is being developed and improved. After the infrastructure of the new railway projects are built, the first iterative cycle of the actual carbon footprint can be established and the accuracy of the model can be enhanced. This will be helpful for controlling the carbon footprint more effectively.

6. THE CHALLENGES

Monitoring and controlling carbon footprint and resources consumption of railways is an on-going and long-term process that has to be undertaken from the design to construction and operation stage. Determination is needed to overcome the obstructions and follow through the process until the benefits are realized. Among all the constraints, financial commitment is one the most critical ones. In certain circumstances, initiatives are favourable for both sustainability and financial aspects. For instance, optimization of station size brings reduction in concrete used as well as construction cost. There are often occasions, however, that the capital cost will be increased if some proposed sustainability provisions are to be incorporated. The major challenge of achieving sustainable development lies in striking a balance between the benefits of the initiatives and various constraints, like financial implication and external interfaces. To resolve such conflicts, thorough planning and analysis would be essential.

7. CONCLUSION

As a railway operator who designs, builds and operates the community asset for several generations of users, the MTR Corporation is making every endeavour to fulfil its social contract to deliver a quality rail transport system while working within development constraints. Sustainability must be addressed in a continuous basis and it is important to take a holistic approach in carbon reduction and to optimise design for both construction and operational emissions. Furthermore, in the process of exploring and implementing various sustainability initiatives, joint effort with the Government, other companies and the public is needed as well for creating a low carbon environment.

REFERENCES

[1] MTR Corporation, Sustainability Report 2009
[2] MTR Corporation, Sustainability Report 2008
[3] MTR Corporation, Environmental Impact Assessment Report – South Island Line (East), August 2010
[4] MTR Corporation, Environmental Impact Assessment Report – Kwun Tong Line Extension, July 2010