Sustainability and Energy Management for Railways' Design Build Operation and Maintenance (DBOM) Projects

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Keywords: *design build operation and maintenance (DBOM), leadership in energy and environmental design (LEED), right of way (ROW), traction power substation (TPS), automatic train supervision (ATS), operation maintenance storage facility (OMSF), supervisory control and data acquisition (SCADA), operation control center (OCC), automatic train regulation (ATR), automatic train operation (ATO), automatic train protection (ATP), operation and maintenance (O&M), heating ventilation air conditioning (HVAC), low voltage distribution (LVD), united states green building council (USGBC), volatile organic compound (VOC), chlorofluorocarbon (CFC), american society of heating, refrigeration and air conditioning engineers (ASHRAE), electromechanical (E&M), maintenance management information system (MMIS)*

Introduction

This paper focuses on the sustainability and energy management requirements and policies that should be considered by a DBOM project. It provides guidelines and recommendations on how best to proceed in encouraging sustainability and energy management.

Specifically, the purpose of this paper is to provide a guidance to the railway's project management to understand the energy management issue, solve the problem of high costs, and make environmentally friendly decisions. This paper provides the railway project management with generic data, analysis, and recommendations to support as to whether sustainability and energy management is in the company's best interest. Also, this paper recommends as to what are the next steps to be taken in order to advance the goal of energy management for a railway transit system.

With regards to the energy management, there is an extensive road map and analysis of the features of the:

- Rail system (e.g. traction power and distribution, rolling stock, SCADA)
- Civil works including LEED
- Construction
- O&M
- Utility tariff structure
- Alternative energy sources
- Training
- Energy awareness programs and benchmarking

The findings of this paper suggest that if a railway company implements a corporate energy management plan, it will not only improve its rolling stock fleet propulsion power and building efficiency, but it will also deepen its commitment to environmental sustainability. This will be achieved by investing in sustainable information technology, minimizing waste streams, ensuring good housekeeping and implementing a cleaner air environmental policy. In preparing this paper I kept under strict consideration a number of quality standards (ISO 9001:2008) and policy options, including LEED certification, LEED construction and major renovation, etc.

Building the business case for energy management and environmental sustainability requires a systematic collection and recording of the designing and construction performance data collection. A strong business case would be required in order to motivate legislative and executive action for more formal green and high-tech mandates or for endorsement. Sustainability related data collection could be piggybacked on existing efforts to provide an unprecedented level of consistent, regular data about real railway system performance over the life cycle correlated with initial green design and construction tactics, resulting in a quantitative evaluation of what tactics really make most sense for railway systems.

It is suggestible that a sustainability and energy management working group should be established in DBOM railway projects in order to identify in detail the vision, and the action plan with regards to the direct and indirect environmental and energy impacts of the proposed railway. Furthermore, the involvement of key stakeholders in the planning, design, construction, operation, maintenance, and commissioning must be compliant with the company's vision and therefore it must develop a coordinated and aligned plan of action to achieve that vision. The outcome of the proposed working group, whether voluntary or formally appointed, should be the creation of a broadly supported railway company vision for what a green rail system should look like for state-owned transit system, accompanied by an action plan specifying steps necessary to achieve the vision.

Consensus-based planning is likely to result in more willing and widespread adoption of environmentally sustainable railway goals and tactics than directives issuing from a single source. As such, the sustainability and energy management working group approach stands the best chance of developing a plan which will be successful in achieving the true goal of any railway project which provides increased environmental sustainability and energy savings for the railway company.

1.0 Scope

This paper discusses all aspects of the sustainability and energy management in the design, construction, commissioning, and O&M within the context of a railway project.

2.0 Sustainability

Sustainability should become an integral part of a railway project's business strategy through corporate dedication towards the community's environment and safety. Specifically, through sustainability the railway company should establish its environmental focus, based on:

1. CO_2 emissions and energy efficiency
    - Focus on reducing CO_2 emissions as well other emissions throughout operations by
        - Optimizing energy use
        - Expanding its operational excellence with regards to rolling stock fleets, and building operations
    - Increase economic value
    - Provide sustainable solutions to company customers, growing the business through cleaner energy markets, and investing in an efficient and reliable infrastructure
2. Waste Management. Decrease energy waste through three key initiatives
    - Decrease energy waste
    - Remove old rail ties from ROW

- Establish an aggressive waste reduction program for the railway company's buildings and yards

3. Environmental shifters. A railway company should be committed to act as environmental shifter by taking extensive measures to minimize the company's impact on ecosystems, while striving for a net positive impact on biodiversity.

2.1 Sustainability action plan

The implementation of sustainability requires the development of a sustainability action plan. This plan should be organized around the following six themes:

1. Improve rolling stock fleet propulsion efficiency
2. Improve vehicle fleets' propulsion efficiency
3. Improve buildings' efficiency
4. Invest in sustainable information technology
5. Minimize waste and conserve a green environment
6. Implement a clean ROW policy across the corridors

2.2 Sustainability and electrification

With regards to the electrification of a railway project, sustainability is a filter which can be used properly when someone evaluates potential socioeconomic or technical impacts and decisions. The key decisions addressed through these electrification performance specifications are usually related to:

1. Design and specification conformance and verification of fixed facilities and equipment
2. Construction and installation conformance and verification of fixed facilities and equipment

The fixed facilities and equipment of an electrified railway transit system include:

1. Paralleling stations
2. Switching stations
3. Traction power substations
4. Overhead contact system supports
5. Wayside power cabinets

3.0 Energy management

Energy management in railways is referred to the methods and techniques applied in order to reduce the amount of energy utilized. This can be achieved by:

- Hardware design via use of energy efficient products
- People and equipment use energy management efficiently

This paper will review some generic methods and guidelines towards the DBOM of an electrified rail transit system. This paper will not go into details in methods given as these will be further developed by the relevant subsystem.

With regards to the electrification of rail transit systems, the goal of the energy management shall be to minimise energy costs by optimising the consumption of energy within the constraints of the railway's baseline service plan. The railway company and the design contractors shall evaluate, by means of the traction power simulation, what opportunities exist for the control of power demand which will allow an economically advantageous reduction in the power capacity of the installed substation, and minimization of energy consumption. Also, the future growth of the rail transit system should be considered.

The traction power of electric rail transit systems is the major energy requirement. Operating voltage, substation power factor, vehicle acceleration, vehicle speed, and vehicle weight impacted energy use and shall be assessed in the energy efficiency trade-off analysis. The current conductor cross section trade-offs of capital costs versus energy savings shall be evaluated.
By providing the means towards monitoring energy usage and stagger, then the starting of individual trains may be able to limit the short-term peak demand. It may be practical to “peak shave” the TPS demand by utilizing a demand-related power supply control system interfaced to the ATS. This will result in reduced demand charges from the supply utility.

The energy management analysis shall analyse the traction power regeneration efficiency, as well as the acceptability and the potential benefit of bilateral power flow to the utility system through the use of four quadrant power conversion. This shall include power quality criteria which may require significant investment and may determine the economic viability.
Facility design criteria should be developed for all stations and buildings in order to minimize energy consumption and increasing costs. These criteria will address heating, cooling, lighting, insulation values, energy-efficient equipment, and the use of automatic sensors, motion detectors, thermostats and similar devices with programmable computer override. Power demand at all facilities by location, time of day, and time of year shall be assessed by the railway company and the design contractors to support the final design for the railway’s electrification, as well as the power distribution along the rail corridors.

4.0 Responsibilities

The sustainability and energy management is often responsibility of the whole system’s engineering team. It is to be implemented by all subsystems in design and selection of equipment. It will also be used by O&M personnel in developing O&M procedures.

5.0 Definitions

Terms	**Definitions**
Alignment	Alignment 3 dimensions geometrical curve corresponding to the axis of the railway’s electrified rail tracks and respecting the constraints described in the norms EN-13803-1 and in the ICD Alignment / Rail System
ATO	Automatic train operation which can control the trains directly
ATP	Automatic train protection protects trains by separating them so as to avoid collision
ATS	Automatic train supervision routes trains and assists in maintaining adherence to schedule
Benchmarking	Benchmarking is the process of comparing one's business processes and performance metrics to industry bests or best practices from other industries. Dimensions typically measured are quality, time and cost
Energy management	Energy management includes planning and operation of energy-related production and consumption units. Objectives are resource conservation, climate protection and cost savings, while the users have permanent access to the energy they need. It is connected closely to environmental management, production management, logistics and other established business functions

HVAC	HVAC is the technology of indoor and automotive environmental comfort. HVAC system design is a sub-discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer
LEED	Leadership in energy and environmental design consists of a suite of rating systems for the design, construction and operation of high performance green buildings, homes and neighborhood
OMSF	An area including the operations department, a maintenance system, repair shops, work bays and related amenities; a yard of Tracks and switches that includes a test track and storage tracks; and administrative offices and ancillary areas related to and necessary in connection with such facility
OCS	The system that contains and supports the overhead contract wire for distributing power to the rail vehicles
Paralleling station	An installation that helps boost the OCS voltage and reduce the running rail return current by means of the autotransformer feed configuration. The negative feeders (NF) and the catenary conductors are connected to the two outer terminals of the autotransformer winding at this location with the central terminal connected to the rail return system. OCS sections can be connected in parallel at PS locations
SCADA	The Supervisory control and data acquisition is a type of industrial control system (ICS). Industrial control systems are computer controlled systems that monitor and control industrial processes that exist in the physical world. SCADA systems historically distinguish themselves from other ICS systems by being large scale processes that can include multiple sites, and large distances. These processes include industrial, infrastructure, and facility-based processes
Sustainability	Sustainability is the capacity to endure. Sustainability interfaces with economics through the social and ecological consequences of economic activity. Sustainability economics involves ecological economics where social, cultural, health related and monetary aspects are integrated. Moving towards sustainability is also a social challenge that entails international and national law, urban planning and transport, local and individual lifestyles and ethical consumerism
Switching station	This is an installation where the supplies from two adjacent TPS are electrically separated and where electrical energy can be supplied to an adjacent, but normally separated electrical section during contingency power supply conditions. It also acts as a paralleling station (PS)
TPS	A traction power substation is an electrical substation that converts electric power from the form provided by the public utility service to an appropriate voltage, current type and frequency to supply railways, with traction current

6.0 Energy and management policy

Today, a railway company should always consider instituting an energy management policy at the start of the implementation of the design and construction phases of a rail transit system that will:

- Improve energy usage efficiency
- Reduce operating energy cost
- Be people oriented (via training and awareness programs)
- Be customer oriented (passenger satisfaction to be taken into account)
- Be cost effective
- Be environmentally friendly

The energy and management policy must encompass the design, construction and O&M of the railway company. The energy management policy, it is suggested that, should be reviewed by the railway company's executive committee.

7.0 Energy distribution

Figure 1 shows the distribution of major energy users within an electrified rail transit system.

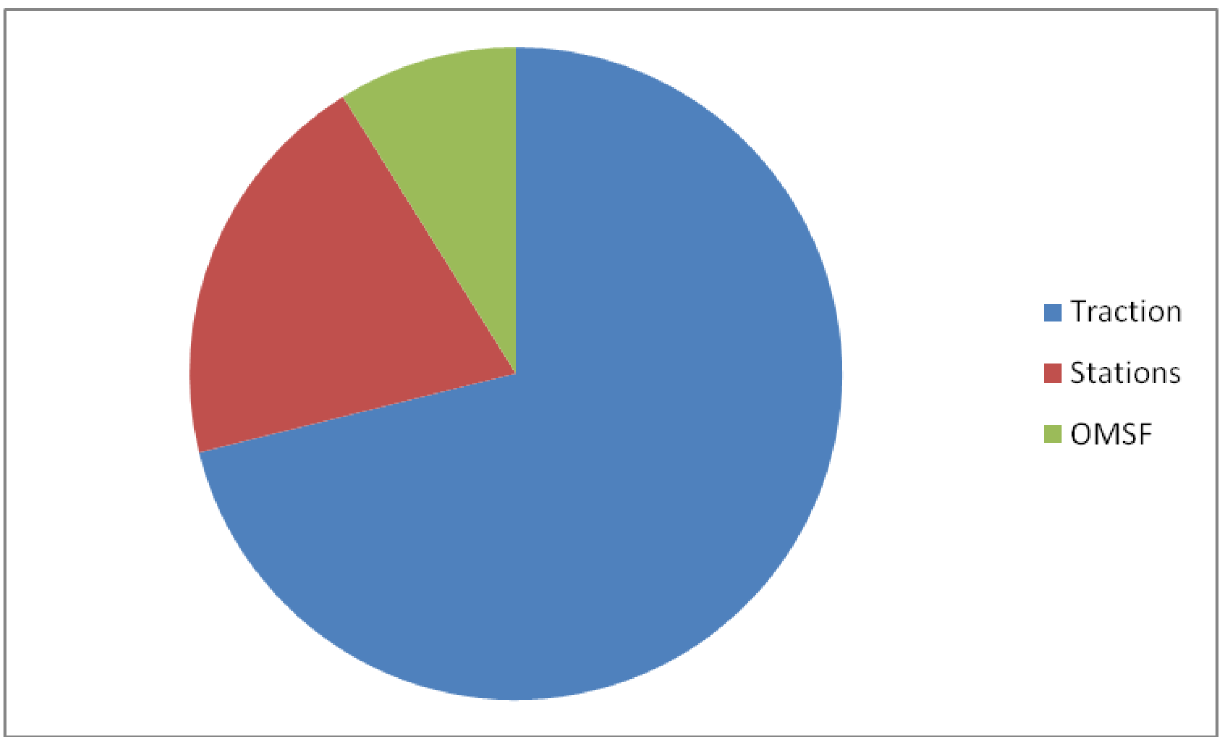

Figure 1. Energy distribution of an electrified rail transit system

As shown in Figure 1 the traction system of the rail system accounts for approximately two thirds (2/3) of the energy used, while the OMSF and the stations account for one third (1/3) of the energy used. The following sections will address each of these and how energy used by each will be managed.

8.0 Features of a rail transit system

This section presents the main features incorporated in a rail transit system with regards to the energy management, and how energy consumption can be minimized.

8.1 Electric trains

Electric trains should incorporate the following features in order to allow minimization of the energy consumption:

- High efficiency electric motors and converters. For example, the overall efficiency from the pantograph to the wheel is between 0,80 and 0,85 for speeds above 30km/h for Alstom's Coradia Duplex
- Energy regeneration
- Lightweight structures
- Aerodynamic shapes
- Efficient auxiliary converters
- Efficient air conditioning units
- Materials with high isolation factors and appropriate colors in order to minimize heat transfer between inside and outside the cars
- Windows with low transmission factors, in order to decrease solar flux entrance inside the cars, if needed

8.2 Traction power

8.2.1 Simulations

During the preliminary design, the railway company should perform traction power simulations of the whole system, taking into account the most precise characteristics of the following:

- Vehicle
    - Motor characteristics (e.g. traction and braking effort as function of speed, efficiency of converters, etc.)
    - Power factor should be close to one in order to minimize line losses
    - Dynamic characteristics (e.g. mass, inertia, resistance to movement including friction and aerodynamic models, etc.)
    - Consumption of the auxiliary equipment
- Alignment (e.g. gradients, civil work permanent speed restrictions, etc.)
- Operation
    - Headway
    - Passenger load
    - Dwell times
- Scenario at initial opening and ultimate capacity
- Power substation
    - Efficiency of transformers
    - Equipment rating
- Traction power distribution
    - Impedance, resistance in the feeder and contact line cables and return circuit
    - Equipment rating

The traction power simulations are often performed during the preliminary design phase in order to allow the rating of the transformers, cables and all equipment of the power, and the traction power distribution equipment.
The simulations are usually performed at normal passenger load (20 % standees) and at normal speed profile. Higher than normal traction power consumptions, when running at higher passenger loads or fast speed profile are often absorbed by standard margins on the transformers.

8.2.2 Energy regeneration

Energy regeneration is implemented and allows, through a combination of rail vehicle on-board features and traction power features, to reuse the braking energy of the trains.
Electro dynamic braking allows for regenerative braking. It is typically used at speeds above a few km/h. The electric energy of the braking vehicle is used on-board the regenerating vehicle which will be used by the auxiliaries of the rail vehicle firstly, and if there is any energy left then it will be sent back to the catenaries where it can be used by other vehicles on this line. Depending on traffic conditions, this might lead to an overall 20% to 30% energy gain for traction power.

8.3 SCADA

The OCC and more specifically the SCADA system will process the metering at power intake level and traction power substation level, so that the losses can be assessed.
Instantaneous consumed power will be available to the SCADA operator, and stored for statistical analysis. The consumption by hour, day, month and year are pertinent basis to energy management analysis. Such diagnostic will allow the implementation of specific operation procedures in order to smooth the consumed power and therefore save money on the utility billing.
Power monitoring will allow:

- For each substation, in normal mode operation, to check the average/peak load and apply special operation procedures in local areas
- For the whole system, the billing should be individually per substation, as well as the consumed power per substation should be also available for analysis

The data to be obtained and stored by the SCADA system can be used to establish a baseline of energy usage. This can be done during the first year of full operation. From this baseline all comparison of energy management will be compared to taking into account increases of ridership in progressive years, maintenance of equipment and life cycle of equipment. This will indicate if the routine maintenance is effective while the equipment ages and is expected to be less energy efficient. It will also indicate if other energy management techniques are effective.

8.4 ATS

The ATS feature has an energy “peak-shave” regulation mode which can be used to avoid having too many trains departing from stations at the same time. This mode works as follows:
For a given train to which a dwell time shall be validated, if the estimated departure time is closer to “x” seconds (configurable value) from the previous departure time (estimated or real) then the dwell time is increased to have at least the minimum interval between both train departures.
This mode could be used to reduce the monthly demand charge, which is a part of the utility billing scheme. In this case the ATR function changes departure times of involved trains to de-synchronize simultaneous departure of trains from platforms. It shall be noted that it has a direct impact on overall traffic regulation results.

8.5 Automatic train control and ecodriving

If an ATO is implemented, then on the same token it should incorporate an ecodriving (ecodriving is a term which is used to describe energy efficient use of vehicles) function able to compute an energy saving speed profile. This feature will communicate with the OCC in order to specify the runtime set by ATS as well as the power limit set by the energy management system.

An ecodriving feature defines speed profiles with optimal setting of acceleration/coasting and braking phases (the algorithm selects optimal values of coasting speed and traction resumption speed), avoiding high energy consumption.

In case that no ATO is implemented in the railway, then the defined energy efficient normal speed profiles will be under the responsibility of the train drivers. Specifically, the normal speed profiles will be displayed on the ATP for the train drivers to follow. Training of use of this system should enhance the drivers' ability to conserve energy.

8.6 Other subsystems

The other rail subsystems have negligible consumptions, except the maintenance/depot equipment addressed in the OMSF paragraph and O&M sections.

8.7 Rail vehicle within OMSF

At the start of the day when the rail vehicle will enter service, we must make sure that the temperature should be appropriate in order the vehicle to be injected immediately.

For example, in the case of the designed Trinidad Rapid Rail it was assumed that at approximately 1500hrs the vehicles parked after the morning peak will renter service. As there were only seven vehicles (some vehicles was assumed that will have continued service) and the time required to cool a vehicle at that time was approximately thirty minutes if the vehicles were not covered. That equated to approximately $1M TT for a twenty year period at 2009 electricity rates. The cost to cover the stabling was estimated to be approximately $2 million euros. Hence the above example shows us that covering a stabling area is not as economical with respect to energy conservation.

The movement of the rail vehicles within the OMSF should be carefully monitored by the OCC, while the speed of the trains within the OMSF should be restricted. Hence the energy used will be minimized.

9.0 Civil work features

9.1 Alignment

The following have been taken into account for the alignment design, whenever feasible at reasonable cost:

- Minimize the distance between the OMSF and the point of the line where the trains will commence their service
- Stabling in terminal stations and/or other stations, so that all trains do not need to go to the OMSF for stabling during the night or off peak hours

9.2 Stations

There are two methods to manage energy within the stations. Firstly, by design parameters and secondly, by monitoring and people management. Stations should be designed in accordance with the LEEDS™ guidelines.

9.2.1 Design parameters

Within the station there are many users of energy. Figure 2 shows the major distribution of all the users.

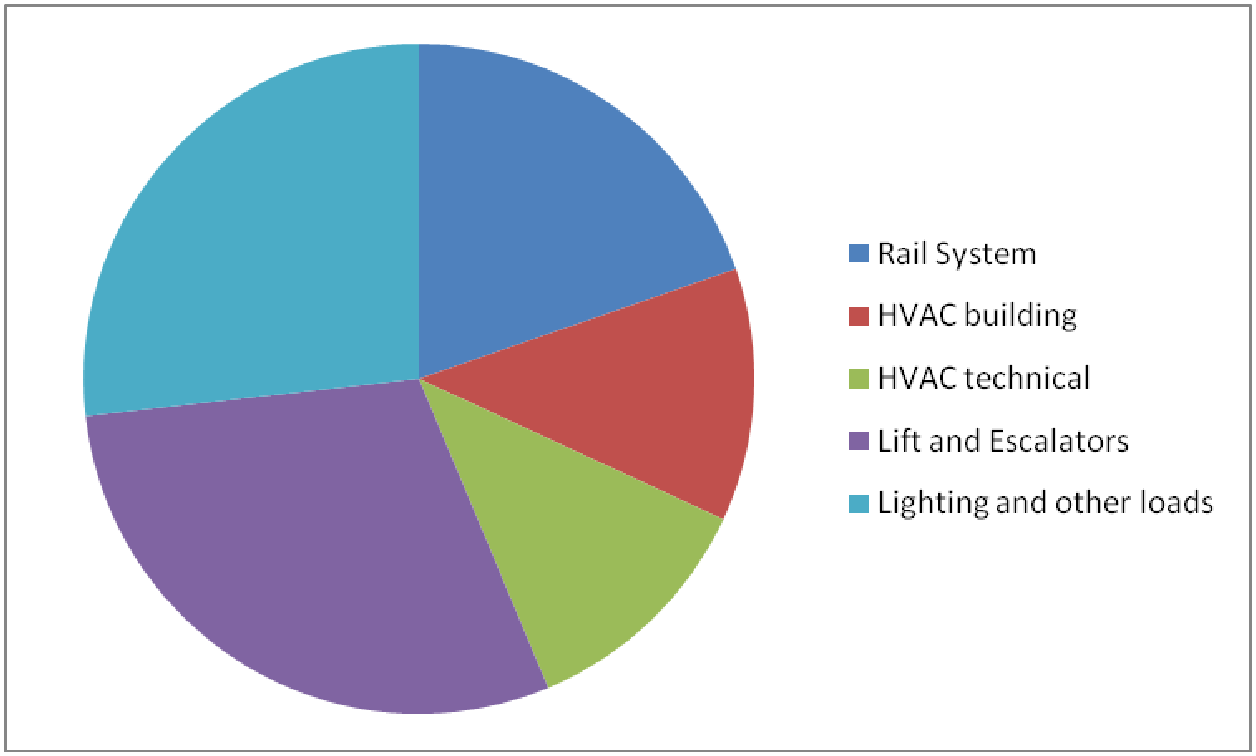

Figure 2. Distribution of all the users in a station

As it can be seen some of the major users of electricity is HVAC system and lighting. Using these as an example, the method of equipment selection and design criteria will be presented. All equipment selection criteria will not be mentioned in this report as these are to be developed by the relevant subsystem.

9.2.1.1 HVAC system

The HVAC systems that mainly are used in the stations could be:

- ENERGY STAR™ qualified air conditioning (ENERGY STAR™[6] qualified central air conditioners have a higher seasonal efficiency rating than standard models, which makes them about 14% more efficient than standard models. Any product that earns an ENERGY STAR™ means products meet strict energy efficiency guidelines set by the US environmental protection agency and the department of energy)
- High-efficiency energy recovery ventilator (high-efficiency energy recovery ventilator air handling units are capable of recovering heat from extracted air. The heat transfer is up to 90% efficient to incoming air hence overall conditioning required for the incoming air is lowered

Natural ventilation is also incorporated in building design to avoid air conditioning system at the concourse Level. As an example, the LVD transformers are installed in a ventilated only technical room, as such the specifications of the transformer will incorporate the environment it will be installed. The other LVD and temperature sensitive equipment are installed in an air conditioned technical room.

9.2.1.2 Lighting system

As the environment changes significantly during the year as well as the length of the days, the railway company must look onto viable options for replacing the natural lighting with economical artificial lighting system. However, natural light should be used as often as possible as this is also a very large user of energy. Also the use of light detectors (photocells) should be considered in order to switch-off lights if natural light sufficient can reduce the energy demand of electrical lighting systems.

The type of lights installed in railway systems could be:

- ENERGY STAR™ qualified LED lighting
- Compact fluorescent lamps (CFL) type where possible (The CFL bulbs use considerable less energy than traditional incandescent light bulbs)
- LED (LED have a longer life cycle than traditional incandescent light bulbs and give more light for the same wattage output).

It should be noted that the types of light that will be used must also fit international lighting standards.

9.2.1.3 Other systems

The same methodology used in determining and selecting the lighting and HVAC systems should be used towards other railway systems (e.g. escalators, elevators which they are very large consumers of energy). Also, energy efficiency should be evaluated against capital cost.
Escalators will also automatically switch off or operate at lower speeds when no one is using it after a preset time hence further reducing its energy usage.

9.2.2 Monitoring and people management

People will operate all the above mentioned equipment and systems within the rolling stock, OMSF, and station therefore proper training, and general awareness campaigns must be implemented.
The SCADA system will also be used to obtain energy usage at each station to be analyzed as the effectiveness of the energy management against the baseline.

9.2.3 LEED

9.2.3.1 What is LEED?

The LEED[9] Green Building Rating System™ encourages and accelerates global adoption of sustainable green building and development practices through the creation and implementation of universally understood and accepted tools, and performance criteria.
LEED is a third-party certification program and an internationally accepted benchmark for the design, construction and operation of high performance green buildings. It provides building owners and operators the tools they need to have an immediate and measurable impact on their buildings' performance.
LEED promotes a whole-building approach towards sustainability by recognizing the performance of the following five key areas in human and environmental health:

- Sustainable site development
- Water efficiency

- Energy efficiency
- Materials selection
- Indoor environmental quality

Credits and prerequisites are also organized into these five categories. An additional category, innovation and design process, addresses sustainable building expertise as well as design measures not covered under these five environmental categories. Regional bonus points are another feature of LEED and acknowledge the importance of local conditions in determining best environmental design and construction practices.
LEED is flexible enough to apply to multiple building types – commercial as well as residential and the “most” appropriate scoring alternative should be been chosen for a transportation project. LEED works throughout the building lifecycle – design and construction, operations and maintenance, tenant fit out, and significant retrofit. Also, LEED for neighborhood development extends the benefits of LEED beyond the building footprint into the neighborhood it serves.

9.2.3.2 LEED benefits and disadvantages

LEED is a program for the “building” sector. LEED is not setup to specifically address transportation facilities. LEED certified buildings typically use resources more efficiently when compared to conventional buildings which are simply built to code. LEED certified buildings often provide healthier work and living environments, which contributes to higher productivity and improved employee health and comfort. The USGBC has compiled a long list of benefits of implementing a LEED strategy which ranges from improving air and water quality to reducing solid waste, benefiting owners, occupiers and society as a whole.

Often when LEED certification is pursued, this will increase the cost of initial design and construction. One reason for the higher cost is that sustainable construction principles may not be well understood by the personnel undertaking the project. This could require time to be spent on research. Some of the finer points of LEED certification (especially those which demand a higher than-orthodox standard of service from the construction team) could possibly lead to misunderstandings between the design team, construction team, and client, which could result in delays. Also, there may be a lack of abundant availability of manufactured building components which meet LEED standards. Pursuing LEED certification for a project is an added cost in itself as well. This added cost comes in the form of USGBC correspondence, LEED design-aide consultants, and the hiring of the required commissioning authority (CxA) – all of which would not necessarily be included in an environmentally responsible project unless it were also seeking LEED certification.

However, these higher initial costs can be effectively mitigated by the savings incurred over time due to the lower-than-industry-standard operational costs which are typical of a LEED certified building. Additional economic payback may come in the form of employee productivity gains incurred as a result of working in a healthier environment. Studies have suggested that an initial upfront investment of 2% extra will yield over ten times the initial investment over the life cycle of the building.

Although the deployment of the LEED standard has raised awareness on green building practices, its scoring system is skewed toward the ongoing use of fossil fuels. More than half of the available points in the standard support efficient use of fossil fuels, while only a handful are awarded for the use of sustainable energy sources. Further, the USGBC has stated support for the 2030 challenge, an effort that has set a goal of using no fossil fuel greenhouse gas emitting energy to operate by 2030.

In addition to focusing on efficient use of fossil fuel, LEED focuses on the end product. For example, because leather does not emit VOCs they are deemed healthy for environments, disregarding the use of extremely harmful chemicals in the process of tanning leather. Other products that do not use harmful chemicals and focus on more sustainable production do not earn any additional points for their attention to environmental concerns.

LEED is a measurement tool and not a design tool. It is also not yet climate specific, although the newest version hopes to address this weakness partially. Because of this, designers may make materials or design choices that garner a LEED point, even though they may not be the most site or climate appropriate choice available.

9.2.3.3 LEED certification

Certification is based on the total point score achieved, following an independent review and an audit of selected credits. With four possible levels of certification (certified, silver, gold and platinum), LEED is flexible enough to accommodate a wide range of green building strategies that best fit the constraints and goals of particular projects.

A rapidly growing number of private sector organizations and governments are adopting LEED certification in their policies, programming and operations, with the goal of achieving and demonstrating sustainability. The reasons for certifying include:

- Gain recognition for green building efforts
- Validate achievement through third party review
- Qualify for a growing array of government incentives
- Contribute to a growing green building knowledge base

9.2.3.4 LEED new construction and major renovations

The following are typical sustainable design goals or initiatives that achieve points that can be awarded to the project and achieve the certification levels mentioned above. LEED has set the number of points that can be achieved in each area. The areas include:

- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Regional priority credits

9.2.3.5 LEED analysis

The LEED analysis should present information that is among the first step of several to help the railway company to make the decision and commitment to include "sustainable design" initiatives, to review impact on environment and agricultural land, to only purchase equipment that meet sustainable objectives, and to modify operation procedures that meet a LEED level of accreditation. This is a decision that has to be made at the beginning of the preliminary design.

Specifically, the railway company should develop a corporate LEED report. The scope of this report[0] will address:

- Summary of the sustainable design and description of what is LEED

- Discussion on benefits and disadvantages for structures and buildings that are LEED certified. The emphasis being on higher initial project capital costs to achieve operating cost savings over time and potential improvement in employee working environment
- Discussion that LEED is a measure of sustainable design and "sustainable design" is a commitment that needs to be incorporated: in the design at the beginning of a project, in the procurement of equipment and in the operation of the facility
- Discussion on LEED certification and ranking
- Identification of typical sustainable design initiatives or goals for the new construction
- Identification of typical water efficiency initiatives or goals
- Identification of typical energy and atmosphere initiatives or goals
- Identification of typical material and resources initiative for sustainable design
- Identification of typical indoor environmental quality initiatives
- Provide a summary of the commitment that has to be made to reach LEED accreditation
- Provide a recommendation to proceed with LEED accreditation or not
- Provide a list of suggested sustainable design objectives

9.2.3.6 Summary of commitment to achieve LEED accreditation

The following summarize the level of commitment required by a railway company and the DBOM contractors in order to achieve sustainable building objectives that achieve LEED accreditation.

- Commitment must be made at the beginning of preliminary design, site selection of rail routing and station site selection to achieve this sustainable design and LEED ranking objective
- Sustainable construction principles, material supply, equipment supply may conflict with project initiatives to use local material of supply or may introduce higher efficiency equipment that is not presently supported by local merchants, services or manufactures
- Commitment must be made to additional resources and funds that are required to:
    - Research the finer points of sustainable design required for LEED for design, construction and facility operation
    - Additional independent LEED design-aide consultants that monitor and award LEED credits. Experience shows that this fee is in the order of $90,000 (2010 rates) per submission and there may be a separate submission for each station
    - Higher initial capital costs to achieve future operational savings, environmental and work environment objectives. Studies have suggested initial upfront investment 2% more in building cost to achieve a savings of 10 times the investment from operating costs over the life of the project
- LEED has specific objectives that if they are not met, the project cannot be certified as LEED. No points are awarded for these prerequisites. Points are awarded when design or facility operation exceed the prerequisite objectives. The prerequisites are:
    - Erosion and sediment control during all construction activities
    - Water use for the project is 20% less than the typical water use for buildings of this type
    - Project energy-related systems are installed, calibrated to perform in accordance with design requirements
    - Energy efficiency is 10% less than typical buildings of this type
    - No CFC based refrigerants
    - Storage and collection of recyclables
    - Minimum ASHRAE standards for indoor air quality
    - No Smoking

- The following are typical design and operation LEED objectives applicable for a railway project:
    - This is a public transportation project which could meet LEED objectives to reduce pollution and land impacts due to automobiles
    - Storm water management which could meet LEED objectives to limit disruption to natural water flows
    - Light management which could meet LEED objectives to reduce impact of light on nocturnal environments
    - Water efficient landscape which could meet LEED objectives to reduce potable water consumption
    - Optimize energy which could meet LEED objectives to reduce energy consumption
    - Eliminate fluorocarbon and halon from fire protection systems
    - Use construction materials that contain recycled material
- The following are examples of LEED objectives for stations that this project will likely not meet:
    - Development density and site selection LEED objectives may not be met for rural stations
    - Due to the large parking requirements at stations, project will not meet LEED objectives to reduce thermal gradients between developed and underdeveloped areas
    - 100% consumption of storm water on site is not achievable

The following is a summary of key points presented in subsection 9.2.3:

- LEED is a program set up for buildings
- Each rail station will likely have to be LEED certified separately
- LEED or sustainable design is an objective that needs to be implemented at the inception of the preliminary engineering of a project
- LEED or sustainable design requires design initiatives, operational objectives and commitment by the railway company to enable a project environment where these objectives can be met
- Sustainable design sets objectives that have a long term benefit by reducing power consumption, reducing water consumption, and providing a sustainable work environment for the employees and the public
- It is suggestible that a railway company should achieve a LEED certified status

9.3 OMSF

Within the OMSF the following steps should be used in order to efficiently manage energy:

- In the workshops, natural ventilation will be incorporated in the design to avoid air conditioning systems in these areas. With properly designed natural ventilation system the temperature in these areas will be suitable for the work to be carried out there
- Other areas such as the OCC, electronic equipment rooms and offices, and air-conditioning systems will be used. As in the stations, the selected air-conditioners could be ENERGY STAR™ qualified or high efficiency energy recovery ventilator type
- As with the stations natural light will be used where ever possible in order to further reduce the energy consumption. Also as in the stations light detectors will also be used to switch on artificial lighting system if the natural light is insufficient. The use of ENERGY STAR™ qualified, CFL type or LED lights will be used where possible
- People should operate all the above mentioned equipment and systems within the OMSF. Training and general awareness campaigns must be implemented too
- The SCADA system will also be used to obtain energy usage at OMSF to be analyzed as the effectiveness of the energy management against the baseline

10.0 Construction

During the construction phase energy will be used. At this stage it will be very difficult to monitor and manage energy usage as the systems to do this are still being built. It is necessary to involve the construction managers and the construction teams in managing energy. These will include switching off machinery not in use, proper maintenance of construction equipment, etc. People awareness is fundamental.

11.0 Operation

The timetables should be conceived with the following guidelines in order to minimize energy consumption:

- When not needed, run at a speed slightly less than maximum operating, speed. This allows also having regulation margin and recovering some delay as well as saving energy. This is ensured by the speed profiles in normal speed, in which the maximum speed could be reduced by 10 km/h or more
- Promote energy efficient train driving, minimizing acceleration during short periods, immediately followed by braking
- Implement, whenever possible, operation procedures minimizing empty (without passengers) trips for trains. For example:
    - If multiple train consist are implemented, run multiple trainset during peak hour and single trainset during off peak hours or on Sunday
    - Implement time tables such that some trains can be stabled in terminal stations, avoiding long empty trips
- When resuming from a congested situation where many trains are stopped due to an incident, the sequence should avoid simultaneous train re-starting, which could lead to a system-wide traction power consumption peak. This function can be implemented by the ATS
- Implement proper timetabling to promote energy efficient running of the train
- The following are to be avoided as they will increase the use of energy
    - Trains running ahead of schedule
    - Trains waiting at stations
    - Trains blocking junctions

Other measures that will help reduce energy consumption and can be implemented through procedures are:

- Within the OMSF
    - Switch off unnecessary depot equipment, lighting (parking structure and perimeter lighting will not be switched off during non-operating hours for security and safety reasons) etc.
    - Power off stabled trains
    - Limit the duration of the warm-up sequence (e.g. HVAC operation) of trains which are waiting to take their service
- Within the stations
    - Switch off unnecessary equipment, lighting (parking structure and perimeter lighting will not be switched off during non-operating hours for security and safety reasons) etc.
    - During operation, choose the set point of the on-board air conditioning for optimum passenger comfort/energy consumption trade off

12.0 Maintenance

As with any E&M devices maintenance allows for the proper running of equipment. All equipment that are going to be used by a rail transit system should be maintained as specified by manufacture or by prudent industry practices and managed by a MMIS.

Proper maintenance will guarantee the energy efficiency of all equipment such as lifts, air conditioners, pumps, lights, trains etc. Examples of maintenance that can be carried out to improve efficiency are schedule inspection and cleaning of filters for air conditioners, pumps etc.

13.0 Utility tariff structure

The required traction power for railway stations and OMSF will be provided by a utility. In this case the following elements should be analyzed:

- Identify the utility's tariff structure. What are the related ranges of maximum power demand, energy charges, and other particular characteristics?
- Identify what is the utility's bill with regards to an industrial customer. The following must be considered:
  - An energy charge with a specified rate
  - A demand charge related to maximum demand
- Identify if the contract with the utility could include an agreement about a reserve capacity, intended to match the customer's highest expected power demand. It is to be noted that in case of fast power demand fluctuations, the utility may consider shorter metering periods, or even other power capacity parameters.
- Make sure that the railway company will apply the utility's tariff for the following categories:
  - Traction power
  - Passenger stations and OMSF

To reduce the power used by a station it is necessary to reduce the demand (KVA). The method used to reduce this is described in section 8.1 of this paper. It is also necessary to carefully specify to utility what will be the exact demand as the minimum bill will be 75% of this. This is if we use less than 75 % of the declared demand referred to by the utility, as the reserve capacity will be billed at the 75% amount. The demand has to be carefully monitored. This can be done by the ATS subsystem. If necessary it is possible to allay to utility to review as reduce the reserve capacity. To further reduce the cost it is necessary to reduce energy charge.

14.0 Alternative energy sources

Alternative energy sources can be considered for use at the OMSF and the stations in order to reduce the electricity demanded from utility.

Solar cells, see Figure 3, can be installed on the roof of the stations and the buildings of the OMSF (aesthetics etc. will have to be considered). These cells will be used to supplement the supply provided by the utility. This is also an environmentally friendly solution helping in the reduction of emissions. Savings in terms of electricity cost must be studied further. The capital, installation and maintenance cost must be compared to the cost of same quantity of electricity provided by the utility. Solar cells can also be considered to provide power for the lighting along the alignment but a cost needs to be done.

Figure 3. Solar powered light posts

15.0 Training and energy awareness programs

The effectiveness of any energy management system is based on people. An awareness campaign with the energy management policy and a vision should be developed by the railway company. This will be promoted internally via posters and other such mediums to ensure all employees are appraised of the energy management system and the role they play individually in the system. These will include simple energy management techniques such as switching off lights in rooms not in use to training.

The general training for train drivers shall have special emphasis to energy awareness as it pertains to driving methods.

The training of service technicians for building maintenance, subsystems maintenance and trains maintenance will include energy management.

16.0 Benchmarking and plan review

The energy management plan has to be constantly reviewed in order for it to be practically evolved towards the maximization of the system's energy efficiency.

As mentioned earlier the railway company's energy consumption will be compared to its baseline year usage to check the efficiency of the energy management systems. Another method that can be used to evaluate the energy management plan is to benchmark the under scrutiny rail system to another comparable rail system.