RENEWABLE ENERGY STRATEGIES FOR THE INDIAN RAILWAYS

Munish Kumar Tiwari*

Keywords: Indian Railways, wind power, solar power, hydro-electric power (HEP), biofuels, geothermal energy, tidal power, wave energy.

Abstract:

Energy and Sustainable development:

It involves the equitable sharing of the benefits of economic activity across all sections of society, to enhance the well-being of humans, protect health and alleviate poverty. If sustainable development is to be successful, the attitudes of individuals as well as governments with regard to our current lifestyles and the impact they have on the environment will need to change.

Situation Analysis and present thought:

It has now been established that the combined efforts of governments, corporations and non-governmental organizations are needed to reverse the damage caused to the environment over the past number of decades. Moreover organizations are also realizing that following environment friendly practices will also result in significant benefits and in the long run be beneficial for their bottom line. For instance, it is quite clear that usage of renewable energy by the Indian Railways (IR) will not only help reduce carbon emissions but also provide the much needed energy security.

* MBA Department, Anand Engineering College, Agra, UP, India.

Objectives:

- To examine the renewable energy options emerging in the UK & EU today, in order to gain a macro perspective
- To identify the renewable energy options suitable for railroad industry and to do an in-depth analysis of measures being taken in the UK to introduce these options
- To look at the futuristic energy options with the objective of planning for the distant future
- To recommend to the Indian Railroad industry, a series of measures that should be adopted in order to achieve energy security, sustainable development & minimize environment damages.

1. Methodology:

1.1 Literature survey: Collect information regarding renewable energy projects. The sources of information would be internet, books, field visits which will enable discussions with the various renewable energy companies in the UK as well as experts from the academia.

Analysis: Carry out a careful analysis of the various options – weigh the pros & cons and try to assess them from an Indian organization's perspective

1.2 Issues & Challenges for implementation: Based on discussions and interviews with experts as well company officials, work out the specific cases of success & failures.

Developing a strategy: A strategy for Indian Railways be devised based on the most appropriate options.

2. Energy requirements on the Indian Railways:

To handle IR vast freight and passenger traffic, it operates as many as **4000 diesel powered** and an equal number of electric locomotives. These locomotives consume 2000 million liters of diesel & 9000 million units of electricity annually. The table below shows the break up

of energy used by the Indian railways in 2 consecutive years – for **traction** and **non-traction** purposes.

	Traction	Non-traction
Electricity (million KWH)	**9,013**	2,361
Diesel (million liters)	2,007	33

Table1. ***Traction*** *means energy used for propulsion i.e. movement of trains* ***Non-Traction*** *means energy for stationary applications viz. Production Units, Workshops, Stations and other maintenance centers*

3. Renewable Energy Defined:

Renewable energy refers to power generated by a renewable source. When the energy is generated, the resource is not depleted or used up. They are naturally replenished, and can either be managed so that they last forever, or their supply is so enormous humans can never meaningfully deplete them. Unlike fossil fuels, most renewable energy sources do not release carbon dioxide and other air pollutants as by-products into the atmosphere. As the amount of fossil fuel resources on Earth decreases, it is becoming increasingly important to find and utilize alternative fuels. **[7]**

Examples of renewable resources include:

- wind power;
- solar power;
- hydro-electric power (HEP);
- biofuels;
- geothermal energy;
- tidal power; and
- wave energy

4. Renewable Energy Scenario in the UK:

Currently, renewable energy resources contribute only about **3.86 %** towards the UK's electricity supply. Part of the reason for their limited use is their significant cost relative to fossil fuel or nuclear power generation. However, as renewable energy technology improves, the cost of these more sustainable forms for energy production will become much more competitive. The break up of renewable energy sources in the UK is as follows:

Source	% Generation
Bio-mass	: 0.94% (735 MW)
Wind	: 0.83% (649 MW)
Hydroelectric	: 2.03% (1579 MW)
Wave	: 0.006% (0.5 MW)
Solar	: 0.051% (4 MW)

Table 2. Source: http://www.dti.gov.uk (Department of Trade & Industry)

4.1 Major challenges faced by the United Kingdom. These are:

_ Reality of Climate change

_ Decline in UK's indigenous energy supplies

_ Need to update much of UK's energy infrastructure

Based on the above the **4 major goals** as spelt out in the **Energy Paper** are as follows:

- to put ourselves on a path to cut the UK's carbon dioxide emissions – the main contributor to global warming - by some 60% by about 2050 with real progress by 2020;
- to maintain the reliability of energy supplies;
- to promote competitive markets in the UK and beyond, helping to raise the rate of sustainable economic growth and to improve our productivity; and
- To ensure that every home is adequately and affordably heated.

5. Renewable energy options for the Indian Railways:

Based on the detailed evaluation of the various renewable energy options, wind, solar, hydro & biofuels have been assessed with the perspective of application on a transportation organization like the Indian railways. Geothermal, tidal and wave are still considered to be too developmental in nature. Some of these are mentioned under the different renewable energy options merely as a reference.

5.1 Wind energy –

Wind farms in the UK tend to have a very quick pay back both in terms of energy as well as finances. The comparison of energy used in manufacture with the energy produced by a power station is known as the 'energy balance'. It can be expressed in terms of energy 'pay back' time, i.e. as the time needed to generate the equivalent amount of energy used in manufacturing the wind turbine or power station. The average wind farm in the UK will pay back the energy used in its manufacture within three to five months, this compares favourably with coal or nuclear power stations, which take about six months. **[9]**

5.2 Ail Wynt – Farming the wind

Cwmni Gwynt Teg – an immensely successful wind farm owned by a cooperative of local farmers in North Wales. It presently has 3 turbines with a proposal to install 9 additional turbines.

Figure 1. Ail Wynt – Farming the wind

India is the fifth largest producer of wind power in the world after Germany, the US, Denmark, and the UK, with a wind power generation achievement of 1507 MW. The wind speeds in India are in the low wind regime with average wind speeds between 17 and 24 km/h. However, with a wind power potential of about 45000 MW, there is significant room for advancement. **[10]** For the IR, this may be a feasible option for the **stationary energy requirements** (**non traction purposes**) viz. in powering the production units and the various workshops. **It is not deemed suitable for traction** viz for powering the overhead electric lines which power the electric locomotives.

5.3 Solar energy – Thermal absorption panels provide a cost effective method of heating water with near zero emissions. They are ideal for supplementing other forms of heating. Hence they are strongly recommended for incorporation in the various railway buildings (*non traction stationary applications*) viz. rest houses, station retiring rooms, staff hostels etc.

Figure 2. OpTIC Centre, St.Asaph, North Wales, UK

One of these is the opto-electronic Technium at St Asaph, North Wales - the OpTIC centre. The building uses Photo Voltaics to create a massive 'solar wall', curving from the roof line into an ornamental pool, which also collects rainwater run-off for use in the building and external irrigation systems.

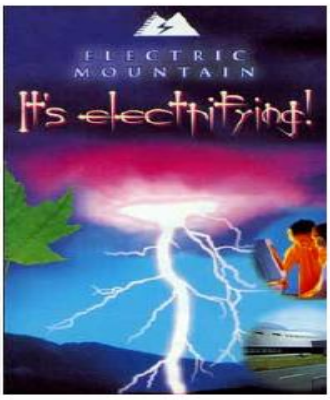
5.4 Hydro-electric Power –

Hydroelectric projects can essentially be classified as small (<25MW) or large (>25MW). From the organizational perspective of the IR, an option may be to invest in small Hydro projects with the objective of harnessing captive power for specific work sites.

5.5 Small hydro electric projects have several advantages viz.

- A sustainable, long-term supply of green electricity with a lifespan well in excess of 50 years
- A highly reliable and secure supply source
- Low running costs
- No annual fuel costs
- No greenhouse gas emissions

Applicability: The potential for small hydro (up to 25 MW) is estimated to be 15000 MW, mainly in the hilly areas of the sub Himalayas and the north-eastern regions of India. There are over 420 small hydro projects aggregating 1423 MW in India (MNES 2002). These projects are spread throughout the country in hilly regions as well as on canal drops. The small hydro is also seen as a potential source along with PV for providing decentralized power to various railway maintenance centers in remote areas of North and North East Frontier Zones.



WHEN IT WAS FULLY commissioned in 1984, Dinorwig Power Station was regarded as one of the world's most imaginative engineering and environmental projects.

Dinorwig's operational characteristics and dynamic response capability are acknowledged the world over. Dinorwig is the largest scheme of its kind in Europe.

Figure 3. Dinorwig Power station is one of the most remarkable examples of an energy project in which massive investment was made with the ultimate objective of preserving the landscape and environment.

5.6 Biomass / Biofuels –

Biomass energy or "bioenergy" includes any solid, liquid or gaseous fuel, derived from organic matter viz. plants, agriculture or forest residue. Focus is on liquid biofuels since they are the most relevant for the transport sector like the railways. In the liquid biofuels category, there are two options viz. ethanol and biodiesel. Since India is largely a diesel economy and diesel also happens to be the fuel on the railroad system, therefore biodiesel option is the one which is most relevant for IR.

The company Lurgi Life Science GmbH took just one year to build one of the largest biodiesel plants in Germany. Using innovative Lurgi technology, 120 000 tons of biodiesel and 12 000 tons of glycerine is being produced per annum in the North Rhine-Westphalian town of Marl.

Figure 4. Biodiesel plant in Germany

6. An in depth analysis of using biodiesel as an alternate fuel:

The understanding of the developments in biofuels in the UK is based on the detailed interaction with representatives of 2 major UK corporations viz. Green energy and D1 oils. The company Lurgi Life Science GmbH took just one year to build one of the largest biodiesel plants in Germany. Using innovative Lurgi technology, 120 000 tons of biodiesel and 12 000 tons of glycerin is being produced per annum in the North Rhine-Westphalian town of Marl. Whereas D1 oil is primarily basing its operations in Indian & Africa, the plan for Greenergy is entirely focused on the UK. Hence details of the various aspects of introducing biofuels in the UK by a company are discussed. Essentially a successful plan for introducing biodiesel as an alternate fuel should ideally encompass the following issues:

The plan of Greenergy to tackle the above issues is discussed in the paragraphs that follow:

6.1 Source of Seed

One of the major issues for biodiesel production is ensuring a steady supply of raw material for the plant Through their Field to Forecourt contract, **[11]** Greenergy has title in the 2003/2004 growing season to approximately 60,000 tonnes of rapeseed for biodiesel production. They also have relationships with major companies producing large quantities of high quality used cooking oil. The Contract will establish a secure supply of UK grown rapeseed as a primary feedstock for Green*ergy*'s biodiesel plant.

6.2 Seed crushing

They toll crush with a major crusher in the UK. This can easily be replicated in India as crushing is a standard activity and companies need not invest in additional infrastructure.

6.3 Blending Plant (esterification)

They are in discussions to build a biodiesel processing plant capable of handling 100,000 tonnes per annum and currently have tolling arrangements with a major processor in the UK.

6.4 Blending & Supply

6.5 Sales to customers

On 29th April, 2004, Tesco became the first major retailer to bring biodiesel to customers around the UK by announcing the start of a national roll-out of Green*ergy* Global Diesel - a new high quality, greener fuel. Global Diesel, supplied to Tesco by Green*ergy*, is a quality blend of 95 per cent Ultra Low Sulphur Diesel and five per cent biodiesel made from rapeseed. **[12]**

Figure 4. Global diesel pump at Tesco

Source: http://www.greenergy.com/company/news_media

7. Environmental Issues:

7.1 Carbon certification: In Carbon-Certifying the fuels, Greenergy have developed considerable expertise in tracking greenhouse gas emissions, running carbon emission reduction projects and registering emission reductions for banking and verification.

7.2 Biodiversity guidelines: To sell as a "**green**" fuel, rape oilseed (*Brassica* spp)-based biodiesel needs to have all-round "green" credentials. For this reason the company has been asking farmers growing rape oilseed for biodiesel.

8. Back to the future:

No renewable & sustainable energy discussion can truly be considered complete without a mention of the **fuel cell** technology. This technology indeed has the potential to revolutionize the energy scenario for the entire planet in the times to come.

9. What is a fuel cell?

A fuel cell contains an anode and a cathode insulated by an electrolyte between them. Hydrogen is supplied to the anode while oxygen is supplied to the cathode. The two gases try to

join, but because of the electrolyte, the hydrogen atom splits into a proton and electron allowing the proton to pass freely through the electrolyte whilst the electron takes a different route, creating an electric current before recombining with the hydrogen and oxygen, creating a molecule of water. This chemical process generates electrical and thermal energy but produces100% pure water as a by-product.

10. Major fuel cell projects:

An international consortium, led by Vehicle Projects LLC of Denver in the US, is developing the world's largest fuel cell vehicle, a 1MW locomotive. Another major ambitions project in the UK is the powering of buses in London with the fuel cell technology.

Figure5. A prototype fuel cell car developed by Toyota on display in Paris

11. Epilogue: Putting it all together:

Railway has two distinct requirements for **traction** and **non traction** (stationary) purposes (ref.5.0).

- For non traction needs, energy options like **wind** and **solar PVs** may prove to be viable and feasible. Small **hydro electric** schemes may also be considered in remote areas of north east & north frontier parts of India where ironically the paucity of power is coupled with an abundance of natural water resources.
- For traction purposes, which incidentally are the mainstay of railway operation, the most logical options remain **biofuels (biodiesel)** in the short run along with **fuel cell (hydrogen)** in the not so distant future.

12. Conclusion:

Usage of these technologies will provide significant benefits in terms of improved environmental benefits along with energy security. Significant use of biofuels for transport has major implications for biofuels production, fuel production, fuels distribution – as well as the rural economy & agriculture. IR needs to adopt a strategic approach to both these important new technologies, bringing together the prospective uses of hydrogen and biofuels in transport with other aspects of the energy systems. It needs to understand more about the options & technologies for hydrogen & biofuels production. It also needs to have a clear vision of the way in which infrastructures can evolve in good time.

13. References:

- http://www.ace.mmu.ac.uk
- http://www.un.org/esa/sustdev/documents/agenda21
- www.indiacore.com/railways.html
- http://www.dti.gov.uk/renewable/index.html
- http://www.indianrail.gov.in/abir.html
- http://www.nrel.gov/clean_energy
- http://www.ace.mmu.ac.uk/eae/Sustainability/Older/Renewable_Energy
- DTI (Feb 2003) Our energy Future- Creating a low carbon economy, Energy White Paper
- http://www.bwea.com/edu/calcs.html
- MNES (Ministry of Non-Conventional Energy Sources). 2002 Annual Report 2001-2002 New Delhi: MNES, Government of India
- http://www.greenergy.com/field_to_forecourt
- http://www.greenergy.com/company/news_media
- Knight Helen (August 2003) Tubular cells, the engineers

Annexure:

14.1 Renewable Energy Options

***14.1.1 Wind Power**:* Air moves around the Earth because of the differences in temperature and atmospheric pressure that exist. Wind turbines harness the movement of air to produce energy. They do not emit any greenhouse gases and air pollutants, apart from those involved in their construction. The wind turns the blades which turn a rotor shaft. The resultant mechanical power is used to drive an electricity generator. Wind turbines are often grouped together in wind farms. They offer a highly sustainable form of energy.

14.1.2 Biofuels: Biofuels are plant material and animal waste, and specifically grown crops, which can be burnt to produce energy. It is sometimes known as "biomass burning". Biomass material may include tree and grass crops, and forestry, agricultural and urban waste. It is the oldest source of renewable energy known to humans. Biofuels are considered to be renewable sources of energy source because the energy they contain comes from the Sun.

14.1.3 Hydroelectric Power: On Earth, water is neither created nor destroyed, but is constantly moved around. Water evaporates from the oceans and other freshwater bodies such as rivers and lakes, and is stored by the atmosphere. Under certain weather conditions water vapour in air condenses to form clouds, and eventually precipitates out as rain, snow, sleet and hail. This precipitation collects into streams and rivers, and flows back to the sea. This is known as the water cycle. All this movement provides an enormous opportunity to create useful energy.

Hydroelectric power (HEP) uses the force of moving water to create electricity.

14.1.4 Geothermal Energy: Rocks beneath the Earth's crust contain naturally decaying radioactive materials like uranium, producing a continuous supply of heat. The amount of heat within 10,000 metres of the Earth's surface contains 50,000 times more energy than all the oil and gas resources in the world. Geothermal energy is power generated by the harnessing of heat beneath the Earth's surface. Wells are used to pipe steam and hot water from deep within the

Earth, up to the surface. The hot water is then used to drive turbines and generate electricity. The regions with highest underground temperatures are in areas with active or geologically young volcanoes. These "hot spots" often occur around the Pacific Rim. This area is also known as the "Ring of Fire" due to the large number of volcanoes.

14.1.5 Wave Power: Ocean waves are a form of wind energy that is concentrated within surface seawater. Friction develops between air and water as wind blows across the water, and waves are produced as energy is transferred between these two elements. Taking the motion of the waves, and translating it into mechanical or electrical energy, generates energy from waves. There are 2 types of instruments that can generate electricity from wave energy: floaters and sitters. Salter's Duck and Cockerell's Raft are examples of floaters and Vickers 'Duct' is an example of a sitter.

14.2 Details about Biodiesel

What is Biodiesel: Biodiesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics.

Process of manufacture: Biodiesel is made through a chemical process called Trans esterification whereby the glycerin is separated from the fat or vegetable oil. The process leaves behind two products -- methyl esters (the chemical name for biodiesel) and glycerin (a valuable byproduct usually sold to be used in soaps and other products). Can biodiesel help mitigate "global warming"?: A 1998 biodiesel lifecycle study, jointly sponsored by the US Department of Energy and the US Department of Agriculture, concluded biodiesel reduces net CO2 emissions by 78 percent compared to petroleum diesel. This is due to biodiesel's closed carbon cycle. The CO^2 released into the atmosphere when biodiesel is burned is recycled by growing plants, which are later processed into fuel.

15. Annexure:

15.1 Biodiversity Guidelines

One of the main reasons that customers choose biodiesel over ordinary diesel is its environmental performance. A major environmental benefit of biodiesel is the fact that it is a renewable fuel producing fewer greenhouse gas emissions. This is why oilseed rape grown in the UK for Green*ergy* is Carbon- Certified®. But to sell as a "green" fuel, oilseed rape-based biodiesel needs to have all-round "green" credentials. That is why Green*ergy* is proposing a set of biodiversity guidelines, drawn up in consultation with the RSPB, which if implemented will help ensure that crops produced for Green*ergy* biodiesel are grown to higher conservation standards.

15.2 Preferential treatment for farmers who respect the biodiversity guidelines

After harvesting the crop, the farmer will be asked to fill in a questionnaire collecting the information needed to Carbon-Certify the crops and asking which of the biodiversity guidelines have been followed. In future years, Green*ergy* will offer farmers who comply with the guidelines preferential treatment over those who do not. Some of the guidelines can be implemented with very little financial consequence to the farming business.

15.3 The biodiversity guidelines

Farmland birds are a very good indicator to the wildlife value of the farm. Following these guidelines will help to support the range of farmland birds that are found on farms growing oilseed rape.

1. Consider growing both winter and spring varieties of oilseed rape, as the different timing of flowering and sowing times will add to wildlife diversity.

2. Do not grow a large area of the same crop and do not grow set aside rape next to commercial rape. If the area of one crop is large, then consider leaving wildlife corridors. These may be two metre grass margins around fields or areas sown with a wild bird cover to provide winter feed and habitat. Funding to support this may be available through Countryside Stewardship Schemes.

3. Only grow varieties where the seed is palatable to wildlife and birds in particular. HEAR oilseed rapeseed is generally unpalatable to birds. If you are growing HEAR for another third party (non- Green*ergy*), we would ask you still to consider 10% wild bird cover to provide palatable seed.

4. Follow good agronomic practice, which will allow threshold levels of weeds and pests to develop before spraying. Molluscicides should be incorporated with the seed if needed. A fine rolled seed-bed is good for the crop and reduces slug activity. The use of insecticides and herbicides should be kept to a minimum for both financial and environmental reasons.

5. Where possible, allow the crop to ripen naturally as this can prolong birds' nesting time. If dessication is required, crops should be sprayed rather than swathed.

6. Use headlands as wildlife corridors. These may be two metre grass margins around fields or areas sown with a wild bird cover to provide winter feed and habitat. Funding to support this may be available through Countryside Stewardship Schemes

7. Only use bee-friendly sprays.

8. If soil type and circumstances allow consider min till, auto casting or direct drilling as this releases less CO2 and uses less fossil fuel than ploughing. The creation of a stale seed-bed by using herbicides should however be avoided if possible.

9. Farmer should support the Voluntary Initiative by doing the following three things:

• Join the National Register of Sprayer Operators (NRoSO)

• Have the sprayer tested under the National Sprayer Testing Scheme (NSTS)

• Complete a Crop Protection Management Plan (CPMP).