Government of India
Ministry of Railways

INDIAN RAILWAYS ORGANIZATION
FOR
ALTERNATE FUELS

VISION AND ROADMAP

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INDIAN RAILWAYS ORGANIZATION FOR ALTERNATE FUELS

VISION, MISSIONS AND ROADMAP

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VISION - IROAF

To emerge as a world class organisation in setting standards, development, research and execution in fuel and energy efficient and eco-friendly technologies, primarily for assimilation in IR.

Introduction

Search for viable alternatives to fossil fuels has been spurred both for reasons of economy and for preventing and reversing global warming. Governments worldwide, through internal initiatives and through international treaties are setting ever tightening goals for curbing and controlling use of energy sources that add Green House Gases (GHGs) and pollute the environment. India, with a large population and rapidly growing economy owes it to the humanity to adopt an environmentally sustainable energy economy. Indian Railways, being the largest single entity, which buys and uses energy in various forms, has the potential to become a leader in promoting the green economy and stimulate growth in the alternate energy industry.

Government of India's Policy

The Government of India, through the Ministry of Renewable Energy, has set the agenda for adoption of renewable energy through the five-year plan targets. The 12^{th} Plan targets include 15,000 MW through Wind Power, 4000MW through Solar, 2000MW through bio-mass etc. totaling 30,000MW of capacity addition only through renewable sources. The 13^{th} Plan targets (Year 2022) are equally ambitious. Quite clearly the Government of India has laid down a plan. IR needs to follow the national policy to contribute its own share to this plan.

Indian Railways - Status

Except for minor projects and showcase installations, Indian Railways have not aligned itself with the targets of the 2022. There is very little that IR is doing on its own to contribute to the agenda set by the Government of India. The steps taken so far by IR are not commensurate with the quantity of energy that it consumes and the influence that it can exert due to it being the single largest buyer of petroleum and electricity.

Technology

Technology exists and is being developed in various areas such as bio-fuels, solar PV, solar steam, solar hydrogen, wind, fuel cells etc. and is becoming affordable.

Natural gas is becoming a fuel of choice, due to new finds, laying of pipelines and infrastructure building for LNG. Even though it is a fossil fuel, due to fewer Carbon atoms in its molecular structure, Natural Gas usage emits less GHG than liquid fuels.

Apart from alternate fuels, it is being progressively realized that saving of petroleum fuels is "another source" of fuel. Advanced technologies exist and are being continuously being developed to make engines and equipment more energy efficient.

Better utilization of electrical energy in workshops, production units and other stationary installations may yield substantial savings.

State of the Industry

Indian Industry has matured in areas of solar, CNG/LNG storage and transportation, wind and first and second generation bio diesel. India still depends on import of technology or equipment for fuel cells, third generation bio-diesel, CNG/LNG kits for engines and fuel efficient and emission control systems. Energy efficient lighting, electric motors and other equipment are now increasingly being deployed in offices and on the shop-floor.

Role of IROAF

IROAF will emerge as the leader IR in introduction of Alternate Energy, Fuel Efficient and Emission Control Technologies, advise and implement these across the Network. It will function as a single window entity for knowledge and database on technologies, Clean Development Mechanism (CDM), suppliers, business partners and consultants. To achieve this, the IROAF will adopt following means amongst others:

(a) Work through a set of Missions, which will be periodically reviewed and updated.

(b) Create a Knowledge Centre – both paper-based and virtual.

(c) Subscribe to leading journals and build a library of subject-related books and other publications.

(d) Tie up with leading institutions through collaborations and memberships.

(e) Coordinate with concerned Ministries, Departments, Research Laboratories, Universities and International entities to explore state of the art and to enrich the knowledge base.

(f) Become a centre for drafting and finalising technical and commercial specifications for alternate energy, and fuel-efficient, energy-efficient and emission-control technologies.

(g) Arrange and participate in national and international technical conferences/ seminars/workshops.

(h) Invite students from engineering colleges to participate in IROAF's activities as part of their summer training programmes.

MISSION 1 – BIO-DIESEL

To become a significant player in use and promotion of Bio-Diesel as a viable alternative to Petro-Diesel and to catalyse investment and R&D in the country by introducing up to 20% bio-diesel in rail-traction by the year 2017.

Introduction

Bio-Diesel is a thrust area in finding solutions to the problems of Global Warming. Green House Gases (GHG) emitted by petroleum fuels are a matter of concern and governments worldwide have taken steps to introduce bio-diesels in varying measures as a substitute of fossil fuels.

Government of India's Policy

The national policy has set a target of 20% by 2017 for blending of bio-diesel and bio-ethanol. The Government of India is also setting up a National Mission on Bio-Diesel to promote production and use of this green fuel.

Indian Railways - Status

Indian Railways (IR) have a fleet of nearly 4500 diesel locomotives and growing rapidly. The annual consumption of high speed diesel is approximately 2.5 billion litres, nearly one-tenth of the national consumption. This makes IR the single largest buyer and user of high speed diesel. The onus on IR, therefore, as a driver in induction of bio-diesel in transportation is higher than on any other entity.

Technology

Suitability of bio-diesel has been adequately established with up to 20% substitution (B20) on engine test beds of RDSO. There is no adverse impact on engine components and no significant penalty in engine power.

Production of bio-diesel involves trans-esterification of vegetable oils and animal fats in a processing plant. Technology and process is well established. Source of oils are typically plantations of Jatropha, Pongamia, raw fish oil, waste/used cooking oil etc.

There is an emerging trend in this field to adapt to third generation bio-diesel, which use lignocellulosic material and micro algae as sources. These use very little land, but are relatively hi-tech.

State of the Industry

Though several large and small bio-diesel plants have been set-up in India in the private sector, many of them have either shut down or are running below capacity. Due to lack of

incentives, bio-diesel produced in India is not priced competitively against petroleum diesel. Many of the plants are surviving on the strength of export market.

Roadmap

With an annual consumption of 2.5 billion liters of high-speed diesel, a 20% blend will create a demand of up to 500 million litres of bio-fuel on diesel locomotives alone. This has the potential to spur the bio-diesel industry in India to unprecedented levels of activities. Unlike the fragmented ownership of the fleets of buses and trucks, IR presents itself as a single user of nearly 4500 diesel locomotives. Even with a numerically small fleet the IR has the potential of not only becoming a major influencing factor in driving the usage, investments and technology pertaining to bio-diesel. This is possible because this fleet is owned by a common management governed by common policy.

IROAF, as the nodal agency, will formulate policies and execute specific projects to achieve this.

MISSION 2 – CNG

To promote use of Compressed Natural Gas (CNG) as a substitute for High Speed Diesel to create a clean environment in urban and semi-urban and to reduce cost of transportation while reducing dependence on imports.

Introduction

Natural Gas is fast becoming a fuel of choice by the industry due to its inherent characteristics of low emission, clean burning and increasingly easy transportability. For the same calorific value, NG emits less CO_2, particulates and NO_x. It is also economical compared to liquid fuels.

Government of India's Policy

The government of India is promoting use of Natural Gas through incentives and liberal policies in import (OGL) and construction of pipelines. Building of international pipelines across Turkmenistan, Iran, Afghanistan and Pakistan are being explored to promote use of this cheap and clean energy source.

Indian Railways - Status

Indian Railways (IR) havetaken tentative steps in introduction of Natural Gas (in the form of CNG) as a fuel substitute on Diesel electric Multiple Units. There are nearly 700 Diesel Power Cars (DPC), which have the potential to be converted to dual-fuel mode.

Technology

Trials with up to 20% substitution of high speed diesel with CNG have been successfully carried out. This is based on the "fumigation technology". Fumigation involves mixing of natural gas in the charge air before supercharging and is generally limited to 20%

In-port Injection Technology involves injection of natural gas just before the opening of the inlet valve. This permits substitution of up to 60-65%.

High Pressure Direct Injection (HPDI) technology permits up to 90-95% substitution. Gas is directly injected into the cylinder through an additional injector. A pilot injection of small quantity of high speed diesel is then made to initiate combustion.

IROAF has planned retrofits with all three technologies.

Natural Gas is safer than liquid fuels like diesel and petrol and LPG due to its smaller range of inflammability.

State of the Industry

Most of the technology and equipment for retrofits are imported. HPDI is nearly proprietary. Conversion of an existing engine to dual-fuel, using any of the three technologies, involves extensive trials, mapping of engine characteristics at various levels of power, fuel substitution and safety related issues.

Roadmap

IROAF will introduce natural gas as a diesel substitute in all DEMUs sheds on IR. In addition, CNG will also be increasingly used on shunting locomotives to curb pollution in urban centres. IROAF will explore all available technologies such as Fumigation, In-port Injection, High Pressure Direct Injection (HPDI) and other emerging technologies to achieve these objectives.

MISSION 3 – LNG

To promote use of Liquefied Natural Gas (LNG) as a substitute of High Speed Diesel in traction to achieve unprecedented economies.Also to introduce LNG as a cheap and green substitute for conventional industrial fuels.

Introduction

Natural Gas is fast becoming a fuel of choice by the industry due to its inherent characteristics of low emission, clean burning and increasingly easy transportability. For the same calorific value, NG emits less CO_2, particulates and NO_x. It is also economical compared to liquid fuels. LNG offers the benefits of high volumetric efficiencies in fuel storage and handling over CNG.

Government of India's Policy

The government of India is promoting use of Natural Gas through incentives and liberal policies in import (OGL) and construction of pipelines. Oil PSUS have jointly created a company, Petronet India Ltd. to channelize imports, port handling, storage, regasification and distribution.

Indian Railways - Status

Indian Railways (IR) havesigned an MOU in the August 2011 with M/S Indian Oil Corporation to introduce LNG, both as industrial fuel and traction fuel.

Technology

The ultimate use of Natural Gas in engines is independent of the sourcing method, i.e. CNG or LNG. Energy density of LNG is better than that of CNG. It, however, requires an additional stage of regasification.

LNG offers several advantages over CNG, such as

(a) Storage is compact due to the liquid state of fuel. Volumetric requirement is one third of that of CNG. It still requires nearly 30% more volume than high speed diesel.

(b) Recent developments in cryogenics have enabled low cost storage and transportation systems. LNG is stored at atmospheric pressure, unlike CNG, which is stored at 200-250 bars. This makes LNG a much safer fuel.

(c) Consistency of purity is higher than that of CNG, due to the process of liquefaction.

Natural Gas is safer than liquid fuels like diesel and petrol due to its smaller range of inflammability. It is safer than LPG, as it is lighter than air, thus any leakage is quickly dispersed.

State of the Industry

Prototype locos with LNG have already been running in North America since 2012.

Oil PSUs are fully equipped to handle import, storage and distribution of LNG. Distribution requires special cryogenic lorries. However, LNG being a new fuel and consequently due to poor demand in the industry the growth of direct use of LNG is still slow. LNG can be carried to all geographical areas not connected with gas pipelines and also to small volume users.

Roadmap

IROAF will be the central agency to introduce Liquefied Natural Gas as a substitute for industrial fuels in workshops and factories and for high speed diesel in traction. Emerging technologies in international railroads will be explored and implemented on Indian Railways. IROAF will also explore substitution of industrial fuels and gases in workshops and production units with LNG. Captive power generation with DG sets will also be converted to LNG.

MISSION 4 – FUEL CELL

To lead the Indian Railways in introduction of fuel cells as a source of electric power for rolling stock and for standalone applications.

Introduction

Fuel Cells promise clean, noiseless and standalone units of power source. They work on direct conversion of fuel (hydrogen derived from fuels) into energy and give out only water as waste. Fuel Cells have still not become mainstream, though small implementations have started, primarily in the automotive sector. They offer modularity similar to batteries, though require relatively complex control systems to work.

Government of India's Policy

The Ministry of New and Renewable Energy has been promoting developments in the area of Fuel Cell since the Eleventh Five-Year Plan. The government is also planning to set up a National Hydrogen Energy and Fuel Cell Centre (NHEFCC) during the Twelfth Plan (2010-17), the proposal on hydrogen and fuel cells envisions acceleratedRD&D, and pilot projects on a variety of technologies and related infrastructure.

Indian Railways - Status

The first prototype small scale fuel cell is operational in an ALCo locomotive in the TKD diesel shed. It is a 2KW system which provides auxiliary power when the main engine of the locomotive is shut down. This is the first ever initiative in Indian Railways.

Technology

Fuel Cells have still not become mainstream, though small implementations have started, primarily in automotive sectors and industrial material handling vehicles. The USA, the European Commission, Japan and China have announced major initiatives and state funding to promote fuel cell technologies.

There are multiple technologies that use inputs like phosphoric acid, molten carbonates, solid oxides etc. but all of them eventually use hydrogen in the converter. Standard units of 10-20 KW are now increasingly available. Fuel Cell units often work in conjunction with a battery and require sophisticated but not control systems to work.

Most of the parts and assemblies are imported. The simplest option would be to use the Proton Exchange Membrane Fuel Cell (PEMFCs) with compressed hydrogen storage in the initial stages.

State of the Industry

A 10 kW PEMFC has been used in a prototype vehicle developed in India, in addition to a battery bank. Efforts are being made to develop indigenous technology for production of fuel cell systems in the country.

Indian Industry is fully capable of building fuel cell systems with indigenous electronic controls and battery, but with imported fuel cell stacks.

Roadmap

IROAF will lead the IR in introduction of fuel cells as a source of distributed electric power. Fuels cell will be gradually inducted for use in workshops and factories in fork-lifters and material trucks, shunting locos, railcars and rail buses, guard vans in freight trains and in specialized wagon and coaching stock for refrigeration as well as in standalone installations.

MISSION 5 – SOLAR ENERGY

To lead the Indian Railways in introduction of fuel cells as a source of electric power for rolling stock and for standalone applications.

Introduction

Solar Photovoltaic (SPV) Solar Cell is now a mature technology. Prices have plummeted due to economies of scale and entry of china in fabrication of SPV panels.

Government of India's Policy

The Ministry of New and Renewable Energyis actively promoting use of solar energy, both in direct generation of power using SPV cells and in use of reflectors-concentrators for heating, cooking and steam generation. The twelfth and thirteenth five-year plans have indicated installation of 4000MW and 15000MW of solar power respectively. The Solar Mission of the Government of India lays down plans for ambitions grid connected solar power units.

Indian Railways - Status

Solar panels have been installed for years in standalone establishment such as remote LC gates, ACD installations and small stations.There has been virtually no application in rolling stock except one some narrow gauge coaches on the JAT-PTK and KLK-SML section.

Technology

Solar Photo Voltaic conversion is a mature technology and has been totally indigenized. The technology is now simple and easy to modularise. SPV units of standard capacities in ranges from 20 to 150 Watts are now available economically.

Standard SPV panels can be mounted atop a coach or a guard van to cater to train lighting load.SPV units must necessarily come with a battery backup with simple electronic control.

State of the Industry

Solar Photo Voltaic Cells have now become a commodity. Bulk production has brought down prices. India is a major producer of SPV panels.

The largest installation of SPV technology in India is in Khimsar, Rajasthan, where a 5MWp unit is satisfactorily working.

Indian Industry is fully capable of building SPV systems with associated battery backup and controls.

Roadmap

IROAF will lead the IR in introduction of Solar Energy on rolling stock for trainlighting and auxiliary power needs. SPV systems will also be used for augmenting lighting of fixed installations, such as workshops, factories and stations.

MISSION 6 – OTHER EMERGING TECHNOLOGIES

To continuously explore emerging and leading technologies in areas of Alternate Fuels, Energy Saving, Emission Control, Environment Friendly usage of Energy and advise Indian Railways to adopt the most effective and responsible energy policies. IROAF will also develop an Emission Standard for rail vehicles, benchmarked on the leading entities of the world.

Introduction

New technologies are emerging continuously all over the world in these areas. There is a need to create a mechanism so that these become known to the policy makers of Indian Railways on a real time basis. There is also a need to adapt these to suit the needs of IR, develop low-cost indigenous equivalents, motivate Indian Industry to participate and most importantly, to create standards for nationwide implementation.

Government of India's Policy

The Government of India has already created stringent standards for emission control for road vehicles. Similar standards need to be developed for rail vehicles and implemented over a reasonable time-frame.

Standards of energy efficiencies are continuously being revised to tighter norms.

Indian Railways - Status

Indian Railways have no internal standards for fuel efficiencies of its fuel consuming equipment, such as rail vehicles, industrial furnaces, ovens or other devices.

Similarly, there are no IR standards for emission control for rail vehicles or stationery installations.

Areas that need attention

- Fuel Efficiency of Diesel Locomotives
- Emission Control on existing fleets of diesel locomotives, generator cars, DMUs, Tower Wagons, Track Machines, Railway-owned DG Sets.
- Pollution due to rolling stock – powered and trailing.
- Creation of a Pollution Control Standard for rail vehicles similar to "Euro" and "Bharat" norms for road vehicles. EPA and UIC standards have been developed in USA and Europe respectively.

- Human waste and bio-mass generate in Railways' premises need to be handled to reduce sewage and pollution overload on the environment, while generating useful fuel gas and/or electricity.

Roadmap

IROAF will lead the IR in introducing the most energy efficient and eco-friendly technologies in its operations, production and maintenance. IROAF will make available as a single window office information on these systems to the entire Indian Railways and other users. IROAF will also develop an emission standard for rail vehicles and industrial equipment and help Indian Railways adapt these.

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