



Research, Design & Development in New and Renewable Energy

7.1 Research & Development activities of the Ministry aim at resource assessment, technology development, demonstration and commercialization. The Ministry supports Research, Design, Development and Demonstration (RDD&D) to develop new and renewable energy technologies, processes, materials, components, sub-systems, products & services, standards and resource assessment so as to indigenously manufacture renewable energy products and systems. A comprehensive policy on RDD&D is in place to support R&D in new and renewable energy sector, including associating and supporting RD&D carried out by industry for market development. During the year, the Government announced Jawaharlal Nehru National Solar Mission (JLNNSM). Research and development is envisioned as one of the key elements of the strategy of the mission. With a view to have more technology focus and to cater to the needs of the Mission, the Ministry revised its policy and guidelines in October 2010. The guidelines have special focus on the following:

- i. Well defined mechanism for appraisal and faster approvals of RDD&D projects and for monitoring of their implementation;
- ii. Providing core-support to R&D institutions to strengthen their expertise in the specific areas for technology development and deployment in the country; and
- iii. The technology validation and demonstration projects in association with industry to facilitate commercialization in the country. There is a provision for supporting technologies sourced from other countries for assessing their suitability and adaptability under Indian conditions.

7.2 The RDD&D framework of the Ministry provides guidelines for project identification, formulation appraisal, approval and financial support. It contains two types of Committees, namely RDD&D Sectoral Project Appraisal Committee (RSPAC) and RDD&D Project Appraisal Committee (RDPAC). These committees have been set up to appraise the RDD&D projects and recommend them for funding by the Ministry and for providing overall guidance to the RDD&D efforts in new and renewable energy sector. In the XI Plan Period, the Ministry has made a provision for Rs. 500 crore for RDD&D in new and renewable energy sector. The focus is on improved efficiency, cost reduction and technology transfer and demonstration for their commercialization. The Ministry followed a pragmatic approach for directed research with clear cut deliverables for taking up R&D projects so that the process of technology development for commercialization could be expedited to achieve the goal set. The year 2010-11 has made remarkable progress in R&D activities giving impetus to development and demonstration of advanced solar technologies particularly advanced solar concentrating technologies for power generation in the country as also in other areas.

IPR

7.3 The officers of R&D Coordination Division represented MNRE in the Inter Ministerial meetings on IPR coordinated by DIPP, Ministry of Commerce, Government of India. Interaction with R&D Institutions/Organizations was pursued for strengthening IPR and patents in new and renewable energy.

NATIONAL BIOMASS COOKSTOVES INITIATIVE (NBCI)

7.4 During the year, under a Special Project on Cookstoves the Ministry held a series of brainstorming consultations with related stakeholders to ascertain the status of biomass cookstoves and to identify ways and means for development and deployment of efficient and cost effective biomass cookstoves in the country.

7.5 During the current year, a pilot project on demonstration of community size biomass

cookstove has been taken up to demonstrate the potential of larger biomass cookstoves for community applications such as Anganwadi, Mid-day Meals in Schools, Dhabas etc. in eight identified States. The feedback of the project will be used for large scale deployment of community cookstoves. The Ministry is considering to take up a pilot demonstration project for deployment of 2 lakhs family type cookstoves during 2011-12.

Strengthening Biomass Cookstoves Test Centres

7.6 Interaction with R&D institutions for strengthening test facilities for performance testing of biomass cookstoves was initiated in view of requests received from cookstove industries for issuance of excise duty exemption. The objective is to maintain quality product. Three test centres have been established to cater to the requirements of testing of cookstove industries for different zone in the country. The Test Centre at IIT Delhi will meet the testing requirements of cookstove industry for north zone, the test centre at Maharana Pratap University of Agriculture Technology, Udaipur will cater the testing requirements of eastern zone and the test centre at IMMT Bhubaneswar for western zone. In addition, testing of biomass cookstoves from industries from southern part of the country is being carried out at CGPL, IISc, Bengaluru under ABRC project.

7.7 The cookstoves are being tested for three performance parameters as stipulated in existing BIS, namely, thermal efficiency, emission ratio of CO/CO₂ and Total Suspended Particles. Three cookstoves have been granted excise duty exemption on the basis of satisfactory performance tested in testing centres. Other two industries have been suggested for improvement in their designs of cookstoves.

Revised Test Protocols and Standards

7.8 Interaction has also been initiated to examine the applicability of the existing BIS which was developed in 1991 and to develop revised test protocols and standards in the light of newer models of biomass cookstoves coming up in market. Some inputs have already been taken and revised draft test protocols and standards are under preparation.

Advanced Biomass Research Centre (ABRC), CGPL, IISc, Bangalore.

7.9 The ABRC project was taken up at Indian Institute of Science Bangalore during 2008-09 with an objective to strengthen the expertise of a research group at CGPL, IISc Bangalore for taking up advanced research for promotion of biomass energy in the country. The project has special focus on advanced research in thermo-chemical

conversion, technology packages development, and development of specifications, test protocols and standards for biomass energy systems. As part of the ABRC project, during the current year, active interaction was pursued with R&D institutions/organizations to consolidate the experience gained in biomass research and to identify gaps and ways to address the issues for technology development and promotion of biomass energy in the country. A document on "Strategy on R&D Activities for thermo-chemical conversion and promotion of biomass energy in the country" is being prepared jointly by the research group at CGPL, IISc, Bangalore and R&D Coord. Group, MNRE under the project and the same is being finalized.

BIOFUELS

7.10 The growing concerns about energy security and environmental pollution caused by ever increasing use of conventional fossil fuels has led to continuing search for environment friendly renewable fuels. Biofuels, which primarily include biodiesel and bio-ethanol, have been recognized the world over as the most suitable substitutes for petro-based fuels. In the Indian context, biofuels assume special importance, particularly from energy security point of view, as the domestic supply of crude oil meets less than 30% of the demand. Several initiatives have been taken to supplement petro-based fuels with biofuels.

7.11 The Ministry of New & Renewable Energy is primarily involved in the development of National Policy on Bio-fuels besides Research, Development and Demonstration on transport and stationary applications using bio-fuels,

strengthening the existing institutional mechanism and overall coordination regarding biofuels.

7.12 A high level National Biofuels Coordination Committee has been constituted under the Chairmanship of Prime Minister, with Ministers of the Ministries and Departments concerned as members, for coordination and policy guidance on different aspects of biofuels development, promotion and utilization. A Biofuels Steering Committee has also been constituted under the Chairmanship of Cabinet Secretary with Secretaries of the Ministries/ Departments concerned as members to provide guidance and to oversee the implementation of the policy on a regular and continuing basis. The first meeting of Biofuels Steering Committee was held in January 2011.

7.13 With a view to assess the productivity and suitability of the 15 identified promising genotypes of *Jatropha*, demonstration projects have been taken up in four States namely Chhattisgarh, Karnataka, Rajasthan and Tamil Nadu. Ministry has sanctioned three new R& D projects on pyrolysis at Indian Institute of Technology Bombay, Mumbai; VIT University, Vellore; and The Energy and Resources Institute (TERI), New Delhi. These projects are aimed at setting up modular pyrolysis units to process various agricultural and agro- industrial biomass wastes at decentralized locations for utilization of multi feedstocks such as agricultural and agro-industrial biomass wastes and wood wastes. During the year, MNRE has sanctioned four other R& D projects namely (i) Developing an atlas of high biomass sorghums amenable to ethanol production to International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Patancheru, Andhra Pradesh; (ii) Integrated Technology Development for Biodiesel Production using Heterogeneous Catalyst to Sardar Swaran Singh National Institute of Renewable Energy

(SSS-NIRE), Kapurthala; (iii) Large scale micro-propagation of elite genotypes of *Jatropha curcas* to Central Salt & Marine Chemicals Research Institute, Bhavnagar; and (iv) Production of Biodiesel from *Olax scandens*, a new and potentially rich source of oil to The Science Foundation for Tribal and Rural Resource Development (SFTRRD), Bhubaneswar.

7.14 Ministry has identified thrust areas on second generation biofuels for taking up Research, Development and Demonstration work leading to commercialization of the technologies. The identified thrust areas are: (i) Lignocellulosic ethanol/bio-butanol production; (ii) Green diesel and BTL; (iii) Algal Biofuels; and (iv) Bio-refineries. Ministry has invited proposals for Research, Development and Demonstration under the identified thrust areas from Universities, Research Institutions and Industry, both in Private and Public Sectors.

Solar Photovoltaics and Solar Thermal ---Details given in Chapter 6 on JNNSM

WIND ENERGY

7.15 The Ministry supports the R&D projects through C-WET for in-house Research & Development projects and through research institutions, national laboratories, Universities and industries. Some of the activities initiated during the year are on performance quantification study on two 20-years design-life exhausted 200 KW wind turbine gear boxes after nano-coating, and establishment of 2 MW wind turbine for carrying out various R&D activities.

NEW TECHNOLOGIES

7.16 New Technologies like Hydrogen Energy, Fuel Cells, Electric and Hybrid Electric Vehicles, Geothermal Energy and Tidal Energy are the emerging technologies that are potentially relevant to transport and power generation sectors. The Ministry is implementing a broad based research, development and demonstration (RD&D) programme for development and promotion of these technologies through research, scientific and academic institutions; national laboratories, universities, industries, state agencies and non-governmental organizations.

Hydrogen Energy & Fuel Cells

7.17 Hydrogen is a clean energy carrier with potential to replace liquid and gaseous fossil fuels in

coming decades. In recent years notable progress has been made in India for the development and demonstration of hydrogen energy and fuel cell technologies. The main drivers of increasing interest in developing technologies for production of hydrogen, its storage and utilization are energy security, depleting fossil fuel reserves, abatement of green house gas emissions and improving air quality.

7.18 The Ministry has been supporting a broad based RD&D programme on different aspects of hydrogen energy technologies including hydrogen production, its storage and utilization for stationary, motive and portable power generation applications using

internal combustion engines and fuel cell technologies. The emphasis of the RD&D programme is to make the evolving hydrogen energy and fuel cell technologies more efficient, convenient, safe and reliable apart from making them cost-competitive.

Hydrogen Production

7.19 Currently, hydrogen is mainly produced by reformation of liquid and gaseous hydrocarbons for use in petroleum refineries, fertilizer production and other applications. While some hydrogen is produced by electrolysis of water, some hydrogen is also available as a by-product from chlor-alkali units. The focus of the Ministry's programme is on development of processes for hydrogen production through renewable energy methods. In this context, R&D efforts for splitting of water through photo-electro-chemical and photo-catalytic methods using solar energy; and thermo-chemical method using nuclear energy and also through the microbial, catalytic reformation and gasification routes of biomass are being pursued in the country. RD&D projects for hydrogen production by reformation of biomass derived glycerol; decomposition of hydrogen sulphide, and renewable and fossil fuel based liquid and gaseous hydrocarbons by non-thermal plasma reformation technique; and electrolysis of water using wind generated electricity are also being implemented with financial support of the Ministry. One new R&D project was supported during 2010-11 at the Institute of Minerals and Materials Technology, Bhubaneswar for production of hydrogen through water splitting using photo-electro-chemical method.

Hydrogen Storage

7.20 Storage of hydrogen in a compact and efficient manner is a major technological challenge and thrust area for research. On-board storage of adequate quantity of hydrogen is essential to provide sufficient range to hydrogen fuelled vehicles. Storage of hydrogen in solid-state materials is considered to be safe in comparison to high pressure gaseous and liquid hydrogen storage and is, therefore, one of the focus areas of research in the country. The Ministry is presently supporting R&D projects on hydrogen storage through development of metal, inter-metallic and complex hydrides and carbon materials. One new R&D project on synthesis of magnesium based hydrogen storage alloys with lower sorption temperatures was supported at Non-Ferrous Materials Technology Development Centre, Hyderabad during 2009-10.

Applications of Hydrogen Energy

7.21 In the area of utilization of hydrogen energy, the main developmental efforts are focused on use of hydrogen alone or by blending it with liquid or gaseous hydrocarbon fuels in internal combustion engines. Hydrogen fuelled three wheelers using hydrogen stored either in metal hydride or in pressurized form in cylinders are being developed in the country. Work on development of multi cylinder internal combustion engine for automotive application has also been supported by the Ministry. R&D efforts for blending of hydrogen with diesel for use in a utility vehicle are also under progress through an industry. One project was supported at Electrical Research and Development Association, Vadodara for development of a metal hydride based hydrogen storage system for stand alone, portable hydrogen fueled genset during 2010-11.

Demonstration Projects

7.22 A hydrogen-compressed natural gas (H-CNG) dispensing station, set up by IOCL at Dwarka in New Delhi with partial financial support

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Wind energy based prototype hydrogen production unit developed by Electrical Research & Development Association, Vadodara

from the Ministry during 2008-09, is being used for dispensing hydrogen (up to 20% by volume) blended CNG fuel in demonstration and test vehicles. Presently there are only two such hydrogen production cum H-CNG dispensing stations in the country.



H-CNG vehicle undergoing field trials

7.23 A development-cum-demonstration project for use of hydrogen (up to 30%) in CNG as fuel in select vehicles (3 buses, 2 cars and 2 three wheelers) to achieve hands-on experience on different aspects of hydrogen like its production, storage, transportation and utilization as an automotive fuel, sponsored by the Ministry during 2007-08, progressed during the year. The project is being implemented through a consortium of SIAM, IOCL and five automobile manufacturers. Initial testing carried out under the project have indicated that blending of hydrogen with CNG can reduce emissions from the vehicles. Currently field trials of the vehicles using 18% hydrogen (by volume) blended with CNG is in progress.

Fuel Cells

7.24 A fuel cell is an electrochemical device that converts chemical energy of hydrogen directly into electricity and heat without combustion. Fuel cell systems generally operate on pure hydrogen and air/oxygen to produce electricity with water and heat as the by-products. Fuel cells are

emerging as a clean and efficient technological option for stationary, transport and portable applications. Fuel cell power systems can be used as uninterrupted power supply (UPS) systems, replacing batteries and diesel generators. In view of the relevance of fuel cells for power generation and transport applications, several organizations are pursuing RD&D activities for development of processes, materials, components, sub systems and systems for fuel cells.

7.25 The focus of the Fuel Cell programme of the Ministry is to mainly support RD&D activities on different types of fuel cells namely Polymer Electrolyte Membrane Fuel Cell (PEMFC), Phosphoric Acid Fuel Cell (PAFC), Direct Methanol Fuel Cell (DMFC), Direct Ethanol Fuel Cell (DEFC), Solid Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells (MCFC). The emphasis of research has been on further improvements in fuel cell related processes, materials, components, sub-systems and fuel cell systems. Efforts for development of a methanol reformer suitable for 50 kW capacity PEMFC power pack continued at IICT, Hyderabad. Research project to undertake analytical and modeling related work in the area of fuel cells with a view to help in designing of sub-systems of

fuel cells progressed at Birla Institute of Technology – Goa Campus. R&D work relating to SOFC and direct alcohol fuel cells was also pursued at Institute of Minerals and Materials Technology, Bhubaneswar and IIT Delhi during the year. Four new R&D projects relating to DMFC and PEMFC were sanctioned to academic institutions and research organizations during 2010-11.

7.26 With a view to demonstrate energy efficient and environment friendly fuel cell technology for niche applications, discussions have been held with various stake holders for undertaking field demonstration projects for powering telecom towers in suitable locations.



Fuel Cell test station set up at IIT Delhi under a R&D Project sponsored by the Ministry

Mission Mode Projects

7.27 Four Mission Mode Projects in the areas of hydrogen production through biological route (IIT Kharagpur as the lead institute), hydrogen storage in hydrides (BHU, Varanasi as the lead institute) and carbon materials (IIT Chennai, Madras as the lead institute) and development and demonstration of hydrogen fuelled internal combustion engines for vehicles (with IIT Delhi and Mahindra & Mahindra as the implementing agencies) are being implemented. These projects of five year duration were sanctioned during 2009-10. Two Technology Mission Mode Project proposals relating to development of PEMFC and SOFC were developed through IIT Madras, Chennai; and IIT Bombay, Mumbai and Thermax, Pune respectively. These are under evaluation.

7.28 With a view of creating a national facility for undertaking dedicated RD&D activities related to hydrogen energy and fuel cells, a Detailed Project Report for setting up of the National Hydrogen Energy and Fuel Cell Centre in the campus of Solar Energy Centre of the Ministry at Gwalpahari in Gurgaon was prepared through the Indian Institute of Technology Delhi

during 2009-10. Based on the comments received from different Ministries and Departments this is being revised.

7.29 Three new R&D Projects in the area of hydrogen energy and four new R&D projects in the area of fuel cells were sanctioned during 2010-11 as on 31.12. 2010. The list of thirty two on-going RD&D projects supported by the Ministry that were under implementation during 2010-11 in the area of hydrogen energy and fuel cell technologies is given in **Table 7.1**. In addition, three new RD&D projects relating to hydrogen energy were considered by the RDPAC/RDSPAC during the year. Six completed R&D projects of which four were in the area of hydrogen energy and two were in the area of fuel cells were also evaluated by the RDPAC during the year.

Tidal Energy

7.30 Among the various forms of energy contained in the seas and oceans, tidal energy has been developed on a commercial scale. Technologies for harnessing other forms of energy from seas and oceans are still under development. France, Russia, China, Canada, United Kingdom and Korea are some of the countries, which are making use of tidal energy on commercial basis. The tidal power potential sites in India are in the Gulf of Kutch, Gulf of Cambay in Gujarat and the Delta of the Ganges in West Bengal.

7.31 In order to develop and harness about 8000-9000 MW of estimated tidal energy potential for power generation, the Ministry is implementing a programme on tidal energy. The first tidal power project of 3.75 MW capacity is being set up by WBREDA through NHPC Ltd. at Durgaduani Creek in Sunderbans, West Bengal. The NHPC Ltd. is in the process of awarding contract for the project, through international bidding process.

Battery Operated Vehicles

7.32 Conservation of imported petroleum products and environmental pollutions are the two major concerns all over the world. As per the estimates, about 35% imported petroleum products are consumed by transport sector and 65% pollution caused by vehicular applications on Indian road. Battery Operated Vehicles /Hybrid Electric Vehicles/Plug Hybrid Electric Vehicles have emerged as one of the alternative transport today worldwide and leading automobile manufacturers are directing their efforts at developing Battery Operated Vehicles /Hybrid Electric Vehicles/Plug Hybrid Electric Vehicles. Efforts are being made by the Ministry to develop and improve battery technology having higher specific energy and power densities, longer life cycle, light weight, rapidly rechargeable and economically viable, which will lead to improved performance of Battery Operated Vehicles /Hybrid Electric Vehicles/Plug Hybrid Electric Vehicles.

7.33 During the year, battery operated vehicle (BOVs) Scheme was modified and continued to be implemented through the States/ UTs/ State Nodal Agencies/ Indian Renewable Energy



Battery operated three wheelers



Battery operated Two wheeler

Table 7.1 On-Going Research, Development and Demonstration Projects as on 31.12.2010 in the area of Hydrogen Energy and Fuel Cells supported by the Ministry

Sl. No.	Name of Project	Year of sanction	Duration	Name of Implementing Agency
HYDROGEN ENERGY				
HYDROGEN PRODUCTION				
1.	Generation of hydrogen from biomass derived glycerol	2007-08	Three years	Indian Institute of Chemical Technology, Hyderabad
2.	Development of transition metal tantalates and oxynitrides for water splitting and pollution abatement	2007-08	Three years	Institute of Minerals and Materials Technology, Bhubaneswar
3.	A novel process for production of hydrogen from renewable and fossil fuel based liquid and gaseous hydrocarbons by non-thermal plasma reformation technique	2008-09	Three years	Central Institute of Mining and Fuel Research, Dhanbad
4.	Non-thermal plasma assisted direct decomposition of hydrogen sulphide into hydrogen and sulphur	2008-09	Three years	National Institute of Technology, Tiruchirapalli
5.	Prototype demonstration of wind hydrogen based stand-alone electrical generation	2009-10	Two years	Electrical Research and Development Association, Vadodara
6.	Hydrogen and liquid fuels from biomass gasification	2009-10	Three years	Indian Institute of Science, Bengaluru
7.	Mission Mode Project on hydrogen production through biological routes	2009-10	Five years	Indian Institute of Technology Kharagpur, Kharagpur (lead institute)
8.	Production of hydrogen gas from biomass and wastes using fluidized bed gasifier	2009-10	Three years	National Institute of Technology, Rourkela
9.	Design and development of functional hybrid nano structures for photo electrochemical water splitting	2010-11	Three years	Institute of Minerals and Materials Technology, Bhubaneswar
HYDROGEN STORAGE				
10.	Hydrogen storage properties of complex hydrides	2007-08	Three years	Indian Institute of Technology Bombay, Mumbai
11.	Numerical and experimental analysis for the development of a metal hydride based hydrogen energy storage device	2008-09	Three years	Indian Institute of Technology Guwahati, Guwahati
12.	Development of nano and metastable magnesium based multi-component alloys through mechanical alloying for hydrogen storage applications	2008-09	Three years	National Institute of Technology, Tiruchirapalli
13.	Mission Mode Project on hydrogen storage (hydrides) : R&D	2009-10	Five years	Banaras Hindu University, Varanasi (lead Institute)
14.	Mission Mode Project on hydrogen storage in carbon materials	2009-10	Five years	Indian Institute of Technology Madras, Chennai (lead Institute)
15.	Synthesis of magnesium based hydrogen storage alloys with lower sorption temperatures	2010-11	Three years	Non-Ferrous Materials Technology Development Centre, Hyderabad

HYDROGEN APPLICATIONS & OTHER ASPECTS

16.	Support to the Existing Hydrogen Energy Centre at Banaras Hindu University Varanasi	2006-07	Five years	Banaras Hindu University, Varanasi
17.	Use of hydrogen (up to 30%) as fuel blended with compressed natural gas in internal combustion engines	2007-08	Three and a half years	Society of Indian Automobile Manufacturers, New Delhi
18.	Development and demonstration of hydrogen fuelled three wheelers	2009-10	Two and a half years	Banaras Hindu University, Varanasi
19.	Development and demonstration of diesel hydrogen dual fuel SUV	2009-10	Two and a half years	Mahindra & Mahindra Ltd., Nashik
20.	Design and development of hydrogen gas burner for industrial application	2009-10	Three years	Indian Institute of Technology Kanpur, Kanpur
21.	Lean limit extension for spark ignited direct injection engine through on-board non-thermal plasma conversion	2009-10	Three years	Annmalai University, Annamalai Nagar
22.	Mission Mode Project on development and demonstration of hydrogen fuelled internal combustion engines for vehicles	2009-10	Five years	Indian Institute of Technology Delhi, New Delhi
23.	Development of a metal hydride based hydrogen storage system for stand alone, portable hydrogen fueled genset	2010-11	Two years	Electrical Research and Development Association, Vadodara

FUEL CELL

24.	50kW fuel cell power pack with methanol as primary fuel for technology demonstration	2002-03	Six years and five months	Indian Institute of Chemical Technology, Hyderabad
25.	Parametric study of the proton exchange membrane (PEM) fuel cell performance	2006-07	Four years	Birla Institute of Technology & Science (BITS), Goa
26.	Solid oxide fuel cells that operate directly on hydrocarbon feedstock	2007-08	Three years	Indian Institute of Technology Delhi, New Delhi
27.	Development of direct alcohol fuel cell and test Protocols	2007-08	Three years	Indian Institute of Technology Delhi, New Delhi
28.	Development of high performance intermediate temperature solid oxide fuel cells (IT-SOFC) by low cost ceramic processing techniques	2007-08	Three years	Institute of Minerals & Materials Technology, Bhubaneswar
29.	Design and development of alkaline fuel cell : Scaling up from bench scale i.e. 185 W to 500W	2010-11	Three years	SICES Degree College of Arts, Science and Commerce, Ambernath (W), Mumbai
30.	Development of high performance direct methanol fuel cell	2010-11	Three years	University of Calcutta, Kolkata
31.	Development of PEM for fuel cell by plasma process	2010-11	Three years	Institute of Advanced Study in Science & Technology, Guwahati
32.	Development of non-fluorinated polymeric membrane for direct methanol fuel cell	2010-11	Three years	Birla Institute of Technology, Ranchi

Development Agency for dissemination of different type of BOVs/HEVs/PHEVs. A total of 315 BOVs of different types have been supported under the programme so far.



Battery operated Electric vehicle

7.34 The Ministry of New and Renewable Energy (MNRE) is supporting a broad-based programme for research, development and demonstration of Battery Operated Vehicles /Hybrid Electric Vehicles/Plug Hybrid Electric Vehicles with the objectives to promote BOVs, to get feed-back on the performance of BOVs in operating conditions. The widespread use of BOV/HEV/PHEVs is, however, constraint by the limited availability of the models, high cost, limited driving range and maximum speed, and lack of infrastructure for charging/replacement of batteries. The Ministry has an ongoing R&D Programme for development of suitable batteries and other components of Battery Operated Vehicles /Hybrid Electric Vehicles/Plug Hybrid Electric Vehicles. Interaction Meetings were held with experts and vehicle manufacturers of different types of electric vehicles and batteries to get feedback to make the scheme more effective. Interactions were also held with the Society of Indian Automobile Manufacturers (SIAM), Society of Manufacturers of Electric Vehicles (SMEV) New Delhi and electric / hybrid electric vehicle manufacturers to explore the possibility of electric and hybrid electric vehicles based on high energy / power density lithium ion batteries.