LATEST TRENDS IN EV/HEV DEVELOPMENT & STANDARDISATION IN INDIA

3rd AAI Summit, Electric Vehicle Session
IMPACT Bangkok (Thailand)
4th December 2014

Presentation by
Anand Deshpande
Deputy Director, ARAI (India)
Contents

- India – Mobility Scenario
- EV Status in the World
- EV Status in India
- EV India Initiatives
- EV Standardization in India
- EV Development & Testing at ARAI
INDIA Mobility Scenario –
Automotive industry at a glance
Indian Automotive Industry

- India- World’s 4th largest consumer of oil. Total oil consumption is approx. 170 MMT
- Imports 70% of total oil demand
- 90% of total consumption is utilized by transport sector
Indian Automotive Industry

- 2nd Largest Two-Wheeler Manufacturer in the World
- World’s largest Motorcycle Manufacturer is in India
- 2nd Largest Tractor Manufacturer in the World
- 5th Largest Commercial Vehicle Manufacturer in the World
- 4th Largest Car Market in Asia – 1,545,000 Vehicles

Source: SIAM

Turnover from 35 to 145 bn USD
Exports from 4.1 to 35 bn USD

Total Registered Vehicles ~160 Mn
Spread of Indian Auto Industry

Source: SIAM
Increasing young population with rising disposable income with annual growth rate of 10 % is fuelling the demand for new vehicles.

India figures as a country of YOUNGER people.
Unique Indian Market

• 160 million registered vehicles in India

• 75% 2-Wheeler vehicles; 5 times of car segment

• In car segment, 75% smaller cars i.e. <1.2 l petrol or <1.4 l diesel

• Affordability is a major deciding factor for a buyer

Source: SIAM and ACMA Presentations
Unique Indian Market

- Present vehicle production is 20 million units & India ranked 6th highest vehicle producer worldwide.

- The Automotive Mission Plan 2006-2016
  - Targeted output of Indian Automobile Sector - $145 Billion
  - Doubling contribution in national GDP (5% to 10%)
  - Additional employment opportunities for 25 Million people in the entire Value Chain

- Automobile production to double by 2020-21
Vehicle density per 1000 population in India expected to grow to 65 by 2030

Survey shows that Indian Vehicle population has increased by 183 folds in the past decade

Source: Estimation of Automobile emissions and control strategies – K. S. Nesamani, University of California, 2009
EV Status In The World
Global Automotive Trends, Driving Innovation

- Remote car management
- Broadcast reception
- Location-based services
- Car to x communications
- Personalization

Connected Mobility

CO₂ reduction
- Electrification of the drivetrain
- Replace mechanics by electr.
- Weight reduction
- Engine efficiency improvement

Safety

Convenience
CO2 Driver

- Tightening of CO₂ emissions are expected in all major markets
- EU has the strictest regulations

Source: GR/VZ
Perceived CO2 benefits

**Diesel Engine**
- Improved Gasoline Engine
  - **12V Stop/Start Belt Starter/Alternator**
    - Vehicle Cost: +1.5%
    - CO2: -4.2%

**Improved Gasoline Engine**
- **12V/42V Micro Hybrid Belt Starter/Alternator/Motor**
  - Vehicle Cost: +5.8%
  - CO2: -23%

**42V/120V Mild Hybrid**
- **Integrated Starter/Alternator/Motor**
  - Vehicle Cost: +13.3%
  - CO2: -34%

**Full Parallel Hybrid**
- 1 or 2 High voltage motor, ZEV mode
  - Vehicle Cost: +23.5%
  - CO2: -45%

**Fuel Cell Hybrid Vehicle**
- Hydrogen Fuel
  - Vehicle Cost: +29.7%
  - CO2: -56%

**Auxiliary Power Unit**
- as ZEV range extender
  - Fuel Cell-Liquid or Hydrogen Fuel
  - Vehicle Cost: +27.5%
  - CO2: -52%

**Improved Parallel Hybrid**
- Batteries, Motors, Control, Exhaust
  - Energy recovery
  - Vehicle Cost: +24.3%
  - CO2: -49%

Source: Horiba
## EV- World Scenario

Estimates in 2010 Predicted Dramatic EV Sales Growth...

<table>
<thead>
<tr>
<th>No.</th>
<th>Base Forecaster</th>
<th>Est. EV Volume 2020</th>
<th>% of Global Auto Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BCG</td>
<td>3.0 Mn</td>
<td>3.0 %</td>
</tr>
<tr>
<td>2</td>
<td>PwC</td>
<td>1.5 Mn</td>
<td>1.5 %</td>
</tr>
<tr>
<td>3</td>
<td>Frost &amp; Sullivan (extrapolated)</td>
<td>4.5 Mn</td>
<td>4.5 %</td>
</tr>
<tr>
<td>4</td>
<td>Bloomberg New Energy Finance</td>
<td></td>
<td>9.0 %</td>
</tr>
</tbody>
</table>

Consensus estimate: Minimum 1000X sales growth in 10 years!
Electric Mobility Gaining Critical Mass

- In 2011, Nissan, Chevrolet, and Mitsubishi sold 44,000 EVs
- In August 2012, 3.6% of all cars sold in Norway were EVs from 0.1% 1.5 yrs ago
- In China over 100 million 2 wheeler EVs exist & 20 million were made last year
- Nearly 40 new production EV models launching by 2013
- Nissan/Renault - $6 billion EV investment, 7 new EVs, 1.5 million fleet by 2016
- GM - $1 billion investment in EV mfg, boosting Volt capacity to 60,000 by 2012
- Mitsubishi – targeting 50% of sales as EV/PHEV by 2020
- BYD - Built team of 10,000 auto, battery engineers for EV R&D
- BMW - New sub-brand, i, for EVs – tagline “Born Electric”
- Startups - Tesla (f. 2003, now $3.5B mkt cap), Fisker (f. 2007, $500M funding)
Large Investments by OEMs and Supply Chain

- Substantial investment in manufacturing capacity build-out funded by private, public investment; growing economies of scale for key components
- 30 new advanced battery factories in US alone from 2010-2012
- Large Investments in Electric Battery research & development
- Implementation of EVs in corporate vehicle fleet to deal with rising oil prices

"President Barack Obama has challenged automakers to put one million EVs on the US road by 2015"
Ever Rising Fuel Prices & Falling Battery Prices
Governments encouraging adoption of EVs

Governments have introduced consumer EV purchase subsidies and tax exemptions, public/commercial EV fleet subsidies, home charging station subsidies, R&D / manufacturing incentives, free parking and public charging / battery swap infrastructure projects.

- **USA**:
  - $7,500; $25B Loans
  - $2.4B stimulus funds

- **France**:
  - €5,000, 20% Incentive
  - Free Parking, $2.2B Charging Network

- **Belgium**:
  - 20%, 30% (business) eco-bonus
  - 75% (government) eco-bonus

- **UK**:
  - €5,000 Congestion/ Excise/ Road-Tax Exemptions

- **Iceland**:
  - Import Tax 30% Exemption
EVs in India

• Past 3 – 5 years witnessed a surge followed by dip in the number of Electric Two Wheelers.

• Three Wheeled Commercial Vehicle Fleet

• Mobility in Industries
Micro-Hybrids in India

- Mass production level Micro-Hybrids (Start-Stop)
- Over 400,000 Micro hybrid SUVs on Indian Roads
- Commercial Micro-hybrid Pick-ups introduced
Hybrid Vehicles Demonstration
EVs in INDIA

- Reva is the leading Indian manufacturer and exporter of EVs

- Toyota Prius and Honda Civic are two of the major HEVs launched in India
Hybrid Vehicle Retrofitment Kit

A plug-in parallel hybrid technology that can be retrofitted in both existing and new cars.
Drivers and Challenges

Drivers
- Government Initiatives
- Rise in Fuel Costs
- Low Operating and Maintenance Cost
- Foreign Dependence for Crude Oil
- Environment Friendly

Challenges
- Low Vehicle Performance
- Inefficient Battery
- Price Constraint
- Power Shortage
- Lack of Infrastructure

Source: Netscribes
National Electric Mobility Mission Plan (NEMMP) 2020

Unveiling of NEMMP at PM Residence – 9th January 2013
NEMMP - 2020 Vision

To encourage reliable, affordable and efficient xEVs that meet consumer performance and price expectations through Government – Industry collaboration for promotion and development of indigenous manufacturing capabilities, required infrastructure, consumer awareness and technology; thereby helping India to emerge as a leader in the xEV Two Wheeler and Four Wheeler market in the world by 2020, with total xEV sales of 6-7 million units thus enabling Indian Automotive Industry to achieve global xEV manufacturing leadership and contributing towards National Fuel Security.
Levers to support xEV Adoption

- Demand creation
  - Govt. Policies
  - subsidies
  - Govt. Purchase
  - mandates

- Supply side interventions
  - Govt. Policies & incentives
  - OEM investments

- R&D
  - Govt. – Industry Collaboration
  - Consortia approach

- Infrastructure
  - Govt. – Industry

Fuel Efficiency
Govt. of India Policy Initiatives

National Electric Mobility Mission Plan (NEMMP) 2020

**Working Group on R&D**
- BMS & Battery
- Power Electronics & Motors
- Testing Infrastructure, Human Resources, Energy efficient Technologies

**Working Group on Infrastructure**
- Technology & Standards
- Infrastructure Rollout

**Working Group on Demand & Supply**
- Demand Incentive Scheme
- Incentive Delivery & Monitoring Mechanism
- Promotion of Hybrid Retro-fitment Kits
Highlights of NEMMP – 2020 ...

• Setting up of **CoEs** for technologies relating to
  – Motors
  – Batteries
  – Integration
  – Testing

• **Demo City** for xEV Implementation being discussed

• **Incentive Policies** for Manufacturers and Users being worked out
EV Standardization & Homologation Activities In India
Vehicle Emission Road Map In India

- 1991: 1st set norms implemented
- 1995: Emission norms for catalytic vehicles
- 1996: 2nd set norms implemented
- 2000/01: BS-I (Country), BS-II metros
- 2005: BS-II (Country), BS-III (11 cities)
- 2010: BS-III (Country), BS-IV (13 cities)
- Another 50 cities to be included by 2015 for BS IV
xEV - INDIAN HOMOLOGATION REQUIREMENTS

✔ EV

✔ HEV

✔ Retro-fitment

✔ Electric 2 Wheelers
OVERALL HOMOLOGATION REQUIREMENTS

Type Approval Tests
Vehicle level

Safety
- Brakes,
  Traction Battery,
  Accelerator Control
  system, Lamp assembly,
  Safety equipment

Electronics
- EMI / EMC

Performance
- Emissions/Range,
  Max Power/
  30 min Power,
  Gradeability

NVH
- Pass by Noise, Horn
# EV - INDIAN HOMOLOGATION REQUIREMENTS

<table>
<thead>
<tr>
<th>Indian Standard</th>
<th>Brief Requirements</th>
<th>ECE Regulation Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS 038</td>
<td>Construction &amp; Functional Safety – Battery mounting, ventilation, creepage distance, insulation resistance, protection against electric shock, on board charger, water effects tests (washing, flooding, heavy rainstorm)</td>
<td>ECE R-100</td>
</tr>
<tr>
<td>AIS 039</td>
<td>Measurement of electrical energy consumption</td>
<td>ECE R-101</td>
</tr>
<tr>
<td>AIS 040</td>
<td>Measurement of electrical range</td>
<td>ECR R-101</td>
</tr>
<tr>
<td>AIS 041</td>
<td>Measurement of net power, max. 30 min power</td>
<td>ECE R-85</td>
</tr>
</tbody>
</table>
## EV - INDIAN HOMOLOGATION REQUIREMENTS

<table>
<thead>
<tr>
<th>Indian Standard</th>
<th>Brief Requirements</th>
<th>ECE Regulation Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS 048</td>
<td>Safety Requirements for Traction Batteries – Electrical &amp; Mechanical Abuse Tests</td>
<td>USABC EV Battery Test Procedures Manual</td>
</tr>
<tr>
<td>AIS 049</td>
<td>Type Approval of Electric Vehicles – Brake performance, grade ability, pass-by noise level, EMI, wiper, lighting system, safety belt, steering column, dashboard etc.</td>
<td>---</td>
</tr>
</tbody>
</table>
# HEV - INDIAN HOMOLOGATION REQUIREMENTS

<table>
<thead>
<tr>
<th>Indian Standard</th>
<th>Brief Requirements</th>
<th>ECE Regulation Ref.</th>
</tr>
</thead>
</table>
| AIS 102 (Part 1) | Type Approval of Hybrid Electric Vehicles – Category L, M, N (GVW < 3500 kg) Tailpipe emissions, fuel consumption, brake performance, engine power, motor power, pass-by noise level, construction & functional safety, grade ability, EMI, wiper, lighting system, safety belt, steering column, dashboard etc. | ECE R-13H  
ECE R-10  
ECE R-83  
ECE R-85  
ECE R-100  
ECE R-101 |
| AIS 102 (Part 2) | Type Approval of Hybrid Electric Vehicles – Category M, N (GVW > 3500 kg) Same as above except engine out emissions, bus body code, interior noise etc. | ----  
Above ECE regulations are taken as reference for formulating Indian standard |
# HEV Retro fitment- INDIAN HOMOLOGATION REQUIREMENTS

<table>
<thead>
<tr>
<th>Indian Standard</th>
<th>Brief Requirements</th>
<th>ECE Regulation Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS 123</td>
<td>Type approval of vehicles retrofitted with hybrid electric system (HES) of M1, M2 and N1 category of vehicles, which i) Comply to BS-II or subsequent emission norms, ii) Operate on either Petrol or Diesel fuel only, iii) Have GVW not exceeding 3500 kg, iv) Have not been retrofitted earlier or are not operating on any other alternate fuel.</td>
<td>ECE R-100 ECE R-101</td>
</tr>
</tbody>
</table>

For Buses: **UNDER DISCUSSIONS**
xEV Charging Infrastructure Standardization
Worldwide Trends in Charger Connector Standards

- DC Charging Standard
- AC Charging Standard

- COMBO2
- GB/T
- CHAdeMO
- COMBO1
- J1772

J1772 (Type 1)
Type 2
Type 3
Worldwide Trends in Charger Connector Standards

Present

Japan
- CHAdeMO
- IEC Type 1 (SAE J1772)

US
- CHAdeMO
- COMBO1 (SAE)
- IEC Type 1 (SAE J1772)

EU
- CHAdeMO
- COMBO2 (IEC)
- IEC Type1 (SAE J1772)
- IEC Type2
- IEC Type3

China
- GB/T, GB

2018 2019 2020

Other charger standards will emerge in the near future. (Wire-less Charge / Battery Changeable System)
Criteria for Selecting Suitable Charging Standards...

• Safety
• Open, royalty free standard
• Voltage/Current range support (In India low voltage/high current)
• Low manufacturing cost of connectors, plugs
• Communication protocol (OEMs prefer CAN over PLC)

Discussions are underway in India for finalising AC/DC charging standard protocols
EV Development and Testing at ARAI
### ARAI Overview

- **Establishment**: 1966
- **Location**: Pune, INDIA (150 km from Mumbai)
- **Manpower**: 600+
- **Facilities**: 12 Laboratories – Vehicle Evaluation, Powertrain, Emissions, Safety & Homologation, Passive Safety, Materials, Automotive Electronics, NVH, CAE, Structural Dynamics, Calibration, Post Graduate Academy & Forging Industry Division
- **Our Offices**: China, Korea and Chennai
- **Investments**: USD $ 60 Million
- **Accreditations**: ISO 9001, 14001, OHSAS 18001 & NABL (ISO 17025)
ARAI Roles

• Ministry approved test agency to carry out certification testing.
• Engaged in sponsored R&D work and development testing.
• ARAI is actively engaged in
  – Preparation & Harmonization of standards.
  – Secretariat for AISC and CMVR-TSC.
  – Deliberation of policy matters affecting Auto R&D.
  – Creation of facilities and building up competence by undertaking forward looking research & technology demonstration projects.
ARAI’s Activities

- **R&D: Automotive Industry Projects, National Interest Projects and Internal R&D Projects**
- **Certification Testing / Homologation**
- **Assisting Govt. of India in Formulation of Regulatory Standards and Harmonization of Regulations**
- **Education and Training**
- **Consulting Services**
R&D Projects at ARAI

**In-house**
- Competence Building Technology Dev.
  - HCNG engine
  - HCCI engine
  - 2w Fuel Injection ECU
  - 3 Cyl. Engine Dev.
  - RUPD with alternate material
  - **EV SCV for intra-city application**
  - control strategies for gasoline direct injection ECU application
  - Evaluation of durability and ride comfort using 3D road profiles

**Govt. Supported**
- National Interest Broader Application
  - Road Profile
  - Nano-particle emission
  - Ambient Air Quality
  - Biodiesel
  - Anthropometry data
  - Dual Fuel Engine
  - Engine out Emissions
  - ISS
  - HIL
  - HALT
  - Wheel Force
  - Vehicle Duty Cycle
  - Forging Process Study
  - **Simulator for EV and HEV**
  - Design analysis of lightweight aluminum bus

**Industry Sponsored**
- Engine family up-gradation for TREM III
- Bus component evaluation
- Multiaxis simulation of HCV chassis
- New engine platform durability
- Vehicle evaluation for Indian driving
- Design of medical mobile units
- Effect of oil on gear pitting
- ECU Development for OBD
- Super structure evaluation
- Failure analysis

**Completed projects**
EV/HEV TESTING INFRASTRUCTURE

Chassis Dynamometer with Emission Measurement Setup
EV/HEV TESTING INFRASTRUCTURE

- Existing facilities
  - Range
  - Power
  - Safety
  - Battery
EV/HEV TESTING INFRASTRUCTURE

Vehicle EMC Chamber

Component EMC Chamber
Further Plan to Support EV Development & Evaluation

• Motor Test Facility

• Battery Simulator

• Battery Performance Test Facility with Environmental chamber

• Hydrogen Analysis System

• HIL set up for EV simulation
EV Projects at ARAI

Development of Offline and Real time Simulator for Electric / Hybrid Electric Vehicle Systems

- Govt. funded Project being carried out by a consortium

- Objective is to indigenize simulation systems for EV/HEV systems which can be used by Indian OEs, Tier-Is and Academia
EV Projects at ARAI

Building a Prototype EV SCV for Intracity Public Transport Application

• The project has been taken up to gain hands-on experience on EV system and build competency in the parameterization and simulation of xEV systems
EV Projects at ARAI

- Development of Parallel Hybrid Small Commercial Vehicle Powertrain Control Systems
- Control strategies and transmission development for a Parallel Hybrid Electric Vehicle
EV Projects at ARAI

Deliverables:

- Prototype Intracity public transport vehicle.
- Comparing Simulation & real-world results for correlation & closeness.
- Competency development in the areas of EV/HEV, modeling and simulation platform and tools for EV/HEV.
- Boundary conditions for electric powertrain development and control system requirements for EV/HEV application in India context.
- Technology guidelines and component specifications for Indian city driving conditions.
EV Focus Areas

- Tracking International Regulations and methods
- Tracking EV Technology Trends
- System integration
- EV configuration, calibration, V&V, benchmarking, analysis
- Innovation and IP Generation
- India specific solutions
- HR Development
Let us Work Together
For A Brighter Future...

Thank you!