TECMEHV - Training and Development of European Competences on Maintenance of Electric and Hybrid Vehicles

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A Project Coordinated by ASCAMM
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In the frame of EU Leonardo da Vinci Programme
for professional formation of Electric Vehicle Operators
• TECMEHV Objectives
• The field of operation: Electric vehicle system
• The integration with infrastructure
• Development of the Competence Framework
• Workflow of Competence Units
• Development of Training Modules
• An example: Training Module Safety
• Conclusions
The overall objectives of TECMEHV are:

- To define, develop, implement and support, in the medium and long term future, the European wide Professional Qualification for the electric and hybrid vehicles maintenance and an
- E-learning platform within the European HEV industry to learn and understand how to manage HEV

TECMEHV project comprises two major activities:

- Definition of the Competence Framework on Electric & Hybrid Vehicles Maintenance, Repair & Operation
- Development of a set e-learning courses on selected key topics, related to the Unit of Competence for online training
Development of a Competence Framework

Definition of a Learning Platform, with Training Modules, addressing the formation of operators with technical competence and professional skill for maintenance and repair Electric and Hybrid Vehicles

Development of e-Learning Modules for Professional Competences

- **Competence Unit**
  The minimum set of professional competence that can be recognized and accredited

- **Training Module**
  The necessary learning to acquire the competence unit

- **Professional Performance**
  The minimum behavior in the activities related to the specific competence field

- **Professional Skill**
  The expected outcome of learning situation after the training module

- **Performance Criteria**
  Acceptable level of professional activity to meet the productive organization target

- **Evaluation Criteria**
  Set of details for each capacity indicating the acceptability in the relevant context
The field of operation

Electric Vehicle Architecture

Charge
Energy Storage Battery Pack
Energy Management & Communication
Peripheral Units
Powertrain

Mains Supply
Fast Charger
Battery Charger
Air cooling
12V DC/DC Converter
Peripheral Units
12V Auxiliary Battery

Equalizer
Traction Battery
B.M.U.
Power and recharg Contactors

V.M.U.
Braking System
Dashboard

Power Link
Logical Link
Cooling (Options)

Brake
Accelerator

Inverter
M.C.U.

Electric motor
Reduction Gear
Driving Selector
Transmission
Integration within the infrastructure

Fixed installations
IEC 60364

Charging interface
IEC 61851 (TC61)

EV electrical aspects
(if not charging)
ISO TS22/SC21

Data transfer
JWG IEC/ISO V2G

Connective interfaces
IEC 62196 (SC23h)

Battery cells
IEC SC21A
Battery assembly
ISO TC22/SC21

SAE also has activities

30 - Direction des Transports et Véhicules électriques - novembre 2009

Organized by  
Hosted by  
In collaboration with  
Supported by
Development of a Competence Framework

Workflow

- Battery Pack Refurbishing
  (Cells replacement – Pack disassembly/assembly – Electrolyte replacement)

- Waste Management
  (Handling – Recycling – Disposal)

- Peripheral Units
  (Brakes – Power steering – Climatization – Lighting)

- Energy Storage
  (Battery + BMS + Cooling + Wirings + Contacts + Fuses)

- Powertrain

- Charge
  (Slow – Fast – DC-DC – Solar – Regenerative)

- Energy Management & Communication
  (Vehicle Management Unit – Car to Car – Car to Infrastructure – Navigation system)

- Safety
  (Electrical safety – Functional safety – Storage safety – Handling safety – Post Crash safety – Individual protective equipment)

Diagnosis


Planning


Verification

- Visual Inspection – Specific functional test – Safety measurements – Ad Hoc Software & Hardware – Communication protocols – Quality control

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## Relation competence Units to E&HV technology

### Competence Units

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
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<tbody>
<tr>
<td>Diagnosis &amp; Verification</td>
<td>(Safety measurements)</td>
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<tr>
<td>Battery Pack Refurbishing</td>
<td>(Cells and electrolyte replacement)</td>
</tr>
<tr>
<td>Planning</td>
<td>(Process sequence – logistics)</td>
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<tr>
<td>Waste Management</td>
<td>(Recycling – Disposal)</td>
</tr>
<tr>
<td>Peripheral Units</td>
<td>(Brakes – Power steering)</td>
</tr>
<tr>
<td>Energy Storage</td>
<td>(Battery + BMS + Cooling + Wiring)</td>
</tr>
<tr>
<td>Powertrain</td>
<td>(Motor + Transmission + Power Electronics)</td>
</tr>
<tr>
<td>Charge</td>
<td>(Slow – Fast – DC – DC – Solar – Regenerative)</td>
</tr>
<tr>
<td>Energy Management &amp; Communication</td>
<td>(VMU – Car to Infrastructure)</td>
</tr>
<tr>
<td>Safety</td>
<td>(Electrical – Functional – Storage – Handling)</td>
</tr>
</tbody>
</table>

### State of Art of E&HV Technology

- **State of art of E&HV present technology**
  - Electric drives/Motors/Power electronics
  - Electrochemical storage systems
  - Thermal-electric hybrid systems
  - Life cycle impact on energy and environment

- **Future tendencies for E&HV technologies**
  - Electric drives – motor in wheel
  - Storage systems
  - Vehicle – electricity supply infrastructure

- **Safety requirements by standards and regulations**
  - On board rechargeable energy storage
  - Operation safety means against failures
  - Protection against electric shock
State of the Art: Electric Drive Machines classification
Comparative features of electric drive machines

**Direct current machine**

- **aef**: average (high power/low speed), efficiency (TTW)
- **cmp**: critical material presence
- **idf**: integration design flexibility
- **lce**: life-cycle efficiency
- **puf**: performance - low torque ripple and NHV, user friendliness and comfort
- **sft**: specific power and torque (high speed capability)

**Synchronous brushless machine with wound rotor**

- **aef**: average (high power/low speed), efficiency (TTW)
- **cmp**: critical material presence
- **idf**: integration design flexibility
- **lce**: life-cycle efficiency
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- **sft**: specific power and torque (high speed capability)

**Asynchronous machine**

- **aef**: average (high power/low speed), efficiency (TTW)
- **cmp**: critical material presence
- **idf**: integration design flexibility
- **lce**: life-cycle efficiency
- **puf**: performance - low torque ripple and NHV, user friendliness and comfort
- **sft**: specific power and torque (high speed capability)
Comparative features of synchronous machines

Switched reluctance machine

Permanent magnet machine

Synchronous reluctance machine

- **aef**: average (high power/low speed), efficiency (ttw)
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Specific performance of battery cells for E&HV

Basic comparison energy/power of cells

- Ragone chart
Comparative features of Lithium batteries

Source: BCG research.
Note: The farther the colored shape extends along a given axis, the better the performance along that dimension.
Development of a Competence for Professional Qualification
Professional Skill

to be put into practice with technical risk prevention, accomplishing with protection regulation and procedures.

Operation oriented

- **Diagnosis & Verification**
  - To analyze the symptoms to define the main maintenance and repair tasks needed.
  - To apply diagnostic techniques in the EHV’s systems and components.
  - Requisition the data from the OBD that define the maintenance/repair operation.
  - To determine the main diagnostic repair needs of an EHV by means of a visual inspection.
  - To prevent injuries and environmental damages during the diagnostic & verification procedure.
  - To determine the quality control checks on the maintenance/repair operation.

- **Battery Pack Refurbishing**
  - To perform inspection checks of the battery pack of an Electric or Hybrid Vehicle.
  - To diagnose the state of health of each component or the battery pack.
  - To replace damaged cells.
  - To balance the state of charge of the cells.
  - To parameterize the BMS for the integration of the replaced cells.

- **Energy Storage**
  - To perform preventive checks of the charging equipment by disconnecting the energy source and normalizing the energy system.
  - To perform repair on the faulty components and part substitution.
  - To perform functional tests on the balanced components.
  - To perform functional tests on the systems during a full charge-discharge cycle.

- **Powertrain**
  - To perform repairs or maintenance operations on the electric traction motor.
  - To perform repairs or maintenance operation on the electric drive of the vehicle.
  - To perform repairs or maintenance operations on the transmission.
  - To perform repairs or maintenance operations on the Motor Control Unit.

- **Peripheral Units**
  - To perform repairs or maintenance operations on the service brake system.
  - To perform repairs or maintenance operations on the parking brake system.
  - To perform repairs or maintenance operations on the charging system.
  - To perform repairs or maintenance operations on the lighting system.

- **Energy Management & Communication**
  - To perform repairs or maintenance operations on the vehicle management unit (VMI).
  - To perform repairs or maintenance operations on the drive control commands and relevant transducers: accelerator, brake, clutch (Fairy), gear shift lever, forward/reverse, parking brake.
  - To perform repairs or maintenance operations on the dashboard displays and switched buttons.
  - To perform repairs or maintenance operations on the Communication System and the related “Driver Machine Interface” system and displays.

Planning

- **To determine the process sequences for maintenance and repairs of EHV’s, taking into account their specifications.**
- **To determine the parts to order to repair or maintain EHV’s according to manufacturer’s requirements.**
- **To analyze the requirements of car repair shops according to manufacturer’s and car repair shop regulations.**
- **To determine the proper high voltage staff qualification according to the tasks to perform for the EHV maintenance team.**
- **To perform the necessary operation to stop, recycle, store and unpack high voltage batteries.**
- **To perform the necessary operation to stop, recycle, store and arrange the chassis and hybrid vehicle components.**
- **To determine the technical resources, according to the tasks to be performed.**
- **To perform the three instructions by maintenance and repair according to the car repair shop, manufacturer’s and law regulations.**

Supported by
Professional Skill Safety addressed

To be put into practice accomplishing with the manufacturer’s, risk prevention, environmental protection specifications and legal policies.

- To react on electrical human accidents accomplishing with law regulations and the current medical knowledge.
- To guarantee the safety of crashed electric and hybrid vehicles accomplishing with risk prevention.
- To work safety on live electric and hybrid vehicles with personal protective equipment.
- To carry out functionality tests accomplishing with technical risk prevention and environmental protection.
- To work safety on electrical high voltage or non-high voltage components of electric and hybrid vehicles.
- To drive and move electric and hybrid vehicles according to their functions according to the manufacturer’s specifications.
- To perform the charge procedure of electric and plug-in hybrid vehicles according to their functions.
- To perform repair and maintenance operations of electric and hybrid vehicles according to their function in consideration with the manufacturer’s, prescriptions.
- To guarantee the safety of crashed electric and hybrid vehicles accomplishing with technical, risk prevention and environmental protection regulations and procedures.
- To store safely disassembled battery packs.
- To store safely new delivered battery packs.
Training Module 9 - Safety

EC9.4.1: To describe the procedure to perform a test drive to check the functionality of the vehicles, according to the manufacturer’s specified specifications, the risk prevention specifications and the environmental protection procedures
Identify the basic functions of the traction system on a general scheme
Example: IVECO Daily electric 35s – 35C layout

1. Traction battery
2. Battery charger
3. Traction motor
4. Inverter
5. Reduction gear
6. Charging plug
7. Charging module
8. DC protection
9. Battery (optional)
Visualize the operational elements for vehicle operation, with reference to specific service manual of the vehicle (example IVECO Daily electric)

Charging system
Connection to grid I

Dashboard drive command display:
Forward = D
Neutral = N
Reverse = R

Emergency red button on dashboard

Parking hand brake
Focusing driving procedures: acquisition on the information and prescriptions from the service manual of the specific vehicle (present example from Daily electric)

1. Battery State Of Charge
2. Battery temperature
3. Traction motor temperature
4. Status of Vehicle (Economy, Performance, Battery in charge)
5. Direction of run
   D = Drive
   N = Neutral
   R = Reverse
6. Messages for the driver
7. Range
Conclusions

• The e-learning Modules are going to be validated by Industrial and Academic Entities from the Countries of the TECMEHV Partners and made ready for application in online courses in the various languages.

• The TECMEHV Competence Framework definition and diffusion with the e-learning Modules is considered to be a substantial contribution for enlarging the culture on the electric and hybrid vehicles and for professional formation of the operators in this field.

• The effective operation along life of the electric vehicles is fundamental for their diffusion and their integration with the electric energy and environmentally friendly transport system.
The 27th INTERNATIONAL ELECTRIC VEHICLE SYMPOSIUM & EXHIBITION
BARCELONA
17th-20th November 2013

A future energy integrated system scenario

The electric vehicle as a key protagonist in the eco sustainable energy and transport system
THANK YOU FOR YOUR ATTENTION!

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