Co-funded by the Erasmus+ Programme of the European Union

Project no. 2020-1-IT01-KA202-008555

"Innovation Garage of Garages"

IO1 – Intellectual Output 1

Train-the-trainer programme for the development of the Innovation Garage in the workplace as a situated learning environment

Output Type: Methodologies/Guidelines – Non formal learning methods

OER – Open Educational Resource

The project is funded by ERASMUS+ Programme of the European Union. The content of this material does not reflect the official opinion of the European Union, the European Commission and National Agencies. Responsibility for the information and views expressed in this material lies entirely with the author(s). Project number: 2020-1-IT01-KA202-008555

Co-funded by the
Erasmus+ Programme
of the European Union

Train-the-Trainer Program: how to train VET learners on EV/BEV/HEV/PhEV Vehicles

Language: English

Author:

Innovation Garage of Garages Partnership

Coordinator: Cisita Parma scarl, Italy

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1.Developing green mobility skills at VET level in the Automotive Sector

Transportation and mobility sector is a strategic asset for the EU competitiveness, both for employment and citizen service purposes, yet it urgently needs measures to reduce emissions and to increase the use of alternative fuels for vehicles.

The main programmatic document for the EU strategy towards sustainability is the **European Green Deal**, first published by the EC in 2019, outlining the following objectives:

-Leading the third industrial revolution through improving buildings and infrastructure, through massive use of electrification and green alternative renewable energy;
-Making transportation more sustainable, with at least 30 million zero-emission cars in operation on European roads by 2030;
-Producing zero emission large aircraft vehicles by 2035;
-Having 90% zero-emission private, public and commercial transportation vehicle park by 2050 across the EU.

According to the 2020 "Sustainable and Smart Mobility Strategy" and Action Plan, the EU vision towards **Green Mobility** relies upon different and complementary pillars, namely **sustainability**, through the spread of renewable and fossils-free fuel, and **digitalization**, through the use of energy-efficient, interconnected and multi-modal mobility means, thanks to the potentiality of IT and communication technology.

Lately, the European Green Deal strategy was also further boosted by the 2023 EU Parliament majority vote to stop the production and sales of endothermic engine vehicles from 2035 onwards.

Information Focus: The European Green Deal

In this section the teacher/trainer will find direct links to informative and educational sources about the European Green Deal text, annexes and commentary materials:

EU Green Deal Paper (English)
EU Green Deal Information Page by the European Commission (English)
Annex to the EU Green Deal Communication (English)

A short yet summative video by the EC on the EU Green Deal is also available:

 The European Green Deal - A Committment to Future Generations

 Educational Videos about the main mobility-related topics within the EU Green Deal:

Transport

EU Emission Trading System

Energy

Car Emissions

The "Fit for 55" is a set of proposals to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU policies are in line with the climate goals agreed by the Council and the European Parliament.
Fit for 55 refers to the EU's target of reducing net greenhouse gas emissions by at least 55% by 2030. The proposed package aims to bring EU legislation in line with the 2030 goal.

 Review of the EU ETS «Fit for 55 package»

Following the COVID19 pandemic crisis, the EC also launched the **Next Generation EU** initiative, which is way more than a recovery plan: worth more than 806 billion Euro, it is a vision and strategy to transform the EU economy towards a greener, more digital and more inclusive society.

Among the main elements in the package, those most relevant for the expected impact on the mobility sector are:

- fighting climate change, with 30% of the EU funds, the highest share ever of the European budget
- fair climate and digital transitions, via the Just Transition Fund and the Digital Europe Programme

The EC is also releasing **scoreboard** documentation to track and measure how the entire Europe and the single countries are doing in terms of efforts and investments towards the goals of both the Recovery Plan and the Green Deal.

The "Green Transition" Pillar includes some charts showing that sustainable mobility has the biggest proportion of expenditures across the EU towards climate objectives and green transition across the EU:

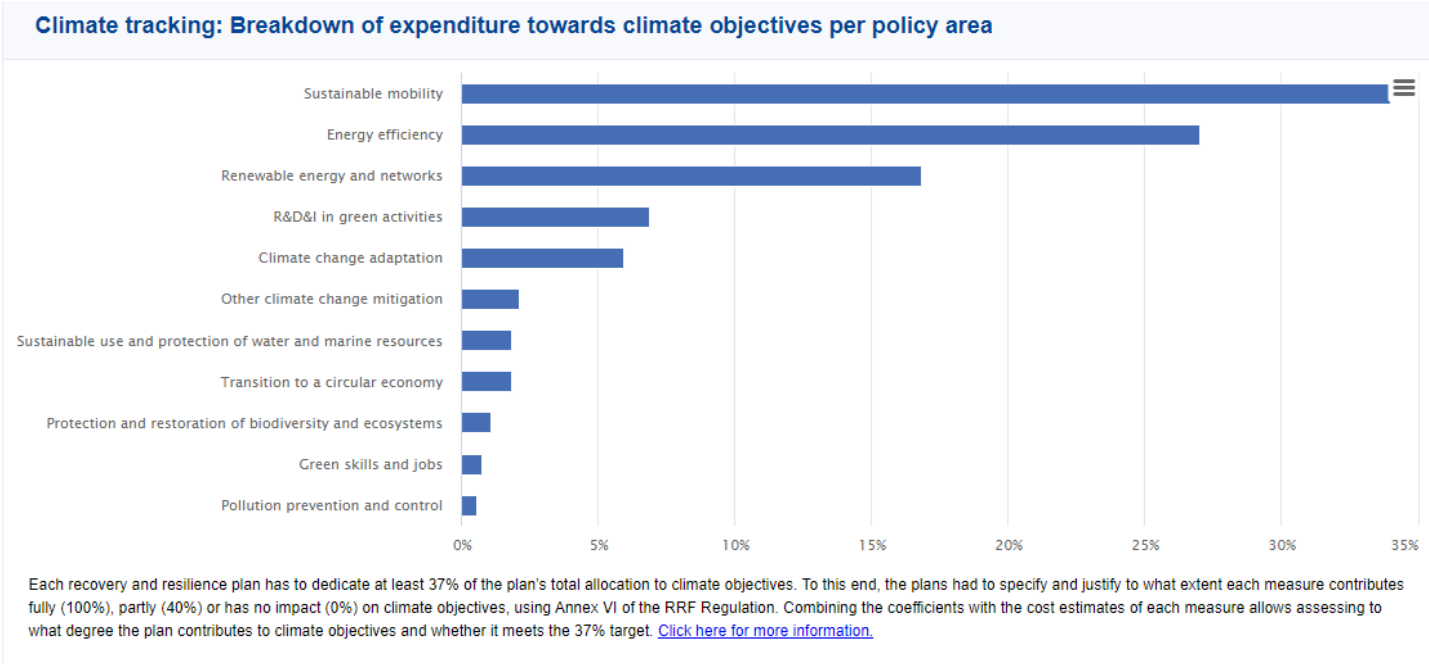


Image Source: EU Recovery and Resilience Scoreboard

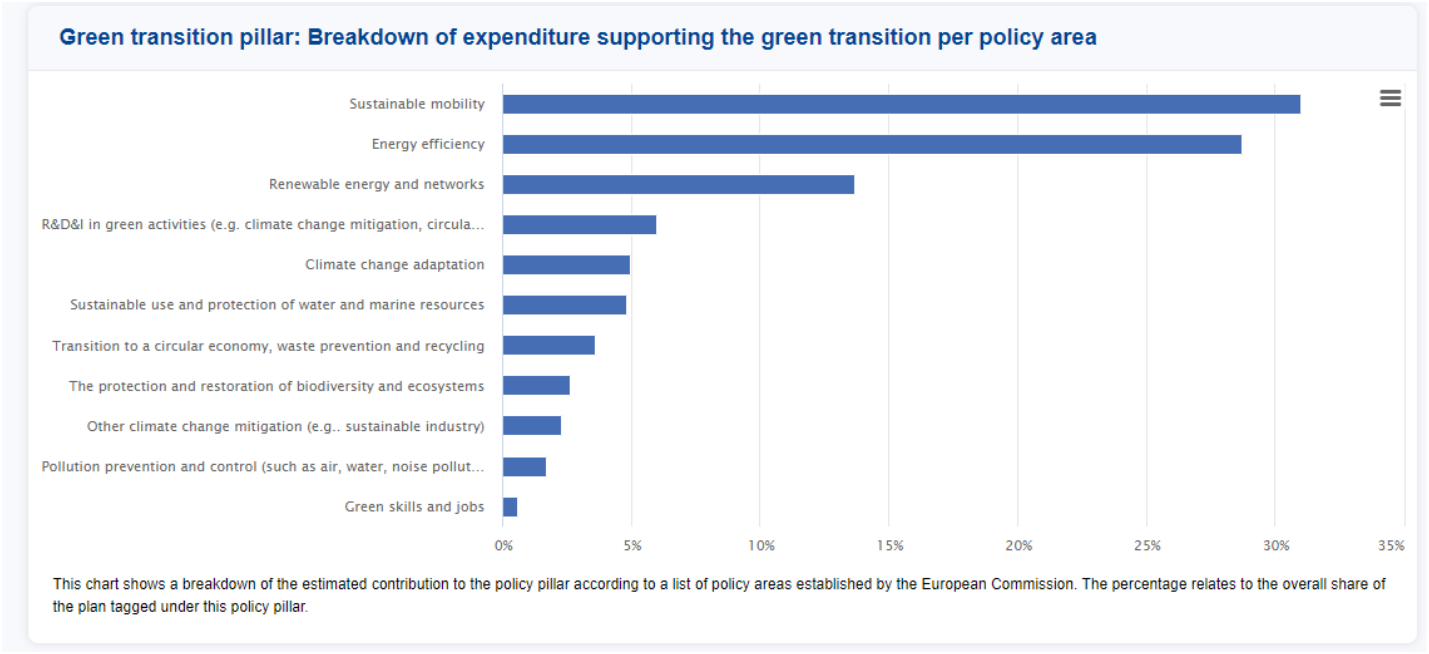


Image Source: EU Recovery and Resilience Scoreboard

Furthermore, the Thematic Analysis report on S**ustainable Mobility**, explains that Member States are working on increasing policies and money investments to improve the alternative and renewable fuels infrastructures and to promote **zero or low emission** mobility through support to e**lectric and hybrid vehicles** (both for private and commercial purposes). In this scenario, 7,6 billion euro investments will increase the network of electric charging stations across the EU.

This is where education, and in particular VET at all levels, from I-VET to H-VET to C-VET, comes into play. VET is a valuable asset for the development of industry-related and job-related skills, in particular to bridge the gap between the offer, represented by the world of education and training at all levels, and the demand, represented by the sector-specific job market.

The VET sector has plenty of contributions to offer to the development of Green Skills for the automotive sector, thanks to the strong relationships it holds with the companies and stakeholders, and to the chance to co-design training programs through work-based learning in a real workplace environment or virtual simulation.

Furthermore, 2023 is celebrated as the European Year of Skills, which strives to empower both individuals and companies, especially SMEs, to contribute to the green and digital transitions, supporting innovation and competitiveness. The goal is to address the skills shortage across the EU in strategic industrial sectors, to boost the competitiveness of member states through initial training, upskilling and/or reskilling of workers, also as away to fight social exclusion and to promote civic engagement and social cohesion, preventing educational failure, unemployment and ultimately, radicalization. A key asset of such strategy relies on making sure that skills are relevant for the labour market needs, while more than three quarters of companies in the EU say they have difficulties finding workers with the necessary skills, while only 37% of adults undertake training on a regular basis.

On the other hand, such initiative just puts in practice the goals of the European Skills Agenda, betting on the potential and urgency of green and digital skills to lift Europe up as a resilience factor after the Covid19 pandemic, both by building education and training capacity to support the uptake of new skills, and by encouraging individuals to pursue highly qualified VET paths.

The Recovery and Resilience Scoreboard gives an overview of the pillar names “Policies for the next generation, children and the youth, such as education and skills”, where it is clear than priority is given to a quality education at all levels, including the digitalization of the infrastructure, as well as to the creation of high quality job opportunities, especially for young people entering the labour market.

Within the Recovery and Resilience Scoreboard charts, the Thematic Analysis on Education illustrates measures across the EU to support the entire education system, fighting educational failure, and boosting vocational and tertiary education, with a focus on science, technology, engineering, and mathematics skills and the participation of women. Additional measures include a reform of the educational guidance system, increasing mentoring activities to ease the transition from school to the labour market, youth employability and social cohesion with particular attention to the green and digital transition.

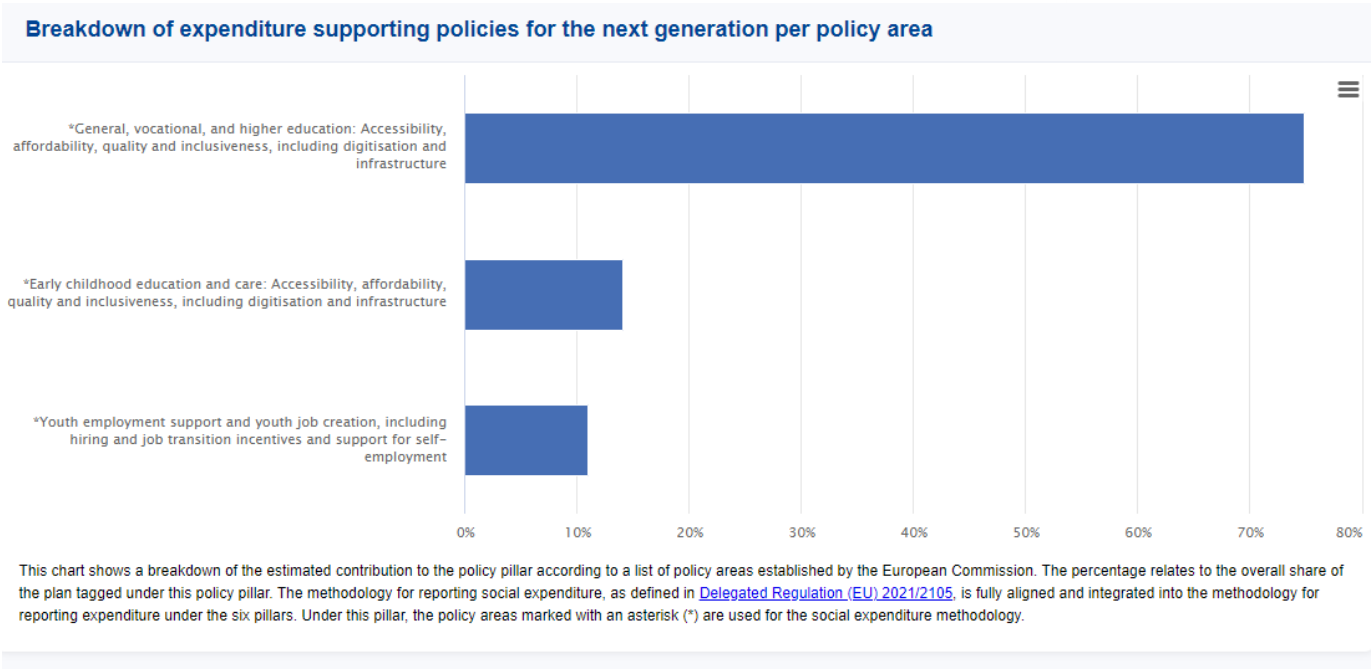


Image Source: EU Recovery and Resilience Scoreboard

In a similar way, the Thematic Analysis on Employment shows a joint effort, from all member states, to support job creation and the modernisation of the labour market, by improving the accessibility of quality job roles, especially from disadvantaged or vulnerable groups, such as young people, women, aged workers, by establishing measures to equip individuals with green and digital skills empowering them to contribute to the competitiveness of the whole national and EU economic system.

This overall political, economical and social post-pandemic scenario across the EU represents the general context where the automotive sector is jointly putting big efforts to recover from forced lockdown during the first phase of Covid19, and to face the threatens posed to the global automotive supply chain by the recent breakthrough of conflict in Eastern Europe.[1]

Exploiting the potential of the green, low or zero-emission engines and fuels, as well as on the digital connectivity of vehicle fleets, the Innovation Garage of Garages project relies on the strategic value of the joint cooperation between the VET system and the production companies to design innovative situated

[1] Other useful resources about the EU policies, strategies or best practices about Green Skills and Work-based learning can be found in the following documentation:
EU competence framework for Green Skills (own initiative opinion);

ETF European Training Foundation study on Work based learning as well as the ETF guide and toolkit publication (2018) named Work based learning: a handbook for policy makers and social partners in ETF countries;

CEDEFOP's publications Apprentices in Work based learning and The Role of Work based learning in VET and tertiary education

learning environments, reproducing and/or virtually simulating the real workplace layout, equipment and organizational roles, to effectively train I-VET, H-VET or C-VET skills about hybrid/electric engines and avionics systems for connected vehicles.

2. Panorama of the green Skills and job profiles within the Automotive Sector

Section A – Desk Analysis of the current skills and job profiles EU frameworks

The variety of the VET qualifications offer at Automotive level across the EU is quite different from a country to another, as it reflects the national prescriptions from the Ministries of Education as well as the demands of the local job market, yet it has converging features when it comes to training programs developing mechanical operations skills as well technical maintenance of the internal combustion vehicle engines (ICE engines).

But as the 21st century dives into the Green & Digital transition, it's harder to imagine which kind of knowledge and skills should I-VET learners acquire, or which upskilling or re-skilling path should workers go through to stay up-to-date in their lifelong professional development.

According to the European Green Deal, alternative fuels and low/zero emission vehicles should reach at least 90% of the total on-road vehicles by 2050. The application of such guidelines takes the EU education and training system to develop job-related skills about hybrid - electric vehicles as well as to electronics circuits supporting assisted and safe drive, thanks to GPS systems and a digital interface for the management of interconnected vehicle fleets as well as human/machine interaction.

A suitable starting point for a VET trainer looking to design a training program to develop e-mobility skills in learners, is looking at 3 frameworks describing the job profiles and qualifications currently existing at EU level:

- The ESCO classification
- The Erasmus+ Sector Skills Alliance DRIVES 591988-EPP-1-2017-1-CZ-EPPKA2-SSA-B (Development and Research on Innovative Vocational Education Skills in the Automotive Sector)
- The Sector Skills Alliance ALBATTS 612675-EPP-1-2019-1-SE-EPPKA2-SSA-B (Alliance for battery technology, training and skills for the e-mobility and battery sector)

ESCO is the multilingual classification of European Skills, Competences, and Occupations. The ESCO classification identifies and categorises skills, competences, and occupations relevant for the EU labour market and education and training. Through a filter research, the IG2 partnership selected around 20 job profiles matching the combination of the following keywords:

- Automotive
- Vehicles
- Battery
- Electricity
- Avionics

1. The ESCO Classification
   1.1. After-sales service technician

1.2. Automotive battery technician
1.3. Automotive electrician
1.4. Automotive engineering drafter
1.5. Automotive test driver
1.6. Avionics technician
1.7. Battery assembler
1.8. Battery test technician
1.9. Electrical cable assembler
1.10. Electrical equipment assembler
1.11. Electrical mechanic
1.12. Electrical supervisors
1.13. Electronic equipment assembler
1.14. Fire service vehicle operator
1.15. Mechatronics assembler
1.16. Microelectronics engineering technician
1.17. Motor vehicle assembler
1.18. Motor vehicle mechanics & repairers
1.19. Vehicle electronics installer

For useful reference use, IG2 partnership collected the Job description for each role mentioned above in the IG2 Teaching & Learning Material Folder, available for open & permanent access in a shared repository.

2. The DRIVES Project Job Roles Classification

The Drives Project Sector Skills Alliance, led by the Technical University of Ostrava (Czech Republic), produced standard reference results for a double purpose: on one side, sectorial intelligence needs analysis and a classification of skills and professional qualifications in current and future high demand for the automotive sector; on the other side, an open access e-learning platform (user registration is required) for acquiring micro-credentials in all the knowledge & skills domains that were identified in the sectorial intelligence phase.

Useful reference material from the overall DRIVES project results, available for free download from DRIVES project Results page as well as from IG2 project IO1 Teaching & Learning materials:

2.1. List of Future Job Roles in the Automotive Sector
2.2. Use of the Drives Project Framework Platform: https://drives-compass.eu/home
2.3. Selection of Study Handouts matching IG2 project field of application:
  2.3.1. Drives Project Insights of the Automotive Sector, 2019
  2.3.2. Skills needs and gaps – offer outcomes
  2.3.3. Skills needs and gaps – gaps between “demand” and “offer” outcomes

With the aim at developing and testing VET training programs for the development of Green Skills for the Automotive sector, namely e-mobility and avionics, IG2 partners selected from the Drives Future Job Roles list the most relevant for the sake of the project:

-ADAS/ADF Testing & Validation Engineer

-Sensor Fusion Expert

-Connected Vehicles Technician

-Automotive Cybersecurity Tester

-Rubber Technologist

-Functional Safety Engineer

-Highly Automated Drive Engineer

-Automotive Mechatronics Expert

-Sustainability Expert

-Robotic Technician

- Predictive Maintenance Technician

Note on EQF levels. As the reader can easily note, a number of the Job profiles listed above are about engineering roles, corresponding to EQF 6 University graduate level. As IG2 project is focusing on EQF 3 - 4 - 5 levels, VET trainers should consider the basic and most operative or technical supervisory skills level of any engineering role in order to design training paths suitable for lower qualifications level.

3. The ALBATTS Project Skills Need Analysis in the Battery Sector

Since the European workforce is being highly affected by the change brought about by the transition to electromobility, there will be an increasing need for new training/ reskilling programmes, adapted to the emerging jobs needs, as we further progress to the 2050 EU Green Deal goal of having 90% zero emission vehicle circulating across the EU.

The Alliance for Batteries Technology, Training and Skills (ALBATTS) aims to be a major contribution to the Green mobility in Europe. As the European battery value chain is being developed, organisations from the demand and supply side of skills/competences are brought together, to establish a blueprint for preparedness of future skills across Europe.

ALBATTS project holds a very ambitious purpose to map all the possible fields of application of the battery sector, ranging from mobile to industrial uses, and from road vehicles to aircraft and maritime means of transportation.
The current document will consider only the EV and HEV road vehicles (either cars or trucks), since this is the specific focus of IG2 project.

Useful reference material from the overall ALBATTS project results:

3.1 **Skills Card** to map the required competences and knowledge to operate in the battery sector:
https://www.project-albatts.eu/en/skillscards

3.2 Selection of Study Handouts matching IG2 project field of application:

3.2.1 Report on State of the Art of Job Roles and Education in the sector

3.2.2 Sectoral Skills Intelligence and Strategy for the European Battery Sector 2019-2023

3.3.3 Analysis of Future Needs 2019-2023

The Skills Card set offers a complete overview of the occupational profiles - and corresponding competencies, within the scope of battery manufacturing, e-mobility and stationary battery storage.

ALBATTS addresses both companies and training providers according to the I-VET and C-VET skills development needs, as mapping competencies within job profiles can be useful to:

- create training opportunities [VET]
- improve existing curricula or training programmes [VET providers]
- readjust/improve employee's selection and recruitment [companies]
- train employees according to the latest sectoral needs [companies]

While the Skills Card ranges through all the different battery application field and levels, for the sake of IG2 project it will be sensible to just focus on VET level job qualifications dealing with automotive sector:

-Automotive Repair and Inspection Personnel
-Battery Manufacturing Technician
-Battery Module Assembly Technician
-Battery Recycling Technician
-Quality Technician

Appendix I (E-mobility Automotive Skills Classification & Glossary) in the present document is providing a list of the Job Roles taken from ESCO framework, DRIVES and ALBATTS project, with the description of the job profiles and skills relevant for the Automotive sector at VET level.

A synoptic comparative view of the three automotive qualification profiles is given below, as a specific interpretation from IG2 partnership.

	DRIVES Development and Research on Innovative Vocational Education Skills	albatts
Motor vehicle assembler		EV Automotive Repair and Inspection Personnel
Automotive Electrician		
Electrical Cable Assembler		
Electrical Equipment Assembler		
Electrical Equipment Inspector		
Electrical Mechanic		
Electrical Supervisor		
Automotive Battery Technician		Battery Manufacturing Technician
Battery Assembler		Battery Module Assembly Technician
Battery Test Technician		Battery Quality Technician
		Battery Recycling Technician
Avionics Technician	ADAS /ADF Testing & Validation Engineer	

	Sensor Fusion Expert	
	Connected Vehicles Technician	
	Automotive Cybersecurity Tester	
	Highly Automated Drive Engineer	
Electronic Equipment Assembler	Automotive Mechatronics Expert	
Electronic Equipment Inspector		
Vehicle Electronics Assembler	Robotic Technician	
	Predictive Maintenance Technician	
Microelectronics Engineering Technician	Functional Safety [Engineer/Technician]	
	Sustainability Manager	
Automotive Engineering Drafter		
Automotive Test Driver		
Fire Service Vehicle Operator		
	Rubber Technologist	
After Sales Service Technician		

4. Further Study Materials available in IG2 Teaching & Learning Materials Folder :
    - HV Regulation: EN 50110-1 Norm and relevant country-level regulations about electrical work
    - ISO/IEC 15504 Information technology – Process assessment, also termed Software Process Improvement and Capability Determination (SPICE) and its application to the automotive sector

Section B. Analysis of the current VET offer at Automotive & E-mobility Level in the IG2 partner countries

The first step for a VET teacher designing an educational path to develop e-mobility skills, either at I-VET or H-VET level, is starting from the learning outcomes that are currently contained in the educational offer. In this way, it's possible to reference Automotive Job Roles & Skills to the actual country-specific VET System in the automotive sector.

The educational scenario at VET level in the automotive sector is quite variable from a country to another: while northern european countries or countries with established practice of dual learning system often include e-mobility in the VET mechanics training courses at all levels, countries with more recent or less structured work-based learning or apprenticeship policies actually foresee e-mobility only at EQF 5 (post-secondary training courses) or EQF 6 (engineering or polytechnics) university courses.

Yet, it is possible to build from scratch a course or modular training units about e-mobility, targeting relevant topics (such as safety rules for HEV/EV management), even if no specific learning objectives are included in the school/training centre programs by the local Ministries of Education.

For example, even if no courses about HEVs/EVs are included in the training offer, VET automotive courses across Europe always include knowledge or practical abilities about electrical mechanics and electronics, or electrical schemes within the vehicle circuits. The following paragraphs will try to highlight any modular unit, knowledge and content matching the e-mobility job-roles and skills that were outlined in the previous chapters, which do have the potential to be exploited as a starting point to trigger e-mobility training.

Where possible and relevant, the present paper will suggest a possible match with the e-mobility job roles identified by the ESCO framework and the Sector Skills Alliances DRIVES & ALBATTS. This will be most significant for the educational offers that are already envisaging e-mobility skills in their curriculum. For those offers which are not yet designed to include HEVs/EVs and /or avionics in the training path, such recommendations will be useful to update their learning program and innovate the didactic methodology as well as the work-based learning environment.

ITALY

As an example for the italian VET offer at automotive level, IG2 project includes two institutions from the Emilia Romagna region, also known as the "Motor Valley" thanks to the establishment of excellence automotive companies such as Ferrari & Maserati in the area of Modena, Ducati and Lamborghini in the area of Bologna, and Dallara in the area of Parma.

IG2 partnership includes an upper secondary VET institution, IIS A. Ferrari, based in Maranello, providing EQF 3 and EQF 4 qualification courses, and a tertiary VET institution, Fondazione ITS Maker Academy, based in Bologna, providing EQF 5 qualification courses.

This chapter offers an overview of the training units, main contents, knowledge and skills of the following courses, selected as the most relevant to start or improve the development of e-mobility training.

- Maintenance and Technical Assistance (EQF 4)
- Technician for the Construction of Transportation Means - Road Vehicles (EQF 4)
- Higher Technician in Hybrid, Electric and Endothermic Engines (EQF 5)
- Higher Technician in Electric & Connected Car and Assisted Driving (EQF 5)

EQF 4 level - VET Secondary Education Diploma

Course Title (1)	**Vocational Course in "Maintenance and Technical Assistance"**
Duration (years)	5
Age of students involved	14-19 years old
EQF Level	4
Hours of frontal classes	Around 400 hours yearly of vocational subjects with 40% time spent in practical laboratories
Hours or practical training (lab)	
Hours or weeks of internships in companies	At least 3 weeks company internship program for each school year

Is it part of a dual learning or apprenticeship program?	No

Within such course, the following contents & learning outcomes are the most appropriate trigger point for initiating a specific training on e-mobility:

- Electrical, mechanical and fluidic components.
- Methods of troubleshooting.
- Operating procedures for disassembly, replacement and reassembly of equipment and facilities.
- Industry diagnostic software.
- Types of faults and how to report, search and diagnose them;
- Sensors and transducers of mechanical process variables;
- Principles of operation and structure of electrical generating and driving machines in direct and alternating current;
- Electrical protection devices, individual and collective;
- Life cycle of an electromechanical, electronic apparatus/plant;
- Techniques and procedures for the assembly and installation of mechanical, electrical and electronic equipment or devices;
- Techniques and procedures for assembling electrical equipment and protection systems;
- Fault diagnosis and intervention procedures;
- Troubleshooting and diagnostic methods;

Such topics can be referenced to the most basic and operative professional levels as outlined in the ESCO classification framework:

- Motor vehicle assembler
- Automotive Electrician
- Electrical Cable Assembler
- Electrical Equipment Assembler
- Electrical Mechanic

Main Modules / Training Units	Teaching/training contents	Learning Outcomes; Theoretical Knowledge to be gained	Learning Outcomes: Practical skills (work-related skills) to be gained
Technology workshops and exercises	Logical and functional diagrams of equipment and systems. Usage characteristics of **electrical, mechanical and fluidic components.** Techniques for searching, consulting and archiving technical documentation. Functionality of equipment, devices and components of interest. Operating principles of basic instrumentation. Types and characteristics of measuring instruments.	Using, through knowledge and application of safety regulations, specific tools and technologies; Understanding, interpreting and analysing system diagrams; Using the technical documentation required by the regulations to ensure the correct functionality of equipment, installations and technical systems for which it is responsible for maintenance; Identifying the components that make up the system and the various materials used, in order to intervene in the assembly, replacement of components and parts, in accordance with	Producing and interpreting drawings and diagrams of devices and installations of various kinds. Interpreting the operating conditions of installations indicated in diagrams and drawings. **Assembling pneumatic, hydraulic and electrical components** by reading diagrams and drawings. Retrieving, updating and archiving technical documentation of interest. Relating the data in the documentation to the device described. Obtaining information on interventions from the documentation accompanying the machine/plant. Using basic measuring instruments and methods.

		established methods and procedures;	
	Methods of **troubleshooting**. Operating procedures for **disassembly, replacement and reassembly** of equipment and facilities. Prevention and protection criteria relating to the management of operations on equipment and systems of interest. Industry **diagnostic** software. Elements of technical documentation. Plant/machine bill of materials	Correct use of measuring, control and diagnostic instruments, making adjustments to systems and installations; Attention to safety in the living and working environment, protection of the individual, the environment and the territory.	Using, also with computer aids, methods and tools for diagnosing maintenance activities in the sector. **Identifying faults** by applying search methods. **Disassembling, replacing and reassembling components and technological equipment by applying safety procedures.** Drafting technical documentation. Preparing the bill of materials for the elements and equipment making up the system.
Mechanical technologies and applications	Mechanical pneumatic and hydraulic systems; Technical documentation of electromechanical instruments; National, EU and international legislation and regulations on	Using, through knowledge and application of safety regulations, specific tools and technologies; Using the technical documentation required by the regulations to ensure	Identifying and describing the main components of pneumatic and hydraulic circuits of machine tools, systems and mechanical apparatus; Interpreting component data sheets; Applying national and EU regulatory and legislative provisions in the field of health and safety;

	safety, health and accident prevention; Malfunctions and breakdowns of machines and installations as causes of accidents; Individual and collective protective equipment; Rules of conduct to safeguard personal safety and environmental protection in living and working places; Operation of hydraulic and pneumatic circuits; Structure and operation of machine tools, systems and mechanical apparatus; Life cycle of a system, apparatus, plant; **Types of faults and how to report, search and diagnose them;** **Sensors and transducers of mechanical process variables;** Techniques for collecting and analysing operating data;	the correct functionality of equipment, installations and technical systems for which it is responsible for maintenance; Identifying the components that make up the system and the various materials used, in order to intervene in the assembly, replacement of components and parts, in accordance with established methods and procedures; Correct use of measuring, control and diagnostic instruments, make adjustments to systems and installations; Managing the needs of the customer, finding the technical and technological resources to offer services that are effective and economically related to the requirements; Analysing the value, limits and risks of various technical solutions for social and	Identifying hazards and assessing risks in different living and working environments; Using, in operational contexts, methods and tools for control and regulation of mechanical maintenance activities; Analysing installations to diagnose faults; Assessing reliability, availability, maintainability and security of a system at different points in its life cycle; Applying environmental protection regulations; Identifying the structure of plant and machine documents, version management and evolutionary updates in their life cycle.

		cultural life with particular attention to safety in the living and working places, protection of the individual, the environment and the territory.	
Electrical and electronic technologies and applications	Standards for graphic representation of electrical networks and installations; Logical and functional diagrams of equipment, systems and installations; **Principles of operation and structure of electrical generating and driving machines in direct and alternating current;** Structure and components of electrical installations; Technical characteristics of electrical components and apparatus; **Electrical protection devices, individual and collective;** Rules of behaviour in the living and working environment, in normal	Using, through knowledge and application of safety regulations, specific tools and technologies; Using the technical documentation required by the regulations to ensure the correct functionality of equipment, installations and technical systems for which it is responsible for maintenance; Identifying the components that make up the system and the various materials used, in order to intervene in the assembly, replacement of components and parts, in accordance with established methods and procedures;	Interpreting and executing drawings and diagrams of electrical installations; Identifying the elements for protecting the electrical equipment of machines and installations; Identifying the power supply modes and related protections provided; Identifying the electrical characteristics of electrical machines, installations and devices; Using, in operational contexts, methods and measuring instruments specific to electrical and electronic maintenance activities; Using, in operational contexts, control and regulation methods and tools specific to electrical and electronic maintenance activities; Describing the structure and functional organisation of devices and installations subject to maintenance work; Analysing installations to diagnose faults.

	and emergency conditions; **Life cycle of an electromechanical, electronic apparatus/plant;** Types of faults and how to report, search and diagnose them; Sensors and transducers of process variables; Analogue and digital signals, congruent systems; Signal analysis; Techniques for collecting and analysing operating data; Regulations and techniques for decommissioning, recycling and disposal of equipment and processing residues;	Correct use of measuring, control and diagnostic instruments, make adjustments to systems and installations; Managing the customer's needs, finding the technical and technological resources to offer services that are effective and economically related to the requirements; Analysing the value, limits and risks of various technical solutions for social and cultural life with particular attention to safety in the living and working places, protection of the individual, the environment and the territory.	
Installation and maintenance technologies and techniques	Techniques and procedures for the a**ssembly and installation of mechanical, electrical and electronic equipment or devices;** Techniques and procedures for	Using, through knowledge and application of safety regulations, specific tools and technologies; Using the technical documentation required by the	Interpreting data and technical characteristics of equipment and plant components; Assembling and installing systems, devices and equipment; Observing health and environmental protection regulations during testing, operation and maintenance;

	installing hydraulic and pneumatic circuits; Techniques and procedures for **assembling electrical equipment and protection systems;** Safety and environmental protection regulations; Maintenance levels; Classification of maintenance operations; Operating characteristics and specifications of mechanical, thermal, electrical and electronic machines and systems; **Fault diagnosis and intervention procedures;** **Troubleshooting and diagnostic methods;** Operating procedures for disassembly, replacement and reassembly of equipment and installations; Reliability, Availability, Maintainability and Safety Analysis;	regulations to ensure the correct functionality of equipment, installations and technical systems for which it is responsible for maintenance; Identifying the components that make up the system and the various materials used, in order to intervene in the assembly, replacement of components and parts, in accordance with established methods and procedures; Ensuring and certifying that systems and machines are set up in a workmanlike manner, collaborating in the testing and installation phase; Managing the needs of the customer, finding the technical and technological resources to offer services that are effective and economically related to the requirements; Analysing the value, limits and risks of various technical	Adopting the prevention and protection devices prescribed by the regulations for safety in the working environment; Identifying the criteria for carrying out device tests; Carrying out maintenance work and testing; Searching for and identifying faults; Planning and controlling maintenance work.

	Maintenance Project Guidelines; Techniques for programming maintenance projects.	solutions for social and cultural life with particular attention to safety in the living and working places, personal protection, environment and territory.	

Course Title (2)	**Technical Course in "Construction of the Transportation Means - Road Vehicles**
Duration (years)	5
Age of students involved	14-19 years old
EQF Level	4
Hours of frontal classes	Around 400 hours yearly of vocational subjects with 40% time spent in practical laboratories
Hours or practical training (lab)	
Hours or weeks of internships in companies	At least 3 weeks company internship program for each school year
Is it part of a dual learning or apprenticeship program?	No

Within such course, the following contents & learning outcomes are the most appropriate trigger point for initiating a specific training on e-mobility:

- Diagnostics of on-board electronic equipment;
- Electrical and electronic systems on board, their automatic controls and maintenance;
- Principles of automation and control techniques for on-board equipment, systems and processes.
- Construction, assembly, disassembly and adjustment of structural elements, systems, and connecting elements, according to industry standards;
- Materials for the construction and maintenance of the vehicle**.**

Such topics can be referenced to the technical and supervisory professional levels as outlined in the ESCO classification framework:

- Automotive Electrician
- Electrical Equipment Assembler
- Electrical Equipment Inspector
- Electrical Supervisor
- Electronic Equipment Assembler
- Electronic Equipment Inspector
- Vehicle Electronics Assembler

Main Modules / Training Units	**Teaching/training contents**	**Learning Outcomes;** **Theoretical Knowledge to be gained**	**Learning Outcomes:** **Practical skills (work-related skills) to be gained**
Electronics, electrical engineering and automation	Diagnostics of **on-board electronic equipment;** Management systems using software; Process automation and control of the vehicles;	Managing the operation of a specific means of transport and intervening in the design, construction and maintenance of its various components;	Using hardware and software to automate equipment and plants. Interpreting the parameters provided by the integrated navigation system.

	Electrical and electronic systems on board, their automatic controls and maintenance; International conventions and EU and national regulations governing the safety of work, operators, equipment and the environment; **Principles of automation and control techniques for on-board equipment, systems and processes.** Assembly procedures for structural assemblies; Conformation and diagrams of technical installations and their operating parameters; Pump characteristics and operating diagrams. Calculation of pressure losses in installations and sizing of ducts.	Maintaining the means of transport and related facilities; Managing repairs of the different equipment of the vehicle by planning their control and adjustment; Managing activities according to quality system procedures, in compliance with safety regulations; Drafting technical reports and documenting individual and group activities related to professional situations.	Using machines, instruments and specific electrical or electronic equipment and applying the relevant procedures. Programming automation systems. Recognising the different types of process controls implemented with automation systems. Scheduling the maintenance of electromechanical devices. Verifying the operation and characteristics of on-board mechanical assemblies.
Structure, construction, systems and installations of the vehicle - road vehicle	Mechanical, technological and functional characterisation of engineered materials, components and parts; Structural testing, testing and acceptance; Procedures for machining, construction, **assembly, disassembly and adjustment**	Identifying, describing and comparing types and functions of various means and systems of transport; Managing the operation of a specific transportation vehicle and	Analysing energy production and transformation systems related to the means of transport. Identifying and describing the different types of inspection and control used in vehicle maintenance.

	of structural elements, systems, and connecting elements, according to industry standards; Workshop equipment; Maintenance programmes - certification and recommissioning procedures - maintenance inspection/quality control/insurance - interface with vehicle operation - software for analysis and simulation; Basic safety concepts, reading risk analyses, prevention and protection systems, application procedures;	intervening in the design, construction and maintenance of its various components; Maintaining the means of transport and related facilities; Operating and maintaining systems, tools and equipment for loading and unloading passengers and goods, including emergency situations; Managing the repair of the different equipment of the vehicle by planning their control and adjustment; Assessing the environmental impact for proper use of resources and technologies; Managing activities according to quality system procedures, in compliance with safety regulations.	Identifying and applying technical regulations specific to the means of transport. Identifying and applying technologies appropriate to the construction and maintenance needs of components or simple systems. Applying the techniques of production, processing, material treatment and surface coating of vehicles and transport systems. Understanding and applying procedures for the maintenance of the vehicle according to the handbook, even written in English. Performing assembly and disassembly of parts or assemblies of the means of transport. Using the specific terminology of the vehicle by associating it with each of its components and functions. Choosing equipment, tools and different instruments and systems in relation to use. Carrying out simple tests and inspections on structures, materials and components intended for the means of transport.

Mechanics, machines and propulsion systems	Structural elements of the vehicle: types, function and physical characteristics of fluids. Dimensioning and design of organs and apparatuses. **Materials for the construction and maintenance of the vehicle.** Mechanical processing, transformation and coating treatments. Adjustment machine tools and related manuals. Standards and technologies for reducing the environmental impact of means of transport.	Identifying, describing and comparing types and functions of various means and systems of transport; Managing the operation of a specific means of transport and intervening in the design, construction and maintenance of its various components; Maintaining the means of transport and related facilities; Managing the repair of the different equipment of the vehicle by planning the control and adjustment; Managing the activities according to the procedures of the quality system, in compliance with safety regulations; Identifying and applying project management methodologies and techniques.	Applying the principles of mechanics to means of transport. Making design, construction and transformation choices in relation to the materials used in the construction of the means of transport. Analysing energy production and transformation systems related to the means of transport. Understanding and applying the standardised maintenance procedures contained in the vehicle manuals, also in English.

EQF 5 level - Higher Technician Diploma

Both courses, currently provided by the ITS MAKER Academy in Bologna, Italy, provide knowledge and skills about the hybrid and electric engines as well as about the avionics and assisted / autonomous drive systems.

Course Title (3)	**Higher Technician in Hybrid, Electric and Endothermic Engines**
Duration (years)	2
Age of students involved	19-21 years old or older
EQF Level	5
Hours of frontal classes	898
Hours or practical training (lab)	302
Hours or weeks of internships in companies	800
Is it part of a dual learning or apprenticeship programme?	No

Main Modules / Training Units	Teaching/training contents	Learning Outcomes: Theoretical Knowledge to be gained	Learning Outcomes: Practical skills (work-related skills) to be gained
Mechanics applied to traction	Speed, acceleration, forces, torques and kinematics applied to traction (suspension, plungers, steering).	Knowledge of power transmission from engine to road/field	The student must demonstrate recognition of the principles of mechanics applied to traction
Machine construction & FEM	Stresses and deformations in engine organs, fatigue and strength, time-varying loads using FEM methodology.	Finite element analysis of the structural design of an engine.	The student must demonstrate the ability to analyse the structural design of an engine using finite elements.

System & Construction of the Vehicles	Structural calculation and mass distribution; engine, systems, packaging in classical and electrical systems; Technical construction characteristics of endothermic engine components: disassembly operations, analysis and verification of possible wear and tear; Analysis and resolution of mechanical causes of engine malfunction. Reassembly and mechanical and electrical phasing.	Development of the vehicle system by components and integration architecture	The student must demonstrate the ability to configure the development of the vehicle system by components and integration architecture
Dynamic simulation of the vehicle (advanced 3D systems)	Dynamic, directional and stability behaviour; distribution of loads and forces of the vehicle in motion.	3D CAD simulation and validation systems of virtual prototypes of complete vehicles and subsystems.	The student will have to demonstrate the ability to simulate and validate virtual prototypes of complete vehicles and subsystems on 3D CAD.
Electronics, electromagnetism and electrotechnics	Electric and magnetic fields and circuits; electrical energy generation, storage and transformation; power electronics.	The operation of the vehicle's main electrical components	The student must demonstrate the ability to distinguish the operation of the vehicle's main electrical components

Control Units and sensors	Electric propulsion control; endothermic injection and combustion management; hybridisation management for full, minimal, range extender configurations.	Components for electronic motor management in different systems.	The student must demonstrate knowledge of electronic motor management.
ICE engine fundamentals	Otto and Diesel Cycles, Efficiency and Layout, Supercharging	Components, operation and efficiency of an internal combustion engine.	The student must demonstrate the ability to analyse the components, operation and efficiency of an internal combustion engine.

Electric Engines	The laws of electromagnetism; Motor components: stator and rotor; DC motors; Asynchronous induction motors - reluctance motors Synchronous permanent magnet motors: axial flux; radial flux; Characteristics and limitations of electric motors; Functional limits, performance, operating maps and efficiency Mechanical integration: Direct drive; Gearbox. Reversibility under braking and energy generation through kinetic energy recovery.	Basic technical features of electric motors in the vehicle system; The different types of electric traction machines; The basic parameters and characteristics, useful for dimensioning the electric motor.	The student must demonstrate the ability to analyse the basic technical connotation of electric motors in the vehicle system.
Efficiency technologies for electric engines	Injection technologies (direct, water), HCCI ignition, intake and exhaust fluid dynamics, turbocharging; New materials and coatings for engine components;	Emission reduction technologies and engine performance optimisation.	The student will have to demonstrate the ability to apply thermal engine efficiency technologies.

Legislation about engines and emissions	Engine regulations on pollutant emissions: towards the Euro 7 legislative step. Combination of engine control strategies and post-combustion emission abatement systems (particulate filter, AdBlue, catalyst).	Apply European and international exhaust emission control regulations.	The student will have to demonstrate knowledge of exhaust emission control legislation.
Electric Propulsion	Traction system configuration; component control and dimensioning; charging, autonomy and performance	Design and maintenance of electrical traction systems.	The student will have to prove that he/she knows how to design and maintain electrical traction systems.
Hybrid Systems	Types of hybridisation (mild, mini, full, plug-in), configurations, controls and performance; diagnosis of Start&Stop and hybrid systems.	Design and maintenance of hybrid traction systems; applying correct diagnosis methodology of the Start & Stop system and intelligent alternator charging mode.	The student will have to prove that he or she knows how to design and maintain hybrid drive systems.
Automatic Control Technologies and Onboard Avionics	On-board systems for automatic control: telecommunications, data transmission, sensors and cybersecurity.	Perform remote diagnostics on engine behaviour.	The student must demonstrate the ability to perform remote diagnostics on engine behaviour.

Accumulators, storage systems and batteries	Electrochemical storage systems and endothermic engines; accumulators and batteries for traction types. Innovative materials (graphene); Fuel cells. Control and management of storage systems; Thermal control of batteries and temperature timing.	Knowledge of the main construction and performance management solutions for storage systems in different vehicles.	The student will have to demonstrate knowledge of how to manage the performance of storage systems in different vehicles.
Regenerative Recovery of Energy (KERS - HERS)	Kinetic energy recovery systems (KERS) and heat recovery systems (HERS).	Configuration and maintenance of dissipated energy regeneration systems.	The student will have to demonstrate that he/she knows how to set up and maintain regeneration systems for dissipated energy.
System control & diagnostics	Control parameters and performance diagnostics of engines and hybrid systems and their reconfiguration options.	Performance of endothermic engines, electric motors and hybrid systems.	The student will have to demonstrate that he/she can analyse the performance of endothermic engines, electric motors and hybrid systems in order to improve their efficiency.

Engine calibration and propulsion	Configuration of motor control parameters in adaptation to the required ground torque effect.	Knowledge of engine calibration procedures to optimise engine performance.	The student will have to demonstrate that he or she knows how to calibrate the engine to optimise its performance.

Course Title (2)	**Higher Technician in Electric & Connected Car and Assisted Driving**
Duration (years)	2
Age of students involved	19-21 years old or older
EQF Level	5
Hours of frontal classes	662
Hours or practical training (lab)	438
Hours or weeks of internships in companies	800
Is it part of a dual learning or apprenticeship programme?	No

Main Modules / Training Units	**Teaching/training contents**	**Learning Outcomes;** **Theoretical Knowledge to be gained**	**Learning Outcomes:** **Practical skills (work-related skills) to be gained**

Reading and interpreting electrical schemes	Parts and assemblies: reading mechanical drawings and electrical and electronic diagrams, with reference also to machining and assembly/installation cycles	Knowledge of machining and assembly cycles based on drawing/technical data.	The student must demonstrate the ability to read and interpret a mechanical technical drawing and an electrical/electronic diagram.
Electronics, electromagnetism and electrotechnics	Electric and magnetic fields and circuits; electrical energy generation, storage and transformation; power electronics	The operation of the vehicle's main electrical components.	The student must demonstrate the ability to distinguish the operation of the vehicle's main electrical components.

Electric Engines	The laws of electromagnetism; Motor components: stator and rotor; DC motors; Asynchronous induction motors - reluctance motors; Synchronous permanent magnet motors: axial flux; radial flux; Characteristics and limitations of electric motors; Functional limits, yields, operating maps and efficiency Mechanical integration: Direct drive; Gearbox. Reversibility during braking and energy generation through kinetic energy recovery.	Basic technical features of electric motors in the vehicle system; The different types of electric traction machines; The basic parameters and characteristics, useful for dimensioning the electric motor;	The student must demonstrate the ability to analyse the basic technical connotation of electric motors in the vehicle system.
Control Units and sensors	Electric propulsion control; endothermic injection and combustion management; hybridisation management for full, minimal, range extender configurations.	Components for electronic motor management in different systems;	The student must demonstrate knowledge of electronic motor management.

System and architecture of vehicles	Structural elements and systems of different vehicle types; Structural calculation and mass distribution; power units, systems, vehicle packaging in hybrid and electric systems; Technical construction characteristics of vehicle systems and their components	Knowledge of the vehicle system in its subsystems and components, with an understanding of the integration architecture.	The student must demonstrate the ability to analyse and understand the vehicle structure by components and integration architecture.
Vehicle construction	Study of the general problems relating to the architecture and components of an electric/hybrid car as a machine, with reference to the main criteria for dimensioning the organs (fatigue, resistance, loads, etc.) and their relations and interactions as a system.	Finite element analysis of the structural design of a hybrid/electric vehicle	The student must demonstrate the ability to analyse the structural design of an electric/hybrid vehicle using finite elements
CAD 3D systems and dynamic simulation of vehicles	Dynamic, directional and stability behaviour; distribution of loads and forces of the vehicle in motion	3D CAD simulation and validation systems of virtual prototypes of complete vehicles and subsystems.	The student will have to demonstrate the ability to simulate and validate virtual prototypes of complete vehicles and subsystems on 3D CAD.

ICE engine fundamentals	Otto and Diesel Cycles, Efficiency and Layout, Supercharging.	Components, operation and efficiency of an internal combustion engine.	The student must demonstrate the ability to analyse the components, operation and efficiency of an internal combustion engine.
Powertrain traction systems	Structure, characteristics, performance of electric and hybrid propulsion systems; speed, acceleration, forces, torques and kinematics applied to traction.	Power transmission from powertrain to road/field.	The learner must demonstrate recognition of the dynamics of electric and hybrid powertrains applied to traction issues.

Onboard Infotainment	On-board computers, infotainment systems and components, operating systems and sw, integration with external operating systems (smartphones and mobile devices). HMI: Human Machine Interface; Body Pc and vehicle control units and their integration into Body Electronics and its systems and components; Infotainment systems; integration with mobile systems and smartphones (Apple, Android); Bluetooth connections and vehicle function control via app; Satellite systems, GPS, localisation and security	The main functions of on-board infotelematics technologies, with particular reference to related systems.	The student will have to demonstrate the ability to configure and maintain vehicle infotainment and connectivity systems

CAN networks and vehicle system communication	KWP2000, LIN, CAN networks, CAN FD, Flex Ray, secure gateway, OTA: basic principles, evolution, interfacing strategies and architectures; CAN networks: HW and SW architecture, communication protocols; Low and high-speed CAN networks; Instrumentation and measurement SW; CAN networks instrumentation and measurement SW: use of instrumentation and vehicle interfacing; measurements and signal interpretation, troubleshooting, basic electrical measurements.	Evolution in data communication between vehicle nodes; Main communication protocols (CAN focus); Practical use of CAN network analysers on the market, recording, analysis, fault simulation.	The student must demonstrate knowledge of data acquisition protocols, instrumentation and techniques and analysis SW configurations.
Legislation about engines and emissions	Engine regulations on pollutant emissions: towards the Euro 7 legislative step; Combination of engine control strategies and post-combustion emission abatement systems (particulate filter, AdBlue, catalyst).	Apply European and international exhaust emission control regulations.	The student must demonstrate knowledge of exhaust emission control legislation.

Electric propulsion	Traction system configuration; component control and dimensioning; charging, autonomy and performance.	Design and maintenance of electrical traction systems.	The student will have to prove that he/she knows how to design and maintain electrical traction systems.
Hybrid Systems	Types of hybridisation (mild, mini, full, plug-in), configurations, controls and performance; diagnosis of Start&Stop and hybrid systems.	Design and maintenance of hybrid traction systems; applying correct diagnosis methodology of the Start & Stop system and intelligent alternator charging mode.	The student will have to demonstrate the ability to design and maintain hybrid drive systems.
Accumulators, storage systems and batteries	Electrochemical storage systems and endothermic engines; accumulators and batteries for traction types. Innovative materials (graphene). Fuel cells. Control and management of storage systems. Thermal control of batteries and temperature timing.	Knowledge of the main construction and performance management solutions for storage systems in different vehicles	The student will have to demonstrate knowledge of how to manage the performance of storage systems in different vehicles.

Regenerative Recovery of Energy (KERS - HERS)	Kinetic energy recovery systems (KERS) and heat recovery systems (HERS)	Configuration and maintenance of dissipated energy regeneration systems	The student will have to demonstrate that he/she knows how to set up and maintain regeneration systems for dissipated energy.
ADAS systems	Driver assistance systems: HW, SW, functionality, integration, redundancy; Main technologies: ABS/ESP, Radar, Cameras, Airbar, parking sensors, Lidar - fusion, servo electric; Safety, comfort and assisted driving functions: speed control, parking and lane change, emergency braking, lane detection and line assist, adaptive lighting and night vision; Functional safety and related regulations. Diagnosis, troubleshooting, analysis of acquired data and use of technical documentation.	Basic characteristics and functionality of sensors, actuators and vehicle nodes. Acquire theoretical and practical knowledge, positions and assembly specifications of the main components. Managing technical documentation and data acquired for diagnosis and control activities.	The student will have to demonstrate knowledge of ADAS, autonomous driving levels and carry out practical procedures on diagnosis/fault finding and calibration.

System diagnostics	Control parameters and performance diagnostics of engines and hybrid systems and their reconfiguration options.	Performance of endothermic engines, electric motors and hybrid systems.	The student will have to demonstrate the ability to analyse the performance of endothermic engines, electric motors and hybrid systems in order to make them more efficient.

NETHERLANDS

All the courses listed below, currently jointly provided by the ROC MIDDEN NEDERLAND - Automotive College, Utrecht, and INNOVAM Nieuwegein, Netherlands, provide knowledge and skills about the hybrid and electric engines as well as about the avionics and assisted / autonomous drive systems.

The following courses provide VET secondary education at automotive level:

First Car Technician (EQF 3)

First Truck Technician (EQF 3)

Technical Specialist Car Technology (EQF 4)

Technical Specialist Truck Technology (EQF 4)

Course Title (1)	**First Car Technician** **First Truck Technician**
Duration (years)	3 years
Age of students involved	16+ years
EQF Level	Level 3

Hours of theoretical study	4 hours per week
Hours or practical training (lab)	4 hours per week
Hours or weeks of internships in companies	2x 8 hours per week
Is it part of a dual learning or apprenticeship program?	Yes

Main Modules / Training Units	**Teaching/training contents**	**Learning Outcomes;** **Theoretical Knowledge to be gained**	**Learning Outcomes:** **Practical skills (work-related skills) to be gained**

Hybrid and electrical drivetrain	Introduction to hybrid and electrical drivetrain Energy streams in hybrid vehicles Electric drive Continuous Variable Transmission Single planetary gear train Transmission ratios Hybrid vehicles with planetary gear train Towing of hybrid vehicles met planetary gear train Recognising different kinds of drive Case study: hybrid and electric drive trains.	Energy streams in hybrid vehicles. Working on Hybrid vehicles Working on EV Theory of ensuring tension-free situation Students can transfer calculations to real measurements and interpret them.	Students are able to recognise Hybrid and EV vehicles name different components. Students can make a hybrid and EV tension-free in a safe manner Students can evaluate and analyze a battery management system

NEN9140 (VOP)	Working with tension Working on hybrid & electric vehicles HV-vehicles in the workshop Persons (who is allowed to do what on (H)EV-vehicles) Different working working procedures HV-vehicles (VOP) Switching of HV-system to tension-free(NEN) Safeguarding and responsibilities NEN9140 Case study: written instruction NEN9140	Working safely with and on EV. Theory of making it tension-free. Students can calculate the charging level on the basis of the theory and evaluate it by the workshop data.	Students learn how to work with different types of electric motors. Students can identify and name the different drive trains and recognise and name the important differences.
Charging system	HV battery Charging plug Charging lead Charging Case study: charging system	Structure of a HV battery and its charging mechanisms	Safely operate the charging procedures of an HV battery

Electric engines	Rotation field Synchronous three-phase current motor with permanent magnet Resolver Short-circuit anchor motor Case study: Electric motors.	Structure of an electric engine	Students can recognize and name the different components of an electric engine and identify the phases of the working mechanism
Inverter/converter battery management	DC/DC inverter Battery Management System Battery balancing Temperature regulation HV battery	Structure of a HV battery	Students can recognize and name the different components of a HV battery and identify the phases of the working mechanism

Course Title (2)	**Technical Specialist Car Technology** **Technical Specialist Truck Technology**
Duration (years)	4 years
Age of students involved	16+ years
EQF Level	Level 4
Hours of theoretical study	4 hours per week
Hours or practical training (lab)	4 hours per week
Hours or weeks of internships in companies	2x 8 hours per week
Is it part of a dual learning or apprenticeship program?	Yes

Main Modules / Training Units	Teaching/training contents	Learning Outcomes: Theoretical Knowledge to be gained	Learning Outcomes: Practical skills (work-related skills) to be gained
Hybrid and electric drive train	Energy streams in hybrid vehicles Electric drive Hybrid vehicles met planetary gear train.	Energy streams in hybrid vehicles. Working on Hybrid vehicles Working theory of making EV tension-free Students can calculate the charging level on the basis of the theory and evaluate it by the workshop data	Students can identify and name the different drive trains and recognise and name the main differences. Students can make a hybrid and EV current-free in a safe manner Students can evaluate and analyze battery management system

Hybrid and electric drive train	Introductory workshop to H(EV)-vehicles Person (who is allowed to do what on (H)EV-vehicles) Protocols Safeguarding and responsibilities Working with tension Working on hybrid vehicles Recognising drive trains Tension-free shifting of HV system Case study: NEN 9140 in the workshop	Working safely with hands on EV. Theory of making tension-free. Students can calculate the charging level on the basis of the theory and evaluate it by the workshop data.	Students learn to work with different kinds of electric motors. Students can identify and name the different drive trains and recognise and name the main differences.
Charging system	HV battery Static check of digital sensors Charging plug Charging lead Charging protocol Case study: charging system.	Structure of a HV battery and its charging mechanisms	Safely operate the charging procedures of an HV battery

Electric motors	Rotation field Synchronous three-phase current motor with permanent magnet Resolver Short-circuit anchor motor Case Study: Electric motors	Structure of an electric engine	Students can recognize and name the different components of an electric engine and identify the phases of the working mechanism
Inverter/converter **battery management**	DC/DC inverter Inverter Battery Management System State of charge Balancing of battery Temperature regulation of HV battery Programme of temperature regulation of HV battery Case study: inverter/converter and Battery Management.	Structure of a HV battery	Students can recognize and name the different components of a HV battery and identify the phases of the working mechanism

Short Modular Courses on e-vehicles, suitable for I-VET and C-VET training as well, are also offered by the Dutch partners, and are mostly attended by workers currently employed in the automotive workshops and companies in the whole country:

Course Title (1)	**Safe working on e-vehicles basics**
Duration	1 day (8 hours)
Age of participants involved	18+
EQF Level	2
Hours of theoretical study	2 (online course)
Hours or practical training (lab)	6
Hours or weeks of internships in companies	none
Is it part of a dual learning or apprenticeship program?	Dual (online and face to face)

Main Modules / Training Units	Teaching/training contents	Learning Outcomes: Theoretical Knowledge to be gained	Learning Outcomes: Practical skills (work-related skills) to be gained
Online module	Safety risks Safety Measures Personal Protection Electrical components Disconnect HV-system	Have knowledge about safety procedures for working on HV-systems	
Face to face module	Safety risks Safety Measures Personal Protection Electrical components Disconnect HV-system		Able to follow safety procedures for working on HV-systems. Able to recognize the different HV-components.

Course Title (2)	Safe working on e-vehicles advanced
Duration	1 day (8 hours)
Age of participants involved	18+
EQF Level	3

Hours of theoretical study	2 (online course)
Hours or practical training (lab)	6
Hours or weeks of internships in companies	none
Is it part of a dual learning or apprenticeship program?	Dual (online and face to face)

Main Modules / Training Units	**Teaching/training contents**	**Learning Outcomes:** **Theoretical Knowledge to be gained**	**Learning Outcomes:** **Practical skills (work-related skills) to be gained**
Online module	Working of Electrical components Procedures to Disconnect HV-system according to manufacturers Hybrid systems E-Brake systems Basics diagnosis of HV-systems	How HV-components work Knowledge of different procedures to disconnect HV-systems Knowledge of regenerative braking works	Able to follow safety procedures for working on HV-systems. Able to perform basic diagnostics on HV-systems.

Face to face module	Working of Electrical components Procedures to Disconnect HV-system according to manufacturers Hybrid systems E-Brake systems Basics diagnosis of HV-systems		

Course Title (3)	**Maintenance and repair of e-vehicles (battery)**
Duration	1 day (8 hours)
Age of participants involved	18+
EQF Level	3
Hours of theoretical study	2 (online course)
Hours or practical training (lab)	6
Hours or weeks of internships in companies	none
Is it part of a dual learning or apprenticeship program?	Dual (online and face to face)

Main Modules / Training Units	Teaching/training contents	Learning Outcomes; Theoretical Knowledge to be gained	Learning Outcomes: Practical skills (work-related skills) to be gained
Online module	HV-battery build-up Battery cells (Ni-Mh, Li-ion) HV-relays, contactors Temperature management Battery charging Charging strategies Safety procedures for working on HV-batteries	Ability to recognize different HV-batteries Knowledge of the different parts that build up an HV-battery pack Knowledge of the safety procedures	Ability to follow safety procedures for working on HV-batteries. Ability to perform maintenance and basic repairs on HV-batteries.
Face to face module	HV-battery build-up Battery cells (Ni-Mh, Li-ion) HV-relays, contactors Temperature management Battery charging Charging strategies Safety procedures for working on HV-batteries		

Course Title (4)	**Diagnosis on e-vehicles (battery)**
Duration	1 day (8 hours)
Age of participants involved	18+
EQF Level	4
Hours of theoretical study	2 (online course)
Hours or practical training (lab)	6
Hours or weeks of internships in companies	none
Is it part of a dual learning or apprenticeship program?	Dual (online and face to face)

Main Modules / Training Units	**Teaching/training contents**	**Learning Outcomes;** **Theoretical Knowledge to be gained**	**Learning Outcomes:** **Practical skills (work-related skills) to be gained**

Online module	How to perform diagnosis on HV-battery systems How to set-up a diagnosis plan Battery management systems Charging systems	Ability to recognize different HV-batteries Knowledge of the different parts that build up an HV-battery pack Knowledge of the safety procedures	Ability to diagnose HV-battery management systems. Ability to diagnose charging systems.
Face to face module	Performing diagnosis on HV-battery systems Setting-up a diagnosis plan Battery management system diagnosis Diagnosis of Charging systems		

Course Title (5)	**Maintenance and repair of e-vehicles (drive line)**
Duration	1 day (8 hours)
Age of participants involved	18+
EQF Level	3
Hours of theoretical study	2 (online course)
Hours or practical training (lab)	6

Hours or weeks of internships in companies	none
Is it part of a dual learning or apprenticeship program?	Dual (online and face to face)

Main Modules / Training Units	**Teaching/training contents**	**Learning Outcomes:** **Theoretical Knowledge to be gained**	**Learning Outcomes:** **Practical skills (work-related skills) to be gained**
Online module	Electric motors (AC, DC, Brushless) Engine controls Regenerative braking 2-wheel drive, 4-wheel drive systems Safety procedures	Ability to recognize different types of electric motors Know the different parts of electric drive systems Know how regenerative braking works.	Ability to recognize all types of electric motors Ability to understand data form the engine management control module

Face to face module	Electric motors (AC, DC, Brushless) Engine controls Regenerative braking 2-wheel drive, 4-wheel drive systems Safety procedures		Ability to make basic repairs on e-drive systems

Course Title (6)	**Diagnosis of e-vehicles (drive line)**
Duration	1 day (8 hours)
Age of participants involved	18+
EQF Level	4
Hours of theoretical study	2 (online course)
Hours or practical training (lab)	6
Hours or weeks of internships in companies	none
Is it part of a dual learning or apprenticeship program?	Dual (online and face to face)

Main Modules / Training Units	Teaching/training contents	Learning Outcomes: Theoretical Knowledge to be gained	Learning Outcomes: Practical skills (work-related skills) to be gained
Online module	How to perform diagnosis on electric motors How to perform diagnosis on HV-drive systems How to set-up a diagnosis plan How to recognize drive line failures Safety procedures	Ability to recognize different types of failure of electric motors and drive lines Ability to set-up a diagnosis plan	Ability to perform diagnosis on electric motors and drive lines Ability to work with a diagnosis plan Ability to diagnose drive line failures
Face to face module	Performing diagnosis on electric motors Performing diagnosis on HV-drive systems Setting-up a diagnosis plan Diagnosis of drive line failures Safety procedures		

LITHUANIA

To provide evidence of the **Lithuanian** context at VET secondary education at automotive level, this paper reports two study courses currently provided at the Car Mechanic High School based in the capital city Vilnius. At VAVM - Vilniaus Automechanikos ir Verslo Mokykla there are two main specialization running on:

-Automotive Mechanic (EQF 4)

-Automotive Electric Equipment Repairer (EQF 4)

Courses do not currently provide a specialisation in HEVs/EVs or avionics circuits, yet work-based training also include maintenance and diagnostics operations on hybrid or electric vehicles. Training modules include contents, knowledge and skills suitable to become the starting point which further e-mobility training can be based upon. Such topics include the following modules:

-Engines technical maintenance

-Transmission technical maintenance

-Automobile electrical equipment repair

-Engines electrical equipment

-Transmission electrical equipment

-Automobile comfort and safety electrical equipment

Such topics can be referenced to the most operative professional levels as outlined in the ESCO classification framework:

- Motor vehicle assembler
- Automotive Electrician
- Electrical Cable Assembler
- Electrical Equipment Assembler
- Electrical Mechanic

Course Title (1)	**Automotive Mechanic**
Duration (years)	3
Age of students involved	17<

EQF Level	4
Hours of theoretical study	About 40% of all time
Hours or practical training (lab)	About 60% of all time
Hours or weeks of internships in companies	11 weeks of short time internships and one long term 600 hour internship at the end of the program.
Is it part of a dual learning or apprenticeship program?	Dual learning program, with an ability of apprenticeship.

Main Modules / Training Units	**Teaching/training contents**	**Learning Outcomes:** **Theoretical Knowledge to be gained**	**Learning Outcomes:** **Practical skills (work-related skills) to be gained**
Introduction into profession	Work safety; Introduction into business;	Basic business knowledge, professional responsibility.	Ability to interact with people, to use and maintain technological equipment, understanding professional responsibility.
Metal technological works	Metal processing technologies; Materials;	Technology of metal processing	Technical measurements, drawings, metal welding, soldering cutting

	Technological equipment.		
Engines technical maintenance	Engine components; Adjustments; Repair techniques; Ecological issues.	Engine components, work principles, repair techniques.	Ability to choose materials for maintenance, repair techniques, technical maintenance, repair, diagnosing malfunctioning components, adaptation and regulation of components.
Otto engines technical maintenance	Otto engine components; Adjustments; Sensors; control units; control principles; repair techniques; ecological issues.	Ignition and fuel system components, work principles, sensors, control units, control principles, repair techniques.	Repair techniques, technical maintenance, repair, diagnosing malfunctioning components, adaptation and regulation of components.

Diesel engines technical maintenance	Diesel engine components; Adjustments; Control principles; Repair techniques; Ecological issues.	Diesel injection system components, work principles, control principles, repair techniques.	Repair techniques, technical maintenance, repair, diagnosing malfunctioning components, adaptation and regulation of components.
Transmission technical maintenance	Transmission components; Adjustments; repair techniques;	Transmission, gearbox components, repair techniques.	Repair techniques, technical maintenance, repair, diagnosing malfunctioning components, adaptation and regulation of components.
Chassis technical maintenance	Chassis components; Adjustments; Repair techniques;	Chassis and brake system components, work principles, repair techniques.	Repair techniques, technical maintenance, repair, diagnosing malfunctioning components, adaptation and regulation of components.

Automobile electrical equipment repair	Basic electronic knowledge; Electronics principles; Electronic components; Repair of electronic devices.	Basic electronics knowledge, Basic laws of physics, electric induction, Ohms law, electronic components and work principles, electrical wiring and its diagrams.	Ability to connect electrical wirings, diagnose electronic malfunctions, replacement of electronic components, repair of components.
Additional modules: Driving; Body diagnostics and repair.	Driving motor vehicles; Road safety; Body repair technology; Body maintenance; Body repair materials.	Road traffic regulations; First aid in accidents; Body components; Body maintenance technology; Repair technology.	Driving of motor vehicles, Choosing right materials for body maintenance; Choosing right materials for body repair; Body repair.

Course Title (2)	**Automobile Electric Equipment Repairer**
Duration (years)	3
Age of students involved	17<
EQF Level	4
Hours of theoretical study	About 40% of all time

Hours or practical training (lab)	About 60% of all time
Hours or weeks of internships in companies	11 weeks of short time internships and one long term 600 hour internship at the end of the program.
Is it part of a dual learning or apprenticeship program?	Dual learning program, with an ability of apprenticeship.

Main Modules / Training Units	**Teaching/training contents**	**Learning Outcomes;** **Theoretical Knowledge to be gained**	**Learning Outcomes:** **Practical skills (work-related skills) to be gained**
Introduction into profession	Work safety; Introduction into business.	Basic business knowledge, professional responsibility.	Ability to interact with people, to use and maintain technological equipment, understanding professional responsibility.
Metal technological works	Metal processing technologies; Materials; Technological equipment.	Technology of metal processing	Technical measurements, drawings, metal welding, soldering cutting

Engines electrical equipment	Engine components; sensors; Control units; Control principles; Repair techniques; Ecological issues.	Engine components, work principles, sensors, control units, control principles, repair techniques.	Ability to choose materials for maintenance, repair techniques, technical maintenance, repair, diagnosing malfunctioning components, adaptation and regulation of components.
Otto engines electrical equipment	Otto engine components; sensors; Control units; Control principles; Repair techniques; Ecological issues.	Ignition and fuel system components, work principles, sensors, control units, control principles, repair techniques.	Repair techniques, technical maintenance, repair, diagnosing malfunctioning components, adaptation and regulation of components.
Diesel engines electrical equipment	Diesel engine components; sensors; Control units; Control principles; Repair techniques; Ecological issues.	Diesel injection system components, work principles, sensors, control units, control principles, repair techniques.	Repair techniques, technical maintenance, repair, diagnosing malfunctioning components, adaptation and regulation of components.

Transmission electrical equipment	Transmission components; Sensors; Control units; Control principles; Repair techniques;	Transmission, gearbox components, work principles, sensors, control units, control principles, repair techniques.	Repair techniques, technical maintenance, repair, diagnosing malfunctioning components, adaptation and regulation of components.
Chassis electrical equipment	Chassis components; sensors; Control units; Control principles; Repair techniques;	Chassis and brake system components, work principles, sensors, control units, control principles, repair techniques.	Repair techniques, technical maintenance, repair, diagnosing malfunctioning components, adaptation and regulation of components.
Automobile electrical equipment repair	Basic electronic knowledge; Electronics principles; Electronic components; Repair of electronic devices.	Basic electronics knowledge, Basic laws of physics, electric induction, Ohms law, electronic components and work principles, electrical wiring and its diagrams.	Ability to connect electrical wirings, diagnose electronic malfunctions, replacement of electronic components, repair of components.

Automobile comfort and safety electrical equipment	Comfort and safety components; Sensors; Control units; Control principles; Repair techniques;	Comfort and safety system components, work principles, sensors, control units, control principles, repair techniques.	Repair techniques, technical maintenance, repair, diagnosing malfunctioning components, adaptation and regulation of components.
Additional modules: Driving; Body diagnostics and repair.	Driving motor vehicles; Road safety; Body repair technology; Body maintenance; Body repair materials.	Road traffic regulations; First aid in accidents; Body components; Body maintenance technology; Repair technology.	Driving of motor vehicles, Choosing right materials for body maintenance; Choosing right materials for body repair; Body repair.

SWEDEN

To portray the Swedish context at VET secondary level in the automotive sector, the present paper will illustrate the public-private cooperation formula represented by Göteborgs Tekniska College, Göteborg, which is a partner of IG2 project together with Volvo Trucks company.

Gothenburg Technical College is an educational and training institution co-owned by Volvo Group, Volvo Cars and the City of Gothenburg.

The institution offers industrial technical training adapted to the needs of the market, providing upper secondary education (EQF 4), vocational higher education courses in applied sciences (EQF 5) as well as company training courses (C-VET). The learning centres are centrally located in Gothenburg in the vibrant Lindholmen city quarter and in the middle of the business district at Volvo Torslanda.

As Volvo Group made a strategic asset out of e-mobility, through the production and commercialization of e-trucks fleet by Volvo Lastvagnar AB, teachers at GTC developed a learning suite about Electro-mobility, designed and taught by trainers with direct experience from the manufacturing and corporate market.

The E-mobility training suite is composed of the following modules, which are in turn included in the qualification or market courses offered at GTC:

Module Title	Duration	Contents
EV Awareness	4 hours (theory)	• Environmental Issues & Constraints • Market development • Total cost of ownership • Technology involved
Battery System Overview	8 hours (theory and practice)	• Battery Technology • Electric Safety • Battery Management • Usage • Durability
Lithium-Ion battery system	16 hours (theory and practice)	• Cell Formats • Physical Chemistry • Supply Chain • System Design • Production
EV charging and power supply	12 hours (theory and practice)	• Modes • Behaviour • Infrastructure • Business Model • Power Components

Electrical machines and transmission	16 hours (theory and practice)	• Drives overview • Hybrid powertrain typologies • Circuit theory

As part of the upper secondary level courses, GTC offers an indentation of the Technical Program plus and indentation of the Industrial Program, both of them including and extending the core modules of the e-mobility suite:

Maintenance Technician – Automation (EQF 4)	Maintenance Technician – Electrical Mechanics (EQF 4)
Robotics Electric Power Technology Applied Automation Technology Industrial Automation Technology	Production Equipment Electric Motor Control Remedial Maintenance

GTC also offers Lifelong training courses about E-mobility for workers and companies (C-VET) in more areas:

Area of "Electric Vehicles and Battery Technology"

Area "Electrical Safety"

Courses have a duration from 4 to 50 hours and are taught partly onsite and partly online. All of them have a modular structure that can build up with other short courses from the catalogue. The main modules are:

- Battery System Lithium-Ion
- Battery System Overview
- Battery Management Connection and Control
- Battery Management Systems
- Battery Technician
- Battery Testing
- Digital Technology Vehicles
- E-vehicles: design and function
- Electric Machines and transmission
- Electric vehicle safety
- Sustainable transport systems

GTC also established an open digital reference library for electro-mobility, meant as an ever-growing archive about electric vehicles, power supply, charging, power storage, sustainable energy system and environmental issues, counting more than 7 thousands resources today.

3. Co-designing the Innovation Garage of Garages

First of all, it's important to explain what do we mean by the term "Innovation Garage".

In this specific project's context, we mean "Innovation Garage" as the process of **bringing together VET Providers and companies** from the **automotive sector** (here referred to as "garage"), to **co-design** both the **training workplace** and the **learning path** for the development of **green mobility skills** at multiple **VET** levels, from I-VET to H-VET to C-VET.

As this is a strategic partnership for cooperation, IG2 project's goal is not about technological innovation in the automotive field, but it's about **innovating** the training **methodology** and the design of the **learning environment**.

Where does it come from? We are borrowing the term from IBM Garage Field Guide, where it stands for an participative and co-operative framework to invite, facilitate and boost innovation and knowledge management from a bottom-up perspective.

By bringing together stakeholders involved in the automotive sector, both at VET system, at teachers/trainers level, at student level and at company level, IG2 project strives to make cooperation happen to co-design learning paths for the green mobility revolution. Co-creation is not just about training programs and skills/qualification frameworks, but it's about the workplace layout as well. The training setting is meant as a situated environment where VET learners and scaffolders from the business world co-execute operations and co-enact organisational roles similar to the real workplace.

In the automotive sector, the Innovation Garage approach was adopted by Thyssenkrupp Group too, as a way to reach a higher level of innovation within the mobility sector. In the corporate mindset, innovation can be created not just by R&D department and shared top-down, but small start-ups among technicians, managers, customers and investors too can be set up to co-design &co-create new product prototypes and processes.

2-Study Materials

In the Teaching & Learning material collection put together by the IG2 project, partners produced contributions to guide VET trainers as well as workshops managers, through the changes affecting the mechanical garages and their evolution from the 2020s up until the 2040s or 2050, which is the ultimate horizon of the European Green Deal scenario about the European Union becoming a zero emission and carbon neutral area. The following documents and presentations, available for free download and consultation under the Creative Common 4.0 Share Alike licence, also cover the development of future automotive workers' skills for a smooth transition towards the job market, as well as the needs analysis of the automotive sector in terms of current gaps generated by the quick evolution of the EVs (electric vehicles), HEV (hybrid electric vehicles), of the digital softwares managing the Autonomous and Assisted Drive systems (ADAS) as well as the remote or in-cloud predictive maintenance (OTA - over the air assistance).

Please find below the list of documents providing scenarios, sets of knowledges and skills as well as instructions about how to configure the layout of an effective training workplace for the development of e-mobility skills at VET level:

- The Workshop of the Future – by Innovam (first published in 2018)
- E-Mobility and Education – Needs Analysis by Innovam
- E-Mobility and Education – Needs Analysis by Zener Italia
- E-Mobility and Education – Needs Analysis by Moller Auto, Lithuania

According to Innovam's analysis, a few drivers of change are affecting the automotive sector at EU and global level, namely:

-the legislation at national and international level, as well as the regulations established by the local Ministries of Transportation

- the rise of Electric Vehicle (EV) technology

-the rise of digital and remote maintenance (OTA - over the air assistance)

-the rise of autonomous and assisted drive systems (ADAS), thanks to the digital and software technology

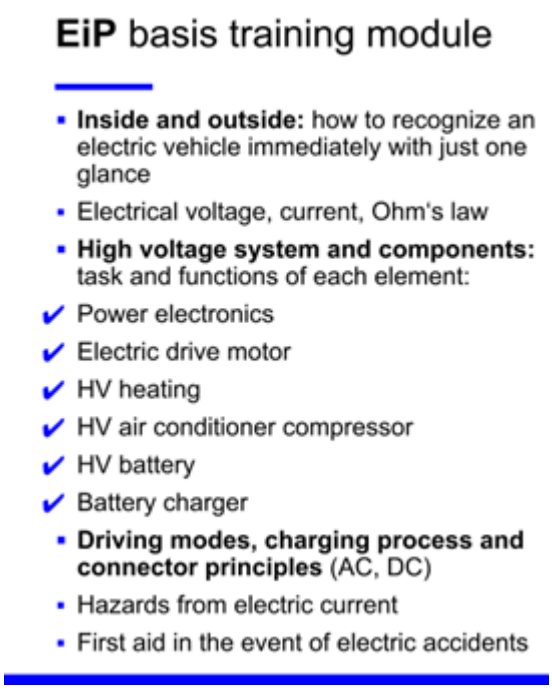
Nonetheless, such four drivers of change are not independently transforming the automotive system but their impact is closely tied to how responsive consumers will be towards such changes in the market. When legislation is not pushing forward towards electrification, and customers are not much interested in choosing connected cars or there are less entrants in the market overall, by 2040 there will be a limited number of drivers releasing real-time data for remote maintenance, and the EV as well as the autonomous drive market will shrink. Since new technologies are not hugely impacting the sector, ICE (internal combustion engines) vehicles will amount to around 70% and traditional mechanics will be still prevailing in workshops, with just a -15%/-20% drop compared to 2020. Pool cars are not widely spread, yet they are common just in bigger cities and MaaS (mobility as a service) is not a big trend.

Since the European parliament decreed in late 2022 that by 2035 no more ICE vehicles should be produced and sold across the EU, such conservative scenario does not seem to be happening though, as consumers will be forced either to own a hybrid or electric car, or to go for car pooling services.

Such recent evolution, occurred after the first release of "The Workshop of the Future" paper (2018), makes an alternative, more progressive overall picture closer, where EVs are spread nationwide over 70% of the total vehicles, connected cars and pooled cars are widely used by the majority of citizens as daily means of transportation within the MaaS scenario, and OTA (over the air) maintenance is regularly performed by a vast number of providers. As this hypothesis is coming true, the organisation of workshops/garages and the traditional role of ICE fitters will be deeply affected, with an estimate of -40% workshop staff needed and traditional mechanics less and less involved in the maintenance operations, which will rather be mostly remote software update.

So, how such changes will mostly affect the training and skills of the staff within the Automotive workshop?

According to Moller Auto - Lithuania, official Volkswagen and Audi dealer, as HEVs and EVs become more and more common, it is vital that all the workers in the workshops are trained as EiP - electrically instructed persons, even while performing basic maintenance or repair operations. On top of that, a smaller number of staff shall be HVTs - high voltage technicians, responsible of de-energising the HV batteries and of the general start-up of an HEV or EV. Only a restricted number of people, fully qualified as HVE - high voltage expert, are allowed to manage high voltage batteries and to activate or deactivate high voltage systems by all means.



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The layout and equipment of an automotive workshop where HEVs and EVs are maintained should always bear warning and danger signs about high voltage circuits over the place:

Workplace: how to identify high-voltage components?

There are various high-voltage marking around a high-voltage vehicle. These markers indicate that hazards due to electric current can be expected on this vehicle:

- Yellow and black barricade tape
- Warning signs and prohibition signs around and on the vehicle
- Warning signs and prohibition signs on components in the vehicle
- Orange wires and components

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Special tools and recommended accessories to be found in the automotive workshop for HEV / HV vehicle maintenance, and useful tools for the VET students' training workplace too:

High-voltage diagnosis box VAS 5581

Using the high-voltage diagnosis box VAS 5581, you can check the high-voltage traction batteries of hybrid, plug-in hybrid and electric vehicles of the Volkswagen Group quickly and easily.
In doing so, the diagnosis box is connected directly to the control unit of the high-voltage battery using the adapter cable, either in the vehicle or once removed, to read off the measured values, e.g. the voltage of the individual modules. To connect with the diagnosis unit that reads out the measured values, the diagnosis interface VAS 6154 is connected directly to the diagnosis box. A defective module can, thus, be found quickly and the repair can take place. The diagnosis box is supplied with voltage via a power pack or a separate accumulator.

Scope of delivery

- 1× high-voltage diagnosis box
- 1× adapter cable
- 1× power pack

Recommended accessories

- \+ Different adapter cables VAS 5581/XX (various ASE numbers)
- \+ Accumulator VAS 5581/10 (ASE 109 051 00 000)

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"Premium" diagnosis unit VAS 6160E

The "Premium" diagnosis unit VAS 6160E with touchscreen embodies the latest generation of diagnosis units. With the special Windows 10 version IoT Enterprise LTSB as its basis, it offers maximum operating comfort and the highest possible operator safety.

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Isolator box, 198-pin VAS 6606

The isolator box VAS 6606 is used for the diagnosis on control devices with 198-pin connections that are being used in the Group since 2010. It has a modular design and is equipped with 66 connections per module.
Adapter cables already present from the V.A.G 1598 series can be used with these modules, with an adapter in some cases. The adapter cables are available as an accessory. The isolator box is voltage safe up to 60 V to ensure that systems from the high-voltage range are sufficiently protected.

Scope of delivery

- 1× isolator box module 1 (coding A+B) with connecting bridges and templates
- 1× isolator box module 2 (coding C+D) with connecting bridges and templates
- 1× isolator box module 3 (coding E+F) with connecting bridges and templates
- 2× test adapters
- 1× earth cable
- 1× transport box

Recommended accessories

+ Test adapter VAS 6606/XX (various ASE numbers)

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Scissor-type assembly platform VAS 6131B

With the scissor-type assembly platform VAS 6131B, engines and gearboxes of the modern power unit generation can be installed and removed as a unit quickly and without additional tools. This power unit assembly has a weight of approx. 800 kg, which means that the standard engine and gearbox jack cannot be used. Operating comfort and simple manoeuvrability set benchmarks and make the product indispensable.

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High-voltage tool set VAS 6762

Comprehensive tool set with insulated tools for high-voltage experts.

Scope of delivery

- 10× screwdrivers
- 15× hexagon socket sets
- 3× screwdriver bits
- 1× reversible ratchet ⅜"
- 2× extensions ⅜" (74 mm/126 mm)
- 4× pliers (universal, flat, nose and combination pliers)
- 1× side cutter
- 1× wire cutter
- 1× cutting knife with insulation
- 1× voltage tester
- 2× set each with 5 end caps 1000 V (Ø 30 mm and Ø 40 mm)
- 2× warning signs ("Dangerous electric voltage" and "Switching prohibited")
- 1× film barrier tape
- 1× tool case
- 1× insulation mat in bag
- 1× release tool T40258

Recommended accessories

+ Hexagon socket, 10 mm VAS 6762/46 (ASE 447 115 00 000)
+ End caps VAS 6762/47 (ASE 317 003 00 000)
+ End caps VAS 6762/48 (ASE 317 004 00 000)

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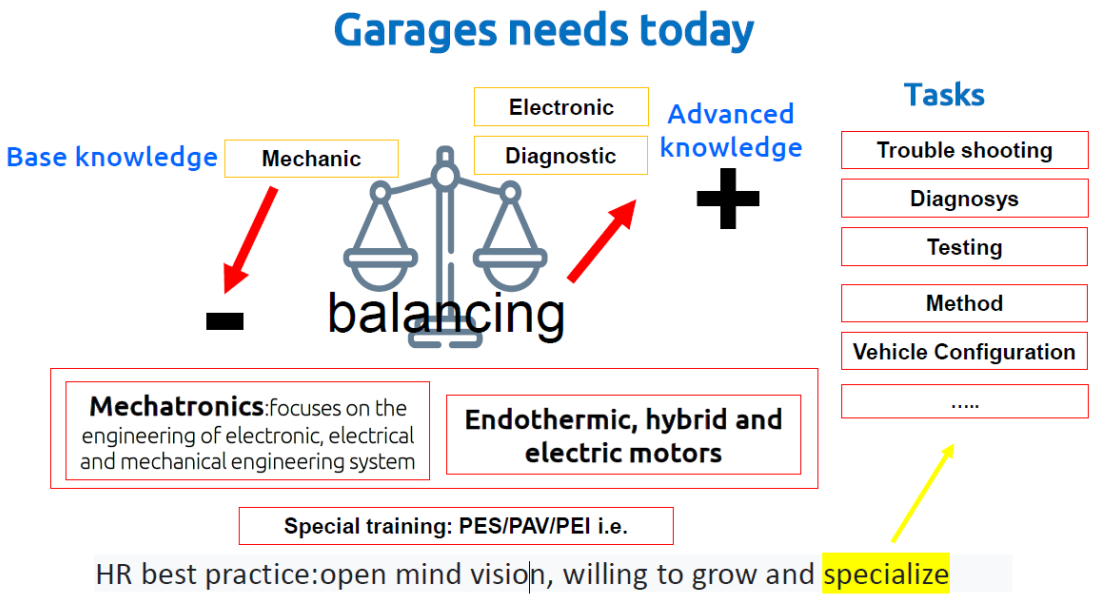
Besides the configuration and layout of the training workplace as well as the equipment and tools, it is strategic to think about which kind of knowledge and skills should the future automotive workers develop since their VET education stages, in order to support the sustainability and digital transition of the whole sector towards the EU Green Deal goals.

According to the gap analysis performed by Zener Italia Company, based in Turin, Italy, the discussion about the evolution of the training contents, methodology and skills needs should be based upon the following topics and questions:

- Deep Analysis of the real company needs to build effective school/company education programs;
- Which are the skills that the company is looking for today and in future, considering the EQF 3/4/5 levels?
- The evolution of vehicles on board electronics: what has changed since EV and connected vehicles started to spread, and which transversal skills must be acquired/evaluated?
- Ability/mindset to measure, develop and evaluate before asking trainees to put their hands on EV parts: availability of information/tools and knowing how to process them.



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As already predicted by "The Workshop of the Future" study by Innovam, as e-mobility spreads further there will be less request of base knowledge about general mechanics, with a tendency to shift to the management of the mechatronical engineering systems. On the other hand, there is already an increase in the demand of advanced comparative knowledge between endothermic (ICE), hybrid and electric engines, with specific skills related to troubleshooting, diagnosis, testing and vehicle configuration. According to such view, VET Trainees should become familiar to:

Electrical wiring diagrams and schemes

Diagnostic tools like oscilloscope and multimeter

Mastering the relation among component > system > vehicle DTC (diagnostic trouble code) and diagnostic strategies

Simulating failure of the electronic system within an HEV or EV car

ECU's management, calibration and parameter settings

Knowledge of the OEM/manufacturer assistance portal to understand procedures, configuration parameters and fault codes

Equipment & Tools to be used

Oscilloscope

Diagnosys (DTC)

```
Details:
  406A810F [C 006A - 81 - b00001111]: MultiaxisAccelerationSensor_InvalidSerialDataReceived
      Syntom MultiaxisAccelerationSensor_InvalidSerialDataReceived
      WarningLamp off;        TestCompleted yes;      TestSinceLastClear Completed;   Fault Present
      SnapshotRecordNumber 1 :
        SnapshotRecordNumberOfIdentifiers 55
        ECU time stamp = 66213 min
        ECU time stamps from Key On = 15 sec
        Key On Counter = 60
        DTC Failure type byte = 0x81
        Odometer = 50033 km
        Vehicle Speed = 0 km/h
        Battery Voltage = 13.50 V
        unknown RDI FE13
```

DTC Table: symptom,condition,validation,healing time, recovery...

[DTC code] Component / Function	[Fault symptom] Symptom	Detection conditions	Possible causes	Fault detection mode	Validation time	Healing Time	MIL Lamp	Effect of recovery
P0220 Accelerator pedal sensor 2	**[0001]** sc Vbatt/5V or oc of sensor Gnd	Po, Cr, Er, Vr	Voltage above upper limit	ENABLING CONDITION: The check is enabled if no failure of the sensor supply 2 is present ERROR RECOGNITION: The sensor raw signal (voltage) is above APPCD_uAPP2_SRCMax_C (3000.978 mV).	APPCD_DebSRCHighDef_C (240 ms)	APPCD_DebSRCHighOK_C (200 ms)	ON1	R1+R10+R37+ R38+R39

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Besides describing the future trends affecting the automotive workshop from 2020 to 2040, Innovam also points out the most relevant knowledge and skills given the deep changes in the garage layout and organization:

Co-funded by the
Erasmus+ Programme
of the European Union

3 Changes in the future workshop

- The rise in software and connected car applications will produce a large volume of vehicle information and user data.
- Cars will have (extensive) self-diagnostic systems. A technical help desk will support the technician remotely.
- The diagnostic equipment will be universal. You'll take out a subscription, which will give you access through third parties to the requisite factory data, including software updates.
- For the purposes of resolving the diagnosed problem, the technicians will use augmented reality, such as the earlier Google Glass or HoloLens, with mechanics simply following the visual instructions.

4 Electrotechnical versus mechanical work

- The increase in electrotechnical work will call for mechanics with specific knowledge and experience.
- Cameras, radars and suchlike will be adjusted automatically using smart (AI) equipment.
- Modules and sub-assemblies will be more likely to be replaced than repaired.
- Increased quality will reduce the maintenance needs of Hybrids, ICE cars and PHEVs by 20%.
- The maintenance needs of Full Electric Vehicles will drop by 50 to 75%. The remaining maintenance will be straightforward, limited to wear and tear parts such as replacing brakes, tires and fluids. Oil changes will no longer be needed.
- Repair work will be rare, as replacements will be cheaper.
- Knowledge of ICT will be required for both electrotechnical and mechanical work.

5 Workshop setup and staff

- The workshop will be divided in mechanical and electrotechnical areas, respectively.
- High-voltage work will require special tools, personal protection equipment and safety procedures.
- Knowledge of ICT will be needed for reading data, for diagnostics and resolution both for electrotechnical and mechanical work.
- Staff will need to be certified on diagnostics with the various software packages.
- The advent of augmented reality tools and self diagnostic systems will bring about changes in terms of required competencies. Staff with a lower level of education who are capable of following instructions for the purposes of replacing parts. And staff with higher level education capable of solving problems running diagnostic procedures.

6 Impact on education

Mechanical
- EQF level 2: Maintenance
- EQF level 3: Maintenance and repair
- EQF level 4: Diagnosis

Electrics/ Electronics
- EQF level 3: Reading data, perform resets and calibrations
- EQF level 4: Diagnosis and repairs
- EQF level 5: Complex diagnosis, flying doctor

HV-systems
- EQF level 2: Only maintenance work on dead HV components. Power source disconnected. EV Instructed Person.
- EQF level 3: Measurements and repairs on HV components. Make sure HV-system is dead (disconnected). EV Skilled Person.
- EQF level 4/5: EV specialist, may work on live systems after specific training only. (Complex) HV diagnosis.

7 Important competencies

General

- Knows how systems work
- Recognizes components and know their function
- Able to read and understand data from ECU's
- Able to find the right procedure in manuals
- Able to understand the procedures
- Able to accurately follow the procedures

HV-systems

- Knows the safety rules
- Follows the safety rules
- Able to check personal protection
- Able to check HV measurement tools
- Understands and follows the 0-voltage procedure of the vehicle

Further Tools for Virtual / Augmented Reality Training:

I**nnovam EV Trainer AR App**, a mobile application to help any learner train about electric vehicles in a simulated virtual environment.

The application is downloadable on smartphones and tablets from Google Play https://play.google.com/store/apps/details?id=com.Innovam.EVTrainer&hl=it&gl=US

The demo video is available on "Innovation Garage Erasmus+ Project" YouTube Channel.

4. Making the Innovation Garage of Garages happen

The last phase of the process entails the co-design, as well as the co-assessment and evaluation of the e-mobility training programs.

This paper is meant as a guideline for the current VET trainers, both at I-VET or C-VET levels, returning the results of the pilot phase of the IG2 project. It also sets the basis for the planning, delivery and assessment of the next skills-specific training programs related to relevant topics within the HEVs/EVs and avionics / autonomous drive systems.

The co-delivery of e-mobility training programs, jointly performed by VET providers and automotive manufacturers, dealers or business owners, shall be composed of 3 main phases:

Phase 1: Design

Phase 2: Troubleshooting & Testing

Phase 3: Assessment

In addition, a further validation/release phase can be envisaged after the assessment is over, to make plans about potential improvements, re-design or research of alternative solutions positively impacting the didactic methodology.

Phase 1: Design

Design is about planning the training program in all of its possible implications. The best starting point usually entails considering the target groups of the teaching activities and their needs about the development of green skills for the automotive sector.

This approach helps trainers/teachers or company technicians to determine the skills gap that the training activity should be able to address, and subsequently the relevant learning objectives of the experimentations.

Given the e-mobility applied knowledge that trainees should acquire, and given the practical nature of the abilities/skills that future automotive workers should develop too, the core contents of the training program shall be a troubleshooting problem or challenge about HEVs/EVs or avionics systems, suitably prepared or simulated by the VET teachers/trainers and/or company technicians, to be presented to learners for a cooperative problem solving and solution.

While designing the training program for the development of green mobility skills, VET providers and /or company managers or technicians should consider the following issues:

Issue	Remarks
Choosing the VET Target Learners	Options to consider: ● I-VET for young people during secondary education ● I-VET for adult learners willing to upskill or reskill ● H-VET for learners in EQF 5 level courses pursuing a post-secondary certificate ● C-VET for workers currently employed in the automotive sector in need of skills update ● EQF levels: EQF 3 - EQF 4 - EQF 5 involved in the training program Disadvantaged learners: ● I-VET learners from migrant or low social-economical background ● I-VET learners with low achievements at risk of drop or educational failure ● I-VET or H-VET learners with physical or cognitive disabilities ● C-VET learners, currently employed in automotive companies, at risk of losing their job due to low qualification or skills obsolescence
Choosing the Learning Objectives	Definition of Learning Objective (Cedefop, 2014) (a) “statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and competence” (b) “sets of knowledge, skills and/or competences an individual has acquired and/or is able to demonstrate after completion of a learning process, either formal, non-formal or informal”. Learning objectives should match the knowledge/ skills needs of the target groups, with the potential of lifting them up.
Choosing the Troubleshooting Problem or Challenge	This should be a practical challenge or troubleshooting situation that trainers should be able to address thanks to their previous skills, with room for the acquisition of further abilities with the supervision of a trainer/teacher. Troubleshooting should reproduce or simulate a specific workplace situation where learners can practise HEVs/EVs or avionics specific skills. This phase should be a total “immersive” one, where trainers are completely focused on the procedure of the practical work

	they are doing.
Identifying Entry Level Knowledge & Skills	According to the learning objectives and troubleshooting challenges, VET teachers/trainers should identify the optimal entry level skills of trainers: -The minimum requirements for the learners to exploit the program and develop new skills -The top level of skills beyond which the program is "too easy" for the learners → in this case, either the level of the training becomes harder or the learners are assigned to a more advanced group.
Choosing the setting: personal equipment, technological tools, machinery	The setting must comply with the safety rules about electrical work as well as about the individual protection of participants. All the trainees must complete at least a work safety course, according to the national legislation, before being admitted to the experimentation. If trainees manage high voltage batteries, specific compulsory training must be attended beforehand. The tools and machinery should be chosen by the VET teachers/trainers according to: -the troubleshooting challenge -the learning objectives -the VET learners' entry skills
Identifying the work procedure	The work procedure depends on: -the troubleshooting challenge -the skills to be developed -the workplace setting including tools and equipments It is just the time sequence and or the logical/consequential procedure that learners should enact for a cooperative problem solving of the troubleshooting challenge
Identifying supervision and scaffolding roles	The training setting should enact the interpersonal relationships happening in the automotive garage. The workplace should provide scaffolding roles and supervisory roles too, helping learners identify both the correct working procedures and the organisational / hierarchical structure of a workshop or manufacturing company.
Learning Outcomes: desired Hard and Soft Skills	These should be the expected outcomes of the experimentation, in terms of technical skills developed by participants - matching the learning objectives stated above, and of behavioural / interpersonal skills of trainees working in

	teams for the achievements of cooperative learning.

Phase 2: Troubleshooting & Testing

This phase represents the actualization of everything that was planned in Phase 1 - Design. It entails running the tests on HEVs/EVs and/or on avionics/electronics/ autonomous drive as designed in Phase 1.

According to the learning objectives and the troubleshooting challenges identified in Phase 1, VET trainers/teachers should decide in Phase 2:

-whether the testing should be done once or multiple times up until satisfactory results have been achieved;

-how many sequences should the troubleshooting operation should be composed of;

-the total duration of the testing (how many hours);

-how many participants at the same time according to the safety requirements and to the workshop/lab/garage capacity;

-whether or not trainees should be splitted up into smaller teams, assigning them to specific roles or operations within the workplace setting.

Troubleshooting should be as “immersive” as possible for both learners and trainers, all of them totally focused on the e-mobility problems to be solved in a team, on the tasks and procedures to be implemented, as well as on performing their respective roles.

VET teachers/trainers in this phase should not evaluate but just monitor the effective and safe run of the experimentation:

-checking safety requirements about electrical work are met and all the individual protection devices are used by people involved

-checking the extent to which learners can work autonomously in the workplace

-decreasing/increasing the difficulty level of the testing according to real time monitoring of the students’s performance;

-stepping into the work procedure when learners need some guidance or help because they are stuck in the job or they are not performing the correct procedure;

- monitoring the organisational relationships among learners within the workplace and providing supervisory roles when needed.

Phase 3: Assessing the Troubleshooting Outcomes

After the workplace testing, the next phase of the process is the evaluation. While testing represents the immersive phase of the learning process, assessment represents the reflection on the action: "Was the troubleshooting in phase 2 effective to reach the objectives set in Phase 1?"

Since the Innovation Garage methodology implies co-designing both the learning path and the learning environment from a multiple bottom-up perspective, feedback on such topic should be collected by the multiple actors participating in the experimentations:

- VET teachers and trainers
- Business Technicians
- VET learners

VET teachers and trainers are the ones in charge to assess whether or not the learning goals of the experimentations are achieved and whether or not the expected outcomes match the initial program in terms of knowledge and skills development. Their reports or records, after the testing is over, should keep track of the following:

A. Students' performance and behaviour
B. Achievement of learning objectives
C. Suitability of entry level knowledge & skills
D. Actual development of new knowledge & skills
E. Effectiveness of the supervision and tutoring strategy
F. Effectiveness of the workplace layout and of the practical tools and equipment

Focusing on students' performance and behaviour is a way of monitoring how the teaching program matches the actual profiles of the learners involved as well as their ability to exploit the potential of the training itself. Within such evaluation, teachers and trainers should also assess whether or not learners were engaged, interested and participative, whether or not they were able to work autonomously yet in a team, whether or not they were able to execute the tasks they were assigned to, whether or not they were able to use the appropriate tools and machinery and to apply safety rules attached to electrical work.

The teachers' assessment form could just be a set of open questions about the extent to which each item was successfully delivered during the testing, but it should be combined with further remarks too, about what was missing, not achieved or poorly implemented. Further questions might set a minimum standard for the level of complexity of the experimentation, given the relevant learning objectives, as well as remarks about how to make the testing easier or harder according to the learners' profiles and/or to the EQF level.

On the other hand, feedback from the business technicians - either from automotive manufacturing companies, automotive repair or assistance garages/workshops or dealers, will be very useful to assess whether or not the knowledge and skills that students developed during the testing are actually transferable to the job market and/or whether there's any missing or "nice to have" skill left to learn in terms of operational competencies. Furthermore, business technicians are the ones who might assess the skills gap of VET trainers too, giving insights about the perspective for further development of the teaching role within the automotive sector. Is there any further specific theme or topic that might complete the skills set? Do

teachers/trainers need to develop further digital or technical skills or deeper mastery of diagnostic tools to transfer such abilities to their students? Since VET represents the meeting point between the educational offer and the demand of the business sector, how could teachers be more effective in bridging the gap between education/training and the job market?

Last but not least, feedback from VET trainees should be collected too, after any testing or troubleshooting experimentation involving them. It is more effective when it is done somewhat anonymously, so that each participant feels free and empowered to offer veritable and honest opinions about anything being asked. It's important that questions are arranged into a comprehensive questionnaire distributed to learners in a digital format, which is more easy to process after all answers are complete and that can be turned into explainable graphs or charts. For this reason, questions should be delivered in the form of statements which trainees should rate how much they agree with, on a scale ranging from 1 (completely disagree) to 5 (completely agree). If relevant, it could be also useful including short paragraphs with room to express explicit remarks or comments about the topic. Questions should be as much specific as possible and should be turned into actionable feedback for the trainers, allowing them to upgrade or improve the experimentation for the next turn.

Example of questions to be included into the feedback questionnaires:

-effectiveness of the testing for the development of specific knowledge & skills (related to electromobility);

-effectiveness of the tutoring or supervision roles from the teachers/trainers in order to support the learning process;

-usability of the workplace learning environment and of the technical tools/equipment provided to run the testing;

-to which extent the previous knowledge and skills allowed learners to successfully complete the testing;

-to which extent the trainee feels ready for the job market after the e-mobility workplace experience

Note on a potential phase 4: release

The last part of the assessment and evaluation phase is the final release of results. Given the troubleshooting problem or challenge about e-mobility that is specifically assigned to the VET learners, the results of the testing should include a working procedure or sequence of practical tasks/operations to be carried out in the workplace. The results might sort the following outcomes:

-either the troubleshooting procedure is accepted and the sequence of practical tasks is validated

-or the working procedure is not able to produce the expected results and is rejected.

When the working procedure used to solve the troubleshooting challenge is not useful to reach either the expected result (e. g., how to de-energise an HV battery of a HEV/EV) or the learning objectives (structure of an HV battery and HV battery management) should be rejected.

If the procedure is rejected, feedback from the VET trainers and from the automotive technicians should be capitalized to design and test an alternative troubleshooting challenge.

Conclusion: who is this paper for?

This paper represents the outcome of Intellectual Output 1 of “Innovation Garage of Garages” Erasmus+ project, aiming at developing green skills for the automotive sector at VET level.

The specific goal of such a paper is to provide guidelines for VET teachers and trainers willing to introduce e-mobility as a modular or integrated path within mechanics or automotive courses.

Multiple actors co-designing the training contents, the workplace layout and tools, as well as the organisational details of the didactic methodology (roles of trainers, facilitators, evaluation and assessment criteria, is the special footprint of the project. Since “Innovation Garage” is a worldwide methodology to introduce bottom-up multi-stakeholders innovation over the workplace premises, what this project is aiming at is renovating the way which “workshops” or “garage” training is usually performed.

So, this is just an empty box that needs to be filled with automotive-specific contents or a pilot model that needs to be fitted against the regular training courses within a VET organisation.

This Train-the-Trainer paper is suitable both for teachers and trainers at I-VET level (schools, training centres for young people or adults) from EQF levels 3-4, or even for H-VET at EQF 5 level (tertiary education other than university level). Nonetheless, e-mobility training can involve managers, technicians or trainers at company level - either at production houses, or repair workshops, or dealers, whenever workers need to develop or upgrade their skills about the management and maintenance of HV batteries, of HEV/EV vehicles and of avionics/assisted / autonomous drive systems.

Appendix

New Job Roles for the Automotive Sectors
New Skills for e-mobility, BEV/HEV, avionics & servicing

For your reference, please consider the Automotive Job Roles in the following charts.

You can find there a list of Job Roles in Automotive, selected both according to the the EU ESCO classification of codified Job Roles for Automotive (EU Skills, Competencies, Qualifications & Occupations), and from the Sector Skills Alliance for the Automotive Sector «Drives» 591988-EPP-1-2017-1-CZ-EPPKA2-SSA-B, aimed at identifying and training new skills for the car and vehicle production sector, from the Sector Skills Alliance for the Battery Sector "Albatts" 612675-EPP-1-2019-1-SE-EPPKA2-SSA-B.

Where the Engineering level (EQF 6) is mentioned, this happens for the sake of completeness and of respect for the original source, but it was not referenced to the partnership's VET level skills profiles within the "Innovation Garage of Garages Project" (EQF 3-4-5).

Job Role	Job Description
After Sales Service Technician	After-sales service technicians provide after-sales service support to customers, such as the installation, maintenance and repair of the sold products. They take corrective actions to ensure customers' satisfaction, resolve technical product-related issues and write customer summary reports.

Automotive Battery Technician	Assembling, installing, inspecting, maintaining and repairing batteries in motor vehicles. Using electrical test equipment to confirm good working condition after installation. Evaluating batteries to determine the nature of power problems. Preparing old batteries for disposal.
Automotive Electrician	Installing, maintaining & repairing electrical or electronic systems in motor vehicles such as: air conditioning systems, lamps, radios, heating systems, batteries, electrical wiring and alternators. Using diagnostic testing equipment to inspect vehicles and find faults.
Automotive Engineering Drafter	Converting the automotive engineers' designs into technical drawings using software. Detailing dimensions, fastening and assembling methods and other specifications used in the manufacture of automotive components, cars, buses, trucks and other motor vehicles.
Automotive Test Driver	Driving prototypes and pre-production vehicles & assessing their performance, safety and comfort. Testing models in various driving situations Preparing reports to help engineers improve their designs and identify problems
Avionics Technician	Installing, testing, inspecting and adjusting electrical and electronic equipment such as navigation, communication and cruise control systems in vehicles. Carrying out maintenance and repair work. Performing functional tests, diagnosing problems and taking corrective action.
Battery Assembler	Welding and assembling the battery components such as electronics parts, wiring, and casing around the cells.
Battery Test Technician	Using positive and negative wired plugs to test battery's resistance capacity. Testing rejected batteries to determine their flaws.
Electrical Cable Assembler	Manipulating cables and wires made of steel, copper, or aluminium so they can be used to conduct electricity in a variety of appliances.
Electrical Equipment Assembler	Assembly of electrical equipment. Assembling product components and wiring according to the blueprints.
Electrical Equipment Inspector	Checking finished electrical products for physical defects and faulty electrical connections. Recording inspection results Sending faulty assemblies back to production.

Electrical Mechanic	Installing, repairing & maintaining mechanical / electrical components of machinery, tools and equipment. Testing electrical parts to ensure efficiency and make improvements accordingly.
Electrical Supervisor	Monitoring the operations involved in installing and servicing electricity cables and other electrical infrastructure.
Electronic Equipment Assembler	Assembling of electronic equipment and systems. Assembling electronic components and wiring according to blueprints and assembly drawings. Assisting in quality inspection and equipment maintenance.
Electronic Equipment Inspector	Checking electronic equipment for any defects and malfunctions. Ensuring that the equipment is correctly assembled according to specifications and national and international regulations.
Fire Service Vehicle Operator	Driving and operating emergency fire service vehicles such as fire trucks. Emergency driving and assist firefighting operations. Ensuring that all material is well stored on the vehicle, transported and ready for usage.
Microelectronics Engineering Technician	Development of small electronic devices and components such as micro-processors, memory chips, and integrated circuits for machine and motor controls. Building, testing, and maintaining the microelectronic systems and devices.
Motor vehicle assembler	Motor vehicle assemblers install and put prefabricated motor vehicle parts and components together. They inspect the motor vehicles for defects, and test the assembled equipment for proper performance and conformity to quality standards.
Vehicle Electronics Assembler	Setting up equipment & accessories in motor vehicles such as CD players and GPS. Using electric drills and routers to install and examine malfunctioning electronic systems.

Erasmus+ DRIVES Development and Research on Innovative Vocational Education Skills

Source: https://www.project-drives.eu/en/driveslearningplatform

Job Role	Job description
ADAS /ADF Testing & Validation Engineer	The purpose of the job role is to generally have an overview of connected and automated driving. The ADAS Testing and Validation Engineer knows the development steps: simulation, laboratory, proving ground and public road testing and also the homologation, which has not yet been fully standardized. The ADAS/ADF testing and validation engineer has a common overview for developing, maintaining, executing, tracking, and reporting the testing and validation processes for ADAS functions. Given the importance of road safety, the effective development requires standardisation.
Sensor Fusion Expert	The expert uses sensors & data fusion to support the production of autonomous intelligent vehicles; Anticipating failures, detecting malfunctions, and ensuring that automated vehicles can operate safely while on the road.
Connected Vehicles Technician	Understanding the design and the structure of devices and applications that connect vehicles and exchange data, in order to provide the vehicle users with a proper description of those devices and applications.
Automotive Cybersecurity Tester	-Automotive cybersecurity norms -Cybersecurity test plan and test suite, which allows to simulate attacks.
Rubber Technologist	Understanding of rubber material, processing methods, behavioral phenomena and compounding methodology.
Functional Safety [Engineer]	Electronic and software faults can lead to failures in cars which can be hazardous, such as e.g. no steering, steering blocking, no brake, self-driving car decisions etc. It is necessary to implement hazard and risk analysis, safety goals, safety concepts following specific design methods, and reaching test coverage applying safety relevant test design techniques.
Highly Automated Drive Engineer	Designing & testing complex vehicle control systems; knowledge about vehicle dynamics and modeling; familiarity with vehicle sensors and signal processing, and the decision-making methods that controls vehicle motion
Automotive Mechatronics Expert	With rising degree of electrification and digitalization of automotive systems, an effective integration of the domains mechanics, electrics and information technology plays a significant role in automotive development processes. Besides engineering expertise in each of the domains, vehicle manufacturer and supplier increasingly need human resources for the management, development and administration of mechatronics systems throughout the entire value creation chain. This includes conception, design, simulation, manufacturing engineering as well as production, logistics, maintenance and quality management of mechatronics systems, which are composed of modules and components of the three mentioned domains.
Sustainability Manager	Internal auditing, analysing sustainability issues within the company and introducing waste and waste minimization practices;

	Following developments in legislation, environmental technologies and waste reduction.
Robotic Technician	Diagnosing and repairing faults on a robot system, program robots and understand robot processes. Automated Manufacturing Systems, Maintenance of robots and Software Implementation/Techniques.
Predictive Maintenance Technician	Implementing methods of data analysis using data collected from the sensors

Source: https://www.project-albatts.eu/en/skillscards

Automotive Repair and Inspection Personnel	Electric vehicle (EV) repair and maintenance personnel are responsible for repair and maintenance of electric vehicles.
Battery Manufacturing Technician	A battery manufacturing technician is responsible for the production of batteries in a manufacturing facility.
Battery Module Assembly Technician	A battery module assembly technician is responsible for assembling battery modules in a manufacturing facility.
Battery Recycling Technician	A battery recycling technician is responsible for the collection, transportation and processing of used batteries in a recycling facility.
Quality Technician	A battery quality technician is responsible for ensuring the quality of batteries and battery systems during the development and production phases.