DRIVES

Development and Research on Innovative Vocational Education Skills

Advanced Powertrain Engineer

Europe

Job Role Skill Set

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Author(s):	DI. Wolfgang Kriegler		
Responsible Project Partner:	FH JOANNEUM GesmbH	Contributing Project Partners:	VSB, BME, ISCN, Semta

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Approved by:	Anke Blume Richard Messnarz		Approval date:	30/04/2020

More information about DRIVES project and contact:

www.project-drives.eu

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1.1 OBJECTIVE

The objective of this deliverable is to provide an introduction to described Job Role within the applied skills definition model.

1.2 PURPOSE OF THE DELIVERABLE

The purpose of this deliverable is to define skills definitions of the Advanced Powertrain Engineer Europe job role within the ECQA skills definition model.

1.3 SCOPE OF THE DELIVERABLE

The deliverable contains

- Description of the content of the Job Role
- Description of used Skill Sets and skills definitions, coverage of Qualification Schemas

The deliverable does not cover:

- Course development, as this will be done after the skill definitions clearly outlined the set of required courses.

2 ECQA SKILLS DEFINITION MODEL

A skills definition contains the following items (see Fig. 1):

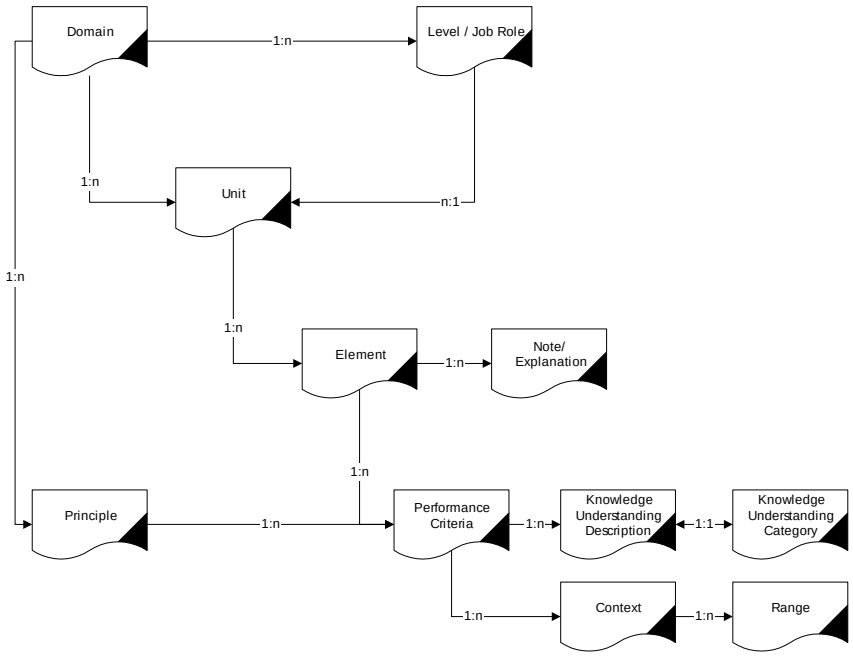


Figure 1 The Skill Definition Model (1:n = one to many relationship)

Context: A category of ranges; it represents some terminology used in a performance criterion that consists of different context, conditions or circumstances. A participant must be able to prove competence in all the different circumstances covered by the context.

Domain: An occupational category, e.g. childcare, first level management or software engineering.

Element: Description of one distinct aspect of the work performed by a worker, either a specific task that the worker has to do or a specific way of working. Each element consists of a number of performance criteria.

Evidence: Proof of competence.

Knowledge and understanding category: A category of knowledge and understanding descriptions.

Knowledge and understanding description: A description of certain knowledge and understanding. To be judged competent in a unit a participant must prove to have and to be able to apply all the knowledge and understanding attached to it.

NVQ (UK based): The National Vocational Qualification standard of England, Wales and N. Ireland.

Performance criterion: Description of the minimum level of performance a participant must demonstrate in order to be assessed as competent. A performance criterion may have relevant contexts.

Principle: A statement of good intentions; it underpins all competent domain practice.

Range: Description of a specific circumstance and condition of a performance criterion statement.

Qualification: The requirements for an individual to enter, or progress within a certain occupation.

Job Role: A certain profession that covers part of the domain knowledge. E.g. domain = Functional Safety, job role = Functional Safety Manager.

Unit: A list of certain activities that have to be carried out in the workplace. It is the top-level skill in the UK qualification standard hierarchy and each unit consists of a number of elements.

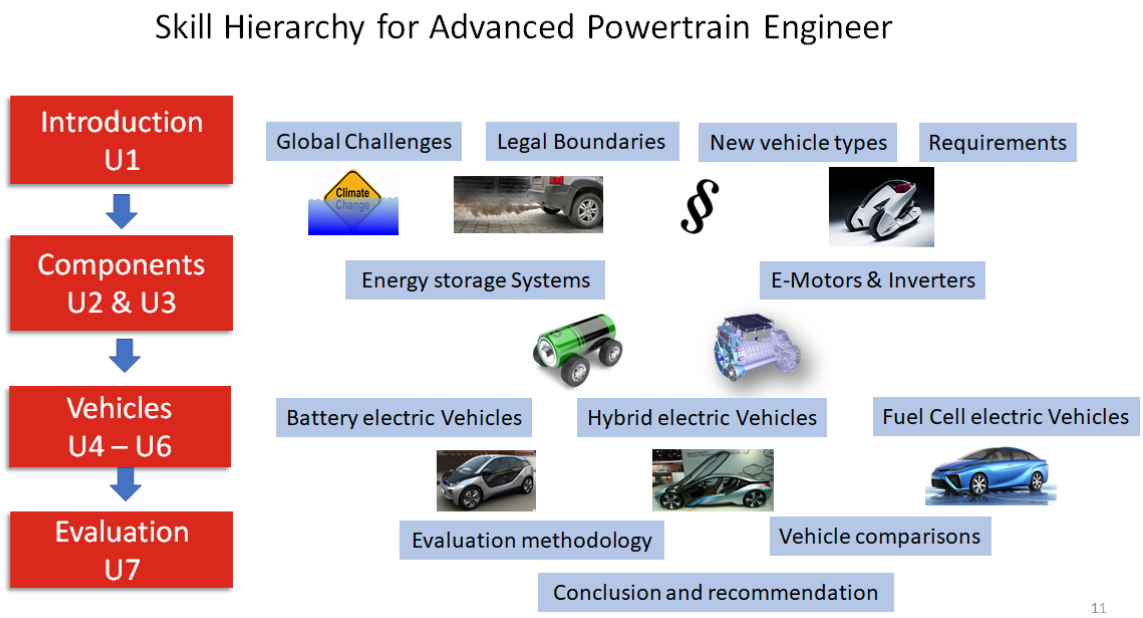
The rationales for developing the ECQA skills definition model is based on the skills definition proposed by the DTI (Department of Trade and Industry) in the UK for the NVQ (National Vocational Qualification) standards. These models have been re-used and slightly modified by other countries when they started employing skill cards [1], [2].

ECQA standards are used to describe the skills sets delivered within the DRIVES project (www.project-drives.eu). Further description and rationales are attached in annexes of this document. The ECQA structure was mapped in DRIVES project to DRIVES Reference and Recognition Framework with the links to ESCO[7], EQF[8], ECTS[9] and ECVET[10]. See more in deliverable DRIVES-D4.1.1 Reference and Recognition Framework – Analysis.pdf (www.project-drives.eu).

3 SKILLS DEFINITION FOR THE JOB ROLE "ADVANCED POWERTRAIN ENGINEER"

3.1 THE SKILLS HIERARCHY

Using the terminology outlined in the skills definition model and including the skills identified during the demand analysis at the beginning of the project, the following skills hierarchy for the job role "Advanced Powertrain Engineer" (APE) has been designed.



Picture 5 : The Skills Set for ECQA Certified "Advanced Powertrain Engineer"

3.2 THE SKILLS DESCRIPTIONS – JOB ROLE ADVANCED POWERTRAIN ENGINEER

Domain Acronym: Engineering

Domain title: Advanced Powertrain Engineering

Domain Description:

Environmental threats such as climate change by CO_2 increase in the atmosphere, harmful emissions such as NOx, limited "cheap" fossil fuel resources, lead to an urgent need to develop new, more environmentally friendly power trains for the mass of vehicles.

Many governments in the world have signed the so called "Paris Treaty" for climate protection, which aims at limitation of global warming by keeping CO_2 emissions so low that the global warming stays well below **2°C**. According to this treaty, the goal of the European Union (EU) is to reduce CO_2 emissions at least by -80% to -95% until 2050.

The objective is – besides changing the energy supply in the EU towards renewable sources – to develop high efficient and affordable electric, hybrid and fuel cell powertrains. As the standard university education delivers experts in the needed domains such as electric and mechanical engineers, engineers with a solid knowledge of all areas in this domain are lacking.

The objective of APE (Advanced Powertrain Engineer) is to create a European-wide accredited training and certification program for Advanced Powertrain Engineers, based on a skill card which is compliant to the European Qualification Framework. APE delivers a modern e-learning based training that is based on practical case studies and best industry practices. This training will be complemented by a world-wide unique web-based integration and overview platform for industry and academia in the domain of new advanced powertrain systems. Certified APE trainers will be available all across Europe, assuring a major impact and sustainability of this ECQA job role.

APE was developed based on an industry-wide agreed syllabus and skills set for a Certified Advanced Powertrain Engineer with a clear focus on practice. The need for qualified technical personnel and managers who serve as “system architects” is obvious. As APE is designed as a modular course, a trainee can attend course Units and Elements separately and independently, although it is recommended to attend the entire APE course.

After participation in the APE course, the trainee can take an exam and become certified as ECQA Advanced Powertrain Engineer. This certificate is valid across Europe and is respected globally.

Job Role Acronym: APE

Job Role Title: ECQA Certified Advanced Powertrain Engineer Europe

Description:

The Skill card comprises the following thematic learning units

1. Introduction to Advanced Powertrains
2. Electrical Energy Storage
3. Electric Powertrain
4. Electric Vehicles
5. Hybrid Vehicles
6. Fuel Cell Vehicles
7. Evaluation of Advanced Powertrain Vehicles

3.3 UNIT APE.U1 INTRODUCTION TO ADVANCED POWERTRAIN ENGINEER

Acronym: APE.U1

Title: Introduction to Advanced Powertrain Engineer

Description:

The first training unit introduces the subject of Advanced Powertrains, discusses the current environmental situation, gives insights in legal boundaries such as harmful emissions and CO_2 restrictions, and will provide a particular focus on issues related to the different fuel options in the futures. Basic knowledge about the complete product/system life cycle is also treated, with the aim to sensitise trainees for the environmental aspects in all life cycle phases.

3.3.1 Unit APE.U1.E1 - Element 1: Introduction to Advanced Powertrains

Acronym: APE.U1.E1

Element Title: Introduction to Advanced Powertrains

Element Note:

This element gives background information on the necessity for a paradigm change in the automotive industry toward less polluting and a better CO_2 footprint of individual transport.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U1.E1.PC1	The student understands the global situation and trends regarding greenhouse gases, especially regarding CO_2.
APE.U1.E1.PC2	The student knows the consequences if no severe actions will be taken in near future.
APE.U1.E1.PC3	The student understands the situation of energy predictions, limited fossil resources and need of changing the energy source especially for transport.
APE.U1.E1.PC4	The student understands and accepts that the conventional way of continuing with fossil fuels in transport cannot fulfil climate goals and will lead to major problems for the environment.
APE.U1.E1.PC5	The student knows the fuel alternatives and the predictions when they come into play.

Table 1: Performance Criteria for the Element APE.U1.E1

3.3.2 Unit APE.U1.E2 - Element 2: New upcoming vehicle technologies

Acronym: APE.U1.E2

Element Title: New upcoming vehicle technologies

Element Note:

This element provides an outlook on future vehicle concepts which will feature electrification, connectivity and automation. It is assumed that all three mentioned topics will complement one another.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U1.E2.PC1	The student understands the upcoming diversity of powertrain concepts and their special field of application.
APE.U1.E2.PC2	The student is able to identify the most common trends in the automotive industry and find arguments for their application.
APE.U1.E2.PC3	The student is able to compare characteristics of more conventional concepts with completely new mobility and vehicle concepts.
APE.U1.E2.PC4	The student understands the role of passive and active safety in such new vehicles and the consequences.
APE.U1.E2.PC5	The student is able to reflect the consequences of these new trends and the paradigm change in mobility.

Table 2: Performance Criteria for the Element APE.U1.E2

3.3.3 Unit APE.U1.E3 - Element 3: Legal boundaries

Acronym: APE.U1.E3

Element Title: Legal boundaries

Element Note:

The element provides insights in the legal situation of Hybrid Electric Vehicles (HEVs), Electric vehicles (EVs) and Fuel Cell vehicles (FCVs).

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U1.E3.PC1	The student is able to reproduce a rough overview about the global toxic emission regulations for vehicles.
APE.U1.E3.PC2	The student knows the applied test procedures and the current limits.
APE.U1.E3.PC3	The student understands the major differences between EU, US/Ca and Japanese regulations.
APE.U1.E3.PC4	The student is able to remember the vehicle standards and their classification.
APE.U1.E3.PC5	The student understands the worldwide different approaches for implementing CO_2 reduction programs, and is able to reflect the CO_2 limits, consequences (fines) and the forecast.

Table 3: Performance Criteria for the Element APE.U1.E3

3.3.4 Unit APE.U1.U4 - Element 4: Requirements for advanced powertrains

Acronym: APE.U1.E4

Element Title: Requirements for advanced powertrains
Element Note:

The element gives basic data (numbers and figures) on the performance of alternative vehicles and shall strengthen the sensibility to the requirements related to practice of alternative powertrains.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U1.E4.PC1	The student knows the amount of energy needed for driving a certain distance, depending on the vehicle class.
APE.U1.E4.PC2	The student knows the efficiency of different powertrain concepts and the energy density of different fuels.
APE.U1.E4.PC3	The student knows how to evaluate, which performance is allowed and acceptable for different vehicles and their applications.

Performance Criterion	Evidence Check: The student can demonstrate
APE.U1.E4.PC4	The student knows the key performance figures and values of alternative powertrains and is able to set them in correlation.

Table 4: Performance Criteria for the Element APE.U1.E4

3.4 UNIT APE.U2 ELECTRICAL ENERGY STORAGE

Acronym: APE.U2

Title: Electrical Energy Storage

Description:

The second training unit deals with the possibilities of energy storage in an independent vehicle. The current state of art is described and an overview on batteries is given. The currently most common battery technology (Li-Ion battery) is discussed in more detail. This unit highlights all aspects of energy storage such as performance, life time, safety considerations, resources and production. Furthermore, an outlook on future cell technologies is given as well as insights into the battery pack, its functions and components.

3.4.1 Unit APE.U2.E1 - Element 1: Overview

Acronym: APE.U2.E1

Element Title: Overview

Element Note:

This element provides an overview about all possible energy storage systems that can be used in vehicles, including all types of batteries, super capacitors and fuel cells.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U2.E1.PC1	The student is able to differentiate the possible energy storage systems and their preferred application for advanced powertrains.
APE.U2.E1.PC2	The student knows the differences between the main battery types, super capacitors and fuel cells.

Performance Criterion	Evidence Check: The student can demonstrate
APE.U2.E1.PC3	The student understands the most important battery terms and parameters.
APE.U2.E1.PC4	The student is able to evaluate the pros and cons for super capacitors compared to batteries.
APE.U2.E1.PC5	The student is able to select the appropriate storage system for the intended vehicle project.

Table 5: Performance Criteria for the Element APE.U2.E1

3.4.2 Unit APE.U2.E2 - Element 2: Li-Ion Batteries

Acronym: APE.U1.E2

Element Title: Li-Ion Batteries

Element Note:

This element focuses on Li-ion batteries, which provide sufficient energy for longer distance driving and enabled the electrification hype of the last ten years. The element contains the design and production of cells and tackles some problems such as the life time and safety of Li-ion batteries.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U2.E2.PC1	The student understands the basics and the working principle of a Li-ion cell.
APE.U2.E2.PC2	The student knows the different possibilities of anode and cathode designs and the choice of electrolytes.
APE.U2.E2.PC3	The student knows the pros and cons of different cell packages and formats.
APE.U2.E2.PC4	The student understands the difference between energy and power cells.
APE.U2.E2.PC5	The student knows the basics of the Li-ion battery cell production.
APE.U2.E2.PC6	The student understands the risks and health hazards of Li-Ion batteries

Table 6: Performance Criteria for the Element APE.U2.E2

3.4.3 Unit APE.U2.E3 - Element 3: Battery Outlook

Acronym: APE.U2.E3

Element Title: Battery Outlook

Element Note:

The element describes the current development status of Li-ion batteries and provides an outlook on ongoing developments to improve the performance of these cells. It also gives a long term perspective on new battery technologies like Li-S and Li-Air technology.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U2.E3.PC1	The student understands the main developments of and trends for standard Li-Ion batteries.
APE.U2.E3.PC2	The student understands the benefits of solid state cells.
APE.U2.E3.PC3	The student knows how to outline the cost development for Li-Ion batteries.
APE.U2.E3.PC4	The student is able to tell about future advanced cells beyond the era of conventional Li-Ion cells.
APE.U2.E3.PC5	The student understands the shortcomings of Li-S and Li-Air cells.
APE.U2.E3.PC6	The student knows different scenarios for Li-supply.

Table 7: Performance Criteria for the Element APE.U2.E3

3.4.4 Unit APE.U2.U4 - Element 4: Battery Systems & Integration

Acronym: APE.U2.E4

Element Title: Battery Systems & Integration

Element Note:

The element provides an insight into the battery pack, its functions and components.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U2.E4.PC1	The student understands the requirements for the battery systems.
APE.U2.E4.PC2	The student knows how to draw a full battery system and is able to explain the functions of the components.
APE.U2.E4.PC3	The student is able to explain the universal set up of a battery system with subsystems and components.
APE.U2.E4.PC4	The student understands the requirements of the battery cooling system and the pros & cons for liquid and air cooling.
APE.U2.E4.PC5	The student knows the main components and functions of the battery management unit (BMU).
APE.U2.E4.PC6	The student is able to explain the differences between “non-native” and “native” outer battery shapes.
APE.U2.E4.PC7	The student knows the different connectors from all over the world.
APE.U2.E4.PC8	The student knows the most important battery system standards.

Table 8: Performance Criteria for the Element APE.U2.E4

3.5 UNIT APE.U3 ELECTRIC TRACTION DRIVES

Acronym: APE.U3

Title: Electric Traction Drives

Description:

The third training unit focuses on the electric drive components such as e-motors, inverters and the coupled transmissions. The most important types of machines are introduced, their functionality, characteristics and properties discussed. Cooling possibilities are also given, and safety aspects presented. Furthermore, an outlook on future technologies is given.

3.5.1 Unit APE.U3.E1 - Element 1: Overview

Acronym: APE.U3.E1

Element Title: Overview

Element Note:

This element provides an overview on all components needed for an electric drive system. These components are the battery, the inverter, the e-motor and other auxiliaries like the DC/DC converter, and chargers. It also describes the high voltage net in an electric vehicle.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U3.E1.PC1	The student is able to describe the complete electric drive system with all components needed.
APE.U3.E1.PC2	The student is able to explain the function of the inverter and the e-motor.
APE.U3.E1.PC3	The student understands how the components are connected and knows the voltage levels of these connections.
APE.U3.E1.PC4	The student is able to draw the rough board net including the high voltage cables and the control wires.

Table 9: Performance Criteria for the Element APE.U3.E1

3.5.2 Unit APE.U3.E2 - Element 2: Electric Traction Machines

Acronym: APE.U3.E2

Element Title: Li-Ion Batteries

Element Note:

This element describes e-motors (electric motors) used in current e-drive systems. The family tree of e-motors with focus especially on the characteristics and properties of asynchronous and synchronous motors is explained. It further deals with cooling and the integration of sensors.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U3.E2.PC1	The student knows all kinds of electric motors and can explain their major characteristics.

Performance Criterion	Evidence Check: The student can demonstrate
APE.U3.E2.PC2	The student is able to explain the differences between asynchronous and synchronous e-motors and can draw the torque characteristics.
APE.U3.E2.PC3	The student knows about the sensors needed in e-motors and their integration.
APE.U3.E2.PC4	The student knows how to select the correct choice of e-motors for given boundaries such as power demand, cooling possibilities, and costs.

Table 10: Performance Criteria for the Element APE.U3.E2

3.5.3 Unit APE.U3.E3 - Element 3: Traction Inverter

Acronym: APE.U3.E3

Element Title: Traction Inverter

Element Note:

The element describes the traction inverter functionality, the used electronic power elements and their current development status. It gives insight into current trends regarding cooling and integration of inverters.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U2.E3.PC1	The student understands the main function of an inverter and its structure.
APE.U2.E3.PC2	The student is able to read the circuit diagram and to describe the function of the components.
APE.U2.E3.PC3	The student knows about the types of switching elements and their application.
APE.U2.E3.PC4	The student knows about development trends in inverters, especially about cooling.
APE.U2.E3.PC5	The student understands the attempts to miniaturization and integration of inverters to e-motors.

Table 11: Performance Criteria for the Element APE.U3.E3

3.5.4 Unit APE.U3.U4 - Element 4: Examples of Electric Drive Systems

Acronym: APE.U3.E4

Element Title: Examples of Electric Drive Systems
Element Note:

The element provides an insight into the interaction between e-motor and inverter as a system.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U2.E4.PC1	The student understands the requirements for electric drive systems.
APE.U2.E4.PC2	The student knows the possibilities how to package electric drive systems.
APE.U2.E4.PC3	The student understands the electric drive systems currently on the market and which arrangements are/were successful.

Table 12: Performance Criteria for the Element APE.U3.E4

3.5.5 Unit APE.U3.E5 - Element 5: Future Aspects

Acronym: APE.U3.E5

Element Title: Future Aspects
Element Note:

The element provides the current trends in the development of electric drive systems towards higher speeds, better cooling, higher integration.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U3.E4.PC1	The student understands how electric drive systems can be further developed and which parameters can increase efficiency while keeping costs low.
APE.U3.E4.PC2	The student knows about the attempts to increase the cooling efficiency, which allows smaller components with lower thermal inertia.
APE.U3.E4.PC3	The student is able to explain the roadmap towards highly integrated solutions for miniaturization.

Table 13: Performance Criteria for the Element APE.U3.E5

3.6 UNIT APE.U4 ELECTRIC VEHICLES

Acronym: APE.U4

Title: Electric Vehicles

Description:

The fourth training unit focuses on pure battery electric vehicles (BEVs). After an introduction with a short glance at the history of electric vehicles, the focus lies on the powertrain possibilities and integration of the powertrain components in the vehicle body. Some benchmark vehicles were selected and presented.

3.6.1 Unit APE.U4.E1 - Element 1: Introduction

Acronym: APE.U4.E1

Element Title: Introduction

Element Note:

This element provides an introduction to pure electric vehicles, touches briefly the history of BEVs and explains the development routes during the last two decades. This element also shows the differences between conversion design and purpose design.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U4.E1.PC1	The student is able to reflect on the development of BEVs in the past and on current developments.
APE.U4.E1.PC2	The student is able to explain the differences between purpose design and conversion design, and tell the pros and cons of these possibilities.
APE.U4.E1.PC3	The student understands the trend of current EV development.

Table 14: Performance Criteria for the Element APE.U4.E1

3.6.2 Unit APE.U4.E2 - Element 2: Powertrain Possibilities and Vehicle Integration

Acronym: APE.U4.E2

Element Title: Powertrain Possibilities and Vehicle Integration

Element Note:

This element describes the powertrain possibilities for pure electric vehicles and the powertrain integration in the vehicle. It covers wheel hub motors, electric drive axle, tandem layout and includes considerations about the necessary transmissions.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U4.E2.PC1	The student knows all kinds of powertrain possibilities of pure electric vehicles.
APE.U4.E2.PC2	The student is able to explain the major benefits or shortcomings of these variants.
APE.U4.E2.PC3	The student knows about examples on the market and can judge their pros and cons.
APE.U4.E2.PC4	The student knows how to select the correct choice of powertrain for given boundaries such as vehicle mission, traction requirements, dynamic demand and costs.

Table 15: Performance Criteria for the Element APE.U4.E2

3.6.3 Unit APE.U4.E3 - Element 3: Battery Body Integration

Acronym: APE.U4.E3

Element Title: Battery Body Integration

Element Note:

The element describes the traction inverter functionality, the used electronic power elements and their current development status. It gives insight into current trends regarding cooling and integration of inverters.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U4.E3.PC1	The student understands the major possibilities for the integration of the battery system in a pure electric vehicle.
APE.U4.E3.PC2	The student is able to explain the benefits, disadvantages and the safety risk of the integration possibilities and the consequences.
APE.U4.E3.PC3	The student knows about the safety issues connected with battery installation and about the required actions to prove and maintain the battery integrity in case of a crash.
APE.U4.E3.PC4	The student knows about the different design philosophies of OEMs in the body integration and their judge the risk evaluation.
APE.U4.E3.PC5	The student is able to select the most favorable installation location for the battery system under given boundary conditions from the vehicle body.

Table 16: Performance Criteria for the Element APE.U4.E3

3.6.4 Unit APE.U4.E4 - Element 4: Selected BEVs

Acronym: APE.U4.E4

Element Title: Examples of Drive systems

Element Note:

The element introduces a variety of BEVs which were and are currently on the market and can be regarded as benchmark examples. This section shall provide an overview on interesting vehicles and give insights into their technology and design philosophy.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U4.E4.PC1	The student knows the benchmark vehicles on the market and can judge their used technologies.
APE.U4.E4.PC2	The student is able to draw conclusions and transfer them into new vehicle projects.

Table 17: Performance Criteria for the Element APE.U4.E4

3.7 UNIT APE.U5 HYBRID VEHICLES

Acronym: APE.U5

Title: Hybrid Vehicles

Description:

The fifth training unit focuses on hybrid electric vehicles (HEVs). After an introduction with a short glance at the history of hybrid electric vehicles, the training focusses on the different hybrid architectures with their corresponding efficiencies, on the selection of the feasible internal combustion engine (ice) and e-motors. A special focus is given on the operating strategies including stop&go, recuperation, load shifting and boosting. Some benchmark vehicles are selected and presented.

3.7.1 Unit APE.U5.E1 - Element 1: Hybrid Architectures

Acronym: APE.U5.E1

Element Title: Hybrid Architectures

Element Note:

This element provides an introduction to hybrid nomenclature, classification and architectures including efficiency considerations. It explains series, parallel and mixed/power split layouts and discusses the necessary clutches and transmission solutions. Further, the training focusses on power dimensioning and cost comparison.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U5.E1.PC1	The student understands all classifications, possible architectures of hybrid powertrains and their implications.
APE.U5.E1.PC2	The student is able to explain the differences in efficiency between the possible architectures and tell the pros and cons of series, parallel and power split solutions.
APE.U5.E1.PC3	The student understands the special role of Plug-In hybrids and can explain the CO_2 emission benefit for the OEMs.
APE.U5.E1.PC4	The student is able to outline the current trends for hybrid vehicles and can draw conclusions for the future.

Table 18: Performance Criteria for the Element APE.U5.E1

3.7.2 Unit APE.U5.E2 - Element 2: Preferred ICE Applications and e-Motors

Acronym: APE.U5.E2

Element Title: Preferred ICE Applications and e-Motors

Element Note:

This element explains which internal combustion engines (ice) might be used for a hybrid powertrain and which ices are mainly used for hybrid drives and why. The training provides a deeper insight into the power dimensioning of the ice engine and the resulting consequences. Combination with e-motors are also discussed. Further, it provides insights in current trends of hybrid vehicles.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U5.E2.PC1	The student knows all kinds of potential ices and their advantages and disadvantages in hybrid application.
APE.U5.E2.PC2	The student is able to explain the major benefits or shortcomings of these variants.
APE.U5.E2.PC3	The student knows about examples on the market and can judge their pros and cons.

Performance Criterion	Evidence Check: The student can demonstrate
APE.U5.E2.PC4	The student is able to select and argue the correct choice of ice for the hybrid powertrains.

Table 19: Performance Criteria for the Element APE.U5.E2

3.7.3 Unit APE.U5.E3 - Element 3: Operating Strategies

Acronym: APE.U5.E3

Element Title: Operating strategies

Element Note:

The element explains and gives insights into the possible operating strategies and the attached energy management of hybrid vehicles. It describes the modes stop&go, energy recuperation, load shifting, boosting and charging and explains their benefits as well as their limiting factors.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U5.E3.PC1	The student is able to name all the important operating strategies of hybrid drive systems.
APE.U5.E3.PC2	The student is able to explain the boundaries for energy recuperation and the limiting factors of it.
APE.U5.E3.PC3	The student knows about the possible benefits connected to load shifting and how load shifting can improve the energy management.
APE.U5.E3.PC4	The student understands the problems connected to intermittent operation of the ice and how to avoid emission problems.
APE.U5.E3.PC5	The student is able to understand the complexity of energy management and can name some methods how to find an optimum operating strategy for selected hybrid architectures.

Table 20: Performance Criteria for the Element APE.U5.E4

3.7.4 Unit APE.U5.U4 - Element 4: Selected HEVs

Acronym: APE.U3.E4

Element Title: Selected HEVs

Element Note:

The element introduces a variety of hybrid electric vehicles (HEVs) and Plug-In HEVs (PHEVs) which were and are currently on the market and can be regarded as benchmark examples. This section shall provide an overview on interesting vehicles and give insights into their technology and design philosophy.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U5.E4.PC1	The student knows the benchmark hybrid vehicles on the market and can judge their technologies.
APE.U5.E4.PC2	The student is able to draw conclusions and transfer them into new vehicle projects.

Table 21: Performance Criteria for the Element APE.U5.E4

3.8 UNIT APE.U6 FCV VEHICLES

Acronym: APE.U6

Title: Fuel Cell Vehicles (FCVs)

Description:

The sixth training unit focuses on fuel cell electric vehicles (FCVs). After introducing the basics of fuels and all types of fuel cells, the focus is given on the polymer membrane fuel cell (PEM) and the functionality, the efficiency and operating characteristics. The second part deals with fuel powertrain assemblies such as the full range FC-system or the range extender application. In the last part some benchmark vehicles are selected and presented.

3.8.1 Unit APE.U6.E1 - Element 1: Basics of Fuel Cells

Acronym: APE.U6.E1

Element Title: Basics of Fuel Cells

Element Note:

This element provides an introduction to fuel cells including their functionality and the existing fuel cell types. It also mentions the operating conditions of fuel cells and addresses possible problems.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U6.E1.PC1	The student understands the function of fuel cells and knows about suitable fuel cell types for vehicles.
APE.U6.E1.PC2	The student can name the auxiliaries needed for the operation of fuel cells and their implications and their boundaries, respectively.
APE.U6.E1.PC3	The student is able to explain the differences in efficiency between the fuel cell and ice.
APE.U6.E1.PC4	The student is able to outline the current trends for fuel cell vehicles and can draw conclusions for the future.

Table 22: Performance Criteria for the Element APE.U6.E1

3.8.2 Unit APE.U6.E2 - Element 2: Fuel Cell Powertrain

Acronym: APE.U5.E2

Element Title: Fuel Cell Powertrain

Element Note:

This element explains the fuel cell powertrain with all necessary components and gives insights into possible dimensioning of these components. The storage of hydrogen is also addressed and besides alternatives the main focus is given on the current gaseous storage systems.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U6.E2.PC1	The student is able to outline a fuel cell powertrain with all components and understands their interaction.
APE.U6.E2.PC2	The student is able to explain the two main dimensions of fuel cell in such a powertrain and can judge their pros and cons.
APE.U6.E2.PC3	The student can select and argue the correct choice and dimensioning of the fuel cell powertrain according a specified mission of such a vehicle.

Table 23: Performance Criteria for the Element APE.U6.E2

3.8.3 Unit APE.U6.E3 - Element 3: Selected FCVs

Acronym: APE.U6.E3

Element Title: Selected FCVs

Element Note:

The element introduces the most important vehicles from the small community of commercially available fuel cell vehicles. Only a few are currently on the market, especially examples from Asian Countries (Japan, Korea) can be regarded as benchmark examples. This section shall provide an overview on these interesting vehicles and give insights into their technology and design philosophy.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U6.E3.PC1	The student knows the benchmark FCVs on the market and can judge their technologies.
APE.U6.E3.PC2	The student is able to draw conclusions and transfer them into new vehicle projects.

Table 24: Performance Criteria for the Element APE.U6.E3

3.9 UNIT APE.U7 EVALUATION OF ADVANVED POWERTRAIN VEHICLES

Acronym: APE.U7

Title: Evaluation of Advanced Powertrain Vehicles (FCVs)

Description:

The last unit provides an insight into evaluation methodologies and focusses on the comparison of the vehicle types, which were introduced in the previous units.

Especially the methods Tank to Wheel (TtW), Well to Tank (WtT) and Well to Wheel (WtW) will be explained and compared with the complete life cycle analysis (LCA). Of course, the main focus is given on CO_2 foot print comparison and on the amount of energy needed for obtaining the raw materials until recycling. In the last part, a conclusion and recommendation will be presented.

3.9.1 Unit APE.U7.E1 - Element 1: Methodology of Evaluation

Acronym: APE.U7.E1

Element Title: Methodology of Evaluation

Element Note:

This element provides an introduction to the methodology of evaluation for all kinds of vehicles but in particular of those with advanced powertrains. The ecological footprint namely the green-house emissions such as CO_2 are the main focus of this element. It describes the different analysis methods such as Tank to Wheel (TtW), Well to Tank (WtT) and Well to Wheel (WtW) and the most comprehensive method, called Life Cycle Analysis (LCA).

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U7.E1.PC1	The student understands the various analysis methods and their implications.
APE.U7.E1.PC3	The student knows and can explain CO_2equivalent and gasoline equivalents.
APE.U7.E1.PC4	The student can explain Tank to Wheel (TtW), Well to Tank (WtT) and Well to Wheel (WtW) and the Life Cycle Analysis (LCA).

Table 25: Performance Criteria for the Element APE.U7.E1

3.9.2 Unit APE.U7.E2 - Element 2: Comparison of Vehicles

Acronym: APE.U7.E2

Element Title: Comparison of Vehicles

Element Note:

This element presents the result of various studies on the comparison of powertrains for passenger cars with the main focus on ecological footprint i.e. greenhouse gas emissions and energy consumption for all life time segments.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U7.E2.PC1	The student is able to judge the pros and cons of powertrains for passenger cars.
APE.U7.E2.PC2	The student is able to reflect the outcome of the comparisons and draw conclusions for his/her further work on powertrains.

Table 26: Performance Criteria for the Element APE.U7.E2

3.9.3 Unit APE.U7.E3 - Element 3: Alternatives and Conclusions

Acronym: APE.U7.E3

Element Title: Alternatives and Conclusions

Element Note:

The element provides an overview on the learnings of the previous elements and gives conclusions for the further development routes for advanced powertrain vehicles.

Performance Criteria:

The student must be able to show evidence of competencies for the following performance criteria/skills (PCs):

Performance Criterion	Evidence Check: The student can demonstrate
APE.U7.E3.PC1	The student knows the variety of future technologies for powertrains in the future and their impacts on CO_2 and energy consumption.
APE.U7.E3.PC2	The student is able to draw conclusions and transfer them into new vehicle projects.

Table 27: Performance Criteria for the Element APE.U7.E3

ANNEXES

The annex provides overview of used skills set, coverage of Qualification Schemas and Legal background for Certification

ANNEX A ECQA DESCRIPTION

ECQA – EUROPEAN CERTIFICATION AND QUALIFICATION ASSOCIATION

ECQA standards are used to describe the skills sets delivered within the DRIVES project (www.project-drives.eu). ECQA is the pilot Certification body, which structure is mapped to DRIVES Reference and Recognition Framework providing the EU-wide overview of training courses and possible certifications, and micro-credentials. DRIVES Reference and Recognition Framework provides links to ESCO[7], EQF[8], ECTS[9] and ECVET[10]. See more in deliverable DRIVES-D4.1.1 Reference and Recognition Framework – Analysis.pdf (www.project-drives.eu).

Europe Wide Certification

The ECQA is the result of a number of EU supported initiatives in the last ten years where in the European Union Life Long Learning Programme different educational developments decided to follow a joint process for the certification of persons in the industry.

Through the ECQA it becomes possible that you attend courses for a specific profession in e.g. Spain and perform a Europe wide agreed test at the end of the course.

Access to a Vast Pool of Knowledge

ECQA currently supports 27 professions in Europe and with the continuous support until 2012 by the European Commission the pool is growing to 30 certified professions in Europe. ECQA offers certification for professions like IT Security Manager, Innovation Manager, EU project manager, E-security Manager, E-Business Manager, E-Strategy Manager, SW Architect, SW Project Manager, IT Consultant for COTS selection, Internal Financial Control Assessor (COSO/COBIT based), Interpersonal Skills, Scope Manager (Estimation Processes), Configuration Manager, Safety Manager, and so forth.

The ECQA guide can be downloaded at www.ecqa.org -> Guidelines.

Defined procedures are applied for:

- Self assessment and learning

- http://www.ecqa.org/fileadmin/documents/Self_Assessment/eucert-users-self-assessment-learning-guide-v5-doc.pdf
- Exam performance
- http://www.ecqa.org/fileadmin/documents/ECQA_Exam_Guide_Participant_v2.pdf

ECQA SKILLS DEFINITION MODEL

The ECQA skills definition model, used for Job Role definition, is described in section 2 of this document.

ECQA SKILL SET STRATEGY

Imagine that in the future Europeans will have a skill set like a card with a chip which stores your skill profile to fulfil specific professions, job roles, and tasks. It's working like an ID card. This future scenario requires -

- A standard way to describe a skill set for a profession, job, or specific task.
- A standard procedure to assess the skill and to calculate and display skill profiles.

Such a common set of skill sets in Europe is needed due to the free mobility of workers. European countries such as UK, The Netherlands, and France already have well established open universities which support APL (Accreditation of Prior Learning). In APL the skills of students are assessed, already gained skills are recognised, and only for the skill gaps a learning plan is established. The skill assessment bases on defined skill units and a skill profile displaying how much of the skill units are covered.

In a previous project CREDIT (Accreditation of Skills via the Internet) [1] in which some of the project partners were involved such an Internet based skills assessment system has been built. Therefore another possible scenario of the future is that representative educational bodies per country in Europe maintain skill profiles in databases which can be accessed via defined ID codes for people.

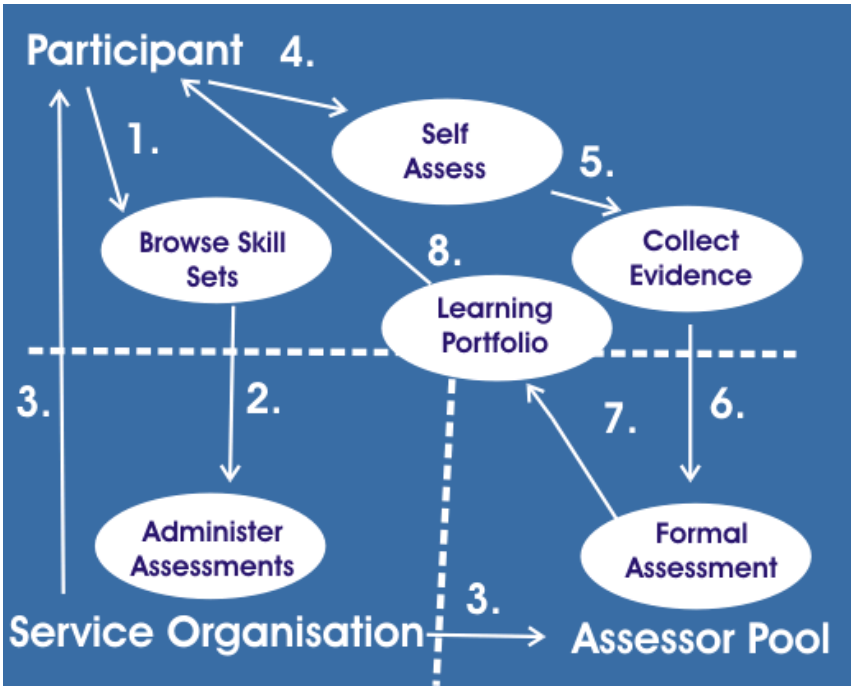
ECQA SKILLS ASSESSMENT MODEL

Step 1 – Browse a Skills Set: You select a set of skills or competencies, which are required by your profession or job using national standards or your company standards. You browse different skills cards and select a job role you would like to achieve.

Step 2 – Register for Self Assessment with a Service Unit : This can be a service unit inside your own company (e.g. a personnel development department) or a skills card and assessment provider outside

your company which offers skills assessment services. In case of the Safety Manager Project the registration will automatically assign a predefined service unit.

Step 3 – Receive an Account for Self-Assessment and Evidence Collection : With the registration you automatically received an account to login to the working space in which you can go through the steps of online self assessment and the collection of evidences to prove that you are capable of certain performance criteria.



Picture 1: Basic steps of the skills assessment model

Step 4 – Perform Self Assessment: You log into the system , browse through the skills required and self assess performance criteria, whole elements or whole units with a standard evaluation scale of non-applicable, not adequate, partially adequate, largely adequate, and fully adequate. A skills gaps profile can be generated and printed illustrating in which areas your self assessment shows improvement potentials.

Testing of Skills (Addition to Step 4) – The system provides a multiple-choice test for each performance criteria so that you can check your capabilities as realistically as possible.

Step 5 – Collect Evidences: Before you want to enter any formal assessment you need to prove your skills by evidences. Evidences can be any electronic files (sample documents, sample graphics, results of some analysis, etc.) or any references with details (e.g. a certificate received from a certain

institution). Evidences you can then link to specific performance criteria or whole elements of skills units.

Testing of Skills (Addition to Step 5) – In traditional learning schemes people have always needed to go to a learning institution (university, accreditation body, professional body, etc.) to take exams and they received a certificate if they pass. This traditional approach however is insufficient when it comes to measuring experience and (soft) skills learned on the job and fails to give recognition to skills gathered on the job. The APL (Accreditation of Prior Learning) approach, by contrast, collects so called evidences. Evidences can be certificates obtained in the traditional way, but also references from previous employers, materials from previous projects in which the person took ownership of results (e.g. a test plan) to prove their capability, as well as any kind of proof of competence gathered on the job. The assessors will then evaluate the evidences provided and not only rely on certificates and exams.

Step 6 – Receive Formal Assessment: Formal assessors are assigned by the service unit to the skills assessment. Once formal assessors log into the system they automatically see all assigned assessments. They select the corresponding one and can see the uploaded evidences. They then formally assess the evidences and assess the formal fulfilment of performance criteria, whole elements or whole units with a standard evaluation scale of non-applicable, not adequate, partially adequate, largely adequate, and fully adequate. In case of missing competencies they enter improvement recommendations, a well as learning options.

Step 7 – Receive Advise on Learning / Improvement Options: After the formal assessment the participants log into the system and can see the formal assessment results from the assessors, can print skills gaps profiles based on the assessor results, and can receive and print the improvement recommendations and learning options. If required, the generation of learning options can also be automated through the system (independent from assessor advises).

ECQA CERTIFICATE TYPES

In the standard test and examination procedures for levels of certificates are offered:

- Course Attendance Certificate
  - Received after course attendance
  - Modular per Element
- Course / Test Certificate
  - Test in a test system (European pool of test questions)
  - 67% satisfaction per element

- Summary Certificate
    - Overview of covered elements where the student passed the test, all elements shall be covered
    - Generation of certificate
- Professional Certificate
    - Uploading applied experiences for review by assessors
    - Rating by assessors
    - Observation of 2 years

The certificates show credited elements in comparison to all required.

ANNEX B ECQA COVERAGE OF QUALIFICATION SCHEMAS

MAPPING BASED ON NVQ QUALIFICATION LEVELS

Qualification / training levels: Five levels of qualification / training are defined by European legislation and this structure can be used for comparability of vocational qualifications from the different European countries.

- Level 1: semi-skilled assistant performing simple work
- Level 2: basic employee performing complex routines and standard procedures
- Level 3: skilled professional with responsibility for others and performing independent implementation of procedures
- Level 4: middle management & specialist performing tactical an strategic thinking
- Level 5: professional / university level

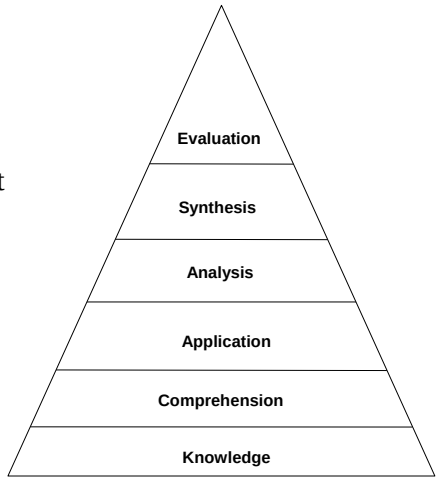
In most cases the same job role can be offered on different levels. e.g. IT Security Manager Basic Level (NVQ level 2), IT Security Manager Advanced level (NVQ Level 3), and IT Security Manager Expert Level (NVQ Levels 4 and 5).

MAPPING BASED ON EUROPEAN QUALIFICATION FRAMEWORK (EQF) LEARNING LEVELS

- Six level taxonomy:

  Level 0: I never heard of it

  1. Knowledge (I can define it):
  2. Comprehension (I can explain how it works)
  3. Application (I have limited experience using it in simple situations)
  4. Analysis (I have extensive experience using it in complex situations)
  5. Synthesis (I can adapt it to other uses)
  6. Evaluation (I am recognized as an expert by my peers)



Picture 3: Blooms Learning levels

Level	Knowledge	Example
Level 1	Basic general knowledge	
Level 2	Basic factual knowledge of a field of work or study	
Level 3	Knowledge of facts, principles, processes and general concepts, in a field of work or study	Six Sigma Yellow Belt
Level 4	Factual and theoretical knowledge in broad contexts within a field of work or study	
Level 5	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	
Level 6	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	Six Sigma Green Belt
Level 7	• Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research • Critical awareness of knowledge issues in a field and at the interface between different fields	Six Sigma Black Belt

Level	Knowledge	Example
Level 8	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields	Six Sigma Master Black Belt

Picture 4 : EQF Learning levels

MAPPING BASED ON ECTS AND ECVET SCHEMA

ECQA has established a procedure to map ECQA skills sets onto the ECTS (European Credit Transfer System) and the ECVET framework n the European Union.

A job role is assigned ECTS and ECVET points using a defined framework.

ECTS Mapping

Each element of the skills set is assigned hours of lecturing and exercises. These hours determine the ECTS points which are then agreed among a cluster on different universities in Europe.

Level	Knowledge	AQUA	ECTS	Safety Manager	ECTS
Level 1	Basic general knowledge	-		-	
Level 2	Basic factual knowledge of a field of work or study	-		-	
Level 3	Knowledge of facts, principles, processes and general concepts, in a field of work or study				
Level 4	Factual and theoretical knowledge in broad contexts within a field of work or study				
Level 5	Comprehensive, specialized, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge				
Level 6	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	AQUA - Automotive Quality Integrated Skills - presentations / theory	3	AQUA - Automotive Quality Integrated Skills - presentations / theory	3
Level 7	- Highly specialized knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research - Critical awareness of knowledge issues in a field and at the interface between different fields	AQUA - Automotive Quality Integrated Skills - with exercises to apply on nan example (e.g. ESCL)	4	AQUA - Automotive Quality Integrated Skills - with exercises to apply on nan example (e.g. ESCL)	4
Level 8	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields	AQUA - Automotive Quality Integrated Skills - implementation in a research at PhD level / with link to a real project	5	AQUA - Automotive Quality Integrated Skills - implementation in a research at PhD level / with link to a real project	5

Picture 5 : Example Automotive Quality Engineer and Safety Manager

The 2 job roles illustrated in the picture above have been assigned to ECTS and are taught using the same skills set at industry and also universities.

ECVET Mapping

Also ECQA provides a framework to assign ECVET points onto elements of the skills set. The ECQA guidance recommends to offer the ECQA course (which is offered as a lecture at university) as a short course (2 weeks with exercises) in industry to retrain for a job role in industry. The recommended size is 30 ECVET points in total. The lecturing time and exercise per element determine how many ECVET points ae assigned to an element of the skills set.

Automotive Quality Engineer			
			ECVET L7&8
U1	4	U1.E1: Introduction	2
		U1.E2: Organisational Readiness	2
U2	32	U2.E1 Life Cycle	8
		U2.E2 Requirements	8
		U2.E3 Design	8
		U2.E4 Test and Integration	8
U3	12	U3.E1: Capability	2
		U3.E2: Hazard and Risk Management	8
		U3.E3 Assessment and Audit	2
U4	12	U4.E1: Measurement	6
		U4.E2: Reliability	6
		ECVET Points Total	60

Picture 6 : ECVET Mapping example - Automotive Quality Engineer

Functional Safety Manager / Engineer			
			ECVET L7&8
U1	2	U1.E1 International Standards	1
		U1.E2 Product Life Cycle	1
		U1.E3 Terminology	
U2	4	Safety management on organisational	1
		Safety Case Definition	1
		Overview of Required Engineering an	1
		Establish and Maintain Safety Plannin	1
U3	16	System Hazard Analysis and Safety Co	4
		Integrating Safety in System Design &	4
		Integrating Safety in Hardware Design	4
		Integrating Safety in Software Design	4
U4	4	Integration of Reliability in Design to I	2
		Safety in the Production,Operation an	2
U5	4	Legal aspects and Liabilities	2
		Regulatory & Qualification Requireme	2
		ECVET Points Total	30

Picture 7 : ECVET Mapping example – Functional Safety Manager / Engineer

ANNEX C ECQA LEGAL BACKGROUND FOR CERTIFICATION

ISO/IEC 17024 STANDARD FOR PERSONNEL CERTIFICATION PROGRAMMES

The ISO/IEC 17024 standard describes standard processes for the examination and certification of people. Some of the basic principles described include:

- Standard exam procedure
- Standard certification procedure
- Identification of persons receiving the certificate
- Independence of examiner and trainer
- Certification system that allows to log the exam to keep a record/proof that the examinee passed the exam
- Mapping of processes towards ISO 17024

ECQA AND ISO/IEC 17024 STANDARD

- ECQA defined standard exam processes
- ECQA defined standard certification processes
- ECQA developed an exam system that generates random exams and corrects exams.
- ECQA developed a certification database to identify persons and map them to exam results
- ECQA established a mapping onto the ISO 17024 norm and published that in form of a self declaration.

LIASION WITH NATIONAL UNIVERSITIES

ECQA established cooperation with national universities who teach job roles with ECTS. The same job roles are offered with ECVET on the market by training bodies.

ANNEX D REFERENCES

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