Higher National Unit Specification

General information

Unit title: Design Principles of a Hydrogen System (SCQF level 8)

Unit code: J5SL 35

Superclass: YB

Publication date: October 2021

Source: Scottish Qualifications Authority

Version: 03, January 2022

Unit purpose

The purpose of this unit is to provide learners with knowledge and skills specific to the design of hydrogen systems and the capability to compare design solutions. Initially, learners will review and compare the design of several hydrogen energy systems so that they can gain an understanding of design specific considerations inherent to different applications. Learners will then learn how to undertake key concepts in hydrogen system design such as evaluation of realistic energy calculations before putting their knowledge into practice by designing a hydrogen technology solution.

This unit has been developed as part of the PDA in Hydrogen: An Introduction for Technicians however it is also available as a freestanding unit.

Outcomes

On successful completion of the unit the learner will be able to:

1 Explain the role of hydrogen in creating clean energy solutions.
2 Compare different hydrogen applications.
3 Perform realistic energy calculations.
4 Design a hydrogen-based solution for a particular application.

Credit points and level

1 Higher National Unit credit at SCQF level 8: (8 SCQF credit points at SCQF level 8)

Higher National Unit Specification: General information (cont)

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Recommended entry to the unit

Access to this unit is at the discretion of the centre. However, it is recommended that learners have completed the units J5SJ 33 *Safe Hydrogen Gas Handling* and J5SK 34 *Operating Principles of a Hydrogen Facility* before commencing this unit.

It would also be advantageous for learners to have completed, or be studying towards, qualifications that develop core engineering design and analysis skills. These could include, but are not limited to, NC or HNC qualifications in: Electrical Engineering, Mechanical Engineering, Engineering Systems, Manufacturing Engineering or Measurement and Control Engineering.

Additionally, learners will benefit from having attained Higher level education in STEM subjects such as Maths and Science or SVQ in engineering disciplines such as Mechanical, Manufacturing or Electrical Engineering.

Learners with suitable relevant industrial experience or qualifications may also be considered.

Core Skills

Achievement of this Unit gives automatic certification of the following:

Complete Core Skill Problem Solving at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the support notes of this unit specification.

Context for delivery

If this unit is delivered as part of a group award, it is recommended that it should be taught and assessed within the subject area of the group award to which it contributes.

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

Higher National Unit Specification: Statement of standards

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Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Where evidence for outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed, and different items should be sampled on each assessment occasion.

Outcome 1

Explain the role of hydrogen in creating clean energy solutions.

Knowledge and/or skills

- Awareness of environmental issues
- Knowledge of competing technologies
- Awareness of current research and development being undertaken in Scotland, UK and Europe
- Awareness of industry support organisations

Outcome 2

Compare different hydrogen applications.

Knowledge and/or skills

- Transportation applications (eg, use of hydrogen fuel in cars, buses, lorries, ships, etc)
- Grid balancing applications
- Hydrogen injection into the gas network
- Hydrogen CHP (Combined Heat and Power) and heating system

Outcome 3

Perform realistic energy calculations.

Knowledge and/or skills

- Consideration of the economics of production
- Calculating of system losses, fuel cell system efficiency and performance analysis
- Operational and storage constraints
- Analysis of several realistic case studies

Higher National Unit Specification: Statement of standards (cont)

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Outcome 4

Design a hydrogen-based solution for a particular application.

Knowledge and/or skills

- Problem investigation and requirement capture
- Design of hydrogen-based solutions
- Evaluation of the performance of the solution
- Compare and contrast designed solution with alternative technologies
- Demonstrate an understanding of system constraints (eg, safety, supply, infrastructure, etc)
- Presentation of final design

Evidence requirements for this unit

Outcome 1

Learners will need to provide written and/or oral recorded evidence to demonstrate they can examine two of the four knowledge and/or skills items.

(a) The learner will consider the various environmental issues driving the development of hydrogen technology, specifically the negative aspects of fossil fuels and the impact on the environment.
(b) The learner will understand the existing technologies in the various industries that hydrogen solutions are predicted to compete with and develop an understanding of the barriers (or potential opportunities) that will affect the rate of uptake of hydrogen technology.
(c) The learner will understand the various strands of research and development being undertaken and the future hydrogen technologies that are predicted to affect the industries of Scotland, the UK and Europe. The learner will explore both short and long term future trends to gain an understanding of the prospective shape of the emerging market for hydrogen.
(d) The learner will be introduced to the various industry support organisations and gain an understanding of their roles in promoting and supporting the future hydrogen industry.

The assessment of Outcomes 1, 2 and 3 should be combined. Learners are required to provide written and/or oral recorded evidence, generated under open-book, supervised, timed conditions.

Higher National Unit Specification: Statement of standards (cont)

Unit title: Design Principles of a Hydrogen System (SCQF level 8)

Outcome 2

Learners will need to provide written and/or oral recorded evidence to demonstrate they can examine two of the four knowledge and/or skills items.

(a) The learner will understand hydrogen technology implementation in transportation. The learner shall explore the existing technologies affecting different sectors of transportation and future technologies that are predicted to increase the rate of adoption within those sectors.
(b) The learner will understand how hydrogen technologies can be used to support the existing electrical transmission and distribution industry by means of offering grid balancing solutions. The learner will understand the capability hydrogen solutions offer in this market and how hydrogen solutions compare with alternative solutions.
(c) The learner will understand how hydrogen gas may be used to support the existing gas supply infrastructure of the UK by offering gas network injection capability. The learner will understand how this offering may be used by the gas network to manage operational constraints and how this capability compares with alternative solutions.
(d) The learner will understand how hydrogen gas may be used in small to medium scale CHP applications offering public utilities (and other energy suppliers) 'green' energy solutions. The learner will also understand how heat captured from hydrogen CHP may be captured and used for heating purposes, increasing the efficiency and therefore desirability of such systems.

The assessment of Outcomes 1, 2 and 3 should be combined. Learners are required to provide written and/or oral recorded evidence, generated under open-book, supervised, timed conditions.

Outcome 3

Learners will need to provide written and/or oral recorded evidence to demonstrate they can examine two of the four knowledge and/or skills items.

(a) The learner will understand the economic drivers that affect the use of hydrogen gas as an alternative fuel source in various industries. For example, the learner will consider the generator dispatch mechanism used in the UK electricity generation industry and how that mechanism dictates the selection of and pricing of generation capacity.
(b) The learner will learn how to calculate system losses and fuel cell system efficiency. The learner will learn the optimal conditions for hydrogen energy conversion and how deviating from these can affect system efficiency. The learner will learn how to assess the output of a hydrogen fuel system and analyse overall system performance.
(c) The learner will gain knowledge of the operational and storage constraints affecting any realistic hydrogen fuel system and will learn to evaluate, on a cost/benefit basis, the effectiveness of mitigating actions that could be taken to alleviate these constraints.

The assessment of Outcomes 1, 2 and 3 should be combined. Learners are required to provide written and/or oral recorded evidence, generated under open-book, supervised, timed conditions.

Higher National Unit Specification: Statement of standards (cont)

Unit title: Design Principles of a Hydrogen System (SCQF level 8)

Outcome 4

Learners will need to provide written and/or oral recorded evidence to demonstrate their knowledge and/or skills by showing the following:

(a) The learner will be introduced to the task by their supervisor and shall learn of the various tools available to them to support their self-directed learning and research task (eg, books, journals, and websites, etc).
(b) The learner will learn how to assess a problem statement and extract the key functional and system level requirements that will affect any proposed solution.
(c) The learner shall demonstrate knowledge of the constraints affecting system design such as costs, infrastructure, supply, and the importance of safety in design.
(d) The learner shall learn how to critically assess their design solution and consider how positively their solution compares to alternatives.
(e) The learner will learn how to communicate technical information to a general public audience.

Learners are required to provide product evidence, generated under open-book, unseen conditions.

Higher National Unit Support Notes

Unit title: Design Principles of a Hydrogen System (SCQF level 8)

Unit support notes are offered as guidance and are not mandatory.

While the exact time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this unit

This unit has been developed to provide learners with an advanced understanding of the design principles involved in the hydrogen gas industry. It is designed to instil in learners both the necessary knowledge and practical experience required to support a future career in hydrogen plant operation, maintenance, and design.

- In Outcome 1, learners explore the potential role that hydrogen gas has in creating clean energy solutions to support the future UK energy sector. The learner shall gain knowledge of the various drivers of hydrogen gas uptake in this sector including emerging environmental issues, future technologies and ongoing strands of research and development. This knowledge will support learners who seek to understand the basis for and potential of hydrogen gas technologies in the energy sector.
- In Outcome 2, learners will study the various implementations of hydrogen gas technologies in widening fields: transportation, electricity grid support, gas network support and in energy generation. Knowledge of such applications shall instil in the learner an understanding of the myriad ways in which hydrogen gas technologies may shape our future energy landscape and increase their breadth of knowledge relating to hydrogen gas application.
- In Outcome 3, learners are introduced to advanced analytical principles in the use of hydrogen gas as a source of fuel. Having an in-depth understanding of realistic energy calculations will enable learners to develop hydrogen gas design solutions in response to industrial requirements and will provide them with the opportunity to develop their skills (through further study) into technical roles such as design and operation of plant.
- In Outcome 4, learners could undertake a project-based coursework exercise in which they will design a hydrogen-based solution in response to realistic industrial requirements. Learners, who shall be supported by a suitably qualified and experienced person in the development of this solution, shall develop essential skills and gain tangible experience to support a future career in design, operation, or maintenance of hydrogen plant.

Guidance on approaches to delivery of this unit

It is anticipated that a sequential approach to delivery should be taken, where learners gain fundamental knowledge by studying and completing Outcomes 1, 2 and 3, before moving onto Outcome 4, where they have the opportunity to practice applying this knowledge to a practical project task.

Higher National Unit Support Notes (cont)

Unit title: Design Principles of a Hydrogen System (SCQF level 8)

Outcomes 1, 2 and 3 shall principally be delivered in a classroom or virtual learning environment. In Outcome 4 learners will be expected to undertake a degree of self-directed learning and research, outside of the classroom, but shall be supported by various classroom activities including an introduction to the task and several scheduled drop-in sessions.

The information contained in Outcome 3 could be presented to learners alongside several industry case studies to demonstrate principles in a realistic and industry relevant format.

In Outcome 4, learners could be introduced to a particular energy problem and tasked with designing a hydrogen-based system that offers a solution to the problem. This task could take the form an individual project-based coursework exercise, in which learners will be expected to undertake a degree of self-directed learning and research, supervised by suitably qualified and experienced persons (ie, from outside of the college environment but with suitable industrial experience or from within the college environment and with academic background in the field of hydrogen energy).

The information pertaining to each outcome could be delivered though a mix of knowledge delivery and video clips and is suitable for remote delivery.

The exact distribution of time between outcomes is at the discretion of the centre, however, the expected time requirements, including the assessment of Outcomes 1, 2 and 3 are as follows:

- Outcome 1 — 6 hours
- Outcome 2 — 6 hours
- Outcome 3 — 8 hours
- Outcome 4 — 20 hours

Guidance on approaches to assessment of this unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

- Outcomes 1, 2 and 3 could be assessed in an extended (multi-part) open-book examination. Outcomes 1 and 2 could principally be examined using short written and/or oral recorded response form questions and multiple-choice form questions. Outcome 3 could be assessed via calculation exercises.
- Outcome 4 could be assessed in the form of a report presenting the learner's design solution, which shall demonstrate that they have considered the key learning outcomes listed above. Additionally, learners could complete a poster presentation of their design solution including a short presentation and fielding of audience questions.

Higher National Unit Support Notes (cont)

Unit title: Design Principles of a Hydrogen System (SCQF level 8)

Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the evidence requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

The Core Skill of Problem Solving at SCQF level 6 is embedded in this unit. When a learner achieves the unit, their Core Skills profile will also be updated to include this Core Skill.

There are also opportunities to develop the following Core Skills in this unit.

Communication, at SCQF level 6, can be developed in learners across all outcomes of this unit. In all outcomes, learners will be exposed to written learning materials and will be expected to discern relevant information. Oral communication skills will be developed principally in Outcome 4, in which learners could give a poster presentation, supported by oral presentation and field of audience questions. Learners will be expected to learn by verbal instruction and will have the opportunity to interact with instructors and fellow learners by questioning learning materials or sharing understandings.

Numeracy, at SCQF level 6, can be developed by learners carrying out the realistic energy conversion calculations contained in Outcome 3. These numeracy skills will be developed further in their application to the design solution contained in Outcome 4.

Information and Communication Technology, at SCQF level 6, can be developed by learners using the internet to access resources and undertake individual learning and research tasks.

Problem Solving, at SCQF level 6, principally in Outcomes 3 and 4 of this unit. In Outcome 3 learners will be exposed to mathematical problems in the form of realistic energy conversion calculations that integrate a wide range of industrial constraints such as economic, environmental, system performance, operational and storage. In Outcome 4, learners shall apply their knowledge and understanding towards the solution of a realistic industrial problem statement and shall practice skills such as: requirement refinement, self-directly learning and research, critical assessment, and design development.

Working with Others, at SCQF level 6, can be developed by using group work within the classroom, industrial and self-directly learning settings, which allows learners to share experiences with their fellow learners. Groups will be encouraged to collaborate to get the most out of their learning experience and to bring forth best practices and understandings to the benefit of all.

History of changes to unit

Version	Description of change	Date
3	Core Skill Problem Solving at SCQF level 6 embedded.	12/01/22
2	Minor amendments made to all outcomes	13/12/2021

General information for learners

Unit title: Design Principles of a Hydrogen System (SCQF level 8)

The Core Skill of Problem Solving at SCQF level 6 is embedded in this unit. When a learner achieves the unit, their Core Skills profile will also be updated to include this Core Skill.

This section will help you decide whether this is the unit for you by explaining what the unit is about, what you should know or be able to do before you start, what you will need to do during the unit and opportunities for further learning and employment.

Following detailed analysis of current and anticipated hydrogen activity in Scotland and Europe, it was concluded that there is reasonable expectation of hydrogen technologies making a significant contribution to the Scottish economy over the next 10 years.

In order to develop the skills required to meet the skill gap in the hydrogen sector, this unit shall educate learners in the wider applications of hydrogen technologies and the principles associated with designing hydrogen plant.

The aim of this unit is to provide you with fundamental knowledge and skills appropriate to working in the hydrogen gas industry. In addition, in completing this unit you will have the opportunity to develop the following core skills at SCQF level 6: *Communication*, *Numeracy*, *Information and Communication Technology*, *Problem Solving* and *Working with Others*.

This unit has been developed as part of the PDA in Hydrogen: An Introduction for Technicians, however, is also available as a freestanding unit. The PDA in Hydrogen: An Introduction for Technicians is a three-unit course that offers an industry and SQA recognised certification demonstrating technician-level training in hydrogen technologies and provides learners with the opportunity to develop current and future skills to meet the needs of industry. The other two units in the PDA are: *Safe Hydrogen Gas Handling* — SCQF level 6 and *Operating Principles of a Hydrogen Facility* — SCQF level 7.

- In Outcome 1, you will explore the potential role that hydrogen gas has in creating clean energy solutions to support the future UK energy sector. You shall gain knowledge of the various drivers of hydrogen gas uptake in this sector including emerging environmental issues, future technologies and ongoing strands of research and development. This knowledge will support you to understand the basis for and potential of hydrogen gas technologies in the energy sector.
- In Outcome 2, you will study the various implementations of hydrogen gas technologies in widening fields of industry including: transportation, electricity grid support, gas network support and in energy generation. Knowledge of such applications shall instil in you an understanding of the myriad ways in which hydrogen gas technologies may shape our future energy landscape and increase their breadth of knowledge relating to hydrogen gas application.
- In Outcome 3, you are introduced to advanced analytical principles in the use of hydrogen gas as a source of fuel. Having an in-depth understanding of realistic energy calculations will enable you to develop hydrogen gas design solutions in response to industrial requirements and will provide you with the opportunity to develop your skills (through further study) into technical roles such as design and operation of plant.
- In Outcome 4, you shall undertake a project-based coursework exercise in which you will design a hydrogen-based solution in response to realistic industrial requirements. You will be supported by a suitably qualified and experienced person in the development of this solution, shall develop essential skills and gain tangible experience to support a future career in design, operation, or maintenance of hydrogen plant.

General information for learners (cont)

Unit title: Design Principles of a Hydrogen System (SCQF level 8)

On successful completion of the unit, you will be able to:

1 Explain the role of hydrogen in creating clean energy solutions.
2 Compare different hydrogen applications.
3 Perform realistic energy calculations.
4 Design a hydrogen-based solution for a particular application.

Outcomes 1, 2 and 3 of this unit will be assessed by written and/or recorded oral evidence in a supervised, open-book and timed assessment environment. For Outcome 4, you will provide product evidence generated under open-book, unseen conditions.