

NextGen: HN educator guide

HND Engineering

Qualification code: GV2A 48

Valid from: August 2026

This guide provides information about the Higher National Diploma (HND) to ensure consistent and transparent assessment year on year. It is for lecturers and assessors, and contains all the mandatory information you need to deliver and assess the HND.

You must read it alongside the grading pack.

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Contents

Purpose of the qualification	1
Mechanical Engineering route	2
Electrical Engineering route	3
Structure	4
Framework	4
Aims of the qualification	9
General aims	9
Specific aims	9
Who is this qualification for?.....	11
Recognising prior learning.....	11
Articulation and progression	12
Professional recognition	13
Credit transfer arrangements	13
Recommended Core Skills entry profile	13
How the qualification meets employer and higher education institution needs	14
Table 1: mapping qualification aims to units.....	15
Table 2: mapping or trade or professional body requirements to units.....	18
Table 3: assessment strategy for the qualification	20
Meta-skills	23
Meta-skills in HND Engineering.....	24
Learning for Sustainability	25
Context.....	25
Learning for Sustainability in NextGen: HN Qualifications.....	26
Grading	28
Whole-qualification grade outcomes	28
Whole-qualification grade descriptors	29
Approaches to delivery and assessment	30
Sequencing or integrating units.....	30
Additional guidance on integrated or holistic assessment	41
Remediation and re-assessment in NextGen: HN Qualifications	43

Information for centres	44
Equality and inclusion.....	44
Internal and external verification	44
Glossary.....	45
Information for learners.....	46
HND Engineering	46
Qualification information.....	46
Appendix 1: example case studies	48
3D printing case study.....	48
Wind turbine case study	50
Hydroelectric power case study	53
Administrative information.....	59
History of changes.....	59

Purpose of the qualification

HND Engineering equips learners with the technical knowledge and skills, as well as the professional skills and personal behaviours (meta-skills), that employers expect from individuals entering into and working within the Scottish engineering and advanced manufacturing sector at HND level.

HND learners may already be in employment and attend centres on a day-release or other part-time basis. The HND framework structure is flexible enough to allow centres to deliver the qualification in various ways, including two-year day release or evening attendance.

The options employed learners choose may reflect the branch of industry in which they are employed, or they may wish to gain knowledge of other areas of engineering to improve their career opportunities. Part-time learners may also use the HND to gain entry to degree-level studies.

Full-time HND learners may be school leavers who have not gained the required university entry qualifications, and hope to use the qualification as an alternative way to gain a more in-depth knowledge of an engineering subject before going to university. Full-time learners may also be more mature persons who are seeking a change of employment. These learners may not have studied for some time and will require additional support to develop their learning skills.

The HND units have been designed to take topics to a more advanced level than is possible in an HNC. They provide learners with opportunities to develop critical knowledge and understanding of theory and practical hands-on skills required by incorporated engineers.

While there is a degree of flexibility within the mandatory optional section of the award to suit local needs, there are still recognised traditional engineering discipline routes. The examples below show potential routes for Mechanical Engineering and Electrical Engineering.

Mechanical Engineering route

Mandatory units

Unit code	Unit title	Qualifications Scotland credits	SCQF credit points	SCQF level
J7BS 48	Engineering Project Management	2	16	8
J7BR 48	Professional Practice in Engineering	3	24	8
J7GL 47	Engineering Mathematics 2	1	8	7

Mandatory optional units

Unit code	Unit title	Qualifications Scotland credits	SCQF credit points	SCQF level
J7BY 48	Thermodynamics, Plant Systems and Fluid Mechanics	3	24	8
J7C1 48	Advanced Materials	3	24	8

Optional unit

Unit code	Unit title	Qualifications Scotland credits	SCQF credit points	SCQF level
J6D9 47	Mechanical Engineering: Practical Skills	3	24	7

Electrical Engineering route

Mandatory units

Unit code	Unit title	Qualifications Scotland credits	SCQF credit points	SCQF level
J7BS 48	Engineering Project Management	2	16	8
J7BR 48	Professional Practice in Engineering	3	24	8
J7GL 47	Engineering Mathematics 2	1	8	7

Mandatory optional units

Unit code	Unit title	Qualifications Scotland credits	SCQF credit points	SCQF level
J7BT 48	Electrical Transformers, Motors and Machine Systems	3	24	8
J7BV 48	Electrical Engineering: Utilisation of Electrical Power, Transmission Lines and Complex Waves	3	24	8

Optional unit

Unit code	Unit title	Qualifications Scotland credits	SCQF credit points	SCQF level
J6D6 47	Electrical Engineering: Practical Skills	3	24	7

Structure

Higher National Diplomas (HNDs) are at SCQF level 8 and are made up of 120 SCQF credit points (15 Qualifications Scotland credits). HNDs must incorporate at least 80 credit points (10 Qualifications Scotland credits) at SCQF level 8.

In HND Engineering, learners engage in projects, personal reflection and practical tasks. A meta-skills outcome is included in the Professional Practice in Engineering unit. Learners also develop meta-skills in the context of the rest of the unit content.

Framework

The HND is made up of mandatory, mandatory optional and optional units. Learners must complete all the mandatory units, 6 Qualifications Scotland credits from the mandatory optional units and 3 Qualifications Scotland credits from the optional units.

Mandatory units

Unit code	Unit title	Qualifications Scotland credits	SCQF credit points	SCQF level
J7BS 48	Engineering Project Management	2	16	8
J7BR 48	Professional Practice in Engineering	3	24	8
J7GL 47	Engineering Mathematics 2	1	8	7

Mandatory optional units (6 Qualifications Scotland credits required)

Unit code	Unit title	Qualifications Scotland credits	SCQF credit points	SCQF level
J7BY 48	Thermodynamics, Plant Systems and Fluid Mechanics	3	24	8
J7C1 48	Advanced Materials	3	24	8
J7C4 48	Sustainable Design Engineering and Innovation Entrepreneurship	3	24	8
J7BW 48	Instrumentation and Control: Transducers, Transmitting Signals and Functional Safety	3	24	8
J7BT 48	Electrical Transformers, Motors and Machine Systems	3	24	8
J7BV 48	Electrical Engineering: Utilisation of Electrical Power, Transmission Lines and Complex Waves	3	24	8
J7C2 48	Analogue Electronics: Design and Analysis	3	24	8
J7C3 48	Digital Electronics: Digital System Design	3	24	8
J7C5 48	Renewable Energy: Generation, Storage and Transmission	3	24	8
J7BX 48	Dynamic Engineering Systems: Modelling, Simulation and Control	3	24	8

Optional units (3 Qualifications Scotland credits required)

Unit code	Unit title	Qualifications Scotland credits	SCQF credit points	SCQF level
J7BY 48	Thermodynamics, Plant Systems and Fluid Mechanics	3	24	8
J7C1 48	Advanced Materials	3	24	8
J7C4 48	Sustainable Design Engineering and Innovation Entrepreneurship	3	24	8
J7BW 48	Instrumentation and Control: Transducers, Transmitting Signals and Functional Safety	3	24	8
J7BT 48	Electrical Transformers, Motors and Machine Systems	3	24	8
J7BV 48	Electrical Engineering: Utilisation of Electrical Power, Transmission Lines and Complex Waves	3	24	8
J7C2 48	Analogue Electronics: Design and Analysis	3	24	8
J7C3 48	Digital Electronics: Digital System Design	3	24	8
J7C5 48	Renewable Energy: Generation, Storage and Transmission	3	24	8
J7BX 48	Dynamic Engineering Systems: Modelling, Simulation and Control	3	24	8
J6D6 47	Electrical Engineering: Practical Skills	3	24	7

Unit code	Unit title	Qualifications Scotland credits	SCQF credit points	SCQF level
J6DA 47	Engineering Systems: Practical Skills	3	24	7
J6DB 47	Instrumentation and Control: Practical Skills	3	24	7
J6D9 47	Mechanical Engineering: Practical Skills	3	24	7
J750 47	Electronics in Practice: Skills and Techniques	3	24	7
J6CW 47	Electrical Engineering Principles	3	24	7
J6D2 47	Electrical Power and Drive Systems	3	24	7
J752 47	Digital Electronics: Theory and Applications	3	24	7
J751 47	Analogue Electronics: Theory and Applications	3	24	7
J89H 47	Engineering Systems: Validation and Verification	3	24	7
J6D4 47	Engineering Systems Principles	3	24	7
J6D0 47	Instrumentation and Control: Measurement Systems	3	24	7
J6D5 47	Instrumentation and Control: Control Systems	3	24	7
J6CV 47	Manufacturing Engineering: Materials and Processes	3	24	7
J6D1 47	Manufacturing Engineering: Simulation and Modelling	3	24	7

Unit code	Unit title	Qualifications Scotland credits	SCQF credit points	SCQF level
J6CX 47	Thermodynamics and Fluid Mechanics	3	24	7
J6D3 47	Engineering Mechanics and Materials	3	24	7
J7L9 47	Engineering Mathematics 3	1	8	7
J7LA 48	Engineering Mathematics 4	1	8	8
J7LB 48	Engineering Mathematics 5	1	8	8
J7GS 46	Engineering Practical Skills	2	16	6
J7GP 47	Applications of Programmable Logic Controllers	1	8	7
J7N3 47	Work-based Learning	3	24	7

Aims of the qualification

General aims

1. Enhance employment prospects.
2. Develop meta-skills that complement technical and professional knowledge and skills.
3. Develop self-awareness and understanding to enable learners to use meta-skills to discuss, increase and enhance employability.
4. Support continuing professional development (CPD) and career development.
5. Enable progression within the Scottish Credit and Qualifications Framework (SCQF).
6. Develop the ability to apply advanced analysis and synthesis skills to solve engineering problems.
7. Develop learning and transferable skills (including meta-skills).
8. Develop the ability to accurately apply a range of mathematical and other analytical techniques to solve advanced engineering problems in the relevant engineering discipline.
9. Develop Learning for Sustainability skills, knowledge, understanding and values.

Specific aims

1. Enable learners to work as engineering technicians or incorporated engineers.
2. Meet the academic requirements for Engineering Technician (EngTech) status, with specific reference to the Engineering Council's five competences:
 - A. Knowledge and understanding
 - B. Design, development and solving engineering problems
 - C. Responsibility, management and leadership
 - D. Communication and interpersonal skills
 - E. Professional commitment
3. Enable progression, with advanced standing, to a degree in engineering or a related subject.

4. Transfer knowledge and skills gained to other areas of employment.
5. Develop project management skills through an enhanced, project-based approach to solving engineering problems.
6. Raise awareness of sustainability, environmental impact and other related areas in an engineering context.
7. Enhance the ability to develop safe systems of work.
8. Develop commitment to professional engineering values.
9. Carry out substantive advanced project analysis and development across key engineering content through project assignments across units.
10. Allow learners to specialise in one or more of the following engineering disciplines:
 - electronics
 - electrical engineering
 - manufacturing engineering
 - mechanical engineering
 - instrumentation and control
 - engineering systems

Who is this qualification for?

This qualification is suitable for learners who want to work in industries within the Scottish engineering and advanced manufacturing sector, or progress to a degree in an engineering discipline.

Entry to this qualification is at your centre's discretion. However, we recommend that learners have one or more of the following:

- an HNC or equivalent Qualifications Scotland qualification in Engineering, or a related discipline such as Construction, Science or Computing
- a qualification comparable to those listed above from another awarding body

It is at your centre's discretion to accept applicants with a different experiential background who could benefit from taking the course or units within the course. This could include adult returners or those with relevant work experience.

Recognising prior learning

Qualifications Scotland recognises that learners gain knowledge and skills through formal, non-formal and informal learning contexts. Formal learning is learning certificated by a recognised awarding or professional body. Non-formal learning includes learning such as employers' in-house training courses. Informal learning is learning based on experience from a variety of environments that is not formally assessed.

It is unlikely that a learner would have the appropriate prior learning and experience to meet all the requirements of a full HND.

We expect that the majority of part-time learners will be employed apprentices attending as part of their apprenticeship, under the supervision of a training officer. During their apprenticeship, learners will have gained a valuable and varied range of practical skills.

This qualification contains an options list of 3-credit practical skills units. These are in the areas of:

- electrical
- mechanical
- engineering systems
- electronics
- instrumentation and control

There is also the more general 2-credit Engineering Practical Skills unit. We recommend that part-time learners receive credit for skills gained as part of their apprenticeship if they correspond with any of these practical skills units, or any other unit within the framework. This gives centres an additional opportunity to discuss apprentice learners' progress with training officers. This could reduce learners' study to 12 credits, with the final 3 credits consisting of recognised prior learning.

Centres should have a discussion on recognition of prior learning with apprentices and training officers at the start of the programme, to match their skills to one of the practical skills units. A complete match is not always possible.

You can find more information and guidance about the [recognition of prior learning on our website](#).

Articulation and progression

Learners who complete this qualification could go on to:

- other qualifications in engineering or related areas
- further study, employment and/or training, such as a degree in engineering or a related discipline
- create a route towards meeting the academic requirements for the Engineering Council Engineering Technician (EngTech) status

Professional recognition

There is no automatic professional recognition on completing this qualification. However, it has been designed to provide a route towards meeting the academic requirements for recognition of Engineering Technician (EngTech) status by the Engineering Council.

Credit transfer arrangements

Centres can make decisions about transferring credit. They can transfer credit if the subject-related content of the units is broadly equivalent. Centres should consider the currency of a learner's achievement before transferring credit.

Recommended Core Skills entry profile

Learners should have the following Core Skills at the stated SCQF levels before starting this qualification. This information can help identify learners who may need additional support.

Core Skill	Recommended SCQF entry profile
Communication	SCQF level 6
Numeracy	SCQF level 6
Information and communication technology (ICT)	SCQF level 6
Problem solving	SCQF level 6
Working with others	SCQF level 6

How the qualification meets employer and higher education institution needs

This qualification is designed in collaboration with employers, higher education institutions (HEIs), practitioners and professional bodies to meet the sector need.

The following tables show how the qualification can benefit employers and HEIs by equipping learners with the necessary skill set:

- Table 1 shows how units map to the aims of the qualification.
- Table 2 shows how the units map to trade or professional body requirements.
- Table 3 shows the assessment strategy for the qualification.

Table 1: mapping qualification aims to units

General aims

All nine general aims are directly relevant to all units.

Specific aims

Key: aim is directly relevant to unit (X), aim is optional in this unit (O)

Unit code	Unit title	Aim 1	Aim 2	Aim 3	Aim 4	Aim 5	Aim 6	Aim 7	Aim 8	Aim 9	Aim 10
J7BR 48	Professional Practice in Engineering	X	X	X	X	X	X	X	X	X	O
J7BS 48	Engineering Project Management	X	X	X	X	X	X	X	X	X	O
J7BY 48	Thermodynamics, Plant Systems and Fluid Mechanics	X	X	X	X	X	X	X	X	X	O
J7C1 48	Advanced Materials	X	X	X	X	X	X	X	X	X	O
J7C4 48	Sustainable Design Engineering and Innovation Entrepreneurship	X	X	X	X	X	X	X	X	X	O

Unit code	Unit title	Aim 1	Aim 2	Aim 3	Aim 4	Aim 5	Aim 6	Aim 7	Aim 8	Aim 9	Aim 10
J7BX 48	Dynamic Engineering Systems: Modelling, Simulation and Control	X	X	X	X	X	X	X	X	X	O
J7BW 48	Instrumentation and Control: Transducers, Transmitting Signals and Functional Safety	X	X	X	X	X	X	X	X	X	O
J7C2 48	Analogue Electronics: Design and Analysis	X	X	X	X	X	X	X	X	X	O
J7C3 48	Digital Electronics: Digital System Design	X	X	X	X	X	X	X	X	X	O
J7BT 48	Electrical Transformers, Motors and Machine Systems	X	X	X	X	X	X	X	X	X	O
J7BV 48	Electrical Engineering: Utilisation of Electrical Power, Transmission Lines and Complex Waves	X	X	X	X	X	X	X	X	X	O
J7C5 48	Renewable Energy: Generation, Storage and Transmission	X	X	X	X	X	X	X	X	X	O
J7GL 47	Engineering Mathematics 2	X	X	X	X	X	X	X	X	X	O
J7L9 47	Engineering Mathematics 3	X	X	X	X	X	X	X	X	X	O

Unit code	Unit title	Aim 1	Aim 2	Aim 3	Aim 4	Aim 5	Aim 6	Aim 7	Aim 8	Aim 9	Aim 10
J7LA 48	Engineering Mathematics 4	X	X	X	X	X	X	X	X	X	O
J7LB 48	Engineering Mathematics 5	X	X	X	X	X	X	X	X	X	O

Table 2: mapping or trade or professional body requirements to units

This table indicates where opportunities to meet the Engineering Council’s competences for the Engineering Technician (EngTech) standard may be found.

Key: aim is directly relevant to unit (X), aim is optional in this unit (O)

Unit code	Unit title	A1	A2	B1	B2	C1	C2	C3	D1	D2	D3	E1	E2	E3	E4	E5
J7BR 48	Professional Practice in Engineering	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J7BS 48	Engineering Project Management	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J7GL 47	Engineering Mathematics 2	X	X	X	X	X	X	X	X	X	X	O	O	O	O	O
J7BY 48	Thermodynamics, Plant Systems and Fluid Mechanics	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J7C1 48	Advanced Materials	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J7C4 48	Sustainable Design Engineering and Innovation Entrepreneurship	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J7BW 48	Instrumentation and Control: Transducers, Transmitting Signals and Functional Safety	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Unit code	Unit title	A1	A2	B1	B2	C1	C2	C3	D1	D2	D3	E1	E2	E3	E4	E5
J7BX 48	Dynamic Engineering Systems: Modelling, Simulation and Control	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J7C2 48	Analogue Electronics: Design and Analysis	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J7C3 48	Digital Electronics: Digital System Design	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J7C5 48	Renewable Energy: Generation, Storage and Transmission	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J7BT 48	Electrical Transformers, Motors and Machine Systems	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
J7BV 48	Electrical Engineering: Utilisation of Electrical Power, Transmission Lines and Complex Waves	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 3: assessment strategy for the qualification

Unit code	Unit title	Assessment method
J7BS 48	Engineering Project Management	Open-book, project-based
J7BR 48	Professional Practice in Engineering	Open-book, project-based
J7GL 47	Engineering Mathematics 2	Closed-book
J7BY 48	Thermodynamics, Plant Systems and Fluid Mechanics	Open-book, project-based
J7C1 48	Advanced Materials	Open-book, project-based
J7C4 48	Sustainable Design Engineering and Innovation Entrepreneurship	Open-book, project-based
J7BW 48	Instrumentation and Control: Transducers, Transmitting Signals and Functional Safety	Open-book, project-based
J7BT 48	Electrical Transformers, Motors and Machine Systems	Open-book, project-based
J7BV 48	Electrical Engineering: Utilisation of Electrical Power, Transmission Lines and Complex Waves	Open-book, project-based
J7C2 48	Analogue Electronics: Design and Analysis	Open-book, project-based
J7C3 48	Digital Electronics: Digital System Design	Open-book, project-based

Unit code	Unit title	Assessment method
J7C5 48	Renewable Energy: Generation, Storage and Transmission	Open-book, project-based
J7BX 48	Dynamic Engineering Systems: Modelling, Simulation and Control	Open-book, project-based
J6D6 47	Electrical Engineering: Practical Skills	Open-book, project-based
J6DA 47	Engineering Systems: Practical Skills	Open-book, project-based
J6DB 47	Instrumentation and Control: Practical Skills	Open-book, project-based
J6D9 47	Mechanical Engineering: Practical Skills	Open-book, project-based
J750 47	Electronics in Practice: Skills and Techniques	Open-book, project-based
J6CW 47	Electrical Engineering Principles	Open-book, project-based
J6D2 47	Electrical Power and Drive Systems	Open-book, project-based
J752 47	Digital Electronics: Theory and Applications	Open-book, project-based
J751 47	Analogue Electronics: Theory and Applications	Open-book, project-based
J89H 47	Engineering Systems: Validation and Verification	Open-book, project-based
J6D4 47	Engineering Systems Principles	Open-book, project-based

Unit code	Unit title	Assessment method
J6D0 47	Instrumentation and Control: Measurement Systems	Open-book, project-based
J6D5 47	Instrumentation and Control: Control Systems	Open-book, project-based
J6CV 47	Manufacturing Engineering: Materials and Process	Open-book, project-based
J6D1 47	Manufacturing Engineering: Simulation and Modelling	Open-book, project-based
J6CX 47	Thermodynamics and Fluid Mechanics	Open-book, project-based
J6D3 47	Engineering Mechanics and Materials	Open-book, project-based
J7L9 47	Engineering Mathematics 3	Closed-book
J7LA 48	Engineering Mathematics 4	Closed-book
J7LB 48	Engineering Mathematics 5	Closed-book
J7GS 46	Engineering Practical Skills	Open-book, project-based
J7GP 47	Applications of Programmable Logic Controllers	Open-book, project-based
J7N3 47	Work-based Learning	Open-book, project-based

Meta-skills

Every NextGen: HN Qualification gives learners the opportunity to develop meta-skills.

Meta-skills are transferable behaviours and abilities that help people to adapt and succeed in life, study and work. There are three categories of meta-skills: self-management, social intelligence and innovation. Each of these is made up of four meta-skills and a number of sub-skills.

- Self-management — focusing, integrity, adapting, initiative
- Social intelligence — communicating, feeling, collaborating, leading
- Innovation — curiosity, creativity, sense-making, critical thinking

From early in the qualification, we want learners to identify and understand the meta-skills they can develop, and to appreciate the personal and professional value of these skills. We want to support learners to continue to articulate, use and build on them long after they have achieved their qualification. In this way, we help learners to develop broad skills profiles, enabling them to thrive in a changing world.

Every NextGen: HN unit signposts opportunities for learners to develop meta-skills, and there is an assessed outcome in one of the mandatory units. When you make your whole-qualification grade decisions, you consider learners' commitment to engaging with meta-skills development.

You do not assess learners on their competence or progress in individual meta-skills. Instead, you assess them on evidence that they have engaged with a personal process of development. Meta-skills development is founded on a clear process of self-assessment, goal setting, action planning and reflective practice.

You can find meta-skills teaching, learning and assessment resources on [our meta-skills web page](#).

Meta-skills in HND Engineering

The mandatory unit Professional Practice in Engineering includes a specific outcome on meta-skills in which learners must show how they have developed their meta-skills.

Learners carry out projects, personal reflection and practical tasks throughout the course, which help them develop meta-skills.

All units in this award reference meta-skills and how they can be progressed and evidenced throughout delivery.

Learning for Sustainability

Context

The United Nations (UN) 2030 Agenda for Sustainable Development, adopted by the UK in 2015, has shaped the development of Scottish, national and international sustainability policy. It sets out the [UN Sustainable Development Goals](#) (SDGs), which are central to the Scottish Government's [National Performance Framework](#). Learning for Sustainability (LfS) is a commitment to embedding the SDGs in Scottish education.

LfS embraces global citizenship, sustainable development, social justice, human rights, climate change, biodiversity loss, equality and inclusion. Learners develop their capacity to deal with the unpredictable social, economic and environmental challenges facing our rapidly changing world.

LfS combines:

- education for sustainable development (ESD)
- global citizenship
- outdoor learning

ESD is the internationally used term for sustainability education. Although LfS has a broader remit, the terms are largely interchangeable. Colleges and universities tend to use ESD, while schools usually use LfS. Both focus on a broad range of social, economic and environmental themes and approaches across all levels of education. Qualifications Scotland uses LfS as an umbrella term.

Learning for Sustainability in NextGen: HN Qualifications

Sustainability is a core component in this qualification.

Learners who complete this qualification should have:

- a general understanding of social, economic and environmental sustainability
- a general understanding of the SDGs
- a deeper understanding of subject-specific sustainability
- the confidence to apply the skills, knowledge, understanding and values they develop in the next stage of their life

Sustainability is embedded in outcome 5 of the mandatory Professional Practice in Engineering unit.

Learners who complete this outcome can:

- assess their own knowledge and understanding of sustainability and the SDGs
- review unit content against the SDGs to identify a sustainability-related issue
- apply knowledge and understanding of sustainability and the SDGs to propose improvements

Sustainability is embedded in the key aims of all levels of professional engineer set by the Engineering Council. Engineers must 'demonstrate appropriate consideration of the principles of sustainability' to gain professional recognition. The Engineering Council lists six principles to guide and motivate professional engineers in their [Guidance on Sustainability](#).

One of the specific aims of this award is to 'raise awareness of sustainability, environmental impact and other related areas in an engineering context'. Specifically, in outcome 5 of the mandatory unit Professional Practice in Engineering, learners must recognise how they can apply sustainability principles in their day-to-day work and identify actions to improve sustainability. Sustainability is also considered in other units within this qualification.

You can cover any of the SDGs that are relevant to the subject area.

Find out more about Qualifications Scotland's approach on the [NextGen: HN Learning for Sustainability web page](#). There is an LfS reflective template available in the 'Resources' section. You may find it helpful as a starting point for considering how the SDGs are, or could be, embedded in a qualification, unit or assessment.

Grading

Please see the grading pack for this qualification for more information on making grade judgements.

Grading in NextGen: HN Qualifications produces a valid and reliable record of a learner's level of achievement across the breadth of the qualification content.

As well as grading the whole qualification, you assess individual units on a pass or fail basis. Each unit has evidence requirements that learners must achieve before you can consider them for whole-qualification grading.

Whole-qualification grade outcomes

Learners who pass NextGen: HN Qualifications receive one of the following grade outcomes for the qualification as a whole:

- Achieved with Distinction
- Achieved with Merit
- Achieved

To determine a learner's whole-qualification grade, you use the grading matrix provided in the grading pack to assess and judge their performance across the key aspects of the HND. You must align your judgements with the following whole-qualification grade descriptors.

Whole-qualification grade descriptors

Achieved with Distinction

The learner has achieved an excellent standard across the course content, going significantly beyond meeting the qualification requirements. They showed a comprehensive knowledge and understanding of course concepts and principles, and consistently used them to apply skills to complete high-quality work. They engaged significantly with the process of developing their meta-skills in the context of their HN Qualification.

Achieved with Merit

The learner has achieved a very good standard across the course content, going beyond meeting the qualification requirements. They showed a very good knowledge and understanding of course concepts and principles, and consistently used them to apply skills to complete work of a standard above that expected for an Achieved grade. They actively engaged with the process of developing their meta-skills in the context of their HN Qualification.

Achieved

The learner has achieved a good standard across the course content, credibly meeting the qualification requirements. They showed a good knowledge and understanding of course concepts and principles, and used them to apply skills to complete work of the required standard. They engaged with the process of developing their meta-skills in the context of their HN Qualification.

Approaches to delivery and assessment

Centres should sequence and integrate assessment across units to reflect the needs of their learners and the resources available. Typical sequences of units for Engineering Systems, Mechanical and Electrical pathways are given below.

Sequencing or integrating units

Delivery of Engineering Systems, Mechanical and Electrical pathways

Engineering Systems

Semester 1 (18 weeks)	Semester 2 (18 weeks)
<ul style="list-style-type: none"> • Engineering Mathematics 2 (1 credit) — 2 hours per week • Engineering Project Management (part) (2 credits) — 2 hours per week • Instrumentation and Control: Transducers, Transmitting Signals and Functional Safety (3 credits) — 6 hours per week • Dynamic Engineering Systems: Modelling, Simulation and Control (3 credits) — 6 hours per week • Grading and meta-skills support (1 credit) — 1 hour per week 	<ul style="list-style-type: none"> • Professional Practice in Engineering (3 credits) — 6 hours per week • Engineering Project Management (part) (2 credits) — 2 hours per week • Sustainable Design Engineering and Innovation Entrepreneurship (3 credits) — 6 hours per week • Grading and meta-skills support (1 credit) — 1 hour per week
Total per week: 17 hours	Total per week: 15 hours

Mechanical

Semester 1 (18 weeks)	Semester 2 (18 weeks)
<ul style="list-style-type: none"> • Engineering Mathematics 2 (1 credit) — 2 hours per week • Engineering Project Management (part) (2 credits) — 2 hours per week • Thermodynamics, Plant Systems and Fluid Mechanics (3 credits) — 6 hours per week • Advanced Materials (3 credits) — 6 hours per week • Grading and meta-skills support (1 credit) — 1 hour per week 	<ul style="list-style-type: none"> • Professional Practice in Engineering (3 credits) — 6 hours per week • Engineering Project Management (part) (2 credits) — 2 hours per week • Sustainable Design Engineering and Innovation Entrepreneurship (3 credits) — 6 hours per week • Grading and meta-skills support (1 credit) — 1 hour per week
Total per week: 17 hours	Total per week: 15 hours

Electrical

Semester 1 (18 weeks)	Semester 2 (18 weeks)
<ul style="list-style-type: none"> • Engineering Mathematics 2 (1 credit) — 2 hours per week • Engineering Project Management (part) (2 credits) — 2 hours per week • Electrical Transformers, Motors and Machine Systems (3 credits) — 6 hours per week • Electrical Engineering: Utilisation of Electrical Power, Transmission Lines and Complex Waves (3 credits) — 6 hours per week • Grading and meta-skills support (1 credit) — 1 hour per week 	<ul style="list-style-type: none"> • Professional Practice in Engineering (3 credits) — 6 hours per week • Engineering Project Management (part) (2 credits) — 2 hours per week • Renewable Energy: Generation, Storage and Transmission (3 credits) — 6 hours per week • Grading and meta-skills support (1 credit) — 1 hour per week
Total per week: 17 hours	Total per week: 15 hours

Outcome delivery

Engineering Systems — Semester 1 (18 weeks)

Engineering Mathematics 2 (1 credit, 2 hours per week)

1. solve trigonometric and hyperbolic function problems
2. use differentiation techniques to solve engineering problems
3. use integration techniques to solve engineering problems

Instrumentation and Control: Transducers, Transmitting Signals and Functional Safety (3 credits, 6 hours per week)

1. design systems to measure strain, position and vibration in industrial applications
2. analyse elements of pneumatic transmission systems
3. analyse elements of instrument electrical transmission systems
4. analyse modulation system components
5. explain elements of digital transmission systems
6. apply safety-instrumented systems (SISs), risk reduction and logic solvers
7. analyse safety integrity levels (SIL) and safety in field instruments

Dynamic Engineering Systems: Modelling, Simulation and Control (3 credits, 6 hours per week)

1. identify dynamic engineering systems and control systems
2. identify mathematical models of dynamic engineering systems
3. model mechanical engineering systems
4. model electrical, electronic and electromechanical engineering systems
5. analyse the response and stability of dynamic engineering systems
6. analyse control systems
7. identify digital control systems

Engineering Project Management (part) (2 credits, 2 hours per week)

1. analyse project management concepts, tools and standards, and demonstrate a knowledge of total quality management (TQM) as applied to an engineering or engineering service industry
2. analyse and apply risk management techniques in project management, including an analysis of security risks and effective mitigation methods, and budget risk and control

Total per week = 16 hours

Engineering Systems — Semester 2 (18 weeks)

Professional Practice in Engineering (3 credits, 6 hours per week)

1. define an engineering project
2. plan an engineering project
3. implement an engineering project
4. develop meta-skills in a vocational or academic context
5. work to engineering codes of practice

Engineering Project Management (part) (2 credits, 2 hours per week)

3. analyse stakeholder needs and translate them into success criteria, while managing project stakeholders and maintaining effective project communications
4. evaluate, report and close a project using recognised project management methods and tools as applied to an engineering or engineering service industry

Sustainable Design Engineering and Innovation Entrepreneurship (3 credits, 6 hours per week)

1. evaluate opportunities for innovation and entrepreneurship
2. evaluate ways to create engineering products
3. elaborate new product design specifications
4. create the best alternative new product concept
5. generate engineering requirements for new product concepts
6. evaluate new product prototype performance

Total per week = 14 hours

Mechanical — Semester 1 (18 weeks)

Engineering Mathematics 2 (1 credit, 2 hours per week)

1. solve trigonometric and hyperbolic function problems
2. use differentiation techniques to solve engineering problems
3. use integration techniques to solve engineering problems

Thermodynamics, Plant Systems and Fluid Mechanics

(3 credits, 6 hours per week)

1. apply the fundamental properties of thermodynamics to a process
2. evaluate the performance of internal combustion engines
3. explain the uses of common types of pumps and fans
4. explain the function of compressed air systems
5. explain the function of air-conditioning systems
6. explain the function of steam generation and distribution systems
7. explain the function of refrigeration systems
8. produce an installation and commissioning plan for an industrial system unit
9. analyse fluid flow patterns
10. solve flow measurements problems
11. solve problems involving incompressible flow in pipe systems

Advanced Materials (3 credits, 6 hours per week)

1. understand the relationship between atomic structures and material properties, and the relationship between molecular structures and material properties
2. determine material properties specifications for applications, and select materials using property charts, data sheets and process compatibility charts
3. understand how altering material structures can enhance or degrade material properties
4. analyse and calculate material strength and stress factors in engineering applications
5. understand the causes of material failure in service, and how they may be mitigated

Engineering Project Management (part) (2 credits, 2 hours per week)

1. analyse project management concepts, tools and standards, and demonstrate a knowledge of total quality management (TQM) as applied to an engineering or engineering service industry
2. analyse and apply risk management techniques in project management, including an analysis of security risks and effective mitigation methods, and budget risk and control

Total per week = 16 hours

Mechanical — Semester 2 (18 weeks)

Professional Practice in Engineering (3 credits, 6 hours per week)

1. define an engineering project
2. plan an engineering project
3. implement an engineering project
4. develop meta-skills in a vocational or academic context
5. work to engineering codes of practice

Engineering Project Management (part) (2 credits, 2 hours per week)

3. analyse stakeholder needs and translate them into success criteria, while managing project stakeholders and maintaining effective project communications
4. evaluate, report and close a project using recognised project management methods and tools as applied to an engineering or engineering service industry

Sustainable Design Engineering and Innovation Entrepreneurship (3 credits, 6 hours per week)

1. evaluate opportunities for innovation and entrepreneurship
2. evaluate ways to create engineering products
3. elaborate new product design specifications
4. create the best alternative new product concept
5. generate engineering requirements for new product concepts
6. evaluate new product prototype performance

Total per week = 14 hours

Electrical — Semester 1 (18 weeks)

Engineering Mathematics 2 (1 credit, 2 hours per week)

1. solve trigonometric and hyperbolic function problems
2. use differentiation techniques to solve engineering problems
3. use integration techniques to solve engineering problems

Electrical Transformers, Motors and Machine Systems

(3 credits, 6 hours per week)

1. analyse the construction and operation of single-phase and three-phase transformers
2. analyse the applications of induction and synchronous motors
3. analyse the functions and applications of transducers and actuators, including power electronics
4. analyse the operations of direct current (DC) and alternating current (AC) drives in industrial applications
5. analyse motor characteristics for industrial loads
6. analyse protection arrangements for motors and ancillary equipment

Electrical Engineering: Utilisation of Electrical Power, Transmission Lines and Complex Waves (3 credits, 6 hours per week)

1. understand sources and construction of electrical power generation and distribution systems
2. understand interconnections of power systems and their protection
3. calculate phasor voltages and currents at two points
4. understand the physical arrangements of an overhead transmission line
5. understand power systems and alternative energy sources
6. discuss new and emerging methods to optimise energy usage

Engineering Project Management (part) (2 credits, 2 hours per week)

1. analyse project management concepts, tools and standards, and demonstrate a knowledge of total quality management (TQM) as applied to an engineering or engineering service industry
2. analyse and apply risk management techniques in project management, including an analysis of security risks and effective mitigation methods, and budget risk and control

Total per week = 16 hours

Electrical — Semester 2 (18 weeks)

Professional Practice in Engineering (3 credits, 6 hours per week)

1. define an engineering project
2. plan an engineering project
3. implement an engineering project
4. develop meta-skills in a vocational or academic context
5. work to engineering codes of practice

Engineering Project Management (part) (2 credits, 2 hours per week)

3. analyse stakeholder needs and translate them into success criteria, while managing project stakeholders and maintaining effective project communications
4. evaluate, report and close a project using recognised project management methods and tools as applied to an engineering or engineering service industry

Renewable Energy: Generation, Storage and Transmission

(3 credits, 6 hours per week)

1. outline a holistic overview of the global energy supply situation
2. analyse a range of renewable energy generation methods
3. describe, with the aid of diagrams, a range of electrical and hydrogen generators
4. describe, with the aid of block diagrams, energy transmission and storage methods

Total per week = 14 hours

Additional guidance on integrated or holistic assessment

Holistic or integrated assessment focuses on assessing a number of outcomes in a unit together, or in some cases, assessing the unit as a whole, rather than by outcome. When assessing a unit of competence holistically, the assessment activities integrate a number of aspects of the competence. Holistic or integrated assessment can reduce the time spent on assessment and can promote greater equity in the assessment process.

When developing or revising a NextGen: HN Qualification, Qualifications Scotland works with a development team to devise an appropriate assessment strategy that accommodates holistic or integrated assessment. However, the practice of integrating units for the purposes of learning and teaching is a centre-led activity.

Units are designed to facilitate holistic or integrated assessment approaches that prevent large, unwieldy assessments.

Sometimes more than one piece of evidence is needed for a unit. For example, if a unit is about building a wall, a learner would need to produce evidence of performance (following the correct procedures and processes when building the wall) and product (a completed wall).

Evidence requirements must do what they say: specify requirements for evidence of learner competence in the unit. The evidence must be of sufficient quality for an assessor or verifier to judge that the learner has achieved the unit.

The qualification uses a project-based approach to gathering evidence, both within and across units. This is aided by centres developing engineering-specific case studies to enable learners to submit project-based evidence.

We have provided three examples of case studies in [Appendix 1](#).

Assessing project units

All learners carry out a group or individual project as part of the Professional Practice in Engineering unit, which also includes a meta-skills outcome. The project used for this unit can be formed from the mini projects used for other units.

Opportunities for e-assessment

Assessment that is supported by information and communications technology (ICT), such as e-testing or the use of e-portfolios or social software, may be appropriate for some assessments in this qualification.

If you want to use e-assessment, you must ensure that you apply the national standard to all evidence and that the conditions of assessment (as specified in the evidence requirements) are met, regardless of the mode of gathering evidence.

Remediation and re-assessment in NextGen: HN Qualifications

Remediation

Remediation allows an assessor to clarify learners' responses, either by requiring a written amendment or by oral questioning, where there is a minor shortfall or omission in evidence requirements. In either case, the assessor must formally note such instances, in writing or as a recording, and make them available to the internal and external verifier.

Remediation is not permitted for closed-book assessments.

The size and structure of the larger NextGen: HN units should mean that the assessor or lecturer is close enough to ongoing assessment activity in project-based units to identify the requirement for remediation as it occurs.

Re-assessment

We must give learners who fail the unit a re-assessment opportunity or, in exceptional circumstances, two re-assessment opportunities. Where we have introduced larger units to the framework, we expect instances of re-assessment to be minimal, due to the approach to assessment and remediation. Where re-assessment is required in a project-based unit, a substantially different project must be used.

Resource requirements

Centres must offer at least one subject-specific engineering discipline and be equipped to deliver the specific engineering content. Centres already offering HND Engineering have suitable resources to deliver this qualification.

Information for centres

Equality and inclusion

The units in this HND are designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

You should consider the needs of individual learners when planning learning experiences, selecting assessment methods or considering alternative evidence.

Guidance on assessment arrangements for disabled learners and those with additional support needs is available on the [assessment arrangements web page](#).

Internal and external verification

You must make sure all assessment methods you use in this qualification are internally verified according to your centre's policies and Qualifications Scotland's guidelines. Information on how to request prior verification for your assessment from Qualifications Scotland is available on our [prior verification web page](#).

Qualifications Scotland carries out external verification to ensure that internal assessment meets the national guidelines for this qualification.

More information on internal and external verification is available in our [Guide to Assessment](#) and in [NextGen: HN Quality Assurance — Guidance for Centres](#).

Glossary

Qualifications Scotland credits: 1 Qualifications Scotland credit equals 8 SCQF credit points.

Qualifications Scotland credit value indicates the contribution the unit makes to a Qualifications Scotland qualification. A Qualifications Scotland credit value of 1 represents approximately 40 hours of learning, teaching and assessment.

SCQF: the Scottish Credit and Qualifications Framework (SCQF) is Scotland's national framework for describing qualifications. We use SCQF terminology in this guide to refer to credits and levels. [For more information on the SCQF, visit the SCQF website.](#)

SCQF credit points indicate the amount of learning required to complete a qualification. NextGen HNCs and HNDs are worth 120 SCQF credit points.

SCQF levels indicate how hard the qualification is to achieve. The SCQF covers 12 levels of learning. NextGen HNCs are at SCQF level 7 and NextGen HNDs are at SCQF level 8.

Information for learners

HND Engineering

This information explains:

- what the qualification is about
- what you should know or be able to do before you start
- what you need to do during the qualification
- opportunities for further learning and employment

Qualification information

HND Engineering equips you with the technical knowledge and skills, as well as the professional skills and personal behaviours (meta-skills), that employers expect from individuals entering into and working within the Scottish engineering and advanced manufacturing sector at HND level.

You complete 6 credits common to all engineering disciplines and 9 credits reflecting a specific engineering discipline. The content mirrors the Engineering Council's five competences that you need to become an Engineering Technician (EngTech).

Although there is no set entry route to this qualification, we recommend you have achieved one or more of the following:

- an SCQF level 6 National Certificate or equivalent qualification in a related subject
- two Highers, one involving numeracy, such as Mathematics, Physics or Computing; and another involving communication, such as Modern Studies or English

HND Engineering is project-based. You must provide evidence that meets the requirements of each unit you take by completing projects and tasks that reflect the knowledge, skills and technology of your chosen specific engineering discipline. Your lecturer will give you engineering-specific case studies to base your projects on. The

number of projects or tasks you need to complete depends on the resources available at your centre.

When you complete the qualification, you will receive a grade of Achieved, Achieved with Merit, or Achieved with Distinction. This is based on the evidence you generate in the units. The mandatory and mandatory optional units count towards your overall grade. The three optional credits do not contribute to your overall grade, but you still must achieve them to complete the award.

Your centre makes judgements about projects using a detailed criteria matrix based on key competences covering:

- academic knowledge
- sector-specific knowledge
- skills
- professional behaviours

You develop meta-skills throughout the qualification. In the project units, evidence of your meta-skills development contributes to your grade.

HND Engineering enables you to progress to:

- other qualifications in Engineering or related areas
- further study, employment or training, such as a degree in engineering or a related discipline

Appendix 1: example case studies

3D printing case study

The term '3D printing' covers a wide range of processes and technologies that involve the production of parts and products in different materials. This form of manufacturing has been available for the past 35 years, but it is only in recent years that the main technologies have reduced to a cost that allows small companies and individuals to get involved.

What makes 3D printing different from traditional manufacturing processes can be summed up in two ways:

1. The printed parts are built layer-by-layer, allowing for complex shapes to be constructed, many of which could not have been made by conventional means.
2. Material is added rather than subtracted, moulded or cast, making the process less wasteful, and more efficient and cost-effective.

3D printing utilises a variety of concepts and techniques across many engineering disciplines. This range of topics includes:

- systems elements — for example, amplifiers, stepper motors, belt drives, control devices
- transducers — applications, principles of operation, standard output signals and their uses
- actuators — applications and principles of operation
- properties of materials used in the specification and design of related systems
- calculations of basic engineering quantities — for example, velocity, acceleration, force, energy, power
- system power sources — hydraulic, pneumatic and electrical
- sub-systems specifically related to 3D printing
- control principles
- open-loop, closed-loop, use of controllers
- control system responses — under-, over- and critically damped
- effects of proportional plus integral plus derivative control

Questions to help direct your studies

As you carry out your research, the following questions will help point you in the right direction:

- Systems can be electrically, pneumatically or hydraulically operated. What are the principles of each, and what are the advantages and disadvantages of each?
- Transducers convert a non-electrical quantity into an electrical signal. List the transducers described in the core units. What are typical applications of each?
- Before constructing a system, a great deal of thought must go into deciding which materials to use. For example, are they rigid, flexible, light, ductile, good conductors, good insulators, good in compression, good in tension? The characteristics of materials in manufacturing processes and during their service life are also major factors in choice of materials. Produce a list of materials identifying their properties and characteristics.
- Amplifiers are used to allow a small force or signal to drive or operate a large load. How is amplification achieved electrically, pneumatically and hydraulically?
- What is meant by open-loop control and closed-loop control? How can the responses of a system be modified to compensate for a change in input?
- Describe linear and angular movement and positioning through Cartesian and polar co-ordinate systems.

Wind turbine case study

As we become more aware of the adverse environmental effects of burning fossil fuels, there is an increasing trend towards developing less harmful methods of power generation. This trend is also driven by the realisation that the resources of coal and oil that we have become dependent on are finite, and eventually will no longer be available to meet our demands.

As an alternative means of generating power, renewable sources of energy are being utilised to produce power to meet our increasing demands. Renewable energy originates from sunlight, wind, tidal, geothermal and other natural sources, and is classed as 'renewable' since it may be either naturally replenished or sustained by actions such as replanting trees.

The development and installation of renewable power-generating systems may depend on a number of factors, such as the amount of power required, the geographical location or the local weather conditions. Scotland's coastline is 7332 miles long, which creates the opportunity for tidal and wave power generation. Coastline, inshore waters, and hilly or mountainous regions are also inherently windy, making many areas of Scotland suitable for siting wind turbines.

Wind turbines are becoming a familiar sight and can be found in cities, offshore and in rural areas. They may be installed as single units or in large numbers to form a wind farm, depending on the user's power requirements.

Turbines come in a wide variety of designs and power-generating capacities for use as supplementary domestic power sources; for small-scale power generation for farms, factories and community projects; and for large-scale commercial supply to the National Grid.

A wind turbine is an engineering system comprising mechanical, electrical and electromechanical sub-systems. The concepts of these systems relate to those introduced in the core units of HND Engineering, and involve applying the basic concepts and techniques to the branch of engineering you are studying. Specifically:

<Insert units or outcomes covered by this case study>

You need to access the internet to help you prepare. The main sources of information for this case study will be websites providing information on a range of topics as suggested below.

<Insert specific elements covered by this case study, such as:>

- system elements — amplifiers, rectifiers, generators, control devices
- transducers — applications, principles of operation, standard output signals and their uses
- actuators — applications, principles of operation
- properties of materials used in the specification and design of wind turbines
- calculations and descriptions of basic engineering quantities — velocity, acceleration, force, energy, power, power consumption
- system power sources — hydraulic, electrical, wind
- sub-systems related specifically to power generation systems
- control principles
- block diagrams and sketching of engineering systems and components
- open-loop, closed-loop, use of controllers
- control system response
- underdamping, overdamping and critical damping
- effects of three-term system control

Questions to help direct your studies

Below is a guide to topics, which may help to direct your research. It poses some questions and is intended to guide you towards relevant areas of information relating to the wind turbine case study.

As you carry out your research, the following questions will help point you in the right direction:

- What are the principles of operation of a wind-powered generation system, and what are the engineering quantities relating to such a system, along with the units of those quantities?

- Transducers convert a non-electrical quantity into an electrical signal. List the transducers described in the core units. What are typical applications of each in relation to wind turbines?
- Before constructing a system, a great deal of thought must go into deciding which materials to use. For example, are the materials rigid, flexible, heavy, light, ductile, good conductors, good insulators, good in compression, or good in tension? The characteristics of materials in manufacturing processes and during their service life are also major factors in choice of materials. Produce a list of materials, identifying their properties and characteristics that would be relevant to wind turbine component construction.
- What is meant by 'open-loop control' and 'closed-loop control'? How can the response of a system be modified to compensate for a change of input?

Hydroelectric power case study

The generation of electrical power from hydro sources is an indirect source of solar power. Solar radiation evaporates water from the seas and land. This heated water vapour rises, and as it rises, it cools and expands, eventually condensing to form clouds. When the resulting rain from the clouds falls on higher ground, it has gained potential energy as a result of the sun's input. Hydroelectric power is created by extracting some of this energy as the water flows back to the sea.

The resource of electricity is measured in kilowatt hours (kWh) for usage at a local level. Globally, it is expressed in terawatt hours (TWh) per year.

Around 25% of the 1.5 billion TWh of solar energy that hits Earth is consumed in the evaporation of water. Therefore, the water vapour in our atmosphere gives a very large store of renewable energy. However, most of this energy is not available to us, because as the water vapour condenses, most of the energy is released as heat in the atmosphere and radiates back into space. A very small percentage (0.06%) is retained by the precipitation that falls on mountains and hills.

The worldwide available resource of energy as water flows toward the sea has been estimated at 40 000 TWh per year. This is approximately 15 times the output of hydropower globally. The technical potential of hydropower that could be captured globally has been estimated at 15 000 TWh.

To harness some of this power, hydroelectric schemes must have two essential properties:

- an effective head (the height, H , through which the water falls)
- the flow rate (the number of cubic metres of water per second, Q)

The power carried by the water is roughly 10 times the product of these two quantities:

$$P(kWh) = 10 \times Q \times H$$

The electric power output is, of course, much less than this input.

Stored potential energy

When water is held at height it represents a stored energy, and can be considered as gravitational potential energy. Roughly 9.81 joules of energy input are needed to lift one kilogram vertically through one metre against the gravitational pull of the Earth. If M kilograms are raised through H metres, the stored potential energy in joules is represented as:

$$\text{Potential energy} = MgH \text{ (equation 1)}$$

g is the acceleration due to gravity, and is given a value of 9.81 ms^{-2} .

The above equation allows engineers to calculate the energy store represented by water held at a given height, providing they know the stored mass and the height (the available head).

Power, head and flow rate

To estimate the resource, the power available at any time is vitally important. The power, P , is the rate at which the energy is delivered (the number of joules per second). This depends on the flow rate of the falling water (the number of cubic metres per second, Q). The mass of a cubic metre of fresh water is 1000 kg, so the mass falling per second will be $1000 \times Q$. It then follows from equation 1 that:

$$P = 1000 \times Q \times g \times H$$

When estimating hydroelectric resources, engineers must take into account energy losses. In a real-life hydroelectric system, the water will lose some energy due to friction. Therefore, the effective head is less than the actual head. Sometimes, the effective head is no more than 75% of the actual height difference. Sometimes, it is as much as 95%.

There are also energy losses in the operating plant itself. At optimum conditions, a hydroelectric turbo-generator is a very efficient machine. It converts 95% to 97% of the input power into electrical output. However, the efficiency — the ratio of output power to input power — is always less than 100%.

Types of hydroelectric plant

Hydroelectric plants can range in capacity from 500 watts up to 10 000 megawatts.

They can be classified in different ways, including:

- the effective head of water
- the rated power output
- the type of turbine used
- the location and type of dam or reservoir

These factors are not independent of each other. The available head and output determine the type of plant.

Low, medium and high heads

A high head is usually recognised as an effective head of more than 100 metres and a low head less than 10 metres.

The low head dam, or barrage, maintains the head of water and also houses the plant. It sometimes has a lock for ships or a ladder run for salmon. These usually have low storage capacity and are dependent on the flow rate at the time of the year, or the prevailing weather. The large volume flow means the plant and associated civil engineering is large, leading to high construction costs.

The medium head is usually associated with large hydroelectric installations with a dam at a narrow point in the river valley. The large reservoir behind the dam is capable of supplying power, except in very prolonged dry conditions. The civil engineering costs are also very high.

The high head reservoir lies well above the outflow level and the penstock carrying the water may be cut through a mountain to reach the turbine. With a high head, the flow needed for a given power is much smaller than for a low-headed plant, so the turbines and generators are more compact. However, the long penstock adds to the cost, and the structure must be able to withstand the high pressures below the large depth of water.

The rated power output is dependent on flow rates and their variability. When calculating power, the local rainfall of the catchment area is taken into account. However, allowances must be made for evaporation, take-up by vegetation and leakage into the ground. Sometimes these factors can account for 75% of the original total. The preferred technique for estimating the power involves establishing the relationships between flow rate and either water depth or water speed at chosen points along the route.

As previously stated, the transfer of energy carried by the water into electrical energy is carried out by the turbo-generator. A turbo-generator is a rotating turbine driven by the water and is connected by a common shaft to the rotor of a generator.

Turbines come in many shapes and forms, and vary in size, with blades ranging from under 1 metre to 20 metres.

Francis turbines are the most common type used in medium-scale to large-scale plants. They can be used where the head is as low as 2 metres to as high as 300 metres. Francis turbines are radial flow turbines. The water flow is inwards, towards the centre. The turbine is submerged and can run with its axis horizontal or vertical. In medium-headed or high-headed turbines, the water flow is channelled through a scroll case. This is a curved tube that reduces in size like a snail shell. Guide vanes inside the scroll direct the water in towards the runner. The shape of the guide vanes is important in producing the smooth flow that leads to high efficiency. Francis turbines run most efficiently when the blade speed is only slightly less than the speed of the water on the blades.

Maintaining the correct speed and direction of the incoming water relative to the runner blades is important too, and this can sometimes lead to problems. If demand falls, the output power can be reduced by reducing the water flow. In a Francis turbine, this is done by turning the guide vanes. This requires a large torque force, which changes the angle at which the water hits the blades and reduces the efficiency.

The Francis turbine does have its limits. If the head is low, a large volume flow is needed for a given power. However, a low head also means low water speed, and these two factors mean a larger input area is required. This led to engineers looking

at and developing propeller-type turbines such as the Kaplan turbine. In the propeller turbine, the area in which the water enters is as large as possible. It covers the entire area swept by the blades. They are therefore suitable for very large volume flows and are used where the head is only a few metres. The advantage over radial-type turbines is that it is easier to improve its efficiency by varying the angle of the blades when the power demand changes. An important feature is that the optimum blade speed is greater than the water speed. This allows a rapid rate of rotation even with low water speeds.

For sites with heads above 250 metres, the Pelton wheel is the preferred turbine. It is essentially a wheel with a set of buckets around the rim. A high-speed jet of water, formed because of the high head hitting the edge between the buckets in turn and under optimum conditions, gives up almost all its kinetic energy. The power is varied by adjusting the jet size or deflecting the jet away from the wheel.

The Turgo or crossflow turbine is a variation on the Pelton wheel. The double cups of the Pelton wheel are replaced by shallower ones, with the water entering on one side and leaving on the other. Its ability to handle a larger volume of water than a Pelton wheel of similar diameter gives it an advantage for generation at medium heads.

Control systems and instrumentation

It is vitally important in modern generating stations to be able to control not just the large head of water, but also the generating equipment. Speeds, temperature, vibration and pressures within the turbine and generating sets must be constantly monitored by various sensors. Maintenance and calibration procedures of this equipment are rigorously controlled.

Because of the large water pressures, the sluice gates are operated hydraulically. The main hydraulic pressure and the open or closed positions of the gate are monitored by electrical pressure switches.

In modern generating stations, the use of these transducers has made the practice of running pressure lines over long distances to the control room unnecessary. It is extremely important at the station to measure the water level. Differential pressure

transducers can be sited locally, and by using a 4-20 mA control loop, the level can be monitored and controlled accurately. Some equipment, however, still uses voltage sensors, and these signals have to be signal-conditioned between the sensor and the control room.

As the turbine and generator run at high speeds, two of the most important control systems in a hydroelectric station are the speed of the generator, and the vibration and temperature analysis of the generator bearings. Removing either the turbine or generator to replace the bearings or rework the bearing housings is a large, time-consuming job that has an effect on the National Grid's capability and security. Other work done at this time would involve checking the integrity of the materials that the generator and the turbine are constructed from, and the various seals that protect the equipment from water entry.

To reduce downtime and prevent equipment failure, the speed of the generator is governed by a controller that takes into account the speed and torque from the head of water to proportionally control the electrical output.

The bearings are monitored constantly for vibration, adequate lubrication and, most importantly, temperature by sensors located in the bearing housings.

Administrative information

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History of changes

Version	Description of change	Date
1.0	<p>'Valid from' date on front cover updated to 'August 2026' and 'This qualification is available in a restricted delivery model' line deleted.</p> <p>On 1 February 2026, Qualifications Scotland replaced SQA as the new national awarding body. We have updated the logo and 'SQA' throughout the document to reflect this.</p> <p>What you need to do differently</p> <p>There is no change to learning, teaching and assessment.</p>	April 2026

Please check [our website](#) to ensure you are using the most up-to-date version of this unit.

If a unit is revised:

- no new centres can be approved to offer the previous version of the unit
- centres should only enter learners for the previous version of the unit if they can complete it before its finish date

For more information on NextGen: HN Qualifications please visit the [NextGen: HN web page](#).

Thank you to everyone who helped us develop this qualification. Your expertise, time and thoughtful input was invaluable.

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