Pearson BTEC
International Level 3 in

Green Energy

L3

Specification

First teaching from September 2026

Issue 1

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About Pearson

We are the world's leading learning company operating in countries all around the world. We provide content, assessment and digital services to students, educational institutions, employers, governments and other partners globally. We are committed to helping equip students with the skills they need to enhance their employability prospects and to succeed in the changing world of work. We believe that wherever learning flourishes so do people.

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All information in this specification is correct at time of publication.

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Welcome

With a track record built over 40 years of student success, our BTEC International Level 3 qualifications are recognised internationally by governments, industry and higher education. BTEC International Level 3 qualifications allow students to progress to the workplace – either directly or via study at a higher level. Over 100,000 BTEC students apply to university every year. Their Level 3 BTECs, either on their own or in combination with A Levels, are accepted by UK and international universities, and higher-education institutes for entry to relevant degree programmes.

Why are BTECs so successful?

BTECs embody a fundamentally student-centred approach to the curriculum, with a flexible, unit-based structure and knowledge applied through assignments. They enable the holistic development of the practical, interpersonal and thinking skills required to succeed in higher education and employment.

When creating these BTEC Internationals we focused on the skills and personal attributes needed to navigate the future, and have worked with many higher education providers, professional bodies, colleges and schools to ensure that their needs are met. Employers are looking for future employees with a thorough grounding in the latest industry requirements and work-ready skills such as critical thinking and problem solving. Higher education needs students who have experience of research, extended writing and meeting deadlines.

We have addressed these requirements by:

- Facilitating and guiding the development of transferable skills through the design and delivery of the qualifications, using a holistic and practical framework which is based on recent research into the most critical skills needed to navigate the future. This Transferable Skills framework has been used to embed transferable skills in the qualifications where they naturally occur and also to signpost opportunities for delivery and development as a part of the wider BTEC learning experience.
- Supporting the delivery of Sustainability Education and Digital Skills development naturally through the content design of the qualifications. Mapping is provided for each qualification to identify where the opportunities for teaching and learning exist.
- Updating sector-specific content to ensure it is relevant and future-facing.
- Implementing a consistent approach to assessment to better engage students, make the qualifications more accessible for them and more manageable for centres to deliver.

We are providing a wealth of support, both resources and people, to ensure that students and their teachers have the best possible experience during their course. See *Section 5* for details of the support we offer.

A word to students

Today’s BTEC Internationals will require commitment and hard work, as you would expect of the most respected applied learning qualification in the world. You will have to complete a range of units, be organised, take some assessments that we will set and your teachers will mark, and undertake practical tasks and assignments. But you can feel proud to achieve a BTEC because, whatever your plans in life – whether you decide to study further or go on to work – your BTEC International will be your passport to success in the next stage of your life.

Good luck and we hope you enjoy your course.

Contents

1 Introduction

Why choose Pearson BTEC International Level 3 Qualifications in Green Energy?

We’ve listened to feedback from all parts of the green energy subject community, including higher education. We’ve used this opportunity of curriculum change to redesign qualifications so that they reflect the demands of a truly modern and evolving energy environment – qualifications that enable your students to apply themselves and give them the skills to succeed in their chosen pathway.

The units focus on developing knowledge, understanding and practical skills relevant to green energy as applied to the modern world. Key features include hands-on research tasks, planning work and reflective practice. Assessments are varied and designed to test both technical proficiency and critical thinking. Evidence of achievement can be through written reports, presentations, peer reviews, and/or live demonstrations. Each unit encourages students to apply concepts to real-world scenarios, fostering deeper understanding. Assessment also emphasises communication, planning and evaluation, aligning with higher education and sector expectations.

Total Qualification Time

Pearson specifies a total number of hours that it is estimated students will require to complete and show achievement for the qualification: this is the Total Qualification Time (TQT). Within TQT, Pearson identifies the number of Guided Learning Hours (GLH) that we estimate a centre delivering the qualification might provide. Guided learning means activities, such as lessons, tutorials, online instruction, supervised study and giving feedback on performance, that directly involve teachers and assessors in teaching, supervising and invigilating students. Guided learning includes the time required for students to complete internal assessment under supervised conditions.

In addition to guided learning, other required learning directed by teachers or assessors will include private study, preparation for assessment, and undertaking assessment when not under supervision, such as preparatory reading, revision and independent research.

BTEC Internationals have been designed around the number of hours of guided learning expected. Each unit in the qualification has a GLH value of 60. There is then a total GLH value for the qualification.

Each qualification has a TQT value. This may vary within sectors and across the suite depending on the nature of the units in each qualification and the expected time for other required learning.

The following table shows the qualifications in this sector and their GLH and TQT values.

Qualification title	Size and structure	Summary purpose
Pearson BTEC International Level 3 Certificate in Green Energy	180 GLH (30 Credits) (380 TQT) Equivalent in size to 0.5 of an International A Level. Three units of which one is mandatory and assessed by a Pearson Set Assignment. Mandatory content (33%).	The Certificate is for students who want an introduction to the sector through applied learning and for whom an element of green energy would be complementary. The qualification supports progression to higher education as part of a programme of study that includes other appropriate BTEC International Level 3 qualifications or International A Levels.

Qualification title	Size and structure	Summary purpose
Pearson BTEC International Level 3 Extended Certificate in Green Energy	360 GLH (60 Credits) (775 TQT) Equivalent in size to one International A Level. Six units of which three are mandatory, two are assessed by a Pearson Set Assignment. Mandatory content (50%).	The Extended Certificate is for students who are interested in learning about the green energy industry alongside other fields of study, with a view to progressing to a wide range of higher education courses, not necessarily in energy-related subjects. The qualification is designed to be taken as part of a programme of study that includes other appropriate BTEC International Level 3 qualifications or International A Levels.
Pearson BTEC International Level 3 Foundation Diploma in Green Energy	540 GLH (90 Credits) (1175 TQT) Equivalent in size to 1.5 International A Levels. Nine units of which five are mandatory, three are assessed by a Pearson Set Assignment. Mandatory content (56%).	The Foundation Diploma is for students who want to study green energy as a one-year, full-time course, or for those wanting to take it alongside another area of complementary or contrasting study as part of a two-year, full-time study programme. The qualification would support progression to higher education if taken as part of a programme of study that included other BTEC International Level 3 qualifications or International A Levels.

Qualification title	Size and structure	Summary purpose
Pearson BTEC International Level 3 Diploma in Green Energy	720 GLH (120 Credits) (1570 TQT) Equivalent in size to two International A Levels. Twelve units of which seven are mandatory, five are assessed by a Pearson Set Assignment. Mandatory content (58%).	The Diploma is for students who want to study green energy as the main element alongside another area of complementary or contrasting study as part of a two-year, full-time study programme. The qualification would support progression to higher education if taken as part of a programme of study that included other BTEC International Level 3 qualifications or International A Levels.
Pearson BTEC International Level 3 Extended Diploma in Green Energy	1080 GLH (180 Credits) (2360 TQT) Equivalent in size to three International A Levels. Eighteen units of which eleven are mandatory, eight are assessed by a Pearson Set Assignment. Mandatory content (61%).	The Extended Diploma is a full-time course for students who want to study green energy as the main focus of a two-year, full-time study programme. The qualification would support progression to higher education in its own right. This qualification could also directly lead to employment in Level 3 roles in the energy sector or via higher-education energy or engineering courses.

Structures of the qualifications at a glance

This table shows all the units and the qualifications to which they contribute. The full structure for these Pearson BTEC International Level 3 Qualifications in Green Energy is shown in *Section 3 Structure*. **You must refer to the full structure to select units and plan your programme.**

Key

Pearson Set Assignment units are shown in bold

M	Mandatory units	O	Optional units

Unit	Unit size (GLH)	Certificate (180 GLH)	Extended Certificate (360 GLH)	Foundation Diploma (540 GLH)	Diploma (720 GLH)	Extended Diploma (1080 GLH)
1 Human Energy Use	60	M	M	M	M	M
2 Earth's Atmosphere, Water, Land and Life	60	O	M	M	M	M
3 Climate Change and Energy Policy	60	O	O	M	M	M
4 Principles of Sustainability	60	O	O	O	M	M
5 Scientific Principles for Energy Systems	60				M	M
6 Mathematics for Energy Technicians	60	O	O	O	O	M
7 Low or Zero Carbon Energy Systems	60	O	O	O	O	M
8 Advanced Mathematics for Energy Technicians	60	O	O	O	O	M
9 Technical and Graphical Drawing for Energy Systems	60		M	M	M	M
10 The Hydrogen Energy Economy	60			M	M	M
11 Renewable Energy Systems	60					M
12 Wind Energy Systems	60		O	O	O	O

Unit	Unit size (GLH)	Certificate (180 GLH)	Extended Certificate (360 GLH)	Foundation Diploma (540 GLH)	Diploma (720 GLH)	Extended Diploma (1080 GLH)
13 Hydroelectric and Marine Energy Systems	**60**		O	O	O	O
14 Biomass and Biofuel Energy Systems	**60**		O	O	O	O
15 Solar Thermal and Photovoltaic Energy Systems	**60**			O	O	O
16 Battery Energy Storage Systems	**60**			O	O	O
17 Smart Energy Systems and Building Efficiency	**60**			O	O	O
18 Low-Carbon Heating Technologies	**60**				O	O
19 Geothermal Energy Applications	**60**					O
20 Water Conservation and Management in Energy Systems	**60**					O
21 Energy Auditing and Consultancy Practices	**60**					O
22 Low and Zero Carbon Transport Systems	**60**					O

Qualification and unit content

Pearson has developed the content of the new BTEC Internationals in collaboration with representatives from higher education and relevant professional bodies. In this way, we have ensured that content is up to date and that it includes the knowledge, understanding, skills and attributes required in the sector.

Centres should ensure that delivery of content is kept up to date. Some of the units within the specification may contain references to legislation, policies, regulations and organisations, which may not be applicable in the country you deliver this qualification in, or which may have gone out-of-date during the lifespan of the specification. In these instances, it is possible to substitute such references with ones that are current and applicable in the country you deliver in, subject to confirmation by your Standards Verifier.

Assessment

Assessment is specifically designed to fit the purpose and objective of the qualification. It includes a range of assessment types and styles suited to vocational qualifications in the sector. All assessment is internal but some mandatory units have extra controls on assessment and are assessed using Pearson Set Assignments.

Pearson Set Assignment (PSA) units

Some units in these qualifications are assessed using a Pearson Set Assignment Brief (PSAB), which is set by Pearson and is marked by teachers. The teachers will make grading decisions based on the requirements and supporting guidance given in the units.

Pearson Set Assignment units are subject to external standards verification processes common to all BTEC units. By setting the assignment for some units, we can ensure that all students take the same set of assessments for a specific unit. For further information on preparing for Pearson Set Assignments, see the *Pearson BTEC International Level 3 Qualifications Supplementary Information* document which is available on our website.

Internally assessed units

All units in these qualifications are internally assessed and subject to external standards verification. In some units, Pearson will set the assessments using Pearson Set Assignments, which are marked by you. In other units, you set and assess the assignments that provide the final summative assessment for each unit, using the examples and support that Pearson provides. Before you assess you will need to become an approved centre, if you are not one already.

You will need to prepare to assess using the guidance in the *Pearson BTEC International Level 3 Qualifications Supplementary Information* document, which is available on our website.

For units where there is no Pearson Set Assignment, you select the most appropriate assessment styles according to the learning set out in the unit. This ensures that students are assessed using a variety of styles to help them develop a broad range of transferable skills. Students could be given opportunities to:

- write up the findings of their own research
- use case studies to explore complex or unfamiliar situations
- carry out projects for which they have choice over the direction and outcomes
- demonstrate practical and technical skills using appropriate tools/processes, etc.

For these units, Pearson will provide an Authorised Assignment Brief (AAB) that you can use.

You will make grading decisions based on the requirements and supporting guidance given in the units. Where a student has not achieved their expected level of performance for an assignment, they may be eligible for one resubmission of improved evidence for each assignment submitted if authorised by the Lead Internal Verifier.

To ensure any resubmissions are fairly and consistently implemented for all students, the Lead Internal Verifier can only authorise a resubmission if certain conditions are met. If the Lead Internal Verifier does authorise a resubmission, it must be completed within 15 working days of the student receiving the results of the assessment.

Feedback to students can only be given to clarify areas where they have not achieved expected levels of performance. Students cannot receive any specific guidance or instruction about how to improve work to meet assessment criteria or be given solutions to questions or problems in the tasks.

If a student has still not achieved the targeted pass criteria following the resubmission of improved evidence for an assignment, the Lead Internal Verifier may authorise, under exceptional circumstances, one retake opportunity to meet the required pass criteria. The retake can be of a task or subset of the assignment brief that is of evidence in a new or revised form. The deadline for submission of the retake must fall within the same academic year.

Language of assessment

Assessment of the units for these qualifications will be available in English but can be translated as necessary. A student taking the qualifications may be assessed in sign language where it is permitted for the purpose of reasonable adjustment.

For information on reasonable adjustments see the *Pearson BTEC International Level 3 Qualifications Specification Supplementary Information* document, which is available on our website.

Grading for units and qualifications

Achievement in a qualification requires a demonstration of depth of study in each unit, assured acquisition of a range of practical skills required for progression to higher education and successful development of transferable skills. Students achieving a qualification will have completed all units.

Units are assessed using a grading scale of Distinction (D), Merit (M), Pass (P) and Unclassified (U). All mandatory and optional units contribute proportionately to the overall qualification grade.

BTEC International qualifications are graded using a scale of P to D*, **or** PP to D*D*, **or** PPP to D*D*D* depending on the size of the qualification. Please see *Section 6* for more details. The relationship between qualification grading scales and unit grades will be subject to regular review as part of Pearson's standards monitoring processes on the basis of student performance and in consultation with key users of the qualification.

Preparing students for the future

Transferable skills

Recent future skills reports have highlighted the growing importance of transferable skills for students to succeed in their careers and lives in this fast-changing world.

Following research and consultation with FE educators and higher education institutions, Pearson has developed a Transferable Skills framework to facilitate and guide the development of transferable skills through these qualifications. The framework has four broad skill areas, each with a cluster of transferable skills as shown below:

1. **Managing yourself**: (1) Taking personal responsibility; (2) Personal strengths and resilience; (3) Career orientation planning; (4) Personal goal setting
2. **Effective learning**: (1) Managing own learning; (2) Continuous learning; (3) Secondary research skills; (4) Primary research skills
3. **Interpersonal skills**: (1) Written communication; (2) Verbal and non-verbal communications; (3) Teamwork; (4) Cultural and social intelligence
4. **Solving problems**: (1) Critical thinking; (2) Problem solving; (3) Creativity and innovation.

Each transferable skill has a set of descriptors that outline what achievement of the skill looks like in practice. Each unit in these qualifications will show whether a transferable skill has been:

1. Fully embedded through the design of the teaching and learning content and assessment of the unit. Skills that are embedded are 'naturally occurring' in that they are inherent to the unit content and do not require extension activities to deliver.
2. Signposted as an opportunity for delivery and development and would require extension activities to deliver.

Units will show a summary of the transferable skills that have been embedded or signposted and *Appendix 2* shows the descriptors for each skill across all the skill clusters.

More information on the framework, its design and relevance for student progression is available in the *BTEC Transferable Skills Guide for Teachers.*

Digital skills

Digital skills are required in every industry as well as in everyday life and, with the acceleration of automation and AI in industry, it is critical for students to understand how digital technologies are relevant and applied in the context of the sector they are studying.

With this in mind, we have used the *Digital Skills Framework* published by the Institute for Apprenticeships and Technical Education (IFATE) as a frame of reference to identify opportunities for the delivery and development of digital skills in this qualification.

The Digital Skills framework for these qualifications has five categories with specific digital characteristics that apply in varying extent across sectors:

1. **Problem solving** – The use of digital tools to analyse and solve problems
2. **Digital collaboration and communication** – Using digital tools to communicate and share information with stakeholders
3. **Transacting digitally** – Using digital tools to set up accounts and pay for goods/services
4. **Digital security** – Identify threats and keep digital tools safe
5. **Handling data safely and securely** – Follow correct procedures when handling personal and organisational data.

Opportunities to develop these digital skills are identified where they are relevant and appropriate to a sector, meaning:

- where they naturally occur
- where they add no assessment burden
- where they will enhance a student's skills and knowledge in the sector.

Appendix 3 shows a mapping of the teaching and learning content to the five categories of the framework to show where opportunities to develop these digital skills exist in these qualifications .

Sustainability skills

To help students develop sustainability skills, practices and mindset, we have designed content in these qualifications , aligned to the *UNESCO Sustainable Development Goals* (17 SDGs), that are relevant and appropriate to the sector. The SDGs are the most common point of reference for content that addresses sustainability and provides a useful and pragmatic way of organising this content.

Sustainability knowledge and understanding may be included in the teaching and learning content but not directly assessed. Alternatively, it could be assessed – the approach chosen for each unit is based on the relevance of the sustainability skills, knowledge or understanding to the purpose and scope of the unit.

Appendix 4 shows a mapping of the teaching and learning content to the relevant SDGs to show where sustainability has been included in these qualifications .

2 Qualification purpose

Pearson BTEC International Level 3 Qualifications in Green Energy

In this section, you will find information on the purpose of these qualifications and how their design meets that purpose through the qualifications' objectives and structures.

Who are these qualifications for?

The Pearson BTEC International Level 3 qualifications in green energy are designed either for students in the 16–19 age group, who wish to pursue a career in green energy via higher education to access graduate entry employment with businesses, or alternatively through junior employment.

The units demonstrate innovation by integrating scientific principles, digital systems and real-world technologies with data-driven analysis and sustainable systems thinking. They connect foundational theory to practical application, emphasising sustainability, emerging technologies and interdisciplinary problem solving, enabling students to design, evaluate and optimise low-carbon energy solutions within evolving energy scenarios.

Which size qualification to choose?

Choosing the most suitable size of qualification will depend on the student's broader programme of study. For example, a student who wishes to focus solely on green energy may take the Diploma or Extended Diploma, while a student who selects a smaller qualification, such as the Certificate or Extended Certificate, may choose to combine it with qualifications from other sectors, to support their desired progression. Smaller qualifications are also suitable for students who are in employment and studying part-time.

Qualification structures have been designed to enable a student who starts with the smallest qualification to progress easily to the larger qualifications.

What do these qualifications cover?

The content of these qualifications has been designed to support progression to particular roles in green energy, either directly into entry-level roles linked to these occupational areas or, more likely, via particular higher-education routes in the particular areas. The qualification content has been designed in consultation with employers, professional bodies and higher-education providers to ensure that the content is appropriate for the progression routes identified.

All students will be required to take mandatory content that is directly relevant to progression routes in all of the identified areas.

In addition, students take optional units that support the progression route identified in the qualification title. For example, students taking the qualification as part of a work-based learning qualification for energy consultancy could take units such as:

- Unit 7: Low or Zero Carbon Energy Systems
- Unit 11: Renewable Energy Systems
- Unit 21: Energy Auditing and Consultancy Practices.

Students looking to follow an engineering route could take units such as:

- Unit 5: Scientific Principles for Energy Systems
- Unit 6: Mathematics for Energy Technicians
- Unit 7: Low or Zero Carbon Energy Systems.

Students looking to follow a specialist technology route could take units such as:

- Unit 5: Scientific Principles for Energy Systems
- Unit 9: Technical and Graphical Drawing for Energy Systems
- Unit 18: Low-Carbon Heating Technologies.

What could these qualifications lead to?

These qualifications support progression to job opportunities in green energy at a variety of levels. Jobs available in these areas could include:

- Climate Scientist
- Compliance Manager
- Energy Consultant
- Renewable Energy Engineer
- Sustainability Analyst
- Wind/Solar Technician.

After achieving this qualification, while students can progress directly to entry-level roles, it is likely that many will do so via higher study. These qualifications are recognised by higher education institutions worldwide and provides students with opportunities to progress into further and higher study across various areas within the green energy sector.

For example:

- Pearson BTEC Higher Nationals in Engineering (Electrical or Mechanical)
- BSc (Hons) in Energy Engineering / Renewable Energy Engineering
- BSc (Hons) in Building Services Engineering / Environmental Engineering.

NB: students should always check the entry requirements for degree programmes with the relevant higher education provider.

3 Structure

Qualification structures

The structures for the qualifications in this specification are:

- Pearson BTEC International Level 3 Certificate in Green Energy (180 GLH)
- Pearson BTEC International Level 3 Extended Certificate in Green Energy (360 GLH)
- Pearson BTEC International Level 3 Foundation Diploma in Green Energy (540 GLH)
- Pearson BTEC International Level 3 Diploma in Green Energy (720 GLH)
- Pearson BTEC International Level 3 Extended Diploma in Green Energy (1080 GLH).

Pearson BTEC International Level 3 Certificate in Green Energy (180 GLH)

Students must complete one mandatory unit and two optional units.

See *Section 6* for rules on qualification awarding.

Mandatory unit – students complete and achieve unit

Unit number	Unit title	GLH	Type	How assessed
1	Human Energy Use	**60**	**Mandatory**	Set Assignment

Optional units – students complete 2 units

Unit number	Unit title	GLH	Type	How assessed
2	Earth's Atmosphere, Water, Land and Life	**60**	**Optional**	Set Assignment
3	Climate Change and Energy Policy	**60**	**Optional**	Set Assignment
4	Principles of Sustainability	**60**	**Optional**	Set Assignment
6	Mathematics for Energy Technicians	**60**	**Optional**	Set Assignment

Unit number	Unit title	GLH	Type	How assessed
7	Low or Zero Carbon Energy Systems	**60**	**Optional**	Set Assignment
8	Advanced Mathematics for Energy Technicians	**60**	**Mandatory**	Set Assignment

Pearson BTEC International Level 3 Extended Certificate in Green Energy (360 GLH)

Students must complete three mandatory units and three optional units.

See *Section 6* for rules on qualification awarding.

Mandatory units – students complete and achieve all units

Unit number	Unit title	GLH	Type	How assessed
1	Human Energy Use	**60**	**Mandatory**	Set Assignment
2	Earth's Atmosphere, Water, Land and Life	**60**	**Mandatory**	Set Assignment
9	Technical and Graphical Drawing for Energy Systems	**60**	**Mandatory**	Internal

Optional units – students complete 3 units

Unit number	Unit title	GLH	Type	How assessed
3	Climate Change and Energy Policy	**60**	**Optional**	Set Assignment
4	Principles of Sustainability	**60**	**Optional**	Set Assignment
6	Mathematics for Energy Technicians	**60**	**Optional**	Set Assignment
7	Low or Zero Carbon Energy Systems	**60**	**Optional**	Set Assignment
8	Advanced Mathematics for Energy Technicians	**60**	**Optional**	Set Assignment
12	Wind Energy Systems	**60**	**Optional**	Internal
13	Hydroelectric and Marine Energy Systems	**60**	**Optional**	Internal
14	Biomass and Biofuel Energy Systems	**60**	**Optional**	Internal

Pearson BTEC International Level 3 Foundation Diploma in Green Energy (540 GLH)

Students must complete five mandatory units and four optional units.

See *Section 6* for rules on qualification awarding.

Mandatory units – students complete and achieve all units

Unit number	Unit title	GLH	Type	How assessed
1	Human Energy Use	**60**	**Mandatory**	Set Assignment
2	Earth's Atmosphere, Water, Land and Life	**60**	**Mandatory**	Set Assignment
3	Climate Change and Energy Policy	**60**	**Mandatory**	Set Assignment
9	Technical and Graphical Drawing for Energy Systems	**60**	**Mandatory**	Internal
10	The Hydrogen Energy Economy	**60**	**Mandatory**	Internal

Optional units – students complete 4 units

Unit number	Unit title	GLH	Type	How assessed
4	Principles of Sustainability	**60**	**Optional**	Set Assignment
6	Mathematics for Energy Technicians	**60**	**Optional**	Set Assignment
7	Low or Zero Carbon Energy Systems	**60**	**Optional**	Set Assignment
8	Advanced Mathematics for Energy Technicians	**60**	**Optional**	Set Assignment
12	Wind Energy Systems	**60**	**Optional**	Internal
13	Hydroelectric and Marine Energy Systems	**60**	**Optional**	Internal

Unit number	Unit title	GLH	Type	How assessed
14	Biomass and Biofuel Energy Systems	**60**	**Optional**	Internal
15	Solar Thermal and Photovoltaic Energy Systems	**60**	**Optional**	Internal
16	Battery Energy Storage Systems	**60**	**Optional**	Internal
17	Smart Energy Systems and Building Efficiency	**60**	**Optional**	Internal

Pearson BTEC International Level 3 Diploma in Green Energy (720 GLH)

Students must complete 7 mandatory units and five optional units.

See *Section 6* for rules on qualification awarding.

Mandatory units – students complete and achieve all units

Unit number	Unit title	GLH	Type	How assessed
1	Human Energy Use	60	**Mandatory**	Set Assignment
2	Earth's Atmosphere, Water, Land and Life	60	**Mandatory**	Set Assignment
3	Climate Change and Energy Policy	60	**Mandatory**	Set Assignment
4	Principles of Sustainability	60	**Mandatory**	Set Assignment
5	Scientific Principles for Energy Systems	60	**Mandatory**	Set Assignment
9	Technical and Graphical Drawing for Energy Systems	60	**Mandatory**	Internal
10	The Hydrogen Energy Economy	60	**Mandatory**	Internal

Optional units – students complete 5 units

Unit number	Unit title	GLH	Type	How assessed
6	Mathematics for Energy Technicians	60	**Optional**	Set Assignment
7	Low or Zero Carbon Energy Systems	60	**Optional**	Set Assignment
8	Advanced Mathematics for Energy Technicians	60	**Optional**	Set Assignment
12	Wind Energy Systems	60	**Optional**	Internal
13	Hydroelectric and Marine Energy Systems	60	**Optional**	Internal

Unit number	Unit title	GLH	Type	How assessed
14	Biomass and Biofuel Energy Systems	**60**	**Optional**	Internal
15	Solar Thermal and Photovoltaic Energy Systems	**60**	**Optional**	Internal
16	Battery Energy Storage Systems	**60**	**Optional**	Internal
17	Smart Energy Systems and Building Efficiency	**60**	**Optional**	Internal
18	Low-Carbon Heating Technologies	**60**	**Optional**	Internal

Pearson BTEC International Level 3 Extended Diploma in Green Energy (1080 GLH)

Students must complete 11 mandatory units and seven optional units.

See *Section 6* for rules on qualification awarding.

Mandatory units – students complete and achieve all units

Unit number	Unit title	GLH	Type	How assessed
1	Human Energy Use	**60**	**Mandatory**	Set Assignment
2	Earth's Atmosphere, Water, Land and Life	**60**	**Mandatory**	Set Assignment
3	Climate Change and Energy Policy	**60**	**Mandatory**	Set Assignment
4	Principles of Sustainability	**60**	**Mandatory**	Set Assignment
5	Scientific Principles for Energy Systems	**60**	**Mandatory**	Set Assignment
6	Mathematics for Energy Technicians	**60**	**Mandatory**	Set Assignment
7	Low or Zero Carbon Energy Systems	**60**	**Mandatory**	Set Assignment
8	Advanced Mathematics for Energy Technicians	**60**	**Mandatory**	Set Assignment
9	Technical and Graphical Drawing for Energy Systems	**60**	**Mandatory**	Internal
10	The Hydrogen Energy Economy	**60**	**Mandatory**	Internal
11	Renewable Energy Systems	**60**	**Mandatory**	Internal

Optional units – students complete 7 units

Unit number	Unit title	GLH	Type	How assessed
12	Wind Energy Systems	**60**	**Optional**	Internal
13	Hydroelectric and Marine Energy Systems	**60**	**Optional**	Internal
14	Biomass and Biofuel Energy Systems	**60**	**Optional**	Internal
15	Solar Thermal and Photovoltaic Energy Systems	**60**	**Optional**	Internal
16	Battery Energy Storage Systems	**60**	**Optional**	Internal
17	Smart Energy Systems and Building Efficiency	**60**	**Optional**	Internal
18	Low-Carbon Heating Technologies	**60**	**Optional**	Internal
19	Geothermal Energy Applications	**60**	**Optional**	Internal
20	Water Conservation and Management in Energy Systems	**60**	**Optional**	Internal
21	Energy Auditing and Consultancy Practices	**60**	**Optional**	Internal
22	Low and Zero-Carbon Transport Systems	**60**	**Optional**	Internal

Pearson Set Assignment units

This is a summary of the type and availability of Pearson Set Assignment units. For further information on preparing for Pearson Set Assignments, see the *Pearson BTEC International Level 3 Qualifications Supplementary Information* document which is available on our website.

Unit	Type	Availability
Unit 1: Human Energy Use	An assignment set by Pearson and marked by the centre. The advised period is 10 hours.	**Single PSA**
Unit 2: Earth's Atmosphere, Water, Land and Life	An assignment set by Pearson and marked by the centre. The advised period is 8 hours.	**Single PSA**
Unit 3: Climate Change and Energy Policy	An assignment set by Pearson and marked by the centre. The advised period is 5 hours.	**Single PSA**
Unit 4: Principles of Sustainability	An assignment set by Pearson and marked by the centre. The advised period is 9 hours.	**Bank PSA**
Unit 5: Scientific Principles for Energy Systems	An assignment set by Pearson and marked by the centre. The advised period is 20 hours.	**Single PSA**
Unit 6: Mathematics for Energy Technicians	An assignment set by Pearson and marked by the centre. The advised period is 6 hours.	**Single PSA**
Unit 7: Low or Zero Carbon Energy Systems	An assignment set by Pearson and marked by the centre. The advised period is 10 hours.	**Bank PSA**
Unit 8: Advanced Mathematics for Energy Technicians	An assignment set by Pearson and marked by the centre. The advised period is 4 hours.	**Single PSA**

4 Units

Understanding your units

The units in this specification set out our expectations of assessment in a way that helps you to prepare your students for assessment. The units help you to undertake assessment and quality assurance effectively.

This section explains how the units work. It is important that all teachers, assessors, internal verifiers and other staff responsible for the programme review this section.

Section	Explanation
Unit number	The number is in a sequence in the sector. Numbers may not be sequential for an individual qualification.
Unit title	This is the formal title that we always use and it appears on certificates.
Unit level	All units are at Level 3.
Unit type	This confirms that the unit is internal or assessed using a Pearson Set Assignment. See structure information in *Section 3 Structure* for full details.
GLH	Units have a Guided Learning Hours (GLH) value of 60. This indicates the numbers of hours of teaching, directed activity and assessment expected. It also shows the weighting of the unit in the final qualification grade.
Unit in brief	A brief formal statement on the content of the unit that is helpful in understanding its role in the qualification. You can use this in summary documents, brochures, etc.
Unit introduction	This is designed with students in mind. It indicates why the unit is important, how learning is structured, and how learning might be applied when progressing to employment or higher education.
Learning aims	These help to define the scope, style and depth of learning of the unit. You can see where students should be learning standard requirements ('understand') or where they should be actively researching ('investigate'). You can find out more about the verbs we use in learning aims in *Appendix 1*.

Section	Explanation
Summary of unit	This helps you to see the main content areas against the learning aims and the structure of the assessment at a glance.
Content	This sets out the required teaching content of the unit. Content is compulsory except where shown as 'e.g.'. Students should be asked to complete summative assessment only after the teaching content for the unit or learning aim(s) has been covered.
Assessment criteria	Each learning aim has Pass and Merit criteria. Each assignment has at least one Distinction criterion. A full glossary of terms used is given in *Appendix 1*. Distinction criteria represent outstanding performance in the unit. Some criteria require students to draw together learning from across the learning aims.
Transferable skills	This summarises the transferable skills present within the unit. The key helps to identify whether they are signposted but require additional assessment, embedded and achieved on completion, or not present in the unit.
Essential information for Pearson Set Assignment Brief (PSAB)	This shows a brief summary of the activities required for the mandatory Pearson Set Assignment Brief (PSAB). Centres must download and use the mandatory PSAB without alteration or contextualisation.
Essential information for assignments	This section gives you information to support the implementation of assessment. It is important that this is read carefully alongside the assessment criteria, as the information will help with interpretation of the requirements.
Further information for teachers and assessors	This gives you information to support the implementation of assessment. It is important that this is used carefully alongside the assessment criteria and assignment.
Resource requirements	Any specific resource requirements that you need to be able to teach and assess are listed in this section.
Essential information for assessment decisions	This information gives guidance for each learning aim or assignment of the expectations for Pass, Merit and Distinction standard. This section contains examples and essential clarification.

Section	Explanation
Links to other units	This shows you the main relationship between units. This can help you to structure your programme and make best use of materials and resources.

Index of units

Unit 1: Human Energy Use

Level: 3

Unit type: Pearson Set Assignment

Guided learning hours: 60

Unit in brief

Students explore how energy use has developed throughout human history and the future challenge of meeting the energy needs for an increasing human population.

Unit introduction

The development of human civilisation is closely linked to our ability to use energy. The rapid development of energy sources, since the start of the Industrial Revolution around 1750, has transformed how billions of people live their daily lives. This has changed how we communicate, travel, cool and heat our homes. More people are gaining access to these energy supplies every year.

In this unit, you will learn about the development of energy types and uses throughout human history. You will develop an understanding of the challenges in meeting the increasing energy needs of a human population predicted to reach at least 10 billion by the year 2100. This challenge needs to be understood in the context of environmental changes arising from the use of fossil fuels.

The knowledge and understanding covered in this unit will help students progress to higher education and professional qualifications, either in energy or another sector. It will also help students to progress to employment in the energy sector.

Learning aims

In this unit you will:

A Explore how energy use and technology have developed throughout human history

B Examine human energy use in the 21st century

C Understand the challenge of meeting future increasing human population energy needs.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Explore how energy use and technology have developed throughout human history	**A1** From the discovery of fire to the early fossil fuel era **A2** The power of electricity **A3** The late fossil fuel era (the Age of Oil) **A4** Nuclear power and renewable energy	This unit is assessed through a Pearson Set Assignment.
B Examine human energy use in the 21st century	**B1** What do we use energy for? **B2** How much energy do we use? **B3** The energy mix	
C Understand the challenge of meeting future increasing human population energy needs	**C1** Predicting future energy needs **C2** New technology **C3** Energy efficiency	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Explore how energy use and technology have developed throughout human history

A1 From the discovery of fire to the early fossil fuel era

- Early humans and the discovery of fire.
- Capturing the sun's energy via photosynthesis:
    - hunter-gatherers
    - agriculture.
- Harnessing the power of animals. The plough and other agricultural tools.
- Wind and water power. The use of windmills and watermills.
- Charcoal use for iron production.
- The use of coal and the development of the steam engine.

A2 The power of electricity

- Static electricity.
- Alessandro Volta and the battery.
- Michael Faraday and electromagnetic induction.
- The electric motor and the electric generator.
- Thomas Edison and the public supply of electricity.
- How electricity can be used in work and leisure, e.g. machines to milk cows.

A3 The late fossil fuel era (the Age of Oil)

- Oil as fuel (petroleum).
- Natural gas.
- Oil and the chemical industry (fertiliser, synthetic drugs, paint and plastics).

A4 Nuclear power and renewable energy

- Nuclear fission.
- Renewable energy:
    - solar
    - wind
    - hydropower
    - ocean energy (tides and waves)
    - geothermal
    - biomass.

Learning aim B: Examine human energy use in the 21st century

B1 What do we use energy for?

- Transportation (road vehicles, aeroplanes, trains and shipping).
- Buildings (heating, cooling, lighting and appliances).
- Industry/manufacturing (machinery and factory production).
- Electricity generation.
- Agriculture (food production, including irrigation systems and farm equipment), which provides the chemical energy (food) that humans need to survive.

B2 How much energy do we use?

- Current global energy use.
- Energy use by country. How does per capita energy consumption data vary between developed and developing countries?

B3 The energy mix

- Why do we use different types of energy?
- Global trends in our energy mix.
- The evolution of energy mixes over time. The balance between non-renewable (coal, oil, natural gas) and renewable energy sources.
    - energy output and reliability (e.g. energy supply, generation risks, output efficiency)
    - economic drivers
    - environmental impact (e.g. high/low emissions, habitat risk, air pollution)
    - resource availability (e.g. availability, ease of supply, dependency risk)
    - long-term sustainability (e.g. climate resilience, transition to low carbon, intergenerational energy).
- Health and safety, ethical and social considerations (e.g. worker welfare, community impacts, energy equity and access).

Learning aim C: Understand the challenge of meeting future increasing human population energy needs

C1 Predicting future energy needs

The factors affecting future energy needs. These include:

- Human population growth.
- Data centres and artificial intelligence (AI): electricity consumption from data centres is projected to reach 3% of global electricity demand by 2030.
- Electrification: electric vehicles and heat pumps are significant drivers of increasing electricity demand.

- Industrial growth: the rise in industrial production and improved living standards are key drivers of energy consumption.
- Weather volatility: extreme temperature conditions require additional energy for heating or cooling.

C2 New technology

- Advanced solar technologies, including floating solar farms.
- Energy storage and grid solutions (new battery technology and smart grids with AI management).
- Green hydrogen.
- Bioenergy with carbon capture.
- Advanced wind energy (floating wind turbines and vertical-axis wind turbines).
- Next-generation nuclear (small modular reactors).
- Nuclear fusion.

C3 Energy efficiency

Key technological innovations to increase energy efficiency:

- Electrification and heat pumps.
- Electric vehicles (EVs).
- Smart digitalisation to enable real-time energy management, optimising consumption in homes, industries and commercial buildings.
- Industrial efficiency and hydrogen solutions.
- Data centre efficiency: as AI accelerates demand, focus is increasing on efficient cooling and computing infrastructure to manage electricity consumption.

Assessment criteria

Learning aim A: Explore how energy use and technology have developed throughout human history

Learning aim B: Examine human energy use in the 21st century

Pass	Merit	Distinction
A.P1 Describe the evolution of human energy use from the origins of humans until the start of the Industrial Revolution. **A.P2** Describe the technological advances in energy production and usage since the start of the Industrial Revolution.	**A.M1** Explain how the technological advances in energy production since the start of the Industrial Revolution have changed how energy is used.	**AB.D1** Evaluate the advantages and disadvantages of three contrasting energy technologies.
B.P3 Describe the main uses of energy in the 21st century. **B.P4** Compare costs and benefits of energy types in use in the 21st century.	**B.M2** Explain current human energy use and the types of energy being used around the world in the 21st century.	

Learning aim C: Understand the challenge of meeting future increasing human population energy needs

Pass	Merit	Distinction
C.P5 Explain the factors that may affect human energy use in the future. **C.P6** Examine new technologies that may provide renewable energy in the future. **C.P7** Review energy efficiency technologies that may reduce overall energy use in the future.	**C.M3** Explore the factors that may affect human energy use in the future. **C.M4** Review the potential benefits of new technologies in meeting our future energy needs.	**C.D2** Examine factors that will affect human ability to meet our future energy needs.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for Pearson Set Assignment (PSA)

Pearson sets the assignment for the assessment of this unit.

The PSA will take 12 hours to complete.

The PSA will be marked by centres and verified by Pearson.

The PSA will be valid for the lifetime of this qualification.

Assessing the PSA

You will make assessment decisions for the PSA using the assessment criteria provided.

The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on PSAs. There is also further information on our website.

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aims A and B

For distinction standard, students show a balanced consideration of contrasting energy technologies, including historical and modern examples, with advantages and disadvantages clearly linked to efficiency, availability, environmental impact and social need. Students integrate global energy-use data, trends in the energy mix and examples from different regions to support their judgements. They compare technologies and systems rather than describing them in isolation and justify conclusions using evidence from the unit content. Writing is coherent and analytical, demonstrating depth of understanding and the ability to weigh competing factors when considering how energy use has evolved and how it currently operates on a global scale.

For merit standard, students provide clear explanations of how developments in energy technology have changed both the way energy is produced and how it is used. Evidence moves beyond description and shows logical links between technological advances such as electrification, oil use and modern renewables and changes in lifestyles, industry and global energy demand. Students explain patterns in current energy use using relevant examples and data, including differences in per capita consumption and variations in national energy mixes. They demonstrate understanding of trends, such as increased electrification and the gradual shift toward renewable sources. Responses are well organised, use appropriate terminology and show cause-and-effect reasoning rather than simple recall of content.

For pass standard, students include clear descriptions of how human energy use has changed over time, from early biomass and animal power through fossil fuels, electricity and modern energy systems. Students show understanding of major historical developments and can outline key uses of energy in the 21st century such as transport, buildings, industry and electricity generation. They use basic global data or examples to show awareness that energy use varies between countries and over time. Evidence remains largely descriptive, but is factually correct and appropriately sequenced. Students correctly recall different renewable and non-renewable energy types in the global energy mix and show that they identify their basic roles without detailed analysis of implications or consequences.

Learning aim C

For distinction standard, students examine future energy needs holistically, drawing together demand drivers, technological innovation and efficiency strategies to reach reasoned conclusions. Evidence demonstrates the critical need to consider whether emerging technologies and efficiency measures can realistically deliver sufficient, reliable and sustainable energy for a growing global population. Students address uncertainty such as technological readiness, resource constraints, infrastructure requirements and social acceptance. They consider different approaches, for example, between increased electricity generation and demand reduction through efficiency. Judgements are supported by well-chosen examples, and responses show an integrated understanding of the complexity involved in meeting future global energy demand.

For merit standard, students explore the future energy challenge by linking demand drivers with potential technological and efficiency-based solutions. Evidence shows awareness of how factors such as data centres, electrification of transport and heating and climate-related temperature extremes interact to increase energy demand. Students review the potential benefits of new technologies, considering feasibility, scalability and contribution to decarbonisation rather than listing features alone. Energy-efficiency measures are discussed in terms of impact on overall consumption rather than individual devices. Responses demonstrate structured reasoning, use relevant examples and show an ability to weigh opportunities and limitations when considering how future energy needs might be addressed.

For pass standard, students show understanding of population growth, electrification, industrial development and changing lifestyles as drivers of increased energy consumption. They describe a range of emerging energy technologies, such as advanced solar, wind, nuclear or hydrogen, and outline how these could contribute to future supply. They also identify energy-efficiency measures, including heat pumps, electric vehicles and digital energy management, explaining in basic terms how these can reduce demand. Responses are structured and accurate but remain largely indicative, with limited consideration of scale, uncertainty or interconnections between supply, demand and efficiency.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in most units.

Unit 2: Earth's Atmosphere, Water, Land and Life

Level: 3

Unit type: Pearson Set Assignment

Guided learning hours: 60

Unit in brief

Students explore interactions between atmosphere, water, land and living systems, developing an understanding of climate, resources and ecosystems. They apply scientific principles to interpret Earth processes in real contexts.

Unit introduction

This unit is relevant to the real world as it enables students to understand how Earth's natural systems operate and interact within current environmental and climate challenges. By studying atmosphere, water, land and living systems, students gain the scientific knowledge needed to interpret climate change, water security, energy use and ecosystem sustainability, supporting informed decision-making as global citizens.

The unit covers the four Earth systems in depth and breadth. You will explore atmospheric structure and climate processes; the hydrological cycle and water availability; lithospheric structure and geothermal processes; and the biosphere organisation and ecosystem interactions. Content integrates physical, environmental and biological science, supported by data analysis, diagrams and applied examples to develop a coherent system-level understanding.

Completion of the unit supports progression to further learning in environmental science, geography, earth science, sustainability and energy-related qualifications. It also provides a strong foundation for careers linked to environmental monitoring, renewable energy, water management, planning, conservation and climate-related industries, where systems thinking and scientific literacy are essential.

Learning aims

In this unit you will:

A Know atmosphere and climate systems

B Understand hydrosphere and water cycles

C Know lithosphere and geothermal processes

D Understand biosphere and ecosystem interactions.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Know atmosphere and climate systems	**A1** Atmospheric structure and composition **A2** Energy balance and heat transfer **A3** Weather and climate processes **A4** Climate systems and change	This unit is assessed through a Pearson Set Assignment.
B Understand hydrosphere and water cycles	**B1** Distribution of Earth's water **B2** The hydrological cycle **B3** Water movement and storage **B4** Water quality and availability	
C Know lithosphere and geothermal processes	**C1** Structure of the Earth **C2** Plate tectonics **C3** Geothermal processes **C4** Geothermal energy	
D Understand biosphere and ecosystem interactions	**D1** The biosphere **D2** Ecosystem structure and function **D3** Biogeochemical cycles **D4** Ecosystem stability and change	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Know atmosphere and climate systems

The structure, composition and behaviour of Earth’s atmosphere and its role in regulating weather and climate.

A1 Atmospheric structure and composition

- Layers of the atmosphere: troposphere, stratosphere, mesosphere, thermosphere.
- Typical altitude ranges (km):
    - troposphere (0–12)
    - stratosphere (12–50)
    - mesosphere (50–85)
    - thermosphere (>85).
- Gaseous composition (% by volume):
    - nitrogen (~78)
    - oxygen (~21)
    - argon (~0.9)
    - carbon dioxide (~0.04)
    - variable water vapour (0–4).

A2 Energy balance and heat transfer

- Incoming solar radiation, reflected radiation, absorbed energy.
- Albedo and surface variation (ice, water, vegetation, urban surfaces).
- Heat transfer mechanisms: radiation, conduction, convection.

A3 Weather and climate processes

- Short-term weather versus long-term climate patterns.
- Air pressure systems, prevailing winds, jet streams.
- Cloud formation, precipitation types, fronts and air masses.

A4 Climate systems and change

- Natural climate drivers: solar variation, volcanic activity, orbital cycles.
- Anthropogenic drivers: greenhouse gas emissions, land-use change.
- Greenhouse gases and why their relative longevity in atmosphere is key: CO_2 (ppm scale ~280 pre-industrial to >420 present), methane, nitrous oxide.
- Climate impacts: temperature rise (°C), sea-level change (mm/year), extreme weather frequency, examples of past climate emergencies linked to human health e.g. acid rain.

Learning aim B: Understand hydrosphere and water cycles

Earth's water distribution, movement and importance to physical and human systems.

B1 Distribution of Earth's water

- Saltwater versus freshwater proportions (%): ~97% saltwater, ~3% freshwater.
- Freshwater stores: ice caps/glaciers, groundwater, surface water.
- Indicative availability: <1% readily accessible freshwater.

B2 The hydrological cycle

- Processes: evaporation, transpiration, condensation, precipitation, infiltration, runoff.
- Water residence times:
  - atmosphere (days)
  - rivers (weeks)
  - groundwater (years–millennia).

B3 Water movement and storage

- Surface flow, groundwater flow, aquifers and recharge zones.
- Watersheds and drainage basins at local and global scales.

B4 Water quality and availability

- Physical, chemical and biological water quality indicators (e.g. turbidity, pH 6–8, dissolved oxygen mg/L).
- Human pressures: abstraction, pollution, climate variability.
- Water scarcity concepts: physical versus economic scarcity.

Learning aim C: Know lithosphere and geothermal processes

The structure of the solid Earth and internal heat-driven processes.

C1 Structure of the Earth

- Crust, mantle, outer core, inner core.
- Thickness ranges (km):
  - crust (5–70)
  - mantle (~2,900)
  - core (~3,500).
- Rock types: igneous, sedimentary, metamorphic.

C2 Plate tectonics

- Plate boundaries: convergent, divergent, transform.
- Plate movement rates (cm/year): ~2–10.
- Associated features: earthquakes, volcanoes, mountain building.

C3 Geothermal processes

- Earth’s internal heat sources: radioactive decay, residual formation heat.
- Geothermal gradient (°C/km): typically 25–30.
- Geothermal features: hot springs, geysers, magma chambers.

C4 Geothermal energy

- Low-, medium- and high-enthalpy resources.
- Indicative temperature ranges: low (<90°C), medium (90–150°C), high (>150°C).
- Environmental and land-use considerations (land footprint and surface disturbance, water use and contamination risk, induced seismicity, local ecosystem and biodiversity impacts).

Learning aim D: Understand biosphere and ecosystem interactions

Living systems and their interactions with physical Earth systems.

D1 The biosphere

- Definition and global distribution of life.
- Links between biosphere, atmosphere, hydrosphere and lithosphere.

D2 Ecosystem structure and function

- Biotic and abiotic components.
- Trophic levels: producers, consumers, decomposers.
- Energy transfer between trophic levels (≈10% efficiency).

D3 Biogeochemical cycles

- Carbon, nitrogen and water cycles.
- Key stores and fluxes: human influence on cycle balance.
- Indicative carbon stores, Gigatonnes of carbon (GtC): atmosphere, vegetation, soils, oceans.

D4 Ecosystem stability and change

- Biodiversity and ecosystem resilience.
- Natural disturbances versus human pressures (deforestation, pollution, climate change).
- Impacts on ecosystem services: provisioning, regulating, cultural, supporting.

Assessment criteria

Learning aim A: Know atmosphere and climate systems

Learning aim B: Understand lithosphere and geothermal processes

Pass	Merit	Distinction
A.P1 Describe atmospheric structure, composition and climate processes. **A.P2** Describe weather–climate relationships, energy balance and circulation patterns.	**A.M1** Explain interactions between atmospheric systems and climate drivers with coherent detail and effective use of relevant examples.	**AB.D1** Assess atmosphere–hydrosphere interactions influencing climate and water availability.
B.P3 Examine hydrosphere distribution and hydrological cycle stages. **B.P4** Examine water storage, movement and availability issues.	**B.M2** Explain water system interactions and human pressures.	

Learning aim C: Know lithosphere and geothermal processes

Learning aim D: Understand biosphere and ecosystem interactions

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td>C.P5 Describe Earth's internal structure and geothermal processes with adequate accuracy and clear reference to tectonic mechanisms.
C.P6 Describe geothermal energy resources and land-use considerations with sufficient detail and consistent technical language.</td><td>C.M3 Explain relationships between geothermal processes, energy potential and environmental effects.</td><td rowspan="2">CD.D2 Discuss lithosphere–biosphere interactions affecting ecosystems and energy use.</td></tr>
<tr><td>D.P7 Explain biosphere structure and ecosystem components and biotic interactions.
D.P8 Describe biogeochemical cycles and ecosystem services linking to environmental systems.</td><td>D.M4 Assess ecosystem interactions and responses to environmental change.</td></tr>
</table>

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for Pearson Set Assignment (PSA)

Pearson sets the assignment for the assessment of this unit.

The PSA will take up to 8 hours to complete.

The PSA will be marked by centres and verified by Pearson.

The PSA will be valid for the lifetime of this qualification.

Assessing the PSA

You will make assessment decisions for the PSA using the assessment criteria provided.

The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on PSAs. There is also further information on our website.

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- world maps, atlases and globes showing atmospheric zones, tectonic plates, ocean circulation and global water distribution
- printed or digital diagrams and case-study resources, covering climate systems, water cycles, geothermal processes and ecosystem interactions.

Essential information for assessment decisions

Learning aims A and B

For distinction standard, students demonstrate high-level understanding through integrated analysis of atmosphere–hydrosphere interactions. Evidence shows how multiple systems simultaneously influence climate behaviour, weather patterns and water availability. They justify their conclusions using data, reasoned arguments or evaluated examples, such as climate trends, extreme weather events or water-stress scenarios. Responses show confident synthesis of ideas rather than topic-by-topic discussion. Students may weigh the relative importance of different drivers, acknowledge uncertainty or consider temporal and spatial variation. Evidence is well-structured, clearly reasoned and demonstrates independent thinking. Conclusions are supported by accurate scientific principles and show a clear understanding of complexity within Earth systems, indicating secure achievement at the highest level.

For merit standard, students demonstrate a stronger understanding by explaining relationships between atmospheric systems, climate drivers and water processes. Evidence typically links causes and effects, such as how atmospheric circulation influences rainfall patterns or how climate variation affects water availability. They use logically structured responses, supported by applied examples and annotated diagrams. Scientific terminology is used accurately and consistently, and explanations show depth beyond surface description. Students may compare locations, timeframes or conditions to illustrate system interactions. Evidence shows coherence across topics, with concepts connected rather than presented in isolation. Understanding is secure and clearly communicated, demonstrating that students can apply knowledge to unfamiliar contexts while maintaining technical accuracy and relevance.

For pass standard, students demonstrate achievement through clear, factual explanations of atmospheric structure, climate processes, water distribution and the hydrological cycle. Responses typically identify key components, processes and terminology accurately, showing basic understanding rather than complexity. Students may use simple diagrams, labelled sketches, short written explanations or structured notes to show how energy moves through the atmosphere and how water circulates between stores. Explanations are generally linear and descriptive, focusing on what happens rather than why interactions occur. Evidence should show consistency across topics and correct use of scientific language, without significant misconceptions. Minor omissions are acceptable, provided the overall understanding of systems and processes is sound and relevant to environmental contexts.

Learning aims C and D

For distinction standard, students demonstrate high-level understanding by discussing interactions between geological processes, geothermal energy use and biosphere dynamics. The evidence reflects a balanced consideration of environmental, ecological and land-use factors, with well-reasoned viewpoints supported by scientific knowledge. They integrate physical and biological concepts to explore consequences, trade-offs or long-term impacts. Contributions may consider scale, sustainability or limits to exploitation, demonstrating confident judgement rather than description. Ideas are synthesised across topics, showing insight into Earth system interdependence. Evidence is clearly organised, uses accurate terminology throughout and demonstrates originality and independence, indicating a mature understanding consistent with advanced achievement.

For merit standard, students demonstrate stronger achievement by explaining how lithospheric processes influence ecosystems and how biological systems respond to environmental conditions. Evidence shows logical chains of reasoning, such as links between geothermal activity, land use and ecological effects. Students use structured explanations supported by diagrams, case examples or applied contexts, showing depth and relevance. Concepts such as resilience, environmental impacts or energy use are explained clearly and accurately. Responses demonstrate coherence, with ideas organised effectively and terminology applied confidently. Students show they can apply understanding beyond recall, adapting knowledge to scenarios involving environmental management or sustainability while maintaining scientific accuracy.

For pass standard, students show achievement by accurately outlining Earth's internal structure, geothermal processes, ecosystem components and basic biological interactions. Evidence commonly includes descriptions of tectonic activity, geothermal features, ecosystems and nutrient cycles, supported by labelled diagrams or short explanations. They demonstrate understanding of concepts, such as energy origin, ecosystem roles and environmental influences, without extended reasoning.

Where examples are used, they are relevant but simple. Scientific terms are mostly accurate, and explanations remain clear and accessible. Evidence focuses on correct identification and description rather than connections between systems. Achievement is shown where students consistently present correct information across topics and demonstrate a secure foundational understanding of physical and biological Earth processes.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in most units.

Unit 3: Climate Change and Energy Policy

Level: 3

Unit type: Pearson Set Assignment

Guided learning hours: 60

Unit in brief

Students explore scientific climate evidence and emissions data to understand Net Zero targets. They examine climate and energy policy frameworks, interpreting geopolitical influences shaping realistic, evidence-informed decarbonisation decisions.

Unit introduction

Understanding climate change evidence and policy context is essential for anyone working with or alongside modern energy systems. Energy decisions are increasingly shaped by climate science, Net Zero targets and social pressures. Students need to understand how scientific evidence informs policy choices, investment priorities and long-term energy planning.

The unit develops your understanding of climate change science and the evidence that underpins it, including greenhouse gases, temperature changes and emissions trends. You will interpret climate and emissions evidence, consider uncertainty and confidence, and explore the meanings of Net Zero Greenhouse Gas Emissions and carbon budgets. The unit also introduces climate and energy policy frameworks and key geopolitical influences, focusing on how these shape energy transitions.

This unit supports progression by building critical thinking and evidence-based reasoning skills that are essential for further study in energy, environmental science and sustainability. It prepares students for employment by developing their understanding of climate evidence, policy drivers and global influences – skills increasingly valued across the energy, environmental and policy-related sectors.

Learning aims

In this unit, you will:

A Understand climate change science and the evidence base for Net Zero targeting

B Be able to interpret emissions, energy-demand drivers and mitigation options using data

C Know climate and energy policy frameworks and geopolitical influences on Net Zero delivery.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand climate change science and the evidence base for Net Zero targeting	**A1** Climate system mechanism overviews **A2** Climate evidence: sources, indicators and interpretation skills **A3** Net Zero and carbon budgets (evidence for targets)	This unit is assessed through a Pearson Set Assignment.
B Be able to interpret emissions, energy-demand drivers and mitigation options using data	**B1** Energy demand and emissions drivers **B2** Working with emissions evidence **B3** Overview of mitigation pathways and trade-off evidence **B4** Strategic role of carbon capture and storage (CCS)	
C Know climate and energy policy frameworks and geopolitical influences on Net Zero delivery	**C1** Overview of policy purposes and frameworks **C2** Overview of policy instruments and implementation challenges **C3** International policy and cooperation **C4** Geopolitics of energy transitions	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand climate change science and the evidence base for Net Zero targeting

A1 Climate system mechanism overviews

- The greenhouse effect:
  - natural greenhouse effect versus enhanced greenhouse effect
  - key greenhouse gases and relative roles:
    - carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapour (H_2O), fluorinated gases/refrigerants (F-gases).
- Anthropogenic drivers of warming (overview of sources):
  - fossil fuel combustion, land-use change, agriculture, industrial processes.
- Forcing and feedback (qualitative):
  - what is meant by 'radiative forcing' (conceptual)
  - examples of climate feedbacks (kept climate-specific, not general systems theory).

A2 Climate evidence: sources, indicators and interpretation skills

- Evidence types and what they show:
  - instrumental temperature records (global and regional)
  - atmospheric CO_2 measurements
  - palaeoclimate proxies (ice cores, sediments)
  - overview of sea level records and cryosphere indicators.
- Data interpretation and communication:
  - reading and describing trends, variability, baselines and anomalies
  - distinguishing short-term variability from long-term change
  - using multiple lines of evidence (triangulation) to strengthen conclusions.
- Uncertainty and confidence:
  - measurement uncertainty versus natural variability
  - confidence language (high/medium/low confidence) and why it matters for decisions.

A3 Net Zero and carbon budgets (evidence to targets)

- Net Zero concepts:
  - gross zero versus net zero
  - the role of emissions reduction versus removals (overview).
- Carbon budgets:
  - what a carbon budget represents and why budgets relate to temperature targets

- interpretation of simple carbon budget visuals.
- Scientific risk framing, in the event of higher global temperatures:
  - environmental, social and economic impacts.

Learning aim B: Be able to interpret emissions, energy-demand drivers and mitigation options using data

Overview of emissions patterns and mitigation levers using datasets and indicators.

B1 Energy demand and emissions drivers

- Energy demand patterns and drivers:
  - sectoral demand (domestic, transport, industry, commercial) and why demand varies
  - economic development, population, technology and behaviour as demand drivers (overview).
- Emissions accounting basics (interpretation focus):
  - total versus per capita versus emissions intensity (what each reveal)
  - measure of carbon dioxide equivalent (CO_2e) and why different gases are combined.

B2 Working with emissions evidence

- Interpreting emissions datasets and visuals:
  - data from within economic sectors e.g. transport emissions by road, aviation and shipping
  - time series and comparative charts
  - identification of drivers of change (policy, fuel switching, economic shocks) using evidence-based reasoning
- Carbon footprints (introductory; analytical, not audit-practice):
  - individuals/products/organisations as comparative indicators
  - limitations of footprint metrics (boundary choices, data quality).

B3 Overview of mitigation pathways and trade-off evidence

- Mitigation levers framed as pathways:
  - demand reduction, efficiency, electrification, decarbonised generation, fuel switching (overview)
  - recognising trade-offs (cost, reliability, equity, time-to-deploy) using evidence summaries.

B4 Strategic role of carbon capture and storage (CCS)

- Purpose and stages:
  - capture, transport, storage.
- Strategic role in Net Zero:
  - 'hard-to-abate' sectors and transitional roles (contextual).
- Policy constraints and limitations:

  - cost/energy penalty, storage capacity constraints, monitoring/liability considerations.

Learning aim C: Know climate and energy policy frameworks and geopolitical influences on Net Zero delivery

How policy is structured and why geopolitics matters.

C1 Overview of policy purposes and frameworks

- Policy objectives:
  - emissions reduction, Net Zero targets, affordability, energy security, resilience.
- Policy frameworks and governance levels:
  - national strategies, international agreements, sectoral roadmaps, Greenhouse Gas Protocol (GHG Protocol), Scope emissions.
- Policy timescales:
  - short/medium/long-term planning and the challenge of lock-in.

C2 Overview of policy instruments and implementation challenges

- Instrument types:
  - targets/standards, incentives/subsidies, carbon pricing.
- Implementation constraints:
  - public acceptance, distributional impacts (fairness), infrastructure lead times, skills supply
  - monitoring and accountability at a policy level (not audit practice).

C3 International policy and cooperation

- Overview of international frameworks:
  - United Nations Framework Convention on Climate Change (UNFCCC), Nationally Determined Contributions (NDCs) and differentiated responsibilities e.g. Paris Agreement 2015, Sustainable Development Goals (SDGs).
- Cooperation challenges:
  - trust, finance, technology transfer, verification.

C4 Geopolitics of energy transitions

- Energy security and supply risk:
  - dependency, diversification, price volatility.
- Geopolitics of transition materials and infrastructure:
  - critical minerals, supply chains, trade and sanctions impacts.
- Implications for Net Zero delivery:
  - why geopolitics can accelerate or slow pathways and shape policy choices.

Assessment criteria

Learning aim A: Understand climate change science and the evidence base for Net Zero targeting

Learning aim B: Be able to interpret emissions, energy-demand drivers and mitigation options using data

Pass	Merit	Distinction
A.P1 Explain enhanced greenhouse effect and main human activities that increase greenhouse gas concentrations. **A.P2** Interpret provided climate indicator evidence to identify long-term change and short-term variability.	**A.M1** Explain how multiple lines of evidence support conclusions about climate change, including a clear statement of uncertainty/confidence.	**AB.D1** Analyse climate-and-emissions evidence to justify narrative about progress towards Net Zero, uncertainty and data limitations.
B.P3 Describe patterns of energy demand and greenhouse gas emissions using sectoral and comparative indicators. **B.P4** Interpret emissions evidence to identify plausible drivers of change and outline mitigation pathways at overview level, including the strategic role of carbon capture and storage (CCS).	**B.M2** Explain trade-offs between mitigation options using evidence (cost, time-to-deploy, security and likely emissions impact), recognising limitations in the data.	

Learning aim C: Know climate and energy policy frameworks and geopolitical influences on Net Zero delivery

Pass	Merit	Distinction
C.P5 Describe aims and structure of national and international climate/energy policy frameworks that support Net Zero. **C.P6** Describe how geopolitical factors (supply risks, critical minerals, trade and conflict) influence energy policy choices and Net Zero delivery.	**C.M3** Explain how policy instruments and geopolitical constraints interact to shape the feasibility and pace of decarbonisation pathways.	**C.D2** Evaluate the effectiveness of a selected policy approach for Net Zero in a specified geopolitical context, using evidence to justify conclusions and acknowledge trade-offs.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for Pearson Set Assignment (PSA)

Pearson sets the assignment for the assessment of this unit.

The PSA will take 5 hours to complete.

The PSA will be marked by centres and verified by Pearson.

The PSA will be valid for the lifetime of this qualification.

Assessing the PSA

You will make assessment decisions for the PSA using the assessment criteria provided.

The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on PSAs. There is also further information on our website.

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aims A and B

For distinction standard, students present a coherent, analytical narrative that integrates climate science, emissions evidence and mitigation strategies to evaluate progress towards Net Zero. Learners successfully interrogate datasets, selecting relevant indicators to support judgements while explicitly acknowledging uncertainty, variability and evidence gaps. Students assess how energy-demand drivers, mitigation choices and technological constraints interact over time, using evidence to justify the relative contribution and limitations of different pathways. They evaluate the strategic role of carbon capture and storage within wider mitigation portfolios, recognising contextual constraints and transitional functions. Conclusions are well-evidenced, balanced and clearly argued, demonstrating insight into the complexity of evidence-based decision-making.

For merit standard, students demonstrate integrated and confident interpretation of climate, emissions and energy-demand evidence, using different datasets to support reasoned explanations. Students connect climate indicators with emissions trends and clearly explain how different lines of evidence reinforce conclusions while appropriately referencing uncertainty. Students analyse energy-demand drivers in more depth, distinguishing structural factors from short-term influences and linking these to emissions outcomes. They use data to explain trade-offs between mitigation pathways, considering factors such as deployment speed, system reliability, cost pressures and emissions impact. Students show awareness of data limitations and boundary choices when interpreting carbon-related indicators. Explanations demonstrate logical sequencing, effective synthesis of evidence and clear justification of interpretations.

For pass standard, students demonstrate understanding of core climate science principles and how evidence supports Net Zero intentions, alongside reasonable interpretation of emissions and energy-demand data. Students make clear links between greenhouse gases, human activities and observed long-term climate trends, distinguishing these from short-term variability using provided indicators. They appropriately read sectoral emissions datasets and comparative visuals to describe patterns in energy use and emissions across sectors or regions. Students show that they can attribute broad drivers of change, such as economic activity, policy intervention or fuel switching, using data-supported reasoning. Mitigation options are outlined at an overview level, with students recognising how different pathways could contribute to emissions reduction.

Learning aim C

For distinction standard, students evaluate the effectiveness of a selected policy approach within a defined geopolitical context, using evidence to justify reasoned conclusions. Students assess how policy design, international relations and resource constraints collectively influence delivery outcomes, acknowledging trade-offs between speed, equity, security and emissions reduction. They weigh the strengths and limitations of the policy approach, considering short- and long-term impacts and external geopolitical pressures. Judgements are balanced and well-supported, demonstrating awareness of uncertainty and contextual dependency.

For merit standard, students explain how policy instruments and geopolitical constraints interact to influence the pace and feasibility of decarbonisation. Students make reasoned connections between policy mechanisms, governance levels and real-world implementation challenges, including infrastructure, fairness and public acceptance. Students show how geopolitical considerations such as supply-chain concentration, energy security risks and international commitments shape both policy ambition and delivery. They integrate policy frameworks with contextual influences, demonstrating understanding of why outcomes vary between regions or over time.

For pass standard, students demonstrate clear knowledge of the purposes and structure of climate and energy policy frameworks supporting Net Zero delivery. They describe how national strategies, international agreements and sectoral approaches are organised and how stated objectives such as emissions reduction, affordability and energy security are reflected in policy design. Students explain how geopolitical factors such as supply dependence, critical materials and international cooperation influence energy policy decisions. Students show awareness of how global and national contexts shape policy priorities and implementation challenges. Explanations are accurate and appropriately scoped, showing understanding of policy roles and interactions without excessive detail.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in most units.

Unit 4: Principles of Sustainability

Level: 3

Unit type: Pearson Set Assignment

Guided learning hours: 60

Unit in brief

Students explore sustainability pillars, their interrelationships and key systems and management concepts used to interpret and respond to environmental, economic and social challenges.

Unit introduction

This unit is relevant to contemporary environmental, economic and social challenges faced by governments, organisations and communities worldwide. Students need to understand sustainability because decisions about resource use, development and policy increasingly require balancing environmental protection, economic viability and social wellbeing. This unit equips students with the conceptual tools needed to interpret sustainability issues and to understand why integrated decision-making is essential in responding to global pressures such as climate change, inequality and resource depletion.

The unit develops your understanding of the three pillars of sustainability and how they interact, alongside key systems and sustainable management concepts such as feedback, resilience, ecological footprint and opportunity cost. You will explore how these concepts are used to interpret sustainability challenges and to justify interventions. Content progresses from foundational knowledge to applied analysis, enabling you to assess trade-offs, system behaviour and the effectiveness of different sustainability responses.

Successful completion of this unit supports progression to further learning in environmental science, geography, policy studies and sustainability-related vocational pathways. It also develops analytical and decision-making skills valued in roles linked to environmental management, business sustainability, planning and public policy.

Learning aims

In this unit you will:

A Understand sustainability pillars and interrelationships

B Know systems and sustainability management concepts

C Be able to apply principles and concepts to sustainability scenarios.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand sustainability pillars and interrelationships	**A1** Pillars of sustainability **A2** Interrelationships between pillars	This unit is assessed through a Pearson Set Assignment.
B Know systems and sustainability management concepts	**B1** Systems concepts **B2** Sustainable management concepts	
C Be able to apply principles and concepts to sustainability scenarios	**C1** Applying pillars to sustainability challenges **C2** Applying systems and sustainable management concepts	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand sustainability pillars and interrelationships [EL – CL]

Understanding the pillars of sustainability and how decisions in one pillar affect the outcomes in the others.

A1 Pillars of sustainability

Pillars of sustainability:

- Society: health, wellbeing, education, relationships, governance.
- Economy: employment, growth, trade, policy.
- Environment: Earth's systems, including the biosphere, lithosphere, hydrosphere and atmosphere.

A2 Interrelationships between pillars

Students will understand that:

- Economic growth has environmental, human health and social impacts.
- Environmental mismanagement affects economic stability.
- Sustainable solutions require integrated consideration of environmental, health and safety and social needs.

Learning aim B: Know systems and sustainability management concepts

Key systems concepts and sustainable management concepts used to respond to sustainability challenges.

B1 Systems concepts

- Resilience: The ability of a system to absorb disturbance, adapt and continue functioning without collapsing into a different state.
- Causality: The pattern of cause-and-effect relationships through which actions and events produce consequences within a system.
- Equilibrium: A dynamic balance where opposing forces or processes offset each other, keeping the system relatively stable over time.
- Critical Transition: A tipping point at which small changes trigger a sudden, often irreversible, shift to a new system state.
- Feedback Mechanisms: Circular processes where system outputs loop back as inputs, amplifying change (positive feedback) or stabilising behaviour (negative feedback).

- Interdependence: The condition in which system components are mutually reliant, so changes in one part affect others and the system as a whole.
- United Nations Sustainable Development Goals: Global framework of integrated goals to end poverty, protect planet and increase prosperity for all.

B2 Sustainable management concepts

- Interventions: Deliberate actions or policies designed to change system behaviour in order to improve sustainability outcomes.
- Ecological Footprint: A measure of how much biologically productive land and water are required to support human activities and absorb wastes.
- Opportunity Cost: The benefits lost when one sustainable choice is made instead of the next best alternative.
- Mitigation and Adaptation: Mitigation reduces the causes of environmental change, while adaptation adjusts systems to cope with its impacts.
- Equality: The principle of fairly distributing resources, opportunities and environmental benefits within and between generations.
- Carrying Capacity: The maximum level of population or activity an environment can sustain without long-term degradation.
- Interdependence: The reliance of social, economic and environmental systems on one another, where changes in one affect the others.

Learning aim C: Be able to apply principles and concepts to sustainability scenarios

The interrelationships between Earth's systems, human activity and sustainability concepts, sustainability challenges and management choices.

C1 Applying pillars to sustainability challenges

Students will apply the pillars framework to:

- Identify social, economic and environmental impacts of human activity.
- Recognise trade-offs between pillars.
- Explain why integrated solutions are required.

C2 Applying systems and sustainable management concepts

Students will use systems and management concepts to:

- Interpret interdependence and feedback between causes and outcomes.
- Explain resilience, stability and critical transitions in sustainability contexts.
- Justify interventions using ecological footprint, opportunity cost, mitigation/adaptation, equality and carrying capacity.

Assessment criteria

Learning aim A: Understand sustainability pillars and interrelationships

Pass	Merit	Distinction
A.P1 Describe social, economic and environmental pillars of sustainability using appropriate terminology. **A.P2** Explain how actions within one sustainability pillar can influence outcomes in the other two pillars.	**A.M1** Analyse interrelationships between sustainability pillars, linked to examples of compromise and conflict.	**A.D1** Evaluate the effectiveness of integrated sustainability approaches in balancing social, economic and environmental priorities.

Learning aim B: Know systems and sustainability management concepts

Learning aim C: Be able to apply principles and concepts to sustainability scenarios

Pass	Merit	Distinction
B.P3 Describe key systems concepts to interpret sustainability contexts. **B.P4** Describe sustainable management concepts linked to examples.	**B.M2** Analyse how systems and sustainable management concepts interact to influence sustainability outcomes.	**BC.D2** Evaluate sustainability decisions, justifying recommendations through integrated application of pillars, systems thinking and management concepts.
C.P5 Describe application of pillars of sustainability and relevant systems or management concepts to sustainability challenges. [SP – CT] **C.P6** Explain how sustainability concepts support decisions aimed at reducing the negative impacts of human activity.	**C.M3** Assess alternative sustainability interventions, considering impacts, feasibility and compromises across social, economic and environmental pillars.	

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT √
MY – PS&R	EL – CL *	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for Pearson Set Assignment (PSA)

Pearson sets the assignment for the assessment of this unit.

The PSA will take 11 hours to complete.

The PSA will be marked by centres and verified by Pearson.

The PSA will be valid for the lifetime of this qualification.

Assessing the PSA

You will make assessment decisions for the PSA using the assessment criteria provided.

The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on PSAs. There is also further information on our website.

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- good-quality real-world sustainability case studies enabling analysis of interrelationships, trade-offs, and intervention decisions
- charts, infographics and footprint metrics to support interpretation of sustainability impacts
- access to reliable sustainability research, policy sources and/or organisational sustainability strategies.

Essential information for assessment decisions

Learning aim A

For distinction standard, students critically consider how well different strategies balance competing priorities across the three pillars, drawing on well-chosen examples to support their conclusions. Evidence typically demonstrates an ability to weigh relative success, limitations and unintended consequences. Students justify viewpoints using linked reasoning across social, economic and environmental considerations, showing awareness of complexity and compromise. Conclusions are clearly reasoned and grounded in evidence. Work at this level shows confidence in handling abstract interrelationships and reflects a good understanding of sustainability as a decision-making framework.

For merit standard, students make clear links between social, economic and environmental factors, explaining how priorities in one area may compromise or create tension in another. Examples are selected to support analysis. Students demonstrate an ability to compare outcomes, highlighting conflicting objectives such as economic growth versus environmental protection, or social wellbeing versus resource use. Their reasoning shows increasing independence, with links drawn across content areas. Evidence is structured logically, and explanations demonstrate a coherent line of thinking that reflects an understanding of sustainability as a dynamic and interconnected system.

For pass standard, students present descriptive accounts that clearly distinguish social, economic and environmental considerations, using appropriate terminology drawn from the content. Examples are likely to be straightforward and may be drawn from familiar scenarios. Students show awareness that actions taken within one pillar can lead to consequences in the others, supported by simple cause-and-effect explanations. Relationships between pillars are simplistic, with evidence tending to focus on obvious impacts. Evidence relies on the given resources, case studies or structured prompts, but demonstrates that students understand sustainability as a balanced concept rather than isolated issues.

Learning aims B and C

For distinction standard, students evaluate sustainability decisions, justifying recommendations with clear and logically connected reasoning. Evidence shows that students consider long-term impacts, system resilience, critical transitions and equity alongside environmental and economic implications. Management concepts such as mitigation, adaptation and opportunity cost are applied selectively to support well-evidenced judgements about the most appropriate interventions. Students demonstrate strategic thinking by prioritising actions based on system behaviour and contextual constraints. Work at this level shows links across concepts and pillars, resulting in reasoned, defensible conclusions that reflect sustainability as a decision-making framework.

For merit standard, students apply multiple concepts together to interpret causes, consequences and trade-offs within sustainability scenarios. Evidence typically shows consideration of feasibility, effectiveness and competing priorities across social, economic and environmental pillars. Students assess alternative interventions, explaining how different choices influence system stability, resource use or social outcomes. Reasoning reflects developing systems thinking, with students recognising interdependence, feedback and constraints such as opportunity cost or carrying capacity. Explanations are coherent, well-structured and supported by contextual understanding, indicating an ability to make informed, balanced judgements.

For pass standard, students use appropriate terminology to explain concepts such as feedback, resilience, ecological footprint or mitigation and link these to simple sustainability scenarios. Applications demonstrate that students can identify social, economic and environmental impacts of human activity and explain how sustainability concepts help inform decisions aimed at reducing negative effects. Explanations may be descriptive, focusing on direct relationships. Students may rely on provided case studies or examples, but evidence shows that they can transfer conceptual knowledge into practical interpretation, demonstrating a functional understanding of how sustainability concepts support responsible decision-making.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in most units.

Unit 5: Scientific Principles for Energy Systems

Level: 3

Unit type: Pearson Set Assignment

Guided learning hours: 60

Unit in brief

Students explore scientific principles governing energy transfer, power, efficiency, electricity, magnetism, heat transfer and thermodynamics in real energy systems.

Unit introduction

This unit underpins how energy systems operate in the real world, using scientific principles governing energy transfer, conversion and efficiency. Students will develop their understanding of how technologies such as motors, generators, transformers and thermal systems perform in practice, why losses occur and why efficiency improvements are essential for cost reduction, sustainability and system reliability in green energy.

The content spans core physics applied to energy systems, including energy pathways, work, power and efficiency; electrical and electromagnetic principles in energy machines; and heat transfer and thermodynamics. You will apply equations to practical scenarios, analyse losses across electrical, mechanical and thermal domains and explore unavoidable efficiency limits.

Completion of this unit strengthens scientific reasoning and analytical skills, supporting progression to advanced study in green energy, engineering or applied science. It also prepares students for occupational roles by providing the essential knowledge needed to understand, evaluate and improve real-world energy systems in employment.

Learning aims

In this unit you will:

A Understand energy pathways, work, power and efficiency in energy systems

B Understand electricity, magnetism and electromagnetism in energy machines (motors, generators, transformers)

C Be able to measure heat transfer and thermodynamics affecting energy-system performance

D Understand carbon dioxide emissions savings.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand energy pathways, work, power and efficiency in energy systems	**A1** Energy stores, pathways and transfer chains **A2** Work, power and energy transfer **A3** Efficiency, losses and energy pathways	This unit is assessed through a Pearson Set Assignment.
B Understand electricity, magnetism and electromagnetism in energy machines (motors, generators, transformers)	**B1** Electrical power and energy in practical machine contexts **B2** Magnetism and field interaction in machines **B3** Electromagnetic induction and energy conversion **B4** Machines, efficiency and loss mechanisms	
C Be able to measure heat transfer and thermodynamics affecting energy-system performance	**C1** Heat, temperature and thermal energy applied to system performance **C2** Heat-transfer mechanisms and loss reduction **C3** Thermodynamics and limits to efficiency **C4** Combined-system thinking: losses across domains	
D Understand carbon dioxide emissions savings	**D1** Carbon dioxide (CO_2) emissions savings **D2** Estimate of CO_2 emissions savings **D3** Potential significance of parasitic energy consumption in green energy systems	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand energy pathways, work, power and efficiency in energy systems

Modelling energy transfers using quantitative relationships to explain where energy goes, why losses occur and how efficiency can be improved at the system level.

A1 Energy stores, pathways and transfer chains

- Energy stores and pathways in engineered systems (electrical, mechanical, thermal).
- Transfer chains and conversions (e.g. electrical → mechanical → thermal losses).
- Useful versus wasted energy; defining the 'useful output' for a stated purpose (context-dependent).

A2 Work, power and energy transfer

Students apply equations to typical energy tasks (motors, electrical generators, wind turbines, hydroelectric turbines and heating or cooling systems).

Fundamental relationships applied in contexts of wind turbine generators, hydroelectric generators and heating or cooling systems.

Work done: $W = F \times d$

W = work done (J), *F* = force (N), *d* = distance moved (m)

Power: $P = \frac{W}{t}$ and $P = \frac{E}{t}$

P = power (W), *W* = work (J), *E* = energy (J), *t* = time (s)

Energy transferred: $E = P \times t$

E = energy (J), *P* = power (W), *t* = time (s)

Heat transfer: $Q = mc_p \Delta T$

- Units and meaning: joule (J), watt (W), kilowatt-hour (kWh), British Thermal Unit (BTU), BTU/hr.
- Power ratings and duty cycles (qualitative): why peak power differs from average power in real devices.

A3 Efficiency, losses and energy pathways

- Efficiency definitions for different transfers (mechanical, electrical, thermal).
- Energy loss mechanisms: friction, resistance heating, turbulence, unwanted heat transfer.
- Efficiency improvement strategies at principle level: reducing friction, reducing resistive losses, insulation/heat recovery, improving matching (load versus supply).

Key relationships applied in context:

Efficiency (decimal): $\eta = \frac{\text{useful output energy}}{\text{total input energy}}$

Efficiency (%): $\eta\% = \left(\frac{\text{useful output}}{\text{total input}}\right) \times 100$

Energy lost: $E_{lost} = E_{in} - E_{useful}$

Learning aim B: Understand electricity, magnetism and electromagnetism in energy machines (motors, generators, transformers)

Electromagnetism in energy machines, including how electrical and magnetic principles enable generation and conversion.

B1 Electrical power and energy in practical energy machine contexts

- Current, voltage, resistance and power as operational quantities for machines.
- Applying machine-relevant relationships (kept purposeful, not repetitive circuit drills):

  Electrical power: $P = V \times I$

  Electrical energy: $E = P \times t$

  (Ohm's law used where required for machine contexts): $V = I \times R$
- Electrical losses in conductors and windings (link to heating and efficiency).

B2 Magnetism and field interaction in machines

- Magnetic fields: field lines, flux as a qualitative idea and why field strength matters.
- Electromagnets: factors affecting strength (turns, current, core material).
- Force effects and torque (qualitative): why motors produce rotation, including Fleming's left-hand rule for motors and right-hand rule for generators.

B3 Electromagnetic induction and energy conversion

- Induction concept: changing magnetic environment → induced potential difference (qualitative).
- Generators: mechanical rotation → electrical output (principle model e.g. basic electromagnetic induction model), including Fleming's right-hand rule for generators.
- Transformers (principle level only): why voltage levels matter for electricity transmission efficiency (qualitative).

B4 Machines, efficiency and loss mechanisms

- Where losses occur in energy machines: resistive heating, eddy currents, friction, hysteresis.
- Comparing motor versus generator operation as conversion of mechanical to electrical energy in opposite directions (inverse conversions).

Learning aim C: Be able to measure heat transfer and thermodynamics affecting energy-system performance

Thermodynamics, heat transfer and unavoidable efficiency limits, using calculations.

C1 Heat, temperature and thermal energy applied to system performance

- Heat versus temperature; thermal equilibrium.
- Specific heat capacity as a performance idea (sensible heating and cooling).

  Applying thermal energy calculations in controlled heat-transfer tasks:

  Thermal energy change: $Q = mc_p\Delta T$.

C2 Heat-transfer mechanisms and loss reduction

- Conduction, convection, radiation (and typical contexts in energy systems).
- Thermal resistance idea (qualitative): why insulation works.
- Heat exchangers and heat recovery.
- Loss reduction strategies: insulation, reflective barriers, reducing unwanted convection.

C3 Thermodynamics and limits to efficiency

- First law (energy conservation) applied to closed processes (qualitative and simple balances).
- Second law (energy degradation) and why waste heat is unavoidable.
- Heat engines and practical limits, and why this drives interest in efficiency and heat recovery.
- System examples used only as illustrations (e.g. thermal plants, engines, heat pumps as conceptual references).

C4 Combined-system thinking: losses across domains

- Multi-step energy conversion chains (electrical ↔ mechanical ↔ thermal).
- Identifying dominant losses and ‘best lever’ improvements based on principle reasoning.
- Trade-offs: reducing one loss may increase another (e.g. insulation versus overheating risk, transformer sizing versus cost).

Learning aim D: Understand carbon dioxide emissions savings

D1 Carbon dioxide (CO_2) emissions savings

- Role of CO_2 emissions savings in local policy and regulations.
- Sensitivities of baseline power generation CO_2 emissions to mix of renewable and non-renewable energy sources, in comparative electricity supply by country/region.
- Implications of power plant system energy efficiencies.
- Barriers to uptake of green energy systems, e.g. securing official authorisation/approval for wind turbines or hydroelectric plant; complying with environmental law for geothermal systems; rooftop or ground-level space available for solar collectors.

D2 Estimate of CO_2 emissions savings

- Grid electricity supply.
- Conventionally fuelled thermal energy systems (oil-fired boilers, gas-fired boilers, grid-supplied electric heating, grid-supplied electric refrigeration chillers).
- Low-carbon energy systems driven by renewable energy sources (solar thermal, solar photovoltaic, solar thermal absorption cooling, wind turbines, tidal energy, hydroelectric, biomass and biogas).
- Low-carbon energy systems driven by non-renewable energy sources (gas-fired combined heat and power (CHP) or gas-fired combined cooling, heat and power (CCHP); gas-fired absorption chillers; district heating or cooling networks; grid-supplied electric heat pumps).

D3 Potential significance of parasitic energy consumption in green energy systems

- Solar hot water (circulation pump and electronic controls).
- Solar photovoltaic-thermal (PVT) (circulation pump, inverter standby power and electronic controls).
- Solar photovoltaic (PV) (tracking) (inverter standby power, electronic controls and automatic photovoltaic panel tracking system).
- Concentrated solar power (CSP) (circulation pump, electronic controls, automatic mirror tracking system).
- Biogas anaerobic digestion (feedstock pre-heating, digester heating, digester mixer, feedstock delivery system, electronic controls).
- Geothermal (circulating pump and electronic controls).
- Ground-coupled cooling (air circulation and electronic controls).

Assessment criteria

Learning aim A: Understand energy pathways, work, power and efficiency in energy systems

Learning aim B: Understand electricity, magnetism and electromagnetism in energy machines (motors, generators, transformers)

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td>A.P1 Explain energy stores and pathways in an energy conversion chain and identify useful and wasted transfers.
A.P2 Use appropriate equations to calculate work done, power or energy transferred in a given energy-system task.</td><td>A.M1 Explain, using calculations, how losses reduce efficiency across a multi-step energy pathway.</td><td rowspan="2">AB.D1 Analyse a multi-stage energy system by quantifying key transfers and losses across electrical, mechanical and thermal domains, recommending efficiency improvements, then justify the most effective efficiency improvements.</td></tr>
<tr><td>B.P3 Explain how magnetic fields and electromagnets support operation of motors, generators or transformers.
B.P4 Use electrical power/energy relationships in a machine context to determine input, output or loss (given suitable values).</td><td>B.M2 Explain how induction and machine design features influence conversion efficiency and typical loss mechanisms.</td></tr>
</table>

Learning aim C: Be able to measure heat transfer and thermodynamics affecting energy-system performance

Pass	Merit	Distinction
C.P5 Use thermal energy relationships to calculate heating/cooling energy changes in a given scenario. [SP – PS] **C.P6** Outline conduction, convection and radiation relevant to energy systems.	**C.M3** Explain, using thermodynamic principles, why waste heat occurs and how heat transfer reduction or recovery can improve overall system performance.	**C.D2** Evaluate competing energy improvement options, their impact on overall efficiency and practical constraints.

Learning aim D: Understand carbon dioxide emissions savings

Pass	Merit	Distinction
D.P7 Explain benefits of CO_2 emissions savings related to green energy systems. **D.P8** Using locally relevant emissions factors, compare CO_2 emissions savings for two different green energy systems.	**D.M4** Explain implications for CO_2 emissions savings of parasitic energy sources in three green energy systems.	**D.D3** Evaluate uptake barriers and potential emissions impact of increased use of energy sources on regional electricity supply.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS √
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for Pearson Set Assignment (PSA)

Pearson sets the assignment for the assessment of this unit.

The PSA will take 20 hours to complete.

The PSA will be marked by centres and verified by Pearson.

The PSA will be valid for the lifetime of this qualification.

Assessing the PSA

You will make assessment decisions for the PSA using the assessment criteria provided.

The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on PSAs. There is also further information on our website.

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- thermal measurement and heat-transfer equipment: temperature probes, thermometers, calorimeters, insulated containers and simple heat-transfer kits for measuring heating, cooling and losses
- calculation and analysis resources: scientific calculators, computers with spreadsheet software, and prepared data sets or specifications for system performance and CO_2 emissions analysis.

Essential information for assessment decisions

Learning aims A and B

For distinction standard, students present a coordinated analysis of a multi-stage energy system. Calculations are used to quantify energy transfers and losses across electrical, mechanical and thermal stages, and the results are interpreted rather than simply stated. The student evaluates which losses have the greatest effect on performance and selects improvement options based on reasoned comparison. Explanations link electromagnetic behaviour, machine operation and efficiency outcomes into a single line of reasoning. Recommendations are supported by numerical evidence and clear scientific explanation, with consideration of practical limits such as cost, complexity or the reduced benefit of further improvement. The evidence shows confident evaluation of whole systems rather than individual components.

For merit standard, students' evidence shows connected explanations rather than isolated responses. Calculations are used to show how losses affect performance across more than one stage of an energy system, rather than being treated as standalone tasks. The student explains how features of machine design or operating conditions influence electrical, mechanical and thermal behaviour, linking electromagnetic principles to efficiency outcomes. Explanations are clearly structured and set within realistic system contexts, showing why losses occur and how they affect overall performance. The student often compares different operating conditions or machines, using calculated values to support explanations. The work shows clear cause-and-effect reasoning and effective links between energy transfer and machine operation.

For pass standard, students' evidence shows understanding of basic scientific ideas used in energy systems and machines. They use standard equations correctly in familiar situations, showing how values for energy, power, electrical input or output are calculated with appropriate units. Explanations describe how energy moves through simple systems, identifying where changes in form occur and where energy is lost. In machine contexts, the students explain how electrical and magnetic effects allow motors, generators or transformers to operate, using accurate but limited descriptions. The work is generally correct and linked to the given context, showing that the student can carry out required calculations and provide relevant explanations, even though the analysis is mainly descriptive and follows taught examples.

Learning aim C

For distinction standard, students evaluate alternative thermal improvement options using calculated data and thermodynamic reasoning. Evidence demonstrates clear judgement when selecting approaches by recognising limits set by the first and second laws of thermodynamics, system design constraints and operating conditions. Thermal calculations are interpreted to assess overall system performance rather than presented in isolation. The student explains where reductions in heat loss or improvements in heat recovery deliver meaningful performance gains and where benefits are inherently limited. Conclusions are justified using linked reasoning about heat transfer, efficiency and unavoidable waste heat, showing a confident understanding of how scientific principles shape realistic improvement decisions.

For merit standard, students explain why waste heat occurs by linking thermodynamic principles to system behaviour. Thermal calculations are used to show how reducing heat transfer losses or recovering heat improves overall system effectiveness. Explanations demonstrate clear cause-and-effect reasoning between conduction, convection and radiation processes and observed performance changes. The student compares improvement options or operating conditions with reference to calculated values, showing that gains in one area may be constrained by physical limits or trade-offs elsewhere. Evidence shows clear connections between thermal behaviour and system efficiency.

For pass standard, students correctly use thermal energy equations to calculate heating or cooling energy changes, applying appropriate values, units and rearrangements. Descriptions of conduction, convection and radiation are relevant to energy-system contexts and explain how heat is transferred and lost. Calculations are generally accurate and linked to the given scenario. Evidence focuses on measured or calculated thermal effects rather than wider evaluation, showing that the student can describe heat-transfer processes and quantify thermal energy changes in familiar situations.

Learning aim D

For distinction standard, students evaluate carbon dioxide emissions savings by considering emissions data, parasitic energy consumption and system-level constraints together. Calculated comparisons are used to assess the net emissions impact of different energy systems rather than headline savings alone. The student explains where increased deployment of certain technologies produces significant emissions reductions and where benefits are reduced by parasitic loads, efficiency limitations or uptake barriers. Conclusions are justified using linked reasoning about emissions factors, energy use and real-world constraints, demonstrating informed judgement about the realistic emissions impact of energy choices at a regional or system scale.

For merit standard, students explain how parasitic energy use affects net carbon dioxide emissions savings in green energy systems. Emissions calculations and comparisons are interpreted to show how additional energy demands reduce overall benefits. The student links system design and operation to emissions outcomes, explaining why improvements in carbon savings may be limited by inefficiencies or auxiliary energy consumption. Comparisons between systems are supported by clear reasoning, showing an understanding of how emission factors and system performance interact.

For pass standard, students compare carbon dioxide emissions savings for different energy systems using the provided or locally relevant emissions factors. Calculations are generally correct and show how technology choice influences carbon output. Explanations describe observable differences in emissions outcomes rather than wider system implications. Evidence demonstrates that the student can calculate and compare emissions savings and explain, in simple terms, why some systems result in lower carbon dioxide emissions than others.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in most units.

Unit 6: Mathematics for Energy Technicians

Level: 3

Unit type: Pearson Set Assignment

Guided learning hours: 60

Unit in brief

Students develop arithmetic, algebra, unit conversion skills as well as calculus techniques to solve energy problems. Sequences and statistical methods are applied to solve real-world problems in green energy.

Unit introduction

This unit is relevant to real-world energy and energy contexts, where technicians are expected to carry out accurate calculations, interpret data and justify decisions using numerical evidence. Students need secure skills in fundamental mathematics to estimate energy use, calculate costs, assess efficiency and communicate results with confidence, ensuring safe, economical and professional practice in energy-related roles.

The unit develops core mathematical competence through applied arithmetic, use of sequences, calculus and data-handling techniques. You will cover energy and electrical calculations, unit conversions, measurement accuracy and error awareness, the application of sequences and calculus, and the interpretation of data using tables and graphs. Learning emphasises the practical use of standard formulae, reasonableness checks, the application of sequences to energy problems, the application of calculus and graphical interpretation and summary measures such as means and gradients, reflecting typical technician tasks rather than abstract mathematics.

Achievement in this unit supports progression to further study in green energy and energy systems by strengthening analytical and data-handling skills. It also enhances employability by equipping students with the quantitative confidence required for occupational roles, apprenticeships and industry-based training pathways.

Learning aims

In this unit you will:

A Understand units, measurement, conversions and error analysis

B Understand how sequences and series can be used to solve energy problems

C Be able to use calculus to solve energy problems

D Be able to undertake data handling and graphical representation.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand units, measurement, conversions and error analysis	**A1** Units and prefixes used in energy and electrical work **A2** Conversions used in technician tasks **A3** Measurement, uncertainty and error handling **A4** Solving engineering problems	This unit is assessed through a Pearson Set Assignment.
B Understand how sequences and series can be used to solve energy problems	**B1** Arithmetic and geometric progressions **B2** Binomial expansion **B3** Power series	
C Be able to use calculus to solve energy problems	**C1** Methods of differential techniques **C2** Methods of integration techniques **C3** Numerical value of a derivative	
D Be able to undertake data handling and graphical representation	**D1** Collecting and organising data **D2** Graphs used in energy contexts **D3** Summary measures and rate of change	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand units, measurement, conversions and error analysis

A1 Units and prefixes used in energy and electrical work

- SI units and common derived units used in energy contexts:
  - W, kW, MW; J and kWh; V, A, Ω; s and h; °C and K.
- Correct use of prefixes (milli-, kilo-, mega-) and avoiding common mistakes (e.g. confusing kW and kWh).

A2 Conversions used in technician tasks

- Time, power and energy conversions used in bills and specifications:

  1 hour = 3600 seconds

  1 kW = 1000 W

  1 MW = 1000 kW

  1 kWh = 3.6 × 10^6 J

  T(K) = T(°C) + 273

A3 Measurement, uncertainty and error handling

- Accuracy, precision and resolution (purpose, importance).
- Rounding and significant figures:
  - choosing an appropriate number of significant figures based on data quality.
- Error handling in measurements:
  - recognising likely sources of error (instrument, reading, environment)
  - communicating limitations clearly and professionally.
- Percentage error (used where a 'true' or reference value is given):

$$\text{Percentrage Error} = \frac{\text{Measured} - \text{True}}{\text{True}} \times 100$$

A4 Solving engineering problems

- Solve hydrodynamic problems:
  - calculating forces at rest and motion
  - calculating forces acting against a retaining wall
  - fluid behaviour; viscous flow, laminar flow, turbulence
  - use of Bernoulli's equation.

- Solved problems should be determined to a specified degree of accuracy, through the use of:
  - significant figures
  - decimal places

Learning aim B: Understand how sequences and series can be used to solve energy problems

B1 Arithmetic and geometric progressions

- Definitions:
  - sequence as an ordered collection of numbers *a*, *b*, *c*, *d*
  - progression as a sequence that increases in a particular pattern, i.e. there is a constant relationship between a number and its successor
  - series as the sum of the values in a sequence *a* + *b* + c + *d* …
  - terminology – first term *a*, last term *l*, connection by law.
- Routine operations involve:
  - arithmetic progression (AP):
    - common difference *d*
    - general expression for a sequence in AP: *a*, (*a* + *d*), (*a* + 2*d*), (*a* + 3*d*),… a+(*n*-1)*d*
    - *n*th term (last term) *l* = *a* + (*n* – l)*d*
    - sum of an AP to *n*th term (arithmetic series):

      $s = a + (a + d) + (a + 2d) + \cdots + (l - d) + l = \frac{1}{2}\,n\,(a + l)$
  - geometric progression (GP):
    - common ratio *r*
    - general expression for a sequence in GP *a*, *ar*, ar^2, ar^3, …, $ar^{(n-1)}$
    - sum of a GP to *n*th term (geometric series):

      $s = a + ar + ar^2 + ar^3 + \cdots + ar^n = \dfrac{a\,(1 - r^n)}{(1 - r)}$
  - convergence
  - sum to infinity.
- Non-routine operations involve:
  - real-world applications, e.g. machinery speeds, increasing or decreasing pattern requirements, drilling costs, manufacturing estimation.

B2 Binomial expansion

- Definitions:
  - Binomial expression that takes the form $(a + b)^n$
  - Binomial theorem when *n* is a positive integer:

    $(a+b)^n = a^n + na^{n-1}b + \frac{n(n-1)}{2!}a^{n-2}b^2 + \frac{n(n-1)(n-2)}{3!}a^{n-3}b^3 + \cdots + b^n$ (a finite series)

    Which can be written as $(a+b)^n = \sum_{k=0}^{k=n} {}_nC_k\, a^{n-k}b^k$ where ${}_nC_k = \frac{n!}{(n-k)!k!}$

    Alternative form

    $(1+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 + \frac{n(n-1)(n-2)}{3!}x^3 + \cdots + x^n$
  - Binomial theorem when *n* is not a positive integer:

    $(+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 + \frac{n(n-1)(n-2)}{3!}x^3 + \cdots + x^n$ for $-1 < x < 1$ only (an infinite series)
- Routine operations involve:
  - construction of Pascal's triangle
  - expansion of $(a + b)^n$ for positive values of *n* using Pascal's triangle.
- Non-routine operations involve:
  - expansion of $(1 + x)^n$ for non-positive integer values of *n* using binomial theorem
  - calculation of the *n*th term using binomial theorem
  - real-world applications, e.g. small errors, small changes, percentage changes, approximation of errors.

B3 Power series

- Definitions:
  - a power series as $f(x) = a_0 + a_1x + a_2x^2 + a_3x^3 + \cdots + a_nx^n$
  - a Taylor series as

    $f(x) = f(a) + f'(a)(x-a) + \frac{f^2(a)}{2!}(x-a)^2 + \cdots + \frac{f^n(a)}{n!}(x-a)^n$
- Routine operations involve:
  - a Maclaurin series as a Taylor series with *a* = 0
  - convergence and divergence
  - conditions for convergence and divergence.
- Non-routine operations involve:
  - numerical value for e using a power series
  - proof that

    $\frac{\mathrm{d}y}{\mathrm{d}x}(e^x) = e^x$ using series
  - real-world applications, e.g. error in area or volume for small error in measurement of length, oscillator frequency for an electrical circuit if components have small errors in their values.

Learning aim C: Be able to use calculus to solve energy problems

C1 Methods of differential techniques

- Gradient of a function.
- Small change in a quantity.
- Differentiation from first principles to produce the limiting value (derivative) of a simple power function, e.g. $y = 2x^2$.
- Leibniz notation $\frac{\mathrm{dy}}{\mathrm{dx}}$ or representing the derivative of a function.
- Notation for the derivative, e.g. $\frac{\mathrm{ds}}{\mathrm{dt}}\ \frac{\mathrm{dQ}}{\mathrm{dt}}$
- Independent variable and the coding method 'with respect to' (w.r.t.).
- Differentiation by standard results ($\mathrm{y} = \mathrm{ax}^{\mathrm{n}}$, where $\frac{\mathrm{dy}}{\mathrm{dx}} = \mathrm{nax}^{(\mathrm{n}-1)}$)
- The derivatives of algebraic (power), trigonometric (sine, cosine), logarithmic and exponential functions (ax^n , sinax, cosax, loge(ax), e^{ax})
- Product and quotient rules: $\frac{\mathrm{d}y}{\mathrm{d}x} = v\frac{\mathrm{d}u}{\mathrm{d}x} + u\frac{\mathrm{d}v}{\mathrm{d}x}, \frac{\mathrm{d}y}{\mathrm{d}x} = \frac{v\frac{\mathrm{d}u}{\mathrm{d}x} - u\frac{\mathrm{d}v}{\mathrm{d}x}}{v^2}$
- Function of a function (chain rule) method.
- Substitution method

C2 Methods of integration techniques

- Symbolic representation $(\,)^{\mathrm{dx}}$
- Algebraic expressions and the constant of integration.
- Types of functions: polynomial, trigonometric (sine, cosine), reciprocal and exponential.
- Routine functions are integrated in one step without the need for manipulation, using standard calculus methods and/or are not applied to an energy context, including:
    - polynomial, e.g. $(x^2 - 3x + 4)\mathrm{d}x$
    - trigonometric (sine, cosine), e.g.$(\sin 5\theta - 3\cos 4\theta)\mathrm{d}\theta$
    - reciprocal, e.g. $\left(\frac{3}{x}\right)\mathrm{d}x$
    - exponential, e.g. $(e^{3r})\mathrm{d}t$
- Non-routine functions are integrated in more than one step requiring manipulation, using standard calculus methods and/or may be applied to an energy context, including:
    - polynomial, e.g. $x^2(x^3 + 5)^2\mathrm{d}x$
    - trigonometric (sine, cosine), e.g. $\left(\frac{\cos\theta}{1-\sin\theta}\right)\mathrm{d}\theta$
    - exponential, e.g. $\mathrm{e}^{t}\cos t\mathrm{d}t$
- Integration of common functions by standard results – axn , sinax, cosax, 1 x , eax
- Indefinite integrals, constant of integration, initial conditions.
- Definite integrals – limits and square bracket notation.

- Integration by substitution.
- Integration by parts.
- Solve energy problems associated with integration techniques.

C3 Numerical value of a derivative

- Substitution of numerical values into the expression for the derivative.
- Instantaneous gradient at a point on a curve.
- Positive, negative and zero values for gradients.
- Gradient values obtained analytically and graphically.
- Examples of rates of change, e.g. velocity/acceleration of a moving object, rate of charge/discharge of a capacitor, heat flow, radioactive decay, cutting tool life, charge/discharge rate for an air receiver, hydraulic flow rates.
- Solved problems should be determined to a specified degree of accuracy, through the use of:
    - significant figures
    - decimal places.

Learning aim D: Be able to undertake data handling and graphical representation

D1 Collecting and organising data

- Data types (discrete/continuous) and choosing suitable tables.
- Using spreadsheets to:
    - structure data, label units correctly, and maintain consistency (overview).
- Identifying outliers/anomalies (as a mathematical check).

D2 Graphs used in energy contexts

- Selecting appropriate graph types (line, bar, scatter) for a stated purpose.
- Plotting graphs with correct:
    - axis labels, units, scales and titles.
- Interpreting a plotted graph mathematically:
    - trend direction, rate of change, turning points (where present).

D3 Summary measures and rate of change

Mean (average):

Mean = (sum of values) ÷ (number of values).

Gradient (rate of change):

Gradient = $\Delta y \div \Delta x$.

- Application of mean to:
  - average daily consumption from meter readings
  - average power demand over a simple interval.
- Application of gradient to:
  - rate of temperature change (given values)
  - rate of energy use increase/decrease over time (given values).

Assessment criteria

Learning aim A: Understand units, measurement, conversions and error analysis

Pass	Merit	Distinction
A.P1 Use correct units and prefixes when measuring and calculating energy-related quantities. **A.P2** Convert between common units used, applying conversions correctly in calculations.	**A.M1** Solve energy problems, using technically correct language and a logical structure.	**A.D1** Evaluate how significant figures and measurement error affect confidence in a calculated result, using example calculations.

Learning aim B: Understand how sequences and series can be used to solve energy problems

Pass	Merit	Distinction
B.P3 Solve given problems using routine arithmetic and geometric progression operations.	**B.M2** Solve given problems accurately using routine and non-routine arithmetic and geometric progression operations.	**B.D2** Evaluate, using non-routine sequence and series operations, solutions of given problems accurately using routine and non-routine operations.

Learning Aim C: Be able to use calculus to solve energy problems

Pass	Merit	Distinction
C.P4 Solve given problems using differential calculus techniques. [SP – CT] **C.P5** Solve given problems using integration calculus techniques. [SP – CT]	**C.M3** Solve problems accurately to derive the numerical value of a derivative.	**C.D3** Evaluate, using appropriate differential and integral calculus techniques, values for given problems using routine and non-routine functions in an energy context.

Learning aim D: Be able to undertake data handling and graphical representation

Pass	Merit	Distinction
D.P6 Organise data in tables, producing appropriate graphs with correct labels and units. **D.P7** Determine means and gradients from data/graphs to interpret rates of change and typical values.	**D.M4** Explain how graph choice, scale and outliers can influence conclusions drawn from a dataset.	**D.D4** Evaluate the reliability of conclusions drawn from a small dataset by comparing alternative graphing/scaling choices and discussing uncertainty due to measurement error and rounding.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT √
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for Pearson Set Assignment (PSA)

Pearson sets the assignment for the assessment of this unit.

The PSA will take 6 hours to complete.

The PSA will be marked by centres and verified by Pearson.

The PSA will be valid for the lifetime of this qualification.

Assessing the PSA

You will make assessment decisions for the PSA using the assessment criteria provided.

The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on PSAs. There is also further information on our website.

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- scientific calculators and formula reference sheets: for arithmetic, algebraic rearrangement, energy, power, efficiency and cost calculations.
- measurement and electrical context equipment: multimeters, plug-in energy monitors or sample nameplate data for realistic technician scenarios.

Essential information for assessment decisions

Learning aim A

For distinction standard, students analyse technician-style scenarios holistically, integrating arithmetic, algebra, units, conversions and error awareness into a justified numerical outcome. Evidence shows confident selection of appropriate formulae without guidance, adapting calculation approaches to suit context rather than following a single routine method. Students compare alternative pathways to reach a result where appropriate, selecting the most efficient or reliable approach. Calculations are supported by a clear explanation of assumptions, limitations and the impact of measurement uncertainty on final values. Students communicate conclusions in a professional manner, showing how checks, conversions and error considerations strengthen confidence in decisions such as estimated costs, efficiency comparisons or equipment suitability. Final results are clearly reasoned, not just numerically correct.

For merit standard, students go beyond correct calculation by clearly explaining how multi-stage energy-related calculations are structured, and why particular methods, units and conversions are appropriate. Evidence shows coherent working that links arithmetic, algebra and unit handling into connected steps rather than isolated operations. Students justify rearranging formulae and selecting values by referring to the physical meaning of quantities such as power ratings, time periods or measured current. Work demonstrates consistent control of significant figures aligned with measurement quality, and students explain how rounding choices affect confidence in results. Error sources such as instrument resolution, reading uncertainty or environmental conditions are identified and related directly to calculated outcomes. Reasonableness checks are explicitly referenced, showing how students validate answers before presenting a final result.

For pass standard, students apply fundamental arithmetic and algebra accurately in familiar energy technician contexts and support this with correct use of units and basic conversions. Students demonstrate this through clear calculations using integers, decimals, fractions, percentages, ratios and simple formulae linked to power, energy, current, voltage, resistance and cost. Submitted work shows correct substitution of values with units retained throughout. Evidence includes appropriate conversions between common units such as watts and kilowatts, hours and seconds, joules and kilowatt-hours, without prompting. Students show awareness of realistic values by checking outcomes against expectations, for example, identifying when a calculated cost or energy use appears unreasonable. Measurement awareness is demonstrated through sensible rounding and basic acknowledgement of accuracy limitations, even if discussion of error remains brief.

Learning aim B

For distinction standard, students critically evaluate problems involving sequences and series, using technically correct language and a coherent structure. Students will use mathematical methods and terminology precisely and apply relevant units when working with mathematical expressions that model scientific situations. Small and large numerical values will be correctly presented in an appropriate format, e.g. scientific notation or standard form. Evidence should include the accurate application of non-routine methods and clear justification of the chosen strategies. Carry-through errors (initial incorrect values or mistakes in a multi-step calculation where subsequent steps are performed correctly) are acceptable if they do not detract from the depth of evaluation and the logical consistency of the reasoning presented.

For merit standard, students accurately apply both routine and non-routine techniques for arithmetic, geometric and power series problems. The numerical work will be carried out to an appropriate degree of accuracy, e.g. using the appropriate number of significant figures and decimal places. Solutions show precision most of the time and adaptability to varied contexts. Carry-through errors are acceptable if they do not undermine the demonstration of method selection and logical progression in problem solving.

For pass standard, students demonstrate the ability to apply standard methods for arithmetic, geometric and power series to solve given problems. Evidence should show correct use of equations and logical steps in routine contexts. Minor arithmetic and/or scaling errors are acceptable, as are carry-through errors. Students demonstrate an appreciation of the need to use units correctly, but may make errors in their application. There will also be evidence of simple checks to determine if numerical answers are appropriate.

Learning aim C

For distinction standard, students will demonstrate confidence in the application of differential and integral calculus methods to the solution of given problems using mathematical functions. Students correctly and efficiently determine six routine and six non-routine differential functions. A reasoned and balanced evaluation (argument) will be presented when considering how variables can be optimised for at least two non-routine functions related to an energy context. Students will correctly and efficiently apply integration techniques to six given problems. Overall, the evidence will be logically structured and easy to understand by a third party with a mathematical background. For example, students use mathematical terminology correctly and use relevant units when working with functions set in energy contexts. Small and large numerical values will be correctly presented in an appropriate format, i.e. standard form or engineering notation. Students will work to a locally specified numerical precision using appropriate significant figures or decimal places.

For merit standard, students will apply the correct skills and methods when producing the derivatives of functions and applying integral calculus methods. Students will correctly differentiate routine and non-routine functions (one polynomial, two trigonometric, one logarithmic and one exponential). Students will compare the results obtained graphically and analytically for the two gradients being investigated; for example, they will discuss the numerical accuracy of the two methods. Students will correctly integrate routine and non-routine functions. Students should solve two problems accurately to derive the numerical value of a derivative. Overall, students' numerical work will be accurate, using an appropriate degree of precision as specified by the assessor in significant figures or decimal places, and relevant units will be used for all functions. A limited number of arithmetic follow-through errors is acceptable for non-routine functions.

For pass standard, students will apply the correct skills and methods when differentiating at least five given routine mathematical functions. Students will correctly manipulate at least one polynomial, two trigonometric, one logarithmic and one exponential functions. Some functions will be sufficiently complex to enable students to select and apply the correct method (product, quotient, function of a function and substitution) when producing first and second derivatives. Students will demonstrate that they can find, graphically and analytically, at least two gradients for each type of function. For the polynomial and trigonometric functions, students will calculate the turning points in the context of rates of change. Overall, students must be able to demonstrate the correct use of a method when differentiating functions and use the correct units. Minor arithmetic and scaling errors are acceptable. There will also be evidence of simple checks to determine if numerical answers are 'reasonable'. Graphical presentation of functions and determination of their gradients can be done using a spreadsheet, provided that formulae are visible (printed out).

Learning aim D

For distinction standard, students evaluate conclusions drawn from data by comparing alternative representations and interpretations. Evidence includes discussion of how changes in scales, graph types or data groupings alter perceived trends or rates of change. Students explicitly relate these effects to uncertainty arising from measurement accuracy, rounding and limited dataset size. Calculated means and gradients are assessed for suitability, with students explaining when averages or linear trends may mask important variation. Conclusions are balanced, clearly stating both what can and cannot be reliably inferred from the data. Students demonstrate professional judgement by communicating limitations transparently and suggesting how improved data collection or presentation could strengthen confidence in outcomes.

For merit standard, students explain how choices made during data presentation influence interpretation. Evidence justifies the graph type and scale in relation to the data and its purpose, rather than simply presenting a graph. Students discuss how different scales, data ranges or overlooked anomalies could lead to misleading conclusions. Mean values and gradients are not only calculated but explained in context, linking numerical results to what they represent in practical energy situations. Students identify outliers and consider whether to retain them or treat them with caution. Conclusions are supported by references to data quality, demonstrating growing awareness of reliability and limitations while remaining grounded in the provided dataset.

For pass standard, students demonstrate competence by organising provided or collected data into clearly structured tables with correct headings and units. Graphs are selected appropriately for the data type and purpose, and are plotted with labelled axes, suitable scales and titles. Evidence includes straightforward interpretation of graphs, identifying general trends or typical values without extended justification. Students correctly calculate means from datasets and determine gradients from graphs where values are given, linking these to basic interpretations such as average consumption or rate of change. Spreadsheet use may be evident for data organisation, provided outputs are clear and consistent. Overall, the work shows that students can present and interpret data accurately in familiar energy-related contexts.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in most units.

Unit 7: Low or Zero Carbon Energy Systems

Level: 3

Unit type: Pearson Set Assignment

Guided learning hours: 60

Unit in brief

Students study low- or zero-carbon technologies, linking system operation to energy demand and user needs. They analyse energy data and apply design, installation and commissioning principles to develop suitable, efficient energy system solutions.

Unit introduction

This unit is relevant to real-world energy transition challenges, where low- and zero-carbon technologies are increasingly used to reduce emissions and improve energy efficiency. Students benefit from understanding how energy systems operate in domestic and light industrial settings, which supports informed decision-making in sustainable design and energy use.

Students will explore key technologies such as solar photovoltaic systems, heat pumps, biomass and energy storage, alongside energy demand analysis and system design principles. Students will learn how to interpret energy data, assess user needs and apply technical knowledge to size, select and integrate systems. They will also develop an understanding of installation and commissioning processes, including safety, compliance and performance verification.

This unit supports progression to further study in renewable energy, engineering or environmental science, and prepares you for roles in installation, energy assessment, system design or sustainability-focused careers within the growing low-carbon sector.

Learning aims

In this unit, you will:

A Know appropriate technology to provide low- or zero-carbon energy to the end user

B Understand the design, installation and commissioning of low- or zero-carbon energy systems for domestic or light industrial consumers

C Understand the energy needs of a domestic or light industrial consumer.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Know appropriate technology to provide low- or zero-carbon energy to the end user	**A1** Low- and zero-carbon energy principles **A2** Low- and zero-carbon energy technologies **A3** Electrical storage and grid interaction **A4** Factors affecting technology selection	This unit is assessed through a Pearson Set Assignment.
B Understand the design, installation and commissioning of low- or zero-carbon energy systems for domestic or light industrial consumers	**B1** System design considerations **B2** Design of low- and zero-carbon systems **B3** Installation requirements **B4** Commissioning and handover	
C Understand the energy needs of a domestic or light industrial consumer	**C1** Energy demand **C2** Data collection and analysis **C3** Building and usage characteristics **C4** Calculating and presenting energy requirements **C5** Using energy assessment outcomes	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Know appropriate technology to provide low- or zero-carbon energy to the end user

A1 Low- and zero-carbon energy principles

- Definition of low- and zero-carbon energy in relation to carbon intensity (gCO_2/Kilowatt-hour/kWh).
- Difference between renewable generation, low-carbon conversion and energy efficiency.
- Relationship between primary energy source, conversion method and end-use energy demand.

A2 Low- and zero-carbon energy technologies

Operating principles, typical applications and suitability for domestic or light industrial use.

Solar technologies

- Solar photovoltaic (PV):
  - conversion of irradiance to electricity
  - typical system sizes (domestic 2–6 Kilowatt Peak/kWp)
  - light industrial (10–50 Kilowatt Peak/kWp).
- Solar thermal (flat plate and evacuated tube):
  - water heating temperatures (30–70 °C)
  - typical collector areas (2–6m² domestic).

Heat pumps

- Air source heat pumps (ASHP):
  - air-to-water and air-to-air systems
  - typical output (4–20Kilowatt/kW)
  - seasonal performance factor (SPF 2.5–4.0).
- Ground source heat pumps (GSHP):
  - vertical and horizontal loops
  - borehole depths (50–150m)
  - seasonal performance factor (SPF 3.5–5.0).
- Water source heat pumps.

Biomass systems

- Biomass boilers and stoves:
  - o fuels (pellets, chips, logs)
  - o typical outputs (10–100kW)
  - o storage and handling requirements.

Wind energy (small scale)

- Micro and small wind turbines:
  - o rated power (1–20kW)
  - o wind speed requirements (≥4–5m/s)
  - o site suitability.

Hydrogen and fuel cells

- Hydrogen as an energy vector; fuel cell principles; current limitations for domestic/light industrial deployment.

A3 Electrical storage and grid interaction

- Battery storage: lithium-ion technologies; typical capacities (5–20 kWh domestic).
- Export, import, and self-consumption concepts.
- Interaction with smart grids and demand response.

A4 Factors affecting technology selection

- Energy demand profile (heat, electricity, hot water).
- Site constraints: space, orientation, ground conditions, access.
- Climate and seasonal variation.
- Capital cost, operating cost, maintenance requirements.
- Carbon reduction potential and lifecycle considerations.
- User requirements and operational behaviour.

Learning aim B: Understand the design, installation and commissioning of low- or zero-carbon energy systems for domestic or light industrial consumers

B1 System design considerations

- Load matching between energy demand and system output.
- System sizing using peak and annual demand data.
- Efficiency, losses and part-load operation.
- Integration with existing building services (e.g. radiators, underfloor heating, electrical supply).

B2 Design of low- and zero-carbon systems

Solar PV systems

- Array orientation and tilt (typical 15–40°).
- Shading analysis and impact on output.
- Inverters, DC/AC conversion and protection devices.
- Typical system voltages and string configurations.

Solar thermal systems

- Collector selection, heat transfer fluids, and storage tanks.
- Pipework insulation and stagnation control.
- Control strategies and auxiliary heating integration.

Heat pump systems

- Heat emitter compatibility (flow temperatures typically 35–55°C).
- Buffer tanks and thermal stores.
- Ground loop and borehole design considerations (GSHP).

Biomass systems

- Boiler sizing and fuel quality.
- Flue design, ash disposal, and safe clearances.

B3 Installation requirements

- Preparation activities: surveys, risk assessments, permits.
- Mechanical installation: mounting, pipework, ducting.
- Electrical installation: cabling, earthing, isolation, protection.
- Compliance with manufacturer guidance and industry standards.
- Health, safety and environmental considerations.

B4 Commissioning and handover

- Pre-commissioning checks.
- Functional testing and performance verification.
- System balancing and parameter setting.
- Documentation: commissioning records, user manuals, warranties.
- Handover to end user, including basic operation and maintenance awareness.

Learning aim C: Understand the energy needs of a domestic or light industrial consumer

C1 Energy demand

- Types of energy demand: space heating, hot water, electrical loads, process loads.
- Domestic versus light industrial demand profiles.
- Daily, seasonal and annual variations in energy use.

C2 Data collection and analysis

- Review of utility bills and meter data (electricity and fuel).
- Typical consumption ranges:
  - Domestic electricity: ~2,500–4,500 kWh/year
  - Domestic heat demand: ~8,000–2000kWh/year.
- Identification of peak loads and base loads.

C3 Building and usage characteristics

- Building size, layout and occupancy patterns.
- Building fabric performance (walls, roofs, floors, glazing).
- Influence of ventilation and infiltration rates.
- Industrial process loads and operational hours (where applicable).

C4 Calculating and presenting energy requirements

- Estimation of annual and peak energy demand.
- Comparison of calculated demand with historic data.
- Presentation of findings using tables, charts or simple diagrams.
- Identification of opportunities for demand reduction and technology suitability.

C5 Using energy assessment outcomes

- Matching assessed demand to appropriate low- or zero-carbon technologies.
- Recognition of system limits and constraints.
- Use of assessment data to inform design decisions.

Assessment criteria

Learning aim A: Know appropriate technology to provide low- or zero-carbon energy to the end user

Pass	Merit	Distinction
A.P1 Outline low- and zero-carbon technologies with links to end-user applications. **A.P2** Describe factors influencing appropriate technology selection (user demand, site conditions and carbon reduction purpose).	**A.M1** Compare low- and zero-carbon technologies, each linked to their suitability for end-user needs.	**A.D1** Evaluate low- and zero-carbon technologies' effectiveness, constraints and end-user needs.

Learning aim B: Understand the design, installation and commissioning of low- or zero-carbon energy systems for domestic or light industrial consumers

Learning aim C: Understand the energy needs of a domestic or light industrial consumer

Pass	Merit	Distinction
B.P3 Describe design considerations for low- or zero-carbon systems, showing sizing, integration and performance requirements. **B.P4** Describe safe installation and commissioning requirements linking to compliance and functional system operation.	**B.M2** Develop coherent system design decisions with implementation considerations and consistency between design choices and installation requirements.	**BC.D2** Evaluate system design and energy assessment decisions, justifying overall effectiveness in meeting consumer demands and carbon reduction.
C.P5 Describe energy demand characteristics with adequate detail, demonstrating comprehension of domestic or light industrial usage patterns. **C.P6** Plan and carry out energy needs assessment with clarity, using appropriate data to represent annual and peak demand requirements. [SP – C&I]	**C.M3** Analyse assessed energy needs with depth, showing consistency between calculated demand, building characteristics and usage behaviour.	

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I √
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for Pearson Set Assignment (PSA)

Pearson sets the assignment for the assessment of this unit.

The PSA will take 10 hours to complete.

The PSA will be marked by centres and verified by Pearson.

The PSA will be valid for the lifetime of this qualification.

Assessing the PSA

You will make assessment decisions for the PSA using the assessment criteria provided.

The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on PSAs. There is also further information on our website.

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- System demonstrators: small-scale solar PV panels, solar thermal rig, heat pump trainer, basic biomass or wind demonstrator units.

Essential information for assessment decisions

Learning aim A

For Distinction standard, students construct well-developed evaluative responses that bring together technical performance, environmental impact and practical constraints to determine the overall effectiveness of technologies. They interpret evidence by weighing advantages and limitations, such as variability of renewable sources, storage requirements and lifecycle carbon implications, in relation to a specific user context. Students justify conclusions by synthesising knowledge of energy demand, system integration and operational behaviour, demonstrating how decisions influence long-term performance and sustainability outcomes. Their responses reflect critical understanding through balanced judgements that connect technical detail with realistic applications. Students present coherent, structured arguments that show clear insight into how multiple interrelated factors determine the effectiveness of low- or zero-carbon energy solutions for defined end users.

For Merit standard, students demonstrate depth by making clear comparative judgements between different low- and zero-carbon technologies, using technical characteristics and performance indicators to justify relative suitability. They connect operational principles, efficiency ranges and environmental conditions to explain why some systems perform more effectively in specific domestic or light industrial scenarios. Students interpret evidence by integrating multiple selection factors, including lifecycle considerations, user behaviour and demand profiles, to show how these influence decision-making. Their comparisons are supported by coherent links between system capabilities and end-user requirements.

For Pass standard, students present knowledge of low- and zero-carbon technologies by selecting relevant examples such as solar photovoltaic systems, heat pumps, biomass and/or small-scale wind and relating their operating principles to realistic end-user applications. They demonstrate understanding by linking technologies to domestic or light industrial contexts, referencing typical outputs, system sizes or performance factors. Students interpret selection factors by connecting energy demand types, site constraints such as orientation or space and user requirements to appropriate technology choices. Their evidence shows clarity through structured explanations that integrate key concepts such as carbon intensity, energy conversion and system purpose.

Learning aims B and C

For Distinction standard, students produce well-justified evaluations that integrate energy assessment, system design and implementation considerations to determine overall effectiveness in meeting energy demand and reducing carbon impact. They interpret complex evidence by synthesising demand calculations, building characteristics and operational constraints to support balanced judgements. Students demonstrate critical insight by assessing how design decisions influence installation feasibility, system performance and long-term operation, including efficiency and reliability. They justify their conclusions by clearly connecting data-driven analysis to practical system outcomes, showing how alternative approaches could affect overall performance. Their responses are coherent and evaluative, demonstrating a high level of technical understanding and the ability to integrate multiple factors into a comprehensive judgement of system suitability for domestic or light industrial applications.

For Merit standard, students develop coherent design responses that effectively link assessed energy demand with appropriate system configurations and implementation considerations. They interpret data by combining calculated demand with building fabric performance, usage behaviour and environmental conditions to inform consistent design decisions. Students demonstrate depth by aligning system sizing, component selection and integration strategies with installation constraints and operational requirements. They connect commissioning processes with expected system performance, showing how testing and adjustment ensure alignment between design intent and actual operation. Their evidence is logically structured and demonstrates clear reasoning, with consistent links between energy assessment outcomes and technical design choices. Students present integrated responses that reflect an understanding of how design, installation and commissioning stages collectively support effective energy system delivery.

For Pass standard, students demonstrate understanding of system design and energy needs by describing how energy demand data informs the selection and configuration of low- or zero-carbon systems. They interpret building characteristics, occupancy patterns and energy usage profiles to explain how systems are sized and integrated with existing services. Students present evidence of installation requirements by outlining key activities such as site preparation, mechanical and electrical setup, and compliance with safety and regulatory standards. They show understanding of commissioning by referring to testing, balancing and documentation processes that ensure systems operate correctly. Students organise their work using clear calculations, tables or charts to represent energy demand, linking these outputs to appropriate system choices.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1 Human Energy Use.
- Unit 6 Mathematics for Energy Technicians.
- Unit 5 Scientific Principles for Energy Systems.
- Unit 17 Smart Energy Systems and Building Efficiency.
- Unit 18 Low-Carbon Heating Technologies.
- Unit 21 Energy Auditing and Consultancy Practices.

Unit 8: Advanced Mathematics for Energy Technicians

Level: 3

Unit type: Pearson Set Assignment

Guided learning hours: 60

Unit in brief

Calculus techniques, matrices, complex numbers and statistical methods are applied to solve real-world problems in green energy. Students progress from routine calculations to advanced problem solving and evaluation using accurate mathematical reasoning.

Unit introduction

This unit is relevant to real-world applications because it equips students with mathematical tools to solve practical problems in green energy, engineering and technology. Understanding calculus techniques and their link to real-life engineering problems, matrices, complex numbers and statistical methods enables students to interpret and model real-life scenarios, from predicting trends to analysing systems. These skills are critical for informed decision-making and underpin many modern innovations and processes.

The unit covers a broad range of mathematical concepts, building in complexity and depth. You will explore calculus techniques and their applications, followed by matrix operations and determinants for solving linear systems. Complex numbers are introduced for handling advanced engineering and physics problems. The unit also addresses statistical measures, probability distributions and regression techniques, ensuring you can analyse data effectively. Each topic progresses from routine operations to non-routine problem solving.

Completing this unit benefits students' ability to apply mathematical reasoning to real-world contexts, supports progression into STEM-related degrees and roles in energy, engineering, data analysis and applied sciences, and provides a strong foundation for lifelong learning and professional growth.

Learning aims

In this unit you will:

A Examine how calculus can be used to solve real-world problems

B Examine how matrices and determinants can be used to solve real-world problems

C Examine how complex numbers can be used to solve real-world problems

D Investigate how statistical and probability techniques can be used to solve energy problems.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Examine how calculus can be used to solve real-world problems	**A1** Differential calculus **A2** Integral calculus **A3** Numerical integration	This unit is assessed through a Pearson Set Assignment.
B Examine how matrices and determinants can be used to solve real-world problems	**B1** Matrices **B2** Determinants	
C Examine how complex numbers can be used to solve real-world problems	**C1** Complex numbers	
D Investigate how statistical and probability techniques can be used to solve energy problems	**D1** Statistical techniques **D2** Probability distributions **D3** Statistical investigation	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Examine how calculus can be used to solve real-world problems

A1 Differential calculus

Application of differential techniques to algebraic (polynomial), trigonometric (sine, cosine), logarithmic and exponential functions for solving real-world problems.

- Standard differential calculus methods
  - polynomial equations of the form $s = 5t^2 - 3t + 4$
  - trigonometric (sine, cosine) equations of the form $y = \sin^2 4x$
  - logarithmic equations of the form $v = 8\log_e(5x)$
  - exponential equations of the form $y = 2e^{(3x+5)}$.
- Differentiation by standard results e.g. $y = ax^n$, where $\frac{dy}{dx} = nax^{(n-1)}$.
- Derivatives of algebraic (powers) ax^n.
- Derivatives of trigonometric (sine, cosine) sinax, cosax.
- Derivatives of logarithmic functions, e.g. $\log_e ax$.
- Derivatives of exponential functions, e.g. e^{ax}.
- Product rule e.g. $\frac{dy}{dx} = \frac{vdu}{dx} + \frac{udv}{dx}$.
- Quotient rule e.g. $\frac{dy}{dx} = \frac{\frac{vdu}{dx} + \frac{udv}{dx}}{v^2}$.
- Function of a function (chain rule) method.
- Second-order derivatives:
  - second derivative of algebraic (polynomial) e.g. $y = ax^n$, where $\frac{d^2y}{dx^2} = n(n-1)ax^{(n-2)}$
  - second derivative of trigonometric (sine, cosine) functions
  - the location of stationary values, to include turning points, points of inflection.

A2 Integral calculus

- Application of indefinite and definite integration techniques to algebraic (polynomial), trigonometric and exponential functions, to solve real-world problems.
- Routine functions integrated in one step without the need for manipulation, using standard integral calculus methods to include:
  - polynomial e.g. $\int(x^2 - 3x + 4)dx$
  - trigonometric (sine, cosine) e.g. $\int(\sin 5\Theta - 3\cos 4\Theta)d\Theta$
  - reciprocal e.g. $\int\frac{3}{x}$
  - exponential e.g. $\int(e^{3t})dt$.

- Integration of common functions by standard results e.g. ax^n, sinax, cosax, $\frac{1}{x}$, e^{ax}.
- Indefinite integrals, constant of integration, initial conditions.
- Definite integrals – limits and square bracket notation.

A3 Numerical integration

Application of the formulae for irregular areas and volumes for numerical integration

- Trapezoidal rule:
  - for comparison of methods in terms of complexity and accuracy.
- Mid-ordinate rule:
  - For comparison of methods in terms of complexity and accuracy.
- Simpson's rule:
  - area under a curve determined using Simpson's rule for comparison with values obtained using calculus.
- Numerical integration using a spreadsheet.
- Arithmetic calculation of various properties of sections, including:
  - cross-sectional area
  - location of centroid
  - neutral axis
  - moment of inertia
  - section modulus
  - radius of gyration.

Learning aim B: Examine how matrices and determinants can be used to solve real-world problems

B1 Matrices

- Definitions:
  - matrix type – element and order (row x column)
  - matrix terminology – element, row, column, order (row x column), equality, zero (null matrix), identity (unit) matrix, transpose, square, leading diagonal, triangular.
- Routine operations involve:
  - addition, subtraction, multiplication by a real number
  - inverse of a (2 x 2) matrix
  - solution of sets of simultaneous equations with two variables using inverse matrix methods.
- Non-routine operations involve:
  - multiplication of matrices
  - solution of sets of simultaneous equations with two variables using Gaussian elimination.

B2 Determinants

- Definitions:
  - the determinant of a matrix as a useful value that can be computed from the elements of a square matrix, denoted by det(*A*) or $|A|$
  - a singular matrix is one with the determinant $|A| = 0$.
- Routine operations involve:
  - the determinant of a (2 x 2) matrix

$$A = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \text{ using } |A| = ad - bc$$

  - the inverse of a two-dimensional matrix

$$A = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \text{ using } A^{-1} = \begin{pmatrix} d & -b \\ -c & a \end{pmatrix}.$$

- Non-routine operations involve:
  - the determinant of a (3 x 3) matrix

$$A = \begin{pmatrix} a & b & c \\ d & e & f \\ g & h & i \end{pmatrix} \text{ using}$$

$$|A| = a\begin{pmatrix} e & f \\ h & i \end{pmatrix} - b\begin{pmatrix} d & f \\ g & i \end{pmatrix} + c\begin{pmatrix} d & e \\ g & h \end{pmatrix}$$

  - use of Cramer's rule to solve for sets of simultaneous equations with two variables
  - real-world applications, e.g. simultaneous linear equations with more than two variables (electrical circuits, vector arrays, machine cutter paths).

Learning aim C: Examine how complex numbers can be used to solve real-world problems

C1 Complex numbers

- Definitions:
  - algebraic form (Cartesian, rectangular notation): ($a + ib$)
  - real part, imaginary part, *i* notation, *i*-operator, powers of *i*
  - modulus:

$$|a + ib| = \sqrt{a^2 + b^2}$$

  - argument:

$$\arg(a + ib) = tan^{-1}\begin{pmatrix} b \\ a \end{pmatrix}$$

  - polar form $r\angle\theta$; θ is usually expressed in radians but may be in another angular measure
  - complex conjugate of $y = a \pm ib$ as $y^* = a \mp ib$.
- Routine operations involve:
  - placement of complex numbers on an Argand diagram
  - addition and subtraction in rectangular form

- multiplication by a constant coefficient
- conversion between rectangular and polar forms $r \rightarrow p$ and $p \rightarrow r$ using trigonometry and a scientific calculator
- multiplication and division of complex numbers in polar form.

- Non-routine operations involve:
  - multiplication in rectangular form
  - division in rectangular form using the complex conjugate
  - de Moivre's theorem: $(r\angle\theta)^n = r^n\angle n\theta$
  - real-world applications, e.g. vectors, electrical circuit phasor diagrams, algebraic form (Cartesian, rectangular notation): $(a + ib)$
  - real part, imaginary part, *i* notation, *i*-operator, powers of *i*
  - modulus: $|a + ib| = \sqrt{a^2 + b^2}$
  - argument:

$$\arg(a + ib) = tan^{-1}\left(\frac{b}{a}\right)$$

  - polar form $r\angle\theta$; is usually expressed in radians, but may be in another angular measure
  - complex conjugate of

$$y = a \pm ib \text{ as } y^* = a \mp ib.$$

Learning aim D: Investigate how statistical and probability techniques can be used to solve energy problems

D1 Statistical techniques

- Routine operations involve:
  - discrete data, continuous data, ungrouped data, grouped data, rogue values
  - presentation of data – bar charts, pie charts, histograms, cumulative frequency curves
  - measures of central tendency (location) – arithmetic mean, median, mode
  - measures of dispersion – variance, standard deviation, range and interquartile ranges
  - linear relationship between independent and dependent variables, scatter diagrams, approximate equation of line of regression y = mx + c represented graphically.
- Non-routine operations involve:
  - equation of linear regression line $y = mx +$ where

$$m = \frac{N\sum_1^N (x_i y_i) - \sum_1^N (x_i)\sum_1^N (y_i)}{N\sum_1^N x_i^2 - \left(\sum_1^N x_i\right)^2} \text{ and } c = \overline{y} - m\overline{x}$$

$$\overline{x} = \frac{\sum_1^N x_i}{N} \text{ and } \overline{y} = \frac{\sum_1^N y_i}{N}$$

- correlation coefficient using Pearson's correlation

$$r_{x,y} = \frac{N\sum_{1}^{N} x_i y_i - \sum_{1}^{N} x_i \sum_{1}^{N} y_i}{\sqrt{N\sum_{1}^{N} x_i^2 - \left(\sum_{1}^{N} x_i\right)^2} - \sqrt{N\sum_{1}^{N} y_i^2 - \left(\sum_{1}^{N} y_i\right)^2}}.$$

- Use of spreadsheets and/or scientific calculators to calculate the equation of the line of regression and the correlation coefficient, e.g. tabulating calculations using trendline and CORREL function in a spreadsheet or a standard scientific calculator.
- Use of spreadsheets and/or scientific calculators to identify the most appropriate type of regression line, e.g. linear, logarithmic, exponential or variable power.

D2 Probability distributions

- Routine operations involve:
  - normal distribution – shape and symmetry, skew, tables of cumulative distribution function, mean, variance
  - normal distribution curve – areas under it relating to integer values of standard deviation.

D3 Statistical investigation

- The use of appropriate mathematical methods to solve the given real-world problem.
- Real-world applications, e.g. inspection and quality assurance, calculation of central tendencies and dispersion, forecasting, reliability estimates for components and systems, customer behaviour, condition monitoring and product performance.
- Reflection on the problem-solving process and solution(s) obtained; refinements where appropriate.
- Presentation of solution(s) to the given real-world problem.

Assessment criteria

Learning aim A: Examine how calculus can be used to solve real-world problems

Pass	Merit	Distinction
A.P1 Demonstrate, using differential calculus techniques, the solutions for two given problems. **A.P2** Demonstrate, using integral calculus techniques, the solution for two given problems. **A.P3** Demonstrate, using simple numerical integration techniques, the solution for a given problem.	**A.M1** Demonstrate, using advanced differential calculus, solutions for each type of given routine function for a given problem.	**A.D1** Demonstrate and validate solutions to given problems using advanced differential and integral techniques.

Learning aim B: Examine how matrices and determinants can be used to solve real-world problems

Learning aim C: Examine how complex numbers can be used to solve real-world problems

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td>B.P4 Solve given problems using routine matrices and determinant operations.</td><td>B.M2 Solve given problems accurately using routine and non-routine matrices and determinant operations.</td><td rowspan="2">BC.D2 Evaluate given energy problems using non-routine matrix, determinant and complex techniques, applying routine and non-routine operations accurately.</td></tr>
<tr><td>C.P5 Solve given problems using routine complex number operations.</td><td>C.M3 Solve given problems accurately using routine and non-routine complex number operations.</td></tr>
</table>

Learning aim D: Investigate how statistical and probability techniques can be used to solve energy problems

Pass	Merit	Distinction
D.P6 Solve an energy problem using routine central tendency, dispersion and probability distribution operations. **D.P7** Solve an energy problem using routine linear regression operations.	**D.M4** Explain own solution to an energy problem accurately using routine and non-routine central tendency, dispersion and probability distribution operations. **D.M5** Explain own solution to an energy problem accurately using routine and non-routine regression operations.	**D.D3** Evaluate the correct synthesis and application of statistics and probability to solve energy problems involving accurate routine and non-routine operations.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for Pearson Set Assignment (PSA)

Pearson sets the assignment for the assessment of this unit.

The PSA will take 4 hours to complete.

The PSA will be marked by centres and verified by Pearson.

The PSA will be valid for the lifetime of this qualification.

Assessing the PSA

You will make assessment decisions for the PSA using the assessment criteria provided.

The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on PSAs. There is also further information on our website.

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- scientific calculator and mathematical software: tools like Excel, MATLAB or GeoGebra for computations, graphing and matrix operations
- visual aids and interactive models: charts, diagrams and digital simulations to illustrate sequences, series, matrices and statistical concepts
- data sets and real-world problem scenarios: authentic examples for applying statistical analysis, regression and probability.

Essential information for assessment decisions

Learning aim A

For distinction standard, students will demonstrate high levels of skill in applying differential and integral calculus methods to the solution of given engineering problems, using mathematical functions. For differential calculus, students will correctly and efficiently manipulate six complex routine functions, while for integral calculus, students will correctly and efficiently manipulate complex routine functions when producing indefinite and definite integrals. Alternative solution methods must be used for integration, where appropriate, to compare the results and the accuracy of the values. For example, validating values using the mid-ordinate rule by comparing them to those achieved using calculus. The evidence will be logically structured and easy to understand by a third party with a mathematical background, who may or may not be an engineer. For example, students will use mathematical terminology correctly and use relevant units when working with functions set in construction contexts. Small and large numerical values will be correctly presented in an appropriate format, such as standard form. Students will work to a specified numerical precision (as determined by the assessor) through the use of appropriate significant figures or decimal places.

For merit standard, students will apply the correct skills and methods when producing the derivatives of functions and determining their gradients. Students will correctly manipulate six routine functions (two polynomial, two trigonometric, one logarithmic and one exponential). Some functions will be sufficiently complex to enable students to select and apply the correct method (product, quotient, function of a function and substitution) when producing first and second derivatives. Students will select and apply the correct methods when producing the definite and indefinite integrals of functions and determining the properties of periodic functions. Students will correctly manipulate eight routine functions, with a further three functions sufficiently complex to enable them to select and apply the correct methods (substitution and by parts) when producing indefinite and definite integrals. Numerical integration will have been accurately completed for four definitive routine functions, using each of the three techniques given (trapezoidal rule, mid-ordinate rule and Simpson's rule). Students' numerical work will be accurate, using an appropriate degree of precision as specified by the assessor, in significant figures or decimal places, and will use relevant units for all functions. A limited number of arithmetic follow-through errors is acceptable for non-routine functions.

For pass standard, students will apply the correct methods when differentiating at least six given routine mathematical functions. Students will correctly manipulate at least two polynomial functions, two trigonometric functions, one logarithmic function and one exponential function. Students will apply the correct methods to integrate at least eight given routine mathematical functions. Students will correctly manipulate at least two routine functions for each function type (polynomial, trigonometric, reciprocal and exponential). At least one of each type will be an indefinite integral, and one of each type will be a definite integral. In total, at least eight different routine functions will be solved. Numerical integration will be completed using each of the three approaches for at least two routine functions; these can be manipulated using a spreadsheet, provided that formulae are visible (printed out). There is evidence of simple checks to determine if numerical answers are reasonable. Students must demonstrate the correct use of a method when differentiating and integrating functions, and use the correct units. They must also demonstrate the correct use of a method and units when integrating functions by a numerical method – minor arithmetic and scaling errors are acceptable. There will be evidence of simple checks to determine if numerical answers are reasonable.

Learning aims B and C

For distinction standard, students evaluate complex problems involving matrices, determinants and related operations, presenting solutions with technical accuracy and structured reasoning. Evidence should include critical analysis of methods and accurate application of advanced techniques. Students demonstrate the ability to apply routine operations with complex numbers to solve given problems. Evidence should show the correct use of standard techniques and logical progression. Carry-through errors are acceptable if they do not compromise the quality of the evaluation or the logical flow of the solution.

For merit standard, students accurately solve problems using both routine and non-routine matrix and determinant operations. Work should demonstrate precision, adaptability and a clear justification of the chosen methods. Students accurately apply both routine and non-routine methods to solve problems involving complex numbers. Solutions should reflect precision, adaptability and clear explanation of processes. Carry-through errors are acceptable if they do not obscure the student's ability to apply appropriate techniques effectively.

For pass standard, show competence in performing routine operations with matrices and determinants to solve given problems. Evidence should reflect the correct application of standard techniques and logical sequencing of steps. Carry-through errors are acceptable provided the initial method and reasoning are sound. Students demonstrate the ability to apply routine operations with complex numbers to solve given problems. Evidence should show the correct use of standard techniques and logical progression. Students will include evidence of simple checks to determine if numerical answers are appropriate.

Learning aim D

For distinction standard, students critically evaluate the synthesis and application of statistical and probability methods in solving energy problems, using technically correct language and logical structure. Students must solve complex problems by applying both routine and advanced statistical methods to large, reliable datasets. After ensuring the data is sufficient for analysis, students will propose and test theoretical relationships between variables using regression. Finally, students will use analytical and graphical tools to calculate these connections and reflect on the accuracy of their linear and non-linear predictions. Evidence should demonstrate the accurate application of advanced techniques and provide a clear justification for the chosen strategies. Carry-through errors are acceptable if they do not detract from the quality of the evaluation.

For merit standard, students accurately apply both routine and non-routine statistical and regression methods to solve problems, providing clear explanations of processes. Evidence should reflect precision, adaptability and structured reasoning. They will apply appropriate routine and non-routine operations (skills and methods) required to process statistical data accurately. For example, they will tabulate data, produce clear graphical presentations and calculate mean and standard deviation values to compare measured results with historical data. They will also produce an accurately annotated scatter diagram, including chart and axis titles, units and gridlines, and calculate both the line of regression and correlation coefficient for a linear relationship, as well as a regression line for a non-linear relationship. Carry-through errors are acceptable if they do not obscure the student's ability to apply appropriate techniques effectively.

For pass standard, solutions may not be complete and there may be some inaccuracies or omissions, but there is evidence of proficiency in the method. Students apply the appropriate routine operations (skills and methods) required to process statistical data. Students will tabulate measurements and create scatter diagrams to estimate regression lines graphically. While the chosen statistical methods may not be optimal, they must be applied correctly and presented logically. Minor omissions, such as missing units on axes or carry-through errors from an incorrect mean, are acceptable as long as the subsequent steps remain mathematically consistent. There will be an appreciation of the need to use correct units and evidence of simple checks to determine if numerical answers are appropriate.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in most units.

Unit 9: Technical and Graphical Drawing for Energy Systems

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students develop knowledge and apply practical skills to produce technical and graphical information for energy-system applications using both manual drawing and computer-aided design (CAD) methods.

Unit introduction

Energy projects rely on clear, accurate drawings to communicate ideas safely and effectively. In real-world energy and engineering environments, technicians, installers and engineers must be able to read and produce drawings that show layouts, components and connections without ambiguity.

The unit introduces you to the fundamental skills needed to interpret and produce technical drawings using recognised conventions and standards, and it may lean more towards professional competency. Content includes orthographic and pictorial drawings, schematics and simple layouts, along with accurate dimensioning, symbols and annotations. You will also develop the basic CAD skills necessary to produce 2D and 3D drawings, enabling you to create drawings and models of energy systems.

This unit supports progression by providing fundamental drawing skills that underpin later technical and design-related learning, including system integration and installation planning. It also enhances employability, as CAD and technical drawing skills are widely valued across roles in energy, engineering, construction and environmental technology.

Learning aims

In this unit you will:

A Know technical drawing standards, conventions and symbols used in energy-system applications

B Be able to produce simple 2D CAD drawings using standard conventions for energy-related components and layouts

C Be able to create basic 3D CAD models and simple assemblies relevant to energy-system components.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Know technical drawing standards, conventions and symbols used in energy-system applications	**A1** Purpose and types of technical drawings **A2** Drawing standards and presentation **A3** Common conventions and notation used in energy-related drawings	Interpretation of drawings and application of conventions to produce accurate 2D CAD layouts, reviewing work for clarity, completeness and consistency.
B Be able to produce simple 2D CAD drawings using standard conventions for energy-related components and layouts	**B1** CAD set-up and workflow essentials **B2** Creating and editing 2D geometry efficiently **B3** Producing 2D drawings for energy-system subjects **B4** Checking, quality assurance and communicating intent	
C Be able to create basic 3D CAD models and simple assemblies relevant to energy-system components	**C1** Principles of 3D modelling **C2** Modelling components relevant to energy applications **C3** Simple assemblies and output generation	Creation of 3D models and assemblies, generating drawing outputs and reviewing design choices.

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Know technical drawing standards, conventions and symbols

A1 Purpose and types of technical drawings

- Purposes: communication, manufacture, installation planning, maintenance documentation.
- Types of drawings used in energy contexts:
  - key orthographic projections and auxiliary views
  - isometric/pictorial drawings
  - schematic diagrams (electrical and fluid)
  - simple layout drawings (e.g. plant room arrangement, equipment placement).

A2 Drawing standards and presentation

- Layout and legibility:
  - sheet sizes and borders
  - line types and line weights (visible, hidden, centre, section)
  - scaling and use of viewports (where appropriate).
- Title blocks and drawing information:
  - drawing title, drawing number, scale, author, date
  - revision tables and change notes.
- Dimensioning and tolerancing:
  - linear and angular dimensions
  - overview of datum and baseline dimensioning
  - basic tolerances and fits.
- Global standards for graphical representation of objects in technical drawings e.g. BS EN ISO 128 series, ASME Y14 series.

A3 Common conventions and notation used in energy-related drawings

- Standard conventions:
  - section views and hatching, key materials indication
  - symbols for surface finish and notes/annotations.
- Use of symbols and schematic language:
  - electrical symbols used on layouts (e.g. isolators, protective devices, connections)
  - fluid symbols (e.g. pipes, valves, pumps, heat exchangers)
  - mechanical symbols (e.g. bearings, shafts, fasteners).

- Interpreting drawings safely:
  - identifying hazards implied by drawings (hot surfaces, high voltage, pressurised lines) as annotation awareness only.

Learning aim B: Be able to produce 2D CAD drawings for energy applications

B1 CAD set-up and workflow essentials

- CAD environment:
  - units, templates, layers, line types/weights
  - snaps, grids, object properties
  - blocks/components and libraries (symbol re-use).
- File discipline:
  - naming conventions, folder control, versioning, exporting PDFs/DWGs (overview).

B2 Creating and editing 2D geometry efficiently

- Drawing tools: line, polyline, circle, arc, rectangle, trim/extend, offset, fillet/chamfer.
- Accurate construction methods:
  - constraints, reference geometry and construction lines
  - using layers to separate services (e.g. electrical versus mechanical versus plumbing).
- Annotation:
  - dimensions, leaders, notes, legends, title blocks
  - consistent text styles and scaling for readability.

B3 Producing 2D drawings for energy-system subjects

Students produce drawings from given briefs, such as:

- A simple plant room layout (equipment footprints, access clearances, pipe routes shown diagrammatically).
- A single-line schematic (e.g. simplified electrical layout diagram using standard symbols).
- A piping schematic for a basic loop (pump–valve–heat exchanger).
- A mounting/layout drawing (e.g. roof array outline or equipment pad layout), focusing on geometry, dimensions and annotation – not energy yield or system performance.

B4 Checking, quality assurance and communicating intent

- Checking for:
  - completeness (views, dimensions, notes)
  - consistency (units, scale, line weights)
  - clashes (overlaps, unreadable annotation, missing access zones).

- Producing a simple drawing pack:
  - general arrangement + schematic + detail (as appropriate)
  - 'fitness for purpose' review against the brief (professional habit).

Learning aim C: Be able to produce 3D CAD modelling and assemblies

C1 Principles of 3D modelling

- Coordinate planes and sketching.
- Constraints and dimensions in sketches.
- Features: extrude, revolve, cut, fillet, chamfer, pattern.

C2 Modelling components relevant to energy applications

Modelling components such as:

- A bracket or mounting plate.
- A simple duct or pipe section with flanges.
- A pump housing envelope (simplified geometry).
- A sensor enclosure or terminal box (simplified).

Note: components are simplified to maintain focus on CAD skills, not detailed product design.

C3 Simple assemblies and output generation

- Creating simple assemblies:
  - mating constraints/relationships
  - role of exploded view.
- Producing outputs:
  - generating 2D views from a 3D model
  - adding dimensions/notes and a title block.
- Export formats and communication:
  - basic rendering/visualisation for stakeholders.
- Overview of export for manufacture/installation documentation.

Assessment criteria

Learning aim A: Know technical drawing standards, conventions and symbols

Learning aim B: Be able to produce 2D CAD drawings for energy applications

Pass	Merit	Distinction
A.P1 Interpret technical drawings for energy-related applications by correctly identifying drawing views, scale, line types and key information in title blocks and notes. **A.P2** Use appropriate drawing conventions and symbols to produce a clear schematic or layout drawing for a given energy-system subject. [EL – MOL]	**A.M1** Justify how drawing standards, annotation and revision control have contributed to clarity, safety and communication in energy documentation.	**AB.D1** Evaluate completed schematic or layout drawings for consistency, accuracy of annotation, and effective symbol use, justifying decisions on presentation and checking processes.
B.P3 Demonstrate accurate 2D CAD drawing using appropriate CAD set-up (units, layers, lineweights) and appropriate geometric tools. **B.P4** Apply dimensions, annotations, symbols and a title block to create a complete 2D drawing suitable for communication of an energy-related layout or schematic.	**B.M2** Explain and apply checking methods to confirm a 2D CAD drawing meets a given brief, including completeness, readability, consistency.	

Learning aim C: Be able to produce 3D CAD modelling and assemblies

Pass	Merit	Distinction
C.P5 Use appropriate 3D CAD model sketch constraints and features of a component relevant to an energy application. **C.P6** Create a simple 3D assembly and generate a clear 2D drawing output that includes key dimensions, annotations and notes for communication.	**C.M3** Explain how 3D models and associated 2D drawing output support communication, reduce errors and improve coordination in energy engineering tasks.	**C.D2** Evaluate how alternative CAD modelling and drawing-output choices (view selection, layer strategy, annotation approach) influence clarity, buildability and error reduction for an energy-related component or layout, justifying revision changes made.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL √	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on setting assignments. There is also further information on our website.

There is a maximum number of 2 summative assignments for this unit.

The relationship of the learning aims and criteria is:

Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, AB.D1)

Learning aim: C (C.P5, C.P6, C.M3, C.D2)

Further information for teachers and assessors

Resource requirements

- appropriate 2D and 3D CAD software
- basic manual drawing equipment for sketching and interpreting technical information.

Essential information for assessment decisions

Learning aims A and B

For distinction standard, students demonstrate evaluative judgement across both knowledge and application. The student critiques completed drawings by comparing alternative presentation, symbol or annotation approaches and selecting those that best suit the energy-system context. Drawings are consistent, accurate and clearly fit for purpose, with revision decisions explicitly justified through discussion of clarity, coordination and usability. Checking activity is systematic rather than corrective, showing anticipation of issues such as clashes, misinterpretation or missing information. The student's evaluation shows a strong understanding of how drawing standards operate in real technical environments and how professional drafting habits contribute to efficient installation, maintenance and communication. Overall, the content supports confident, reflective technical practice rather than following rules alone.

For merit standard, students demonstrate use of technical drawing knowledge with greater control and justification. Work explains how conventions, annotation methods and presentation choices support clarity, coordination and safe interpretation within energy-system contexts. 2D CAD drawings are well organised and consistently presented, with considered layer use, line weights and annotation styles that improve readability. The student demonstrates purposeful checking, identifying why revisions were needed and how these improved completeness, alignment with the brief or communication intent. Decisions are explained using correct technical language, showing understanding rather than procedural repetition. The content shows that the student can not only produce drawings correctly but can also explain how standards and checking practices reduce ambiguity and professional risk.

For pass standard, students recognise and apply foundational technical drawing knowledge in a practical context. Work demonstrates an understanding of the purposes of different drawing types, and uses recognised conventions, symbols and layout features accurately, even if explanations are brief. 2D CAD drawings are complete and readable, showing correct set-up decisions such as units, layers and line types, alongside appropriate geometry and annotation. Drawings follow the given brief and clearly communicate layout or schematic information, with dimensions, notes and title block information present.

Checking activity is evident through basic corrections or improvements, showing the student can identify obvious omissions or inconsistencies. Overall, the content reflects reliable technician-level competence and accurate use of established drawing practices suitable for clear communication.

Learning aim C

For distinction standard, students show evaluative decision-making in both modelling and drawing output. The student compares alternative modelling strategies, view selections or annotation approaches and explains how changes improve clarity, buildability or error reduction. Revisions are justified using the intended use of the drawing, such as installation, checking or coordination. Assemblies and outputs demonstrate professional judgement rather than minimum compliance, with modelling decisions clearly aligned to communication outcomes. The content reflects a mature understanding of how CAD choices influence real-world technical processes and demonstrates reflective, improvement-led practice consistent with advanced technician expectations.

For merit standard, students explain how 3D modelling and drawing outputs support understanding and reduce errors in energy-engineering tasks. Modelling choices are purposeful, with sketch constraints and features applied in a way that supports consistency and modification. Assemblies are organised logically, and 2D outputs are selected to show critical information clearly. The student explains how views, dimensions or annotations would support installers, technicians or other stakeholders. The content reflects growing awareness of coordination and communication needs beyond the CAD environment, showing how modelling supports safe and efficient technical work.

For pass standard, students produce basic but accurate 3D CAD components relevant to energy applications. Models use appropriate sketch constraints and standard modelling features to create recognisable forms without unnecessary complexity. A simple assembly is produced that demonstrates correct spatial relationships between components. Generated 2D drawing outputs are clear and include essential dimensions, annotations and notes to communicate shape, size and function. Work shows that the student understands how 3D models translate into usable drawings, even if the reasoning is concise. The content demonstrates secure foundational modelling skills and the ability to generate outputs suitable for basic communication and coordination tasks.

Unit 10: The Hydrogen Energy Economy

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students explore hydrogen as an energy carrier, covering production pathways, quality requirements, storage, transport and distribution constraints.

Unit introduction

This unit is strongly linked to real-world developments, as hydrogen plays an increasing role in low-carbon energy systems, transport and industrial decarbonisation. Students need to understand hydrogen because it is being used to address 'hard to electrify' sectors and presents unique challenges in production, storage, safety and infrastructure that differ from other energy carriers. Significant amounts of stored hydrogen are also increasingly expected to form vital parts of the electricity supply grid for any nation relying extensively on renewable sources of electricity generation.

The unit provides specialist coverage of hydrogen as an energy carrier rather than a primary energy source. Students will explore hydrogen properties and production routes such as electrolysis and reforming. This unit will also discuss in depth the storage and transport options, as well as the operation of hydrogen fuel cells. The unit also addresses infrastructure requirements, efficiency losses and hydrogen safety, including hazards, materials compatibility and risk control.

This unit supports progression by preparing students for further study in hydrogen technologies, energy engineering and emerging clean energy systems. It also builds industry-relevant knowledge valued in sectors such as transport, power generation, process engineering and energy infrastructure development.

Learning aims

In this unit you will:

A Know production pathways and hydrogen quality

B Know hydrogen storage, transport and distribution

C Understand hydrogen applications, including fuel cells and hydrogen internal combustion engines (H_2ICE)

D Understand hydrogen health and safety, infrastructure and operational requirements.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Know production pathways and hydrogen quality	**A1** Hydrogen as an energy carrier **A2** Production methods (process and constraints) **A3** Hydrogen 'colours' as technical descriptors **A4** Hydrogen quality, purity and end-use requirements	Assessment uses structured descriptions, explanations and comparisons, supported by diagrams and data, to evidence understanding of solar energy conversion principles.
B Know hydrogen storage, transport and distribution	**B1** Compressed hydrogen gaseous storage **B2** Liquid hydrogen cryogenic storage **B3** Overview of solid-state and chemical carrier options **B4** Distribution pathways and infrastructure compatibility	
C Understand hydrogen applications, including fuel cells and hydrogen internal combustion engines (H_2ICE)	**C1** Fuel cell fundamentals (principles and outputs) **C2** Fuel cell types and operating characteristics **C3** Fuel cell balance of plant (BoP) equipment and system integration **C4** Hydrogen internal combustion engines (H_2ICE) **C5** Application fit and limitations	Assessment covers component identification, configuration analysis and operational reasoning through scenario-based tasks, diagrams and data interpretation of system integration and performance influences in realistic applied contexts settings.

Learning aim	Key content areas	Assessment approach
D Understand hydrogen health and safety, infrastructure and operational requirements	**D1** Hydrogen hazards and risk characteristics **D2** Detection, ventilation and safe system design features **D3** Materials, embrittlement and compatibility during operation **D4** Infrastructure requirements and deployment constraints	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Know production pathways and hydrogen quality

A1 Hydrogen as an energy carrier

- Energy carrier definition (human-made substance/fuel or physical system that contains energy that can be converted to other forms, such as mechanical and heat).
- Hydrogen as a secondary energy carrier (requires production from primary energy).
- Key physical/chemical properties influencing systems:
  - low volumetric energy density (drives compression/liquefaction decisions)
  - wide flammability range and low ignition energy (drives safety case)
  - leakage and diffusion behaviour, buoyancy (drives detection/ventilation choices).
- Practical energy metrics:
  - calorific value (CV), higher heating value (HHV) versus lower heating value (LHV) (why water vapour matters for reported efficiency).

A2 Production methods (process and constraints)

- Electrolysis (green hydrogen pathway focus):
  - basic principle; inputs/outputs; water quality requirements; renewable energy sources, including suitability of wind, solar and hydropower electricity for electrolysis, including baseload and co-located generation models
  - efficiency losses across electricity to hydrogen conversion
  - operational considerations: intermittency, stack performance degradation.
- Steam methane reforming (SMR):
  - SMR overview and why CO_2 is produced, including desulphurisation, coking, catalysts and catalyst poisoning
  - SMR and carbon capture and storage (CCS) concept.
- Emerging/alternative routes:
  - biomass-derived hydrogen
  - pyrolysis and other novel approaches.

A3 Hydrogen 'colours' as technical descriptors

- Grey, blue and green described in terms of their primary energy feedstock, processing, CO_2 handling and their typical constraints:
  - energy efficiency penalties
  - dependency on energy source
  - relevance of CO_2 capture availability for blue routes.

A4 Hydrogen quality, purity and end-use requirements

- Why purity matters:
  - fuel cell catalyst sensitivity
  - water vapour, CO/CO_2 contamination issues.
- Matching production and purification requirements to end use (transport, industry, grid services).

Learning aim B: Know hydrogen storage, transport and distribution

B1 Compressed hydrogen gaseous storage

- Compression rationale and typical pressure categories.
- Storage vessel considerations:
  - materials and embrittlement awareness
  - temperature rise during compression (safety/operations).
- Energy penalty concept: compression requires energy input.

B2 Liquid hydrogen cryogenic storage

- Why liquefaction is used (density improvement) and key challenges:
  - very low temperatures and boil-off management
  - insulation and venting requirements.
- Logistics suitability: bulk transport versus on-site generation trade-offs.

B3 Overview of solid-state and chemical carrier options

- Metal hydrides and adsorption (benefits/limits).
- Chemical carriers, e.g. ammonia/liquid organic hydrogen carriers (LOHC), in the context of storage/transport strategies.
- Selection logic focused on:
  - safety profile, handling complexity, release/conversion needs.

B4 Distribution pathways and infrastructure compatibility

- Overview of pipeline versus road transport versus shipping.
- Materials compatibility and embrittlement considerations.
- Overview of refuelling and dispensing constraints:
  - compression stages, pre-cooling.
- Interfaces with existing systems:
  - blending in gas networks (issues: safety, appliance compatibility – does not include policy debate).

Learning aim C: Understand hydrogen applications, including fuel cells and hydrogen internal combustion engines (H_2ICE) [EL – MOL]

C1 Fuel cell fundamentals (principles and outputs)

- Fuel cell purpose: chemical to electrical conversion without combustion, waste heat, combined heat and power (CHP).
- Core components and roles:
  - anode/cathode/electrolyte; flow fields; fuel cell stack.
- Reaction concept:
  - hydrogen oxidation and oxygen reduction; water/heat by-products.

C2 Fuel cell types and operating characteristics

- Proton exchange membrane (PEM) fuel cells:
  - typical use cases (transport, rapid response, micro-generation, small building CHP)
  - sensitivity to impurities.
- Solid oxide fuel cell (SOFC):
  - high-temperature operation and typical stationary roles.
- Phosphoric acid fuel cells (PAFC).
- Electrical power and durability.
- Selection based on:
  - operating temperature, startup time, durability, system complexity, CHP electricity and heating baseload.

C3 Fuel cell balance of plant (BoP) and system integration

- Why fuel cells need supporting systems:
  - air supply
  - humidification/thermal management
  - power electronics (inverter) efficiency and losses at system level.

C4 Hydrogen internal combustion engines (H_2ICE)

- Hydrogen-based internal combustion engines (H_2ICE):
  - basic principles, comparison with fuel cells (advantages and disadvantages)
  - current applications, including case studies (e.g. JCB, Toyota, Yamaha, Cummins)
  - infrastructure requirements.

C5 Application fit and limitations

- Transport applications (cars/buses/trains).
- Stationary applications (backup electrical power source, distributed generation, combined heat and power in domestic and commercial buildings, specialised safety systems including storage standards and maintenance procedures).
- Industrial uses (process heat/feedstock).

- Renewables-dominated domestic electricity supply and heating, grid backup.
- Comparing hydrogen versus battery solutions:
  - range/energy density versus efficiency/infrastructure
  - refer to fuel cells and H_2ICE.

Learning aim D: Understand hydrogen health and safety, infrastructure and operational requirements

D1 Hydrogen hazards and risk characteristics

- Key hazard properties:
  - flammability, ignition, invisibility of flame, odourless, colourless
  - leak behaviour and accumulation risk, buoyancy in air (enclosures, roof spaces).
- Hazard identification and control principles:
  - elimination/substitution (where relevant), engineering controls, administrative controls, PPE (hierarchy of control overview)
  - generation of nitrogen oxides.

D2 Detection, ventilation and safe system design features

- Leak detection concepts:
  - sensor placement logic.
- Ventilation and dispersion principles.
- Electrical area classification awareness.
- Isolation, purging, vent stacks and emergency shutdown logic.

D3 Materials, embrittlement and compatibility during operation

- What embrittlement is and why it matters for:
  - pipelines, valves, storage vessels.
- Compatibility considerations (seals, fittings, permeation).

D4 Infrastructure requirements and deployment constraints

- End-to-end infrastructure map:
  - production → storage → transport → dispensing/use.
- Key constraints:
  - energy penalty of compression/liquefaction
  - siting and safety case requirements
  - competence and maintenance planning overview.
- Standards and compliance awareness:
  - purpose of codes and standards.
- Co-located energy systems and distributed hydrogen production, including hydropower-electrolysis integration (e.g. dam-based or pumped storage systems), offshore, onshore and hybrid configurations.

Assessment criteria

Learning aim A: Know production pathways and hydrogen quality

Learning aim B: Know hydrogen storage, transport and distribution

Pass	Merit	Distinction
A.P1 Describe hydrogen production methods (electrolysis and SMR), outlining key inputs/outputs and practical constraints. **A.P2** Describe why hydrogen quality/purity requirements differ by end use and outline typical implications for processing and system selection.	**A.M1** Explain how production route choices influence efficiency losses, purity needs and suitability for different applications.	**A.D1** Analyse a hydrogen deployment scenario by selecting and justifying an end-to-end pathway (production and storage/transport, plus end use), using technical constraints (efficiency losses, purity, logistics and safety) and clearly stated assumptions.
B.P3 Describe options for hydrogen storage and transport (compressed gas, liquid hydrogen and one alternative carrier/ solid-state concept). **B.P4** Outline key constraints for hydrogen distribution (energy penalty, materials compatibility, logistics and safety requirements).	**B.M2** Explain, for a given scenario, why one storage/transport option is more suitable than another using technical trade-offs and constraints.	

Learning aim C: Understand hydrogen applications, including fuel cells and hydrogen internal combustion engines (H_2ICE)

Learning aim D: Understand hydrogen health and safety, infrastructure and operational requirements

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td>C.P5 Describe how a hydrogen fuel cell produces electrical energy, the main components and outputs.
C.P6 Explain two fuel cell types, linking them to appropriate applications.
C.P7 Describe how hydrogen-based internal combustion engines work (H_2ICE), their applications in sectors including transport.</td><td>C.M3 Explain how fuel cell characteristics and balance-of-plant (BoP) requirements influence application fit and system performance limitations.
C.M4 Compare and contrast benefits and drawbacks of different hydrogen-utilising technologies.</td><td rowspan="2">CD.D2 Evaluate the risk profile and operational practicality of the chosen hydrogen pathway, proposing justified risk controls and infrastructure measures.</td></tr>
<tr><td>D.P8 Describe key hydrogen hazards and identify appropriate risk controls using the hierarchy of control.
D.P9 Explain infrastructure requirements for a hydrogen pathway from production to end use, including operational safety features (detection, ventilation, isolation).</td><td>D.M5 Explain how safety, materials compatibility and operational constraints influence hydrogen infrastructure choices and uses.</td></tr>
</table>

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL *	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

* Signposted to indicate opportunities for development as a part of wider teaching and learning

√ Embedded in teaching, learning and assessment

blank Not embedded or signposted in unit

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on setting assignments. There is also further information on our website.

There is a maximum number of two summative assignments for this unit.

The relationship of the learning aims and criteria is:

- Learning aims A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, AB.D1).
- Learning aims C and D (C.P5, C.P6, C.P7, D.P8, D.P9, C.M3, C.M4, D.M5, CD.D2).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Hydrogen system demonstration equipment, such as a small PEM fuel cell kit with load, enabling safe visualisation of energy conversion and outputs.
- Storage and distribution models, including cut-away or schematic representations of compressed gas cylinders, cryogenic tanks and pipeline systems.
- Safety and monitoring equipment, for example, portable hydrogen gas detectors and ventilation/dispersion demonstration apparatus for hazard awareness.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, students take an integrated, end-to-end view of a hydrogen pathway. Work demonstrates the ability to select and defend a coherent combination of production, storage or transport, and end use within a defined scenario. Assumptions are clearly stated, and technical constraints such as efficiency losses, purity sensitivity, infrastructure limits and safety considerations are used to support decisions. Students weigh alternatives and justify why one approach offers greater overall practicality or suitability. Evidence may take the form of a short technical report that synthesises multiple content areas rather than addressing them in isolation. Achievement is characterised by structured analysis, consistent technical logic and confident evaluation showing how system choices interact across the whole hydrogen pathway.

For Merit standard, students make meaningful connections between production choices, hydrogen quality and storage or transport decisions. Work demonstrates clear reasoning about how efficiency losses, purity requirements, and practical constraints influence technology selection. Students typically explain why certain pathways are preferable in specific contexts, using qualitative comparisons rather than simple lists. Evidence may include annotated diagrams, short calculations or structured explanations that link hydrogen properties to system behaviour. Storage and distribution options are compared using trade-offs such as energy penalty, logistics or compatibility. Students show understanding of how decisions made at the production stage affect later stages in the pathway. Achievement at this level is characterised by coherent explanation, technical reasoning and application of knowledge to realistic scenarios.

For Pass standard, students can present clear, technically correct descriptions of hydrogen production routes and storage or transport options. Work demonstrates awareness of key processes, inputs and outputs and recognises that different approaches have practical constraints. Students may explain concepts such as electrolysis, reforming, compression or liquefaction in a straightforward way, supported by simple diagrams or structured notes. Evidence usually references hydrogen properties such as density or flammability but does not deeply explore implications. Storage and distribution options are outlined separately, with limited comparison. Students show an understanding that hydrogen quality varies by end use, though links between purity and applications may remain general. Overall, achievement at this level is characterised by accurate recall and logical organisation of core technical knowledge, without extended justification or scenario-based reasoning.

Learning aims C and D

For Distinction standard, students evaluate the overall practicality and risk profile of a chosen hydrogen application within a defined context. Work demonstrates how safety characteristics, infrastructure requirements and operational constraints influence feasibility and long-term reliability. Students justify control measures and design choices using hazard behaviour, materials compatibility and system integration considerations. Alternatives may be weighed to show why one configuration offers improved manageability or reduced risk. Evidence typically integrates application choice, safety strategy and infrastructure planning into a single coherent explanation. Achievement is characterised by balanced evaluation, technically grounded judgement and clear justification that avoids policy argument and focuses on operational and engineering constraints.

For Merit standard, students link application choices to system characteristics, safety requirements and operational constraints. Work explains how features such as operating temperature, balance-of-plant (BoP) requirements or impurity sensitivity influence where hydrogen technologies can be used effectively. Students compare different application options, identifying benefits and limitations using technical reasoning. Safety evidence moves beyond listing hazards to explaining how materials choice, ventilation, detection and operational procedures shape infrastructure design. Students demonstrate understanding that safety and performance considerations are interconnected. Achievement at this level is marked by reasoned explanation, comparative discussion and clear links between technology behaviour, risk management and practical deployment.

For Pass standard, students demonstrate understanding of how hydrogen is used in energy applications and recognise the main safety and infrastructure considerations. Work typically explains how fuel cells generate electrical output and identifies key components and by-products. Students describe at least one additional hydrogen application, such as combustion engines, without extended comparison. Safety evidence demonstrates awareness of common hazards, basic detection methods, and the purpose of control measures. Infrastructure understanding is shown by outlining the main stages from production to use. Achievement at this level is characterised by clear, factual explanations that show understanding of processes and risks, but with limited evaluation of suitability, system interaction or operational complexity.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 13: Hydroelectric and Marine Energy Systems.
- Unit 18: Low-Carbon Heating Technologies.
- Unit 21: Energy Auditing and Consultancy Practices.

Unit 11: Renewable Energy Systems

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students explore renewable technologies, resource suitability, grid integration and market influences to understand how energy systems are selected, combined and operated in real-world contexts.

Unit introduction

This unit is relevant to the real world because renewable energy systems now underpin national energy strategies, infrastructure investment and decarbonisation goals. Understanding how renewable options are selected, integrated and managed helps students make sense of everyday energy issues such as grid reliability, energy costs and environmental impact. The unit equips students with practical insight into how energy decisions are made in professional settings, building confidence in applying technical knowledge to realistic energy challenges.

The content covers a broad range of renewable technologies and resource considerations, alongside electricity system operations, grid integration challenges and market influences. Students will explore comparative evaluation, system trade-offs, variability management and lifecycle thinking, while also addressing health, safety and environmental principles across project stages. Depth is achieved through linking technology choice to context, system constraints and project viability rather than isolated components.

Completion of the unit supports progression to further study in energy, engineering or sustainability and provides a strong foundation for employment in renewable energy, utilities, infrastructure planning and related technical or advisory roles.

Learning aims

In this unit you will:

A Understand comparative evaluation of renewable energy options

B Understand energy grid integration and market drivers

C Know health, safety and environmental principles for renewable projects.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand comparative evaluation of renewable energy options	**A1** Energy stages and systems **A2** Renewable resources and 'fit to context' **A3** Domestic and industrial examples of energy technology and how technologies can be connected **A4** Comparative criteria and trade-offs **A5** Decision contexts	Scenario-based investigation requiring students to compare renewable technologies and explain grid integration challenges and justified decision-making.
B Understand energy grid integration and market drivers	**B1** Electricity system overview **B2** Integration challenges specific to variable renewables **B3** System-level trade-offs **B4** Market drivers and project viability	
C Know health, safety and environmental principles for renewable projects	**C1** Common hazards and safe systems of work **C2** Environmental management principles **C3** Responsible end-of-life and circularity	Identify hazards, explain controls and evaluate environmental impacts across a renewable project lifecycle.

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand comparative evaluation of renewable energy options

[SP – CT]

A1 Energy stages and systems

- Differences between primary, delivered and useful energy stages.
- What is an energy source, and what is an energy system?
- Renewable energy systems across full lifecycle stages (resource extraction, manufacturing, installation, operation, maintenance and end-of-life).

A2 Renewable resources and 'fit to context'

- What makes an energy source renewable? Key distinctions from non-renewables.
- Resource characteristics that affect suitability:
  - variability and predictability (e.g. wind, solar, tidal, river flow, geothermal)
  - geographic constraints, site dependence and microclimate
  - dispatchability and flexibility at overview level.

A3 Domestic and industrial examples of energy technology and how technologies can be connected

Use of 'what it is/where it fits' profiles for:

- Wind (onshore, offshore, stand-alone, building-integrated).
- Solar (PV, solar thermal, concentrated solar power).
- Hydroelectric and marine energy (wave, tidal).
- Bioenergy routes (biomass, biogas, biofuels).
- Geothermal, as a contextual comparison.

A4 Comparative criteria and trade-offs

Using a consistent comparison framework:

- Energy output characteristics:
  - capacity factor and intermittency
  - matching generation profiles to demand patterns
  - energy storage, introduced qualitatively.
- Constraints and impacts:
  - land/sea use, visual/noise considerations, biodiversity sensitivities, environmental impacts
  - resource and materials considerations.
  - environmental and energy impacts using lifecycle approaches (e.g. energy payback time, lifecycle emissions).

- Lifecycle thinking:
  - manufacture, installation, operation, decommissioning and recycling.

A5 Decision contexts

- Selecting options for different contexts:
  - urban versus rural, coastal versus inland, remote/off-grid versus on-grid versus hybrid.
- Recognising uncertainty and assumptions in comparisons.
- Local regulations and standards.

Learning aim B: Understand energy grid integration and market drivers

B1 Electricity system overview

- Core functions: generation, transmission, distribution, demand.
- Why grids must balance supply and demand continuously.
- Constraints that matter to renewables integration:
  - network capacity and connection limitations
  - curtailment as a system outcome
  - power quality and stability concepts, introduced qualitatively.

B2 Integration challenges specific to variable renewables

- Balancing and flexibility needs:
  - forecasting, dispatch planning
  - reserve and flexibility services.
- System stability at an accessible level:
  - frequency stability (grid level), inertia concepts
  - voltage stability (local level)
  - role of power electronics.
- Managing variability through system solutions:
  - demand response
  - energy storage types as categories (battery, pumped hydro, thermal, hydrogen as ‘energy carrier’)
  - interconnection and geographic diversity.

B3 System-level trade-offs

- Trade-offs across whole-system objectives:
  - cost versus reliability versus environmental impact
  - centralised versus distributed generation
  - resilience considerations.

- Avoiding 'technology drift':
  - causes of 'technology drift' in renewable energy integration
  - integration logic versus component detail in renewable energy integration.

B4 Market drivers and project viability

- What drives investment and deployment:
  - capital cost and financing risk
  - revenue streams: energy sales and flexibility/ancillary value
  - constraints that affect economics: carbon pricing, social cost of carbon, curtailment risk, connection delays, supply chain limitations
  - regulation and standards context.
- Distinguishing market signals from policy frameworks:
  - policy mechanisms are not evaluated here in depth.

Learning aim C: Know health, safety and environmental principles for renewable energy projects

C1 Common hazards and safe systems of work

- Risk assessment basics:
  - hazard identification, risk rating, control hierarchy.
- Common renewable project hazards:
  - working at height, electrical hazards, lifting/handling, confined spaces, weather exposure.
- Competence and compliance thinking:
  - why permits, method statements and training matter.

C2 Environmental management principles

- Typical environmental considerations across renewables:
  - habitat disturbance, noise/visual impacts, water impacts, waste and end-of-life.
- Mitigation logic
  - avoidance, minimisation, restoration/offsetting.
- Stakeholders and social licence:
  - consultation as a risk and acceptance factor
  - methods of achieving successful social licence for renewable energy projects.

C3 Responsible end-of-life and circularity

- Why decommissioning planning matters.

Assessment criteria

Learning aim A: Understand comparative evaluation of renewable energy options

Learning aim B: Understand energy grid integration and market drivers

Pass	Merit	Distinction
A.P1 Explain key costs and benefits of renewable energy technology families.	**A.M1** Compare resource characteristics, site constraints, lifecycle considerations and suitability of renewable options.	**AB.D1** Discuss a recommended renewable energy deployment and integration scenario with justification from an appropriate mix of renewable options.
B.P2 Explain renewable integration challenges (variability, stability, curtailment).	**B.M2** Explain system-level market drivers, constraints and trade-offs linked to integration of renewables.	

Learning aim C: Know health, safety and environmental principles for renewable projects

Pass	Merit	Distinction
C.P3 Describe common health and safety hazards and risk control measures for a selected renewable project.	**C.M3** Explain how health, safety and environmental requirements can influence project planning and stakeholder acceptance for a selected renewable project.	**C.D2** Evaluate health and safety and environmental considerations across a renewable project lifecycle.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT *
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on setting assignments. There is also further information on our website.

There is a maximum number of two summative assignments for this unit.

The relationship of the learning aims and criteria is:

- Learning aims: A and B (A.P1, B.P2, A.M1, A.M2, AB.D1).
- Learning aim: C (C.P3, C.M3, C.D2).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- System visualisation tools, such as printed grid diagrams, energy flow schematics and lifecycle stage charts, for explaining integration, trade-offs and decision contexts.
- Basic calculation and analysis tools, including calculators and simple spreadsheets, for capacity, variability, demand matching and qualitative cost comparisons.

Essential information for assessment decisions

Learning aim A

For Distinction standard, students present a well-reasoned analysis that synthesises technology choice, grid integration and market considerations within a single scenario or decision context. Their evidence shows confident use of comparative frameworks and clear justification for selecting and combining renewable options. Students recognise uncertainty, assumptions and trade-offs, explaining how system reliability, environmental impact and economic factors interact at the whole-system level. Grid constraints, variability management and market pressures are integrated into the analysis, rather than treated as separate topics. Examples are applied critically, demonstrating insight into how strategic decisions are shaped by both technical and commercial realities. The overall response is balanced, logical and clearly rooted in system-level thinking rather than individual components.

For Merit standard, students move beyond description by making reasoned comparisons and connections between technologies, grid operation and market conditions. Their evidence shows they can weigh multiple factors such as resource quality, site limitations, lifecycle impacts and system constraints, when comparing renewable options. Students explain how integration challenges influence technical and economic decisions, drawing links between variability, flexibility requirements and system-wide trade-offs. Market drivers such as costs, revenue streams and regulatory constraints are discussed in relation to project viability rather than in isolation. The work demonstrates structured thinking, with comparisons clearly framed and supported by relevant examples. Overall, students demonstrate a coherent understanding of why specific combinations of renewables are more suitable in certain contexts.

For Pass standard, students show a secure understanding of renewable energy options and how they operate within electricity systems. Their evidence typically explains the main characteristics of different renewable technologies and links those characteristics to where and why they are used. Students identify relevant resource factors such as variability, site constraints and basic lifecycle considerations, showing that they understand how context affects suitability. When discussing grid integration, they demonstrate awareness of why balancing supply and demand matters and outline common challenges posed by variable generation. Evidence often includes simple descriptions of curtailment, storage or demand response, supported by straightforward examples. The work is generally accurate and grounded in the unit content, although comparisons and system explanations remain mostly descriptive rather than detailed or evaluative.

Learning aim C

For Distinction standard, students evaluate health, safety and environmental considerations across the full lifecycle of a renewable energy project. Their evidence shows critical judgement, weighing short- and long-term risks alongside environmental responsibilities and end-of-life planning. Students consider how decisions made during design, construction, operation and decommissioning influence safety performance, environmental impact and public acceptance. Different mitigation strategies are compared, with justification of why certain approaches are more appropriate in specific contexts. Stakeholder and environmental risks are treated as integral to project success rather than external constraints. Overall, students demonstrate reflective, lifecycle-based thinking supported by realistic examples and logical conclusions.

For Merit standard, students explain how health, safety and environmental requirements influence planning and decision-making throughout a renewable project. Their evidence shows cause-and-effect thinking, for example, how risks, mitigation measures or regulatory expectations shape project design, scheduling and stakeholder engagement. Students discuss how effective environmental management and consultation help reduce risk and improve acceptance, linking technical controls to wider project outcomes. Safety documentation, competence requirements and mitigation strategies are explained in context rather than listed. The work demonstrates a clear understanding of why these considerations matter operationally and socially, with examples that show how good practice supports both compliance and project viability.

For Pass standard, students provide clear evidence that they understand common health, safety and environmental issues associated with renewable energy projects. Their work typically identifies key hazards relevant to a selected project and outlines appropriate control measures using accepted safety principles. Students show awareness of environmental factors such as habitat disturbance, noise, waste and end-of-life considerations, linking these to basic mitigation approaches. Evidence demonstrates t hat students recognise the importance of safe systems of work, competence and compliance, even if explanations remain straightforward. The content is accurate, relevant to the chosen project, and clearly aligned with real working practices, though it tends to focus on identification rather than broader impact.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 17: Smart Energy Systems and Building Efficiency.
- Unit 18: Low-Carbon Heating Technologies.
- Unit 21: Energy Auditing and Consultancy Practices.

Unit 12: Wind Energy Systems

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students explore wind turbine components, operation and performance within modern low-carbon energy systems. Develops understanding of wind resource assessment, site selection and safe maintenance practices for onshore and offshore turbines.

Unit introduction

This unit equips students with knowledge and understanding of how wind power contributes to modern, low-carbon energy systems. Wind energy plays a critical role in national and international decarbonisation strategies, and technicians, planners and engineers must understand how turbines operate safely and efficiently within variable environmental conditions. This unit enables students to interpret real-world wind energy challenges related to performance, reliability, siting and maintenance.

The unit covers the operational context of wind turbines, including energy conversion principles, turbine components and operating regimes. Students explore wind resource assessment through surface roughness, wind shear, turbulence and measurement techniques, linking site characteristics to performance expectations. Safety-critical maintenance practices are also examined, focusing on hazards, access systems, isolation procedures, emergency response and environmental protection during maintenance activities.

Completion of this unit supports progression into further study in green energy, engineering or environmental science. It also prepares students for employment or apprenticeships in the wind energy sector by developing applied technical understanding, risk awareness and workplace-ready operational skills.

Learning aims

In this unit, you will:

A Understand wind turbine components, configurations and operation

B Understand wind resource assessment and site selection

C Be able to plan safe maintenance practices.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand wind turbine components, configurations and operation	**A1** Wind energy conversion **A2** Turbine architecture and major components **A3** Operational strategies and typical constraints	Assessment uses a vocational scenario with written and diagrammatic tasks, requiring students to explain turbine operation and analyse site wind data to justify performance expectations and operational constraints.
B Understand wind resource assessment and site selection	**B1** Site screening factors **B2** Surface roughness and terrain effects **B3** Wind shear with height **B4** Wind rose and directionality **B5** Turbulence intensity and gustiness **B6** Measurement approaches	
C Be able to plan safe maintenance practices	**C1** Wind turbine maintenance context and common tasks **C2** Core safety hazards and control measures **C3** Access systems, rescue and emergency response **C4** Environmental considerations during maintenance	Assessment is based on planned activities, supported by written justification, where students demonstrate safe maintenance procedures, hazard control, access, isolation and weather-informed decision-making using realistic turbine service scenarios.

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand wind turbine components, configurations and operation

A1 Wind energy conversion

- Wind as a kinetic resource and why power capture is sensitive to wind speed (qualitative relationship; no advanced modelling).
- Key operating regions:
  - cut-in, rated and cut-out behaviour (why turbines do not run at all speeds).
- Aerodynamic control concepts (overview):
  - pitch control and stall control (purpose and outcomes).

A2 Turbine architecture and major components

- Structural elements:
  - tower, nacelle, rotor, hub (roles and typical constraints).
- Rotor system:
  - blades (lift generation concept), pitch mechanism, hub.
- Drivetrain and conversion:
  - gearbox versus direct-drive configurations (overview), generator role (no deep electromagnetism).
- Yaw system and sensors:
  - yaw alignment purpose; basic instrumentation (anemometer/wind vane) used for operation.
- Power electronics and transformer (overview only):
  - why conditioning and stepping voltage matter (no grid engineering depth).

A3 Operational strategies and typical constraints

- Start-up/shut-down logic and protective actions:
  - high-wind shutdown, overspeed protection, braking concepts.
- Condition and performance considerations (overview):
  - how wear and environmental exposure affect operation (leading into maintenance).
- Onshore versus offshore context (high-level):
  - access and corrosion exposure; differences framed as operational/maintenance implications rather than design.

Learning aim B: Understand wind resource assessment and site selection

B1 Site screening factors

- Macro- and micro siting concepts:
  - o why terrain, obstacles and local topography matter for wind flow.
- Constraints:
  - o access, setbacks, environmental receptors and grid proximity are acknowledged without becoming planning-policy teaching.

B2 Surface roughness and terrain effects

- Surface roughness:
  - o roughness categories (e.g. sea, open land, woodland, urban) and how roughness increases turbulence and reduces wind speed near the ground.
- Obstacles and wake effects:
  - o sheltering, speed deficit and turbulence in the lee of obstacles (wind farm and micro siting implications).

B3 Wind shear with height

- Wind shear concept:
  - o why wind speed typically increases with height; implications for hub height choice.
- Vertical wind profile:
  - o atmospheric stability influences and why shear varies by time of day and surface type.

B4 Wind rose and directionality

- Wind rose purpose:
  - o summarising wind direction frequency and relative strength; interpreting dominant directions for turbine alignment and layout thinking.
- Directional variability implications:
  - o yaw activity, wake alignment and operational loading.

B5 Turbulence intensity and gustiness

- Turbulence concepts:
  - o turbulence intensity and why it matters for fatigue loads and maintenance needs.
- Sources of turbulence:
  - o roughness, obstacles, complex terrain and atmospheric conditions.

B6 Measurement approaches

- Wind measurement methods:
  - o met (meteorological) masts, anemometry, remote sensing (Light Detection and Ranging/LiDAR, Sonic Detection and Ranging/SODAR).
- Data quality awareness:
  - o siting of sensors, duration of measurement and representativeness.

Learning aim C: Be able to plan safe maintenance practices

C1 Wind turbine maintenance context and common tasks

- Maintenance types:
  - routine inspection, preventive maintenance, corrective maintenance.
- Typical turbine maintenance activities:
  - visual inspection, lubrication, filter changes, bolt torque checks, basic sensor checks.

C2 Core safety hazards and control measures

- Key hazards:
  - fire risks, working at height, dropped falling objects, electrical hazards, rotating machinery, confined spaces, weather exposure, manual handling, transfer of personnel.
- Control hierarchy applied to wind maintenance:
  - planning, permit-to-work awareness, toolbox talks, PPE (personal protective equipment), exclusion zones, rescue preparedness.
- Isolation and lock-off principles:
  - electrical isolation concept, mechanical immobilisation, stored energy awareness (hydraulic/pneumatic).

C3 Access systems, rescue and emergency response

- Safe access:
  - ladders, lifts, fall arrest systems, anchor points.
- Emergency response:
  - rescue from height principles, evacuation triggers, communication protocols.

C4 Environmental considerations during maintenance

- Minimising environmental disturbance:
  - oil spill prevention, waste handling, wildlife sensitivity during access.

Assessment criteria

Learning aim A: Understand wind turbine components, configurations and operation

Learning aim B: Understand wind resource assessment and site selection

Pass	Merit	Distinction
A.P1 Describe components of a wind turbine, their functions, including rotor, drivetrain, yaw and control systems. **A.P2** Explain turbine operational behaviour (cut-in/rated/cut-out) and the purpose of pitch/yaw control at overview level.	**A.M1** Explain, in detail, how operating strategies and component functions influence reliability and typical operational constraints.	**AB.D1** Analyse a wind project scenario by linking turbine operational requirements with wind-specific site characteristics to justify suitability and key operational constraints.
B.P3 Describe how surface roughness and obstacles can influence wind flow and site suitability. **B.P4** Examine wind shear with height, turbulence impacts and purpose of a wind rose.	**B.M2** For a selected scenario, explain how roughness, shear, wind directionality and turbulence could affect expected performance and operational loading considerations.	

Learning aim C: Be able to plan safe maintenance practices

Pass	Merit	Distinction
C.P5 Identify typical hazards associated with wind turbine maintenance and appropriate control measures. [SP – PS] **C.P6** Describe safe wind turbine maintenance for access and isolation.	**C.M3** Explain how safe maintenance planning can support reliable operation and reduce risks.	**C.D2** Evaluate maintenance approach, justifying decisions linked to weather conditions.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS √
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- Learning aim: C (C.P5, C.P6, C.M3, C.D2).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Demonstration models and visuals: physical or digital wind turbine models, component diagrams and cutaway images to support understanding of structure, operation and site interaction.
- Health and safety equipment: basic PPE (helmet, harness visuals, gloves), lock-off devices and permit-to-work examples for maintenance teaching.
- Measurement and data tools: example anemometer datasets, wind measurement records and simple calculation tools for wind speed, shear and performance discussions.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, students demonstrate an integrated, analytical understanding by evaluating turbine suitability within a specific wind project context. Evidence shows students synthesising turbine operational requirements with wind resource characteristics to justify key constraints and performance considerations. Students successfully link factors, such as turbulence sources, wind shear profiles and directional variability, to operational control, loading and maintenance implications. Responses show informed judgement, supported by relevant data interpretation and contextual reasoning, rather than a generic explanation. Students explain trade-offs clearly, for example, between hub height, site roughness and operational stress. Work is coherent, technically fluent and scenario-driven, demonstrating the ability to apply wind energy principles in a realistic planning or engineering decision-making context.

For Merit standard, students demonstrate a developed understanding by explaining how turbine operation and site conditions interact to influence performance and loading. Evidence shows students linking wind shear, turbulence and directionality to operational strategies such as pitch and yaw control. Students use contextual data or scenario information to explain why particular environmental conditions may increase wear, affect reliability or constrain output. Explanations include cause-and-effect reasoning, showing how component behaviour responds to varying wind conditions. Students may reference measurement approaches or wind roses to justify assumptions about expected operating conditions. Work demonstrates logical structure, accurate use of terminology and clear connections between turbine design features and site-specific wind characteristics, indicating confident applied understanding.

For Pass standard, students demonstrate secure foundational understanding by describing wind turbine components, operational behaviour and basic site factors using correct technical terms. Evidence typically shows students explaining how wind speed affects power capture, identifying key turbine systems and outlining how terrain, surface roughness and obstacles influence wind flow. Students interpret simple wind energy concepts without detailed optimisation, linking operating regions or site features to performance in a straightforward way. Work may include labelled diagrams, short explanations or structured responses that show awareness of how turbines interact with their wind environment. Students show that they can follow given contextual information and apply core knowledge to a defined scenario, demonstrating readiness to progress to more detailed considerations of performance and reliability.

Learning aim C

For Distinction standard, students demonstrate evaluative judgement by reviewing maintenance activities and justifying safety decisions in relation to environmental and operational conditions. Evidence shows students assessing how weather, access limitations or turbine state influenced maintenance planning and execution. Students explain why alternative actions were taken or avoided, linking conditions to risk, control effectiveness and operational outcomes. Evaluations consider both personal safety and wider implications for turbine reliability and environmental protection. Work shows reflective reasoning, demonstrating readiness for real-world wind turbine maintenance contexts where conditions are dynamic and judgement is critical.

For Merit standard, students must demonstrate planned, risk-aware maintenance practice by explaining how preparation and control measures support safe and reliable turbine operation. Evidence shows students justifying their chosen safety steps and linking hazards to control strategies such as isolation, access systems or rescue preparedness. Students explain how planning, sequencing and communication reduce risk, particularly in variable weather or site conditions. Written or verbal explanations demonstrate understanding of why specific controls are necessary rather than simply following instructions. This indicates students can contribute meaningfully to maintenance activities with growing autonomy and situational awareness.

For Pass standard, students demonstrate safe working awareness by identifying common wind turbine maintenance hazards and appropriate controls. Evidence shows that students are planning established procedures for access, isolation and basic maintenance tasks, using PPE correctly and responding appropriately to instructions. Students recognise hazards, such as working at height, exposure to weather or electrical risks, and demonstrate controlled behaviour when carrying out planned actions. Records or checklists are designed to ensure that tasks are completed methodically and safely. Evidence shows compliance and understanding rather than evaluation, indicating they can plan safe working under supervision within defined boundaries and recognise the importance of safety systems in a wind energy maintenance environment.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 17: Smart Energy Systems and Building Efficiency.
- Unit 18: Low-Carbon Heating Technologies.
- Unit 21: Energy Auditing and Consultancy Practices.

Unit 13: Hydroelectric and Marine Energy Systems

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students explore principles, technologies and site factors in hydroelectric and marine energy, including water dynamics, turbine engineering and system optimisation.

Unit introduction

Hydroelectric and marine energy systems are central to the global shift toward low-carbon power and Net Zero Greenhouse Gas Emissions targets. This unit helps you understand how water-based energy resources are used to generate reliable, renewable electricity, enabling you to evaluate real-world solutions that balance performance, cost, and environmental impact. These insights are valuable for careers in energy, engineering, and environmental sectors.

You will study the principles of energy in moving and stored water, hydrological and marine processes, and energy conversion efficiency. You will explore technologies such as dams, run-of-river systems, and tidal and wave devices. You will also examine system components, grid integration, and key environmental, site, social, and regulatory considerations to make informed feasibility judgements.

This unit supports progression to study in renewable energy, engineering, environmental science, and sustainability. It develops analytical, technical, and evaluative skills valued by employers in power generation, infrastructure planning, environmental assessment, and water resource management roles.

Learning aims

In this unit you will:

A Understand principles of water-based energy generation

B Know water-based system types and technologies

C Be able to assess environmental and site considerations.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand principles of water-based energy generation	**A1** Energy in water systems **A2** Hydrological and marine processes **A3** Energy conversion principles	Explanation of water energy principles, apply calculations, and analyse how flow, head, and efficiency affect energy generation performance.
B Know water-based system types and technologies	**B1** Measurement of water use and performance **B2** Hydroelectric power systems **B3** Turbines and components **B4** Marine energy systems **B5** Integration with other energy systems	Analysis of technologies, compare system suitability, and assess environmental, social, and site factors to make justified recommendations using evidence.
C Be able to assess environmental and site considerations	**C1** Site selection considerations **C2** Environmental impacts **C3** Social, economic and regulatory factors	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand principles of water-based energy generation

Physical principles that allow moving and stored water to be converted into useful electrical energy.

A1 Energy in water systems

- Water as an energy resource:
  - physical and chemical properties of water, including differences in marine and freshwater resources
  - definitions of hydroelectric and marines energy systems.
- Forms of energy in water:
  - gravitational potential energy
  - kinetic energy.
- Relationship between:
  - water height (head)
  - flow rate
  - energy output.
- Conversion of mechanical energy to electrical energy.
- Comparison with other energy sources, including renweable and non-renewable.
- Integration with green hydrogen production.

A2 Hydrological and marine processes

- The water cycle and its relevance to hydroelectric power.
- River flow and seasonal variability.
- Tides and tidal cycles:
  - gravitational effects of the Moon and Sun.
- Ocean waves:
  - formation due to wind
  - wave energy transfer.
- Predictability of hydro and marine energy compared with wind and solar.

A3 Energy conversion principles

- Turbine operation:
  - conversion of water movement to rotational energy.
- Role of generators in electricity production.

- Energy losses:
  - friction
  - turbulence
  - electrical resistance.
- Efficiency in water-based energy systems.
- Factors limiting maximum power output.

Learning aim B: Know water-based system types and technologies

Hydroelectric and marine energy technologies and how they are applied in real-world energy systems.

B1 Measurement of water use and performance

- Quantitative measures:
  - flow rate (Q), head (H) and energy output
  - power equation: $P = \rho g Q H \eta$
  - efficiency of turbines and generators.
- Water metrics:
  - Throughput vs consumption
  - System efficiency ratios.
- Monitoring approaches:
  - Sensors and flow measurement instrumentation.

B2 Hydroelectric power systems

- Large-scale hydroelectric systems:
  - dams and reservoirs
  - flow control systems.
- Run-of-river systems.
- Pumped storage hydroelectricity:
  - energy storage and grid balancing.
- Advantages of hydroelectric power:
  - reliability
  - energy storage capability.
- Limitations:
  - high capital costs
  - site-specific requirements.
- System-level inefficiencies:
  - mismatch between supply and demand
  - underutilisation of available water resource.

- Digital optimisation:
  - smart monitoring systems
  - artificial intelligence-driven predictive maintenance and system control.

B3 Turbines and components

- Common turbine types:
  - Pelton
  - Francis
  - Kaplan.
- Matching turbine type to:
  - head
  - flow rate.
- Key components:
  - penstocks
  - turbines
  - generators
  - control systems.
- Operational considerations:
  - maintenance
  - lifespan.

B4 Marine energy systems

- Tidal energy.
- Tidal range systems (barrages and lagoons).
- Tidal stream systems.
- Advantages:
  - Predictability.
- Limitations:
  - site availability
  - marine corrosion issues
  - environmental impacts.
- Wave energy
  - principles of wave energy capture
  - types of wave energy devices:
    - oscillating water columns
    - point absorbers.

- Other emerging technologies:
  - ocean thermal enenrgy conversion (OTEC)
  - salinity gradient power (osmotic power).
- Potential impact of artificial intelligence on productivity and manintenance costs.

B5 Integration with other energy systems

- Connection to the electricity grid.
- Role of hydroelectric power in grid stability, relate to green hydrogen production for energy storage.
- Marine energy as an emerging technology.
- Contribution to renewable energy targets and Net Zero strategies.

Learning aim C: Be able to assess environmental and site considerations

How environmental, geographical, social, economic and regulatory factors influence the feasibility of hydroelectric and marine energy projects.

C1 Site selection considerations

- Physical site factors:
  - water availability
  - head and flow
  - tidal range
  - wave climate.
- Geographical considerations:
  - river valleys
  - coastal features.
- Accessibility and infrastructure.
- Proximity to electricity networks.

C2 Environmental impacts

- Environmental benefits:
  - low operational greenhouse gas emissions.
- Potential environmental impacts:
  - habitat disruption
  - changes to river flow
  - sediment transport
  - effects on fish and marine life
  - CO_2 emissions from concrete production
  - Greenhouse gas contribution from biogenic methane production from rotting organic build-up.

- Differences between hydroelectric and marine impacts.
- Mitigation strategies:
  - fish passes
  - environmental flow management
  - careful site design.

C3 Social, economic and regulatory factors

- Social impacts:
  - displacement of communities
  - visual impact
  - recreational use of water bodies
  - potential cross-border geo-political conflicts due to water rights/ river course changes.
- Economic considerations:
  - construction costs
  - long-term operation and maintenance, saltwater corrosion.
- Planning and regulatory requirements (overview):
  - environmental impact assessments (EIAs)
  - stakeholder consultation.
- Balancing energy generation with environmental protection.

Assessment criteria

Learning aim A: Understand principles of water-based energy generation

Pass	Merit	Distinction
A.P1 Explain how energy is obtained from moving and stored water. **A.P2** Examine principles of energy conversion in hydroelectric and marine energy systems.	**A.M1** Assess how water flow, head and system efficiency affect energy output.	**A.D1** Evaluate how conditions, system efficiency and energy conversion principles interact to determine the performance of hydroelectric and marine energy systems.

Learning aim B: Know water-based system types and technologies

Learning aim C: Be able to assess environmental and site considerations

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td>B.P3 Describe different types of hydroelectric and marine energy systems.
B.P4 Outline key components and technologies used in water based energy systems.</td><td>B.M2 Compare the locations and energy needs of different water-based technologies.</td><td rowspan="2">BC.D2 Evaluate environmental, social and site specific factors when considering the development of hydroelectric or marine energy system.</td></tr>
<tr><td>C.P5 Identify environmental and site factors that affect hydroelectric and marine energy systems.
C.P6 Assess potential environmental and social impacts of water-based energy projects. [SP – PS]</td><td>C.M3 Analyse how site selection, environmental and social factors influence system design and feasibility.</td></tr>
</table>

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS √
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on setting assignments. There is also further information on our website.

There is a maximum number of two summative assignments for this unit.

The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, AB.D1)

Learning aims: C and D (B.P3, B.P4, C.P5, C.P6, B.M2, C.M3, BC.D2)

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Flow measurement and monitoring equipment (e.g. flow meters, pressure sensors, data logging interfaces) to quantify water use and system performance.
- Hydroelectric and turbine demonstration models or rigs (bench-top or virtual simulation) to illustrate flow, head, and energy conversion principles.

Essential information for assessment decisions

Learning aim A

For distinction standard, students provide comprehensive evaluation by synthesising scientific principles, calculations and system understanding to explain how multiple interacting factors determine performance. Students evaluate how water properties, environmental conditions and system design collectively influence energy generation, demonstrating depth of understanding across hydrological and marine contexts. Students analyse trade-offs between efficiency, output and practical constraints, using evidence to justify conclusions about optimal performance. Students integrate consideration of energy conversion processes, turbine performance and system losses to form well-supported judgements. Students demonstrate systems thinking by linking theoretical principles with real-world performance outcomes, presenting coherent and evidence-based conclusions. Students provide detailed reasoning that brings together calculations, conceptual understanding and applied knowledge to evaluate how energy generation can be optimised within water-based systems.

For merit standard, students demonstrate analytical understanding by interpreting calculated data to explain how flow rate, head and system efficiency interact to influence energy output. Students explain relationships between variables using cause-and-effect reasoning, linking changes in physical conditions to variations in performance. Students analyse energy losses such as friction and turbulence, explaining their impact on overall efficiency and identifying practical approaches to reduce these losses. Students integrate knowledge of turbine operation, hydrological processes and energy conversion to explain how system design influences output. Students apply technical language accurately and structure responses to show clear reasoning, using examples to support analysis. Students demonstrate the ability to move beyond explanation by connecting multiple content areas to show how engineering and environmental variables combine to affect performance in water-based energy systems.

For pass standard, students present clear and structured explanations of how water stores and transfers energy, demonstrating understanding of gravitational potential and kinetic energy within hydroelectric and marine contexts. Students apply relevant formulae to calculate energy output, showing logical working and correct substitution of variables such as flow rate, head and efficiency. Students explain how turbines and generators convert mechanical energy into electrical energy, linking physical principles to system operation. Students describe how hydrological and marine processes, including river flow and tidal movement, influence energy availability and predictability. Students use appropriate terminology and integrate basic scientific concepts with practical examples of energy systems, demonstrating accurate interpretation of how water-based energy generation operates and how different variables affect performance outcomes.

Learning aims B and C

For distinction standard, students evaluate, within one selected scenario, how environmental, social, economic and site-specific factors interact to determine the feasibility and sustainability of a proposed system. Students compare alternative technological approaches within the scenario, justifying decisions based on performance, environmental impact and long-term viability. Students weigh competing priorities, such as maximising energy output while minimising ecological disruption and social impact, forming balanced and evidence-based conclusions. Students evaluate mitigation strategies and regulatory considerations, explaining how these influence design, implementation and operation across the system lifecycle. Students demonstrate systems thinking by linking site decisions to broader energy objectives, including grid integration and resource efficiency. Students present well-structured, critical evaluations that synthesise multiple factors into a coherent and justified assessment of system suitability within the selected context.

For merit standard, students analyse, within one selected scenario, how hydroelectric or marine technologies are chosen and developed based on site-specific, environmental and social factors. Students explain how physical conditions such as flow characteristics, tidal range or coastal features influence technology selection and system configuration. Students analyse how environmental considerations, including ecosystem sensitivity and resource management, shape design and operational decisions. Students integrate social and economic factors, explaining how community impact, cost and infrastructure requirements affect feasibility. Students demonstrate clear links between system performance and environmental constraints, explaining how monitoring and mitigation strategies support sustainable operation. Students present coherent, scenario-based analysis that applies technical knowledge to real-world conditions, demonstrating reasoned judgement and accurate use of terminology.

For pass standard, students describe a range of hydroelectric and marine energy systems, including dams, run-of-river and tidal technologies, outlining their main components and operational features. Students identify key environmental and site factors such as water availability, geography and proximity to infrastructure, explaining how these influence system selection in straightforward terms. Students outline potential environmental and social impacts, including effects on habitats and communities, demonstrating awareness of both benefits and constraints. Students describe how monitoring and control systems support operation, referring to tools such as sensors and flow measurement devices. Students present structured responses using appropriate terminology, linking technologies to site considerations and demonstrating clear understanding of how system design and location are influenced by practical and environmental factors.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in :

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 18: Low-Carbon Heating Technologies.
- Unit 20: Water Conservation and Management in Energy Systems.
- Unit 21: Energy Auditing and Consultancy Practices.

Unit 14: Biomass and Biofuel Energy Systems

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students explore biomass resources, conversion methods, biogas and liquid biofuels, and understand system design and applications across local and global energy contexts. They assess sustainability, emissions and social and economic impacts.

Unit introduction

This unit is relevant to real-world energy challenges, particularly the need for alternatives to fossil fuels that do not contribute to atmospheric carbon dioxide levels and are locally appropriate. By understanding biomass and biofuel energy systems, students gain insight into technologies already being used globally to support waste management, rural development and energy security. The unit helps students recognise how biological resources can be harnessed responsibly, building awareness of sustainability, emissions and social impact – knowledge that is increasingly valuable across the energy and environmental sectors.

The unit covers a broad yet coherent range of content, from biomass feedstocks and conversion methods to biogas, liquid biofuels and system design. Students will progress from understanding production processes to assessing environmental, social and economic impacts, including emissions, health and resource use. Assessment will allow students to describe, explain and evaluate systems, provide evidence of realistic contexts, and demonstrate both technical understanding and informed judgement.

Completion of this unit supports progression into further study in green energy, environmental science or engineering. It also develops applied knowledge and analytical skills valued in energy, sustainability and technical support roles.

Learning aims

In this unit you will:

A Understand biomass sources and conversion methods

B Understand biofuel production processes

C Be able to assess sustainability and emission impacts.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand biomass sources and conversion methods	**A1** Biomass as an energy resource **A2** Biomass conversion methods **A3** Low-technology biomass systems in diverse communities	Tasks exploring biomass sources, conversion methods andlow-technology systems.
B Understand biofuel production processes	**B1** Introduction to biofuels **B2** Biogas and methane production **B3** Methane digesters and system design **B4** Liquid biofuels	Tasks exploring biofuel production processes, sustainability, emissions, social and economic impacts.
C Be able to assess sustainability and emission impacts	**C1** Emissions and environmental impacts **C2** Sustainability of biomass energy **C3** Social and economic impacts	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim a: Understand biomass sources and conversion methods

The range of biomass resources available and the different methods used to convert biomass into useful energy.

A1 Biomass as an energy resource

- Definition of biomass energy.
- Biomass as a renewable energy source.
- Types of biomass feedstock:
  - wood and forestry residues, including wood chip pellets
  - peat
  - agricultural residues
  - energy crops
  - animal waste
  - food and organic waste.
- Availability of biomass in:
  - developed regions
  - rural and low-income communities.
- Role of biomass in local and decentralised energy systems.

A2 Biomass conversion methods

- Direct combustion:
  - heat generation
  - overview of electricity generation.
- Overview of thermochemical conversion:
  - gasification
  - pyrolysis.
- Biological conversion:
  - anaerobic digestion.
- Comparison of conversion methods:
  - efficiency
  - scale
  - cost
  - technological complexity.

A3 Low-technology biomass systems in diverse communities

- Importance of low-technology biomass systems.
- Examples of low-technology applications:
  - improved cookstoves
  - small-scale biogas digesters
  - community-based heating systems.
- Benefits of low-technology systems:
  - affordability
  - local materials
  - energy access.
- Limitations:
  - efficiency
  - emissions
  - water usage
  - maintenance requirements.

Learning aim B: Understand biofuel production processes

How biomass is processed into liquid and gaseous biofuels and how these fuels are used.

B1 Introduction to biofuels

- Definition of a biofuel.
- Major types of biofuel:
  - biogas/methane
  - bioethanol
  - biodiesel.
- Emerging biofuels:
  - biohydrogen
  - biomethanol
  - sustainable aviation fuel, e.g. alcohol-to-jet (ATJ), Fischer–Tropsch synthetic paraffinic kerosene (FT-SPK).

B2 Biogas and methane production

- Principles of anaerobic digestion.
- Stages of anaerobic digestion (overview):
  - hydrolysis
  - acidogenesis
  - methanogenesis.

- Feedstocks used in digesters:
  - animal manure
  - food waste
  - crop residues.
- Composition of biogas:
  - methane
  - carbon dioxide.
- Uses of biogas:
  - cooking
  - heating
  - electricity generation.

B3 Methane digesters and system design

- Types of methane digesters:
  - fixed-dome
  - floating-drum
  - plug-flow.
- Key components:
  - digester tank
  - inlet and outlet
  - gas storage.
- Operating conditions:
  - temperature
  - feedstock consistency.
- Advantages and limitations of digester systems.
- Suitability for household, farm and community use.

B4 Liquid biofuels

- Types of liquid biofuels:
  - bioethanol
  - biodiesel
  - sustainable aviation fuel.
- Bioethanol production:
  - fermentation of sugars and starches (overview).
- Biodiesel production:
  - use of vegetable oils and waste oils (overview) (hydrotreated vegetable oil (HVO), fatty acid methyl esters (FAME))

  - sustainable aviation fuel (overview) (hydroprocessed esters and fatty acids (HEFA), power-to-liquid (PtL), ATJ, FT-SPK).
- Uses of liquid biofuels:
  - transport fuels
  - blending with fossil fuels
  - infrastructure of supply.
- Comparison with biogas systems.

B5 Complete and incomplete combustion and the formation of associated pollutants

- **Combustion types**
  - Complete combustion:
    - Fuel + $O_2 \rightarrow CO_2 + H_2O$
  - Incomplete combustion:
    - Fuel + limited $O_2 \rightarrow CO + C$ (particulates) + H_2O
- **Pollutant formation**
  - CO → toxic, incomplete combustion
  - CO_2 → greenhouse gas
  - NO_x → high-temperature combustion
  - Particulates → unburnt carbon (soot)
- **Applied context**
  - Biomass boilers vs open burning
  - Engine combustion (biofuels)
  - Air quality impacts.

Learning aim C: Be able to assess sustainability and emission impacts

Environmental, social and economic impacts of biomass and biofuel energy systems.

C1 Emissions and environmental impacts

- Greenhouse gas balance:
  - carbon cycle
  - carbon neutrality (conceptual understanding).
- Emissions from biomass combustion:
  - carbon dioxide
  - particulates.
- Comparison of emissions:
  - traditional biomass use
  - improved biomass systems
  - fossil fuels.

- Environmental impacts of biogas systems:
  - reduced methane release from waste
  - improved waste management.

C2 Sustainability of biomass energy

- Renewable nature of biomass.
- Sustainable biomass supply:
  - land use
  - food versus fuel considerations
  - water use, biomass crop versus drinking water.
- Impact on:
  - forests
  - agriculture
  - biodiversity.
- Importance of local sourcing and waste-based biomass.
- Role of biomass in energy access and development.

C3 Social and economic impacts

- Health impacts:
  - indoor air quality
  - reduced smoke exposure.
- Economic impacts:
  - reduced fuel costs
  - local job creation.
- Social benefits:
  - improved energy access
  - reduced reliance on imported fuels.
- Limitations and challenges:
  - maintenance
  - training
  - cultural acceptance.

Assessment criteria

Learning aim A: Understand biomass sources and conversion methods

Pass	Merit	Distinction
A.P1 Describe different sources of biomass used for energy production. **A.P2** Explain methods used to convert biomass into useful energy.	**A.M1** Explain how biomass source and conversion method influence energy output and system suitability.	**A.D1** Analyse how low-technology biomass source, conversion technology and scale, affect the sustainability and efficiency of a selected bioenergy system.

Learning aim B: Understand biofuel production processes

Learning aim C: Be able to assess sustainability and emission impacts

Pass	Merit	Distinction
B.P3 Explain how biogas and methane are produced using anaerobic digestion. **B.P4** Examine biofuel production processes and their applications.	**B.M2** Explain why different biofuel production methods are suited to contrasting scales and contexts.	**BC.D2** Evaluate environmental, social and emission impacts of biomass and biofuel energy systems in contrasting community and development contexts.
C.P5 Assess environmental and sustainability impacts of biomass and biofuel energy systems. [EL – MOL] **C.P6** Examine emission impacts associated with biomass and biofuel use.	**C.M3** Explain how sustainability and emission factors influence the use of biomass and biofuel energy systems.	

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL √	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on setting assignments. There is also further information on our website.

There is a maximum number of two summative assignments for this unit.

The relationship of the learning aims and criteria is:

- Learning aim: A (A.P1, A.P2, A.M1, A.D1).
- Learning aims: B and C (B.P3, B.P4, C.P5, C.P6, B.M2, C.M3, BC.D2).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Access to digital learning resources for diagrams, process animations, system schematics and contemporary case examples.
- Data sources and comparison tables for emissions, efficiency, costs and sustainability impacts across biomass and biofuel systems.
- Basic modelling and visualisation tools, such as system diagrams, flow charts or spreadsheets, to support analysis and evaluation.

Essential information for assessment decisions

Learning aim A

For Distinction standard, students present a well-developed analysis that integrates biomass source, conversion approach, technological scale and context. Evidence demonstrates informed judgement, for example, showing how low-technology systems operate effectively within particular sustainability, economic or community constraints. Students should describe both low- and high-technology systems, comparing, contrasting and evaluating detailed designs and operating theories of both. Students evaluate system effectiveness by weighing benefits against limitations such as emissions, maintenance demands or efficiency losses. Responses provide reasoned, logically derived conclusions. Students show control over technical vocabulary and use comparative evidence to justify decisions or recommendations. Analytical depth is demonstrated through the synthesis of multiple content strands, rather than isolated explanations, indicating a holistic understanding of biomass energy systems and their real-world operation.

For Merit standard, students move beyond description to develop explanatory links between biomass source characteristics, conversion technologies and resulting energy outputs. Evidence shows students making reasoned connections, for example, linking moisture content or feedstock type to conversion efficiency or suitability for particular scales of use. Students use comparisons to explain why certain combinations of resource and conversion methods are more appropriate in specific geographic, economic or technological contexts. Responses demonstrate structured reasoning, supported by examples. Students typically demonstrate evidence across multiple scenarios and show that they understand compromises between efficiency, cost, scale and complexity. This level of response indicates a coherent understanding of how biomass systems function as integrated energy solutions.

For Pass standard, students demonstrate a secure foundational understanding drawn directly from the unit content. Evidence typically shows clear identification and description of a range of biomass feedstocks, with coverage extending across plant-based materials, wastes and residues. Students explain how biomass can be converted into useful energy using approaches such as direct combustion, biological processes and thermochemical methods, with explanations grounded in taught examples rather than abstract theory. Responses are generally descriptive but accurate, using correct terminology and demonstrating awareness of where different biomass resources are found and broadly how they are used. Depth is limited, but understanding is appropriate for students who can explain processes in their own words and apply examples consistently across familiar contexts.

Learning aims B and C

For Distinction standard, students produce integrated evaluations of biofuel systems that combine production processes with environmental, social and emission impacts across contrasting development or community contexts. Evidence shows well-reasoned judgement, weighing benefits, such as reduced greenhouse gas emissions, improved waste management and enhanced energy access, against limitations, including land-use pressures, maintenance requirements, cultural acceptance or economic constraints. Students synthesise content from across Learning aims B and C to reach justified conclusions rather than presenting parallel discussions. Responses demonstrate autonomy, balance and analytical depth, supported by relevant examples. Students' evaluations clearly show how sustainability, emissions and technical factors collectively determine the effectiveness and appropriateness of biomass and biofuel energy systems.

For Merit standard, students explain how technical, sustainability and emission factors influence the selection and use of biofuel systems across contrasting scales and contexts. Evidence shows that students link production methods, system design and operating conditions to environmental and social outcomes, such as emissions reductions, health improvements or resource efficiency. Students explain how factors, including feedstock availability, land use, carbon balance and local infrastructure, shape decisions about system suitability for household, farm, community or larger-scale use. Responses demonstrate structured reasoning, with clear cause-and-effect links supported by examples drawn from unit content. Students move beyond isolated facts to explain interactions between production processes and sustainability considerations, showing a developed understanding of biofuels as context-dependent energy solutions.

For Pass standard, students demonstrate an accurate and consistent understanding of how biofuels are produced and the core environmental and sustainability issues associated with their use. Evidence shows a clear explanation of anaerobic digestion stages, common feedstocks and the production of liquid biofuels, alongside identification of typical applications such as cooking, heating, electricity generation and transport. Students also examine key sustainability and emission considerations, including greenhouse gas emissions, indoor air quality, waste management benefits and comparisons with fossil fuels or traditional biomass use. Responses are largely descriptive and structured, indicating that students can reliably recount taught processes and their impacts. Evidence may include written explanations, diagrams or simple comparisons that demonstrate awareness of environmental, social and economic effects without extended judgement or synthesis.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 17: Smart Energy Systems and Building Efficiency.
- Unit 18: Low-Carbon Heating Technologies.
- Unit 21: Energy Auditing and Consultancy Practices.

Unit 15: Solar Thermal and Photovoltaic Energy Systems

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

The unit integrates solar photovoltaic and solar thermal technologies to explain the principles, components, operations and performance within low-carbon energy systems. Students interpret data and evaluate integrated systems for practical applications.

Unit introduction

This unit is relevant to the real world as solar energy systems are increasingly central to low-carbon building design, energy security and sustainability targets. By understanding how solar photovoltaic and solar thermal technologies operate, students gain practical insight into how buildings can meet electrical and thermal energy demands more efficiently. This knowledge equips students with transferable skills that reflect current industry practice and growing employer demand in the renewable energy sector.

The unit provides breadth and depth by covering solar energy conversion principles, system components, configurations and integrated operation. Students will explore photovoltaic electricity generation, solar thermal heat collection, storage options and hybrid arrangements. Operational factors, control strategies and user behaviour are examined to show how performance is influenced in practice. Students will also interpret basic performance data, comparing expected and actual outcomes to evaluate system effectiveness and limitations.

Successful completion supports progression into further study in renewable energy, building services engineering or environmental science. It also prepares students for entry-level roles, apprenticeships or technical training in installation, maintenance, energy management and sustainability-focused careers.

Learning aims

In this unit you will:

A Understand solar energy conversion principles and system purposes

B Know integrated solar system components, configurations and applications

C Understand operational factors, controls and user influence on performance

D Be able to carry out and interpret basic solar system performance checks.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand solar energy conversion principles and system purposes	**A1** Solar resource and energy conversion principles **A2** Solar thermal energy conversion **A3** Solar photovoltaic energy conversion **A4** Comparative system purposes and end-use matching	Assessment uses structured explanations and comparisons, supported by diagrams and data, to evidence understanding of solar energy conversion principles concepts.
B Know integrated solar system components, configurations and applications	**B1** Core components of solar thermal systems **B2** Core components of photovoltaic systems **B3** Energy storage and auxiliary systems **B4** System configurations and integration **B5** Applications and scale	Assessment covers component identification, configuration analysis and operational reasoning through scenario-based tasks, diagrams and data interpretation of system integration and performance influences in realistic applied context settings.
C Understand operational factors, controls and user influence on performance	**C1** Environmental and site-related factors **C2** Control systems and operational strategies **C3** User behaviour and demand patterns **C4** Performance limitations and system losses **C5** Reliability, maintenance and lifespan	

Learning aim	Key content areas	Assessment approach
D Be able to carry out and interpret basic solar system performance checks	**D1** Performance data and measurements **D2** Expected versus actual performance **D3** Interpretation and evaluation **D4** Environmental and system-level evaluation	Assessment involves analysing system performance data, identifying trends, explaining anomalies and effectiveness against expected operation and system limitations.

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand solar energy conversion principles and system purposes

A1 Solar resource and energy conversion principles

- Nature of solar radiation: direct, diffuse and reflected components.
- Solar spectrum and relevance to thermal absorption and photovoltaic (PV) response.
- Relationship between irradiance, collector/module area and energy output:
    - irradiance typically 200–1,000 W/m^2.
- Seasonal, geographical and daily variation in solar availability.
- Comparison of energy quality: low-grade thermal energy, electrical energy.

A2 Solar thermal energy conversion

- Principles of solar thermal collection: absorption, heat transfer and insulation.
- Types of collectors and operating temperature ranges:
    - flat-plate collectors (30–70 °C)
    - evacuated tube collectors (50–120 °C).
- Heat-transfer fluids and antifreeze use.
- Typical applications: domestic hot water, space heating support, pre-heating.
- New and emerging technologies: concentrated solar power (CSP), e.g. parabolic, supercritical CO_2, solar thermochemistry.

A3 Solar photovoltaic energy conversion

- PV effect and p–n junction behaviour.
- Monocrystalline, polycrystalline and thin-film PV cells.
- Relationship between irradiance, voltage, current and power output.
- Typical PV module efficiencies (15–23%) and performance variation.
- New and emerging technologies: high efficiency cells, e.g. Tunnel Oxide Passivated Contact (TOPCon), heterojunction technology (HJT), interdigitated back contact (IBC); tandem technology; perovskite-silicon; bifacial panels; thermal skins and fabrics; thermoradiative cells.

A4 Comparative system purposes and end-use matching

- Matching solar thermal systems to heat demand profiles.
- Matching PV systems to electrical demand profiles
- Advantages and limitations of each technology.
- Rationale for combined or complementary use within buildings and energy systems.

Learning aim B: Know integrated solar system components, configurations and applications

B1 Core components of solar thermal systems

- Collectors, mounting frames and orientation requirements, 33% rule for roof coverage.
- Heat-transfer circuits, pumps and valves.
- Thermal storage cylinders and buffer tanks:
  - typical domestic storage volumes: 150–300 L.
- Expansion vessels, pressure relief and safety devices.
- New and emerging technology: e.g. advanced thermal energy storage (TES), molten salts.

B2 Core components of photovoltaic systems

- PV modules and array configurations (series/parallel).
- Inverters: string, micro-inverter, hybrid inverter, 33% rule for inverters.
- Direct current (DC) and alternating current (AC) isolators, protection devices and cabling.
- Monitoring and data-logging systems.

B3 Energy storage and auxiliary systems

- Thermal storage versus electrical storage.
- Battery technologies (lead-acid, lithium-ion) and indicative capacities:
  - domestic systems typically 3–15 kWh.
- Interaction with auxiliary heaters and grid supply.
- New and emerging technologies: next-generation molten salts, phase change materials (PCMs), solid-particle storage, solar thermochemistry for green hydrogen production.

B4 System configurations and integration

- Grid-connected, off-grid and hybrid systems.
- Integration of PV and solar thermal within a single building.
- Roof space constraints and system prioritisation, legislative factors.
- Interaction with existing heating, hot water and electrical systems.
- Hybrid and integrated systems: smart applications, e.g. building-integrated photovoltaics (BIPV), photovoltaic-thermal (PVT), solar + heat pump integration, digital twins and artificial intelligence (AI).

B5 Applications and scale

- Domestic, commercial and small-scale industrial applications.
- New-build versus retrofit considerations.
- Urban versus rural deployment challenges.
- Environmental impact analysis/legislation.

Learning aim C: Understand operational factors, controls and user influence on performance

C1 Environmental and site-related factors

- Orientation and tilt angle effects:
  - typical optimal tilt: 20–45° depending on latitude.
- Shading, soiling and obstruction impacts.
- Ambient temperature, cloud cover, precipitation and other effects on PV performance.

C2 Control systems and operational strategies

- Differential temperature control in solar thermal systems.
- Inverter control strategies and maximum power point tracking (MPPT).
- Interaction between solar generation, storage and demand.
- Priority control for thermal versus electrical loads.

C3 User behaviour and demand patterns

- Hot water usage profiles and timing.
- Electrical demand matching and load shifting.
- Role of smart timers, immersion diverters and user settings.

C4 Performance limitations and system losses

- Thermal losses, stagnation and overheating risks.
- Electrical losses: cabling, inverter efficiency, temperature derating.
- Typical system losses (10–30% depending on technology and installation).

C5 Reliability, maintenance and lifespan

- Routine checks and basic maintenance requirements
- Indicative lifespans:
  - PV modules (20–30 years)
  - solar thermal collectors (15–25 years)
  - some broad indication of payback times for capital/maintenance investment.

Learning aim D: Be able to carry out and interpret basic solar system performance checks

D1 Performance data and measurements

- Solar irradiance, temperature, voltage, current and energy yield.
- Use of basic instruments (thermometers, multimeters, monitoring software).
- Typical PV system outputs for domestic installations:
  - annual yield often 800–1,100 kWh per installed kWp.

D2 Expected versus actual performance

- Understanding manufacturer data and design expectations.
- Comparison of measured output with theoretical or predicted values.
- Identification of underperformance indicators.

D3 Interpretation and evaluation

- Interpreting trends over time and seasonal variation.
- Identifying causes of reduced performance.
- Impact of controls, storage and user behaviour on outcomes.

D4 Environmental and system-level evaluation

- Contribution to carbon reduction and energy demand displacement:
  - indicative carbon savings dependent on grid carbon intensity.
- Strengths and limitations of integrated solar systems.
- Suitability for different building types and user needs.

Assessment criteria

Learning aim A: Understand solar energy conversion principles and system purposes

Pass	Merit	Distinction
A.P1 Describe how solar radiation is converted into thermal energy and electrical energy in solar systems. **A.P2** Explain typical end uses of solar thermal and photovoltaic systems across domestic and commercial applications.	**A.M1** Compare differences in performance characteristics, efficiencies and output profiles between thermal and photovoltaic technologies.	**A.D1** Analyse suitability of solar thermal and photovoltaic technologies for contrasting energy demands and environmental conditions.

Learning aim B: Know integrated solar system components, configurations and applications

Learning aim C: Understand operational factors, controls and user influence on performance

Pass	Merit	Distinction
B.P3 Describe key components of solar thermal and photovoltaic systems and their roles within integrated installations. **B.P4** Explain common system configurations, including grid-connected, off-grid and hybrid solar arrangements.	**B.M2** Analyse how component selection and configuration influence system integration, energy distribution and overall functionality.	**BC.D2** Evaluate how system design, controls and operational factors collectively determine the effectiveness and reliability of integrated solar systems.
C.P5 Compare environmental and operational factors that affect solar thermal and photovoltaic system performance. **C.P6** Explain how user behaviour and control strategies influence energy capture, storage and utilisation.	**C.M3** Analyse interactions between environmental conditions, controls and user demand affecting overall system efficiency.	

Learning aim D: Be able to carry out and interpret basic solar system performance checks

Pass	Merit	Distinction
D.P7 Describe methods used to obtain basic performance data from solar thermal and photovoltaic systems. **D.P8** Explain how measured performance data is compared with expected or predicted system behaviour. [SP – CT]	**D.M4** Examine performance data to identify causes of underperformance or efficiency losses in solar systems.	**D.D3** Evaluate system performance outcomes to judge effectiveness, limitations and environmental contribution of integrated solar installations.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT √
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on setting assignments. There is also further information on our website.

There is a maximum number of 3 summative assignments for this unit.

The relationship of the learning aims and criteria is:

- Learning aim: A (A.P1, A.P2, A.M1, A.D1).
- Learning aims: B and C (B.P3, B.P4, C.P5, C.P6, B.M2, C.M3, BC.D2).
- Learning aim: D (D.P7, D.P8, D.M4, D.D3).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Solar hardware exemplars: small PV panel/module, solar thermal collector model or cutaway, mounting samples for visual inspection and comparison.
- Measurement and monitoring: multimeters, thermometers, irradiance meters, basic data loggers or monitoring software access for performance discussion.
- Reference materials: manufacturer datasheets, system schematics, wiring diagrams, formula sheets and health-and-safety guidance.

Essential information for assessment decisions

Learning aim A

For Distinction standard, students demonstrate in-depth understanding by evaluating the appropriateness of solar thermal and photovoltaic technologies for contrasting energy scenarios. Evidence shows balanced judgement that considers energy demand profiles, environmental conditions and system limitations. Students integrate technical principles with contextual factors, such as building use or climatic variation, to support conclusions. Reasoning is coherent and supported by realistic assumptions or indicative data. Students may compare alternatives and acknowledge trade-offs without oversimplification. The response is technically accurate and clearly reasoned throughout, showing the student can successfully interpret taught content and apply it to unfamiliar or complex contexts.

For Merit standard, students build on understanding by demonstrating clear reasoning when comparing efficiency, output profiles, seasonal behaviour and suitability for different demand patterns. Students justify statements using appropriate data ranges, diagrams and/or contextual examples, demonstrating deeper understanding of how principles translate into system behaviour. Explanations explore cause-and-effect relationships, such as the influence of irradiance, temperature or demand timing. Students use consistent technical language and show awareness of limitations as well as benefits. The work shows effective synthesis of content rather than isolated facts, indicating the student can meaningfully interpret solar energy principles in applied contexts.

For Pass standard, students demonstrate understanding by explaining how solar energy is converted into useful heat or electricity using accepted scientific principles. Evidence shows appropriate use of terminology when describing solar radiation, absorption, photovoltaic effects and typical output characteristics. Students make clear links between system purpose and end use, such as hot water provision or electricity supply, and match technologies appropriately to at least one of each of domestic and/or commercial contexts. Responses are technically sound, although largely descriptive. Any calculations or reference values used are realistic, though not explored in depth. Overall, the student shows reliable understanding that reflects the taught content.

Learning aims B and C

For Distinction standard, students demonstrate evaluative judgement by judging how system design, control strategies and operational influences collectively affect performance and reliability. Evidence integrates technical design considerations with environmental and user-related factors to form well-reasoned conclusions. Students compare and contrast advantages, limitations and practical constraints, showing awareness of interactions across the whole system. Explanations are coherent, balanced and supported by plausible assumptions or contextual examples. The student moves confidently between component-level detail and system-level outcomes, demonstrating successful interpretation of content. Conclusions are justified, realistic and reflect an in-depth understanding of integrated solar system behaviour.

For Merit standard, students demonstrate analytical understanding by explaining how design choices, configuration and control strategies influence integrated system performance. Evidence shows reasoning about interactions between components, storage methods, operational conditions and demand patterns. Students explore how changes in environment or behaviour affect outcomes, using examples or simplified data where appropriate. Links between thermal and electrical subsystems are clearly explained, showing an understanding of system integration rather than separate technologies. Responses reveal structured thinking and effective use of technical concepts, with attention to performance impacts and system efficiency. The student shows the ability to interpret taught content to explain operational behaviour.

For Pass standard, students show understanding of how integrated solar systems are constructed and operated by correctly outlining key components, typical configurations and basic control approaches. Evidence demonstrates awareness of how systems are arranged to deliver heat and electricity and of how external factors, such as weather and user demand, influence operation. Students describe relationships between components, controls and outputs in a clear, logical manner. Use of diagrams or flow descriptions supports understanding, though explanations remain largely descriptive. Students apply taught terminology correctly and show that they recognise how system parts interact without extensive interpretation. The evidence reflects a secure grasp of how integrated solar installations function at a practical level.

Learning aim D

For Distinction standard, students demonstrate evaluative judgement by using performance evidence to assess overall system effectiveness and limitations. Evidence shows integrated interpretation of data, operational context and environmental impacts. Students draw justified conclusions about system contribution, reliability and suitability, supported by realistic assumptions. Strengths and weaknesses are weighed logically, while constraints are acknowledged. The student’s evaluation shows strong synthesis of performance data and technical understanding, indicating confident and critical interpretation of the subject content.

For Merit standard, students demonstrate analytical ability by interpreting performance data to identify causes of reduced output or inefficiency. Evidence shows clear reasoning when linking observed results to potential factors such as environmental conditions, control behaviour or losses. Students compare actual and expected performance and explain discrepancies using taught concepts. Data is interpreted logically, with trends, rather than isolated observations, identified. Students show understanding of uncertainty and variation, and explanations indicate confident engagement with performance information. This reflects the student’s ability to use data to diagnose system behaviour rather than simply report results.

For Pass standard, students show a reliable understanding by correctly describing how basic performance data is obtained and interpreted. Evidence includes appropriate references to measurements such as temperature, electrical output or energy yield, and shows accurate comparison with expected values. Students explain what the data indicates about system operation in straightforward terms. Data handling is clear and consistent, though interpretation remains mostly descriptive. Students show awareness of normal variation and basic performance trends. The work demonstrates that students can use provided or captured data meaningfully to show whether a system is operating as intended.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 17: Smart Energy Systems and Building Efficiency.
- Unit 18: Low-Carbon Heating Technologies.
- Unit 21: Energy Auditing and Consultancy Practices.

Unit 16: Battery Energy Storage Systems

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students explore battery chemistry, charging behaviour and performance in stationary and transport energy storage systems.

Unit introduction

This unit is highly relevant to the rapid growth of battery energy storage in renewable energy systems and transport electrification. Students benefit from understanding how batteries enable a reliable power supply, support net zero targets and underpin technologies such as electric vehicles and grid-scale storage. Developing this knowledge equips students to interpret real-world systems they encounter as energy users, technicians or future engineers, and builds confidence in a sector of increasing economic and environmental importance.

The unit covers both scientific principles and applied design. Students will explore electrochemical energy storage, common battery chemistries and how different battery types suit stationary and transport applications. They develop skills in specifying and designing battery energy storage systems, including sizing, configuration and component selection. The unit also examines charging and discharging behaviour, performance degradation, monitoring and control, alongside safety, recycling and environmental impacts across the battery lifecycle.

Completion of this unit supports progression to further study in engineering, renewable energy or applied science, and provides relevant technical understanding for entry-level roles in energy storage, electric transport, system installation or maintenance.

Learning aims

In this unit you will:

A Understand battery chemistry and battery types used in energy storage and transport applications

B Be able to design battery energy storage systems for stationary and transport uses

C Understand charging, discharging and performance characteristics of battery systems

D Be able to determine safety, recycling and environmental impacts of battery energy storage systems.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand battery chemistry and battery types used in energy storage and transport applications	**A1** Principles of electrochemical energy storage **A2** Battery chemistries **A3** Battery types and applications	Practical and written assessment exploring battery principles and system design, including calculations, configuration tasks and justification of design decisions for applications.
B Be able to design battery energy storage systems for stationary and transport uses	**B1** Energy storage requirements and applications **B2** System sizing and configuration **B3** Battery system components **B4** Design constraints and compromises	
C Understand charging, discharging and performance characteristics of battery systems	**C1** Charging and discharging behaviour **C2** Performance characteristics **C3** Monitoring, control and optimisation	Analytical assessment examining performance behaviour, monitoring data, safety risks, recycling processes and environmental impacts, supported by evaluation and justified conclusions.
D Be able to determine safety, recycling and environmental impacts of battery energy storage systems	**D1** Battery safety considerations **D2** End-of-life, recycling and reuse **D3** Environmental and sustainability impacts	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand battery chemistry and battery types used in energy storage and transport applications

How batteries store and release energy and compare battery technologies used in stationary energy storage and transport systems.

A1 Principles of electrochemical energy storage

- Batteries as electrochemical energy storage devices.
- Conversion between:
  - chemical energy
  - electrical energy.
- Basic battery structure:
  - anode
  - cathode
  - electrolyte
  - separator.
- Movement of ions and electrons during charge and discharge.
- Difference between:
  - primary (non-rechargeable) batteries
  - secondary (rechargeable) batteries.

A2 Battery chemistries

- Common rechargeable battery chemistries:
  - lead-acid
  - lithium-ion
  - lithium iron phosphate (LFP)
  - nickel-metal hydride (NiMH).
- Key characteristics of different chemistries:
  - energy density
  - power density
  - cycle life
  - cost
  - safety.

- Comparison of chemistries for:
  - stationary storage
  - transport applications.

A3 Battery types and applications

- Small-scale battery systems:
  - portable electronics
  - small domestic storage.
- Large-scale stationary battery energy storage system (BESS):
  - grid-scale storage
  - renewable energy integration.
- Transport applications:
  - electric vehicles (cars, buses, vans)
  - rail applications (hybrid and battery trains)
  - marine and aviation key applications.
- Suitability of battery types for different use cases.

Learning aim B: Be able to design battery energy storage systems for stationary and transport uses

How to specify and design battery systems that meet defined energy and power requirements.

B1 Energy storage requirements and applications

- Purpose of battery energy storage:
  - load shifting
  - peak shaving
  - backup power
  - renewable energy smoothing.
- Differences between stationary and transport requirements:
  - energy compared to power needs
  - weight and volume constraints
  - duty cycles.

B2 System sizing and configuration

- Key design parameters:
  - energy capacity by kilowatt-hour (kWh)
  - power rating by kilowatt (kW).

- Series and parallel battery configurations:
  - effect on voltage
  - effect on capacity.
- Matching battery capacity to:
  - load profiles
  - transport journey requirements.
- Allowances for degradation and future capacity loss.

B3 Battery system components

- Battery modules and packs.
- Battery management systems (BMS):
  - monitoring voltage, current and temperature
  - cell balancing.
- Power electronics:
  - inverters
  - converters.
- Cooling and thermal management systems.
- Enclosures and mounting systems.
- Integration with:
  - renewable generation
  - electricity grids
  - electric drivetrains.

B4 Design constraints and compromises

- Space, weight and structural considerations.
- Cost constraints:
  - capital cost
  - operational cost.
- Performance versus lifespan trade-offs.
- Reliability and redundancy considerations.
- Designing for maintenance and accessibility.

Learning aim C: Understand charging, discharging and performance characteristics of battery systems

How battery systems operate in real conditions and how performance is measured and managed.

C1 Charging and discharging behaviour

- Charge and discharge processes.
- Charging methods:
  - slow charging
  - fast charging.
- State of charge (SoC).
- Depth of discharge (DoD).
- Charge and discharge rates (C-rate – qualitative understanding).
- Differences between stationary and transport charging profiles.

C2 Performance characteristics

- Battery efficiency:
  - round-trip efficiency.
- Capacity fade and degradation over time.
- Cycle life and calendar life.
- Effects of:
  - temperature
  - charging rate
  - Depth of Discharge (DoD).
- Impact of performance degradation on system design.

C3 Monitoring, control and optimisation

- Role of BMS.
- Monitoring key parameters:
  - voltage
  - current
  - temperature.
- Optimising battery performance:
  - operating within safe limits
  - avoiding overcharge and deep discharge.
- Performance comparison between:
  - stationary BESS
  - transport battery systems.

Learning aim D: Be able to determine safety, recycling and environmental impacts of battery energy storage systems

Risks, lifecycle impacts and sustainability of battery energy storage systems.

D1 Battery safety considerations

- Electrical hazards:
  - short circuits
  - overcurrent.
- Thermal hazards:
  - overheating
  - thermal runaway.
- Mechanical hazards:
  - impact damage (transport systems).
- Risk assessment and hazard mitigation.
- Importance of:
  - BMSs
  - protective enclosures
  - safe operating procedures.

D2 End-of-life, recycling and reuse

- Battery lifespan and end-of-life issues.
- Recycling of battery materials:
  - metals
  - electrolytes.
- Environmental risks of improper disposal.
- Second-life applications:
  - reuse of electric vehicle (EV) batteries for stationary storage.
- How laws and regulations can ensure responsible Life-cycle Assessment (LCA).

D3 Environmental and sustainability impacts

- Environmental benefits of battery storage:
  - enabling renewable energy
  - reducing fossil fuel use.
- Environmental impacts:
  - resource extraction
  - manufacturing emissions.
- Comparison of battery systems with alternative storage technologies.
- Role of batteries in net zero and decarbonisation strategies.

Assessment criteria

Learning aim A: Understand battery chemistry and battery types used in energy storage and transport applications

Learning aim B: Be able to design battery energy storage systems for stationary and transport uses

Pass	Merit	Distinction
A.P1 Describe the basic operating principles of rechargeable batteries. **A.P2** Explain different battery chemistries and their applications in energy storage and transport systems.	**A.M1** Explain how battery chemistry influences performance, lifespan and suitability for different applications.	**AB.D1** Analyse how battery chemistry, system design and operating conditions affect the performance and reliability of battery energy storage systems.
B.P3 Carry out battery energy storage system designing to meet given energy and power requirements. [EL – CL] **B.P4** Select appropriate battery configurations and system components for a given application.	**B.M2** Explain how design constraints and compromises influence battery energy storage system design.	

Learning aim C: Understand charging, discharging and performance characteristics of battery systems

Learning aim D: Be able to determine safety, recycling and environmental impacts of battery energy storage systems

Pass	Merit	Distinction
C.P5 Describe charging and discharging characteristics of battery energy storage systems. **C.P6** Examine factors that affect battery performance and degradation.	**C.M3** Explain how variations in charging methods and operating conditions impact battery efficiency, performance and longevity.	**CD.D2** Evaluate the sustainability of battery energy storage systems, considering safety, recycling and environmental impacts across stationary and transport applications.
D.P7 Describe safety risks associated with battery energy storage systems. **D.P8** Explain recycling, reuse and environmental considerations for battery systems.	**D.M4** Explain how safety and environmental considerations influence battery system design and operation.	

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL √	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on setting assignments. There is also further information on our website.

There is a maximum number of two summative assignments for this unit.

The relationship of the learning aims and criteria is:

- Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, AB.D1).
- Learning aims: C and D (C.P5, C.P6, D.P7, D.P8, C.M3, D.M4, CD.D2).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Battery hardware and models: representative cells, modules or training packs (lead-acid, lithium-ion/LFP equivalents) and schematic cutaway diagrams to support understanding of structure, chemistry and applications.
- Design and calculation tools: specification data sheets, load profiles, calculators or spreadsheets to support system sizing, configuration and degradation allowances.
- Monitoring and safety resources: BMS demonstrations, safety guidance, risk-assessment templates and case studies of stationary and transport BESS.
- Lifecycle and impact materials: authoritative resources on recycling, second-life use, environmental impacts and net zero context for battery energy storage.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, students demonstrate an integrated and analytical understanding of the relationships between battery chemistry, system design and operating requirements. Evidence shows well-reasoned evaluation of how different chemistries behave under varying conditions and how these behaviours influence overall system reliability and performance. Design outcomes are coherent, realistic and clearly optimised for their intended application, with trade-offs explicitly examined and justified. Students compare alternative approaches and explain why selected solutions best meet technical and operational needs. System designs reflect professional-level thinking, considering constraints such as redundancy, maintenance, safety margins and long-term performance. Calculations, explanations and conclusions are consistently accurate and supported by logical reasoning, showing confident application of knowledge across unfamiliar or more complex design scenarios.

For Merit standard, students present a more developed understanding of how battery chemistry influences performance, lifespan and suitability across stationary and transport applications. Evidence shows a clear explanation of why particular chemistries are preferable for given use cases, supported by consideration of factors such as energy density, safety, cycle life and cost. System design work demonstrates competent sizing and component selection that reflects realistic operating requirements, including allowances for degradation and practical constraints. Students justify design choices and show awareness of compromises, such as balancing performance against lifespan or cost. Explanations move beyond description to link electrochemical principles with design decisions. Calculations and configurations are accurate and contextualised, indicating that students are interpreting design requirements rather than simply following instructions.

For Pass standard, students demonstrate a secure foundational understanding of how rechargeable batteries operate and how different battery chemistries are used in energy storage and transport contexts. Evidence typically shows accurate identification of key components, processes and characteristics, alongside straightforward selection of battery types for defined applications. Design evidence includes basic system sizing and configuration activities that meet the stated energy and power requirements, with correct use of series and parallel arrangements. Students' designs are generally functional and appropriate, though they rely heavily on provided parameters and simplified assumptions. Explanations remain descriptive, with limited linkage between chemistry choice and system performance. Calculations, where present, are correct but not extended or justified. Overall, evidence shows that the student can apply taught principles to familiar contexts in a structured way, but without deeper evaluation of compromises or constraints.

Learning aims B and C

For Distinction standard, students evaluate the sustainability of battery energy storage systems by integrating performance behaviour, safety management and lifecycle environmental impacts. Evidence shows balanced consideration of benefits and limitations, such as enabling renewable energy while accounting for material extraction, degradation and end-of-life challenges. Students compare approaches across stationary and transport applications, highlighting how differing duty cycles and operating environments affect sustainability aims. Safety, recycling and environmental factors are analysed as interconnected elements rather than isolated topics. Judgements are supported with clear reasoning and relevant examples, demonstrating depth of understanding and the ability to apply principles to complex or unfamiliar scenarios. Conclusions reflect informed evaluation aligned to real-world energy and decarbonisation contexts.

For Merit standard, students explain how charging strategies, operating conditions and system management influence performance, lifespan and safety. Evidence demonstrates understanding of how factors such as temperature, charge rate and depth of discharge affect degradation and reliability. Students explain how safety and environmental considerations shape operational decisions and system design, including the role of monitoring and control systems. Recycling, reuse and sustainability are discussed with reference to lifecycle impacts and regulatory expectations. Responses show clear cause-and-effect reasoning, linking technical operation to performance outcomes and wider environmental implications. Students use examples from both stationary and transport contexts to support their explanations, indicating confident interpretation rather than simple recall.

For Pass standard, students provide clear descriptions of how battery systems charge and discharge and identify key factors that affect performance and degradation. Evidence shows understanding of terms such as state of charge, depth of discharge and basic charging methods, alongside recognition of common safety risks and end-of-life issues. Students describe some environmental considerations and recycling routes in a general but accurate manner. Responses demonstrate awareness of safe operation and the need for responsible disposal or reuse, though explanations tend to be surface-level. Links between operating conditions, performance outcomes and safety or environmental impacts are limited. Overall, evidence shows that students can recognise and describe important characteristics and risks, but with minimal interpretation of how these factors interact in real-world systems.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 17: Smart Energy Systems and Building Efficiency.
- Unit 18: Low-Carbon Heating Technologies.
- Unit 21: Energy Auditing and Consultancy Practices.
- Unit 22: Low and Zero Carbon Transport Systems.

Unit 17: Smart Energy Systems and Building Efficiency

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students explore smart energy systems, digital grids, sensors and data analysis, alongside building efficiency, cybersecurity and data ethics.

Unit introduction

This unit is relevant to the modern energy sector, where digitalisation, data and smart technologies are reshaping how energy is generated, distributed and consumed. Students benefit from understanding how smart energy systems support efficiency, resilience and decarbonisation in buildings and wider energy networks. The unit equips students with the knowledge and practical insights needed to interpret real-world energy data, understand system interactions and appreciate the ethical responsibilities associated with digital energy use.

The unit covers a broad and balanced range of content, from the principles of smart grids and digital energy systems to the practical use of sensors and energy monitoring tools. Students examine how energy is used in buildings, assess efficiency measures and evaluate improvement options. The unit also addresses cybersecurity, data protection and ethical considerations, ensuring students understand both technical and responsible system operation across domestic and non-domestic contexts.

Successful completion supports progression to further study in energy, engineering or sustainability-related disciplines. The unit also develops transferable skills valued in employment, including data interpretation, analytical thinking and professional judgement, preparing students for roles within the evolving smart energy and building management sectors.

Learning aims

In this unit, you will:

A Understand smart grids and digital energy systems

B Be able to use sensors, data and energy monitoring tools

C Be able to assess building energy efficiency measures

D Understand cybersecurity and data ethics in smart energy systems.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand smart grids and digital energy systems	**A1** Traditional and smart energy systems **A2** Smart grids **A3** Digital energy systems and applications	Smart energy system and building energy data investigation.
B Be able to use sensors, data and energy monitoring tools	**B1** Sensors and measurement devices **B2** Energy monitoring and data collection **B3** Data analysis and interpretation	
C Be able to assess building energy efficiency measures	**C1** Energy use in buildings **C2** Building fabric and system efficiency measures **C3** Assessing building energy efficiency	Building efficiency improvements and smart energy system evaluation, considering performance data, cybersecurity and ethical responsibilities.
D Understand cybersecurity and data ethics in smart energy systems	**D1** Cybersecurity in smart energy systems **D2** Data protection and privacy **D3** Data ethics and responsible use	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand smart grids and digital energy systems

How digital technologies are transforming energy generation, distribution and consumption.

A1 Traditional and smart energy systems

- Overview of traditional electricity networks:
    - centralised generation
    - one-way power flow.
- Limitations of traditional grids:
    - limited visibility
    - difficulty integrating renewables
    - technical limitations (fault detection, frequency stability, scalability challenges).
- Definition and reasons for smart energy systems.
- Role of digitalisation in modern energy networks.

A2 Smart grids

- Key features of smart grids:
    - two-way power flow
    - real-time monitoring
    - automated control
    - system integration (smart grids' reliance on devices and systems working together across different platforms and manufacturers).
- Components of a smart grid:
    - smart meters
    - sensors and communication networks, and data systems
    - control centres.
- Benefits of smart grids:
    - improved reliability
    - integration of renewable energy
    - demand-side management.
- Challenges and limitations:
    - cost
    - complexity
    - cybersecurity risks.

A3 Digital energy systems and applications:

- Role of digital technologies in energy systems:
  - data analytics
  - automation
  - uses of artificial intelligence.
- Examples of digital energy applications:
  - demand response
  - virtual power plants
  - smart charging for electric vehicles.
- Interaction between smart grids, renewable energy and energy storage systems.
- Contribution of smart systems to net zero targets.
- Flexibility markets (how modern energy systems value the ability to shift or adjust demand in response to grid conditions).

Learning aim B: Be able to use sensors, data and energy monitoring tools

Practical skills in collecting, analysing and interpreting energy data to support efficiency and system optimisation.

B1 Sensors and measurement devices:

- Purpose of sensors in energy systems.
- Common sensor types:
  - temperature
  - electrical current and voltage
  - power and energy meters
  - occupancy sensors.
- Smart meters:
  - functions and data collected.
- Accuracy, resolution and reliability of sensors.

B2 Energy monitoring and data collection:

- Energy monitoring systems for buildings:
  - electricity
  - heating.
- Data logging and remote monitoring.
- Data types:
  - real-time data
  - historical data.
- Frequency of data collection and its importance.
- Identifying and interpreting anomalies and unusual energy use.

B3 Data analysis and interpretation:

- Organising data using:
    - tables
    - graphs.
- Identifying trends and patterns:
    - daily
    - weekly
    - seasonal.
- Comparing energy performance:
    - before and after efficiency measures.
- Using data to inform decisions:
    - operational changes
    - maintenance needs.
- Limitations of data, assumptions and measurement uncertainty.

Learning aim C: Be able to assess building energy efficiency measures

How buildings use energy and evaluate measures to improve efficiency and reduce carbon emissions.

C1 Energy use in buildings:

- Typical energy uses in buildings:
    - space heating and cooling
    - hot water
    - lighting
    - appliances and equipment.
- Differences between domestic and non-domestic buildings.
- Factors influencing building energy performance:
    - building fabric
    - occupancy behaviour
    - controls and systems.

C2 Building fabric and system efficiency measures:

- Fabric efficiency measures:
    - insulation
    - glazing
    - air tightness.

- Building services efficiency measures:
  - efficient lighting
  - heating and cooling system upgrades
  - controls and automation.
- Role of smart technologies in efficiency:
  - smart thermostats
  - automated lighting.
- Interaction between efficiency measures and renewable technologies.

C3 Assessing building energy efficiency:

- Purpose of an energy efficiency assessment.
- Methods of assessment:
  - energy audits
  - benchmarking.
- Key performance indicators:
  - energy use per area
  - peak demand.
- Prioritising efficiency measures:
  - cost
  - ease of implementation
  - energy and carbon savings.
- Presenting recommendations clearly to building users.

Learning aim D: Understand cybersecurity and data ethics in smart energy systems

Risks associated with digital energy systems and ethical responsibilities when handling energy data.

D1 Cybersecurity in smart energy systems:

Importance of cybersecurity in digital energy infrastructure.

- Types of cyber threats:
  - unauthorised access
  - data manipulation
  - system disruption.
- Vulnerabilities in:
  - smart meters
  - building management systems
  - grid control systems.

- Basic cybersecurity measures:
    - access controls
    - software updates
    - network segmentation.

D2 Data protection and privacy:

- Types of data collected by smart energy systems:
    - energy consumption patterns
    - occupancy indicators.
- Risks to privacy from detailed energy data.
- Principles of data protection:
    - confidentiality
    - integrity
    - availability.
- Responsibilities of organisations handling energy data ethically and securely.

D3 Data ethics and responsible use:

- Ethical considerations in data collection and use within smart energy systems.
- Informed consent and transparency.
- Fair and responsible use of data:
    - avoiding misuse
    - preventing discrimination.
- Balancing innovation with privacy and security.
- Role of ethics in building user trust in smart energy systems.

Assessment criteria

Learning aim A: Understand smart grids and digital energy systems

Learning aim B: Be able to use sensors, data and energy monitoring tools

Pass	Merit	Distinction
A.P1 Describe the main features of smart grids and digital energy systems. **A.P2** Explain how smart grids support the integration of renewable energy and demand management.	**A.M1** Explain how digital technologies improve the monitoring, control and efficiency of modern energy systems.	**AB.D1** Analyse how smart grid technologies and data monitoring systems interact to improve building and energy system performance.
B.P3 Use sensors or monitoring tools to collect energy data. [EL – PRS] **B.P4** Present energy data using appropriate tables or graphs.	**B.M2** Explain how energy data can be used to identify inefficiencies and improve system performance.	

Learning aim C: Be able to assess building energy efficiency measures

Learning aim D: Understand cybersecurity and data ethics in smart energy systems

Pass	Merit	Distinction
C.P5 Describe energy efficiency measures applicable to buildings. **C.P6** Carry out a basic assessment of building energy efficiency and identify improvement measures.	**C.M3** Explain how energy efficiency measures reduce energy use and carbon emissions in buildings.	**BC.D2** Evaluate the effectiveness of building energy efficiency measures, using energy data, linking to data security, privacy and ethical responsibilities.
D.P7 Describe cybersecurity risks associated with smart energy systems. **D.P8** Describe ethical and privacy considerations when handling energy data.	**D.M4** Explain how cybersecurity and data ethics influence the design and operation of smart energy systems.	

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS √	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on setting assignments. There is also further information on our website.

There is a maximum number of two summative assignments for this unit.

The relationship of the learning aims and criteria is:

- Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, AB.D1).
- Learning aims: B and C (C.P5, C.P6, D.P7, D.P8, C.M3, D.M4, CD.D2).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Smart energy system exemplars: access to smart grid case studies, smart meters, demand-response and digital energy system demonstrations to illustrate system operation and integration.
- Monitoring and data tools: basic sensors, energy meters, data loggers or simulation software, with spreadsheet or graphing tools for data handling and analysis.
- Building efficiency reference materials: building plans, energy audit templates, benchmarking data and guidance on fabric, services and control efficiency measures.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, students present coherent analytical evidence that integrates smart grid technologies with energy monitoring data to evaluate real-world system or building performance. They synthesise knowledge of digital infrastructure, control systems and data analytics, demonstrating how these elements interact to deliver measurable performance improvements. Evidence shows students selecting relevant datasets, critically interpreting patterns over time, and explaining impacts on efficiency, flexibility and reliability. Judgements are well-reasoned, balancing technical benefits against system constraints such as cost, complexity or cybersecurity risk. Students clearly articulate how insights derived from data could influence strategic or operational decisions. Achievement at this level demonstrates confident systems thinking and a strong ability to evaluate digital energy solutions using evidence-based reasoning.

For Merit standard, students show a secure understanding of how digital technologies and data monitoring improve energy system and building performance. Evidence demonstrates explanation rather than description, with students linking smart grid functions to improvements in efficiency, responsiveness or integration of variable energy sources. Data collected using sensors or monitoring tools is interpreted to identify inefficiencies, trends or abnormal patterns, with clear reasoning. Students justify how specific datasets inform operational decisions, such as system optimisation or opportunities for energy reduction. Visual data presentation is purposeful and directly supports conclusions drawn. At this level, students demonstrate growing analytical confidence by connecting digital infrastructure, monitoring capability and performance improvement, while recognising limitations such as data accuracy or resolution.

For Pass standard, students provide accurate, structured evidence showing a foundational understanding of how smart grids and digital energy systems operate alongside basic use of energy monitoring tools. Evidence typically includes clear descriptions of system features, supported by appropriately selected examples of sensors, smart meters or monitoring outputs. Students collect energy data using suitable tools and present it clearly in tables or graphs, demonstrating correct data handling rather than depth of interpretation. Explanations remain mostly descriptive, showing that students recognise how digital systems enable monitoring, renewable integration and demand management. Practical evidence confirms that monitoring tools have been used correctly and safely, with relevant data for the system or building context provided. Overall, achievement at this level shows competent engagement with digital energy concepts and accurate presentation of collected data, with limited analysis or linkage between system design and performance outcomes.

Learning aims B and C

For Distinction standard, students offer evaluative evidence that weighs the effectiveness of building energy efficiency measures while critically considering data security, privacy and ethical responsibility. Assessments are interpreted to justify strategic improvement decisions, supported by reasoned comparison of options and anticipated outcomes. Students demonstrate mature judgement by balancing energy and carbon benefits against practical constraints and digital risks. Cybersecurity and ethical considerations are embedded throughout the evaluation, not treated as separate issues, demonstrating an integrated understanding of smart building operations. Evidence reflects professional-level thinking, with students presenting clear, justified conclusions suited to building owners, users or system managers.

For Merit standard, students generate reasoned explanations linking energy efficiency measures to reductions in energy use and carbon emissions, supported by assessment findings. Evidence shows students justifying selected improvement measures based on performance indicators, feasibility or potential impact. Cybersecurity and data ethics are integrated into explanations, with students explaining how these considerations influence system design or operation. Students demonstrate awareness of how data sensitivity, access controls and ethical use affect trust and system effectiveness. Recommendations are clearly prioritised and communicated, showing balanced consideration of technical, operational and ethical factors.

For Pass standard, students demonstrate sound awareness of how energy is used in buildings and the range of measures that can improve efficiency. Evidence typically includes a basic assessment of a building's energy performance, identifying priority areas such as fabric, services or controls. Students also show understanding of cybersecurity and ethical issues associated with smart energy data, recognising common risks and responsibilities when handling energy information. Recommendations are relevant and realistic but largely descriptive, focusing on what could be improved rather than why. Ethical and security considerations are acknowledged in general terms, showing that students understand the need to protect data and respect privacy when using smart technologies.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 14: Biomass and Biofuel Energy Systems.
- Unit 18: Low-Carbon Heating Technologies.
- Unit 21: Energy Auditing and Consultancy Practices.

Unit 18: Low-Carbon Heating Technologies

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students explore heat pumps, district heating, installation, controls and performance analysis. They develop an understanding of low-carbon heating design, carbon reduction and system evaluation through applied technical knowledge and realistic energy contexts.

Unit introduction

This unit is highly relevant to the real-world transition to low-carbon heating and net zero targets. Students benefit from understanding how technologies, such as heat pumps and district heating systems, regulate building thermal demand (heating and, where applicable, cooling) while reducing greenhouse gas emissions. The knowledge gained enables students to make informed decisions in domestic, commercial and urban energy contexts and develop awareness of practical sustainability challenges.

The unit covers both theoretical and applied content. Students explore the operating principles and performance of heat pumps, alongside the design and operation of district heating and heat networks. They examine installation requirements, control strategies, commissioning processes and methods for measuring carbon reduction and analysing system performance.

Completion of this unit supports progression to further study in renewable energy, building services engineering or sustainability-related pathways. It also prepares students for employment or apprenticeships in low-carbon heating, energy management or infrastructure roles by developing technically grounded and transferable skills.

Learning aims

In this unit, you will:

A Understand the use of heat pumps and their system operation

B Understand district heating and heat networks

C Be able to determine installation requirements and control strategies for low-carbon heating systems

D Be able to measure carbon reduction and carry out performance analysis of low-carbon heating systems.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the use of heat pumps and their system operation	**A1** Principles of heat pump operation **A2** Types of heat pumps **A3** Heat pump performance and system efficiency	Assessment uses tasks comparing heat pump and district heating systems, requiring students to explain operation, components, performance influences, advantages and challenges using real-world technical contexts and applied scenarios.
B Understand district heating and heat networks	**B1** Principles of district heating **B2** Heat network components **B3** Advantages and challenges of heat networks	
C Be able to determine installation requirements and control strategies for low-carbon heating systems	**C1** Installation requirements **C2** Controls and system operation **C3** Commissioning and handover	Assessment uses applied tasks for students to interpret installation requirements, justify control strategies and analyse performance and carbon data, demonstrating effective system operation, optimisation and evaluation within realistic low-carbon heating scenarios.
D Be able to measure carbon reduction and carry out performance analysis of low-carbon heating systems	**D1** Carbon emissions and heating **D2** Measuring carbon reduction **D3** Performance analysis	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand the use of heat pumps and their system operation

How heat pumps operate and why they are a key low-carbon heating technology.

A1 Principles of heat pump operation

- Heat pumps as low-carbon heating systems.
- Heat pump operation to provide cooling, through transfer of heat from indoor spaces to external environment.
- Transfer of thermal energy rather than direct heat generation.
- Basic vapour compression cycle (qualitative):
    - evaporator
    - compressor
    - condenser
    - expansion device.
- Role of electricity in heat pump operation.
- Comparison with conventional fossil-fuel boilers.

A2 Types of heat pumps

- Air source heat pumps (ASHP):
    - air-to-water systems
    - air-to-air systems, including reversible operation for heating and cooling of indoor spaces.
- Ground source heat pumps (GSHP):
    - horizontal ground loops
    - vertical boreholes.
- Water source heat pumps (overview).
- Advantages and limitations of each type:
    - efficiency
    - installation complexity
    - space requirements
    - cost.

A3 Heat pump performance and system efficiency

- Coefficient of performance (COP).
- Seasonal performance factor (SPF), cooling performance in reversible systems, including efficiency considerations and seasonal use.

- Factors affecting heat pump performance:
  - source temperature
  - heat distribution system temperature
  - building heat demand.
- Importance of low-temperature heat distribution:
  - underfloor heating
  - oversized radiators.

Learning aim B: Understand district heating and heat networks

How heat can be generated centrally and distributed efficiently to multiple buildings.

B1 Principles of district heating

- Definition of district heating and heat networks.
- Centralised heat generation and distribution.
- Difference between individual heating systems and heat networks.
- Typical heat sources:
  - heat pumps
  - combined heat and power (CHP)
  - waste heat
  - overview of biomass.

B2 Heat network components

- Heat generation plant.
- Distribution pipework:
  - flow and return circuits
  - insulation.
- Heat interface units (HIUs).
- Pumps and control systems.
- Heat meters and monitoring equipment.

B3 Advantages and challenges of heat networks

- Advantages:
  - improved system-level efficiency
  - ability to use low-carbon and waste heat sources
  - reduced emissions at building level.
- Challenges:
  - high installation costs
  - disruption during installation
  - heat losses in distribution.

- Suitability for:
  - residential developments
  - campuses
  - light industrial estates.

Learning aim C: Be able to determine installation requirements and control strategies for low-carbon heating systems

How low-carbon heating systems are installed, controlled and commissioned to ensure safe and efficient operation.

C1 Installation requirements

- Site assessment considerations:
  - space requirements
  - access
  - noise constraints (heat pumps).
- Electrical supply requirements:
  - power demand
  - upgrades.
- Hydraulic system considerations:
  - pipe sizing
  - buffer tanks and thermal stores.
- Integration with existing heating systems (retrofit).

C2 Controls and system operation

- Purpose of controls in heating systems.
- Control strategies:
  - thermostats
  - weather compensation
  - time scheduling.
- Zoning and temperature control.
- Importance of correct control setup for efficiency and comfort.
- User interaction with controls.

C3 Commissioning and handover

- Purpose of commissioning:
  - safety
  - performance verification.

- Typical commissioning checks:
  - flow rates
  - temperatures
  - control settings.
- Importance of documentation and user guidance.
- Role of maintenance in long-term performance.

Learning aim D: Be able to measure carbon reduction and carry out performance analysis of low-carbon heating systems [SP - PS]

How low-carbon heating systems reduce emissions and assess their real-world performance.

D1 Carbon emissions and heating

- Carbon emissions associated with:
  - gas heating
  - oil heating
  - electric heating.
- Operational emissions of heat pumps and heat networks.
- Influence of electricity grid carbon intensity.
- Comparison of carbon emissions between technologies.

D2 Measuring carbon reduction

- Estimating carbon savings:
  - before-and-after comparisons
  - annual energy use comparisons.
- Factors influencing carbon reduction:
  - system efficiency
  - user behaviour
  - control strategies.
- Limitations of carbon calculations (overview).

D3 Performance analysis

- Monitoring system performance:
  - energy input
  - heat output.
- Identifying performance issues:
  - short cycling
  - incorrect control settings
  - insufficient heat emitters.

- Using performance data to:
  - optimise system operation
  - inform maintenance needs.
- Role of performance analysis in meeting net zero targets.

Assessment criteria

Learning aim A: Understand the use of heat pumps and their system operation

Learning aim B: Understand district heating and heat networks

Pass	Merit	Distinction
A.P1 Describe how heat pumps operate and transfer heat. **A.P2** Examine different types of heat pumps and their applications.	**A.M1** Explain how system design and operating conditions affect heat pump performance.	**AB.D1** Analyse how heat pump or heat network design and installation influence system efficiency and carbon reduction.
B.P3 Describe the principles and components of district heating systems. **B.P4** Describe advantages and challenges associated with heat networks.	**B.M2** Explain why district heating systems are suitable for certain building types and locations.	

Learning aim C: Be able to determine installation requirements and control strategies for low-carbon heating systems

Learning aim D: Be able to measure carbon reduction and carry out performance analysis of low-carbon heating systems

Pass	Merit	Distinction
C.P5 Describe installation requirements for low-carbon heating systems. **C.P6** Describe control methods used to manage low-carbon heating systems.	**C.M3** Explain how installation quality and control strategies affect system efficiency and user comfort.	**CD.D2** Evaluate the effectiveness of a low-carbon heating solution using performance and carbon data in a given application.
D.P7 Describe how low-carbon heating systems reduce carbon emissions. **D.P8** Describe methods used to assess system performance and carbon savings.	**D.M4** Explain how performance data can be used to improve carbon reduction outcomes.	

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS *
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on setting assignments. There is also further information on our website.

There is a maximum number of two summative assignments for this unit.

The relationship of the learning aims and criteria is:

- Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, AB.D1).
- Learning aims: C and D (C.P5, C.P6, D.P7, D.P8, C.M3, D.M4, CD.D2).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Heat pump training resources: cutaway diagrams or training rigs, system schematics, and manufacturer datasheets for ASHP, GSHP and heat networks.
- Controls and monitoring equipment: thermostats, weather-compensation controllers, heat meters and basic data-logging or monitoring interfaces.
- Measurement and analysis tools: electrical energy meter, temperature sensors, flow diagrams and calculation worksheets for carbon and performance analysis.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, students demonstrate a secure and detailed understanding by analysing how system design and installation decisions influence both efficiency and carbon outcomes. Their evidence integrates multiple factors, such as operating temperatures, distribution systems and network scale, to justify conclusions about system performance. Students compare heat pumps and heat networks, weighing the benefits and limitations in specific scenarios. Explanations go beyond taught examples, demonstrating independent reasoning and clear cause-and-effect relationships. Judgements are supported by technically accurate explanations rather than assertions. Students communicate findings clearly and professionally, showing a depth of understanding suitable for applied technical contexts.

For Merit standard, students present coherent explanations that link system design choices to operational performance and suitability. Their work shows how factors such as source temperature, heat emitters and building type influence the effectiveness of heat pumps and district heating systems. Students compare technologies in a structured way, explaining why particular systems are appropriate for specific settings such as residential developments or campuses. Evidence demonstrates logical reasoning and applies knowledge to contextual examples rather than simple descriptions. Students recognise constraints, such as installation complexity or heat losses, and explain how these affect real-world performance. Overall, explanations show developing analytical skill and clearer connections between technical characteristics, efficiency and deployment decisions.

For Pass standard, students provide essential explanations of how heat pumps and district heating systems function, using correct terminology and simple system descriptions. Their evidence shows an understanding of core processes such as heat transfer, centralised heat generation and energy distribution. Students outline different types of heat pumps and identify key components found in heat networks, demonstrating awareness of typical applications and basic advantages. Examples may include short comparisons between systems or brief descriptions of where each technology is commonly used. Explanations lack depth and may rely heavily on taught material. Students demonstrate correct understanding but do not explore interactions between system design, operating conditions or performance outcomes in depth.

Learning aims C and D

For Distinction standard, students evaluate the overall effectiveness of a low-carbon heating solution using performance and carbon data in context. Their work synthesises installation decisions, control strategies, commissioning outcomes and measured performance to form justified conclusions. Students identify limitations within the system and explain their implications for efficiency, emissions and long-term operation. Judgements are balanced, technically sound and supported by interpreted data rather than isolated figures. Evidence demonstrates independent thinking and a strong understanding of how optimisation and monitoring contribute to net zero objectives. Communication is precise and professional, reflecting real-world technical evaluation practices.

For Merit standard, students explain how installation quality and control strategies influence system efficiency, occupant comfort and carbon outcomes. Their evidence links commissioning checks, control settings and monitoring data to observed system performance. Students use measurements or performance information to explain how improvements can be made such as adjusting controls or addressing inefficiencies. They demonstrate understanding of how user behaviour and operational choices affect outcomes. Explanations show clear reasoning and application to realistic scenarios rather than generic descriptions. Students begin to interpret performance data, using it to justify conclusions about effectiveness and improvement strategies in low-carbon heating systems.

For Pass standard, students describe key installation requirements, control methods and commissioning activities associated with low-carbon heating systems. Evidence shows awareness of practical considerations such as space, electrical supply and basic control functions. Students explain in straightforward terms how low-carbon systems reduce emissions and how performance or carbon outcomes can be measured using simple comparisons. Descriptions are accurate but remain surface-level, with limited interpretation of data or system behaviour. Students identify typical performance indicators and monitoring methods, but do not explore their interrelationships in detail. Work demonstrates a basic ability to follow processes and explain what is done during installation, operation and performance assessment.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 10: The Hydrogen Energy Economy.
- Unit 17: Smart Energy Systems and Building Efficiency.
- Unit 21: Energy Auditing and Consultancy Practices.

Unit 19: Geothermal Energy Applications

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students explore geothermal resources, energy extraction methods and system design for heating and electricity generation. They assess environmental impacts, limitations and feasibility, developing knowledge applicable to low-carbon energy system career pathways.

Unit introduction

This unit is highly relevant to the global transition towards low-carbon energy systems and net-zero strategies. By understanding how geothermal energy is sourced and how the systems used are designed and evaluated, students develop insight into a reliable and weather-independent renewable technology increasingly used for heating, cooling and electricity generation. This knowledge enables students to engage with real-world challenges such as decarbonising buildings, improving energy security and selecting appropriate technologies for different geographical contexts.

The unit covers the origin and distribution of geothermal resources, distinguishing between shallow and deep systems and the methods used to extract heat sustainably. Students explore geothermal heating and power generation systems, including design considerations such as site conditions, system sizing and integration with other energy technologies. Environmental benefits, risks and limitations are examined in depth, enabling students to weigh feasibility, sustainability and impact across contrasting scenarios.

Completion of this unit supports progression to further study in green energy, engineering and environmental science. This unit also provides sector-relevant knowledge valued in roles linked to energy systems design, sustainability consultancy and low-carbon project planning.

Learning aims

In this unit you will:

A Understand geothermal resources and methods of heat extraction

B Understand geothermal system design and applications

C Be able to determine environmental impacts and limitations of geothermal energy systems.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand geothermal resources and methods of heat extraction	**A1** Origin and distribution of geothermal energy **A2** Types of geothermal resources **A3** Heat extraction methods	Examination of geothermal resources, extraction methods and system design, using explanations, diagrams, comparisons and applied case study analysis.
B Understand geothermal system design and applications	**B1** Geothermal heating systems **B2** Geothermal electricity generation **B3** System design considerations	
C Be able to determine environmental impacts and limitations of geothermal energy systems	**C1** Environmental benefits of geothermal energy **C2** Environmental impacts and risks **C3** Limitations and feasibility	Evaluation of environmental impacts and limitations, using case studies, comparisons and justified conclusions supported by analysis of feasibility and sustainability factors.

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand geothermal resources and methods of heat extraction

The origin of geothermal energy and how heat is extracted from the Earth for heating and electricity generation.

A1 Origin and distribution of geothermal energy

- Geothermal energy as heat from the Earth's interior (deep high grade >500m below surface, >50°C) and heat from above earth's surface (shallow low grade 0-500m below surface, 10-25°C).
- Sources of geothermal heat:
  - radioactive decay
  - residual heat from Earth formation
  - sun and air temperature (climate).
- Temperature gradient with depth.
- Geological conditions required for deep high grade geothermal resources:
  - heat
  - permeability
  - fluid presence.
- Global distribution of deep high grade geothermal resources:
  - tectonic plate boundaries
  - volcanic regions
  - other, for example, crust thickness.
- Comparison of deep high grade geothermal potential in different regions.
- Typical shallow low grade geothermal potential dependent on surface layer types and climate.

A2 Types of geothermal resources

- Low-temperature shallow low grade geothermal:
  - shallow ground heat
  - widespread availability.
- High-temperature deep high grade geothermal:
  - deep reservoirs, superhot rock energy (SHR)
  - volcanic and tectonic regions.

- Hydrothermal systems:
  - hot water
  - steam reservoirs.
- Enhanced geothermal systems (EGS) (overview):
  - artificially created permeability.
- Differences between shallow and deep geothermal energy systems.

A3 Heat extraction methods

- Ground heat exchangers:
  - horizontal loops (water-based and air-based earth tubes)
  - vertical boreholes.
- Extraction of hot water and steam from deep reservoirs.
- Millimeter-wave drilling.
- Supercritical carbon dioxide wells.
- Use of production and reinjection wells.
- Importance of reinjection for resource sustainability.
- Energy losses and efficiency considerations.

Learning aim B: Understand geothermal system design and applications

How geothermal energy systems are designed and applied in different contexts.

B1 Geothermal heating systems

- Ground source heat pump (GSHP) systems:
  - closed-loop systems
  - open-loop systems.
- Heating with natural hydrothermal systems.
- Integration with buildings:
  - space heating
  - hot water
  - ventilation pre-heat/ventilation cooling (earth tubes/labyrinthes).
- Importance of low-temperature heat distribution systems.
- Geothermal district heating.
- Advantages of geothermal heating:
  - reliability
  - low operational emissions.

B2 Geothermal electricity generation

- Principles of geothermal power generation.
- Types of geothermal power plants (overview):
  - dry steam
  - flash steam
  - binary cycle.
- Suitability of different plant types to resource temperature.
- Continuous (baseload) nature of geothermal electricity.
- Comparison with other renewable electricity sources.

B3 System design considerations

- Site investigation and resource assessment:
  - geology
  - ground conditions, soil layers
  - access to existing infrastructure, including electricity grid and water sources.
- System sizing considerations:
  - heat demand/cooling effect
  - available ground area
  - drilling depth.
- Integration with other energy systems:
  - heat pumps
  - district heating
  - operational lifespan and maintenance requirements, including corrosion problems with high-temperature steam.

Learning aim C: Be able to determine environmental impacts and limitations of geothermal energy systems

Environmental benefits, risks and constraints associated with geothermal energy systems.

C1 Environmental benefits of geothermal energy

- Low operational greenhouse gas emissions.
- Reduced air pollution compared with fossil fuels.
- Reliable, weather-independent energy supply.
- Contribution to net zero and decarbonisation strategies.

C2 Environmental impacts and risks

- Land use and visual impacts.
- Water use and contamination risks.
- Release of gases and minerals (trace emissions).
- Induced seismicity associated with deep geothermal and EGS.
- Noise and disruption during drilling and installation.

C3 Limitations and feasibility

- Site-specific nature of geothermal resources.
- High upfront costs:
  - drilling
  - exploration risk.
- Technical complexity of deep geothermal systems, including corrosion challenges, drilling challenges and emerging solutions including Millimeter-wave drilling.
- Comparison of geothermal limitations with:
  - wind
  - solar
  - biomass.
- Role of regulation, monitoring and mitigation measures.

Assessment criteria

Learning aim A: Understand geothermal resources and methods of heat extraction

Learning aim B: Understand geothermal system design and applications

Pass	Merit	Distinction
A.P1 Describe the origin and types of geothermal resources. **A.P2** Explain methods used to extract heat from geothermal resources.	**A.M1** Explain how geological conditions affect geothermal resource availability and heat extraction.	**AB.D1** Analyse how geothermal resource characteristics influence system design and application choices.
B.P3 Explain geothermal heating and electricity generation systems. **B.P4** Describe design considerations for geothermal energy systems.	**B.M2** Explain how geothermal system design is influenced by resource characteristics and end use.	

Learning aim C: Be able to determine environmental impacts and limitations of geothermal energy systems

Pass	Merit	Distinction
C.P5 Describe environmental benefits of geothermal energy systems. [SP – CT] **C.P6** Describe environmental impacts and limitations of geothermal energy.	**C.M3** Explain how environmental risks and limitations influence the feasibility of geothermal energy projects.	**C.D2** Evaluate the suitability of geothermal energy as a low-carbon solution, considering environmental impacts, limitations and sustainability.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT √
MY – PS&R	EL – CL	IS – V&NC	SP – PS
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- Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, AB.D1).
- Learning aim: C (C.P5, C.P6, C.M3, C.D2).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Basic classroom visual aids: printed large-format geological cross-sections, geothermal system schematics and process flow posters for reference during teaching.
- Calculation equipment: scientific calculators and shared classroom whiteboards for demonstrating numerical comparisons, efficiencies and feasibility considerations.
- Case studies of existing geothermal sites, e.g. ground source heating system for buildings and/or groups of buildings and high grade geothermal system for industrial process.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, students provide analytical, well-structured evidence that demonstrates informed decision-making regarding system design and application, including heating and electricity generation systems. They evaluate how geothermal resource characteristics shape engineering choices, economic viability and operational performance across contrasting scenarios. Evidence shows consideration of trade-offs, such as efficiency versus drilling depth or system complexity versus long-term reliability. Students justify choices using comparative reasoning rather than isolated explanations, often synthesising geological, technical and application-based factors into a single argument. Conclusions are clearly supported by evidence drawn from across the content, demonstrating breadth and depth of understanding. Responses show confident command of subject-specific language and a professional, technically reasoned approach consistent with real-world geothermal system planning.

For Merit standard, students present coherent explanatory evidence that links geothermal resource characteristics to system design and application choices. They show an understanding of how factors such as temperature gradient, permeability, fluid availability and depth influence feasibility, efficiency and system configuration. Students explain why different extraction methods or plant types are appropriate for particular resources and end uses, rather than simply describing them. Evidence often integrates multiple content areas, such as linking system sizing and heat demand to available ground conditions or resource temperature. Written explanations are supported by reasoned comparisons, structured paragraphs or annotated diagrams that demonstrate cause-and-effect relationships. Students move beyond single examples and show consistency in applying principles across different geothermal contexts.

For Pass standard, students show correct use of terminology when describing geothermal heat sources, differences between low- and high-temperature resources, and the basic principles of ground source heating and electricity generation systems. Students apply knowledge to familiar contexts, such as domestic heating or power plant operation, showing awareness of how systems function rather than why specific design decisions are made. Diagrams, annotated schematics or short written explanations are commonly used to illustrate extraction methods, heat exchangers or plant types. Responses remain largely descriptive, with limited integration between geological conditions and system design, but demonstrate secure understanding of core concepts drawn directly from the taught content.

Learning aim C

For Distinction standard, students present evaluative evidence that balances environmental impacts, limitations and long-term sustainability when judging the suitability of geothermal energy. They consider competing factors, such as carbon reduction benefits versus local environmental risks, and justify conclusions using well-reasoned arguments. Evidence shows critical comparison with alternative renewable options and awareness of how monitoring, regulation and technological development influence sustainability outcomes. Students synthesise information rather than treating issues separately, demonstrating mature judgement aligned with real-world environmental decision-making. Conclusions are clearly justified, with reasoning that reflects both global decarbonisation goals and site-specific constraints, showing depth of understanding and independent evaluative thinking.

For Merit standard, students explain how environmental risks and limitations influence the practical feasibility of geothermal projects. Evidence shows clear links between environmental considerations and project decisions, such as how induced seismicity, water management or land use constraints affect suitability at specific sites. Students demonstrate understanding of mitigation and regulation as influencing factors rather than listing impacts in isolation. Comparisons with other renewable technologies are used to support explanations, showing how geothermal energy's strengths and limitations differ by context. Responses show logical structure and develop points with supporting detail, indicating that students can interpret environmental information and apply it meaningfully to project feasibility.

For Pass standard, students clearly outline environmental benefits, impacts and limitations associated with geothermal energy systems. Evidence shows correct identification of advantages such as low operational emissions and reliable energy supply, alongside impacts including land use, noise or water considerations. Students describe limitations that affect feasibility, such as site dependency or high upfront costs, using straightforward examples. Responses typically remain descriptive, with impacts and benefits addressed separately rather than weighed against each other. Evidence may take the form of short written sections, tables or summaries that reflect taught content accurately and use appropriate terminology. Students show awareness of environmental considerations but make limited connections to decision-making or wider sustainability contexts.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 17: Smart Energy Systems and Building Efficiency.
- Unit 18: Low-Carbon Heating Technologies.
- Unit 21: Energy Auditing and Consultancy Practices.

Unit 20: Water Conservation and Management in Energy Systems

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students investigate water use, efficiency and conservation in energy systems. They analyse impacts, optimise processes and evaluate sustainability and lifecycle considerations.

Unit introduction

This unit is highly relevant to modern energy systems, where water is a critical but increasingly constrained resource. Understanding how water is used, managed and conserved enables students to contribute to more efficient and sustainable energy production. This benefits students by developing practical, industry-relevant knowledge aligned to global priorities such as resource efficiency, environmental protection and net zero targets.

Students will explore how water is used across a range of energy technologies, examining demand, efficiency and the water–energy nexus. Students will measure and analyse water use using appropriate metrics, identify inefficiencies and investigate optimisation strategies. They will also study conservation approaches, treatment technologies and monitoring systems, alongside evaluating lifecycle impacts, environmental considerations and regulatory requirements.

This unit supports progression into further study in engineering, environmental science or energy management, as well as employment in energy, utilities and sustainability roles. It develops transferable skills in analysis, system optimisation and decision-making, which are highly valued across technical and scientific industries.

Learning aims

In this unit you will:

A Understand water use within energy systems

B Be able to assess and optimise water use in energy systems

C Understand water conservation strategies and technologies

D Know sustainability and lifecycle impacts of water use in energy systems.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand water use within energy systems	**A1** Water as a resource in energy systems **A2** Other key uses of water **A3** Water demand across energy technologies **A4** Water-energy nexus	Practical investigation analysing water use in an energy system, applying metrics, identifying inefficiencies and proposing justified optimisation strategies.
B Be able to assess and optimise water use in energy systems	**B1** Measurement and metrics **B2** Identifying inefficiencies **B3** Optimisation strategies **B4** System optimisation approaches	
C Understand water conservation strategies and technologies	**C1** Conservation principles **C2** Recycling and reuse systems **C3** Treatment and purification technologies **C4** Monitoring, control and integration	Case study evaluation of water conservation technologies, analysing lifecycle impacts, regulatory considerations and sustainability performance within an energy system context.
D Know sustainability and lifecycle impacts of water use in energy systems	**D1** Lifecycle water use **D2** Environmental impacts **D3** Regulatory and compliance considerations **D4** Sustainability and net zero context	

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand water use within energy systems

A1 Water as a resource in energy systems

- Unique physical and chemical properties of water:
  - heat transfer characteristics: specific and latent heat capacities
  - electrochemical characteristics: solvent properties and electrolysis.
- Roles of water: energy transfer, cooling, steam generation, kinetic and gravitational energy, cleaning, processing, fuel extraction.
- Water as a constrained operational resource.
- Link to system efficiency and reliability.

A2 Other key uses of water

- Freshwater drinking water using potable water, desalination.
- Wastewater.
- Agricultural uses including irrigation.

A3 Water demand across energy technologies

- Thermal generation and cooling demand in energy production
- Water consumption by power generation technologies:
  - conventional fossil fuel-based power generation
  - nuclear power generation
  - solar power generation
  - hydroelectric power generation and storage
  - geothermal power generation.
- Water cooling in applications including heavy industry and microprocessor-based data centres.
- Hydrogen production: electrolysis feedwater and purity requirements.
- Bioenergy and industrial systems water use.
- Desalination instalations and their links to power generation.
- Comparative context across technologies.

A4 Water–energy nexus

- Interdependence between water and energy systems.
- Resource competition and regional pressures.
- Links to resilience (drought, climate variability).

Learning aim B: Be able to assess and optimise water use in energy systems

B1 Measurement and metrics

- Water withdrawal versus consumption versus discharge.
- Efficiency indicators (e.g. water intensity per energy output).
- Use of flow rates and system balances.

B2 Identifying inefficiencies

- Losses: leaks, evaporation, blowdown.
- Inefficient cooling or process control.
- Poor maintenance impacts.
- Mismatch between supply and demand.

B3 Optimisation strategies

- Process optimisation and operational control.
- Cooling system selection and improvement.
- Maintenance and leak detection planning.

B4 System optimisation approaches

- Water mapping of energy systems.
- Prioritising high-use processes.
- Balancing efficiency, cost and performance.
- Use of artificial intelligence in optimisation of system design, matching of supply with demand, maintenance and leak detection planning.

Learning aim C: Understand water conservation strategies and technologies

C1 Conservation principles

- Hierarchy: avoid → reduce → reuse → recycle.
- Demand reduction in operational settings.

C2 Recycling and reuse systems

- Closed-loop systems.
- Condensate recovery.
- Greywater applications.

C3 Treatment and purification technologies

- Filtration, softening, demineralisation (conceptual).
- Disinfection and contaminant control.
- Managing discharge quality.

C4 Monitoring, control and integration

- Smart monitoring approaches (sensors, logging).
- Control systems for efficient use.
- Integration of conservation technologies into energy systems.

Learning aim D: Know sustainability and lifecycle impacts of water use in energy systems

D1 Lifecycle water use

- Stages: abstraction → use → discharge/reuse.
- Embedded and operational water impacts.

D2 Environmental impacts

- Thermal pollution and ecosystem effects.
- Chemical contamination risks.
- Water stress and local impacts.

D3 Regulatory and compliance considerations

- Abstraction licensing and discharge consents.
- Monitoring requirements and thresholds.
- Role of compliance in system design.

D4 Sustainability and net zero context

- Water management in sustainable energy systems.
- Trade-offs: energy versus water use.
- Resource resilience and long-term planning.

Assessment criteria

Learning aim A: Understand water use within energy systems

Learning aim B: Be able to assess and optimise water use in energy systems

Pass	Merit	Distinction
A.P1 Explain how water is used in energy systems, including key processes and resource roles. **A.P2** Describe water demand across different energy technologies and the concept of the water–energy nexus.	**A.M1** Explain how energy system type and operating conditions influence water demand and resource use.	**AB.D1** Analyse an energy system by mapping water use and identifying justified optimisation strategies based on system performance and constraints.
B.P3 Measure and describe water use using appropriate metrics, including withdrawal, consumption and efficiency indicators. [MY – TPR] **B.P4** Identify common inefficiencies and outline strategies to reduce water use in energy systems.	**B.M2** Explain how optimisation strategies improve water efficiency while affecting cost, performance and reliability.	

Learning aim C: Understand water conservation strategies and technologies

Learning aim D: Know sustainability and lifecycle impacts of water use in energy systems

Pass	Merit	Distinction
C.P5 Explain water conservation strategies and technologies used in energy systems. **C.P6** Describe monitoring and control methods used to manage water use.	**C.M3** Explain how conservation and treatment technologies are applied to improve water efficiency and system performance.	**CD.D2** Evaluate water management approaches in an energy system, justifying technology selection and assessing lifecycle, environmental and operational impacts.
D.P7 Describe lifecycle stages of water use and associated environmental impacts in energy systems. **D.P8** Outline basic regulatory and sustainability considerations for water management.	**D.M4** Explain how lifecycle impacts, regulatory requirements and sustainability considerations influence water management decisions.	

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR √	EL – MOL	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on setting assignments. There is also further information on our website.

There is a maximum number of two summative assignments for this unit.

The relationship of the learning aims and criteria is:

- Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, AB.D1).
- Learning aims: C and D (C.P5, C.P6, D.P7, D.P8, C.M3, D.M4, CD.D2).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Flow measurement and monitoring equipment (flow meters, pressure gauges, data logging sensors) to quantify water use and support system analysis.
- Bench-scale water treatment kits (filtration, demineralisation and basic purification apparatus) to demonstrate conservation and treatment processes.
- Energy system models or simulation software to map water flows, identify inefficiencies and test optimisation strategies.
- Laboratory glassware and testing tools (turbidity tubes, pH meters, conductivity meters) to assess water quality and lifecycle impacts.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, students produce detailed and systematic analyses of water use within a selected energy system, integrating mapping techniques to show flows, losses and key demand points. They apply quantitative and qualitative evidence to justify optimisation strategies, demonstrating clear reasoning based on system constraints, operational priorities and performance requirements. Students synthesise information from multiple sources to evaluate the effectiveness of different approaches, considering efficiency, reliability and sustainability in combination. Their work shows a high level of precision in the use of metrics and a strong ability to interpret system behaviour under varying conditions. Conclusions are well supported, demonstrating critical understanding of how water management decisions impact overall system performance and long-term resource efficiency.

For Merit standard, students develop coherent explanations that link system type, scale and operating conditions to variations in water demand and performance. They interpret water-use data to explain patterns, trends and inefficiencies, accurately selecting and applying appropriate metrics. Students explain how specific optimisation strategies, such as improved cooling technologies or enhanced maintenance regimes, influence system performance, demonstrating understanding of trade-offs between water efficiency, cost and operational reliability. Their analysis shows an ability to connect different aspects of system performance, including resource constraints and environmental considerations. Evidence is supported by relevant technical reasoning and may include comparative analysis across energy technologies, demonstrating an integrated understanding of how water use can be effectively assessed and improved.

For Pass standard, students present clear and structured accounts of how water is used across different energy systems, showing awareness of key processes such as cooling, steam generation and hydrogen production. They use appropriate terminology to outline variations in water demand between technologies and recognise the interdependence between water and energy resources. Students apply basic measurement approaches, using relevant metrics such as withdrawal and consumption, and demonstrate these through simple calculations or data interpretation. They identify common sources of inefficiency, including leaks and evaporative losses, and outline realistic approaches to reducing water use within defined system contexts. Their work shows logical organisation and sufficient technical detail to demonstrate understanding, supported by relevant examples or data drawn from studied systems.

Learning aims B and C

For Distinction standard, students evaluate water management approaches within energy systems by critically assessing the suitability of different conservation and treatment technologies. They justify selections based on lifecycle impacts, operational requirements and environmental performance, showing a clear understanding of trade-offs between efficiency, cost and sustainability. Students integrate knowledge of regulatory frameworks, environmental constraints and system design considerations to form well-reasoned conclusions. Their evaluation demonstrates depth, drawing together monitoring data, lifecycle analysis and broader sustainability priorities such as net zero objectives. Evidence shows a high level of synthesis, with students articulating how water management strategies contribute to resilient, efficient and environmentally responsible energy systems, supported by precise and well-structured technical reasoning.

For Merit standard, students explain how conservation strategies and treatment technologies are applied in practice to improve water efficiency and system performance. They show a clear understanding of how reuse systems, purification processes and monitoring approaches interact within integrated energy systems. Students explain lifecycle impacts in greater depth, linking environmental effects and compliance requirements to decision-making in system design and operation. They consider how regulatory frameworks and sustainability goals influence the selection and implementation of technologies. Their work demonstrates the ability to connect operational practice with wider environmental and legal contexts, supported by relevant technical explanation and examples. Evidence reflects a developed understanding of how water management contributes to system efficiency and long-term sustainability outcomes.

For Pass standard, students describe a range of water conservation strategies and technologies used in energy systems, including reuse, recycling and treatment processes. They show understanding of how monitoring and control methods support effective water management, referencing tools such as sensors or basic control systems. Students outline lifecycle stages of water use, from abstraction through to discharge or reuse, and identify associated environmental impacts such as thermal effects or contamination risks. They demonstrate awareness of regulatory considerations and sustainability principles, including the need to manage water resources responsibly. Their responses are appropriately structured, using relevant terminology and examples to demonstrate understanding of how conservation approaches and lifecycle considerations apply within energy system contexts.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 17: Smart Energy Systems and Building Efficiency.
- Unit 18: Low-Carbon Heating Technologies.
- Unit 21: Energy Auditing and Consultancy Practices.

Unit 21: Energy Auditing and Consultancy Practices

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students develop a practical understanding of energy auditing, data collection and analysis for efficiency improvement. They build reporting skills by presenting clear audit findings and justified recommendations to real clients professionally.

Unit introduction

This unit is relevant to the real-world operation of buildings and energy systems, where controlling energy use, costs and carbon emissions is a growing priority. Students benefit from understanding how energy audits are carried out in practice, developing insight into how organisations identify inefficiencies and make informed decisions about improvement. The unit builds practical awareness of how technical evidence supports sustainability goals and commercial outcomes, reflecting authentic consultancy and facilities-management contexts.

The content covers the full audit cycle, from understanding the purpose, scope and standards of energy auditing through to hands-on data collection, organisation and analysis. Students will work with typical energy data sources, apply basic analytical techniques and interpret patterns such as base load and seasonal variation. The unit then develops students' professional reporting skills, enabling them to present findings clearly and justify energy-efficiency recommendations using technical, economic and practical considerations.

Completion of this unit supports progression to further study in energy, engineering or sustainability by strengthening analytical, reporting and professional judgement skills. It also prepares students for entry-level roles supporting energy management, auditing, facilities operations or consultancy work.

Learning aims

In this unit you will:

A Understand the use of energy auditing methods and tools

B Be able to collect and analyse energy data

C Be able to report energy audit findings and recommend energy efficiency improvements.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the use of energy auditing methods and tools	**A1** Purpose and scope of energy audits **A2** Energy auditing standards and approaches **A3** Energy auditing tools and equipment	Research-based investigation and data analysis, using realistic energy information.
B Be able to collect and analyse energy data	**B1** Energy data collection **B2** Data organisation and processing **B3** Data analysis techniques	
C Be able to report energy audit findings and recommend energy efficiency improvements	**C1** Energy audit reporting **C2** Developing energy efficiency recommendations **C3** Consultancy practice and client communication	Scenario-based reporting task requiring communication of findings, justified recommendations and prioritised actions for a client.

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand the use of energy auditing methods and tools

Why energy audits are carried out and how different methods and tools are used in professional energy consultancy.

A1 Purpose and scope of energy audits

- Definition of an energy audit.
- Purpose of energy auditing:
  - reducing energy consumption
  - reducing carbon emissions
  - reducing operating costs.
- Typical clients:
  - domestic consumers
  - commercial buildings
  - light industrial sites.
- Difference between:
  - walk-through audits
  - detailed audits.
- Limitations and assumptions in energy auditing.

A2 Energy auditing standards and approaches

- Common audit stages:
  - planning and preparation
  - site survey
  - data collection
  - analysis
  - reporting and recommendations.
- Use of checklists and templates.
- Importance of consistency and accuracy.
- Use of greenhouse gas reporting frameworks e.g.:
  - GHG Protocol (Scopes 1, 2, 3)
  - ISO 14064.
- Role of national and international regulations in emissions reporting.

- Ethical responsibilities of an energy consultant:
  - objectivity
  - transparency
  - confidentiality.

A3 Energy auditing tools and equipment

- Tools for data collection:
  - utility bills and meter readings
  - smart meter data
  - sub-metering.
- Survey and inspection tools:
  - thermometers and temperature probes
  - infrared thermography
  - light level meters.
- Digital tools:
  - spreadsheets
  - simple energy analysis software.
- Advantages and limitations of different tools.

Learning aim B: Be able to collect and analyse energy data

Practical skills to gather energy data and analyse it to identify inefficiencies and opportunities for improvement.

B1 Energy data collection

- Types of energy data:
  - electricity consumption
  - gas and other fuel use.
- Sources of data:
  - energy bills
  - meter readings
  - monitoring systems.
- Time periods and resolution:
  - monthly
  - daily
  - half-hourly (overview).
- Ensuring data quality:
  - checking for missing or unusual values
  - identifying anomalies.

B2 Data organisation and processing

- Organising data using:
    - tables
    - spreadsheets.
- Converting energy data into carbon emissions using emission factors ($kgCO_2e$ per kilowatt-hour or fuel unit).
- Sources of emission factors, e.g. government datasets, international databases.
- Differences between location-based and market-based electricity emissions.
- Separating energy use by end use:
    - heating
    - lighting
    - equipment.
- Normalising energy data:
    - floor area
    - occupancy or operating hours.

B3 Data analysis techniques

- Identifying:
    - base load
    - peak demand
    - seasonal trends.
- Use of graphs:
    - line graphs
    - bar charts.
- Comparing:
    - current performance
    - previous periods
    - typical benchmarks.
- Linking energy use to:
    - user behaviour
    - building characteristics
    - system operation.
- Calculating total greenhouse gas emissions for a building or organisation.
- Interpreting emissions alongside energy consumption to assess environmental impact.
- Benchmarking emissions against typical values or regulatory targets.

Learning aim C: Be able to report energy audit findings and recommend energy efficiency improvements

How to communicate audit findings clearly and make justified recommendations suitable for clients.

C1 Energy audit reporting

- Purpose of an energy audit report.
- Typical report structure:
  - executive summary
  - site description
  - data analysis findings
  - recommendations.
- Importance of clear, non-technical language for clients.
- Use of charts, tables and visuals.
- Stating assumptions, limitations and uncertainties.

C2 Developing energy efficiency recommendations

- Types of recommendations:
  - no-cost/low-cost measures
  - behavioural changes
  - operational improvements
  - technology upgrades.
- Assessing recommendations using:
  - estimated energy savings
  - cost considerations
  - disruption and practicality.
- Prioritising recommendations:
  - quick wins
  - longer-term investments.

C3 Consultancy practice and client communication

- Role of the energy consultant:
  - adviser
  - communicator.
- Presenting findings to clients:
  - written reports
  - presentations.

- Responding to client questions and concerns.
- Supporting implementation:
  - signposting to technologies
  - follow-up audits.
- Professional conduct and ethical behaviour.

Assessment criteria

Learning aim A: Understand the use of energy auditing methods and tools

Learning aim B: Be able to collect and analyse energy data

Pass	Merit	Distinction
A.P1 Describe the purpose and stages of an energy audit. **A.P2** Examine the use of methods and tools to audit energy.	**A.M1** Explain how different auditing methods and tools are selected for different sites or clients.	**AB.D1** Analyse how the choice of auditing methods and data analysis techniques affects the accuracy and usefulness of an energy audit.
B.P3 Collect and organise energy data from provided or simulated sources. **B.P4** Analyse energy data to identify patterns, inefficiencies, emissions and areas of high energy use.	**B.M2** Explain how data analysis supports decision-making in energy auditing.	

Learning aim C: Be able to report energy audit findings and recommend energy efficiency improvements

Pass	Merit	Distinction
C.P5 Report energy audit findings clearly. [SP – CT] **C.P6** Recommend appropriate energy efficiency measures based on audit findings.	**C.M3** Explain how recommendations are prioritised based on energy savings, cost and practicality.	**C.D2** Evaluate the effectiveness of energy audit recommendations in meeting client needs, considering technical, economic and behavioural factors.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL	IS – WC	SP – CT √
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
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There is a maximum number of two summative assignments for this unit.

The relationship of the learning aims and criteria is:

- Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, AB.D1).
- Learning aim: C (C.P5, C.P6, C.M3, C.D2).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Energy audit data sources and tools: sample utility bills, meter readings (real or simulated), access to smart-meter or interval data, and basic survey instruments (temperature probes, light meters) for audit context.
- Digital data handling tools: spreadsheet software with graphing functions for organising, converting, normalising and analysing energy data.
- Reporting and presentation tools: word-processing and/or presentation software for producing structured audit reports, charts and client-focused outputs.
- Reference and guidance materials: energy audit standards, benchmarks and exemplar audit reports to support method selection, analysis accuracy and professional practice.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, students present a well-reasoned and evaluative approach that integrates auditing methods with advanced data interpretation. Evidence shows that students consider in depth how methodological choices, data resolution and analytical techniques influence the reliability and usefulness of audit findings. They evaluate the limitations, assumptions and uncertainties associated with tools, data sources and normalisation approaches, explaining how these factors affect the conclusions drawn. Analysis demonstrates independence, drawing together multiple data sets, benchmarks and contextual factors to form coherent judgements about performance and inefficiency. Students clearly articulate the consequences of alternative methodological decisions, showing how improved choices could strengthen audit accuracy. The overall evidence reflects professional-level judgement, analytical depth and a strong understanding of the interaction between audit design and data-driven insight.

For Merit standard, students show a more assured and reasoned approach to energy auditing and data analysis. Evidence indicates that students can justify the selection of auditing methods and tools for different types of sites or clients, showing awareness of practical constraints and data quality considerations. They organise and normalise energy data effectively, separating energy use by end use and relating consumption patterns to building characteristics, occupancy or operation. Analysis moves beyond description to explanation, with students linking trends, peaks and anomalies to likely causes such as behaviour, controls or system performance. Graphs and comparisons are used purposefully to support decision-making rather than simply illustrate data. Overall, student work demonstrates consistency, accuracy and a clear understanding of how analysed data informs meaningful audit outcomes.

For Pass standard, students demonstrate a secure but straightforward understanding of how energy audits are carried out and how energy data is handled. Evidence typically shows that students can outline the purpose and scope of an energy audit and follow recognised audit stages from planning through to reporting. They use appropriate tools and data sources, such as utility bills or meter readings, and organise data into clear tables or spreadsheets. Analysis is mainly descriptive, identifying obvious patterns such as high-use periods, base loads or seasonal variation. Students convert data into comparable units and produce simple graphs to illustrate trends. Explanations focus on what the data shows rather than why it behaves in a particular way, and interpretation remains closely guided by provided scenarios or templates. The work demonstrates accuracy in basic methods and calculations, but limited depth of justification or critical judgement.

Learning aim C

For Distinction standard, students evaluate how well proposed recommendations address client needs within technical, economic and behavioural constraints. Evidence shows that students weigh trade-offs between different improvement options, justifying choices using audit data, implementation context and client priorities. They reflect on how behavioural change, operational practices and technology upgrades interact to influence overall effectiveness. Reports demonstrate a high level of professional communication, clearly articulating limitations, risks and uncertainties while remaining accessible and persuasive. Students consider how recommendations could be implemented and monitored over time, showing awareness of consultancy practice beyond the report itself. The evidence demonstrates evaluative insight, strategic thinking and strong professional judgement.

For Merit standard, students demonstrate a more analytical and client-focused approach to reporting and recommendation development. Evidence shows that students explain the reasoning behind prioritised recommendations, considering factors such as potential savings, cost, disruption and feasibility. Reports are well-organised, clearly written and supported by relevant visuals that enhance understanding rather than duplicate text. Students adapt language and emphasis to suit the intended audience and respond logically to likely client concerns. Recommendations show a balance between short-term improvements and longer-term investments, with clear links back to audit findings. Overall, work reflects thoughtful judgement and an emerging consultancy mindset.

For Pass standard, students produce clear and logically structured reports that communicate the outcomes of an energy audit to a non-technical audience. Evidence typically includes a basic report structure with summaries of findings supported by tables, charts or simple visuals. Students identify suitable improvement measures that link directly to the issues revealed by their data analysis, such as high-consumption areas or inefficient practices. Recommendations are appropriate and realistic, though justification may be brief and largely descriptive. Students acknowledge assumptions or limitations simply and present information in a clear, professional tone. Communication demonstrates an understanding of client needs, but remains largely instructional rather than advisory.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 17: Smart Energy Systems and Building Efficiency.
- Unit 18: Low-Carbon Heating Technologies.

Unit 22: Low and Zero Carbon Transport Systems

Level: 3

Unit type: Internal

Guided learning hours: 60

Unit in brief

Students investigate transport usage and emissions while exploring low- and zero-carbon technologies shaping mobility.

Unit introduction

This unit is relevant to the real world, as transport is a major contributor to global carbon emissions and climate change. Understanding how transport systems operate and how they are transitioning to low- and zero-carbon alternatives equips students with knowledge directly linked to everyday travel, infrastructure decisions and sustainability challenges faced by societies worldwide.

In this unit, students explore how transport is currently used at local, national and international levels, and compare emissions from cars, commercial vehicles, shipping and aviation. Students examine low- and zero-carbon transport technologies, including electric and hydrogen-powered systems, and learn how they work. They also compare performance, cost and infrastructure needs, developing a rounded understanding of technical, environmental and societal impacts.

The unit supports progression to further study in science, engineering, environmental studies and transport-related disciplines. It also prepares students for employment in growing sectors such as sustainable transport, energy systems, policy, planning and engineering by developing analytical skills and applied technical understanding valued by employers.

Learning aims

In this unit, you will:

A Understand current usage patterns of transport at local, national and international scales

B Know low- and zero-carbon transport technologies replacing conventional systems

C Be able to compare transport usage and carbon emissions from different transport modes

D Understand how battery- and hydrogen-powered transport systems work and the implications of transition.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand current usage patterns of transport at local, national and international scales	**A1** Local transport usage **A2** National transport usage **A3** International transport usage **A4** Influencing factors	Evidence understanding of transport usage patterns across scales.
B Know low- and zero-carbon transport technologies replacing conventional systems	**B1** Influencing factors **B2** Public transport systems **B3** Freight and logistics **B4** Maritime and aviation alternatives **B5** Supporting systems	Assessment technology case studies when demonstrating how low- and zero-carbon systems operate.
C Be able to compare transport usage and carbon emissions from different transport modes	**C1** Internal combustion engine (ICE) cars **C2** Commercial road vehicles **C3** Shipping **C4** Aircraft **C5** Comparative analysis	Assessment using comparative calculations, emission tables and analysis differences between transport modes.
D Understand how battery- and hydrogen-powered transport systems work and the implications of transition	**D1** Battery-powered systems **D2** Hydrogen-powered systems **D3** Performance comparisons **D4** Cost considerations **D5** Infrastructure implications **D6** Transition impacts	Assessment using technical explanations and evaluations of performance, costs and infrastructure implications of alternative systems.

Content

The essential content is set out under content areas. Students must cover all specified content before the assessment.

Learning aim A: Understand current usage patterns of transport at local, national and international scales

How people and goods are typically transported and factors shaping transport demand and mode choice.

A1 Local transport usage

- Private car use versus public transport uptake.
- Active travel (walking, cycling, micromobility).
- Typical journey purposes (e.g. commuting, education, services).
- Urban, suburban and rural contrasts.

A2 National transport usage

- Road transport dominance in passenger and freight transport.
- Rail usage for intercity travel and bulk freight.
- Coach and domestic aviation use.

A3 International transport usage

- Aviation for passenger movement (short-, medium- and long-haul).
- Maritime shipping for global freight.

A4 Influencing factors

- Cost, convenience, speed and reliability.
- Infrastructure availability and capacity.
- Socio-economic and cultural factors.
- Government policy, taxation and regulation.
- Effectiveness of clean air zones.

Learning aim B: Know low- and zero-carbon transport technologies replacing conventional systems

Alternative transport technologies already in use or emerging across different sectors.

B1 Influencing factors

- Battery electric vehicles (BEVs).
- Plug-in and full hybrid systems.
- Hydrogen fuel cell vehicles (FCEVs).

B2 Public transport systems

- Electric buses and trolleybuses.
- Hydrogen bus fleets.
- Electrified rail systems and metros.
- Ways to increase public adoption of public transport.

B3 Freight and logistics

- Electric vans and rigid trucks.
- Hydrogen heavy goods vehicles (HGVs) developments.

B4 Maritime and aviation alternatives

- Hybrid and electric ferries.
- Shore-side power for ports.
- Sustainable aviation fuels (SAFs).

B5 Supporting systems

- Smart transport systems.
- Energy storage and charging technologies.

Learning aim C: Be able to compare transport usage and carbon emissions from different transport modes

Different environmental impacts of transport modes using quantitative and qualitative measures.

C1 Internal combustion engine (ICE) cars

- Typical CO_2 emissions per kilometre.
- Usage intensity and vehicle occupancy.

C2 Commercial road vehicles

- Vans and HGVs.
- Emissions relative to payload and distance.

C3 Shipping

- Emissions per tonne-kilometre.
- Fuel types and efficiency advantages.

C4 Aircraft

- Emissions per passenger-kilometre.
- Differences between short-haul and long-haul flights.

C5 Comparative analysis

- Passenger versus freight emissions.
- Efficiency versus total emissions contribution.
- Transport's share of national and global carbon emissions.

Learning aim D: Understand how battery- and hydrogen-powered transport systems work and the implications of transition

Alternative propulsion systems and evaluation of implications for infrastructure and society.

D1 Battery-powered systems

- Battery chemistry and energy storage.
- Electric motors and power control.
- Regenerative braking.

D2 Hydrogen-powered systems

- Hydrogen production methods (e.g. electrolysis).
- Fuel cells and electricity generation.
- Storage, transport and safety considerations.

D3 Performance comparisons

- Range and refuelling/charging time.
- Efficiency and reliability.
- Suitability for cars, buses, Heavy Goods Vehicles (HGVs) and trains.

D4 Cost considerations

- Purchase price versus running costs.
- Maintenance and lifecycle costs.

D5 Infrastructure implications

- Charging network requirements.
- Grid capacity and renewable integration.
- Hydrogen refuelling infrastructure.

D6 Transition impacts

- Environmental, economic and social effects.
- Workforce and skills implications.
- Timescales and transition challenges.

Assessment criteria

Learning aim A: Understand current usage patterns of transport at local, national and international scales

Pass	Merit	Distinction
A.P1 Examine current local transport usage patterns, considering common journey purposes, modes used and factors influencing availability. **A.P2** Explain national and international travel patterns for passengers and freight, including dominant modes and typical usage contexts.	**A.M1** Analyse factors influencing transport mode choice at different scales.	**A.D1** Evaluate how current transport usage patterns affect energy demand and carbon emissions across local, national and global contexts.

Learning aim B: Know low- and zero-carbon transport technologies replacing conventional systems

Pass	Merit	Distinction
B.P3 Describe low- and zero-carbon transport technologies used in road and public transport systems. **B.P4** Describe emerging low- and zero-carbon technologies applied to freight, maritime or aviation transport sectors.	**B.M2** Explain how low- and zero-carbon transport technologies reduce emissions compared with conventional internal combustion systems.	**B.D2** Discuss effectiveness of different low- and zero-carbon technologies in meeting future transport and sustainability demands.

Learning aim C: Be able to compare transport usage and carbon emissions from different transport modes

Pass	Merit	Distinction
C.P5 Describe carbon emissions associated with internal combustion cars and commercial road vehicles under typical usage conditions. [EL – MOL] **C.P6** Describe carbon emissions from shipping and aircraft, considering differences in distance, load and operational efficiency.	**C.M3** Analyse differences in carbon emissions across transport modes using usage data and efficiency comparisons.	**C.D3** Evaluate the relative environmental impacts of passenger and freight transport modes at national and international scales.

Learning aim D: Understand how battery- and hydrogen-powered transport systems work and the implications of transition

Pass	Merit	Distinction
D.P7 Explain how battery-powered transport systems operate, including energy storage, electric motors and regenerative processes. **D.P8** Explain how hydrogen-powered transport systems generate usable energy and safely store and supply hydrogen fuel.	**D.M4** Analyse performance and cost differences between battery, hydrogen and conventional transport systems.	**D.D4** Assess infrastructure, economic and societal implications of transitioning to battery- and hydrogen-powered transport systems.

Transferable skills

Managing Yourself	Effective Learning	Interpersonal Skills	Solving Problems
MY – TPR	EL – MOL √	IS – WC	SP – CT
MY – PS&R	EL – CL	IS – V&NC	SP – PS
MY – COP	EL – SRS	IS – T	SP – C&I
MY – PGS	EL – PRS	IS – C&SI	

Table key

*	Signposted to indicate opportunities for development as a part of wider teaching and learning
√	Embedded in teaching, learning and assessment
blank	Not embedded or signposted in unit

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. The *Pearson BTEC International Level 3 Qualifications Supplementary Information* document gives information on setting assignments. There is also further information on our website.

There is a maximum number of two summative assignments for this unit.

The relationship of the learning aims and criteria is:

- Learning aim: A (A.P1, A.P2, A.M1, A.D1).
- Learning aim: B (B.P3, B.P4, B.M2, B.D2).
- Learning aim: C (C.P5, C.P6, C.M3, C.D3).
- Learning aim: D (D.P7, D.P8, D.M4, D.D4).

Further information for teachers and assessors

Resource requirements

For this unit, students must have access to:

- Access to up-to-date transport usage and emissions datasets, including national statistics, global transport data and case-study summaries.
- Battery, electric motor and hydrogen fuel cell demonstration models or cutaways to support understanding of alternative propulsion systems.
- Transport infrastructure visuals, including maps, charging network plans, hydrogen refuelling layouts and system diagrams for applied learning.

Essential information for assessment decisions

Learning aim A

For Distinction standard, students demonstrate in-depth understanding by making well-reasoned judgements about the significance of current transport usage patterns. Their evidence evaluates how patterns of transport use influence wider outcomes, particularly energy demand and emissions, across different scales. Students draw together multiple factors and examples to support their conclusions, such as by comparing the impacts of private car dependency with those of mass transit systems. Evidence shows insight, supported by contextual references, and considers implications rather than just patterns. The work reflects a strong command of the subject and shows that the student can synthesise information to justify conclusions clearly and logically.

For Merit standard, students demonstrate a developed understanding of transport usage patterns by linking different factors to explain why patterns vary across scales. Their evidence shows how economic, social, geographic and infrastructural factors influence transport choices, using relevant examples to illustrate these relationships. Students present contextual information to support their points, such as differences between urban and rural travel or between passenger and freight demand. The work shows connections between usage patterns and wider systems, for example, how infrastructure investment or policy influences behaviour.

For Pass standard, students show an accurate understanding of how transport is used at different scales, mostly with factual evidence. Their work demonstrates awareness of common transport modes used locally, nationally and internationally, supported by simple examples such as commuting patterns, freight movement or leisure travel. Evidence typically includes brief references to why particular modes dominate in specific contexts, such as affordability, availability or journey purpose. Information is generally correct but may lack depth, as it is not linked or compared in detail. The evidence shows that students can recognise usage patterns and contextual differences, but it does not yet explore relationships or impacts in depth.

Learning aim B

For Distinction standard, students demonstrate depth of understanding by considering how effective different low- and zero-carbon technologies are in meeting future transport demands. Their evidence weighs strengths and limitations across technologies and contexts, such as suitability for passenger versus freight use. Students consider broader implications, such as scalability, integration with energy systems or operational challenges. Judgements are supported by relevant examples and reflect a balanced view of technological potential and constraints. The work shows insight and the ability to draw conclusions from evidence.

For Merit standard, students present well-explained evidence showing how low- and zero-carbon technologies operate and reduce environmental impacts. Their work explains key principles behind the technologies and links them to emission reduction or improved efficiency. Students use examples to show differences between conventional and alternative systems, demonstrating understanding of why these technologies represent a transition. Evidence is structured and clearly reasoned, with explanations supported by factual detail rather than listed points. The student shows the ability to connect technological features to outcomes, indicating understanding of applied transport technology concepts.

For Pass standard, students provide evidence showing understanding of a range of low- and zero-carbon transport technologies currently in use. Their work identifies different technologies across transport sectors, with brief explanations of their purpose and where they are applied. Examples may include electric road vehicles, alternative public transport systems or cleaner freight solutions. Evidence generally lacks depth and is focused on what the technologies are and where they are used, rather than how effective they are. Students demonstrate recognition of the role these technologies play in reducing reliance on traditional systems, supported by straightforward examples drawn from the unit content.

Learning aim C

For Distinction standard, students demonstrate a comprehensive understanding by making evaluative judgements about the overall environmental impact of different transport modes. Their evidence considers both usage intensity and emission characteristics to determine significance at national and international scales. Students integrate multiple perspectives, such as passenger versus freight demand, efficiency versus total emissions, and short-term versus long-term impacts. Conclusions are justified using coherent arguments and relevant evidence. The work reflects a sophisticated interpretation of transport emission data and shows the ability to synthesise information to support well-founded conclusions.

For Merit standard, students provide comparative evidence that explains why emission levels vary between transport modes. Their work uses relevant data, calculations or contextual information to support comparisons, such as efficiency per passenger or per tonne-kilometre. Students clearly explain contributing factors, including distance, load, technology and operational efficiency. Evidence is logically structured and demonstrates an understanding of relative impacts rather than isolated figures. The student shows confidence in interpreting information and drawing reasoned comparisons that reflect how transport usage influences emission outcomes.

For Pass standard, students show an understanding of emissions associated with different transport modes through clear, factual evidence. Their work identifies how emissions relate to specific transport types, such as cars, commercial vehicles, shipping or aircraft, using typical usage scenarios. Evidence includes basic data and/or illustrative comparisons, focusing on emissions characteristics rather than detail. Students demonstrate recognition of differences between passenger and freight transport, but comparisons remain straightforward. The work shows secure subject knowledge, with generally correct references to emission trends across transport modes.

Learning aim D

For Distinction standard, students demonstrate a comprehensive understanding by assessing the wider implications of transitioning to battery- and hydrogen-powered transport systems. Their evidence considers infrastructure requirements, energy systems, economic impacts and societal consequences. Students present balanced arguments, recognising both opportunities and challenges associated with large-scale adoption. Judgements are supported through relevant examples and clear reasoning. The work reflects a strong synthesis of technical, economic and social considerations, showing that the student can interpret evidence holistically to support informed conclusions about future transport transitions.

For Merit standard, students demonstrate a deeper understanding by comparing battery and hydrogen systems with conventional transport in terms of performance and cost. Their evidence considers factors such as efficiency, range, refuelling or charging time, and operational expenses. Students use examples to explain suitability for different transport applications, showing awareness of practical considerations. Explanations are well developed and supported by contextual detail. The work reflects a confident interpretation of technical and economic information and shows how system characteristics influence real-world use.

For Pass standard, students provide accurate technical evidence explaining how battery- and hydrogen-powered transport systems function. Their work outlines key components and processes, such as energy storage, conversion and vehicle operation. Students show an understanding of basic differences between the systems and conventional technologies through clear explanations. Evidence may include diagrams or short written accounts focused on operational principles rather than performance evaluation. Understanding is sound but limited to core processes and features, demonstrating foundational technical knowledge aligned with taught content.

Links to other units

The assessment for this unit will draw upon some of the underpinning knowledge, understanding and skills covered in:

- Unit 1: Human Energy Use.
- Unit 6: Mathematics for Energy Technicians.
- Unit 5: Scientific Principles for Energy Systems.
- Unit 17: Smart Energy Systems and Building Efficiency.
- Unit 18: Low-Carbon Heating Technologies.
- Unit 21: Energy Auditing and Consultancy Practices.

5 Planning your programme

Is there a student entry requirement?

As a centre it is your responsibility to ensure that students who are recruited have a reasonable expectation of success on the programme. There are no formal entry requirements but we expect students to have qualifications at or equivalent to Level 2.

Students are most likely to succeed if they have:

- five international GCSEs at good grades, and/or
- BTEC qualification(s) at Level 2
- other appropriate qualifications or achievement at year 11 or age 16 in core subjects. Students may demonstrate ability to succeed in various ways. For example, students may have relevant work experience or specific aptitude shown through diagnostic tests or non-educational experience.

If students are studying in English we recommend that they have attained at least Level B2 in the Common European Framework of Reference for Languages or Pearson Global Scale of English 51. Please see resources available from Pearson at www.pearson.com/english.

Supporting you in planning and implementing your programme

There will be lots of free teaching and learning support to help you deliver the new qualifications:

- Delivery guides are provided for each mandatory unit as well as a selection of optional units. These guides are intended to give an introducton to the unit, an overview of the assessment requirements, and a summary of the teaching content to be delivered and assessed.
- Sample delivery plans for all qualification sizes, designed to help you plan and deliver a teaching programme across a specified duration. These plans consist of the mandatory units required in each size as well as a selection of optional units recommended by us.
- Sample schemes of work are provided for each mandatory unit as well as a selection of optional units. These schemes of work are intended to show you how to deliver the teaching and assessment for each unit within the guided learning hours given. Each scheme of work provides an example of how each lesson can be structured, identifying key teaching topic areas, and how this content can be delivered using a range of teacher and student activities. These are available in Word™ format for ease of customisation.
- Our resources guide sets out the minimum resources required to support the planning, teaching and preparation for assessments for all units in this specification.

- For units assessed with a Pearson Set Assignment Brief, we have provided a sample assignment as an example of the form of assessment for the unit. For the remaining units, we will allow you to set your own assignments, according to your students' preferences and to link with your local employment profile. We also provide Authorised Assignment Briefs, which are approved by Pearson Standards Verifiers.

Using Pearson Progress to support the planning, delivery and management of internal assessments

Pearson Progress is a digital support system that helps you to manage the assessment and quality assurance of these qualifications. This application supports the delivery, assessment and quality assurance of International BTECs in centres and supports teachers, assessors and students as follows:

- course creation
- creating and verifying assignments
- creating assessment plans and recording assessment decisions
- upload of assignment evidence
- tracking progress of every student.

The system is accessible to teachers and students so that they both can track their progress.

Training and support from Pearson

There are many people available to support you and give you advice and guidance on the delivery of these qualifications. They include the following:

- Subject Advisors – they understand all Pearson qualifications in their sector and can answer sector-specific queries on planning, teaching, learning and assessment.
- Standards Verifiers – they can support you with preparing your assignments, ensuring that your assessment plan is set up correctly, and support you in preparing student work and providing quality assurance through sampling.
- Regional teams – they are regionally based and have a full overview of the BTEC qualifications and of the support and resources that Pearson provides. Regions often run network events.
- Customer Services – the 'Support for You' section of our website gives the different ways in which you can contact us for general queries. For specific queries, our service operators can direct you to the relevant person or department.

Pearson provides a range of training and professional development events to support the introduction, delivery, assessment and administration of BTEC International Level 3 qualifications. These sector-specific events, developed and delivered by specialists, are available both face to face and online.

We also offer ‘Getting Ready to Teach’ events which are designed to get teachers ready for delivery of the BTEC International Level 3 qualifications. They include an overview of qualification structures, planning and preparation for internal assessment, and quality assurance.

Beyond the ‘Getting Ready to Teach’ professional development events, there are opportunities for teachers to attend sector- and role-specific events. These events are designed to connect practice to theory; they provide teacher support and networking opportunities with delivery, learning and assessment methodology.

Details of our training and professional development programme can be found on our website.

6 Understanding the qualification grade

Awarding and reporting for the qualification

This section explains the rules that we apply in awarding a qualification and in providing an overall qualification grade for each student. It shows how all the qualifications in this sector are graded.

Eligibility for an award

In order to be awarded a qualification, a student must complete all units AND achieve a Pass or above in all mandatory units unless otherwise specified. Refer to the structure in *Section 3 Structure*. Students must:

- complete and **have an outcome** (D, M, P or U) for all units within a valid combination
- achieve all the **mandatory units at Pass or above** shown in *Section 3 Structure*
- achieve the **minimum number of points** at a grade threshold.

It is the responsibility of a centre to ensure that a correct unit combination is adhered to. Students who do not achieve the required minimum grade (P) in units shown in the structure will not achieve a qualification.

Students who do not achieve sufficient points for a qualification or who do not achieve all the required units may be eligible to achieve a smaller qualification in the same suite, provided they have completed and achieved the correct combination of units and met the appropriate qualification grade points threshold.

Awarding the qualification grade

The final grade awarded for a qualification represents an aggregation of a student's performance across the qualification. As the qualification grade is an aggregate of the total performance, there is some element of compensation in that a higher performance in some units may be balanced by a lower outcome in others.

BTEC International Level 3 qualifications are awarded at the grade ranges shown in the table below.

Qualification	Available grade range
Certificate, Extended Certificate, Foundation Diploma	P to D*
Diploma	PP to D*D*
Extended Diploma	PPP to D*D*D*

The *Calculation of the qualification grade* table, shown later in this section, shows the minimum thresholds for calculating these grades. The table will be kept under review over the lifetime of the qualification. The most up-to-date table will be issued on our website.

Pearson will monitor the qualification standard and reserves the right to make appropriate adjustments.

Students who do not meet the minimum requirements for a qualification grade to be awarded will be recorded as Unclassified (U) and will not be certificated. They may receive a Notification of Performance for individual units. The *Information Manual* gives full information.

Points available for units

The table below shows the number of **points** available for units. For each unit, points are allocated depending on the grade awarded.

Grade	Unit size (60 GLH)
U	0
Pass	6
Merit	10
Distinction	16

Claiming the qualification grade

Subject to eligibility, Pearson will automatically calculate the qualification grade for your students when the unit grades are submitted and the qualification claim is made. Students will be awarded qualification grades for achieving the sufficient number of points (with valid combinations) within the ranges shown in the relevant *Calculation of the qualification grade grade* table for the cohort.

Calculation of the qualification grade

Applicable for registration from 1 September 2026.

Certificate		Extended Certificate		Foundation Diploma		Diploma		Extended Diploma	
180 GLH		360 GLH		540 GLH		720 GLH		1080 GLH	
Grade	Points threshold	Grade	Points threshold	Grade	Points threshold	Grade	Points threshold	Grade	Points threshold
Unclassified	0	U	0	U	0	U	0	U	0
Pass	18	P	36	P	54	PP	72	PPP	108
						MP	88	MPP	124
								MMP	140
Merit	26	M	52	M	78	MM	104	MMM	156
						DM	124	DMM	176
								DDM	196
Distinction	37	D	74	D	108	DD	144	DDD	216
						D*D	162	D*DD	234
								D*D*D	252
Distinction*	45	D*	90	D*	138	D*D*	180	D*D*D*	270

This table is subject to review over the lifetime of the qualification. The most up-to-date version will be issued via our website.

Example grading tables

In this section, you will find examples of how students can meet a range of qualification grade thresholds based on the unit points accumulated, to determine an overall qualification grade.

Pearson BTEC International Level 3 Certificate in Green Energy (180 GLH)

Achievement of a Certificate with a Merit grade

Unit number	GLH	Type (Int/PSA)	Grade	Unit points
1	60	PSA	Pass	6
2	60	Int	Merit	10
7	60	Int	Distinction	16
TOTAL	**180**		**Merit**	**32**

In this example, the student has sufficient points for a Merit grade. The student has met the minimum requirement for Pass or higher in the mandatory unit.

Pearson BTEC International Level 3 Extended Certificate in Green Energy (360 GLH)

Achievement of an Extended Certificate with a Pass grade

Unit number	GLH	Type (Int/PSA)	Grade	Unit points
1	60	PSA	Distinction	16
2	60	PSA	Merit	10
9	60	Int	Pass	6
3	60	Int	Pass	6
6	60	Int	Pass	6
12	60	Int	Pass	6
TOTAL	**360**		**Pass**	**50**

In this example, the student has sufficient points for a Pass grade. The student has met the minimum requirement for Pass or higher in the mandatory units.

Pearson BTEC International Level 3 Foundation Diploma in Green Energy (540 GLH)

Achievement of a Foundation Diploma with a Distinction grade

Unit number	GLH	Type (Int/PSA)	Grade	Unit points
1	60	PSA	Distinction	16
2	60	PSA	Merit	10
3	60	PSA	Distinction	16
9	60	Int	Distinction	16
10	60	Int	Pass	6
6	60	Int	Merit	10
13	60	Int	Merit	10
14	60	Int	Distinction	16
15	60	Int	Distinction	16
TOTAL	**540**		**Distinction**	**116**

In this example, the student has sufficient points for a Distinction grade. The student has met the minimum requirement for Pass or higher in the mandatory units.

Pearson BTEC International Level 3 Diploma in Green Energy (720 GLH)

Achievement of a Diploma with a PP grade

Unit number	GLH	Type (Int/PSA)	Grade	Unit points
1	60	PSA	Pass	6
2	60	PSA	Merit	10
3	60	PSA	Merit	10
4	60	PSA	Pass	6
5	60	PSA	Merit	10
9	60	Int	Pass	6
10	60	Int	Merit	10
12	60	Int	Unclassified	0
13	60	Int	Unclassified	0
14	60	Int	Merit	10
15	60	Int	Pass	6
16	60	Int	Merit	10
TOTAL	**720**		**PP**	**84**

In this example, the student has sufficient points for a PP grade despite receiving an Unclassified result for Units 12 and 13. The student has met the minimum requirement for Pass or higher in the mandatory units.

Pearson BTEC International Level 3 Diploma in Green Energy (720 GLH)

Achievement of a Diploma with an MM grade

Unit number	GLH	Type (Int/PSA)	Grade	Unit points
1	60	PSA	Merit	10
2	60	PSA	Merit	10
3	60	PSA	Distinction	16
4	60	PSA	Pass	6
5	60	PSA	Distinction	16
9	60	Int	Pass	6
10	60	Int	Merit	10
12	60	Int	Pass	6
13	60	Int	Pass	6
14	60	Int	Merit	10
15	60	Int	Distinction	16
18	60	Int	Merit	10
TOTAL	**720**		**MM**	**122**

In this example, the student has sufficient points for an MM grade. The student has met the minimum requirement for Pass or higher in the mandatory units.

Pearson BTEC International Level 3 Diploma in Green Energy (720 GLH)

An Unclassified result for a Diploma

Unit number	GLH	Type (Int/PSA)	Grade	Unit points
1	60	PSA	Unclassified	0
2	60	PSA	Merit	10
3	60	PSA	Distinction	16
4	60	PSA	Pass	6
5	60	PSA	Distinction	16
9	60	Int	Pass	6
10	60	Int	Merit	10
12	60	Int	Pass	6
13	60	Int	Pass	6
14	60	Int	Merit	10
15	60	Int	Distinction	16
16	60	Int	Merit	10
TOTAL	**720**		**Unclassified**	**112**

In this example, the student has sufficient points for an MM grade but has not met the minimum requirement for Pass or higher in all of the mandatory units. An Unclassified result for Unit 1.

Pearson BTEC International Level 3 Extended Diploma in Green Energy (1080 GLH)

Achievement of an Extended Diploma with an MMM grade

Unit number	GLH	Type (Int/PSA)	Grade	Unit points
1	60	PSA	Pass	6
2	60	PSA	Merit	10
3	60	PSA	Pass	6
4	60	PSA	Pass	6
5	60	PSA	Distinction	16
6	60	PSA	Pass	6
7	60	PSA	Pass	6
8	60	PSA	Merit	10
9	60	Int	Pass	6
10	60	Int	Distinction	16
11	60	Int	Merit	10
12	60	Int	Pass	6
13	60	Int	Unclassified	0
14	60	Int	Merit	10
15	60	Int	Pass	6
17	60	Int	Merit	10
19	60	Int	Distinction	16
22	60	Int	Merit	10
TOTAL	**1080**		**MMM**	**156**

In this example, the student has sufficient points for an MMM grade despite receiving Unclassified result for Unit 13. The student has met the minimum requirement for Pass or higher in the mandatory units.

Pearson BTEC International Level 3 Extended Diploma in Green Energy (1080 GLH)

Achievement of an Extended Diploma with a DDD grade

Unit number	GLH	Type (Int/PSA)	Grade	Unit points
1	60	PSA	Distinction	16
2	60	PSA	Merit	10
3	60	PSA	Merit	10
4	60	PSA	Pass	6
5	60	PSA	Distinction	16
6	60	PSA	Pass	6
7	60	PSA	Distinction	16
8	60	PSA	Distinction	16
9	60	Int	Merit	10
10	60	Int	Distinction	16
11	60	Int	Merit	10
12	60	Int	Distinction	16
13	60	Int	Merit	10
14	60	Int	Merit	10
15	60	Int	Distinction	16
17	60	Int	Merit	10
19	60	Int	Distinction	16
22	60	Int	Merit	10
TOTAL	**1080**		**DDD**	**220**

In this example, the student has sufficient points for a DDD grade. The student has met the minimum requirement for Pass or higher in the mandatory units.

Pearson BTEC International Level 3 Extended Diploma in Green Energy (1080 GLH)

An Unclassified result for an Extended Diploma

Unit number	GLH	Type (Int/PSA)	Grade	Unit points
1	60	PSA	Unclassified	0
2	60	PSA	Merit	10
3	60	PSA	Pass	6
4	60	PSA	Pass	6
5	60	PSA	Pass	6
6	60	PSA	Pass	6
7	60	PSA	Merit	10
8	60	PSA	Merit	10
9	60	Int	Merit	10
10	60	Int	Pass	6
11	60	Int	Merit	10
12	60	Int	Unclassified	0
13	60	Int	Pass	6
14	60	Int	Merit	10
15	60	Int	Unclassified	0
17	60	Int	Merit	10
19	60	Int	Pass	6
22	60	Int	Merit	10
TOTAL	**1080**		**Unclassified**	**122**

In this example, the student has sufficient points for a PPP grade but has not met the minimum requirement for Pass or higher in all of the mandatory units. An Unclassified result for Unit 1.

Appendix 1 Glossary of terms used for internally assessed units

Term	Definition
Adequate	Student work is satisfactory or acceptable in quality and quantity.
Analyse	Students break the issue/situation down into the key elements and show their understanding of the issues/situation applied to the scenario/context. Responses would be significantly beyond generic.
Apply/use/employ	Students implement a method, technique, process or approach in an activity.
Assess	Students give careful consideration to all the factors or events that apply, identify which are the most important or relevant, and make a judgement on the importance of the factors.
Carry out	Students demonstrate skills through practical activities, in line with certain requirements.
Clear/ly	The qualities required are well demonstrated, unambiguous and beyond a basic level.
Coherent	Student intentions are clear, logically structured and can be interpreted by others.
Compare	Students show knowledge and understanding by identifying the main factors relating to two or more items/situations or aspects of a subject that is extended with the required explanations, e.g. similarities/differences, advantages/disadvantages, impacts.
Comprehensive	Used to describe either scope or depth, for example: Student work is well developed and thorough, covering all aspects/information in terms of both depth and breadth. OR Students demonstrate in-depth and accurate understanding of the aspects being assessed.
Confident	Student work demonstrates well-developed and secure application of skills or processes that are significantly beyond a basic level.

Term	Definition
Consistent	Students demonstrate reliable and constant practice that maintains a set standard.
Create/produce	Students generate an idea/outcome to specific criteria.
Demonstrate	Students carry out and apply knowledge, understanding and/or skills in a practical situation.
Describe	Students provide an account of something, or highlight a number of key features of a given topic or process, that shows a level of understanding.
Detailed	Students cover most if not all of the expected requirements and demonstrate a high level of understanding.
Develop	Students apply a process of improving/progressing skills, concepts or work in order to produce outcomes.
Discuss	An issue, situation or process will be presented and the student will need to break the issue/situation/process down into the key elements, show their understanding of the issues/situation/process applied to the scenario/context (so generic answers are not acceptable), and show interrelationship in their answers.
Effective	Students demonstrate skills or provide outcomes that are well developed with a range of proficient qualities and that achieve objectives.
Evaluate	Students consider various aspects of a subject's qualities in relation to its context such as strengths or weaknesses, advantages or disadvantages, pros or cons. They will come to a judgement supported by evidence, which will often be in the form of a conclusion.
Examine	Students demonstrate an ability to thoroughly inspect something in order to determine its qualities beyond a basic exploration.
Explain	Students can give an insight into the topic showing some level of understanding by providing reasons or examples.
Explore	Students undertake practical research or investigation to develop their skills or understanding of the topic/activity.
Implement	Students take actions or measures to put something into effect.

Term	Definition
Investigate	Students perform a systematic inquiry into a topic using research skills, usually to demonstrate their understanding of a topic.
Justify	Students give relevant and logical reasons or evidence to support their actions or opinions.
Partial/some	To an extent, but not completely. Students do not include all of the requirements.
Perform	Students demonstrate a range of skills required to complete a given activity.
Prepare	Students organise a task/equipment/individuals/activities in advance of carrying it out.
Realistic/feasible	Students demonstrate insight into the logistics and manageability of proposals/plans/objectives/ideas and show consideration of the potential to achieve the outcomes.
Refine/optimise	Students make considered improvements to outcomes.
Review	Students consider evidence in order to make judgements about the qualities.
Understand	Students demonstrate insight or ability to interpret a subject.
Undertake	Students demonstrate skills through practical activities, often referring to given processes or techniques.

Appendix 2 Transferable Skills framework

Code = transferable skill initials-skill cluster initials

Managing yourself

Code	Skill cluster	Performance descriptor
MY-TPR	Taking personal responsibility	• Demonstrates understanding of their role and responsibilities and the expected standards of behaviour. • Demonstrates compliance with codes of conduct and ways of working. • Makes use of available resources to complete tasks. • Manages their time to meet deadlines and the required standards. • Demonstrates accountability for their decisions or actions.
MY-PS&R	Personal strengths and resilience	• Identifies own personal strengths and demonstrates the ability to use these in relevant areas. • Demonstrates the ability to adapt own mindset and actions to changing situations or factors. • Uses challenges as learning opportunities.

Code	Skill cluster	Performance descriptor
MY-COP	Career orientation planning	• Undertakes research to understand the types of roles in the sector in which they could work. • Reviews own career plans against personal strengths and identifies areas for development to support progression into selected careers. • Takes part in sector-related experiences to support career planning.
MY-PGS	Personal goal setting	• Sets SMART goals using relevant evidence and information. • Reviews progress against goals and identifies realistic areas for improvement. • Seeks feedback from others to improve own performance.

Effective learning

Code	Skill cluster	Performance descriptor
EL-MOL	Managing own learning	• Maintains a focus on own learning objectives when completing a task. • Demonstrates the ability to work independently to complete tasks. • Reviews and applies learning from successful and unsuccessful outcomes to be effective in subsequent tasks.
EL-CL	Continuous learning	• Engages with others to obtain feedback about own learning progress. • Responds positively to feedback on learning progress from others. • Monitors own learning and performance over the short- and medium-term.
EL-SRS	Secondary research skills	• Defines the research topic or question. • Uses valid and reliable sources to collate secondary data. • Interprets secondary data and draws valid conclusions. • Produces a reference list and cites sources appropriately.
EL-PRS	Primary research skills	• Defines the research topic or question. • Carries out primary data collection using appropriate and ethical research methodology. • Interprets primary data to draw valid conclusions.

Interpersonal skills

Code	Skill cluster	Performance descriptor
IS-WC	Written communication	• Produces clear formal written communication using appropriate language and tone to suit purpose.
IS-V&NC	Verbal and non-verbal communications	• Uses verbal communication skills effectively to suit audience and purpose. • Uses body language and non-verbal cues effectively. • Uses active listening skills and checks understanding when interacting with others.
IS-T	Teamwork	• Engages positively with team members to understand shared goals, and own roles and responsibilities. • Respectfully considers the views of team members and consistently shows courtesy and fairness. • Completes activities in line with agreed role and responsibilities. • Provides support to team members to achieve shared goals.
IS-C&SI	Cultural and social intelligence	• Demonstrates awareness of own cultural and social biases. • Demonstrates diversity, tolerance and inclusivity values in their approach to working with others.

Solving problems

Code	Skill cluster	Performance descriptor
SP-CT	Critical thinking	• Demonstrates understanding of the problem or issue to be addressed. • Makes use of relevant information to build ideas and arguments. • Assesses the importance, relevance and/or credibility of information. • Analyses, interprets and evaluates information to present reasoned conclusions.
SP-PS	Problem solving	• Presents a clear definition of the problem. • Gathers relevant information to formulate proposed solutions. • Selects relevant and significant information to formulate proposed solutions. • Identifies negative and positive implications of proposed solutions. • Presents and justifies selected solutions to problems.
SP-C&I	Creativity and innovation	• Identifies new and relevant ideas to help solve a problem. • Refines ideas into workable solutions based on test results and/or feedback.

Appendix 3 Digital Skills framework

Problem solving

Using digital tools to analyse and solve problems:

Performance descriptor	Unit mapping
Use digital tools and techniques for research, collaboration and resolution of problems.	Unit 7
Have up-to-date knowledge of ways that technology is used within a sector.	Unit 7
Present ideas and findings using digital tools.	Unit 7
Use digital tools to manipulate data.	Unit 7

Digital collaboration and communication

Using digital tools to communicate and share information with stakeholders:

Performance descriptor	Unit mapping
Understand and use digital collaboration and communication platforms.	Unit 7
Use collaboration tools to meet with, share and collaborate with customers and colleagues.	Unit 21

Transacting digitally

Using digital tools to set up accounts and pay for goods/services:

Performance descriptor	Unit mapping
Use online systems to access and update digital records.	Unit 17
Set up accounts to complete transactions.	Unit 17

Digital security

Identify threats and keep digital tools safe:

Performance descriptor	Unit mapping
Understand the types of malware.	Unit 7
Understand the threats involved in carrying out online activities.	Unit 7
Protect personal and organisation information and data.	Unit 7
Keeping systems secure.	Unit 7

Handling data safely and securely

Follow correct procedures when handling personal and organisational data:

Performance descriptor	Unit mapping
Manage passwords and keep them secure.	Unit 21
Identify websites and services that are secure and insecure.	Unit 21
Understand the digital policy for a sector.	Unit 21
Understand the impact of online data.	Unit 21
Understand copyright and intellectual property.	Unit 21

Appendix 4 Sustainability framework

Sustainable development goal	Unit mapping
SDG 4: Quality education	All Units
SDG 6: Clean water and sanitation	Unit 13
SDG 7: Affordable and clean energy	Units 10 through 22
SDG 8: Decent work and economic growth	Units 3, 11 and 18
SDG 9: Industry, innovation and infrastructure	Unit 1, 3, 17 and 22
SDG 11: Sustainable cities and communities	Unit 1, 3, 17 and 22
SDG 12: Responsible consumption and production	All Units
SDG 13: Climate action	All Units
SDG 14: Life below water	Unit 13
SDG15: Life on land	Units 1 through 20
SDG 16: Peace, justice and strong institutions	Unit 3
SDG 17: Partnerships for the goals	Units 3 and 4

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