Marubeni Europower

HyBont

Bridgend Green Hydrogen Project

GREEN HYDROGEN:
A GUIDE FOR LOCAL AUTHORITIES

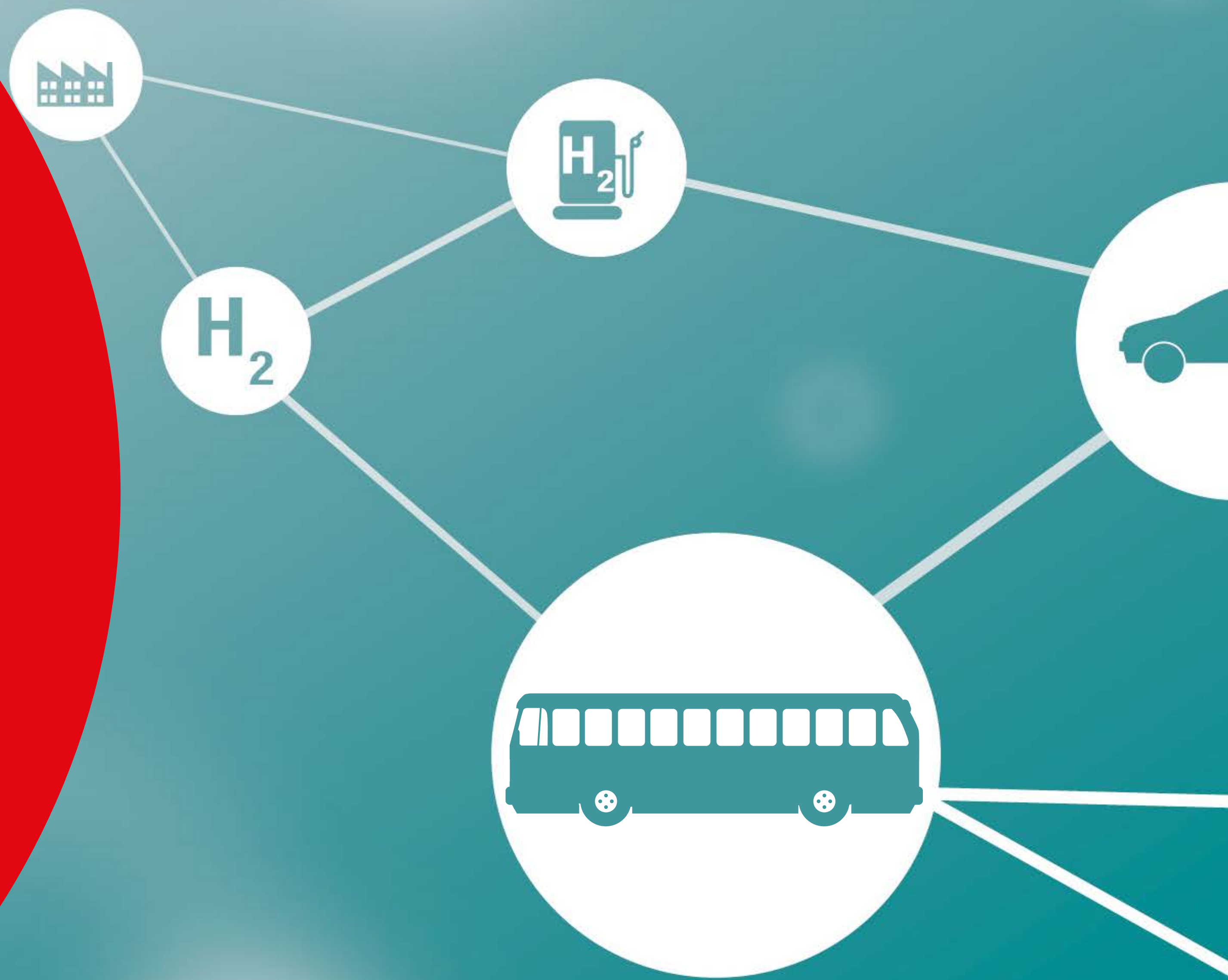
FROM THE EXPERIENCE OF TAKING A SCHEME THROUGH THE PLANNING PROCESS

October 2023

Ariennir gan
Lywodraeth Cymru
Funded by
Welsh Government

SBRI Government challenges. Ideas from business. Innovative solutions.

Contents



Marubeni Europower

Project Team

RPS – Making Complex Easy – A Tetra Tech Company

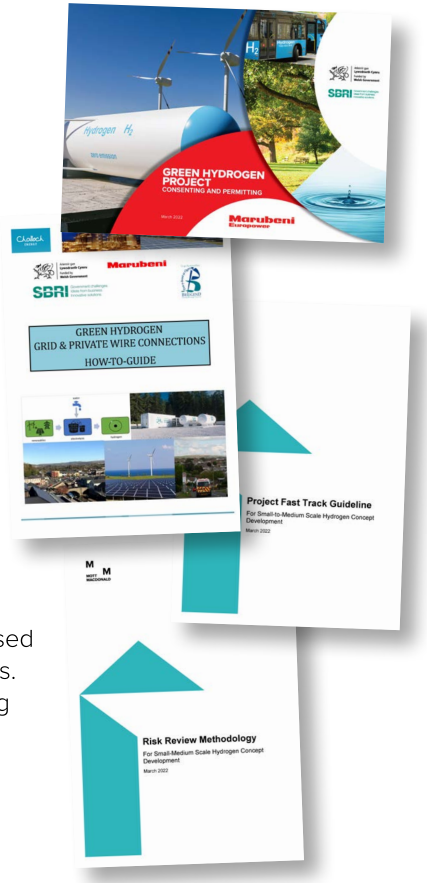
Mott MacDonald

Challoch Energy

1. Purpose and Scope

Purpose and Scope

In March 2022, ‘How to Guides’ for green hydrogen projects were completed, focussed on i) consenting and permitting, ii) grid and private wire connections, and iii) risk review and fast-track development methodology. The purpose of these guides was to assist those developing proposals for small-medium scale (less than 25MW) green hydrogen production and distribution in Wales.



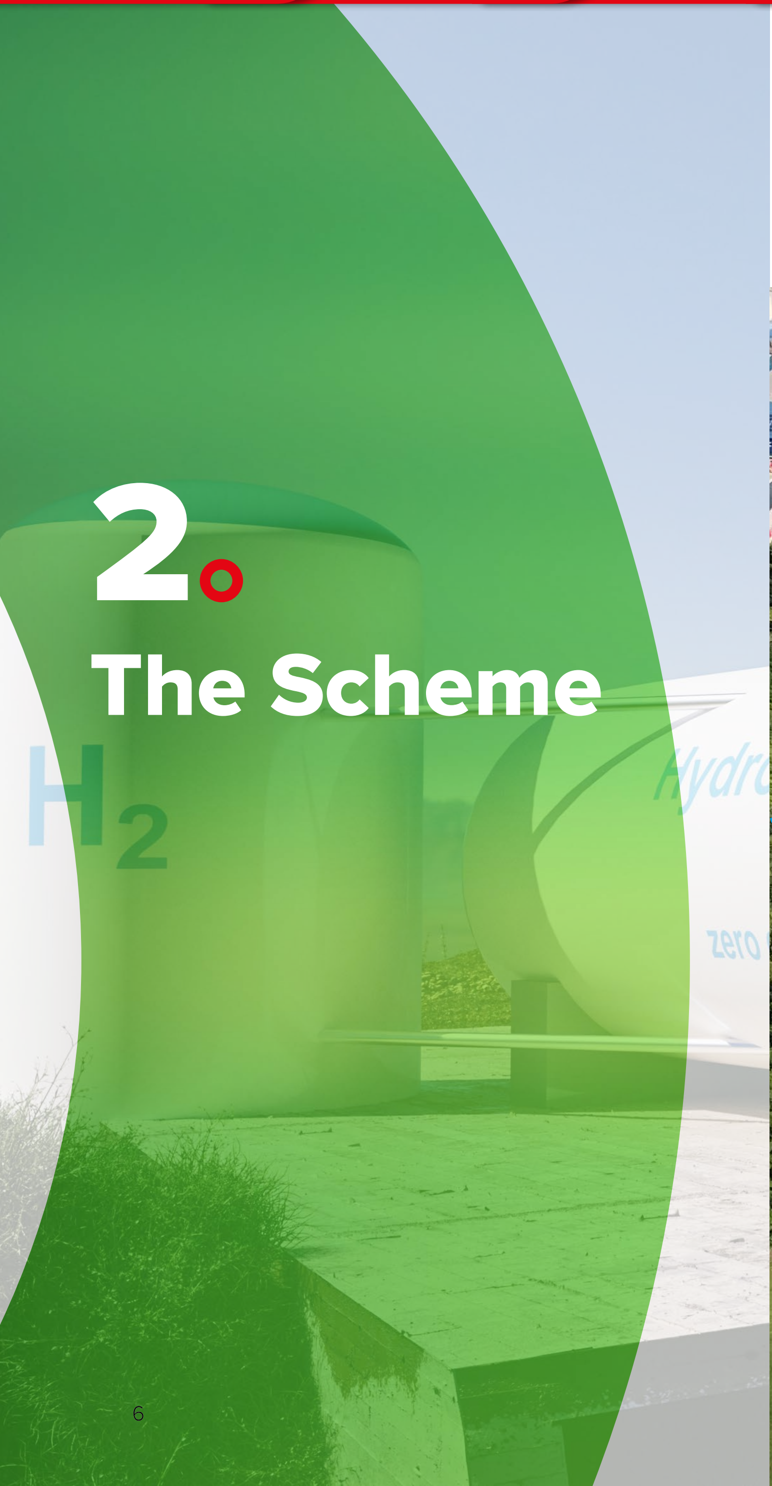
The aims of the guides were to improve understanding of the technology involved, the component infrastructure that features in a green hydrogen development and the regulatory process. The guides steered the reader through general information on the technology involved, the scope and relevance of guidance and legislation, the nature and extent of supporting assessments and plans envisaged to support applications and the general timeframes.

This guide builds on the first and is intended to be used by local authorities and other decision-making bodies. In seven chapters, it sets out the experience of taking an actual scheme through the development process from preparation, through consultation to planning submission, exploring the following:

- The Planning Approach
- Hydrogen Technology and Market Capability
- Electrical Connection Development
- Basic Engineering Fast-Track Project Methodology.

The guide concludes with a ‘top tips’ summary from each chapter, setting out the main lessons learnt from the application preparation process and the key steps.

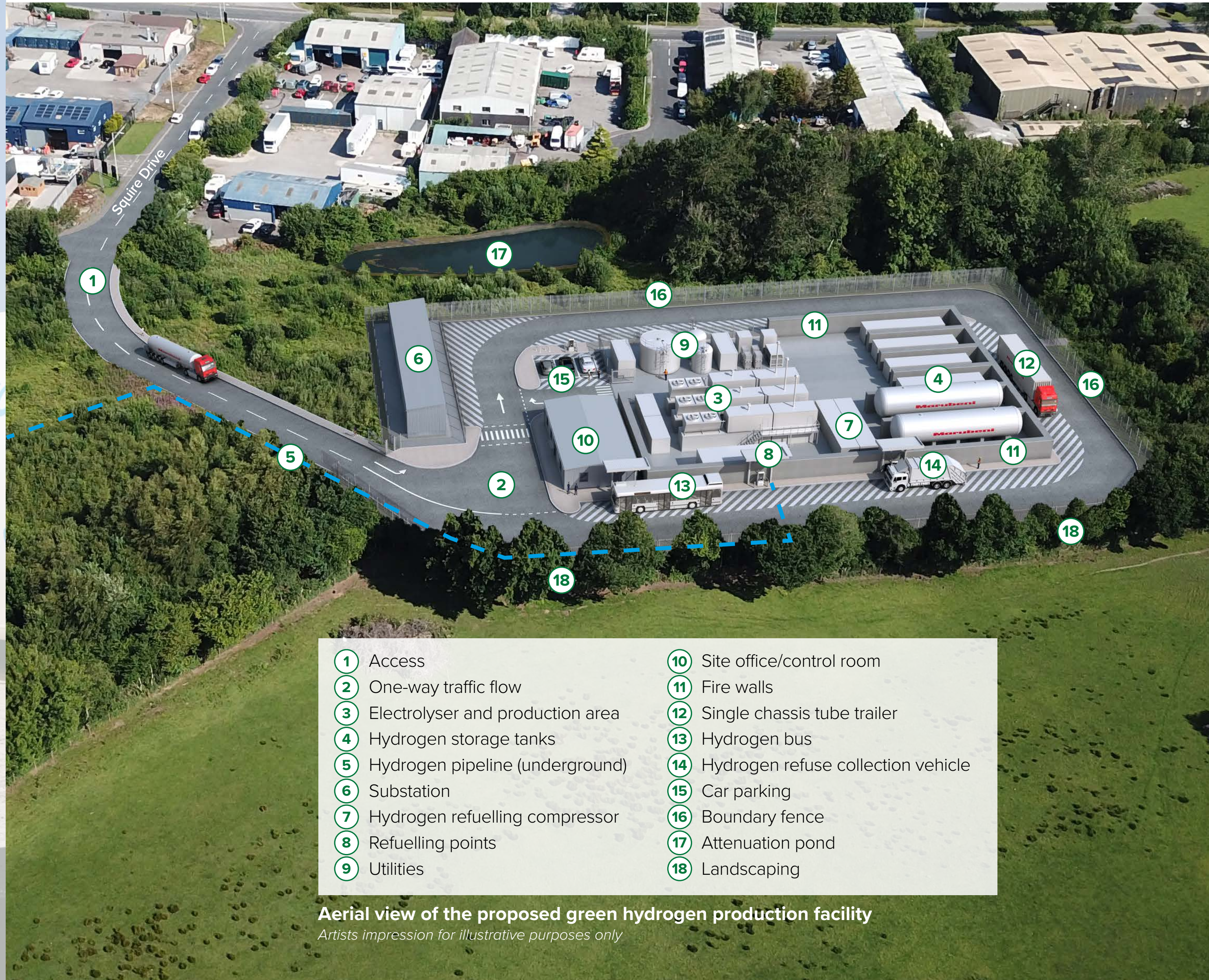

H2
HYDROGEN
ENERGY STORAGE



2. The Scheme

The Scheme

The main hydrogen production plant scheme components are as set out on the illustrative image below and the solar array plan on the following page.



Aerial view of the proposed green hydrogen production facility
Artists impression for illustrative purposes only

Indicative Solar Farm Landscaping Plan

A key piece of information that should appear at the outset of the project, which is key to any planning application is the 'description of development' that forms an integral part of the eventual planning permission. This encapsulates the use and extent of activity and development within the redline boundary of the application. For this proposal, the description of development was as follows:

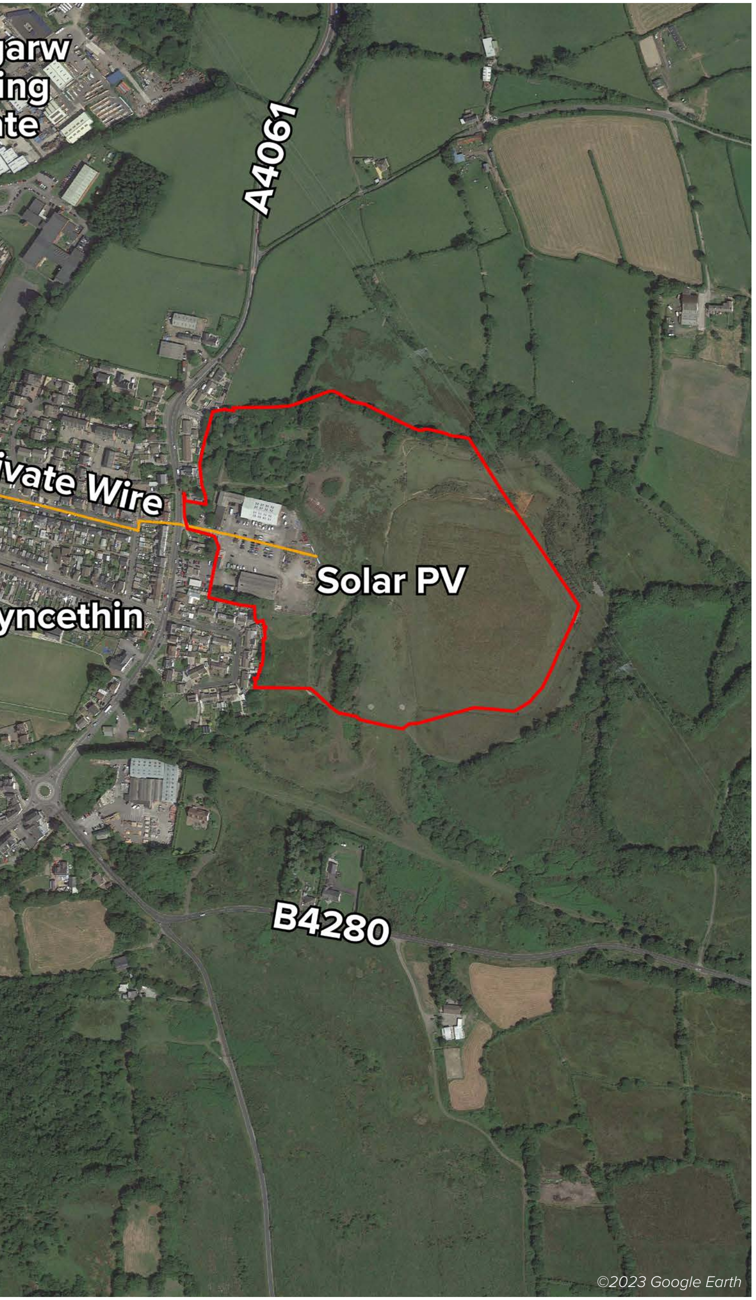
> *Development of a green hydrogen production facility with electrolysers, hydrogen storage, hydrogen refuelling station, admin building, substation, back-up generator and hydrogen pipeline 'off-take'; with access, circulation, parking, lighting, security fencing, hard and soft landscaping, and drainage infrastructure on land at Brynmenyn, Bridgend. Together with the installation of a solar photovoltaic electricity generating station (solar farm), comprising ground-mounted solar panels, inverters, transformer units, control and storage building, switch gear and a substation; with access, circulation, parking, lighting, security fencing, hard and soft landscaping, drainage infrastructure and temporary construction compound, on land at Bryncethin, Bridgend. Sites to be connected via an underground electrical wire.*

For marketing purposes, the scheme has been named as the **HyBont Bridgend Green Hydrogen Project** and a draft logo developed (shown opposite).

The proposed hydrogen plant and associated development site is to be located on land at Brynmenyn and Bryncethin, within the administrative area of Bridgend County Borough Council (BCBC). The location and extent of the main sites, hydrogen pipeline and private wire alignment are illustrated opposite.

The hydrogen plant is proposed to be built on land within the Brynmenyn Industrial Estate that is allocated in the adopted Bridgend Local Development Plan for industrial development. The solar array is to be located on land adjacent to the Bryncethin BCBC depot. The solar array is to be linked to the hydrogen plant by a private wire. There will be a circa 1km hydrogen pipeline connection between the plant and the 'Ynysawdre heat cluster' (college, primary school, and leisure centre).

Aerial Site Location Plan


garw
ing
te
A4061
ivate Wire
Solar PV
yncethin
B4280
©2023 Google Earth

3. The Planning Approach

Design Evolution

Bridging the 'Information Gap'

It is fair to say that at the outset of the planning process, the task from those that be involved in the decision making process is to gain as much information as possible about the potential proposal, particularly in terms of the development of a green hydrogen production facility, where the experience of dealing with similar applications will undoubtedly be limited, if non-existent.

It is always written in pre-application advice guidance notes/forms, that the most meaningful advice requests are those that provide as extensive and detailed submissions as possible from which an informed response will be received. This is always a finely balanced part of the process because the best time to seek pre-application advice is at the outset of a project, when survey, technical and design information will be lacking. A lack of knowledge, or pre-conceptions/misconceptions can create issues for all parties from the outset that can hinder the development of a proposal on its journey to the submission of a planning application.

The following are considered to be the core topic areas that the Council will want to get a firm understanding on as early as possible in the planning application journey to help bridge the 'information gap'. Many of them are of equal importance to the applicant/developer's knowledge (as well as investment and other decision making) for example is the principle of development acceptable, is it or is it not Environmental Impact Assessment development?

- **Site selection** – what has led the developer to select the site/locality in terms of land use allocation/designation, operational, physical, locational or market drivers? Are they clearly articulated and do they support the proposed location? Remember that there is no specific need assessment or requirement to justify the site location other than normal tests to determine if something is acceptable in planning terms.
- **Design and site layout** – what is the scheme and what are its core parameters in terms of scale for example?
- **The principle of the development** – what is the prevailing policy context and the constraints/influences upon the chosen site location and what does that lead to in terms of how the Council will respond to the principle of the scheme?
- **What are the consenting requirements**: for example, is the proposal an Environmental Impact Assessment development?

- **Additional information** – what will the Council require to fully assess the proposal when it becomes an application for planning permission, what surveys/assessments and plans are necessary and who should be consulted?

CASE STUDY

Site Selection: The 'proximity principle'

Over 10 local authorities were appraised as part of the site selection exercise and, following a shortlisting process including policy considerations, targets for decarbonisation of heat and transport, and ambition to tackle the climate emergency, Bridgend County Borough Council (BCBC) was selected.

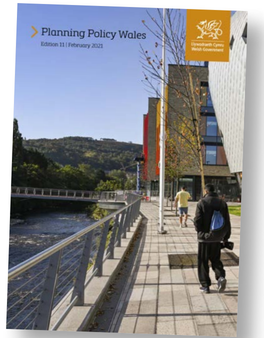
Within the BCBC boundary, Brynmenyn was considered attractive to the scheme because of the proximity to a cluster of energy projects to the south of the County Borough. An opportunity was seen to create an energy supply chain in the location for the production, storage and refuelling/distribution of hydrogen and provision of heat to a number of potential anchor loads in the location.

Key reasons the site within Brynmenyn Industrial Estate was identified as suitable for a green hydrogen facility, include:

- It is **allocated for employment uses** in the adopted Local Development Plan. In addition to this, both it and the Bryncethin site were vacant and neither contains best and most versatile (BMV) agricultural land. Taking all this into consideration, the development is considered acceptable in principle.
- Both of the main development sites at Brynmenyn and Bryncethin are under **single ownership**, making it more straightforward to assemble the land necessary to facilitate the scheme.
- **Close to end users:** the site is well located for local users of heavier vehicles such as BCBC's refuse collection vehicles and potentially public buses, to fuel with green hydrogen. In addition, the transportation and storage of hydrogen is expensive and locating the production and refuelling facility close to existing depots means it is both convenient and cost effective for end users.
- **Opportunities for a district heat network:** the electrolysis process for green hydrogen produces heated water as a by-product. This could be used, alongside a backup hydrogen supply, to heat nearby community buildings such as Ysgol Gynradd Brynmenyn Primary School, Coleg Cymunedol Y Dderwen and the Halo Ynysawdre. Swimming Pool and Fitness Centre in Ynysawdre. The position of the proposed electrolyser is a key factor for determining the viability of the heat network, which diminishes with distance. The electrolyser's position is therefore key to enabling this innovative solution to provide local benefits.
- **Proximity to solar power:** solar energy is a key component of green hydrogen production and a direct power connection from the solar farm to the electrolyser is required. The Bryncethin site is close to Brynmenyn Industrial Estate and is identified as a suitable location for a solar farm generating up to 5.5MW. The site is currently used for sheep grazing, which could continue once the solar arrays are installed, and the topography means there will be minimal visual impact from the development.

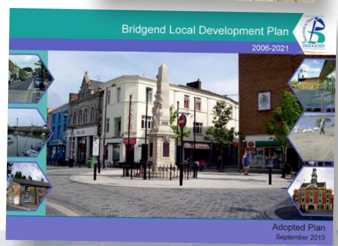
Other sites in Bridgend County Borough were considered, including one near Junction 36 with good access to the M4, however, this was discounted for reasons, including it being considered too far away to support the Ynysawdre heat network viability.

Design and Site Layout



Planning Policy Wales (PPW)[1] in its Chapter 5 establishes a number of requirements for Planning Authorities in connection with renewable and low carbon energy development, from ensuring that development plan policies are supportive, that they direct developments to the right locations and set out clearly the local criteria against which proposals will be evaluated.

PPW further establishes that prior to an application being submitted, developers for renewable and low carbon energy developments are encouraged, wherever possible, to consider how to avoid, or otherwise minimise, adverse impacts through careful consideration of location, scale, design and other measures.



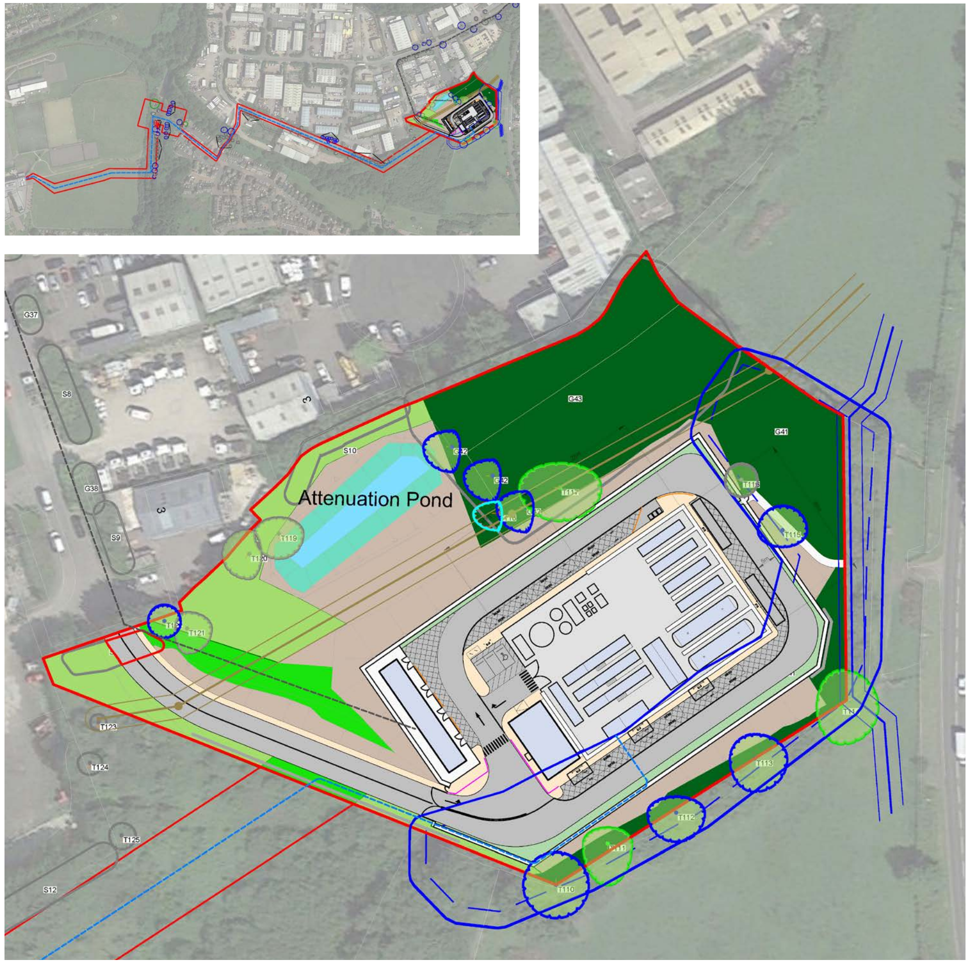
The Bridgend Local Development Plan (LDP)[2] Policy SP2, deals with Design and Sustainable Place Making. The policy sets out that all development should contribute to creating high quality,

Relevant Online Resources (PDF):

[1] Planning Policy Wales (PPW) Edition 11

[2] Bridgend Local Development Plan (LDP)

attractive, sustainable places which enhance the community in which they are located, whilst having full regard to the natural, historic, and built environment. Matters such as scale and prominence, avoiding certain impacts such as noise and air pollution as well as safeguarding and enhancing biodiversity/green infrastructure are set out as being important to the amenity and viability of neighbouring uses and occupiers. The proposal is for the development of plant and infrastructure and thus there is naturally an operational and functional aesthetic in appearance, but through careful layout and siting, matters of sensitive receptor amenity were considered. Retaining screening



Indicative Green Hydrogen Production Facility Landscaping Plan

planting and keeping the solar array out of the most sensitive parts of the Bryncethin site were key design drivers.

In this case, careful consideration has been given to the design of the green hydrogen facility, to optimise production and minimise hazards – the following being three important examples that are applicable to a range of contexts/locations:

1. Access: the access point will be at a lower level than the majority of the surrounding land and the access road will provide a shallow gradient for heavy vehicles, maximising accessibility for customers and staff. A one-way traffic flow minimises the size of site required, removing the need for turning circles for large vehicles and making instructions for drivers as simple as possible.

2. Landscaping: the key to place-making for an infrastructure dominated scheme such as this, is to ensure that it sits well within its landscape context over time. Creating a variety of native planting zones, screening and/or softening the development from particular viewpoints and making the overall scheme as bio-diverse as possible have all been design drivers in this case, particularly given the site has not been previously developed and has an established green infrastructure context.

3. Sustainable Urban Drainage Systems (SuDS): As with the overall scheme development, early engagement on drainage matters is important. SuDS should be designed in from the start of the evolution of a scheme, as opposed to the scheme being designed/masterplanned and the drainage then fitted into the site as an 'after thought'. Some of the systems, such as swales and attenuation ponds can be 'space hungry' and that is why, should they be needed as part of the solution, adequate room is provided as part of an overall green infrastructure approach in the early scheme evolution stage. Demonstrating to the SuDS Approving Body (SAB) as well as Dŵr Cymru Welsh Water that a site can be effectively drained early in the design process via engagement and the seeking of pre-application advice will be an important part of being confident that a scheme will be acceptable to these regulatory bodies at the time of applications for planning permission and SAB approval.

Thresholds and Assessment Criteria

The UK Hydrogen Strategy (BEIS August 2021) acknowledges the lack of a comprehensive regulatory regime for hydrogen projects and that in the early 2020s, hydrogen networks will be delivered through the existing regulatory and legal framework. It is anticipated that planning and permitting regimes may be updated by the mid-2020s.

As set out in the first How to Guide, at present the regime in which hydrogen sits for planning, is the Town and Country Planning Act 1990[3]. In Wales, there are three main consenting routes that an energy project that generates electricity at an installed generating capacity can be considered under. For a proposal to qualify, particular criteria and thresholds apply:

- Town and Country Planning Act – up to 10MW
- Developments of National Significance (DNS) - 10-350MW
- Nationally Significant Infrastructure Projects (NSIP) – 350MW+

This hydrogen production project does not qualify as a DNS, nor do any of its related component parts and as such, the planning application can be submitted in its entirety to and be determined by BCBC as the local planning authority.

The next considerations that determine activity in the preparation of the planning application are whether it meets the definition of 'major development' and/or whether it is deemed to be development that falls under the Environmental Impact Assessment Regulations.

On the topic of Environmental Impact Assessment (EIA), the first How to Guide concluded, on the basis of a review of green hydrogen proposals from across the UK, together with specific consultation with relevant determining bodies that included BCBC, Welsh Government and Natural Resources Wales, that it was highly unlikely that a green hydrogen project at the scale proposed would be considered EIA development. However, given that each case needs to be assessed on its own circumstances, in order to ascertain whether or not the proposed scheme required an EIA, Screening Request was submitted to BCBC in July 2022[4]. Subsequently, the request for the Local Planning Authority to adopt a 'Screening Opinion' on the proposed development was assessed against Schedules 1, 2, 3, to The Town and Country Planning (Environmental Impact Assessment) (Wales) Regulations 2017.

In accordance with the **Town and Country Planning (Environmental Impact Assessment) (Wales) Regulations 2017**[5] as amended (the EIA Regulations), the request described the characteristics of the proposed development and identified available information regarding the likely impacts of its construction, operation and decommissioning. The request concluded that the proposed development is not considered to fall within Schedule 1 of the EIA Regulations. The proposed development was considered to be Schedule 2 development based solely on the combined area of both sites. Therefore, EIA may be required if it is considered that there are likely to be significant environmental effects as a result of the proposed development.

On the basis of the information available at the time of the request, the EIA screening opinion concluded in September 2022 that the development is unlikely to have a significant environmental effect and an EIA was not required.

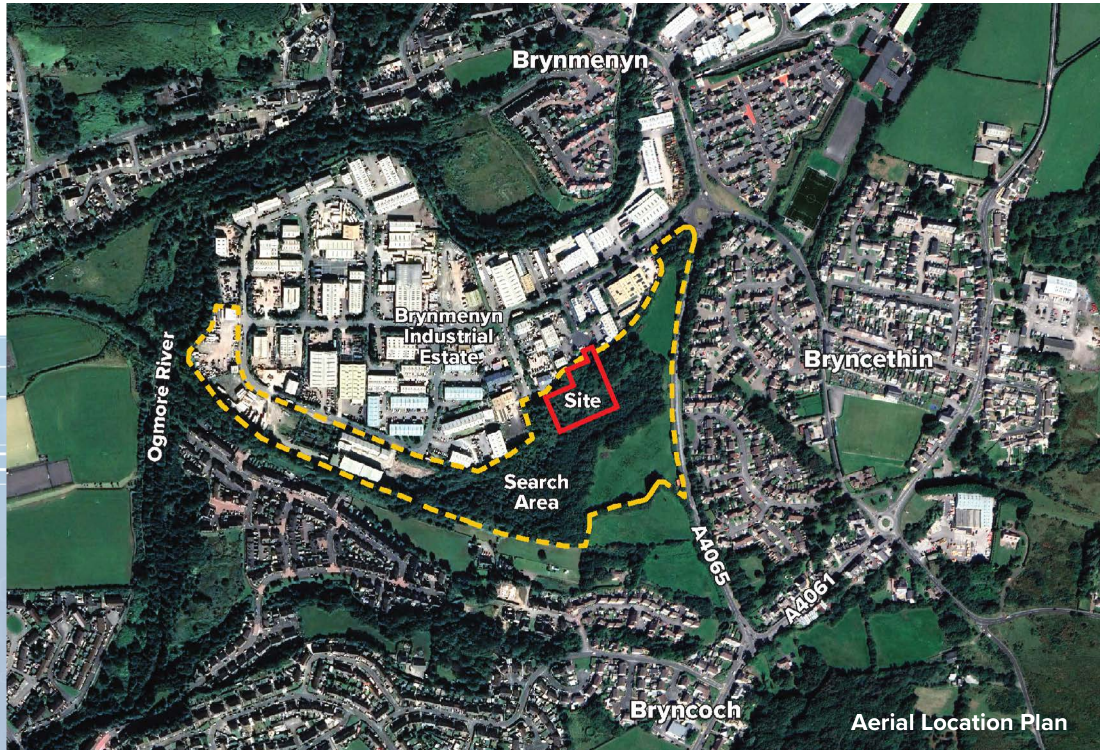
Scoping and Supporting Assessments

Formal pre-application written advice under reference PE/192/2022 was submitted on 26th August 2022, following a pre-application meeting with relevant officers on 16th August 2022.

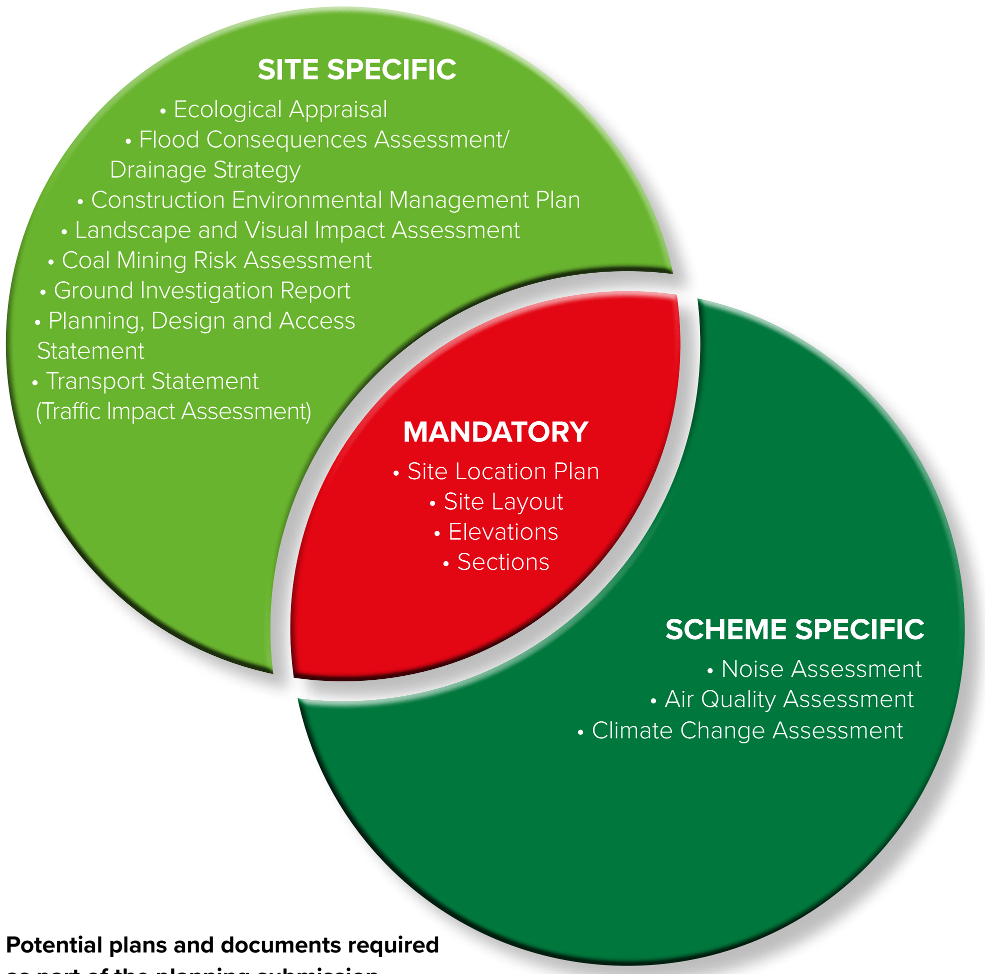
As part of the pre-application request, an exercise was undertaken to review local validation and site-specific requirements and identified the information that would need to accompany a future application. The pre-application review used a search area that was identified on land around the Brynmenyn Industrial Estate. Further assessment led to the identification of a possible site location in the north-east corner of the search area. Both the 'search area' and 'the site' are shown below on the aerial location plan.

Relevant Online Resources:

[3] Town and Country Planning Act 1990
[4] EIA Screening Opinion request, July 2022
[5] Town and Country Planning (Environmental Impact Assessment) (Wales) Regulations 2017



Aerial Location Plan



Potential plans and documents required as part of the planning submission

There are mandatory plans and documents required as part of the submission of any planning application, but given that green hydrogen production is likely to be new to officers and others in the decision-making process, it is recommended that as much contextual information is sought at the outset of the application preparation process so that all main component parts (production plant, solar array, pipeline and private wire) are as fully understood as possible. This will result in officers and members being able to confidently respond to approaches from local interested parties should they need to prior to submission, during consultation and consideration of the proposal.

The following table provides details of the information likely to be required to accompany a planning application. The table below includes the plans and technical reports required by the LPA to validate the application. The table is split into national validation requirements and likely local validation requirements. Note also that site-specific requirements and the surrounding context to an application site can determine whether a specific type of assessment is required to support the submission. The content of a planning application will also be informed by pre-application consultation advice, which is to be encouraged both with the LPA and also via discretionary consultation with statutory consultees.

National Validation Requirements

National validation requirements are required by legislation, such as a Design and Access Statement, without which the application cannot be processed.

Application Document	Requirement	Scheme Relevance
Application Form	The application form is mandatory for planning permission and associated consent regimes for use across all local planning authorities in Wales.	Required for all planning applications.
Ownership Certificates	The relevant certificate concerning the ownership of the application site must be completed. Ownership certificate A, B, C or D are available through the Standard Application Form. For the purpose of these certificates an 'owner' is anyone with a freehold interest, or leasehold interest with at least 7 years left to run on the lease. Where the owner(s) or tenant(s) of the application site is not the applicant, a notice must be completed and served in accordance with Article 10 of the DMPWO or Regulation 7 of the Planning (Listed Buildings and Conservation Areas) (Wales) Regulations 2012. It must be served to the owner(s) or tenant(s) prior to the submission of the application.	Required where not in sole control of land within the application boundary.

Application Document	Requirement	Scheme Relevance
Design and Access Statement	A DAS must explain the design principles and concepts that have been applied to the development. It must also demonstrate how the proposed development's context has influenced the design.	Article 7 of the DMPWO includes the requirement for a Design and Access Statement (DAS) to accompany all major planning applications (outline and full).
Location Plan	Plans should be drawn to an identifiable scale, preferably 1:1250 or 1:2500 and include a north point, date and drawing number. They should be based on an up-to-date map and should wherever possible show at least two named roads and surrounding buildings. The properties shown should be numbered or named to ensure that the exact location of the application site is clear. A blue line must be drawn around any other land owned by the applicant, close to or adjoining the application site.	Required for all planning applications.
Block Plan	A block plan should be submitted at a recognised metric scale of at least 1:500 (imperial scales will not be accepted).	Required for applications for operational development for buildings and plant.
Existing and Proposed Elevations	These should [be drawn to an identifiable scale (e.g. 1:50 or 1:100) and] clearly show the proposed works in relation to what is already there. To aid the local planning authority's understanding of the development proposal, all sides of the proposal must be shown and these should indicate, where possible, the proposed building materials and the style, materials and finish of windows and doors.	Required for applications for operational development for buildings and plant.

Application Document	Requirement	Scheme Relevance
Existing and Proposed Floor Plans	Drawn to an identified scale (e.g. 1:50 or 1:100) and explain the proposal in detail. Where existing buildings or walls are to be demolished these should be clearly shown. The drawings submitted should show details of the existing building(s) as well as those for the proposed development. New buildings should also be shown in context with adjacent buildings (including property numbers where applicable).	Required for applications containing buildings.
Existing and Proposed Site Sections	Where a proposal involves a change in ground levels, illustrative drawings should be submitted to show both existing and finished levels to include details of foundations and eaves and how encroachment onto adjoining land is to be avoided. Such plans must be drawn to an identified scale (e.g. 1:50 or 1:100) and show a cross section(s) through the proposed building(s).	Required for applications for operational development for buildings and plant.
Existing and Proposed Roof Plans	Existing and proposed roof plans are required where the proposed development involves an alteration or extension to the roof. These should be drawn to an identified scale, accurately show the direction of north and detail the shape of the existing / proposed shape of the roof. Details such as the roofing material and their location is also typically specified on such plans.	Required for applications containing buildings.

Local Validation/Site Specific Requirements

Local validation requirements consist of information essential to determine applications for major development that result from local circumstances within the LPA area. Information required for valid applications where the application is for major development is often published on the LPA's website. We are aware from our existing application work in Wales that some Councils do not have a specific validation checklist and some case officers refer to Section 7 Annex: Planning Applications – Lists of Validation Requirements to the Development Management Manual.

Based on our experience and understanding of the nature of a hydrogen proposal, the local requirements are likely to be the following:

Application Document	Requirement	Need for Inclusion
Flood Consequences Assessment	A Flood Consequences Assessment (FCA) will be required in accordance with Technical Advice Note 15 'Development and Flood Risk' (2004) for all applications that involve development within flood zones C1, C2 and those parts of zone B where flooding has been identified as a material consideration to allow for localised problems. Where a site partially falls within zone C1 or C2 it will be a matter for the local planning authority to judge whether an FCA is required.	All planning applications (outline and full) for major 'highly vulnerable' and 'less vulnerable' development within the C1 or C2 zones identified in Technical Advice Note (Wales) 15 (TAN15).
Coal Mining Assessment	Where an application falls within the consultation area defined by the Coal Authority, the Coal Mining Risk Assessment issued by the Coal Authority together with a specialist investigation and assessment of risk and remedial measures should form a part of the application.	As advised in consultation with the Coal Authority.
Air Quality/Odour Assessment	Not specified in the Development Management Manual	Water treatment and hydrogen production processes are generally odourless and the only waste gas produced, oxygen, is easily dispersed at this scale. The requirement for an air quality assessment might relate to vehicle movements and could be relevant where there are sensitive receptors adjacent to site location.
Contaminated Land/ Ground Investigation Assessment	To ensure contamination is properly identified and remediated in a safe and effective manner during the development process, applications for development involving ground excavations on land previously used for industrial purposes are required to include a contaminated land study. Applications will need to demonstrate that a site is free from significant contamination or can be overcome through mitigation, thereby ensuring that the land is suitable for the development proposed.	Dependent upon previous land use context.
Tree Survey	A tree survey is required for any building or engineering works where there are trees within or adjoining the application site. The statement should be produced in line with the guidelines set out in BS5837:2005. The British Standard requires an arboriculturist to record information about trees on the site independently of and prior to any specific design for development.	Dependent upon site and context.

Application Document	Requirement	Need for Inclusion
Foul and Surface Water Drainage Strategy	Required to demonstrate that the development proposal has appropriate drainage and is not likely to unacceptably increase flooding or surface water run-off or overload the public foul or surface water systems.	Relevant to all planning applications that have drainage implications and SAB approval is mandatory where the construction area is 100sqm or more.
Landscape and Visual Impact Assessment (LVIA)	Required to assess the visual and landscape impacts of development proposals. The LVIA must comply with the current edition of the Guidelines for Landscape and Visual Impact Assessment, published by the Landscape Institute and Institute of Environmental Management and Assessment.	All planning applications (full and outline) for major development where at least 10% of the application site does not fall within the definition of 'Previously Developed Land' in PPW. May be able to be dealt with through Design and Access Statement – likely to depend on matters such as eventual height of any stacks, scale of buildings and plant and screening opportunities.
Ecological Assessment	Development proposals that may impact upon important species, habitats or sites (in particular those protected under national or European legislation or that are Section 74 species or habitats of principal importance for the conservation of biological diversity). must be accompanied by an ecological assessment of the proposed development site.	Dependent on site context and that of the surrounding area in terms of designations, habitats etc - relevant to brownfield as well as greenfield sites and to existing buildings and structures that could support nesting birds and bats.

Application Document	Requirement	Need for Inclusion
Noise Assessment	Applications for developments that raise issues of disturbance by noise to the occupants of nearby existing buildings, and for developments that are considered to be noise sensitive and which are close to existing sources of noise should be supported by a noise assessment prepared by a suitably qualified acoustician. Guidance is provided in Technical Advice Note 11: 'Noise' (1997).	Dependent upon proximity to noise sensitive receptors such as residential or business land uses. The electrolyser does not constitute a significant noise source. There will be at least one compressor and a number of pumps that might do, without mitigation. The levels of traffic associated with the site would also need to be taken into account.
Transport Assessment	Planning Policy Wales' (11th edition, 2021) sets development thresholds above which a Transport Assessment (TA) is expected to be submitted with the associated planning application. The TA will reflect the scale of the development and the extent of the transport implications of the proposal. The TA process will include the production of a 'Transport Implementation Strategy' (TIS) for the development. The TA will provide information on the likely modal split of journeys to and from the site and the TIS should give details of proposed measures to improve access by public transport, walking and cycling, to reduce the need for parking associated with the proposal, and to mitigate transport impacts.	Planning applications for developments falling into the categories identified in TAN 18: Transport must be accompanied by a Transport Assessment. The proposal may require service access. Service access for freight or delivery vehicles should be integrated into the analysis and subsequent implementation strategy.

It should be noted that if the proposal is deemed to be EIA development, that many of the above technical assessments will form and inform relevant chapters of the Environmental Statement.

Hazardous Substances Consent

A hazardous substances consent is triggered where the storage and use of hazardous substances is at or above the controlled quantity set within the Planning (Hazardous Substances) Regulations 2015. For hydrogen facilities a HSC would be triggered by 2 or more tonnes of hydrogen or 200 or more tonnes of oxygen.

Although sites handling and storing hazardous substances are required to comply with health and safety legislation, it is recognised even after reasonably practicable measures have been applied that there remains a residual risk to people in the vicinity or to the environment from an accident. The purpose of a hazardous substances consent (HSC) is to ensure that this residual risk is considered before a hazardous substance is allowed to be present at or above a controlled quantity.

A HSC is applied to and issued by the local planning authority with the HSE providing technical input to the determination process. In determining applications for a HSC, consideration is given to where and how the hazardous substance is present, the nature of the site (both existing and proposed) and the nature of the surrounding area.

It is generally considered good practice to submit an application for HSC at the same time as the planning application to which it relates but there is no specific requirement that this is done.

Hazardous substances authorities should provide applicants with a decision within 8 weeks from receipt of a valid application. Alternatively, it should be given within any extended period agreed in writing between the applicant and the hazardous substances authority.

COMAH

COMAH applies to facilities that store hazardous substances above specified thresholds. Two tiers of facility are identified, Lower and Upper Tier, with Upper Tier sites being considered higher risk and are subject to a higher degree of regulation.

For hydrogen the thresholds for COMAH are:

- Lower Tier – 5 tonnes
- Upper Tier – 50 tonnes

Oxygen a by-product of the hydrogen generation process is also regulated under COMAH, with the following thresholds applied:

- Lower Tier – 200 tonnes
- Upper Tier – 2,000 tonnes

In the event that COMAH is triggered, the applicant will need to notify the competent authority (HSE/NRW) 3-6 months before construction of the facility begins.

The notification will need to include the following information:

- name and address of the COMAH operator; address of the establishment;
- name or position of the person in charge of the establishment;
- details of dangerous substances present (or likely to be present*) on site; quantity and physical form of those dangerous substances;
- brief description of site activities related to the dangerous substances; features of the environment which could lead to a major accident on the site;
- elements of surrounding environment which could make the consequences of a major accident worse.
- Lower Tier sites will need to establish a major accident prevention policy (MAPP), this needs to be developed within 3 months of the site falling under COMAH.
- For small and medium scale green hydrogen sites it is likely storage volumes will fall below these thresholds. However should they apply a COMAH safety report must be developed (note the safety report can also include the sites MAPP otherwise a separate MAPP is required). For new sites a pre-construction COMAH safety report needs to be submitted to the competent authority prior to commencing construction.


Gas Act 1986
1986 CHAPTER 44
HSE
Dangerous substances and explosive atmospheres
Dangerous Substances and Explosive Atmospheres Regulations 2002
Approved Code of Practice and guidance
L138 (Second edition)
Published 2013
HSE
The Control of Major Accident Hazards Regulations 2015
Guidance on Regulations
HSE
Control of substances hazardous to health
The Control of Substances Hazardous to Health Regulations 2002 (as amended)
Approved Code of Practice and guidance

From ‘Draft’ to ‘Final’

Pre-Application Consultation

The scale of the proposed development in this case meant that, in planning terms, it was considered a ‘major’ development for which there is a requirement to undertake pre-application consultation as defined in Article 2 of the Town and Country Planning (Development Management Procedure) (Wales) Order 2012[6].

The scheme went out to the mandatory pre-application consultation (PAC) on the 18th November 2022, and remained open for responses until the 6th January 2023. This was longer than the required 28 days which allowed for the Christmas holiday period being a time of expected low engagement/response.

All of the draft planning application documents were made available at the HyBont consultation website[7].

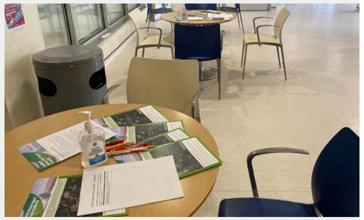
The consultation programme involved the hosting of a 2-day public engagement event on the 13th and 14th of December, 2022 to which the 1,200 plus people that had been notified of the start of the PAC process were informed. Some of the headline statistics of the PAC engagement are set out below:

over 1,200 letters/leaflets sent to residential and business addresses

over 700 unique visitors to the project website

2 public exhibition drop in events attended by **over 130** people

over 100 people provided feedback



Post-PAC to the Final Planning Application

Following the end of the formal PAC process, the applicant considered and reflected upon the responses received to the consultation. This period of reflection enables a developer/applicant to decide whether, as a result of specific responses, it wishes to or should in fact, amend something in the proposal before submitting the actual planning application.

Where consultation does not attract a large number of responses, or is overwhelmingly positively received, this period post PAC and pre-submission can be as little as one or two weeks in which the applicant finalises plans and documents and moves straight to making the application, confident that it will be well received.

In this case and given the largely negative nature of the responses received and the consistency of topics raised, the applicant decided to run a further, informal public information day prior to submission of the planning application. Once the mandatory consultation process has been complied with, there is no time limit for then submitting the actual application and it is not unusual for further engagement to be carried out should the need arise.

This additional engagement on the 9th March, 2023 took the following form[8]:

- A series of Factsheets were prepared on key topics of interest to consultees such as hydrogen safety, why the location and layout were as proposed and transport considerations.
- The CGI illustrative image was further developed and contained more detail than at pre-app consultation stage.
- A series of new information boards were prepared for display.
- A preview Q&A presentation session was held with local businesses in advance of the public drop-in on the information day.

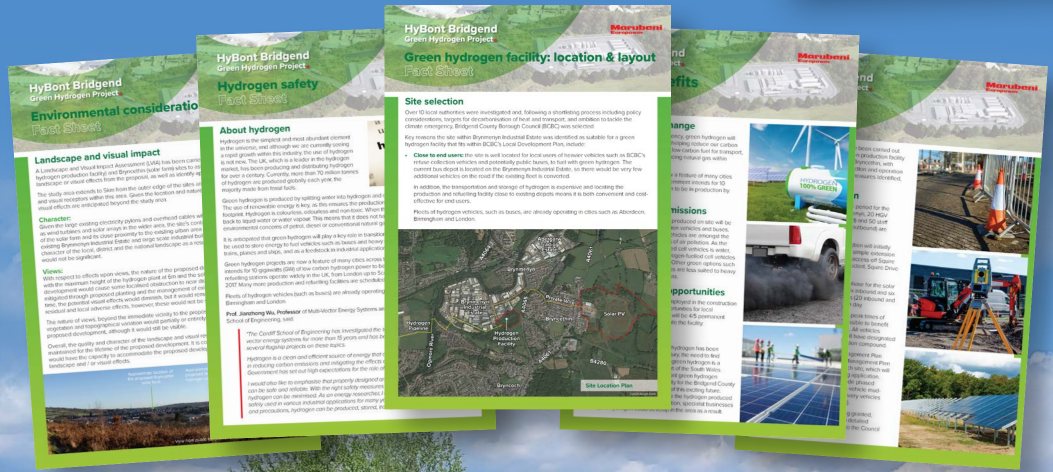
Relevant Online Resources:

[6] Town and Country Planning (Development Management Procedure) (Wales) Order 2012

[7] HyBont Project Website (archived PAC documents and consultation material)

[8] HyBont Project Website (public information event material - March 2023)

HyBont Information Boards (March 2023)



HyBont Fact Sheets (March 2023)

HyBont Summary Leaflet (March 2023)

Eye level view of the proposed green hydrogen production facility
Artists impression for illustrative purposes only

4. Hydrogen Technology and Market Capability

Hydrogen Technology

The need to understand hydrogen technology used in green hydrogen projects is paramount to developing assumptions that support the technical development of the design. One of the key technology selections for green hydrogen projects is the hydrogen production technology.

For small-to-medium scale green hydrogen projects, the technologies mature enough for consideration are Alkaline Electrolysis and Proton Exchange Membrane (PEM) Electrolysis. Alkaline electrolysis is a mature technology that was first used to generate hydrogen over 100 years ago whilst PEM electrolysis is a newer technology.

History of Electrolysis

The electrolysis of water has a long history. In 1800 Alessandro Volta invented the voltaic pile and William Nicholson and Anthony Carlisle subsequently used it for the electrolysis of water. However, the invention of the Gramme machine by Zénobe Gramme in 1869 provided the first cheap method for the production of hydrogen.

The first process for the industrial synthesis of hydrogen and oxygen through electrolysis was developed by Dmitry Lachinov in 1888. By 1902 more than 400 industrial water electrolysis units were in operation. In the first half of the 20th century, there was a huge demand for hydrogen in the production of ammonia fertilisers. This need for hydrogen stimulated the development of water electrolysis technology, which was helped by the low cost of hydroelectricity at the time.

In 1927 Norsk Hydro Electrolysers, implemented the first large industrial alkaline water electrolyser installation for ammonia production. Subsequently, two additional plants with 300 electrolysers and a hydrogen production of approximately 30,000 m3/h each were built in Norway. In 1948, the first pressurised industrial alkaline electrolyser was manufactured by Zdansky/Lonza.

The first PEM Electrolysers was introduced in the 1960s by General Electric, these were developed to overcome some of the drawbacks and limitations of the alkaline electrolysis technology, including capability to produce high-purity hydrogen gas. The proton exchange membrane process was first developed as a method for producing electricity for the Gemini Space Program, and later adapted for electrolysis.

In the 1980s, researchers at the University of Southern California and the University of California, Los Angeles began to investigate the use of PEM electrolysis for the production of hydrogen from renewable energy sources, such as solar and wind power. This work led to the development of the first PEM electrolysis systems for renewable hydrogen production. The first commercial scale PEM electrolyser was installed in 1987 at Stellram SA, a metallurgical specialty company, in Nyon, Switzerland. The unit was designed to produce up to 20 Nm^3/h of hydrogen at a pressure of 1-2 bar.

What is PEM electrolysis?

PEM electrolysis is a method of producing hydrogen gas (H_2) from water (H_2O) using an electrochemical process. This process involves passing an electric current through water to split the water molecules into their constituent parts: hydrogen and oxygen.

This takes place in an electrolyser cell. The cell contains an anode and a cathode separated by a proton exchange membrane. The anode and cathode are connected to a direct current (DC) power source, which provides the energy necessary to split the water molecules. This can be powered by renewable energy sources such as solar, wind or tidal.

When an electric current is passed through the cell, water molecules at the anode are split into oxygen gas and positively charged hydrogen ions (protons). The PEM membrane is a critical component of PEM electrolysis acting as a barrier which allows only protons to pass through to the cathode, while preventing the oxygen gas from mixing with the hydrogen gas.

PEM Electrolyser Technology Development & Current Market Capability

Since the development of the first commercial PEM electrolysers in the 1980s, significant advances have been made in the development of PEM electrolysis technology. In the 1990s and 2000s, several companies and research institutions developed high-performance PEM electrolysis cells and systems, which enabled the efficient and cost-effective production of hydrogen gas from renewable energy sources. As a relatively new technology, advancements are continuing to be made in the development of PEM electrolysers, with significant increased conversion efficiencies, compactness, and cost performance expected with roll-out across a potentially much larger green hydrogen market.

Engagement with electrolyser suppliers developing products for the UK market has led to an information profile for PEM and alkaline electrolyser technical characteristics being

develop as shown in the Table below. For the consideration of small-to-medium scale green hydrogen project development, PEM was found to be more suitable at the time of analysis, with key factors being based on the parameters being more suited to the small-to-medium scale project power supply, hydrogen demand profile, hydrogen purity, module size & configuration.

	PEM Electrolysis	Alkaline Electrolysis
Electrolyte	Polymer (Nafion)	20-40% KOH
Anode	IrO_2, RuO_2	Fe, Ni, Ni-Co alloy
Cathode	PT, PT-Pd	Fe, Ni, Ni-Mo alloy
Cell Area	<0.3 m^2	<4 m^2
Cell temperature	50-80 °C	60-80 °C
Stack pressure	Up to 80 bar	Up to 30 bar
Hydrogen Purity	99.9% – 99.9999%	99.5% – 99.9998%
Cell voltage	1.8 - 2.2 V	1.8 - 2.4 V
Current density	1.0-2.0 A/cm^2	0.2-0.4 A/cm^2
Energy consumption stack	4.7-5.0 kWh/Nm^3	4.4-4.8 kWh/Nm^3
Energy consumption system	5.3 to 5.6 kWh/Nm^3	5 to 5.4 kWh/Nm^3
Operating Range (%)	9-100%	30-100%
System Response (ramp up)	40% (full load)/second	7% (full load)/second
(Ramp down)	40% (full load)/second	10% (full load)/second
Cold Start Time	5 minutes	20 minutes +
Lifetime stack	40,000-60,000 h	60,000-90,000 h
Degradation (% increased power req. for same H2 output)	1-1.5% per year	1-1.5% per year
Maturity / Scale	Commercial at small and medium size (multiple suppliers <5MW per module)	Commercial & Mature at small, medium, and large scale (multiple suppliers >5MW per stack, >40MW per module)

Market Engagement

The information developed above may be helpful in informing the expected technical capability of electrolyser technology for small-to-medium green hydrogen projects in a similar context. However, it is important to note that the green hydrogen technology market is quickly changing and new products and suppliers are developing at pace in the current environment in both alkaline and PEM technology fields and in other more novel electrolyser technologies such as solid oxide electrolyser cell (SOEC).

It is therefore important that green hydrogen projects include early engagement with the hydrogen equipment supply chain and the following methodology is suggested to form part of the basic engineering fast-track approach as detailed in Chapter 6.

A list of some of the OEM suppliers that demonstrated products matching small-to-medium scale green hydrogen projects development is shown following; this is not an exhaustive list and the market is rapidly developing:

- Cummins
- Elogen
- Enapter
- Hitachi Zosen
- ITM
- NEL
- Plug Power
- Siemens Energy
- SinoHy
- Sungrow


Hydrogen H2
zero emission

5. Electrical Connection Development

Introduction

The goal of this section is to assist in identifying suitable electrical supply sources for the hydrogen facility, and determining the necessary infrastructure required for the electrical connection. When developing the electrical connection, the main constraint is reliable and low-cost power from renewable energy sources, preferably a combination of wind and solar. Three options are available to supply renewable electricity to the hydrogen plant, namely via the grid, via a private wire connection to an off-site renewable electricity producer, or directly from on-site renewable electricity. The choice will depend on the site's location, and the availability or feasibility of infrastructure development around the facility. It is important to note that all these options aside from grid supply will require a backup power connection to the grid.

For facilities with a power rating of 8MW or less, electricity can be supplied at a voltage of 11kV depending on power requirements. Otherwise, the supply voltage must be 33kV or higher. To facilitate the supply of electricity at the required voltage, an on-site substation with a transformer to drop the voltage from the supply voltage to the site voltage is necessary. With these considerations in mind, this guide explores each of the options in detail and provides an outline for the design of a private wire to convey the power from the generator to the hydrogen production facility.

Private Wire Electricity Source Assessment

Local Renewable Generator

The first option explored in this guide for sourcing renewable electricity for a green hydrogen facility is through a private wire connection to an off-site renewable energy producer. A private wire connection is a direct connection between a generator and a consumer, allowing for the supply of electricity without the involvement of the local distribution network operator.

To pursue this option, it is advisable to ensure that the renewable energy generator is located within a 5km radius of the facility. Any further, and costs will become too great in addition to increased transmission losses. Additionally, the renewable generator must have sufficient capacity to meet the facility's electricity demand.

It is important to recognise that the connection to the off-site generator will likely be non-firm. This means that the generator's supply may not be available continuously due to factors such as maintenance or adverse weather conditions. Therefore, backup electrical connection is necessary to guarantee a continuous supply of electricity to the hydrogen facility. There are two options available for securing a backup electrical connection: i) a separate grid connection dedicated exclusively for essential loads ii) or a changeover switch that automatically switches the power supply to the site to the grid, should interruptions from the private wire occur.

When sourcing from an off-site renewable energy generator, connection is made via an electrical breaker. The breaker serves as a safety device that can interrupt the connection in case of a fault. There must be sufficient space on the generator's site substation to accommodate the electrical breaker for the private wire. It is possible that the generator's substation may not be able to accommodate the necessary breaker. In such cases, additional infrastructure development may be necessary.

Onsite Generation

Another option for sourcing renewable electricity for a green hydrogen facility is to co-locate the facility with an onsite renewable generator. This involves installing renewable energy generation infrastructure on-site, such as solar panels or wind turbines, to power the hydrogen production process.

To pursue this option, a G-99 application for a grid connection agreement is required. This application outlines the technical details of the proposed connection to the grid and the expected electricity generation and usage patterns of the generator and hydrogen facility. Additionally, the generator may be subject to export limitations depending on location. As such, it is imperative to size the power generation appropriately such that the hydrogen facility can absorb virtually all the electricity generated and thus prevent the needs for any export to grid.

It is crucial to reinforce this design consideration when seeking a grid connection agreement from the Distribution Network Operator (DNO). The site's precise energy consumption pattern and needs must be demonstrated to prove that export to the grid will not occur. By default, the DNO assumes that the grid will absorb all the generation at some point, for instance if the facility is down for maintenance but the generator is still running. Early engagement with the DNO is key to ensure that the grid connection agreement process goes smoothly and that it meets the requirements of the on-site renewable generator and the hydrogen facility.

When co-locating the hydrogen facility with an on-site renewable generator, backup electrical connection is necessary to guarantee a continuous supply of electricity to the hydrogen facility if the renewable generator is down. This electricity can be procured through the grid via a standard supply agreement. It is essential to ensure the G-99 connection agreement allows for sufficient import capacity to cover the facility's essential loads. The existing network's capacity must also be analysed to verify the import connection will not strain the DNO's network and thus lead to network reinforcement.

The backup import capacity should cover at least the facility's essential loads, but does not need to cover the plant's maximum size. Effectively, it is recommended to make the backup grid connection as small as possible to keep costs to a minimum and facilitate the works required for the site and the DNO.

Overhead & Underground Line Routing and Design

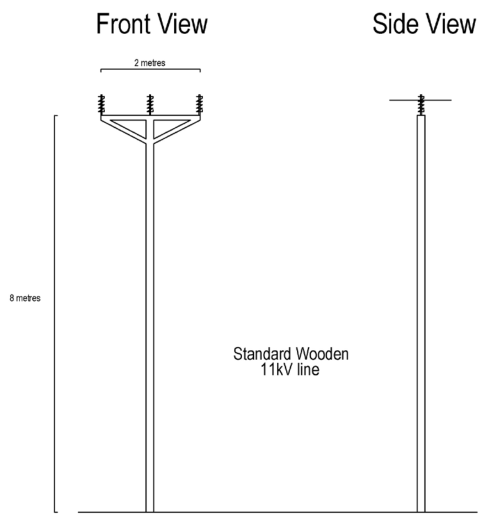
Overhead Lines

After identifying a suitable renewable energy generator and determining the necessary electrical infrastructure for the green hydrogen facility, the next step is to evaluate the routing of the private wire connection between the two.

Overhead power lines are generally preferred due to their lower cost - they are generally much cheaper than underground cabling and are cheaper to maintain. However, it is important to avoid crossing railway lines, major roads, or DNO overhead lines. When crossing DNO lines, the private wire will have to be undergrounded for at least 50m on each side of the DNO's cable (100m of undergrounding total). It is also important to avoid heavily wooded areas, as they require a set-off space to accommodate overhead power lines. The goal is to minimise the sections requiring undergrounding, as this can be costly and time-consuming.

To identify any of these constraints on the route, it is important to obtain utility maps. These can typically be accessed publicly online via resources such as LineSearchBeforeYouDig. In addition to utility maps, other desktop tools such as Google Earth can be used for initial site surveying.

However, prior to any construction, it is important to undertake a walking tour and Cable Avoidance Tool (CAT) survey of



Pole Design (11kV)

the site for each pole location. Doing so ensures there are no underground utility lines or other obstructions that could impede the construction process. It is also necessary to communicate with the DNO so they can also confirm the route does not affect their network. By taking these steps, the construction process can proceed smoothly and efficiently, with few if any unexpected obstacles.

Underground Lines

When routing underground cables, it is important to take certain precautions to ensure the safety and reliability of the system. The first step is to obtain utility maps that identify all potential infrastructure along the route. This includes sewage lines, gas lines, water infrastructure, and more. One useful tool for obtaining publicly available maps is the LineSearchBeforeYouDig online tool.

However, it is important to note that public maps are often outdated, so it is essential to verify them with updated maps closer to the construction period. This will help ensure that any potential issues are identified and addressed before construction begins. In addition to obtaining accurate maps, it is also important to ensure that the underground cabling design follows DNO standards. These standards specify the burial depth and filling materials based on the terrain and are typically available on the DNO's website.

However, prior to any construction, it is important to undertake a walking tour and an underground utility survey (CAT/Ground-penetrating Radar (GPR)) of the site. Doing so ensures there are no underground utility lines or other obstructions that could impede the construction process. It is also necessary to communicate with the DNO, the water company and gas pipeline utility so they can also confirm the route does not affect their network. By taking these steps, the construction process can proceed smoothly and efficiently, with few if any unexpected obstacles.

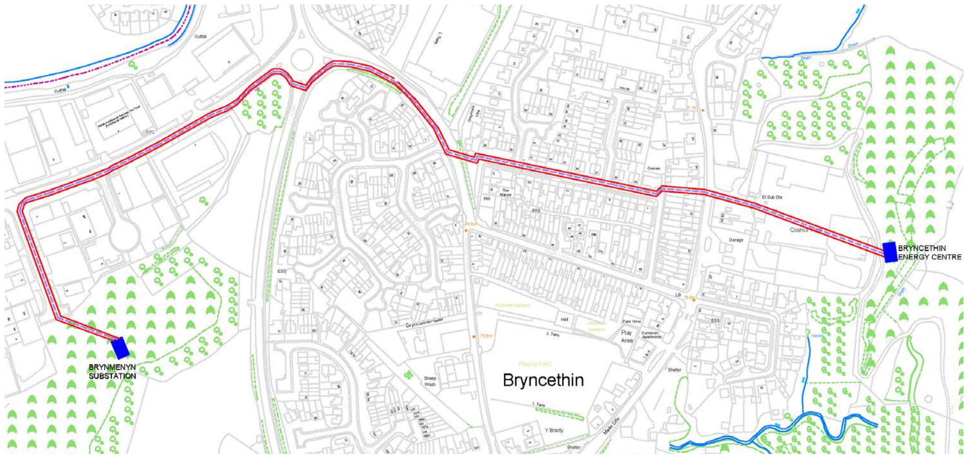
Design

When designing a route for an electrical private wire, there are several key factors to consider. First and foremost, it is recommended that you follow the design guidelines provided by your local DNO. These guidelines are typically available on their websites and specify the type of equipment, overhead line design, undergrounding requirements, and more.

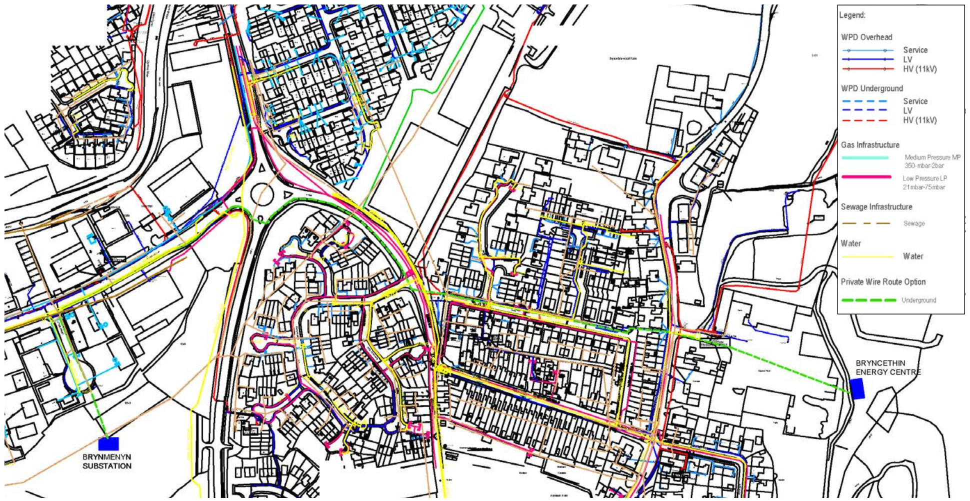
When designing the route, it is important to analyse the current DNO network to ensure that your private wire won't interfere with any existing infrastructure. Upon completion of the analysis, engage with the DNO as early as possible. Early engagement is key to ensuring that any potential issues are identified and addressed before any work progresses.

Ideally, the route should be as straight and simple as possible. This minimises the use of stays for poles, further reducing costs. In most cases, single poles are sufficient, although H-poles may be needed for certain terrain. When selecting the route, it is also important to keep to the edge of fields where possible; bear in mind surrounding farmers' needs for ploughing and other agricultural activities if crossing their fields.

Additionally, proper earthing and protection studies are required to properly protect the generator from the private wire. Finally, it is important to ensure that the equipment



Private Wire Route Map (Bryncethin to Brynmenyn)



Utility Map (Bryncethin to Brynmenyn)

installed is accessible without requiring access to or isolation from the generator's substation.

By following these guidelines, the design will yield a private wire route that is safe, efficient, and reliable.

Landownership and Wayleaves

It is highly likely that the private wire route will cross through private land. Wayleaves will be required for access rights on these sections. To obtain the necessary wayleaves, a thorough ownership survey is required. This will help identify who the landowners are and how to contact them, starting the dialogue needed to obtain the necessary permissions.

To ensure that landowners are fully informed about the project, it is recommended to visit each one in person and explain the project. It is important not to rely on emails or letters, as this can lead to misunderstandings and delays. When dealing with farmers, avoid troubling them during busy periods such as lambing or harvest – respect their schedules.

Note that easements and wayleaves incur an initial fee, which includes the costs of the land agent, as well as annual fees. When dealing with segments that cross highways, it is essential to verify that the land is privately owned. In most cases, the land will belong to the local council.

It is expected that landowners will seek more than the fair value for the use of their land. As such, it is recommended to obtain an independent valuer's report to set expectations and counter excessive pricing. Overall working with landowners is akin to working with DNOs: be prepared, well informed, and work closely together. This allows for all parties to feel comfortable with the work ahead and for the project to proceed smoothly.

Renewable Power Grid Supply

A final option for sourcing renewable power to the site is through the grid supplied using a `sleeved' renewable power purchase agreement (PPA). Electricity is supplied to the site using the existing electricity grid. It is imperative, however, to verify whether grid is capable of handling the power requirements of the site or if it needs to be reinforced. To this end, an application needs to be made to the local DNO.

Relevant Online Resources and PDF:

[9] LineSearchBeforeYouDig tool

[10] Distribution Network Operator Connection Service

[11] G99 ENA form, Version 9

Prior to making any application, a thorough evaluation of the local area and distribution infrastructure is needed. This can be done using utility maps freely available on the DNO`s data portal website, though an approval for access must be granted. These maps typically provide information for the 11kV and above lines. Access to the portals also provides the necessary planning data. Local electricity suppliers can also be identified via publicly available maps on the LineSearchBeforeYouDig tool[9].

Recall, however, that hydrogen projects above 8MW require an electricity supply voltage of 33kV or higher. Such high voltage supply may not available within the recommended 5km of the site, meaning a different supply source is needed to avoid excessive costs. This needs to be confirmed as soon as possible as it affects project viability.

Grid Connection Agreements & DNO Engagement

To obtain any connection to the grid and local distribution network, an application must be submitted to the DNO. It is best to undertake the application in steps:

1. A budget estimate can be requested from the DNO's new connection service[10]. This is a non-binding estimate of the work required for your connection to be accommodated. Usually, it is provided within one month, though beware that some DNOs levy a charge for the service (National Grid charges £300). The estimate is based on a choice of location, capacity, voltage, or technology. You will need to specify the site address, planned works, the electrical capacity required, and contact details. A letter of authority from the site owner may be requested, should you be acting on their behalf.
2. If your green hydrogen project will be utilising 33kV lines or higher, contacting the DNO's Primary Systems Design team is recommended. Doing so provides an opportunity to explain the project and understand the macro-level constraints of the DNO for your project.
3. A Formal application for a connection must be made to the new connections service, which includes:
    a. Letter of Authority dated within the last twelve months and signed by the landowner (not a land agent).
    b. G99 ENA form, Version 9[11] (including fault levels and transformer information).
    c. A map highlighting the site boundary and proposed substation location.
    d. A single line diagram detailing the electrical topology of the site.
4. Once a formal offer from the DNO is made, you have 90 days to accept, at which point it expires.
    a. Upon acceptance, 10% of the connection costs must be paid, with the balance paid as outlined in the offer.
5. Lastly, part of the offer includes a contestable element. This can be addressed by a qualified third party or by the DNO itself.

6. Basic Engineering Fast Track Project Methodology

Basic Engineering Fast Track Project Methodology

The Fast-track Guideline steers the reader through the technical development of the basic engineering aspects of a small-to-medium scale green hydrogen production facility including understanding technical inputs, developing the site layout, identifying and mitigating process hazards, developing a functional specification. Key parameters are subsequently suggested as baseline technical points to enable projects in a similar context to fast-track their development.

Based on the consideration of these factors along with experience of developing hydrogen projects generally, a high-level plan for basic engineering development was developed which included market engagement and process hazard risk review to focus on prioritised focal areas. The process hazards review methodology was developed taking account of the project factors in order to draw out process hazards and feed these back into the design.

The chapter shall refine the key component functionality and specification including development of functional specifications suitable for the construction phase EPC contractor engagement. It will include the below items, of which some high-level considerations are summarised.

Technical Inputs	Site Layout	Process Hazards Review	Functional Specification	Key Parameters
– Hydrogen Equipment Specifications – Market Capability – Site Conditions – Power Supply – Hydrogen Offtakers	– Accessibility – Material Flows – Personnel Flows – Hydrogen Safety – Constructability – Utilities & Interfaces	– Hazard Identification – Mitigation Plan – Focal Areas	– Hydrogen Equipment – Hydrogen Storage – Hydrogen Refuelling Stations – Electrical – Civils & Utilities	– For replicable small-to-medium scale green hydrogen in similar project contexts

For each key aspect, features specific to small-to-medium scale green hydrogen concept development are detailed, along with guidelines on how to streamline the project, leading to Key Parameters that may help inform future projects in a similar context.

Technical Inputs

The key technical inputs developed in the basic engineering design for the small-to-medium green hydrogen project are suggested as focal points.

Hydrogen Equipment Specifications & Market Capability

Key to the basic engineering development of the green hydrogen projects is use of real data from the market in order to ensure that the equipment can be specified under the technical assumptions of the project. A set of parameters for Alkaline and PEM electrolyser technology that can help to inform projects in a similar context is given in Chapter 4; however, each project should consider early market engagement given the fast-changing green hydrogen market.

A suggested market engagement approach is detailed as follows for hydrogen equipment suppliers (including OEMs and EPC contractors) which provides a balance between developing information for the technical development of design, as well as understanding the market requirements for the later stages of procurement:

1. Development of a long list of candidates for OEM equipment and for EPC
2. Development of a Pre-screening process, with candidates being assessed against a series of set criteria.
3. Development of a Pre-Qualification Questionnaire (PQQ) to be issued to OEM equipment suppliers and EPC contractors; an example of questions that can draw out the competence and capability of green hydrogen production suppliers is shown in Appendix A[12].
4. Responses on the PQQ Worksheet should be evaluated against a series of set criteria.
5. Successful candidates to be shortlisted for invitation to tender.

Information provided from the market is valuable and should be considered within the basic engineering design to develop the site layout and functional specification.

Site Conditions

Site condition data are particularly important at this stage of design and the key areas of focus for small-to-medium scale green hydrogen projects should be considered in the following table, with suggested level of development.

Relevant Online Resources (PDF):

[12] Example Electrolyser Vendor Questionnaire (Appendix A)

Site Condition Aspect	Level of Development	Comment
Utilities (electrical, gas, telecommunications, water, drainage)	Utility Supplier Engagement Desktop Utility Survey Ground Penetrating Radar Survey	Required to ensure civils & utilities development suitable for site location and site boundary interfaces, including acceptable flows in/out of materials (water/drainage) from site.
Ground Conditions	Geotechnical Survey (Desktop) Unexploded Ordnance Survey Geophysical Survey Coal Mining Risk Assessment Topographical Survey Site Investigation (Intrusive works)	Required to ensure civils platform is suitable and that ground condition risks are acceptable. Refer to Chapter 3 for more detail on the assessment.
Noise	Noise Assessment (including background noise measurement on site)	Required to ensure suitable equipment specification and site layout to consider noise. Refer to Chapter 3 for more detail on the assessment.
Ecology	Desktop Study On-site Surveys as required	To determine ecological requirements which may affect site positioning or specification of equipment. Refer to Chapter 3 for more detail on the assessment.
Traffic Assessment & Vehicle Tracking	Desktop Study Vehicle Tracking Plans	To ensure adequate access and traffic management provisions for construction and operation of the site. Refer to Chapter 3 for more detail on the assessment.

The data should be developed from desktop study by specialists in each area and on-site surveying developed as soon as these can be actioned.

Information developed from understanding the site conditions has a significant impact on the site location itself and particularly around definition of the interfaces e.g power supply, utilities, access etc.

Power Supply

Information of the electrical power supplies to the small-to-medium scale hydrogen facility are critical to the engineering development. Refer to Chapter 5 which discusses this aspect in detail.

Site Layout Development

Development of a site layout to the equipment-block level of detail is a significant stage to reach during the basic engineering stage. The site layout should be developed from the technical inputs defined earlier and as more information is made available, the site layout should be iterated to account for the requirements.

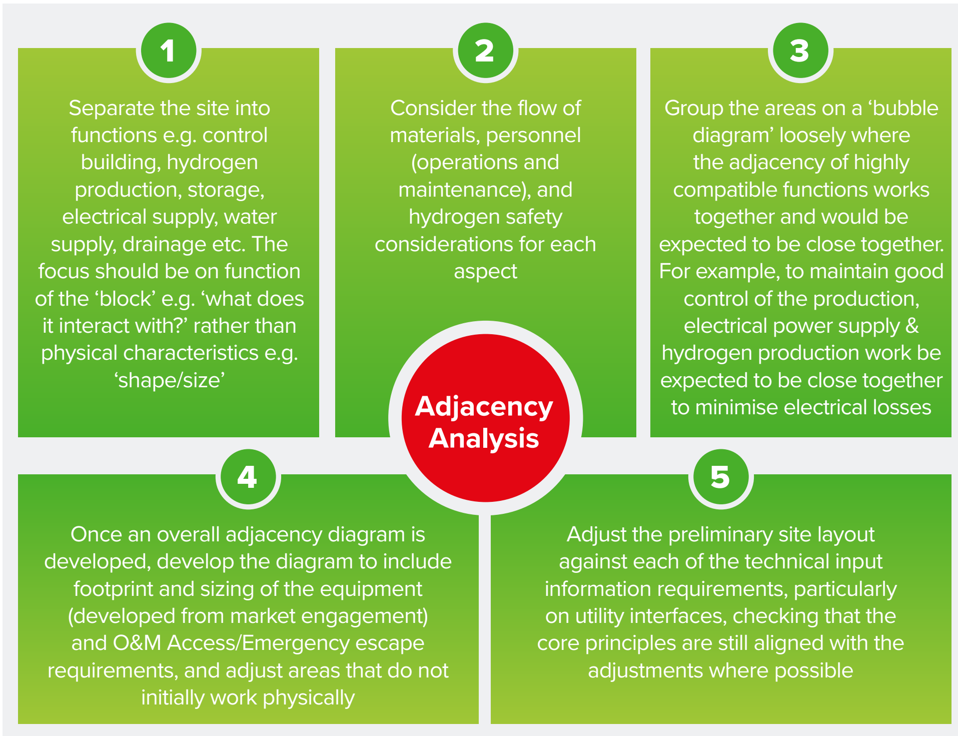
In order to minimise significant deviations in the site layout, it is important to develop a core site layout that has a design philosophy in mind accounting for key principles that when followed, result in an efficient and safe site layout.

The key principles for strong layout design in small-to-medium green hydrogen facilities are shown in the Table below.

Core Principle	Reason
Material Flow	By placing equipment and processes in the natural order of material flow, space is generally maximised, which results in more efficient and compact layouts. Minimising material flow routes also minimises cost and complexity by reducing amount of equipment which also reduces maintenance requirements and therefore increases safety of the facility.
Personnel Flow	Operational and maintenance personnel should be placed in the natural order of operating and maintaining the site, resulting in more efficient use of resources and better operation and maintenance quality.
Hydrogen Safety	A site's safety is enhanced by locating personnel at a distance from hydrogen inventories and leakage risk areas. The location of electrical equipment and other potential ignition sources away from hydrogen inventories and hydrogen leakage risk areas improves intrinsic safety and reduces the burden on engineered safety mechanisms, resulting in safer and more cost-effective sites.

The above core principles are key to developing a strong site layout that will be efficient in multiple aspects. These principles often conflict e.g. materials flow in the opposite direction to personnel flow; however, the high level principles should be followed where possible.

'Adjacency analysis' is a strong method of developing a site layout from core principles and a suggested approach is detailed below:



Process Hazard Review

Identification of process hazards for the project ensures that efforts are focused towards eliminating risks early in the design process and mitigating residual hazards where not appropriate to design out. The design and layout would be developed iteratively to incorporate these findings.

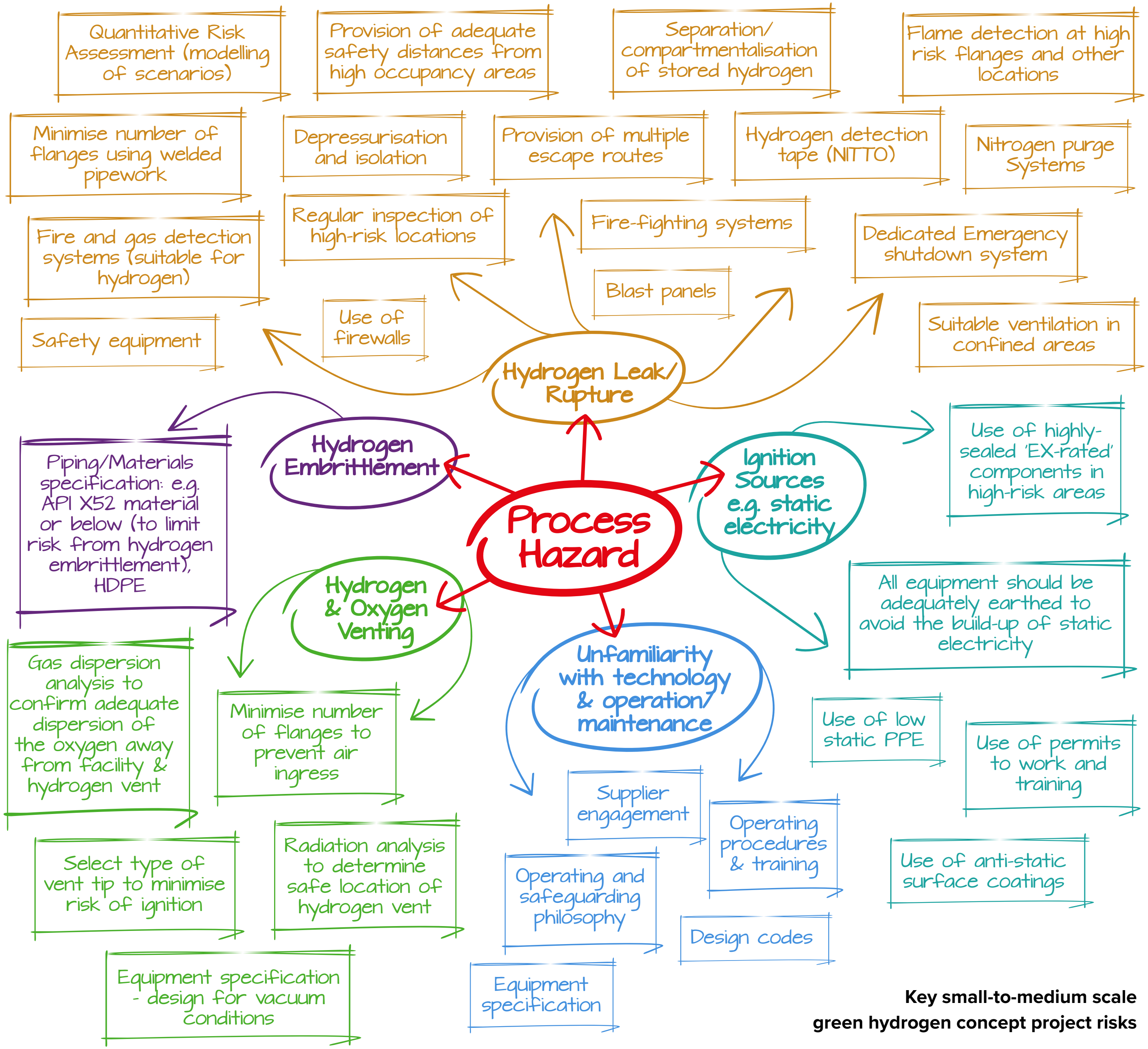
The process hazard review is suggested to commence shortly after the draft site layout is developed in a collaborative workshop environment. It is important to ensure representation of key project stakeholders at this stage to comprehensively capture potential process hazards as well as promote close engagement during the fast-track development.

The outcome of the process includes a Process Hazards Register (HAZID record)[13] with prioritised process risks which feed back into the technical design process to iterate and improve the design, and ensuring health, safety, and environmental best practice compliance.

Some of the key risk areas specific to green hydrogen projects are shown in the diagram opposite, along with suggested mitigation measures (both preventative and mitigative) to some of these process hazards – the hazards and mitigations are not exhaustive and are shown to demonstrate the considerations that may assist small-to-medium scale green hydrogen projects in a similar context.

Relevant Online Resources (PDF):

[13] Process Hazard Review Methodology (Appendix B)



Key small-to-medium scale green hydrogen concept project risks

Functional Specification Development

The functional specification is a document that outlines the requirements and specifications for the hydrogen production facility. It defines the functionality, behaviours, and performance of the hydrogen production facility, as well as the expected input and output for each function. Functional specifications include a detailed description of hydrogen production facility features, user interface design, and interactions with other systems. The document is a key document that sets the requirements of the facility to enable procurement and engagement of the onward supply chain including hydrogen equipment vendors and engineering, procurement, and construction (EPC) contractors. A strong specification allows the supply chain to understand the technical requirements and provide a market offering based on their capability.

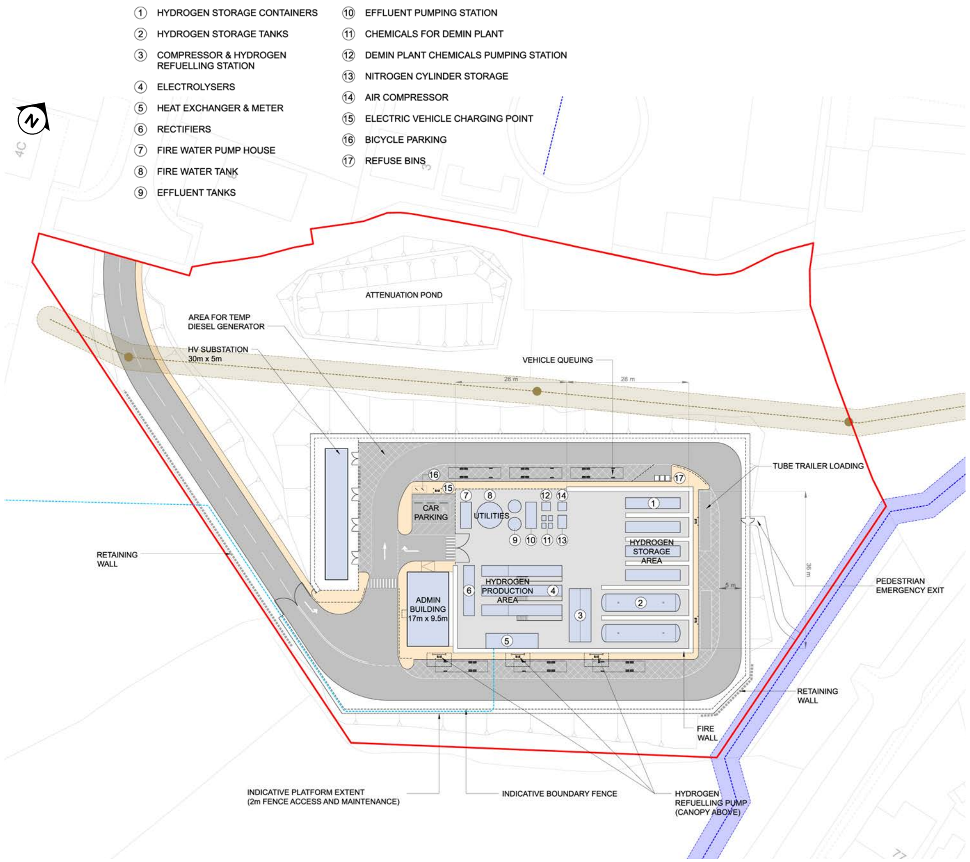
The key components that would be expected to be specified (specific to green hydrogen projects) are detailed below, along with some key areas for consideration that will need to be defined to ensure effective specification of the functions:

Key Component	Considerations
Hydrogen Equipment	Electrolyser Parameters (see Chapter 4), Pressure Levels, Control Ranges, H_2/O_2 Vent location/height & dispersion, Hydrogen Specification, Height Limits, Water Supply, Cooling System Requirements, Noise, Hydrogen Safety e.g. HVAC, Design Lifetime, Certification & Labelling, Fugitive Hydrogen Emissions, Control System, Spare Parts
Hydrogen Storage	Storage Capacity, Configuration (vertical/horizontal), Height limits, Pressure Levels, Fugitive Hydrogen Emissions, Design Lifetime, Control System, Spare Parts
Hydrogen Refuelling Stations	Refuelling Hydrogen fuel specification (purity, temperature, pressure), Refuelling rate/time, Canopies, Vehicle sizing, Cooling system, Height Limits, Design Lifetime, Control & Billing Systems, Spare Parts
Hydrogen Pipelines	Pressure Levels, Flow rates, Odourisation, Interfaces & Isolation, Design Lifetime, Control & Metering Systems, Spare Parts

Key parameter setting for hydrogen projects

Key parameter setting for small-to-medium scale green hydrogen concept and basic engineering development allows comparison to be made against projects in a similar context.

A set of baseline key parameters is given for small-to-medium scale green hydrogen project development with comments given. The suggested baseline parameters (on the following page) are provided based on lessons learnt from the Marubeni HyBont Bridgend Green Hydrogen project; each project should be considered specifically, however, the baseline parameters are unlikely to significantly deviate for a similar green hydrogen project at small-to-medium scale in this region.



Brynmenyn Green Hydrogen Production Facility - Site Layout

No.	Key Parameter	Suggested Baseline	Comment
1	Boundary requirements	Power: HV Tx (11kV to 33kV)	As a rule of thumb for capacities: • Below 5MW, 11kV distribution • Above 5MW, 33kVdistribution Power supply capacity factor from solar or wind or grid connection must be factored into the sizing of the electrolyser.
2	Footprint & layout Considerations	Production: 80-170 m^2/MW_{elect} Hydrogen Equipment: ~650m^2/MW_{elect} Full facility inc. refuelling: 1,300 m^2/MW	Approximate footprint for a hydrogen production facility: • Alkaline: 100-170 m^2/MW_{elect} • PEM: 80-130 m^2/MW_{elect} For a contained hydrogen production and storage area, excluding refueling etc., 650 m^2/MW_{elect} may be expected, with a total site footprint of 1,300 m^2 for provision of refueling station, access, and ancillaries e.g. SuDS, landscaping etc. Site selection may consider sites significantly larger than this to account for site-specific features e.g. limited access, preservation orders etc.
3	Water treatment to generate high purity water	Ion Exchange 10.5 litre per kg Reverse Osmosis 20 litre per kg	Ion exchange may be considered as a baseline, assuming typical town's water is available. Additional purification systems (such as reverse osmosis) could be considered with higher water consumption and effluent generation, but lower consumable requirements. Additional costs will be incurred if river water or sea water are selected as an alternative.
4	Hydrogen demand (transport)	~20kg/d per high-mileage heavy vehicle ~3kg/d per heavy vehicle intermittent use ~0.5 kg/d per average mileage light vehicle	Hydrogen demand may be built up for the vehicle fleets expected to be refuelled – baseline consumption data are noted for high-mileage heavy vehicles (e.g. refuse collection vehicle, buses), heavy vehicle with intermittent use (e.g. road gritter), and average mileage light vehicles e.g. cars, vans.
5	Hydrogen demand (heating)	Site-specific Multi-building heat	Hydrogen for heat is site-specific. Flexibility by exporting hydrogen for heat via tube-trailer truck may be considered given benefits to range of customers, as well as balancing hydrogen supply/demand. At the small-to-medium scale, hydrogen to provide baseload and peak heating is suitable for industrial application requiring high-grade (temperature) heat and at the multiple-building level for low grade heat (space heating/hot water) and may be considered as baseline. In particular hydrogen for heat is highly suitable to manage peak heating requirements e.g. winter heating top-up when electrical networks are stretched or renewable generation is low. Supply at the district/town level is possible at larger scale; however, seasonal effects would be more significant at this level and would require significant additional storage (such as salt cavern storage) which may not be feasible at many locations. Supply to gas grid may be considered as option.

No.	Key Parameter	Suggested Baseline	Comment
6	Electrolyser technology	PEM/Alkaline	PEM/Alkaline technologies are both considered to be a suitable solution based on technical maturity. The market is evolving quickly and early engagement with suppliers is critical. (Refer to Chapter 4 for more details).
7	Hydrogen separation system	Vendor-specific	Hydrogen separation equipment are likely to be specific to PEM/Alkaline electrolyser suppliers.
8	Hydrogen conditioning (drying and deoxygenation	Vendor-specific	Consumer requirements will determine hydrogen purity. Higher purity hydrogen would be required for fuel cells than would be required for hydrogen for heating. Hydrogen conditioning equipment are likely to be specific to PEM/Alkaline electrolyser suppliers.
9	Hydrogen compressors	Reciprocating	Multi-stage reciprocating hydrogen compression is suitable for a wide range of pressures across varying supplies/demands and may be considered as baseline. Other technologies may be suitable.
10	Hydrogen Refuelling Station	Vendor-specific	Trucks and cars have different refuelling requirements and dispenser operate at different supply pressure levels (trucks/buses 350 bar, cars and small commercial vehicles 700bar) Standard refuelling rates of 60 g/s are available in the current market (truck/bus refuel <30 mins), with faster refuelling speeds in development.
11	Hydrogen storage	1 to 5 days' production	Hydrogen storage at the small-to-medium scale is required to allow for swings in demand as well as planned or unplanned maintenance. Usually, storage is in the range of 1 to 5 days' production and 3 days' has been determined to provide a suitable storage point for small-to-medium scale facilities. It should be noted that the amount of hydrogen at the facility will affect the permitting requirements e.g COMAH (Control of Major Accident Hazards), HSC (Hazardous Substances Consent) etc. (Refer to Chapter 3 for more details).
12	Hydrogen distribution system (refuelling station and/or pipeline)	Hydrogen re-fuelling station Tube-trailer truck Pipeline	Hydrogen refuelling station to provide vehicle refuelling provides key functionality for the small-to-medium scale hydrogen facility and may be considered baseline, particularly as part of the hydrogen production facility. A refuelling station may only be located at the facility however there is also the option to include additional re-fuelling stations at more remote locations if required. Tube-trailer truck filling provides significant flexibility benefits for the small-to-medium scale hydrogen facility and may be considered baseline if distribution to more remote bulk hydrogen consumers is required. Pipeline supply of hydrogen is site-specific and will most like be used for nearby consumers with high hydrogen demands or for hydrogen for heat.

No.	Key Parameter	Suggested Baseline	Comment
13	Primary Cooling system	Air Cooling or cooling towers	There are three main options to provide cooling to the electrolyser, transformer and rectifier. The selection depends on the availability of suitable cooling sources nearby: • Open loop cooling: uses a large water source such as a river or the sea to continuously bring fresh coolant to cool the equipment. • Cooling towers: uses evaporative cooling with some consumption of water • Air cooling: transfers heat to the air so does not require a water source.
14	Waste Heat Recovery	Water Plate Heat Exchanger	Waste Heat recovery is site-specific and will most likely be used for nearby consumers with low-grade heat requirements (<50°C), which could include supply to water-source heat pumps. Waste Heat Recovery may supplement primary cooling system as part of the primary cooling system coolant loop; however, it cannot be used as sole source of cooling as it cannot be relied upon.
15	Oxygen handling system (stack or compression and storage/pipeline)	Oxygen to Vent	Oxygen is a valuable by-product that can also be sold to consumers if they are located nearby e.g. powerplants, oxy-fuel burners, aerobic digestion etc. however there is a significant additional cost for the oxygen handling/compression/storage/pipeline that may be required.
16	Effluent treatment and connection to discharge to sewer/surface water	Oil Separator with pH adjustment	Process effluent is not expected to be significantly contaminated/hazardous for a facility of this nature and scale. Effluent treatment with oil separation including pH adjustment may be considered as baseline.

7. 'Top Tips'

'Top Tips'

The journey in the preparation of this Guide has identified a number of important lessons learnt that are worth highlighting when taking forward a green hydrogen production development.

- **Public communication** - engage early and frequently. Front-loading the communication is vitally important, both from a scheme sponsor and local authority perspective. It is imperative to get as many facts as possible out into early messaging to ensure control of the narrative, given that green hydrogen production developments are a topic on which there will be little experience/knowledge locally. This will help to manage the amount of miss-information that can emerge.
- **Engineering, Procurement and Construction engagement** – PEM electrolyser manufacturing and the construction of complete hydrogen production, storage and refuelling facilities are nascent sectors. Simplifying and standardising the contracting process with defined interface points, standard contract terms and a clear scope fast-tracks the development process.
- The use of **Computer Generated Images (CGIs)** to visualise the scheme, as well as **technical factsheets** have proven invaluable in bringing the proposals to life and helping to fill the 'information gap' in a non-technical and easily understood format.
- **Establish the key physical and spatial parameters** of the scheme proposals as early as possible as that will streamline and help accelerate the technical assessment and design process.
- **Understand the electricity system** around the scheme, speak to the local distribution network operator and seek to minimise the costs of connection and any upgrade. If possible develop directly-connected (private wire) renewable electricity assets to supply as much electricity to the green hydrogen production plant as feasible.
- **Transport electricity or transport hydrogen?** Establishing the electrolyser location early on to have a 'fix' on whether the proposal will transport electricity or transport hydrogen is important. Lots of questions will emerge in particular through public consultation on site selection and 'why here?' and having a logical narrative on the reason for the electrolyser location will be one of the key components in making the case for the site-selection.

Marubeni Europower

95 Gresham Street
London EC2V 7AB
United Kingdom

T: +44 (20) 7826 8811

RPS | Consulting UK & Ireland

2 Callaghan Square
Cardiff
CF10 5AZ, United Kingdom

T: +44 (0)29 2066 8662

Marubeni
Europower