The Economic Impact of Pumped Storage Hydro

A report to Scottish Renewables
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BiGGAR Economics

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BUCCLEUCH

ILI GROUP

sse Renewables

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Foresight
FOR A SMARTER FUTURE

Contents

Glossary

LLES – Large scale, long duration electricity storage
Output Capacity – the amount of energy that a facility can generate at any one time and is typically represented in terms of megawatts (MW) or gigawatts (GW)
Storage Capacity – the amount of energy stored in a facility, based on the amount of water stored. This is typically presented in terms of gigawatt hours (GWh)
GVA – Gross Value Added, this is a measure of economic value added by an organisation or industry. It is typically estimated by subtracting the non-staff operational costs from the revenues of an organisation
Employment – this is a measure of employment which considers the headcount employment in an organisation or industry
Years of Employment – this is a measure of employment which is equivalent to one person being employed for an entire year and is typically used when considering time bound employment impacts, such as those associated with construction

1. Executive Summary

Pumped storage hydro can help the UK meets its Net Zero commitments, while generating substantial economic impacts.

By 2035, six projects being developed by members of the UK Pumped Storage Hydro Working Group are expected to substantially contribute to the UK Government's power decarbonisation target and to security of supply:

- **more than doubling pumped storage hydro's output capacity to 7.7GW**; and
- **more than quadrupling its storage capacity to 122GWh.**

The combined investment in these projects is expected to be around **£6-8 billion**. During the development and construction phase, they are expected to contribute:

- **£4.2-5.8 billion GVA** and **67,900-92,800 years of employment** in the UK (peaking at 10,700-14,800 jobs);
- including **£677-926 million GVA** and **10,600-14,500 years of employment** in the local areas where the projects are based (peaking at 1,290-1,780 jobs).

These projects will also support employment in operations and maintenance for decades after their construction. Annually, they are expected to support:

- £68 million GVA and 1,230 jobs in the UK;
- including £13 million GVA and 190 jobs in the local areas.

Pumped storage hydro can play an even bigger role in supporting the UK's energy system in the future and generate further economic impacts. To understand its potential economic impact, **an increase in output capacity to around 15GW, in line with UK Government targets,** and **an increase in storage capacity to 272GWh by 2050 was modelled**, building on the findings of the economic impact assessment.

When combined with the initial six projects it was estimated that the development and construction of pumped storage hydro would require an investment of **£19-21 billion**. By 2050, development and construction spend could generate:

- **£13.3-14.8 billion GVA** and **228,700-253,700 years of employment** in the UK (equivalent to £492-550 million GVA and 8,470-9,400 jobs annually);
- including **£2.1-2.4 billion GVA** and **30,700-34,600 years of employment** in local area (equivalent to £79-89 million GVA and 1,080-1,200 jobs annually).

By 2050 the operational impact of additional pumped storage hydro could be:

- £169 million GVA and 3,710 jobs in the UK;
- including £42 million GVA and 650 jobs in the local areas.

To meet the UK Government's Net Zero by 2050 target, substantial increases in clean, renewable energy are required. As many of these technologies, such as offshore wind, are intermittent, **flexible low carbon energy generation and storage assets are needed to support the grid**, which includes energy storage.

As the **established and proven technology**, pumped storage hydro is well-placed to play this role. Many of the best locations for pumped storage hydro are **in areas where significant renewable capacity will be added**, e.g. the north of Scotland. As a result, pumped storage hydro can:

- increase the efficiency of the grid, including through reduced curtailment;
- bring savings to consumers, requiring less transmission infrastructure and other low carbon energy generation assets; and
- increase security of supply.

Several pumped storage hydro projects have already **received planning permission**, and are therefore **'shovel ready'**, with construction able to commence once an appropriate policy and regulatory framework has been established. The technology **will continue to operate for well over 40 years** with minimal maintenance.

The construction of pumped storage hydro is very labour intensive, with a **significantly higher share of local and UK content than comparable technologies** and relatively long timescales (construction typically takes five to seven years).

This means that it can support high quality, long term employment in rural areas, that are often experiencing declines in their working age populations and lack of employment opportunities. As a result, pumped storage hydro has the potential to attract and retain working age adults and boost growth in rural areas, **supporting levelling-up**.

The alternatives to investment in pumped storage hydro, are other forms of storage or transmission that are generally **earlier stage, riskier technologies** and therefore likely to be **more expensive**. While supply chains are developing, these technologies may have a **smaller share of UK content** and **therefore generate less economic impact in rural and other areas**.

However, current market arrangements do not provide the long-term investment signals required to bring forward investment in pumped storage hydro. The barriers to large scale, long duration electricity storage, which includes pumped storage hydro, are recognised by the UK Government. **It has committed to introducing a policy to support further deployment of these technologies in 2024**.

The UK Pumped Storage Hydro Working Group **advocates for a cap and floor mechanism**, which has already been successfully introduced for interconnectors and would guarantee a minimum level of revenue. This would **reduce risk and incentivise investment.**

2. Introduction

In early 2023 BiGGAR Economics was commissioned by members of the UK Pumped Storage Hydro Working Group to estimate the potential economic impact of investment in the pumped storage hydro sector.

2.1 Pumped Storage Hydro in the UK

Pumped storage hydro is a technology that allows energy to be stored, by configuring two bodies of water at different elevations so that by allowing water to flow from the higher elevation to the lower electricity can be created, while pumping water uphill allows energy to be stored.

There are two metrics that are important for understanding the capacity of pumped storage hydro:

- the output capacity: the amount of energy that a facility can generate at any one time and is typically represented in terms of megawatts (MW) or gigawatts (GW); and
- the storage capacity: the amount of energy stored in a facility, based on the amount of water stored. This is typically presented in terms of gigawatt hours (GWh), meaning that a 6GWh facility could theoretically produce 1GW of energy for six hours.

In the UK there are currently four pumped storage hydro facilities, located in Scotland and in Wales, which have a combined storage capacity of 26.7GWh and an output capacity of 2.8GW. These four projects were commissioned between 1963 and 1984, generally with the intention of capturing excess electricity produced by nuclear power stations. It has been almost forty years since a pumped storage hydro facility has been commissioned in the UK.

In order to meet its Net Zero commitment, which include substantial increases in the capacity of intermittent renewable energy generation, the UK Government has identified a need for significantly more grid-scale storage capacity, which could include pumped storage hydro.

2.2 UK Pumped Storage Hydro Working Group

The UK Pumped Storage Hydro Working Group is convened by Scottish Renewables and is comprised of a number of developers who are taking forward proposals to develop pumped storage hydro facilities in the UK. The findings of this report are endorsed by members of the working group which, in addition to the funders of this report, include Dorothea Pumped Hydro, Gilkes Energy, CCSQ and the British Hydropower Association.

Buccleuch Estates and Foresight Energy Infrastructure Partners, Drax, Intelligent Land Investments (ILI) and SSE Renewables, who are also members of the working group, are collectively taking forward six schemes, which are being considered as part of this study (a number of other schemes are being developed which are outwith the remit of the study). The six projects are shown in Table 2-1.

Table 2-1 Pumped Storage Hydro Projects

Project (Year Operational)	Developer	Location	Output Capacity (MW)	Storage Capacity (GWh)
Red John (2027)	ILI	Highland, Scotland	450	2.9*
Glenmuckloch (2029)	Buccleuch Estates/ Foresight	Dumfries & Galloway, Scotland	210	1.6
Cruachan Expansion (2030)	Drax	Argyll & Bute, Scotland	600	1.6
Corrievarkie (2031)	ILI	Perth & Kinross, Scotland	600	14.5
Coire Glas (2031)	SSE Renewables	Highland, Scotland	1,500	30.0
Balliemeanoch (2034)	ILI	Argyll & Bute, Scotland	1,500	45.0
Total			**4,910**	**95.8**

Source: Developers, *May be up to 3.7GWh.

If all six projects were to be constructed, this would increase the UK's storage capacity by 95.8GWh to 122.1GWh (an almost 5-fold increase compared to current storage capacity), and the output capacity would increase by 4.9GW to 7.7GW.

2.3 Study Objectives and Report Structure

The key objectives of the study were to:

- understand the contribution that pumped storage hydro can make to meeting strategic policy goals and targets, which is discussed in Chapter 3;
- estimate the economic impact of planned projects, which is quantified in Chapter 4; and

- assess the scale of economic impact associated with a significant increase in pumped storage hydro, which is considered in Chapter 5.

The findings are summarised in Chapter 6, Chapter 7 provides a conclusion and summaries of the economic impact of individual projects are included in an Appendix.

3. Strategic Case

Pumped storage hydro aligns with the UK's Net Zero ambition and aspirations to level up the UK.

3.1 UK Government Net Zero Commitment

The Climate Change Act 2008 is the foundation to the UK's approach to tackling and responding to climate change[1]. It requires that emissions of carbon dioxide and other greenhouse gases are reduced, and that adaptation is undertaken to alleviate the risks posed by climate change. In 2019, the UK Government made Net Zero by 2050 a legal requirement[2].

The Sixth Carbon Budget, which was published in 2020, sets a cap on emissions for the period 2033-2037[3] and reports that to meet its Net Zero commitment, the UK needs to reduce emissions in 2035 by 63% compared to 2019. Its Balanced Pathway to reach Net Zero, is based on the UK's electricity generation being entirely decarbonised by 2035. Beyond this date further increases in electricity generation capacity will be required to meet rising energy demand, including from electrically powered heating and transportation. It projects that electricity demand in the UK will increase from 310TWh annually in 2020 to 677TWh in 2050.

Under the Balanced Pathway, variable renewable energy will reach 60% of generation by 2030, 70% by 2035, and 80% by 2050. This will mainly come from wind, particularly offshore wind. As variable renewable energy is intermittent and produces an inconsistent supply of energy, flexible low-carbon energy generation and on-demand storage, such as pumped storage hydro, will become increasingly important.

3.1.1 The Smart Systems and Flexibility Plan 2021

The Smart Systems and Flexibility Plan, published by the UK Government in 2021[4], sets out the how the country will move towards a smarter and more flexible energy system.

To date, much of the grid's flexibility has been provided by fossil fuels, where coal or gas fired power stations are turned up or down to meet varying demand. To meet Net Zero, it will be necessary to create an energy system that matches variable demand to variable renewable generation, using flexible sources that generate no or very little greenhouse gases.

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[1] UK Government (2008), The Climate Change Act 2008
[2] UK Government (2019), The Climate Change Act 2008 (2050 Target Amendment) Order 2019
[3] Climate Change Committee (2020), Sixth Carbon Budget – The UK's path to Net Zero
[4] Department for Business, Energy and Industrial Strategy (2021), Transitioning to a net zero energy system: smart systems and flexibility plan 2021

The Smart Systems and Flexibility Plan indicates that around 30GW of total low carbon flexible capacity in 2030, and 60GW in 2050, may be needed to maintain energy security and cost-effectively integrate high levels of renewable generation.

Low carbon flexibility can be provided by:

- **Flexible demand**: shifting electricity demand from periods where electricity is scarce to periods where electricity is abundant, cheaper, and cleaner. For instance, charging electric vehicles at night when there is lower demand;
- **Flexible generation**: low carbon power plants, which could use biomass, gas with carbon capture and storage or potentially hydrogen, could be used to generate electricity at short notice during periods of peak demand;
- **Smart grids and interconnection with other countries**: shifting electricity across grids and between countries to locations where it is needed, levelling out differences in supply and demand across large areas; and
- **Electricity storage**: storing low carbon energy for when it is needed, for example in batteries or in pumped storage hydro. When electricity generation is abundant, electricity can be stored for periods when it is scarce.

3.2 Energy Security

The British Energy Security Strategy, published by the UK Government in 2022[5], aims to deliver secure, clean, and affordable energy for the long term. It was published in response to substantial increases in international wholesale energy prices, which significantly increased the cost of living.

The challenges to the UK's energy security identified in the strategy are:

- reducing reliance on Russian fuel imports while maintaining security of supply;
- moderating the impact of global commodity price rises on the UK economy and businesses;
- increasing energy independence to mitigate the impact of international energy market trends; and
- maintaining the UK's commitment to reach Net Zero by 2050.

The strategy identified accelerating the energy transition as the best way to improve energy independence in the long term. Boosting low carbon power generation capacity is central to the strategy as it will allow electrification of sectors such as heat and transport using domestically generated electricity.

This will be achieved by increasing targets for the following energy generation technologies:

- **offshore wind**: increasing capacity from the current 11GW to 50GW by 2030, including 5GW of floating offshore wind energy;

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[5] UK Government (2022), British energy security strategy. Note, the Irish grid is not included.

- **onshore wind**: increasing capacity from the current 14GW with consideration given to local community views, and developments incentivised by lower electricity prices for those living in the vicinity;
- **nuclear**: increasing capacity from the current 8GW to 24GW by 2050, which could mean the constriction of up to eight new reactors; and
- **solar**: increasing capacity from the current 14GW to 70GW by 2030.

The strategy recognises that the swift expansion of intermittent power generation must be aligned with adequate energy storage capacity, the importance of which was highlighted by a prolonged period of low windspeed in the UK in 2021.

While technologies such as green hydrogen have important potential for the future, pumped storage hydro provides a reliable and well-established solution currently. It aligns with the UK's drive towards an expansion of wind energy and can increase security of supply.

3.3 The Contribution of Pumped Storage Hydro

3.3.1 The Technology

Pumped storage hydro is the longest established, most developed, and reliable large-scale energy storage technology, with facilities dating from the 1890s. As a result, it is the predominant large-scale energy storage technology worldwide, accounting for more than 96% of worldwide energy storage capacity[6]. Given this long history of more than a century in application pumped storage hydro is the most mature and reliable form of electricity storage.

It generates no emissions and is an extremely fast ramping technology that can go from zero to full output in a few minutes. It has a proven ability to perform a wide range of system services that provide flexibility and enable renewable energy integration and grid stability.

A study undertaken by researchers at University College London in 2021[7] found that a 4.5GW increase in pumped storage hydro's output capacity could lead to substantial savings of up to £690 million annually by 2050, due to increased deployment of variable technologies, such as offshore wind, and reduced need for other types of low carbon flexible generation.

It also found that pumped storage hydro can reduce overall system emissions by displacing conventional fossil fuel plants, reduce grid congestion resulting in capital savings of up to £2 billion, and deliver other ancillary grid services such as frequency response and system inertia.

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[6] Blakers et. al (2021), A review of pumped hydro energy storage.
[7] Imperial College London (2021), Whole-System Value of Long-Duration Energy Storage in a Net-Zero Emission Energy System for Great Britain

Furthermore, these schemes have very long lifetimes: the UK's oldest operational pumped storage hydro scheme is at Ben Cruachan and it has been in operation since 1963, a period of 60 years, and will continue to operate for the foreseeable future.

While in the future a range of technologies could provide large scale, long duration electricity storage, pumped storage hydro is the most proven and reliable technology, and does not require any further innovation, and can have substantial economic and other benefits.

The Scottish Government's draft Energy Strategy and Just Transition Plan[8] identifies the crucial role that pumped storage hydro will play in a future Net Zero energy system as well as the need to introduce a support mechanism to allow these projects to proceed to construction.

3.3.2 Integration with Wind Energy Production

Currently, due to constraints in the electricity grid some low carbon energy produced by wind farms is not able to be connected with consumers resulting in lower or zero output (known as curtailment), which reduces the efficiency of the energy system and increases costs to consumers.

A study for Drax found that in 2021[9], there was 2.3TWh of curtailment in the UK, equivalent to providing enough electricity to power 800,000 homes each year. The study undertaken by researchers at Imperial College London found that 4.5GW of pumped storage hydro could reduce curtailment by up to 11TWh in 2050[10].

The National Grid is investing in expanding transmission infrastructure, particularly to more fully integrate Scotland with other parts of the UK. However, given the long timeframes associated with this investment and the UK Government's substantial planned increase in offshore wind capacity to 50GW by 2030 (much of it in Scotland), grid capacity is likely to be a continuing constraint on the transmission of renewable energy.

Pumped storage hydro is a compelling solution to mitigating this inefficiency and storing the excess energy. Around 60% of wind energy curtailment lasted for more than three hours, which could be stored and used at other times if long duration storage was available, of which pumped storage hydro is the most established and commercially viable.

Furthermore, the potential sites for pumped storage hydro stations are located in Highland, Argyll and Bute, Perth and Kinross, and Dumfries and Galloway. These would be geographically well-placed to provide electricity storage for existing onshore wind developments as well as the planned offshore wind in the North Sea and North Atlantic, which may add over 25GW of capacity.

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[8] Scottish Government (2023), Draft Energy Strategy and Just Transition Plan

[9] LCP (2022), Renewable curtailment and the role of long duration storage

[10] Imperial College London (2021), Whole-System Value of Long-Duration Energy Storage in a Net-Zero Emission Energy System for Great Britain

3.3.3 Market Incentives

A report undertaken by KMPG on behalf of Drax found that due to the design of the electricity market there is a high degree of uncertainty, which disincentivises investment in pumped storage hydro[11].

Revenues from the provision of flexibility and long-duration storage services can be uncertain and highly variable. This is compounded by the long timescales associated with pumped storage hydro, which means that the energy market when the project becomes operational may be different from the environment when it was commissioned. These uncertainties, as well as the significant upfront capital costs, creates a high level of risk for investors.

To address these concerns a cap and floor mechanism is recommended, which has been effectively deployed to incentivise investment in interconnectors, another technology that can be used to balance supply and demand. Under this scheme there would be a minimum level of guaranteed revenue (the floor) so if a pumped storage hydro project does not receive enough income from its operations, its revenue would be topped up. If income exceeds the maximum level of revenue (the cap), the developer would transfer this excess to the system operator. Specific design features would also need to be included to reflect the nature of pumped storage hydro technology, particularly around the costs of charging.

This mechanism would have the benefit of addressing market challenges, without creating market distortions, would be recognised by investors and increase the efficiency.

The UK Government recognises the benefits of large scale, long duration electricity storage (LLES), which includes pumped storage hydro, as well as the barriers to deployment. It has committed to ensuring the ‘deployment of sufficient LLES to balance the overall system by developing appropriate policy to enable investment by 2024’[12] and is undertaking consultations to understand the best mechanism to deploy.

3.4 Contribution to Levelling Up and Just Transition

Most pumped storage hydro sites are in rural areas in Scotland and North Wales, where lochs or reservoirs in mountainous terrain create the opportunity to pump water from lower to higher altitudes. Economic activity associated with development and construction of pumped storage hydro in these rural areas aligns with the ambition of the UK Government to generate economic growth in regions that have been left behind and the Scottish Government's commitment to achieve a just energy transition.

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[11] KPMG (2021), Long duration storage and flexibility: Income Stabilisation Mechanism.

[12] BEIS (2022), Facilitating the deployment of large-scale and long-duration electricity storage: Government Response

3.4.1 Levelling Up

The UK Government's Levelling Up programme[13] aims to reduce regional inequality, extending economic prosperity to areas that have fallen behind. It aims to boost productivity, pay, jobs and living standards, and to spread opportunities across the UK.

Many of the local authorities identified as being of the highest priority category are rural areas and the Levelling Up Agenda aims to strengthen the economies of rural areas by developing rural infrastructure, delivering rural services, and managing the natural environment.

3.4.2 Just Transition

The Scottish Government's recently published draft Energy Strategy and Just Transition Plan highlights the importance of ensuring that all of Scotland's communities and regions share the benefits and opportunities of transitioning to Net Zero.

By bringing large scale infrastructure projects to rural and relatively remote areas of Scotland, pumped storage hydro will be an important part of delivering this objective. Additionally, by bolstering energy security by providing low-cost long duration electricity storage pumped storage hydro will have a critical role in ensuring consumers have access to affordable, reliable energy.

3.4.3 Population Projections

In rural areas, a decrease in the working age population indicates a lack of employment opportunities, as people leave for urban areas in search of greater opportunities.

Population projections for Scotland suggest that its population will increase by 3% during the time period from 2018 to 204314, compared to 9% for the UK as a whole[15]. The local authority areas where the proposed projects are based are expected to see population declines of up to 15% over the same time.

These declines are particularly concentrated in the working age population. While the working age population of Scotland is expected to fall by 4% compared to 2018 and the UK working age population is expected to increase by 3%, the local authorities considered are expected to see declines of 9-25%, equivalent to over 10,000 working age adults in each study area (Table 3-1 and Table 3-2).

[13] Department for Levelling Up, Housing and Communities (2022), Levelling Up the United Kingdom
[14] National Records Scotland (2019), 2018-based principal population projections for council areas.
[15] ONS. (2019). Principal Population Projections, 2018-based

Table 3-1 Population Projections 2018-2043 (%)

	Argyll & Bute	Dumfries & Galloway	Highland	Perth & Kinross	Scotland	UK
Total	-15%	-8%	-1%	-1%	3%	9%
0-15	-28%	-22%	-15%	-18%	-10%	-2%
16-64	-25%	-17%	-9%	-11%	-4%	3%
65+	16%	20%	34%	37%	36%	43%

Source: National Records of Scotland (2019), 2018-based principal population projections for council areas. ONS. (2019). Principal Population Projections, 2018-based.

Table 3-2 Population Projections 2018-2043 (absolute)

	Argyll & Bute	Dumfries & Galloway	Highland	Perth & Kinross	Scotland	UK
Total	-12,808	-12,221	-2,290	-1,519	+136,719	+5,982,425
0-15	-3,705	-5,176	-6,062	-4,443	-96,337	-290,567
16-64	-12,639	-14,593	-13,661	-10,164	-131,483	+1,052,172
65+	+3,536	7,548	17,433	13,088	+364,539	+5,220,795

Source: National Records of Scotland (2019), 2018-based principal population projections for council areas. ONS. (2019). Principal Population Projections, 2018-based.

3.4.4 The Role of Pumped Storage Hydro

While the areas considered in this report are projected to see significant declines in the working age population, the construction of pumped storage hydro has the potential to significantly increase economic activity and support jobs in these rural areas.

Unlike many other storage technologies, pumped storage hydro is labour intensive with a significant proportion of the work involving traditional civil engineering tasks, such as digging earth and pouring concrete, which cannot easily be outsourced. Furthermore, these are relatively long-term projects with construction times typically extending to five or seven years, providing workers with long-term employment, creating relative stability to companies and incentivising investment in plant, machinery and skills.

As a result of the nature of the employment supported and the relatively long-term contracts, pumped storage hydro has the potential to attract and retain the working age population in areas that may otherwise see significant declines.

3.5 Summary of Strategic Case

To meet the UK Government's Net Zero by 2050 target, substantial increases in clean, renewable energy are required. As many of these technologies, such as offshore wind, are intermittent, flexible low carbon energy generation assets are needed to support the grid, including energy storage and interconnectors.

As an established and proven technology, pumped storage hydro is well-placed to play this role. It is also situated in areas where significant renewable capacity will be added, e.g. the north of Scotland. As a result, pumped storage hydro can increase the efficiency of the grid, including through reduced curtailment, bring savings to consumers, requiring less transmission infrastructure and other low carbon energy generation assets, and increase security of supply.

The construction of pumped storage hydro is labour intensive, with a significantly higher share of local and UK content than comparable technologies and relatively long timescales (construction typically takes five to seven years).

This means that it can support high quality, long term employment in rural areas, that are often experiencing significant declines in their working age populations and lack of employment opportunities. As a result pumped storage hydro has the potential to attract and retain working age adults and boost growth in rural areas, aligning with the UK Government's Levelling-Up aspirations.

The UK Government recognises the benefits and barriers to developing large-scale storage, such as pumped storage hydro and has committed to developing appropriate policy to enable investment by 2024. The UK Pumped Storage Hydro Working Group recommends a cap and floor to incentivise investment.

The alternatives to investment in pumped storage hydro, are other forms of storage that are generally earlier stage, riskier technologies and therefore likely to be more expensive and take longer to deploy. While supply chains are developing, these technologies may have a smaller share of UK content and therefore generate less economic impact in rural areas.

4. Economic Impact of Proposed Projects

This chapter considers the potential economic impact of proposed pumped storage hydro schemes in the UK during their development and construction, and operational phases.

4.1 Methodology

4.1.1 Metrics of Assessment

The primary metrics of assessment used in this report are:

- Gross Value Added (GVA): this is a measure of economic value added by an organisation or industry. It is typically estimated by subtracting the non-staff operational costs from the revenues of an organisation;
- Years of employment: this is a measure of employment which is equivalent to one person being employed for an entire year and is typically used when considering time bound employment impacts, such as those associated with construction; and
- Jobs: this is a measure of employment which considers the headcount employment in an organisation or industry.

4.1.2 Types of Impact

The economic impacts associated with the development and capital expenditure are time bound impacts, whereas operational expenditure delivers long-term impact.

For each contract, an assumption was made about the proportion that would be secured in each study area by considering the ability of businesses to complete contracts and the expected shares of contracts by area provided by the developers. Each type of contract was then assigned an industrial sector from the UK's Standard Industrial Classification (SIC) codes. Based on these sectors, economic ratios and multipliers were derived, which were then used to estimate economic impacts.

There are three types of economic impact associated with similar developments:

- direct impact: this is the direct impact associated with Tier 1 suppliers, including employing and paying staff, and generating profits. This impact is calculated by dividing the expenditure on a contract by the turnover/GVA and turnover/employee ratios for the relevant sectors to estimate the direct GVA and employment impacts[16];

- indirect impact: this is the impact associated with spending in the supply chain of Tier 1 suppliers. This is captured by applying Type 1 economic multipliers[17] to the direct economic impacts; and
- induced impact: this is the impact associated with staff spending their wages in the wider economy, and is captured by subtracting Type 1 multipliers from Type 2 multipliers, and applying this to the direct impact.

4.1.3 Study Areas

The study areas considered in analysing the economic impact of the proposed pumped storage hydro projects include:

- the local authority areas in which the projects are based;
- the region/nation of the UK in which the projects are based; and
- the UK.

4.2 Increase in Installed Capacity

The six projects assessed as part of this study represent a significant increase in the UK's installed capacity of pumped storage hydro. Based on the projected operational dates provided by the developers, the total installed capacity would increase from 26.7GWh currently to 122.1GWh in 2034, an increase of 95.8GWh. This is almost five times the UK's current capacity.

The first projects could be commissioned as soon as 2027 (Red John) and 2029 (Glenmuckloch), with a significant increase in capacity occurring in 2031 when Coire Glas and Corrievarkie could become operational. Balliemeanoch could add significant capacity in 2034.

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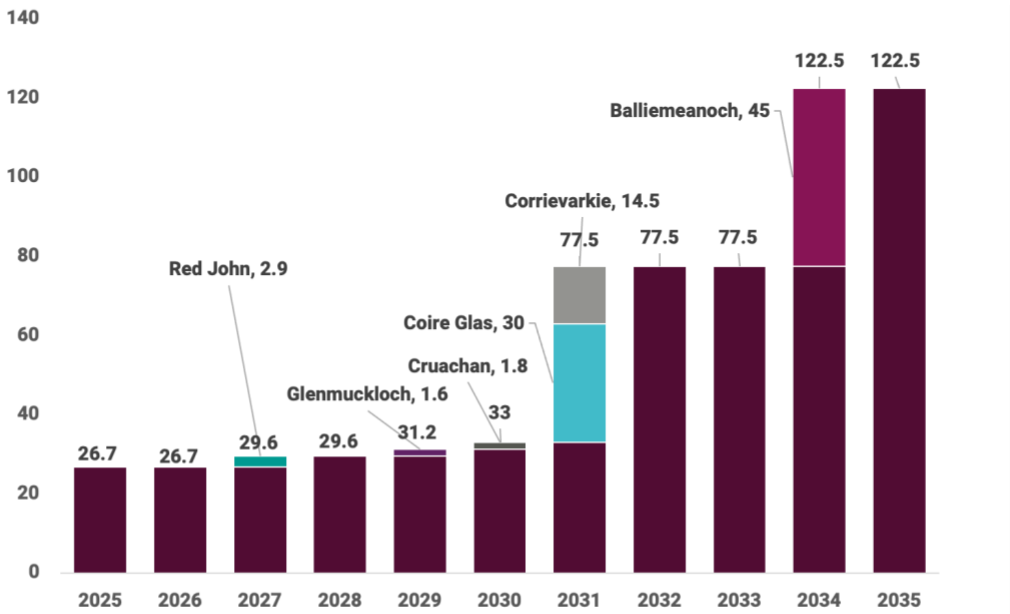
[16] ONS (2020), Annual Business Survey 2018 Revised
[17] ONS (2019), UK Economic Multipliers 2015

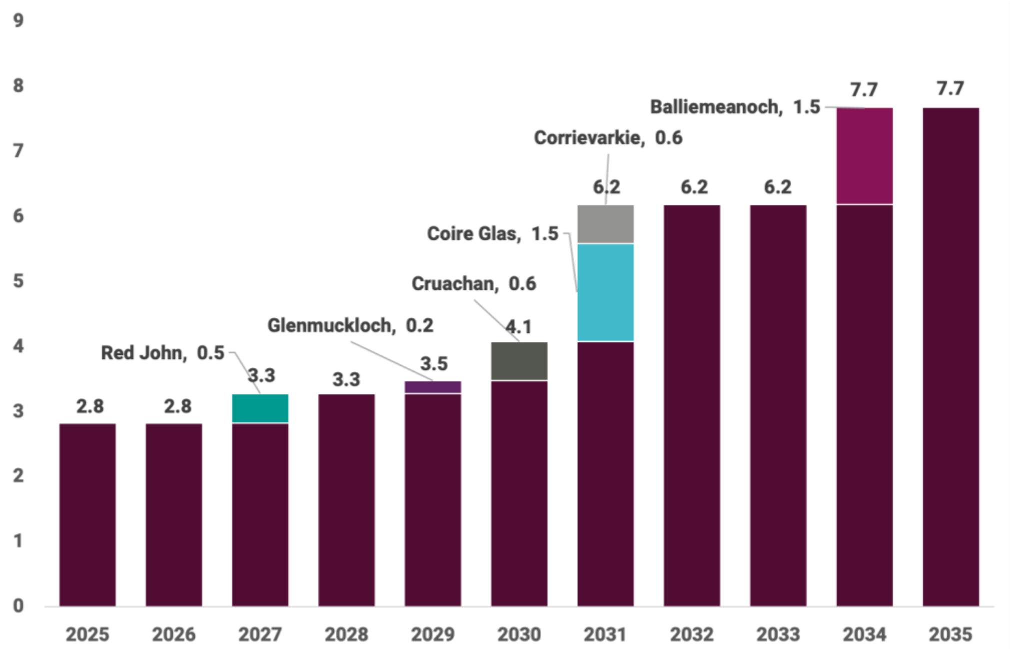
Figure 4.1: UK Installed Pumped Storage Hydro Capacity over Time (GWh), 2025-2035



Source: BiGGAR Economics Calculations based on developer data.

The UK currently has 2.8GW of pumped storage hydro output capacity, and the six proposed projects would represent an increase to 7.7GW by 2034, 4.9GW higher than currently. This is more than two and a half times the UK's current capacity.

Figure 4.2: UK Installed Output Capacity over Time (GW), 2025-2035



Source: BiGGAR Economics Calculations based on developer data.

4.3 Economic Impact of Development and Construction

Information on the overall development expenditure and capital expenditure associated with each of the projects was provided by developers, including broad breakdowns of spend by category. This suggested that the average range of construction expenditure for a project was £1.3-1.8 million per MW[18], and this has therefore been applied across the projects. On this basis, total spending would be between £5.9 billion and £8.1 billion.

To understand how this spending will generate impact, spending was split into the following component contracts:

- development and planning;
- civil engineering;
- equipment; and
- other capital spending.

The largest expenditure component was associated with civil engineering, equivalent to £4.1-5.8 billion, or 68% of total development and construction spend. Contracts associated with equipment would contribute around 19% of total expenditure. Other spending, including costs such as those associated with access roads, enabling works, and contingency and risk spending, could account for 13% of total expenditure, with development and planning accounting for less than 1%.

Table 4-1 Development and Construction Spending by Contract Type

	% Capex	Low Value (£m)	High Value (£m)
Development and Planning	<1%	18	27
Civil Engineering	69%	4,062	5,570
Equipment	19%	1,112	1,513
Other Spending	12%	730	981
Total	**100%**	**5,922**	**8,091**

Source: BiGGAR Economics Analysis. Note: Totals may not sum due to rounding.

The approach to estimating the economic impacts of the pumped storage hydro projects is based on the type of work the developments will require and the location of associated activity.

Therefore, each contract was split into more detailed components, based on information provided by the developers and analysis previously undertaken by BiGGAR Economics, and matched to certain sectors, e.g. civil engineering.

[18] This is based on market conditions and may be subject to change as projects develop further.

To understand where this economic activity will occur, assumptions were made about the share of associated contracts each study area is likely to secure. This was based on information provided by the developers, as well as the economic structure of each study area. The level of employment in each sector was also used to sense check whether the projected increase in employment would be feasible.

On this basis, they would be expected to secure £1.3-1.8 billion worth of contracts (22%), with particular strengths in civil engineering (26% of contracts).

Businesses in the UK would be expected to secure contracts worth £4.2-5.9 billion (72%), with equivalent to 90% of civil engineering spending. The lowest share would be related to equipment: while there are opportunities for British firm related to pumps, control units etc, the most significant cost will be associated with the turbine which is likely to be imported.

Table 4-2 Development and Construction Expenditure by Study Area

	Local Areas		Nation		UK	
	%	£m	%	£m	%	£m
Development and Planning	31%	6	77%	14	100%	18
Civil Engineering	26%	1,020	77%	3,131	90%	3,637
Equipment	0%	-	4%	44	10%	107
Other Spending	35%	255	60%	440	71%	519
Total (Low)	**22%**	**1,281**	**61%**	**3,629**	**72%**	**4,281**
Total (High)	**22%**	**1,754**	**61%**	**4,966**	**72%**	**5,857**

Source: BiGGAR Economics Analysis of case study evidence. Note: Totals may not sum due to rounding

Having estimated the size of the contracts that could benefit each of the study areas, it was then possible to consider the GVA and employment that these could support. Each contract category was split into its component contracts and assigned relevant industrial sectors, based on SICs[19].

In addition, the non-local workforce staying in the area during construction would be expected to have an economic impact as they spend part of their wages in the local area. This was estimated based on that these staff would spend around 25% of their wages in the local area, typically in the retail and food and beverage sectors.

Direct GVA was then estimated by applying the relevant turnover per GVA from the UK Annual Business Survey (ABS)[20]. It was therefore estimated that the proposed

[19] Office for National Statistics (2009), Standard Industrial Classification of industrial Activities (SIC 2007).
[20] Office for National Statistics (2020), Annual Business Survey 2018 - Revised.

projects could generate £472-646 million GVA in the local areas, £1.2-1.7 billion GVA in the region/nation and £1.5-2.0 billion GVA in the UK.

Table 4-3 Development and Construction, Direct GVA by Study Area (£m)

	Local Areas	Nation	UK
Development and Planning	3	7	9
Civil Engineering	342	1,048	1,221
Equipment	-	19	45
Other Spending	100	168	197
Construction Workforce	27	-	-
Total (Low)	**472**	**1,245**	**1,472**
Total (High)	**646**	**1,703**	**2,013**

Source: BiGGAR Economics Analysis of case study evidence. Note: Totals may not sum due to rounding

It was possible to estimate the number of direct jobs supported by spending in development and construction contracts by dividing expenditure in each contract by the turnover per job ratios for the relevant sectors. In this way, it was estimated that the pumped storage hydro projects could generate 7,741-10,595 direct job years in the local areas, 17,936-24,533 direct job years in the region/nation and 21,224-29,029 direct job years across the UK as a whole.

Table 4-4 Development and Construction, Direct Employment by Study Area (years of employment)

	Local Areas	Nation	UK
Development and Planning	56	130	163
Civil Engineering	4,834	14,790	17,164
Equipment	-	307	739
Other Spending	1,634	2,709	3,157
Construction Workforce	1,216	-	-
Total (Low)	**7,741**	**17,936**	**21,224**
Total (High)	**10,595**	**24,533**	**29,029**

Source: BiGGAR Economics Analysis of case study evidence. Note: Totals may not sum due to rounding

To estimate indirect (supply chain spending) and induced (staff spending) impacts, the ‘knock-on’ effects generated across the economy by spending associated with development and construction contracts, it was necessary to apply the relevant Type 1 and Type 2 GVA multipliers from the Scottish Government Input-Output Tables[21]

[21]Scottish Government (2020), Supply, Use and Input-Output Tables.

and UK Government Input-Output Tables[22] to direct GVA. Since the multipliers refer to sectoral interactions occurring at the level of the national economies, it was necessary to adjust them when considering impacts taking place locally.

Adding up direct, indirect and induced impacts, it was estimated that the proposed pumped storage hydro projects could generate £677-926 million GVA in the local areas, £2.3-3.2 billion GVA in the region/nation and £4.2-5.8 billion GVA across the UK.

As a significant share of the development and construction impacts will be generated over the long term as the projects begin the construction phase, the net present value (NPV) impact was calculated by applying a discount rate of 3.5% per year to total GVA, as recommended by HM Treasury guidance[23]. In this way, it was estimated that the NPV impact of development and construction would be £550-753 million in the local areas, £1.9-2.6 billion in the region/nation and £3.4-4.6 billion in the UK.

Accounting for direct, indirect and induced effects, it was estimated that the proposed pumped storage hydro projects could generate 10,559-14,452 job years across the local areas (peaking at 1,286-1,780 jobs), 31,532-43,129 job years in the region/nation (peaking at 4,997-6,919 jobs) and 67,879-92,848 job years across the UK (peaking at 10,694-14,807 jobs).

Table 4-5 Development and Construction, Total GVA by Study Area (£m)

	Local Areas	Nation	UK
Direct	472	1,243	1,472
Indirect	107	734	1,684
Induced	98	358	1,057
Total (Low)	**677**	**2,338**	**4,212**
Total (High)	**926**	**3,199**	**5,764**
NPV (Low)	*550*	*1,882*	*3,392*
NPV (High)	*753*	*2,573*	*4,639*

Source: BiGGAR Economics Analysis of case study evidence. Note: Totals may not sum due to rounding.

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22 ONS (2019), UK Economic Multipliers 2015

23 HM Treasury (2022), The Green Book: Central Government Guidance on Appraisal and Evaluation

Table 4-6 Development and Construction Employment by Study Area (years of employment)

	Local Areas	Nation	UK
Direct	7,741	17,904	21,224
Indirect	1,499	9,864	29,669
Induced	1,319	3,765	16,986
Total (Low)	**10,559**	**31,532**	**67,879**
Total (High)	**14,452**	**43,129**	**92,848**
Jobs Peak (Low)	*1,286*	*4,997*	*10,694*
Jobs Peak (High)	*1,780*	*6,919*	*14,807*

Source: BiGGAR Economics Analysis of case study evidence. Note: Totals may not sum due to rounding

4.4 Economic Impact of Operations and Maintenance

This section considers the long-term impacts that will occur during the operational phases of the projects to 2060. It should be noted, given the very long operational lifetimes of pumped storage hydro projects, that the projects are expected to continue operation after 2060. These impacts are different from those arising during the development and construction phase due to their longevity. As a result, the impacts in this section are presented in three formats:

- average impact, which considers the average annual impact;
- undiscounted impact, which uses the total impact to 2060; and
- NPV impact, which applies a discount rate to the figures provided in the financial analysis.

During each year of operation, the projects will create impact by hiring staff directly. Each of the developers provided estimates on the number of staff employed as well as the expected staff costs. In some cases these jobs will be based somewhere than the facility itself, and this was accounted for in the calculations.

On this basis, it was estimated that 83 direct jobs would be created in the local areas with staff costs of £6 million, and 109 jobs in the region/nation and the UK, with staff costs of £8 million.

Table 4-7 Annual Operations and Maintenance Impacts by Study Area

	Local Areas	Nation	UK
Staff costs (£m)	83	109	109
Employment	6	8	8

Source: BiGGAR Economics Analysis

As well as employing staff directly, the facilities will have impacts due to spending in their supply chains, for example minor and major maintenance, transmission costs and one-off grid costs. Based on data provided by developers, it was estimated that on average this would account for £88 million in annual supply chain spending.

By considering the expected locations of supply chain spending and expected sectors, it was estimated that the UK could benefit from a total of £54 million in operations and maintenance spending, equivalent to 61% of total operational expenditure across the projects, while the region/nation could secure from £28 million in contracts (32%) and the local areas would be expected to secure £13 million (14%)

Table 4-8 Operations and Maintenance Supply Chain Expenditure by Study Area

	Local Areas	Nation	UK	Total
Supplier Expenditure (£m)	13	28	54	88
Supplier expenditure (%)	14%	32%	61%	-

Source: BiGGAR Economics Analysis

In order to calculate the direct impacts, total staff costs were assumed to be direct GVA and direct impact generated by spending in supply chain was estimated by applying turnover/GVA and turnover/employee ratios for the relevant sectors.

As with the development and construction phase, it was necessary to estimate the indirect and induced impacts associated with operations and maintenance contracts by applying the relevant Type 1 and Type 2 GVA multipliers, determined by the sectors of spend and the operational jobs.

Adding up direct, indirect and induced impacts, it was estimated that during annual operations and maintenance, the projects could generate an average £13 million GVA in the local areas, £30 million GVA in the region/nation and £68 million GVA across the UK.

Considering the total potential impact generated by the operations of the pumped storage hydro projects to 2060, it was estimated that they could generate £389 million GVA in the local areas, £901 million GVA in the region/nation and £2.0 billion GVA across the UK.

By applying the discount rate across the total impact to 2060, the NPV impact of the projects was estimated at £186 million GVA across the local areas, £428 million GVA in the region/nation, and £954 million GVA in the UK.

Table 4-9 Operations and Maintenance, Total GVA by Study Area (£m)

	Local Areas	Nation	UK
Direct	10	21	28
on-site	*6*	*8*	*8*
Indirect	1	4	19
Induced	2	6	21
Total	**13**	**30**	**68**
Undiscounted	389	901	2,004
NPV	*186*	*428*	*954*

Source: BiGGAR Economics Analysis of case study evidence. Note: Totals may not sum due to rounding

As with GVA, direct employment associated with supply chain spending was estimated by applying the relevant turnover per job ratios of the sectors expected to carry out operations and maintenance contracts. Together with direct operational jobs, it was therefore estimated that, annually, the pumped storage hydro projects could support 151 direct jobs in the local areas, 310 direct jobs in the region/nation and 439 direct jobs across the UK.

By applying the relevant Type 1 and Type 2 GVA and employment multipliers, it was estimated that, each year of operation, the projects could generate a total 188 jobs in the local authority areas, 507 jobs in the region/nation and 1,229 jobs across the UK.

Table 4-10 Operations and Maintenance, Total Jobs by Study Area

	Local Areas	Nation	UK
Direct	151	310	439
on-site	*83*	*109*	*109*
Indirect	14	102	442
Induced	23	95	349
Total	**188**	**507**	**1,229**

Source: BiGGAR Economics Analysis of case study evidence. Note: Totals may not sum due to rounding.

5. Role in the Future Energy System

Pumped storage hydro can play a significant role in meeting the UK's future energy needs and generate substantial economic benefits.

5.1 Future Increase

As discussed in the Chapter 3, the UK has ambitious targets to increase the capacity of its electricity system, for which pumped storage hydro can play an important part.

As part of its smart systems and flexibility plan, the UK Government has outlined a vision for the capacity of low carbon flexible assets such as interconnectors and storage, to increase to 30GW by 2030 and 60GW by 2050. An increase in the capacity of pumped storage hydro and other long duration storage has not been explicitly modelled as part of this, but (mainly short-term) storage is expected to contribute 15-30GW.

The National Grid, as part of its Future Energy Scenarios strategic planning to accommodate the significant increase in intermittent renewable energy has modelled different scenarios for how much extra pumped storage hydro the UK may need by 2030 and 2050. Under the Leading the Way Pathway, the Grid envisages 64.8GWh of storage capacity and 4.8GW of output capacity by 2030, increasing to 83.7GWh and 6.0GW by 2050[24].

On this basis, the six projects would be expected to exceed the National Grid's most optimistic scenario by 2034, and it is likely that other projects in North Wales and Scotland could increase this further. This suggests that potential contribution that pumped storage hydro can make significantly exceeds government targets.

5.1.1 Modelled Scenario

Pumped storage hydro can play a significant and growing role in the future of the UK's energy mix. In order to understand the potential economic impact associated with the technology, an increase in output capacity to around 15GW by 2050 has been modelled. This represents the low end of what the UK Government expects to be required to meet the future needs of the energy system and represents around double the capacity of existing capacity and six proposed projects.

The modelled increase assumes that the total capacity will increase incrementally from 7.7GW in 2035 to 15.2GW in 2050, with a corresponding increase in the storage

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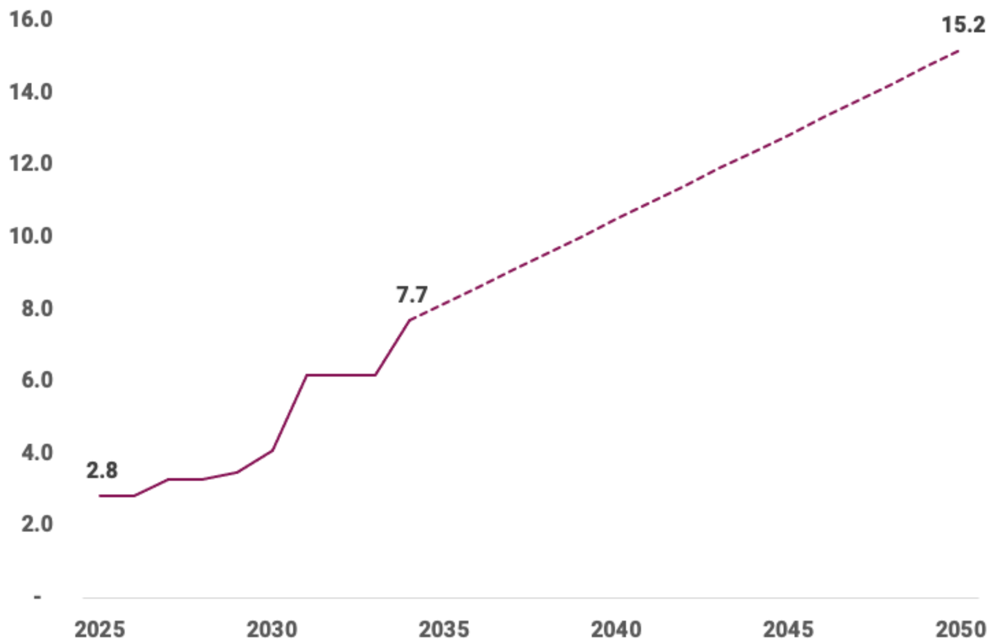
[24] National Grid (2022), Future Energy Scenarios, Data Workbook – FL.16

capacity from 122.1GWh to 272.1 GWh. This is based on a typical project consisting of 10GWh of storage capacity and 0.5GW of output capacity.

Figure 5.1: Scenario for Projected UK Installed Output Capacity, 2025-2050 (GW)



Source: BiGGAR Economics Assumptions

5.2 Development and Construction Impact

5.2.1 Illustrative 'Typical' Project

This section focuses on the 'typical' spend and impact for illustrative purposes, but this may vary considerably depending on a number of factors, such as the geographical and technical constraints of the site, the capacity of the local area or region and the decisions of the developer.

Based on the data and the characteristics of the sector it was assumed that each project element would be correlated with either the storage capacity (i.e. civil engineering costs and other costs increase in line with storage capacity) or the output capacity (e.g. spending on equipment). Development spend is assumed to be similar across projects, regardless of size.

On this basis, the 'typical' project would be expected to cost £851 million and consist of £5 million in development spend, £583 million in civil engineering spend, £162 million in equipment spend and £103 million in other spending. This is based on the higher end of the range of project spending, as it has been assumed that the current sites would be the ones that are considered most economical.

Table 5.1 Average Spending Associated with Project Elements

	Spending per unit	Typical Spend
Development (per project)	£5m	£5m
Civil Engineering (per GWh)	£58m	£583m
Equipment (per GW)	£323m	£162m
Other Spend (per GWh)	£10m	£103m
Total		**£851m**

Source: BiGGAR Economics Calculations

Based on analysis of the six projects being developed by members of the UK Pumped Storage Hydro Working Group, typical assumptions were made about the share of contracts that could be secured in each study area, though these may vary considerably depending on the project.

On this basis, it was estimated that the typical local area would secure around 22% of contracts (£184 million), while the typical region/nation would secure 61% (£521 million) and the UK would secure 72% (£615 million).

Table 5.2 Typical Spend by Area

	Local Areas		Region/Nation*		UK	
	%	£m	%	£m	%	£m
Development	30%	1	77%	3	100%	5
Civil Engineering	26%	147	77%	449	90%	522
Equipment	-	-	4%	6	10%	16
Other Spend	35%	36	60%	62	71%	73
Total spend	**22%**	**184**	**61%**	**521**	**72%**	**615**

Source: BiGGAR Economics Calculations. Region/Nation includes Scotland, Wales, North (England), North West etc.

To estimate the total GVA and employment associated with this spending, the economic ratios (i.e. turnover/GVA and turnover per employee) and multipliers (i.e. indirect and induced multipliers) were considered for each area and each project elements, including the construction workforce.

On this basis, it was estimated that the total economic impact associated with typical project would be £98 million GVA and 1,555 years of employment int the local area, £336 million GVA and 4,540 years of employment in the region/nation and £606 million GVA and 9,762 years of employment in the UK.

Table 5.3 Typical Total GVA by Study Area (£m)

	Local Areas	Region/Nation	UK
Direct	68	179	212
Indirect	15	105	242
Induced	14	51	152
Total	**98**	**336**	**606**

Source: BiGGAR Economics Calculations

Table 5.4 Typical Total Employment by Study Area (years of employment)

	Local Areas	Region/Nation	UK
Direct	1,141	2,579	3,054
Indirect	217	1,419	4,262
Induced	196	542	2,445
Total	**1,555**	**4,540**	**9,762**

Source: BiGGAR Economics Calculations

5.2.2 Impact of the Sector

On the basis of an increase in output capacity as outlined in Section 5.1.1 (i.e. increasing output capacity to around 15GW from 7.7GW, and increasing storage capacity from 122.1GWh to 272.1GWh) it was estimated that over the period from 2026 to 2050 the total investment required would be £12.8 billion, of which £2.8 billion would be secured in local areas (with an average annual spend of £115 million), £7.8 billion would be secured in regions/nations (averaging £325 million) and £9.2 billion would be secured in the UK (averaging £384 million)

To calculate the NPV it was assumed that the typical development period would be three years while the typical construction period would be six years. On this basis, the NPV of spend would be £1.6 billion in the local area, £4.6 billion in the region/nation and £5.4 billion in the UK.

Table 5.5 Total Development and Construction Spending by Study Area (£m)

	Local Areas	Region/Nation	UK	Total
Undiscounted	2,760	7,810	9,217	12,771
NPV	*1,634*	*4,600*	*5,425*	*7,392*
Average	115	325	384	526

Source: BiGGAR Economics Calculations

It was estimated that the average economic impact over time would be £61 million GVA and 838 jobs in local areas, £210 million GVA and 2,684 jobs in regions/nations and £378 million GVA and 6,701 jobs in the UK.

Table 5.6 Total Development and Construction Impact by Study Area, GVA £m)

	Local Areas	Region/Nation	UK
Undiscounted	1,470	5,033	9,081
NPV	*871*	*2,966*	*5,350*
Average	61	210	378

Source: BiGGAR Economics Calculations

Table 5.7 Total Development and Construction Impact by Study Area, Employment

	Local Areas	Region/Nation	UK
Years of Employment	20,123	64,413	160,832
Average	838	2,684	6,701

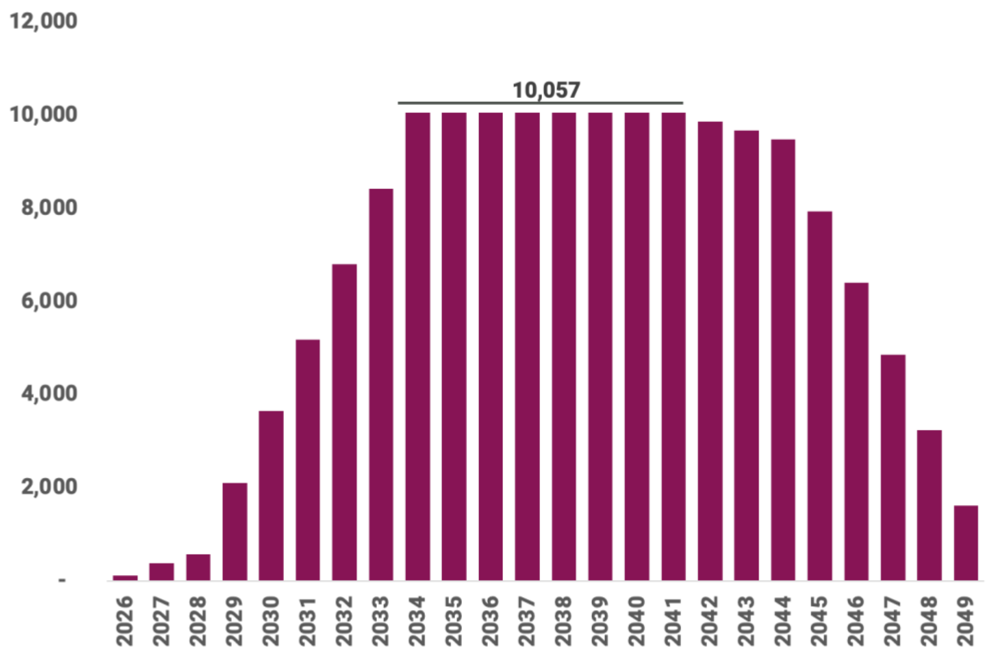
Source: BiGGAR Economics Calculations

5.2.3 Impact over Time

The long expected timescales associated with pumped storage hydro projects suggests that to increase capacity in the future, clear investment signals about the sector's role are required in advance of projects becoming operational.

On the basis of the projected increase in capacity, the timescales of impact and the economic impact per project it was estimated that UK employment associated with pumped storage hydro would peak at around 10,057 in the years between 2034 and 2041. It should be noted that this only applies to projects expected to become operational between 2026 and 2050 and the impact of projects becoming operational after this time period has not been considered.

Figure 5.2: UK Employment Supported by Projected Capacity, 2026-2049



5.3 Operations and Maintenance

As well as generating development and construction impacts, the projected increased in pumped storage hydro would also be expected to lead an increase in economic activity associated with operations and maintenance. As with development and construction, the economic impact in each of the study areas was estimated based on the information provided by developers, the economic analysis and the projected increase in capacity.

On this basis, it was estimated that the typical annual expenditure at a pumped storage hydro facility would be £10 million. This would be expected to support £2 million GVA and 35 jobs in the local area, £3 million and 65 jobs in the region/nation, and £7 million GVA and 168 jobs in the UK.

Table 5.8 Typical Operations and Maintenance Impact

	Local Areas	Region/Nation	UK
Turnover (£m)	3	4	7
GVA (£m)	2	3	7
Employment	35	65	168

Source: BiGGAR Economics Calculations

By 2050, it is projected that annual operational expenditure of the sector would be £156 million, and that this would support £29 million GVA and 463 jobs in local areas, £50 million GVA and 864 jobs in the regions/nations and £102 million GVA and 2,481 jobs in the UK.

Table 5.9 Operations and Maintenance Impact of Sector, 2050

	Local Areas	Region/Nation	UK
Turnover (£m)	43	67	108
GVA (£m)	29	50	102
Employment	463	864	2,481

Source: BiGGAR Economics Calculations

Over the period from 2035-2060, it was therefore estimated that the total economic impact would be £534 million GVA in the local areas (£211 million NPV), £924 million GVA in the region/nation (£365 million NPV) and £1.9 billion GVA in the UK (£742 million NPV).

Table 5.10 Total Operational Impact by Study Area, GVA (£m) 2035-2060

	Local Areas	Region/Nation	UK
Undiscounted	534	924	1,878
NPV	211	365	742

Source: BiGGAR Economics Calculations

6. Economic Impact Summary

This section summarises the quantitative economic impacts associated with pumped storage hydro.

6.1 Development and Construction

Based on the six projects being developed plus the projected increase in capacity, it was estimated that an increase to around 15GW of output capacity would require investment of £18.7-20.9 billion. Of this, around £4.0-4.5 billion (22%) could be secured in local areas, £11.4-12.8 billion could be secured in regions/nations (61%) and £13.5-15.1 billion could be secured in the UK (72%).

Table 6.1 Total Development and Construction Spend, 2023-2050

	Local Areas	Region/Nation	UK	Total
Spending (Low) (£bn)	4,041	11,439	13,498	18,693
Spending (High) (£bn)	4,515	12,775	15,074	20,862
Spending (%)	22%	61%	72%	-

Source: BiGGAR Economics Calculations

The average annual impact to 2050 was estimated to be £79-89 million GVA and 1,078-1,200 jobs in local areas, £273-305 million GVA and 3,556-3,986 jobs in the region/nation and £492-550 million GVA and 8,471-9,396 jobs in the UK.

Table 6.2 Total Development and Construction Impact 2023-2050, GVA (£bn)

	Local Areas		Region/Nation		UK	
	Low	High	Low	High	Low	High
Undiscounted	2.1	2.4	7.4	8.2	13.3	14.8
NPV	*1.4*	*1.6*	*4.8*	*5.5*	*8.7*	*10.0*
Average (£m)	79	89	273	305	492	550

Source: BiGGAR Economics Calculations

Table 6.3 Total Development and Construction Impact by Study Area, Employment

	Local Areas		Region/Nation		UK	
	Low	High	Low	High	Low	High
Employment	30,682	34,575	96,000	107,619	228,711	253,681
Average	1,078	1,200	3,556	3,986	8,471	9,396

Source: BiGGAR Economics Calculations

6.2 Operations and Maintenance

It was estimated that by 2050 the proposed increase in capacity could lead to an operations and maintenance impact of £42 million GVA and 651 jobs in local areas, £80 million GVA and 1,372 jobs in regions/nations and £169 million GVA and 3,710 jobs in the UK.

Table 6.4 Total Operations and Maintenance Impact, 2050

	Local Areas	Region/Nation	UK
GVA (£m)	42	80	169
Employment	651	1,372	3,710

Source: BiGGAR Economics Calculations

Based on the projected capacity, it was estimated that the total impact between 2023 and 2060 would be £923 billion GVA in the local areas (£397 million NPV), £1.8 billion GVA in regions/nations (£793 million NPV) and £3.9 billion GVA in the UK (£1.7 billion NPV).

Table 6.5 Total Operations and Maintenance Impact 2023-2060, GVA (£m)

	Local Areas	Region/Nation	UK
Undiscounted	923	1,825	3,882
NPV	*397*	*793*	*1,696*

Source: BiGGAR Economics Calculations

6.3 Total Expenditure

The total expenditure between 2023 and 2060, could generate £3.1-3.3 billion GVA in local areas, £9.2-10.1 billion GVA in regions/nations and £17.2-18.7 billion GVA in the UK.

Table 6.6 Total Impact 2023-2060, GVA (£bn)

	Local Areas		Region/Nation		UK	
	Low	High	Low	High	Low	High
Undiscounted	3.1	3.3	9.2	10.1	17.2	18.7
NPV	*1.8*	*2.0*	*5.6*	*6.3*	*10.4*	*11.7*

Source: BiGGAR Economics Calculations

7. Conclusion

Pumped storage hydro sector can make a significant contribution to helping the UK meet its Net Zero commitments and generate substantial economic benefits.

The UK was the first major economy to pass legislation to commit to a legally binding Net Zero target. The UK Government has also been clear that economic growth is a priority. One of the five immediate priorities of the Prime Minister for 2023 was to: "*grow the economy, creating better-paid jobs and opportunity right across the country.*"[25]

When the Department for Energy Security and Net Zero was established in February 2023, one of the six priority outcomes identified was to: "*seize the economic benefits of Net Zero, including the jobs and growth created through investment in new green industries.*"[26]

Pumped storage hydro has the potential to deliver on multiple policy objectives, including:

- Contributing to the **Net Zero** 2050 target, increasing **security of supply** and bringing **savings to consumers** by providing the energy storage required by substantial increases in renewable energy;
- Generating **substantial economic benefits for the UK**, since the construction of pumped storage hydro is very labour intensive, with a significantly higher share of local and UK content than other energy storage technologies;
- Providing **jobs and growth across the country**, including high quality, long term employment in **rural areas**, that are often experiencing declines in their working age populations and lack of employment opportunities.

However, current market arrangements do not provide the long-term investment signals required to bring forward investment in pumped storage hydro. The UK Pumped Storage Hydro Working Group advocates for a cap and floor mechanism, which has already been successfully introduced for interconnectors and would guarantee a minimum level of revenue. This would reduce risk and provide strong market signals.

[25] Prime Minister's Office (4 January 2023), Prime Minister sets out his five key priorities for 2023: Speech by Prime Minister Rishi Sunak
[26] Cabinet Office and Prime Minister's Office (7 February 2023), Making Government Delivery for the British People

This could unlock substantial private sector investment, which will have significant economic benefits in the UK and in the local areas where projects take place. It was estimated that the six projects developed by the UK Pumped Storage Hydro Working Group and potential growth to 2050 would require an investment in development and construction of **£19-21 billion**. By 2050, this investment could generate economic impacts of:

- £13.3-14.8 billion GVA and 228,700-253,700 years of employment in the UK (equivalent to £492-550 million GVA and 8,470-9,400 jobs annually);
- including £2.1-2.4 billion GVA and 30,700-34,600 years of employment in local area (equivalent to £79-89 million GVA and 1,080-1,200 jobs annually).

8. Appendix: Project Summaries

8.1 Balliemeanoch

Balliemeanoch Pumped Storage Hydro is a proposed scheme consisting of 45.0GWh of storage capacity and an output capacity of 1,500MW. This would make it the largest pumped storage hydro scheme in the UK.

The developer is Intelligent Land Investments, and the scheme is located in Argyll and Bute, 9km northwest of Inveraray and 3km east of the village of Balliemeanoch. It will expand the existing body of water at Lochan Airigh and connect it to Loch Awe to its north.

The scheme is currently under development with a scoping report submitted in 2022. It is anticipated that construction could begin as soon as 2030, with the scheme becoming operational in 2034.

Over the construction period, it was estimated that Balliemeanoch could contribute:

- £187-259 million GVA and 3,024-4,188 years of employment in Argyll and Bute (with employment averaging 275-381 jobs over 11 years);
- £762-1,056 million GVA and 10,302-14,266 years of employment in Scotland (with employment averaging 937-1,297 jobs); and
- £1,370-1,897 million GVA and 22,094-30,597 years of employment in the UK (with employment averaging 5,510-7,630 jobs).

During the operational phase, it was estimated that each year Balliemeanoch could contribute:

- £4 million GVA and 57 jobs in Argyll and Bute;
- £10 million GVA and 175 jobs in Scotland; and
- £24 million GVA and 437 jobs in the UK.

8.2 Cruachan Expansion

The Cruachan Expansion is a proposed scheme to expand the existing Cruachan Pumped Storage Hydroelectric generation station, which first opened in 1965, the first reversible pumped storage hydro system of its scale. The proposed expansion would consist of an additional 1.6GWh of storage capacity (though this is subject to change) and an output capacity of 600MW.

The developer is Drax, and the scheme is located in Argyll and Bute, at the Cruachan Reservoir by Loch Awe. The scheme is currently under development with an application submitted to the Scottish Government in May 2022. It is anticipated that construction could begin as soon as 2025, with the scheme becoming operational in 2030.

Over the construction period, it was estimated that Cruachan Expansion could contribute:

- £61-73 million GVA and 9673-1,172 years of employment in Argyll and Bute (with employment averaging 139-167 jobs over 7 years);
- £217-261 million GVA and 3,039-3,657 years of employment in Scotland (with employment averaging 434-522 jobs); and
- £395-475 million GVA and 6,531-7,861 years of employment in the UK (with employment averaging 933-1,123 jobs).

During the operational phase, it was estimated that each year the Cruachan Expansion could contribute:

- £1 million GVA and 7 jobs in Argyll and Bute;
- £2 million GVA and 22 jobs in Scotland; and
- £3 million GVA and 49 jobs in the UK.

8.3 Coire Glas

Coire Glas Pumped Storage Hydro is a proposed scheme consisting of 30GWh of storage capacity and an output capacity of up to 1,500MW.

The developer is SSE Renewables, and the scheme is located near Loch Lochy in Scottish Highlands, approximately 10km from the village of Invergarry.

The scheme is currently under development with planning consent received in 2020. It is anticipated that construction could begin as soon as 2024, with the scheme becoming fully operational in 2031.

Over the construction period, it was estimated that Coire Glas could contribute:

- £221-307 million GVA and 3,370-4,668 years of employment in Highland (with employment averaging 421-583 jobs over 6 years);
- £675-935 million GVA and 9,076-12,570 years of employment in Scotland (with employment averaging 1,134-1,571 jobs); and
- £1,212-1,678 million GVA and 19,456-26,947 years of employment in the UK (with employment averaging 2,432-3,368 jobs).

During the operational phase, it was estimated that each year Coire Glas could contribute:

- £3 million GVA and 48 jobs in Highland;
- £7 million GVA and 142 jobs in Scotland; and
- £18 million GVA and 351 jobs in the UK.

8.4 Corrievarkie

Corrievarkie Pumped Storage Hydro is a proposed scheme consisting of 14.5GWh of storage capacity and an output capacity of 600MW.

The developer is Intelligent Land Investments, and the scheme is located in Perth and Kinross, near Loch Ericht, around 8km west of the village of Dalnaspidal.

The scheme is currently under development with a scoping report submitted in 2021. It is anticipated that construction could begin as soon as 2027, with the scheme expected to become operational in 2031.

Over the construction period, it was estimated that Corrievarkie could contribute:

- £79-110 million GVA and 1,285-1,781 years of employment in Perth and Kinross (with employment averaging 161-223 jobs over 8 years);
- £343-474 million GVA and 4,566-6,325 years of employment in Scotland (with employment averaging 571-791 jobs); and
- £608-842 million GVA and 9,713-13,455 years of employment in the UK (with employment averaging 1,214-1,682 jobs).

During the operational phase, it was estimated that each year Corrievarkie could contribute:

- £3 million GVA and 31 jobs in Perth and Kinross;
- £5 million GVA and 76 jobs in Scotland; and
- £11 million GVA and 182 jobs in the UK.

8.5 Glenmuckloch

Glenmuckloch Pumped Storage Hydro is a proposed scheme consisting of 1.6GWh of storage capacity and an output capacity of 210MW.

The scheme is being developed by Buccleuch Estates and Foresight Energy Infrastructure Partners, and will be located in Dumfries and Galloway, approximately 4km from Kirkconnel.

The scheme was granted planning consent in 2016, with consent extended in 2022. Construction is expected to begin as soon as 2023, with the scheme anticipated to be operational by 2029.

Over the construction period, it was estimated that Glenmuckloch could contribute:

- £56-77 million GVA and 778-1,078 years of employment in Dumfries and Galloway (with employment averaging 130-180 jobs);
- £85-117 million GVA and 1,175-1,631 years of employment in Scotland (with employment averaging 196-272 jobs); and
- £170-236 million GVA and 2,760-3,831 years of employment in the UK (with employment averaging 460-638 jobs).

During the operational phase, it was estimated that each year Glenmuckloch could contribute:

- £1 million GVA and 20 jobs in Dumfries and Galloway;
- £1 million GVA and 36 jobs in Scotland; and
- £3 million GVA and 77 jobs in the UK.

8.6 Red John

Red John Pumped Storage Hydro is a proposed scheme consisting of 2.9GWh of storage capacity and an output capacity of 450MW.

The developer is Intelligent Land Investments, and the scheme is located in Highland, just east of Loch Ness.

An environmental impact assessment was submitted in 2018 and consent was granted in 2021. It is anticipated that construction could begin as soon as 2024, with the scheme becoming operational in 2027.

Over the construction period, it was estimated that Red John could contribute:

- £72-100 million GVA and 1,128-1,565 years of employment in Highland (with employment averaging 282-391 jobs over 4 years);
- £256-355 million GVA and 3,431-4,757 years of employment in Scotland (with employment averaging 858-1,189 jobs); and
- £458-634 million GVA and 7,325-10,157 years of employment in the UK ((with employment averaging 1,831-2,539 jobs).

During the operational phase, it was estimated that each year Red John could contribute:

- £2 million GVA and 26 jobs in Highland;
- £4 million GVA and 57 jobs in Scotland; and
- £9 million GVA and 133 jobs in the UK.

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