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Facilitating energy storage to allow high penetration of intermittent renewable energy

Development of Bulk Energy Storage & Natura 2000

Deliverable 3.3

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Acronyms

AA	–	Appropriate Assessment
CAES	–	Compressed Air Energy Storage
CCS	–	Carbon Capture and Storage
EC	–	European Commission
ECJ	–	European Court of Justice
EIA	–	Environmental Impact Assessment
EST	–	Energy Storage Technology
EU	–	European Union
FCS	–	Favourable Conservation Status
GW	–	Gigawatt
NK2	–	Natura 2000
MW	–	Megawatt
PHES	–	Pumped Hydro Energy Storage
PV	–	Photovoltaic
RES	–	Renewable Energy Source
RES-E	–	Renewable Energy Sources for Electricity generation

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Executive Summary

The Birds and Habitats Directives can have a significant bearing on the success or otherwise of a new Pumped Hydro Energy Storage (PHES) and Compressed Air Energy Storage (CAES) development. The purpose of this document is to provide sector specific guidance on how best to ensure that PHES and CAES developments are compatible with the provisions of the Birds and Habitats Directive with particular focus on Article 6 procedures. The guidance is designed for use by competent authorities, developers and consultants and will be of interest to Non-Governmental Organisations and other stakeholders.

The main bulk Energy Storage Technologies (EST) plants available are PHES and CAES. PHES can be categorised further according to water management as closed loop, semi-open or open systems. PHES is currently the only commercially proven large scale (5 MW – 2 GW) EST with over 300 plants installed worldwide with a total installed capacity of over 95 GW (Roberts, 2009).

The main elements of a PHES scheme include two water reservoirs, a power house and a penstock and tailrace connecting the power house to the upper and lower reservoirs respectively. When energy production exceeds demand, the excess energy is used to pump water from the lower to the upper reservoir and during times of peak demand, water is released from the upper reservoir to flow through turbines, into the lower reservoir, producing hydroelectric power.

The Birds and Habitats Directives form the cornerstone of the EU's nature conservation policy that is built on two pillars: (1) the Natura 2000 (N2K) network of protected sites and (2) the system of species protection. The Habitats Directive requires the appropriate assessment of the implications of plans or projects for N2K site/s. The appropriate assessment process 'tests' whether the plan or project will have '*an adverse effect on the integrity of the site*'.

PHES developments are large infrastructural projects involving major civil, mechanical and electrical engineering works and by their nature, size and scale they have the potential to have significant environmental effects. PHES developments are inextricably linked to water resources and watercourses (e.g. rivers, lakes and artificial reservoirs). Depending on the quality and the level of human interference, water environments can support important and threatened habitats and species. This potential interaction between ecological resources and PHES can result in potentially significant ecological impacts.

An appropriate assessment is undertaken subsequent to a plan or project being subjected to the screening exercise. Due to the size, scale and nature of PHES and CAES developments, there will be a requirement for them to be screened for appropriate assessment in nearly all cases. An appropriate assessment is an impact assessment tool to determine the implication of a plan or project on the integrity of the N2K site, either alone or in combination with other plans and projects, with respect to the site's ecological health (structure and function) and its conservation objectives.

Importantly, the outcome of the assessment informs decision-making, that is, it is legally binding. If the outcome of the assessment is positive and no reasonable scientific doubt remains regarding the absence of negative effects to the site, then the competent authority can grant consent and authorise the plan or project. **The competent authority shall only approve or authorise a PHES or CAES project having ascertained that it will not adversely affect the integrity of the site/s concerned.**

Where adverse impacts cannot be ruled out, the assessment must proceed to Stage 3 where alternative solutions are examined. Alternative design, sites and technologies need to be examined to determine if they can feasibly achieve the objective of the plan or project. Where a feasible alternative is identified, then it must be subject to a screening exercise and process repeated as necessary.

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Where no alternatives exist, the plan or project must proceed to Stage 4. A decision must be taken on whether it is considered to qualify as a plan or project of ‘imperative reasons of overriding public interest’ (IROPI). If it qualifies, adequate compensatory measures must be designed to ensure the coherence of the N2K network.

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1. Introduction

1.1. Nature of the document

The purpose of this document is to provide guidance on how best to ensure that new bulk Energy Storage Technology (EST) developments are compatible with the provisions of the Birds and Habitats Directive. The main provision of the Habitats Directive is the protection of the ecological integrity of the N2K network. The bulk EST developments under consideration in this document are Pumped Hydro Energy Storage (PHES) and Compressed Air Energy Storage (CAES). Due to the low number of operational CAES worldwide the main emphasis of the document is on PHES.

The focus of this document will be around the stepwise procedure for the assessment of the potential impact of new PHES and CAES plans or projects on the ecological features (e.g. protected habitats, species) for which a site is designated. The assessment is based on Article 6(3) and 6(4) of the Habitats Directive, which provide procedural safeguards to ensure any new development is undertaken in a sustainable manner in the context of Natura 2000 (N2K) sites.

The assessment refers to the process by which relevant information is gathered by project or plan proponents and presented to the competent authority for consideration and evaluation. It is the competent authority that makes the decision to approve the plan or project, or not, based on the information received.

The guidance is designed for use by competent authorities, developers and consultants and will be of interest to Non-Governmental Organisations and other stakeholders.

While this document provides guidance on the application of the Birds and Habitats Directives; it is not of a legally binding nature. It rests with the European Court of Justice to ultimately interpret a directive through cases brought before it.

The guidance should be read in conjunction with the directives and national legislation as well as other EC guidance documents.

1.2. Structure of the document

Section 1	In the introduction the need for guidance is established.
Section 2	Following the introduction, an overview of PHES and CAES technology is provided to ensure the reader has a good comprehension of the types of bulk EST under consideration in this document.
Section 3	Further detail is provided on the characteristics of PHES projects, examining potential environmental impacts associated with PHES and CAES projects while focusing on ecological related impacts.
Section 4	The policy context of this guidance is presented describing the Birds and Habitats Directives as well as their interrelationship with EIA and SEA.
Section 5	The interrelationship of plans and projects and the importance of carrying out appropriate assessment early in the plan or project development process are discussed.
Section 6	The final section contains the main stage by stage guidance for new bulk EST projects.

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1.3. *Need for Guidance*

A need for future development of bulk ESTs has been recognised by the stoRE project and other sources (see Zach *et al*., 2012). As a consequence of the large size, scale and nature of these developments potential interactions with N2K sites may arise. This document provides guidance on the approval procedure ensuring future development is compliant with the provisions of the Birds and Habitats Directives.

1.3.1. Need for Bulk EST

The stoRE project examines the role that bulk EST could play in allowing greater penetration to the grid of intermittent renewable energy such as wind and photovoltaic (PV) by providing ancillary services. These services may include balancing supply and demand and improving power quality. As mentioned, the bulk ESTs considered in this document are Pumped Hydro Energy Storage (PHES) and Compressed Air Energy Storage (CAES). Other bulk ESTs, such as hydrogen fuel cell storage are not considered.

One of the tasks of the stoRE project was to examine the need for bulk EST in Europe and the related findings are set out in a report by Zach et al., 2012. In the report, it was outlined that the major applications for bulk EST are expected to be management of variable / intermittent RES-E (Renewable Energy Sources for Electricity generation) and energy price arbitrage, i.e. storing RES-E generation in off-peak hours and re-storing it again. Other applications outlined include the provision of secondary and tertiary control reserves. With the age related phasing out of thermal power plants in the future, new power plant capacities will be required. The resultant gaps can be filled with PHES systems or new flexible thermal power plants. The report concludes that there is a strong requirement for existing and new PHES in almost all of the European electricity market regions to (partly) cover the future electricity generation gap.

1.3.2. N2K Network of Sites

Among the tasks of the stoRE project was the production of a guidance document on the development of bulk EST, namely PHES and CAES, plans or projects that might affect N2K sites. These are sites that have been designated under EU nature legislation i.e. Birds (2009/147/EC) and Habitats (92/43/EEC) Directives, for the protection of habitats and species that are considered of European importance and that are managed by the Member States for nature conservation. These protected sites are collectively referred to as the N2K network. The network aims to ensure the long-term survival of valuable and threatened habitats and species. N2K is not a system of strict nature reserves where all human activities are excluded. While the network includes nature reserves, most of the land is privately owned, with the emphasis on ensuring that future management is sustainable, both ecologically and socio-economically. N2K sites include Special Protection Areas (SPAs) and Special Areas of Conservation (SACs).

Figure 1 below illustrates their wide and frequent distribution across the EU.

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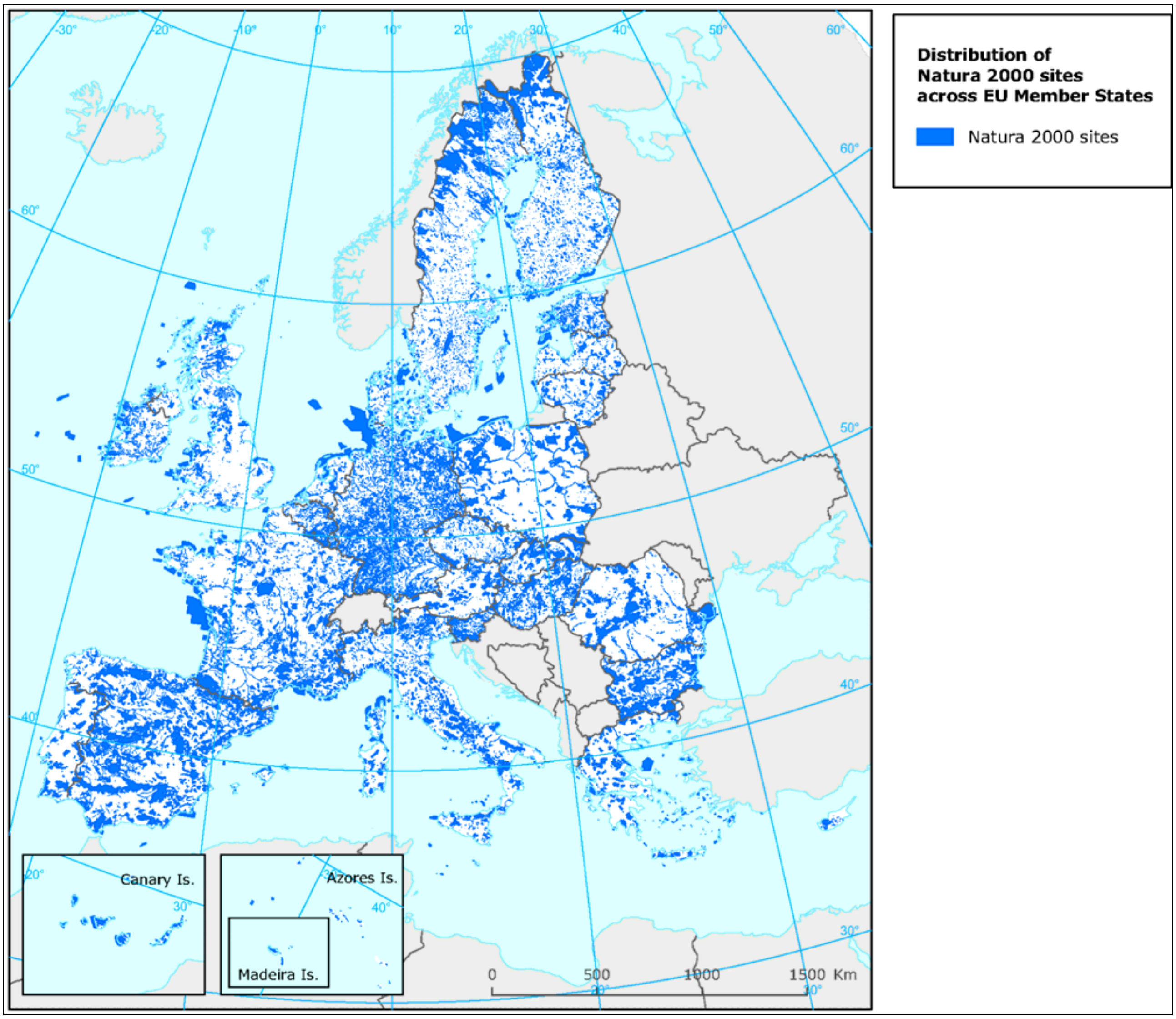

Figure 1. Distribution of N2K sites across the 27 EU Member States (source: EEA)

1.3.3. Environmental Implications of Future Bulk EST Developments

PHES and CAES are large civil projects with potentially significant environmental impacts. Many of the existing EST developments were built in the past in a time when fewer environmental regulations existed. Current and future developments must be carried out in a sustainable manner and be compliant with relevant European environmental directives.

As well as providing for the conservation of N2K sites, the Habitats Directive provides for the assessment of development proposals which are likely to impact on designated sites. PHES and CAES are proven technologies but future development is limited by site restrictions. With the widespread and frequent coverage of N2K sites across Member States together with the large size, scale and nature of bulk EST developments, PHES and CAES projects have the potential to interact with N2K sites. PHES are often located in more remote or rural upland areas with significant topography and have strong associations with watercourses (lakes, river, groundwater, coastal waters). It is commonplace for watercourses in such areas to be designated as part of the N2K network. Therefore, new PHES developments in particular have the potential to negatively

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affect N2K sites. While the interaction of N2K sites with proposed PHES development does not always preclude development, it does make it more difficult.

These sector specific guidelines have been developed to offer guidance to proponents of plans and projects of this technology on how to comply with the requirements of the Birds and Habitats Directives, and ultimately to facilitate the sustainable development of future bulk EST.

As well as this guidance two further documents relating to environmental considerations of PHES and CAES have been published under the stoRE project. The stoRE report on the environmental performance of existing energy storage installations by Wänn *et al*., (2012) describes the operational environmental impact of PHES and CAES. A further report (Wänn *et al*. 2013) outlines recommendations for furthering the sustainable development of future bulk EST. Relevant sections of these reports, in particular the technology overview and case studies, have been reproduced in this document.

These and other project reports are available at http://www.store-project.eu/ .

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2. Technology Overview

2.1. Background

PHES is currently the only commercially proven large scale (5 MW – 2 GW) EST, with over 300 plants installed worldwide with a total installed capacity of over 95 GW (Roberts, 2009). Between 1970 and 1990, 42 facilities were installed in the EU compared with 8 plants between 1990 and 2009 (Deane et al., 2010). This significant reduction in new installed capacity partly reflects the preference for lower cost and easier implementable gas turbine technology over PHES during the previous two decades (Denholm et al., 2010). In recent years, there has been a renewed interest in PHES technology resulting in the planning and building of a number of new plants in Europe and Japan mainly as a result of the increase in variable renewable generation such as wind (Deane et al., 2010) and PV. PHES is an area of significant growth for the hydropower sector in Europe, especially in the central and peninsular regions of the continent (Eurelectric, 2011).

In contrast, only two CAES facilities are in operation worldwide; Huntorf, Germany and McIntosh, Alabama, USA. One of the reasons cited for the few numbers of operational plant is that the anticipated return on investment is too small to compete with other (more proven) opportunities for the capital invested (Pickard et al., (2009)).

Traditionally, PHES (and CAES) were energy storage providers utilised to help balance the production curve of non-flexible base-load generators such as coal and nuclear power. PHES pumped during the night when there was low demand (i.e. off peak hours) and generated electricity during times of high demand (i.e. peak hours). However, this mode of operating PHES plants has changed since larger amounts of variable wind and PV have become available on the electricity market. There is a growing interest in the grid services these bulk power technologies can provide. More recently PHES has been used to provide ancillary services to the electricity grid, and can therefore pump and generate at all hours of the day depending on the particular demands of the grid at any given time.

PHES remains the more attractive solution for bulk power as CAES continues to face economic challenges. Under a high-growth renewable scenario, storage technologies will likely be required to maintain the stability of the European power mix. Intermittent Renewable Energy Sources (RES) such as wind and PV continue to increase their share in the EU power mix. It is predicted that utilities will drive most of the future PHES development to balance their portfolio, which results in a developer driven development scenario. However, new energy storage technologies are unlikely to be deployed on a large scale under current unfavourable market and regulatory conditions (ERP, 2011).

Open cycle gas turbines (OCGT) and hydropower can in the same way as PHES and CAES provide flexibility on the generation side delivering upward or downward adjustment services. However, they are not energy storage as they are unable to ‘consume’ electricity (i.e. pump) to charge a reservoir (Vasconcelos et al., 2012). As a result of these benefits bulk ESTs are seen as Renewable Energy Source (RES) enablers particular for bulk input of variable RES-E such as wind and PV (Zach et al., 2011).

2.2. PHES

The basic functional principle of a PHES system is described in this section. Water stored in an upper reservoir is processed through a turbine to recover its potential energy in the form of mechanical (kinetic) energy. The turbine runs a generator which converts the mechanical energy

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into electrical energy, which is fed into the electricity grid (generating mode). Unlike run-of-the-river hydro, the water does not just drain off; it is captured in a lower reservoir. In times of low electricity demand / low electricity prices (or excess electricity supply due to high RES-E) the water is raised again to the upper reservoir by a pump which is powered by an electrical motor (pumping mode). Therefore, in the pumping mode the PHES system is a load in the electricity system. (Zach *et al*., 2012).

As well as energy storage PHES provides the electricity grid with ancillary services such as: grid balance, grid flexibility, supply smoothing, black start capabilities, spinning reserve, auxiliary reserve, peak shavings, regulation control, security, etc. (Foley et al., 2010). Historically, PHES has operated together with conventional base-load generation (e.g. nuclear, lignite, coal), which are more efficient when generating at a constant rate, and are therefore traditionally associated with peak (i.e. generating) and off-peak (i.e. pumping). More recently, PHES has become increasingly important for its grid balancing capability rather than for its peak power/off-peak consumption capabilities.

The stoRE project distinguishes between three different types of PHES according to their water management (Malachy Walsh and Partners, 2011):

- Open-system PHES (commonly known as pump-back PHES)
- Semi-open PHES
- Closed loop PHES

Box 1. What is the difference between hydropower and PHES services?

PHES is classed under the hydropower family alongside run-of-the-river and hydropower. Run-of-the-river is subject to seasonal river flows and usually has little to no storage possibilities (maximum 48 hours). These plants are most often found on rivers that have a consistent and steady flow and therefore provide base-load to the electricity system.

Hydropower facilities with dams have the capacity for water storage in which water is stored for daily, weekly, monthly or annual water supply needs. Usually, these facilities will store water during the wet season for later use during the dry or cold/hot season, but can also be partially discharged on a daily basis to provide peak load and ancillary services. Hydropower can thus provide base-load and peak-load as required. A hydropower facility's ability to store water is sometimes mistakenly referred to as 'energy storage'. However, experts call this ability 'fuel piling' (similar to heaping wood by a stove).

In contrast, the pumping capability of PHES 'stores' low-price electricity from the grid by pumping water from a lower to a higher reservoir and releases the energy again as required. PHES is classed as energy storage because of its ability to act either as an electricity producer when the electricity system is in need of electricity or as load (i.e. uses its pumps) when there is too much electricity on the grid and not enough demand.

2.2.1. Open-system PHES

The open-system PHES, more commonly known as pump-back, is a system where there is continuous flow of water through both the upper and lower reservoir. Of the three types of PHES, this type is the most comparable to a hydropower facility. An existing hydropower plant can be retrofitted with a reversible pump-turbine thus turning the facility into a pump-back, or the facility can be constructed as a pump-back directly e.g. Thissavros PHES Greece operated by Public Power Corporation (PPC). The difference between a pump-back and the other two PHES types is

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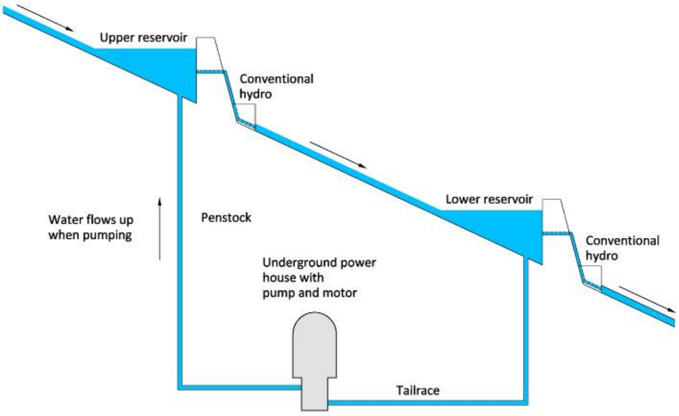
that if the pumps were to be switched off for a long period of time, the facility can still operate and generate power; in effect it reverts to a hydropower facility.



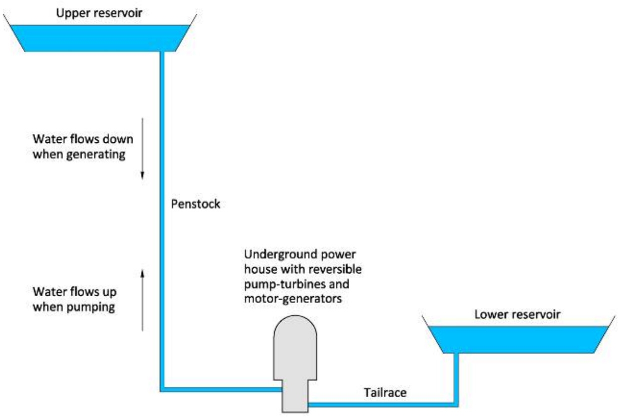
Source: Malachy Walsh and Partners

Source: Metka

Figure 2. Schematic description of the open-system PHES; Thissavros PHES.

2.2.2. Closed loop PHES

The closed loop PHES is constructed using two reservoirs that are separated by vertical distance. These reservoirs may be either natural or artificial. Where pump-back PHES is situated within a river system and directly interacts with the river channel, the closed loop PHES will be closed off from other water bodies once operational. However, the initial filling of the reservoir is with water from its own catchment or a nearby water body. The reservoirs are usually "topped up" periodically while due to water loss from evaporation from water within the catchment. An example of the closed loop system is Turlough Hill in County Wicklow, Ireland, which is operated by the Electricity Supply Board (ESB). The upper reservoir is artificial while the lower reservoir is a natural lake that has been modified.



Source: Malachy Walsh and Partners

Source: ESB

Figure 3. Schematic description of the closed loop PHES; Turlough Hill PHES.

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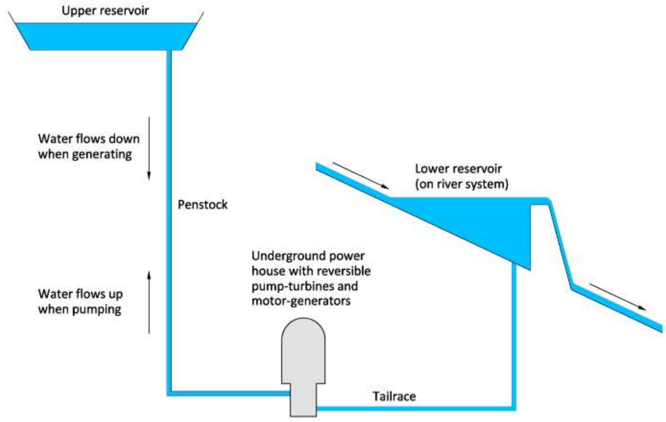
2.2.3. Semi-open PHES

The semi-open PHES is the least known of the three categories and forms a hybrid between the two other PHES types. One reservoir is closed off from other water sources and is usually artificial; the other reservoir will usually be part of a river, i.e. a substantial amount of water still flows through this reservoir. An example of the semi-open system is Goldisthal in Germany in the state of Thuringia, which is operated by Vattenfall Europa AG.

Another variation of the semi-open PHES is the sea water PHES. In this case, the upper reservoir is a finite man-made reservoir and the lower reservoir is the ocean. So far there is only one operational sea water PHES in the world, in Okinawa, Japan where the PHES facility has an installed capacity of 30MW.



Source: Malachy Walsh and Partners

Source: Vattenfall Europa AG

Figure 4. Schematic description of the semi-open loop PHES; Goldisthal PHES.

2.3. CAES

A CAES facility is essentially a gas turbine power plant that stores compressed air in underground caverns (over-ground pressure-tanks can be used but are not economically for bulk storage). The main principle of a (conventional) CAES system is that it utilises excess electricity from the grid to compress air and store it in large underground salt caverns. When the need for additional electricity arises on the grid the air in the caverns is discharged, mixed with natural gas and fed through the generator to produce electricity. CAES is considered to be a hybrid system since it still requires natural gas to operate: to reheat the air during discharge. However, the natural gas requirement is a third that of a conventional gas turbine (Akorede et al., 2010).

During compression the air heats up and in a conventional CAES this heat is removed to allow the air to be cooled to ambient temperatures before storing it. During expansion the air will naturally cool down. However, for the air to enter the combustion chamber it first needs to be heated again using an external source (natural gas). This process is referred to as a diabatic process.

There is ongoing research into adiabatic CAES systems, which retain heat and return it to the air during expansion for power generation. An example is the ADELE project in Germany, where the excess heat released during air compression can be temporarily stored until the heat is needed again during discharge. This principal differs from conventional CAES in that it eliminates the need

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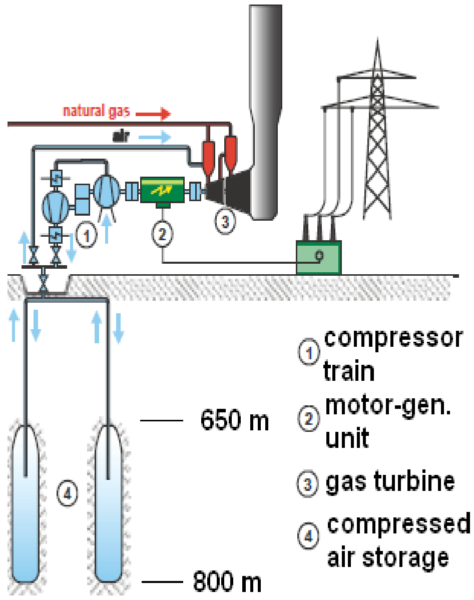
for natural gas, which will increase cycle efficiency from the current 42-54% to 70% (RWE Power AG, 2010).

Underground salt caverns are the favoured geological structures, as these structures are solid yet plastic and permeable. The only two CAES facilities in existence worldwide, Huntorf, Germany and McIntosh, Alabama, USA, are diabatic and were commissioned in 1978 and 1991, respectively.



Source: Crotogino et al., 2001

Source: KBB

Figure 5. Schematic description of CAES; Huntdorf CAES.

2.4. Suitable Sites for PHES and CAES Projects

Both PHES and CAES are resource driven facilities that **require very specific site conditions** to ensure the viability of a project. For PHES, the most essential criterion is the availability of locations with a difference in elevation and access to water (Deane et al., 2010). PHES require very specific site conditions, which are:

- favourable topography - high head (vertical distance between the two reservoirs) and significant storage capacity
- good geotechnical conditions
- access to the electricity transmission networks
- water availability

For example, in Ireland it is estimated that there may be less than 20 physically viable freshwater PHES sites limited to mountainous areas[1]. Greater potential for physically viable PHES sites exist

[1] Pers. Comm. Sean Doyle, Chartered Engineer, Associate Director of Malachy Walsh and Partners

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in countries with greater coverage of significant topography. Unsurprisingly, the majority of PHES facilities in Europe are concentrated in the Alpine regions of France, Switzerland and Austria (Deane et al., 2010). In contrast, wind farms are physically viable in a wide variety of topographies provided an exploitable wind resource exists. Furthermore, potential PHES sites are often associated with environmental and access constraints, which further limits the number of suitable sites.

Therefore, one of the difficulties in developing future storage facilities relates to the particular site conditions required by these technologies resulting in a limited availability of suitable development sites. PHES sites are commonly located in upland areas with significant topography, removed from large populations and relatively unmodified by human interference. For this reason, they may support threatened or important biodiversity interests, and in order to protect this resource some of these areas have been designated as N2K sites. Development sites may coincide or interact with N2K sites and projects may adversely affect habitats and species of nature conservation importance. This further restricts the availability of sites.

Like PHES, CAES also has specific site requirements. The caverns used in both of the existing facilities are salt caverns. Salt domes are also the geology of choice due to their geological properties; plastic yet solid and permeable (BBC Brown Boveri). Other structures that can be used are existing empty caverns, aquifers and depleted natural gas fields (King and Moridis, 2009). For CAES, the availability of suitable geology / cavern sites for storing compressed air is essential. The salt domes geology type is also favourable for other uses including natural gas storage and carbon capture and storage (CCS) technology (Gillhaus, 2007).

Therefore, a limited number of suitable PHES and CAES development sites exist. Any new interest in PHES and CAES faces significant siting and environmental challenges and, for CAES, competition from other salt cavern uses.

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3. Policy Context

3.1. Nature Protection and Biodiversity

The Birds and Habitats Directives form the cornerstone of the EU's nature conservation policy that is built on two pillars: (1) the N2K network of protected sites and (2) the system of species protection. Together the two directives protect over 1,000 animals and plant species and over 200 habitat types that are deemed to be of European importance. Habitat types as defined by the Habitats Directive are those that are in danger of disappearance, have regressed to a small area of are intrinsically restricted, or present outstanding examples of typical characteristics of European biogeographic regions. A summary of the most relevant parts of the directives is provided in the following sections.

A section on the Environmental Liability Directive, which indirectly relates to the Birds and Habitats Directives, is also included.

It is worth noting that the articles referred to in this document are based on the English language version of the directives. The expression or meaning of certain words or phrases in other languages of the directives may vary.

3.1.1. Birds Directive

The Birds Directive (2009/147/EC) was originally published in 1979 and has been substantially amended several times. It provides for the protection, management and control of all species of naturally occurring birds. Under Article 4, species listed in Annex I are subject to special conservation measures including the designation of Special Protection Areas (SPAs) with particular attention given to the protection of wetlands of international importance. The directive provides for SPAs for regularly occurring migratory species not listed in Annex I not only in their geographical area but also breeding, moulting and wintering areas and staging posts along their migration routes.

3.1.2. Habitats Directive

The main objective of the Habitats Directive (92/43/EEC) is to contribute towards ensuring biodiversity through the conservation of natural habitats and wild flora and fauna across the European territory. Measures taken to achieve this '*shall be designed to maintain and restore, at a **favourable conservation status**, natural habitats and species of wild fauna and flora of Community interest*' (see *Box 5*). The directive does not protect all habitats and species only those that are threatened and/or of European importance. The directive provides for:

(1) Protection of sites of nature conservation importance that support habitats types and species listed in the annexes of the directive

(2) Strict protection of species in Annex IV (overlap exists between species listed in Annex II and IV though not all species listed in Annex IV are listed in Annex II e.g. all bat species are protected under Annex IV)

Protection of sites:

SAC's are Special Areas of Conservation, which are sites that are designated to enable the natural habitat types (listed in Annex I of directive) and populations of the species (listed in Annex II) it supports to be maintained and/or restored at a favourable conservation status in their natural

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range. These habitat types and species are collectively referred to as target features. Sites should significantly contribute to the maintenance of biological diversity within their particular biogeographical region.

The main focus of the directive is on maintaining and/or restoring a favourable conservation status the most seriously threatened habitats and species of community interest i.e. target features, across their range. Member States are required to establish conservation measures which correspond to the ecological requirements of the habitat types and species present on the sites and to develop management plans for SACs. These sites shall contribute to achieving favourable conservation status for the habitat types and species for which they are designated across their natural biogeographic range.

Collectively, SPAs and SACs form the N2K ecological network. Under Article 3 of the Habitats Directive provisions were made to incorporate SPAs into the N2K network. There are a total of 26,106 N2K sites, 5,347 which are SPAs, covering a total area of 949,910km^2. Bulgaria has the highest percentage of national cover of N2K sites at 34% and the UK has the lowest percentage cover of sites at 7%. On average the N2K network covers 17.5% of EU27 territory (excluding Croatia). (N2K Barometer, 2011 (excluding Croatia, which joined the EC in 2013)).

Annex I of the Habitats Directive lists 218 European natural habitat types, including 71 priority types (i.e. habitat types in danger of disappearance and whose natural range mainly falls within the territory of the European Union) (EC, 2003). *Table 1* below lists the broad habitat categories that may be typically associated with PHES. Within each of these categories there are several habitat types listed within Annex I.

Table 1. List of main Annex I habitat categories and corresponding indicative locations

Habitat Category	Locations
Coastal habitats	Coastal regions (marine PHES)
Freshwater habitats	All watercourses
Heath and scrub	Upland mountainous regions
Rocky habitats	Upland mountainous regions
Forests	All regions
Bogs	Upland and lowland remote regions

Article 6 of the Habitats Directive defines how to manage and protect N2K sites. Though the directive also provides for a strict system of species protection, the focus of this guidance is **N2K sites and requirement for their protections under Article 6** in the context of new PHES and CAES development. Article 7 obligates Member States to protect SPAs under the provisions of Article 6. Article 6 is examined in greater detail in Section 6.1.1 below.

This document provides guidance on the stepwise procedure for the appropriate assessment of the potential impact of new PHES and CAES plans or projects on N2K sites, and specifically on the habitat types and species for which the site is designated. The assessment is based on Article 6(3) and 6(4) of the Habitats Directive, which provide procedural safeguards to ensure any new developments are undertaken in a sustainable manner in the context of N2K sites. The Habitats Directive does not prohibit new developments or activities; however it does require an assessment of their implications for N2K sites and associated conservation objectives.

Appropriate assessment is a four stage process and is summarised in the following paragraphs. The stages are described in detail in Section 5 below.

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The appropriate assessment specifically refers to the process by which relevant information is gathered by PHES/CAES project or plan proponents and presented to the competent authority for consideration and evaluation. Based on the information received the competent authority conducts the appropriate assessment, which in reality can be considered an administrative exercise given that the proponent (usually ecologists on their behalf) gathers the bulk of the information, conduct the assessment and present it in a report to the authority for consideration. In certain countries such as Spain and Northern Ireland the authority undertakes the full appropriate assessment. The plan or project can be approved if it is deemed that it will not adversely impact the integrity of the N2K site. If the PHES/CAES plan or project is likely to adversely impact the integrity of the N2K site or potentially significant impacts cannot be ruled out (i.e. precautionary principle) the competent authority may require additional information, modification of the design or may withhold consent.

The **precautionary principle** is brought to bear where preliminary objective scientific evaluation indicates that there are reasonable grounds for concern of potentially adverse impacts; in other words significant adverse impacts cannot be ruled out due to a lack of knowledge or uncertainty in relation to the associated plan or project risks (EC, 2000).

In rare instances a PHES/CAES plan or project deemed to adversely affect the integrity of the N2K site may be authorised, if there are no other means to achieving its objectives *and* it is considered of overriding public interest. Compensation measures will be required in such cases and such measures must be able to ensure that the overall coherence of N2K network is protected.

Bulk EST developments are large infrastructural projects involving major civil, mechanical and electrical engineering works and are likely to have significant effects on the environment. It is likely that a new PHES project in particular is likely to be subject to one or more of the four stages of appropriate assessment.

Species Protection:

The second pillar of the Habitats Directive provides for the protection of species listed under Annex IV wherever they occur, within and outside N2K network of sites. Over 400 species are protected and many of these are listed under Annex II. These species require protection throughout their natural range but do not always require the designation of sites. The aim of the directive is to establish a strict system of protection for these species across all Member States. An allowance for derogation from the directive exists under a set of defined conditions.

3.1.3. Environmental Liability Directive

The Environmental Liability Directive sets up a framework for environmental liability based on the "polluter pays" principle, with a view to avoiding and repairing environmental damage. Environmental damage is defined as:

- direct or indirect damage to the aquatic environment (*water*) covered by Community water management legislation;
- direct or indirect damage to species and natural habitats (*nature*) protected at Community level by the 1979 "Birds" Directive or by the 1992 "Habitats" Directive;
- direct or indirect contamination of the land (*soil*) which creates a significant risk to human health.

There are two liability schemes. The first relates to dangerous occupational activities such as agricultural or industrial activities requiring an Integrated Pollution Prevention and Control licence. The second liability scheme applies to all occupational activities where there is damage or

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imminent threat of damage to species or natural habitats (*nature*) protected by Community legislation only. In this case, the operator will be held liable only if he is at fault or negligent. It is this liability scheme which would be applicable to PHES and CAES operators.

4. Potential Environmental Impacts

In order to understand the environmental impacts of PHES or CAES facilities, it is essential to understand the nature of this development as this is the foundation on which the impact assessment is conducted. A technology overview of bulk EST was presented in the previous section. This section provides further details of the main environmental aspects of PHES and CAES projects.

4.1. PHES Project Components

PHES requires a water resource and usually has an intimate association with reservoirs, lakes, rivers or coastal waters. A closed loop system requires two lakes or reservoirs, and for economic reasons one of these is usually a natural lake. A semi-open system requires a closed and an open waterbody. An open system is on a river.

PHES type	Reservoir	Artificial lake (reservoir)	Natural lake	River	Coastal waters
Open-system	Upper Reservoir			✓	
	Lower Reservoir			✓	
Semi-open system	Upper Reservoir	✓	✓		
	Lower Reservoir	✓		✓	✓
Closed system	Upper Reservoir	✓	✓		
	Lower Reservoir	✓	✓		

4.1.1. PHES

The main elements of a PHES scheme include two water reservoirs, a power house and a penstock and tailrace connecting the power house to the upper and lower reservoirs respectively. When energy production exceeds demand, the excess energy is used to pump water from the lower reservoir to the upper one and during times of peak demand, water is released from the upper reservoir to flow through turbines, into the lower reservoir, producing hydroelectric power.

Upper Reservoir:

The upper reservoir can be a natural or artificial lake, or a river. In the case of an artificial lake, the upper reservoir can be any shape but are typically oval, circular or irregular and usually support layer/s of impermeable lining. The reservoir dam or embankment is typically a rock-filled dam structure and the finished embankment is graded, landscaped and/or vegetated and in certain situations can be hidden from view from below (e.g. Rönkhausen PHES, Germany, pictured below right). A peripheral road is constructed at its base separated from the embankment by drainage structures. Alternatively, the dam may comprise compacted concrete walls (e.g. the reconstructed Taum Sauk reservoir in Missouri pictured below left). Where the lower reservoir is an existing lake or river, overtopping of the upper reservoir can occur when too much water is pumped up from the lower reservoir.

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Taum Sauk PHES. Source: Renewable Energy World	**Rönkhausen PHES**. Source: Wikimedia Commons

A natural lake may need to be impounded with a dam structure on one or more sides to increase the capacity and control flow. This removes the natural physical connection between the lake and the outflowing river where one exists.

Penstock:

The penstock is the pipe that conveys water between the reservoirs through the turbine. Reversible pump / turbines act as motor-driven pumps for the pumping phase and as turbines for the generating phase. The generator serves as a motor to drive the turbine for the pumping phase. In the case of closed and semi-open PHES, the penstock usually comprises a series of lined tunnels. For example Dinorwig PHES in Wales is comprised of 16km of underground tunnels within Elidir Mountain.

Powerhouse:

The powerhouse is located near the lower reservoir and it houses the turbines and ancillary equipment. The majority of the structure is below ground level. The depth of a power house is determined by the requirement to set the level of the pump turbines at a distance below the lowest water surface level in the lower reservoir. The power house may need to accommodate a permanent gantry crane. The powerhouse at Goldisthal PHES is 147m in length, 49m high and 16m wide. Dinorwig PHES is Europe's largest man-made cavern.

Lower Reservoir:

The lower reservoir can be a natural or artificial lake, a river or the sea. The lower reservoir has to have a capacity at least equal to that of the upper reservoir. In the case of a natural lake the lake can remain unchanged or may be impounded to allow for a greater capacity. The lake capacity of the lower reservoir at Dinorwig PHES - a closed loop system - Llyn Peris (pictured below right), was increased by the removal of slate. A river must be dammed at its lower end to control water flow and ensure sufficient capacity (e.g. Goldisthal PHES). The Yanbaru PHES on the island of Okinawa in Japan is the only sea PHES in existence worldwide (pictured below right). It is a semi-open system with an artificial upper reservoir while the sea acts as a lower reservoir.

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Dinorwig PHES. Source: Wikipedia

Yanbaru PHES. Source: Hydroworld

Tailrace:
The tailrace is the pipe system / tunnel that delivers water away from the turbines to the lower reservoir. The intake structure may also support a fish screen. The water velocity at the screens can vary depending on the size of the intake structure.

Substation:
The powerhouse is connected to the electrical grid via the substation. The electrical substation containing the transformer and electrical switch gear and is typically located outside the powerhouse.

4.1.2. Construction

PHES developments are large infrastructural projects involving major civil, mechanical and electrical engineering works and by their nature, size and scale they can potentially have significant environmental effects. The principal components of a PHES project are reservoirs, which may have to be constructed or impounded, underground tunnels and a powerhouse to house the machinery. Other ancillary elements may include access roads and associated drainage works, construction compounds and grid connection. Grid connection may be underground or overground and its length will vary depending on the proximity of the nearest external substation. These elements in themselves can result in potentially significant environmental effects. While projects may have defined site boundaries confined to the construction footprint, the zone of influence of the associated environmental effects can be extensive.

These large scale civil projects require significant volumes of construction materials, equipment and resources. For example the construction of Dinorwig PHES required 1 million tonnes of concrete and 4,500 tonnes of steel[2].

PHES development types can take several years to develop and design. Once construction begins on a PHES project, it can take a minimum of 5 years to complete. Therefore, the full development of a PHES project can take approximately 15 years from time of inception to commissioning; more than half the time is allocated to project development, planning process and approval procedure.

By their nature, project development takes place predominantly in rural and remote areas with significant topography. Ground conditions may vary between the upper and lower reservoirs.

[2] http://www.fhc.co.uk/dinorwig.htm

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Retrofitting of existing hydropower schemes with PHES has a lower environmental impact i.e. adding a pump to a hydropower plant creates a pump-back system utilising existing reservoirs. While it can result in changes to the operational regime, it is often seen as a more benign solution as the receiving environment has already been modified and is regulated by the existence of the hydropower plant. Most pump-back PHES constructed in recent years in Europe are hydropower plants that have been retrofitted with pumps.

Box 2. Summary of main elements of construction

Phases: Mobilisation, site set-up, pre-construction activities, road and haul route construction, excavations, drilling, tunnelling, grid connection, commissioning, demobilisation.

Plant, machinery and equipment: excavators, dumpers, bulldozers, cranes, trucks, piling rig, pumps, rollers, generators, batching plant.

Activities: lake drainage, cofferdam, excavations, rock breaking, importation of materials, export of materials / waste disposal, waste management, transportation, concrete pouring, landscaping.

Pollutions controls: dust suppression, erosion and sediment plans, constructed drainage, fuel management, waste management.

Materials: rock fill, impermeable geomembrane, aggregate, fencing, concrete and cementitious material, reinforcement, fuel and oil, lighting.

Traffic: mobilisation and demobilisation of construction plant, delivery of material and construction personnel and vehicular movements generate the majority of traffic.

4.1.3. Operation

PHES and CAES plants are operated to supply electricity during peak demand, which can vary from hour to hour. This type of production responds rapidly to fluctuations in electricity demand.

The principal activity of a PHES is the pumping of water from the lower reservoir to the upper reservoir and the controlled release during the generation cycle. The pumping operation can take several hours. Other activities will include the day to day inspection and maintenance of the plant. The plant will likely operate in response to grid demand. A PHES can be designed to have a structural life of over 100 years. Mechanical equipment will typically need replacement after 40 years although there are many schemes worldwide where the original equipment has been used for far greater lengths of time. The Waldeck PHES scheme in Edersee in Germany still uses some of the original turbines that were installed when the scheme was constructed in the 1930s.

4.1.4. Decommissioning

While a scheme could be used indefinitely by continual refurbishment of the structural and mechanical elements, provision can be made for permanent decommissioning of the scheme. However, given the scale of the civil works that would be involved, full decommissioning is unlikely and a partial decommissioning of the scheme can reasonably be assumed to be the most likely option.

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4.2. CAES

Due to the low development of CAES (only two operational worldwide) this section focuses primarily on PHES.

A new CAES scheme may include some or all of these key elements:

- Underground caverns
- Above ground plant containing turbine, motor/generator, fuel

For CAES, the main issue is the availability of suitable geological structures for storage of compressed air. The preferable salt dome geology type can take up to 6 years to mine. Environmental issues can arise with disposal of the brine. The location of CAES will be dictated by the availability of suitable caverns, and unlike PHES they are not dependent on sensitive water or upland areas. Therefore, provided they are sited away from environmentally sensitive areas such as N2K sites, the construction phase impacts associated with CAES can be managed and mitigated more easily than PHES. The operational ecological impacts associated with CAES are relatively low.

4.3. Environmental Impacts

Bulk EST developments are likely to have significant effects on the environment by virtue, *inter alia*, of their nature, size or location. As mentioned, PHES and CAES projects are large infrastructural projects involving major civil, mechanical and electrical engineering works and can take several years to construct. Due to their specific physical requirements (high head, favourable topography, and water availability) PHES projects are often located in more sensitive environments.

Environmental impacts associated with PHES construction may be similar to mineral extraction, energy and water infrastructure project types. While the environmental effects of PHES are similar to those of hydropower, they are ultimately different technologies with differing impacts. Some of the environmental impacts of CAES may be comparable to the construction of natural gas storage that use salt caverns.

Environmental impacts of PHES will vary considerably depending on the following:

- type of PHES system (closed, semi-open, open)
- project siting
- degree of man-made modification of the existing natural environment

A report published as part of the EU stoRE project examined the environmental impacts of six operational PHES and CAES plants (Wänn et al. (2012)). A summary of the conclusions is presented in the following table where each environmental topic has been classified as having a high, medium or low environmental impact. Huntorf, the only operational CAES in Europe, is considered to have had a low impact on biodiversity. Kopswerk 2 PHES (Austria) and Bolarque 2 PHES (Spain) are plants where an existing hydropower plant has been retrofitted with the addition of pumps and thus the receiving environment was highly modified and regulated. Therefore, the ecological impact was assessed as low. Thissavros PHES (Greece), Goldisthal PHES (Germany) and Turlough Hill PHES (Ireland) were new builds constructed in relatively unmodified natural environments and were considered to have resulted in high ecological impacts.

Table 2. Summary table of negative impacts during operation highlighted from the case studies (categorised as H-high, M-medium or L-low environmental impacts)

		CAES	Pump-back PHES	Semi-open PHES			Closed loop PHES
Potential Issues/EIA terms of reference		Huntorf	Thissavros	Kopswerk2	Goldisthal	Bolarque2	Turlough Hill
Human Impact	Population	L	L	L	L	L	L
	Traffic	L	L	L	L	L	L
	Cultural Heritage	L	L	L	L	L	L
	Material Assets	L	L	L	L	L	L
Ecology & Natural Systems	Biodiversity	L	H	L	H	L	H
	Fisheries	L	H	L	M	L	M
	Air and Climate	L-H*	L-H*	L-H*	L-H*	L-H*	L-H*
	Landscape & Visuals	L	M	L	M	M	M
	Water Resources & Quality	L	H	L	M	L	M
Physical Environment	Noise & Vibration	L	L	L	L	L	L
	Soils, Geology & Sediment Transport	L	H	L	M	L	L
	Hydrology & Hydrogeology	L	H	M	H	L	H

- Recommended to review each individual case study
- Inclusion of combined impacts with existing land uses and pressures
- Limited raw data

Much of the current EU environmental legislation was transposed into national legislation in the last two decades. Due to the low number of PHES (and CAES) developed during this period, experience in developing these large, and often complex, infrastructural projects in the current regulatory environment is limited, both on the side of the developer and decision-making authorities. Relatively few examples of Appropriate Assessments (AA) or Environmental Impact Statements (EIS) exist as a result. This can make it difficult to anticipate the environmental effects of the construction and operation of these large infrastructural projects. While existing impacts can be established from monitoring there is limited detail on baseline environment in order to establish / determine what changes in the environment have occurred as a result of the development.

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4.4. Ecological Impacts of PHES

The table below outlines the main potential ecological impacts associated with PHES. These are listed under a number of environmental topics headings, all of which can interact with the receiving ecological environment. The construction phase for these large scale civil projects may take 5 years or longer and so the associated impacts are considered short-term (0-7 years). These plants may be operational for 40 years or more.

Table 3. Potential significant adverse environmental effects of PHES affecting ecology

Potential Issue	Construction and Operational Impacts
Ecology	*Construction impacts*: Short-term construction phase disturbance to habitats and species. Permanent loss or fragmentation of terrestrial or aquatic habitats to accommodate artificial reservoirs. Permanent loss or fragmentation of terrestrial or aquatic habitats by inundation of dammed river. Increased risk of invasive species colonisation (including introduction, dispersal and / or creation of favourable habitat)
	Operational impacts: Permanent alteration of terrestrial or aquatic habitats downstream due to artificial regulation of the water resource / flow regime upstream at the plant.
Water	*Construction impacts*: Increased suspended solids in watercourses due to soil disturbance and erosion during excavation and other earthworks. Risk of fuel/oil/chemical spill during construction from vehicles, machinery and equipment.
	Operational impacts: Hydrological disturbance to watercourses, or groundwater aquifers, from tunnelling and other underground structures resulting in adverse impacts to water dependent habitats and species. Alteration of natural lake morphology, characteristics and biology through draining (construction) and regulation. Alteration of natural river and lake hydromorphology. Alteration of natural river flow.
Air and climate	*Construction impacts*: Increased dust may impact on nearby sensitive habitats and species.
	n/a
Noise	*Construction impacts*: Short-term construction noise disturbance to sensitive species. Temporary blasting and drilling noise disturbance to sensitive species. Traffic noise disturbance to sensitive species.
	n/a

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Potential Issue	Construction and Operational Impacts
Soils and Geology	*Construction impacts*: Risk of landslide, peat slippage or subsidence during construction phase could result in habitat loss or pollution of receiving watercourses. Soil erosion during the construction phase could result in increase in suspended sediments in receiving watercourses (may result in increase in phosphorous depending on existing land use and management).
	n/a

4.4.1. Interaction of PHES with the Water Environment

Rivers and lakes provide nutrients, transport and habitats to many organisms. Multiple uses of European rivers have put immense pressure on water resources so much so that few of its major lowland rivers are now in an entirely natural state (EC, 2012). The principal issues affecting European rivers are nutrient enrichment and physical intervention such as river regulation. Other issues affecting rivers are acidification, organic micropollutants, heavy metals and radioactivity (EC, 2007).

Lakes and reservoirs may be considered more vulnerable to pollution than running waters or marine waters, since water volumes are not frequently renewed and the morphology of lakes can lead to the accumulation of pollution (Leonard and Crouzet, 1998).

PHES developments are inextricably linked to water resources and watercourses (e.g. rivers, lakes and artificial reservoirs). Depending on the quality and the level of human interference, water environments can support important and threatened habitats and species. This potential interaction between ecological resources and PHES can result in potentially significant ecological impacts.

The **zone of influence** of a plan or project is the areas / resources that may be affected by the biophysical changes caused by activities associated with the project (IEEM, 2006). During the course of plan or project development, ecological features of interest within the zone should be identified and their impact assessed. The zone of influence during the construction and operational phases may differ. During the operational phase the zone of influence may extend upstream and a considerable distance downstream.

A **closed loop system** is as the name suggests independent of other watercourses and water is simply moved between reservoirs. During the construction phase the reservoir will likely need additional water, which may be sourced from the same, or a neighbouring, catchment. In instances where an outlet to a stream or a river from a natural lake exists, that natural physical connection will be lost; however, the system can maintain a regulated outflow. Therefore, as a result of the diversion of water resources, removal of the physical connection and alteration of the downstream flow regime the impact of a closed loop system may extend beyond the PHES footprint.

An **open or pump-back system** is essentially a conventional hydroelectric plant with a pump-back facility that uses natural river flow. The main impacts are associated with the dam; they occur upstream where river habitat is transformed into an artificial lake habitat and downstream where the hydraulic or flow regime is dramatically changed. Both these changes can result in dramatic ecosystem shifts. The zone of influence can extend considerable distances upstream and downstream. Continuity is lost and the ability of the river to continue its natural processes is severely compromised as a result of the modification of the physical environment and regulation of the flow regime.

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PHES responds to peak demand, which can vary from hour to hour; it follows that the discharges of water downstream from pump-back and semi-open systems can also vary resulting in an unstable downstream flow regime. While efforts are made to mimic the natural processes, this can be overtaken by the demand of the electricity grid, and the replacement of natural flow becomes a secondary objective. Some of the larger open system reservoirs can have secondary uses such as irrigation and flood protection; therefore, the flow regime downstream of these plants may exhibit a seasonal as well as an hourly or daily variation.

A **semi-open system** is a combination of closed loop and open system where the upper reservoir is a lake but the lower reservoir uses natural river flow. The river is dammed downstream of the intake. Water is temporarily diverted to the upper reservoir and released back into the lower reservoir before moving downstream of the dam. Therefore, the impacts of a semi-open system are a combination of the closed loop and open systems.

4.4.2. Significance of Impacts

Legislation and policy guidance frequently require significant impacts to be distinguished from other impacts, although little guidance on how the distinction should be made is available. An ecologically significant impact is defined as an impact (negative or positive) on the integrity of a defined site or ecosystem and/or the conservation status of habitats or species within a given geographical area (IEEM, 2006). Potentially significant ecological impacts are grouped under 'significance indicators' (habitat loss, habitat and hydromorphological alteration, habitat and species fragmentation, disturbance and displacement of species) and discussed in the following sections.

4.4.3. Habitat Loss

Natural habitats are areas where organisms live and are made up of living (biotic) components and non-living (abiotic) components e.g. water, soil, geology and can be entirely natural or semi-natural. Habitat loss is essentially the destruction of natural or semi-natural habitat with complete loss of its structure (e.g. vegetation communities that make up a habitat) and function (role of habitat and interaction with species and abiotic components).

Direct loss of terrestrial habitats is generally associated with the construction phase of a project and affects land cover. A loss of terrestrial habitats will occur to accommodate the footprint of the new artificial upper or lower reservoirs in the case of closed or semi-open systems. Permanent habitat loss associated with a closed system is typically limited to the vicinity of the development footprint. In a semi-open system, terrestrial and riparian habitats will be inundated along the length of section of river that acts as the lower reservoir. In the case of open-system PHES the main habitat is lost as a result of the inundation of large areas of a river basin upstream of the project; some loss also results from the footprint of the PHES components. Construction of dams and the subsequent creation of reservoirs may be detrimental to terrestrial habitat and animals, as the habitats are inundated and the river habitat is profoundly changed and replaced by an artificial lake environment.

The sensitivity, conservation importance and status of the lost habitat and associated dependent species affected together with the type and nature of the PHES will dictate the significance of the habitat loss impact. Other factors that affect the significance of an impact include environmental trends such as climate change and the cumulative impact of proposed and existing developments.

4.4.4. Habitat and Hydromorphological Alteration

Habitat alteration occurs as a result of changes to land use and affects the structure and function of a habitat. Deterioration of a habitat may eventually lead to habitat loss. Habitat alteration is mainly associated with the ecological impacts of the operational phase of the plant and water dependent habitats are the principal habitats affected. Hydromorphological impacts are a specific

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type of habitat alteration where manmade changes to watercourses such as the damming of rivers, impoundment of lakes, construction of reservoirs and alteration of river channels and lake shores, which have the result of altering the habitat.

Rivers are complex natural systems whose integrity depends on the natural dynamic character. Streamflow quantity and timing are considered critical components of water supply, water quality and the ecological integrity of river systems. Streamflow is strongly correlated with many critical physicochemical characteristics of rivers such as water temperature, channel geomorphology, and habitat diversity and is considered a 'master variable' that limits the distribution and abundance of riverine species (Power et al., 1985 in Poff *et al*., 1997). Dams and impoundments radically change the structure and function of rivers by disrupting river continuity. This may impact aquatic organisms, riparian and floodplain habitats and species. In open-systems the existence of the dam can also prevent sediment transport to downstream and coastal environments such as river deltas.

Due to the regulation of the watercourse upstream, the effects of a semi-open or open-system PHES may be experienced a distance downstream of a plant. In pump-back or open-system PHES, fluctuations in discharge patterns will affect riparian vegetation downstream of the dam in terms of species cover and diversity as a result of alteration of the natural waterlogging and inundation regime. Associated species may also be profoundly affected. For example according to Petts (1988) as cited in Larinier (2001) fluctuating water levels and velocities due to power output from the peaking plant may inhibit fish spawning behaviour, sweep juveniles downstream during high flow or leave eggs or juveniles stranded by sudden reduction in flow.

Different aquatic species have different tolerances to changes in their environmental parameters e.g. flow, temperatures, dissolved oxygen. Often the more ecologically valuable species are the most sensitive and least tolerant. The modified habitats created (e.g. artificial lake, inundated river) often create environments that are more suited for non-native and exotic plant, fish, invertebrate and mammalian species with the result that non-native species often out-compete the natives. This in turn results in a modified ecosystem that may become unstable, nurture disease vectors or are no longer able to support the historical environmental components (World Commission on Dams, 2000). In the Thissavros reservoir in Greece situated along the Nestos River, Perch (*Perca fluviatilis*) has become the dominant species although it did not exist in that ecosystem prior to construction, showing that changes in habitat are also changing the species balance.

Lakes are typically characterised by their physical and thermal / mixing characteristics and processes in lakes are strongly determined by temperature profile, which depends on climate, wind and lake depth. The frequency of mixing or overturn in lakes is important in determining chemical exchanges between lake layers and oxygenation. (Leonard and Crouzet, 1998). Changes in lake morphology such as impoundment and water regulation can have a dramatic impact on these physical and mixing processes so much so that the lake can no longer support many of its characteristic flora and fauna species; this may ultimately result in habitat loss.

The physical modification of lakes to facilitate closed and semi-open PHES systems affects the natural morphology and physical characteristics of the lake (e.g. circulation patterns), which in turn affects their biology. This will affect the habitat and species diversity and abundance. It is unlikely that the natural vegetation of lake littoral zones or shorelines, which are associated with biological production and spawning, can tolerate the artificial lowering of the lake levels and the regular lowering and raising of lake levels associated with the daily operation of plant.

While closed loop systems can maintain an outflow to a previously connected river they do prevent the movement of fish from the river to the lake / lower reservoir. This can affect fish that depend on lake environments for spawning.

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The sensitivity or the conservation importance of the habitat altered and associated dependent species affected will dictate the significance of the ecological impact.

4.4.5. Habitat and Species Fragmentation

Habitat and species fragmentation is most apparent as a result of the open system PHES, which are developed along large river channels primarily with the construction of dams. Habitat fragmentation can be both longitudinal and lateral, where longitudinal hindrance is a result of the presence of the dam and lateral hindrance occurs via the expansion of the river to a lake that may make it impossible for certain terrestrial species to cross from one side to the other. Longitudinal hindrance can result in the extinction of fish populations, which are highly dependent on longitudinal movement, along a river. According to Hynes (1970) as cited in World Commission on Dams (2000) many insects need to migrate up or downstream as well, such as the glochidia larvae of freshwater mussels that are carried by host fish, or the mayflies and stoneflies that move upstream to lay their eggs so as to counteract the drift downstream of their larvae. Migration is thus blocked by a dam to varying degrees. Habitat and species fragmentation is nearly always a significant ecological impact in new open system PHES. The significance of fragmentation in retrofitted pump-back systems is likely to be lessened due to the existence of a hydropower plant and the associated modification of the natural environment that has already taken place.

The significance of fragmentation associated with closed and semi-open PHES will depend on the sensitivity or conservation importance of the affected habitats and species, and the interconnectivity and availability of ecological corridors in that landscape.

4.4.6. Disturbance and Displacement of Species

Disturbance and displacement impacts that arise during the construction phase include noise emissions from construction activity, vehicles and equipment. The significance of the disturbance and displacement impacts would depend on the sensitivity of the affected species and may be seasonally affected e.g. species may be more sensitive to disturbance during breeding seasons.

Operational disturbance and displacement effects mainly arise from the movement of water between the upper and lower reservoir. There is a risk of entrapment of fish species within the intake structures; however, fish screens can be installed on the intake structure.

4.5. Ecological Impacts of CAES

Provided that a CAES plant is not located in a very sensitive environment, potentially significant ecological impacts of CAES would be expected to be limited to the construction phase. While new PHES plants are often confined to more natural and water environments, a CAESs primary association is with salt caverns / domes.

One of the main ecological impacts associated with CAES is the leaching or flushing of salt within the existing caverns to facility CAES. When leaching (i.e. during construction) or flushing (i.e. for maintenance) it is an advantage to be close to the sea and return the brine, at established salt concentrations, back to the sea. Salt in the domes may contain heavy metals such as manganese, chromium, mercury and zinc that will be flushed out with the salt. With large salt quantities to be discharged, the risk is that large quantities of heavy metals may cause significant environmental impact, which may impact on marine invertebrate and fish populations.

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4.6. *Environmental Assessment*

4.6.1. Strategic Environmental Assessment Directive

Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment is commonly known as the Strategic Environmental Assessment (SEA) Directive.

SEA is a tool for determining the positive or negative impact that a proposed **plan or programme** may have on the environment. The SEA Directive provides high level protection of the environment and contributes to the integration of environmental considerations into the preparation of plans and programmes. SEA is a formal systematic evaluation of the likely significant environmental effects of implementing a plan or programme in order to make an informed decision before adopting a plan or programme. As a result a plan may be modified prior to its adoption (DoEHLG, 2004). The SEA Directive is mandatory for plans/programs that are prepared for agriculture, forestry, fisheries, energy, industry, transport, waste/water management, telecommunications, tourism, town and country planning or land use. These plans set the framework for future development consent of projects listed in Annex I and II of the Environmental Impact Assessment Directive. SEA is also required for plans and programmes that have been determined to require an appropriate assessment under the Habitats Directive.

4.6.2. Environmental Impact Assessment Directive

Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment is commonly known as the EIA Directive.

Environmental Impact Assessment (EIA) is a tool for determining the positive or negative impact that a proposed **project** may have on the environment. The EIA consists of gathering, analysing and presenting information on the likely environmental impacts of a project; it is an instrument to help improve the basis on which decisions are taken. EIA focuses on the significant environmental impacts associated with a project. The directive applies to a wide range of defined public and private projects**,** which are defined in Annexes I and II. All projects listed in Annex I of the directive are considered as having significant effects on the environment and require an EIA. Projects listed in Annex II require the discretion of each Member State to determine the need for EIA through a screening process, which determines the effects of projects on the basis of thresholds and criteria or case by case. All PHES and CAES projects are likely to require an EIA under Annex I or II. Under Annex I(24) an EIA is required where any change to, or extension of projects, listed are proposed, where such a change or extension in itself meets the thresholds set out in Annex I.

CAES or PHES are not in the list of projects included in Annex I and II. Aspects or components of PHES projects may come under other listed Annex I project types such as dams, quarries, underground mining, hydropower or water storage. Components of CAES projects may come under Annex II projects such as underground mining, deep drilling or surface storage of natural gas. In rulings related to the EIA Directive, the European Court of Justice has consistently emphasised the fundamental purpose of the Directive as expressed in Article 2(1), i.e. those projects "likely to have significant effects on the environment by virtue, *inter alia*, of their nature, size or location are made subject to a requirement for development consent and an assessment with regard to their effects" (EC, 2008). In nearly all cases proposed PHES or CAES projects will be subject to EIA.

An EIA is also a stepwise procedure that comprises the following main stages:

- **Screening** – determines need for EIA and is required for projects listed in Annex II of the directive
- **Scoping** – determines the content and extent of the environmental information to be contained in the EIA

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- **Preparation of the Environmental Impact Statement** report – this contains the environmental information presented to the competent authority by the developer
- **Consultation** – the environmental information must be made available to the authorities with environmental responsibilities and other interested parties before a decision is made. They must be given an opportunity to comment on the project. (EC, 2001 (a))

4.6.3. Relationship of SEA, EIA and AA

SEA applies to plans and programmes whereas EIA applies to project level planning. Similar to EIA its objective is to protect the environment and promote sustainable development. The SEA Directive was introduced in response to growing criticism of the EIA Directives limited consideration of: alternatives[3], cumulative impacts and lack of contribution to the achievement of wider global environmental and sustainable development aims (Carroll and Turpin, 2009). SEA is undertaken at earlier stages in the decision-making cycle and aims to prevent adverse environmental impacts. EIA on the other hand is generally carried out once strategic decisions have been taken and is therefore undertaken at a later stage in the cycle. SEA considers a wider range of alternatives and cumulative impacts on a broad scale with an emphasis on meeting environmental objectives. EIA can only address a limited range of alternatives. SEA also consults widely with the public and environmental authorities. The SEA process can however have limited environmental information and a greater level of uncertainty than project EIA. The process focuses on national or regional issues with less focus on impacts at a local level.

SEA, EIA and AA are all impact assessment tools that stem from different European Directives and have different applications, which are set out in Table 4 below. On the one hand AA focuses solely on the impact of plans, programmes and projects on sites that make up the N2K network, with particular attention to their target features, conservation objectives and site integrity. The integrity of a site relates to a site's conservation objectives and is considered to be the quality or condition of being whole or in a dynamic way means the resilience and ability of a site to evolve in a favourable manner. SEA and EIA, on the other hand, have a wide environmental focus, encompassing the assessment of potential impacts on habitats and species within and outside European sites, examining the overall implications for biodiversity. (González *et al*., 2012). SEA and EIA informs decisions making the authorities aware of potentially significant environmental impacts associated with plans, programmes and projects prior to authorisation. In contrast, AA determines the decision on whether or not to authorise plans, programmes and projects and is legally binding.

[3] Alternatives usually means the examination of alternative ways to achieve the same objectives or alternative means (alternative sites, processes or management) to deliver the project

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Table 4. Comparison of main legal and procedural differences between SEA, EIA and AA (Source: González et al., 2012).

SEA	EIA	AA
Assessment of potential impacts of certain **plans and programmes** on the environment; Informs decision-making	Assessment of potential impacts of certain **projects** on the environment; informs decision-making	Assessment of potential impacts of proposals on **European sites**; determines decision based on the precautionary principle
Potential short/long-term, direct/indirect, synergistic and cumulative effects on a range of environmental factors, including flora, fauna and biodiversity and their inter-relationship	Potential short/long-term, direct/indirect effects on a range of environmental receptors, including flora and fauna	Potential short/long-term, direct/indirect and in-combination effects on conservation interests, objectives and site integrity of the European sites only

Plans and programmes likely to require SEA, or projects likely to require EIA, are by their nature likely to impact on N2K sites. Where the appropriate assessment is integrated into the SEA or EIA, the assessment required by Article 6 should be clearly distinguishable and identified within the SEA or EIA report, or reported separately. It is important to note that the requirement for an appropriate assessment for SEA at the plan level does not preclude the requirement of appropriate assessment for EIA at the project level. SEA will be required where a plan or programme requires an appropriate assessment. In certain cases a requirement for appropriate assessment may trigger the need for EIA.

The key difference between appropriate assessment and SEA and EIA relates to the implications of the outcome of the various assessments. If a PHES/CAES plan or project is likely to adversely impact the integrity of the N2K site, or potentially significant impacts cannot be ruled out and the precautionary principle must be applied, the competent authority must withhold consent. In contrast, if significant environmental impacts are identified in SEA or EIA, the competent authority uses the outcome to inform its decision-making and it is not bound to withhold consent.

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5. Optimum Project Development

5.1. Interrelationship between Plans and Projects

A very clear interaction and hierarchy exists between policies, plans, programmes and projects progressively becoming more specific in time and place. This top-down strategy reflects the decision-making cycle and contributes to sustainable development. Plans can be developed at national, regional and local level and there can be an interrelationship between plans at different levels. Plans set the framework for future development consent of projects (Dixon *et al*., 2010). The legislation and policy, and plans and programmes levels should facilitate decision making procedures at project level, which is the last stage in the decision-making cycle. If the decision-making authority (which is generally at regional or local level) does not find relevant or supporting national/regional plans or policies that indicate a need for bulk EST, the project is more likely to be rejected.

In order to facilitate development of storage projects, energy sector plans (including grid development) should incorporate future bulk EST development where the need has been identified at policy level or in the mandatory National Renewable Energy Action Plans by Member States. In those cases where the need for storage (e.g. PHES) has not been identified at policy level or in the NREAP, it is unlikely that specific plans and programmes will make provisions for future PHES. If developers in these countries still wish to pursue PHES projects in this policy and strategic planning 'vacuum' they will be adopting a developer led approach i.e. bottom-up approach commencing at the project level. Currently, in the absence of strategic plans and programmes, energy storage development within the EU is primarily developer led. This has resulted in an increased financial and planning approval risk due to lengthy and onerous planning approval procedures.

Further detail on the interrelationship between policies, plans, programmes and projects is available in Wänn *et al*. (2013).

5.2. Importance of Appropriate Assessment in Plan or Project Development

Strategic energy plans will be subjected to the SEA process where the environmental performance of the plans is tested against environmental objectives. SEA can identify areas/sites that are sufficiently robust to accommodate PHES/CAES and those where the environment is sensitive and should be avoided. The SEA process requires an understanding of the vulnerabilities and sensitivities in our environment (including cumulative impacts) and to seek alternative solutions to integrate environmental concerns with broader social and economic needs (Carroll and Turpin, 2009).

Plans developed at a strategic level are also subject to appropriate assessment, which would highlight any possible interactions between N2K sites and a proposed project site/area. A proposed project must prove beyond reasonable scientific doubt that the project will not have a significant impact on the integrity of N2K site/s. It may not be clear at an early stage in project development how the project, regardless of distance, may impact on a N2K site. The SEA process can help determine the 'zone of impact influence' for PHES development which will likely extend beyond the project footprint. The process can be used as a tool to determine suitable and unsuitable deployment areas for PHES projects.

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Where significant environmental effects have been identified, these projects can be avoided, or further investigation may be warranted at the strategic level to determine if adequate mitigation can be implemented. Only projects, where on the basis of best available data indicate that no likely significant effects are expected to occur, should proceed to project level. As the level of detail required will differ at project level and as new data becomes available, an appropriate assessment may be required to further test the acceptability of a project. Currently, most developers are avoiding N2K sites for PHES development due to the perceived associated difficulties (Lacal-Arantegui *et al*., 2012).

The scope for examining alternatives to achieve a policy objective is significantly reduced at the project level planning stage, which in the hierarchy of planning is considered to be at the end of the decision-making cycle.

Due to the binding nature of the outcome of the assessment, **it is recommended that the appropriate assessment be the first impact assessment conducted** on any PHES or CAES plan or project prior to SEA or EIA. If the outcome is negative, or significant impacts cannot be ruled out, this will establish the need to gather additional information, modify the design, seek an alternative design or location, or as a last resort abandon the plan or project altogether. **Alternatives that avoid adverse effects on N2K sites should be considered at the earliest stage of plan or project development**.

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Case Study 1: Atdorf PHES (see Wänn et al. 2013 for full text)

Schluchseewerk is a specialised pumped storage operator in the South West of Germany that was established in 1928. Due to the growing need for electricity at the time a solution was to utilize the water potentials in the Black Forest. The company now owns and operates five PHES facilities with a total of 20 pumps / turbines that together generate 1,836MW and pump 1,604MW. Of the five PHES, the most recent was commissioned in 1976. In 2007, a proposal was put forward to develop an additional PHES facility, and in 2008, it was publicly announced that the company were planning to develop the Atdorf PHES project.

The Atdorf project will be a closed loop PHES with a head of 600m. Both the upper and the lower reservoir will be located in newly constructed greenfield sites with the capacity to hold a volume of 9 million m^3 of water. The new PHES will contribute an additional 1,400MW to the Schluchseewerk PHES portfolio.

While Schluchseewerk is highly competent as an operator, the company had no recent experience of developing PHES in a regulatory environment that has fundamentally changed since the last projects were completed in the 1960s and 1970s. The original plan was to begin construction in 2012 with completion in 2018; however, the expected completion date has since been extended to 2026 due to delays in the planning process and the unfavourable regulatory market.

Wänn *et al*. (2013) outline some of the problems encountered by the project during the planning process. This case study focuses on the N2K issues that only emerged during the latter PFV (Planfeststellungsverfahren / regional planning procedure) stage and the potential impacts of the project on several nearby N2K sites. This was not highlighted as an obstacle at the ROV (Raumordnungsverfahren / first stage of project approval) stage. Due to the level of tunnelling required (the project requires a total of 26km of tunnels), there is potential for hydrogeological impacts to occur at the N2K sites, namely, “Weidfelder bei Gersbach und an der Wehra” ('pastures or hay meadows near Gersbach and by the Wehra River') and “Murg zum Hochrhein” ('Murg upon Upper Rhine'). Among other problems identified at a late stage in the project development process, it seems that for several priority habitats significant impacts can’t be ruled out with the necessary certainty. Examples include *6230 Borstgrasrasen (species-rich nardus grassland) and *91E0 Auwälder mit Erle, Esche, Weide (alluvial forests alder, ash, willow), as well as several “non priority” habitat types.

At this stage Schluchseewerk has invested significant financial resources into this project with a number of obstacles only becoming evident during the later PFV stage. The identification of potential obstacles to planning approval so late in the planning process is often one of biggest disincentive to developers of this technology.

5.3. Approval Process

As mentioned the regulatory environment is generally not familiar with the assessment of new bulk EST developments as most of the existing PHES plants were developed between 1960 and 1990. Decision-making may take place at a local level where authorities have limited capability and resources to deal with these projects. There is an absence of recent experience of project development, and relevant guidelines and EIA literature. In both situations, the scope of the appropriate assessment can significantly increase due to the lack of experience and uncertainty of the authority in assessing PHES applications.

Documenting and sharing best practice and experience regarding project development and planning approval processes, and construction, mitigation and operation of existing projects, could help counter the general lack of experience of PHES development amongst developers in the current regulatory environment (Wänn *et al*. 2013).

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Further detail on the issues relating to the approval process facing developers of bulk EST is available in Wänn *et al*. (2013).

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6. The Appropriate Assessment Process for PHES & CAES Plans and Projects

6.1. Introduction

This section on the appropriate assessment process is largely based on the EC publications listed in *Box 3* below. The proposed plans and projects considered here relate to PHES and CAES only, with a greater emphasis on the former, though the same procedure applies to all other plan and project types. The purpose of the appropriate assessment procedure is to determine whether the plan or project will likely interact with the N2K site and if it would adversely affect its integrity.

***Box 3. EC Publications with information relevant to the Appropriate Assessment process for PHES and CAES**:*

- EC (2001). Managing N2K Sites: the provision of Article 6 of the Habitats Directive 92/43/EEC http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/provision_of_art6_en.pdf
- EC (2002). Assessment of Plans and Projects Significantly Affecting N2K Sites http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/natura_2000_assess_en.pdf
- EC (2007). Guidance Document on Article 6(4) of the Habitats directive 92/43/EEC http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/new_guidance_art6_4_en.pdf

6.1.1. Article 6 of the Habitats Directive

Article 6 of the Habitats Directive establishes the provisions governing the conservation and management of N2K sites (see Box 4). It plays an important role in establishing the relationship between conservation and activities (plans or projects) affecting N2K sites (MCS, 2013). Article 6 establishes provisions to safeguard N2K site (SACs and SPAs) requiring Member States to manage and protect sites in a sustainable manner. Article 6 is made up of four paragraphs; the first two paragraphs relate to the management of sites for conservation purposes while the second two paragraphs relate to the setting out of the procedural safeguards and authorisation criteria for sites with regard to land use (see Table 5).

Article 6(1) requires Member States to actively conserve the habitat types and species listed in Annex I and II within the N2K site and make appropriate plans or other measures to facilitate this process.

Article 6(2) focuses on the everyday management of the N2K site. It imposes a duty to Member States to avoid deterioration of habitat types and species and ensure that no changes are made to the site that might prevent it achieving the directives objectives. Members must take appropriate steps to avoid deterioration; neglect by inaction is not an option.

Articles 6(3) and 6(4) are concerned with plans or projects not directly connected with the everyday management of the N2K site such as PHES and CAES developments. These articles provide for the procedures that are to be followed for plans and projects that may affect a site's conservation

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objectives. The core aim of this document is to provide stepwise guidance on these procedural safeguards.

Article 6(3) sets out the requirement for a project to be subject to an **appropriate assessment** of its implications if it is likely to have significant effects, or significant effects cannot be ruled out, upon the N2K site. The appropriate assessment must determine in a scientifically robust manner whether a project is likely to have adverse effects on the N2K site. If a project is deemed likely to have an adverse impact, or an adverse impact cannot be ruled out, alternative ways or means to achieve the projects objectives must be considered. If no feasible alternatives exist, the proposal is of overriding public interest, and appropriate compensatory measures can be offered, Article 6(4) can be invoked in exceptional cases only.

Box 4. Article 6 of the Habitats Directive

(1) For special areas of conservation, Member States shall **establish the necessary conservation measures** involving, if need be, appropriate management plans specifically designed for the sites or integrated into other development plans, and appropriate statutory, administrative or contractual measures which correspond to the ecological requirements of the natural habitat types in Annex I and the species in Annex II present on the sites.

(2) Member States shall take appropriate steps to avoid, in the special areas of conservation, the deterioration of natural habitats and the habitats of species as well as disturbance of the species for which the areas have been designated, in so far as such disturbance could be significant in relation to the objectives of this Directive.

(3) Any plan or project not directly connected with or necessary to the management of the site but ***likely to have a significant effect*** *thereon, either individually or in combination with other plans or projects, shall be subject to* ***appropriate assessment*** *of its implications for the site in view of the site's conservation objectives. In the light of the conclusions of the assessment of the implications for the site and subject to the provisions of paragraph 4, the competent national authorities shall agree to the plan or project only after having ascertained that it* ***will not adversely affect the integrity of the site*** *concerned and, if appropriate, after having obtained the opinion of the general public*.

(4) *If, in spite of a negative assessment of the implications for the site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for* ***imperative reasons of overriding public interest****, including those of a social or economic nature, the Member State shall take all compensatory measures necessary to ensure that the overall coherence of N2K is protected. It shall inform the Commission of the compensatory measures adopted.*

Where the site concerned hosts a priority natural habitat type and/or a priority species, the only considerations which may be raised are those relating to human health or public safety, to beneficial consequences of primary importance for the environment or, further to an opinion from the Commission, to other imperative reasons of overriding public interest.

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Table 5. Summary of the main provisions of Article 6 of the Habitats Directive

Article	Requirements of Article 6	
6 (1)	Conservation management	Establish necessary conservation measures (in SACs only; conservation measures for SPAs established under the Birds Directive) and appropriate statutory, administrative or contractual measures.
6 (2)		Avoid deterioration of habitat types and disturbance to species within SACs and SPAs insofar as it could prevent achieving the objectives of the directive.
6 (3)	Procedural safeguards applying to land use	Undertake appropriate assessment to determine the impact of plans and projects likely to have a significant effect on a N2K site (SAC or SPA). The competent authority can then only approve a plan or project if it can determine that it will not adversely affect the integrity of the site in question.
6 (4)		If the assessment concludes that the plan or project will result in adverse impacts, and importantly if no alternatives exist, the plan or project can only proceed if imperative reasons of overriding interest (IROPI) exist.

6.1.2. Favourable Conservation Status

According to Article 1(e) of the Habitats Directive, the '*conservation status*' of a habitat '*means the sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions as well as the long-term survival of its typical species*' within the territory of the Member States. Article 1(i) defines the conservation status of a species as '*the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its population*' across the territory of the Member States.

The N2K network is considered to be one of the main instruments for ensuring biodiversity across the European territory, and this is the overarching objective of the Habitats Directive. The N2K network is composed of sites hosting the natural habitat types listed in Annex I and the habitats of the species listed in Annex II. According to Article 3 of the directive, the aim of the N2K network is to enable these habitat types and species to be 'maintained, or where appropriate, restored to favourable conservation status in their natural range'. Each Member State is obliged to contribute to the creation of the N2K network in proportion to the representation within its territory of the natural habitat types and habitats of the species and designate SACs and SPAs. The overall aim of the directive is to contribute to achieving favourable conservation (FCS) status of Annex I habitat types and Annex II species of the Habitats Directive as well as regularly occurring migratory bird species and species listed in Annex I of the Birds Directive (see *Box 5*).

Under Article 17 of the Habitats Directive, every six years each Member State is required to report on the implementation of the directive including the conservation status of natural habitat types listed under Annex I and species listed under Annex II. The conservation status of habitat types and species within and outside of N2K sites contribute to the overall conservation status. The term, 'favourable conservation status' (FCS), refers to the biogeographic or national or European level. The assessment of the conservation status of habitats and species is done using statistical analysis, which for habitats involves an analysis of the range, area, structure and function, and future prospects, and for species involves an analysis of the range, population, habitat for the species and future prospects.

The results of the 2001-2006 reports show that FCS has not been achieved for many habitat types and species either at biogeographic or national level (EC, 2009). At the biogeographic level nearly 65% of the 701 Annex I habitat assessments were unfavourable while only 17% of the habitats assessments are favourable. The status of the remaining habitats was unknown at the time of

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publication. Distinct differences were evident between biogeographic regions. For example none of the habitat assessments from the Atlantic region were favourable whereas 20-30% of habitat assessments were favourable in the Mediterranean and Alpine regions. According to the same report, of the 2,220 species assessments conducted only 17% of assessments were favourable while 52% were unfavourable.

According to EC (2009), it is unrealistic to expect to see a clear positive relationship between the N2K and the conservation status of habitat types and species listed in the directive. However, there is evidence that SPAs, designated under the Birds Directive and adopted 13 years before the Habitats Directive, contributes significantly to the protection of bird species. At the time of publication of this report, the Commission had not yet published the composite report summarising the habitat and species assessment for the period 2007-2012.

Box 5. Favourable Conservation Status (FCS)

The conservation status of a natural habitat will be taken as ‘favourable’ within the territory when:

- its natural range and areas it covers within that range are stable or increasing, and
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
- the conservation status of its typical species is favourable.

The conservation status of a species will be taken as ‘favourable’ within the territory when:

- population are maintaining themselves on a long-term basis as a viable component of its natural habitats, and
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

6.1.3. Conservation Objectives

A PHES or CAES related plan or project must be subject to appropriate assessment of its implications for N2K site/s. The objective of Appropriate Assessment is to ensure that any plan or project likely to adversely affect a N2K site’s integrity is not authorised. Assessing whether a site’s integrity will be affected is done in view of the sites conservation objectives.

Article 6(2) refers to the prevention of the deterioration or disturbance of the target features (habitat types and species listed in Annex I and II for which SACs and SPAs have been designated) in N2K sites. This could be considered the minimum conservation objective for every site.

The target features identified within a N2K site form the basis of a site’s conservation objectives. The conservation objectives in turn form the basis for establishing site related conservation measures, which are informed by the ecological requirements of the target features and are the practical mechanisms Member States are obliged to put in place to achieve objectives. Conservation objectives should contribute to maintaining or achieving FCS at the national, biogeographic or European level. While each site contributes to the attainment of FCS this objective can only be defined and achieved at the level of the natural range for a habitat or species. The general objective of achieving FCS must be reflected in site related conservation objectives and measures so that the desirable condition of the target features is achieved in order to maximise the contribution of any particular site to attaining FCS at the national, biogeographical

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or European level. This provides the basis for establishing conservation objectives. The target features may require maintenance and/or restoration to sufficiently contribute to achieving FCS at higher levels.[4]

6.1.4. Summary of appropriate assessment process

The appropriate assessment process determines whether the plan or project is likely to adversely affect site integrity. The assessment is exclusively confined to the Annex I habitat types and Annex II species within the N2K site. It is a very rigorous process and has a number of steps and 'tests' which are difficult to pass. This document is designed to provide guidance for each stage of the process of which there are four. Each stage determines whether it is necessary to proceed to the next stage. The precautionary principle applies during the process. *Figure 6* below provides a flowchart illustrating the main stages and steps of appropriate assessment.

A screening process, Stage 1, establishes whether or not there is a risk to the N2K site determining the need for appropriate assessment. A project does not have to be within or even adjacent to a N2K site/s for it to have a potentially adverse effect on the conservation objectives of sites and to trigger the need for an appropriate assessment. If the screening determines with certainty there is no risk then there is no need to proceed to the next stage and the plan or project can be authorised.

An appropriate assessment, Stage 2, is undertaken subsequent to a plan / project being subjected to the screening exercise. It is an impact assessment tool to determine the implication of a plan or project on the integrity of the N2K site/s, either alone or in combination with other plans/projects, with respect to the sites ecological health (structure and function) and its conservation objectives. The outcome of the assessment informs decision-making.

If the outcome of the assessment is positive and no reasonable scientific doubt remains regarding the absence of negative effects to the site, then the competent authority or decision-maker can grant consent and authorise the plan or project. A plan or project can only be consented or authorised by the competent authority if it is satisfied that it will not adversely affect the integrity of the site.

The competent authority shall only approve or authorise a PHES or CAES project having ascertained that it will not adversely affect the integrity of the site/s concerned.

Where adverse impacts are likely to occur or cannot be ruled out, the plan or project must be abandoned or the assessment can proceed to Stage 3 where alternative solutions are examined. Alternative design, sites and technologies should be examined to determine if they can feasibility achieve the objective of the plan or project by other means. Where a feasible alternative is identified, then it must be subject to a screening exercise and process repeated as necessary.

Where no alternatives exist, the plan or project can proceed to Stage 4 where derogation to Article 6(4) can be sought. A decision must be taken on whether it is considered to qualify as a plan or project of 'imperative reasons of overriding public interest' (IROPI). If a plan or project does qualify as IROPI then suitable compensatory measures must be designed and secured to offset the adverse impact to, and ensure the coherence of, the N2K network is maintained; these measures must be practically achievable.

The appropriate assessment procedure is discussed in detail in the following sections.

[4] European Commission note on setting conservation objectives for Natura 2000 sites.

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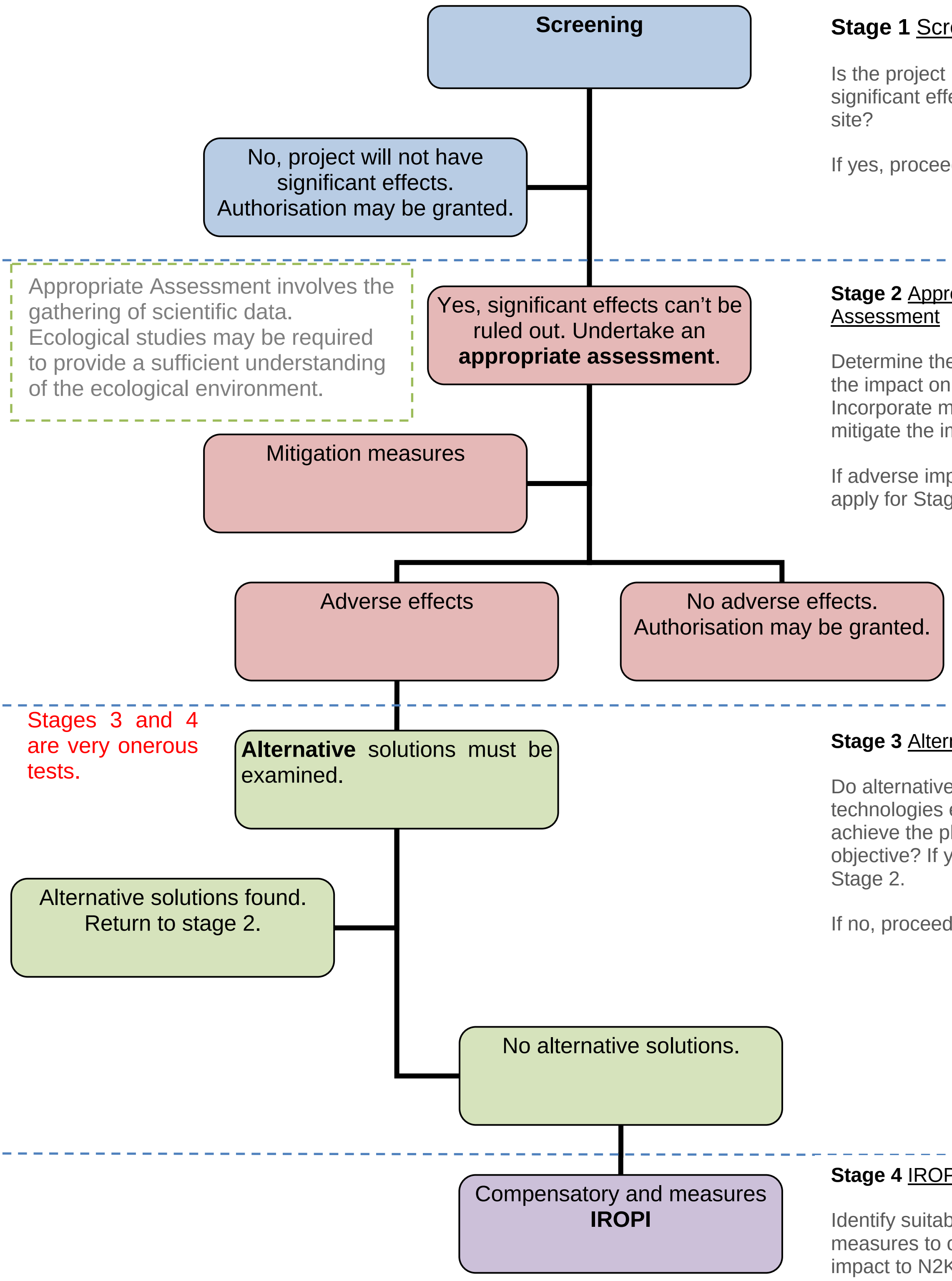

Stage 1 Screening

Is the project likely to have a significant effect on the N2K site?

If yes, proceed to Stage 2.

Stage 2 Appropriate Assessment

Determine the significance of the impact on the N2K site. Incorporate measures to mitigate the impact.

If adverse impacts persist apply for Stage 3.

Stage 3 Alternatives

Do alternative design, sites or technologies exist that will achieve the plan or projects objective? If yes, return to Stage 2.

If no, proceed to Stage 4.

Stage 4 IROPI

Identify suitable compensatory measures to offset adverse impact to N2K network that are practically achievable.

Is the plan or project of overriding public interest?

Figure 6. Flowchart summarising stages of appropriate assessment

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6.2. *Stage 1 – Screening for Appropriate Assessment*

Screening is the process which identifies the likely impacts upon a N2K site of a project or plan, either alone or in combination with other plans or projects, and considers whether these impacts are likely to be significant.

6.2.1. When is a screening for appropriate assessment required?

The screening stage determines the need for a plan or project to be subject to appropriate assessment of its implications for the conservation objectives of a N2K site. **Screening is required for any PHES or CAES related plan or project that may interact with, or is capable of having an effect on, a N2K site**. A plan or project does not have to be within, adjacent to or even near a N2K site for it to have an effect. For example, a project may be a distance upstream of a site or share the same groundwater body and still have an effect. The test is whether the plan or project is capable of having an appreciable or significant effect on the site.

The competent authority can conduct a pre-assessment to determine the need for a screening exercise. If impacts cannot be ruled out then it must be subject to the full requirements of Article 6(3).

The Habitats Directive does not provide a definition for plans or projects. Both plans and projects are interpreted in a very broad sense by EU legislation and the European Court of Justice (ECJ). The definition of projects is not limited to construction works and may be as broadly considered in terms of any interventions in the natural environment. The leading case on the need for appropriate assessment is Waddenzee. In the Waddenzee judgement case C-127/02[5] the ECJ ruled that licences issued by the Secretary of State for agriculture, nature conservation and fisheries to the Cooperative producers association of Netherlands cockle fisheries for the mechanical fishing of cockles in SPAs of the Waddenzee that this was within the concept of a project as defined under the EIA Directive. (EC, 2006)

Table 6 outlines the types of plans, projects and activities that may be relevant PHES and CAES and which require prior consent and therefore may be subject to appropriate assessment.

Table 6. Bulk EST plans and projects subject to Article 6

Plans	Energy sector plans, bulk EST specific plans, other related plans e.g. River Basin District Plans under the Water Framework Directive (2000/60/EC)
New projects	All planning applications especially those seeking consent for new developments, extensions or retro-fitting existing plant; all developmental consents
Ongoing activities	All activities requiring consent e.g. new or renewing historic licences, permits. Changes to operational regimes may be subject to Article 6

[5] Judgment of the Court of 7 September 2004 in case C-127/02, paragraphs 57 and 61

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6.2.2. What does the screening exercise involve?

The objective of a screening exercise is to establish whether a plan or project is **likely to have a significant effect on a N2K site**, either alone or cumulatively with other plans and projects and considers whether it can be objectively concluded that these effects will not be significant.

Screening for appropriate assessment involves the following:

- Establish whether the plan or project is necessary for the management of a N2K site.
- Description of the Plan.
- Identification of N2K sites potentially affected.
- Identification and description of individual and cumulative impacts likely to result from the plan.
- Assessment of likely significant effects.
- Exclusion of sites where it can be objectively concluded that there will be no significant effects.

If the plan or project relates to the management of a N2K site, no further assessment is required. PHES and CAES plans and projects are not directly connected with a sites management so this step is not applicable.

All relevant components of the project must be fully described in order to ascertain what aspects will interact with the N2K site. These should include but are not limited to: size and scale, physical changes, resources, waste, duration and phasing. Only those aspects of the development that have the potential to impact on a N2K sites conservation objectives are considered.

In order to adequately determine the cumulative or in-combination effect on the N2K site, existing and proposed projects within the regional vicinity and catchment/s must be identified and described.

The screening stage of AA involves compiling a list of European sites within a zone of potential impact influence for later analysis which may or may ultimately not be impacted upon by the proposal. All N2K sites within the zone of influence of the proposal location should be characterised in the context of the rationale for designation and target features. A number of useful sources are identified in *Box 6*.

Box 6. Useful Information Sources

- National Nature Conservation agencies and non organisations that manage N2K sites
- Management Plans for individual N2K sites (if available by the conservation authority)
- Conservation objectives or statements for individual N2K sites
- Standard Data Forms for individual N2K sites
- European and national online GIS map viewers

Following this, the potential impacts associated with the proposal should be identified before a determination is made of the likely significance of these impacts in-combination with other plans and projects. If there is a possibility that likely significant effects will occur then a full appropriate assessment will be required. The screening stage triggers the need for appropriate assessment by

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determining whether there might be a significant effect, however, the need to establish such an effect occurs at the next stage.

For a plan or project to be screened out, it must be conclusively demonstrated that there is no possibility of the occurrence of significant impacts to the N2K site, either alone or in-combination with other plans or projects. If it cannot be conclusively determined that there will be no appreciable effect on the site, or if doubt remains as to the significance of effects, it will also be necessary for the plan or project to be tested further at Stage 2.

If it can be determined with certainty that the plan or project will not have a significant effect on the N2K network, either alone or in-combination with other plans or projects, then there is no requirement to proceed beyond Stage 1 Screening. However, the decision must be recorded. **Due to the size, scale and nature of PHES and CAES developments, there will be a requirement for them to be screened for appropriate assessment in nearly all cases**.

6.2.3. Can mitigation be considered in the screening exercise?

The purpose of mitigation is to avoid or reduce identified significant impacts. There are a number of categories of mitigation:

- Strategic – considering alternative sites or means of achieving the plan / project objective e.g. alternative to electricity storage.
- Design – considering alternative scheme layouts to avoid or reduce impact.
- Management – considering measures to reduce the identified impact e.g. dust control, environmental management plans (Carroll and Turpin, 2009).

According to the EC (2002), the screening exercise should be carried out, '*in the absence of any consideration of mitigation measures that form part of the project or plan and are designed to avoid or reduce the impact of a project or plan on a N2K site*'... *'To ensure the assessment is as objective as possible, the competent authority must first consider the project or plan in the absence of mitigation measures that are designed into a project*'. This contrasts with EIA guidance from the EC (2001 (b)) which recommends that mitigation is considered when assessing the impacts of a project to determine whether an assessment is needed. The Habitats Directive does not provide any direction in relation to the level, if any, of mitigation that can be taken into account in the screening stage. In the Hart[6] case judgement in the UK the court ruled that mitigation should be taken into account in the screening exercise provided the proponent has fully recognised, assessed and reported the effects.

In considering CAES or PHES plans or projects, screening should be carried out in the absence of consideration of design and management options for mitigation. Should these mitigation options be required to avoid or reduce the significance of an impact they need to be considered at Stage 2 of appropriate assessment.

6.2.4. Who carries out the screening exercise?

Screening can be carried out by the project proponent, the competent authorities, specialist agencies etc. depending on how MS have transposed the directive into national law. In the case where the plan or project proponent conducts the screening (who may contract the services of an ecological or Appropriate Assessment expert), they compile the report, draw conclusions and present it to the competent authority for consideration. In making their assessment the competent

[6] R (Hart District Council) v Secretary of State for Communities and Local Government and others.

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authority may consult with relevant nature conservation organisations and apply the precautionary principle before making the final screening decision.

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6.3. *Stage 2 – Appropriate Assessment*

Appropriate assessment is the consideration of the impact on the integrity of the N2K site of the project or plan, either alone or in combination with other plans or projects, with respect to the site's structure and function and its conservation objectives. Additionally, mitigation of these impacts can be considered.

6.3.1. Purpose

The purpose of the appropriate assessment is to consider the implications of a plan or project, in this case for PHES and CAES, for the N2K site in detail based on sound and objective scientific information. The aim of the assessment is to provide a sufficient level of information to the competent authority on which to base their appropriate assessment of the plan or project. The plan or project should be fully described particularly in relation to the aspects that could interact with the surrounding environment. The test is whether the plan or project will have 'an adverse effect on the integrity of the site'. There is no mandatory method for conducting an appropriate assessment; however the EC (2001) as well as MS have published guidelines, which are referenced above in *Box 3*.

6.3.2. Gathering the Information

Contrary to the screening exercise in Stage 1, this stage requires the plan or project proponent to gather much more information. This usually takes the following format: desk study; consultation; and field study.

Existing collated data can be re-examined and assessed to decipher any information gaps. Scoping of the appropriate assessment is a useful exercise as it identifies what issues or subjects must be covered, the data that needs to be gathered and the field studies needed to be completed in support of the assessment. It is also recommended that consultation with stakeholders such as the relevant nature conservation agency and other organisations to gain their views should be conducted at this stage. It is important that adequate baseline data is gathered in order to conduct the assessment. This can be a difficult, costly and lengthy process where new surveys are required especially those concerning the characterisation of the hydrological and hydrogeological environment.

The zone of influence of the plan and project needs to be identified and the N2K sites within that zone identified. In the case of river catchments this may need to extend further downstream and as far as coastal areas in certain cases. Geographic and spatial relationship between the plan or project and the N2K site e.g. distances, water catchments, slope, pollution pathways (source – pathway – receptor), will need to be distinguished.

Knowledge of the characteristics and aspects of other plans or projects that may interact with the N2K site will also be required in order to carry out the cumulative assessment.

Apart from the information sources listed in *Box 6*, other useful information sources include publications from Non-Governmental Organisations and research institutions. Information on the N2K site should include:

- The conservation objectives

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- Evaluation of the sensitivity of species and habitat types
- Other conservation issues
- Other pressures on the site
- Ecological health (key structural and functional relationships that create and maintain the sites integrity) of the elements that make up the site

A full understanding of the relevant ecological processes and requirements of habitat types and species is required. An example of the studies that may be necessary depending on the characteristics of the site and the ecological requirements of the target features effected to fully inform the baseline ecological assessment include but are not limited to:

- Surveys to characterise the existing terrestrial ecological environment: habitats, vegetation, birds, mammals, invertebrates.
- Aquatic surveys to determine species diversity and abundances: fisheries, freshwater invertebrates.
- Physio-chemical analysis to determine the existing water quality.
- Hydrological and hydrogeological studies to determine the interaction of the proposal with all surface waters and groundwaters.

6.3.3. Impact Assessment

Impact assessment refers to the change that is predicted to take place to the existing condition of the environment (target features in the context of Appropriate Assessment) should a proposed plan or project development go-ahead (Carroll and Turpin, 2009). Impacts are considered in terms of source, pathway and receptor. The predictive method used to assess the level of impact should be included in the assessment documentation, or final statement. The identified impacts should be as accurate as possible, quantified and the rationale for each explained. The description of the impacts should consider the following:

- Construction or operational phase
- Positive or negative
- Direct and indirect
- Temporary and permanent as well as short-, medium- and long-term
- Cumulative or in-combination plans or projects
- Likelihood of occurrence

The assessment needs to consider all elements that are necessary to the ecological structure and functioning of the site and focus on the qualifying features. Each component or aspect of the plan or project must be considered in the context of its interaction with each of the target features of the site. Impact prediction can be difficult and often more than one ecological expert will be required e.g. avian, fishery, rare plant specialists etc. Furthermore, the various experts should consult, interact and exchange information with one another during the assessment. Ecologists and hydrologists together with the project engineers and designers will need to exchange information to describe and assess the interactions between the ecological and hydrological environments.

Once the impact is described it will be necessary to determine its ecological significance. The significance of an effect is commonly judged by comparing the extent of the change with particular standards and criteria relevant to the topic in question (Carroll and Turpin, 2009). In terms of

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appropriate assessment significance is measured against the conservation objectives of the N2K site and whether these will be compromised by the proposal. The precautionary principle is applied. It must be objectively determined whether the predicted impacts will adversely affect the conservation objectives, which focus on the target features whose conservation status contributes to the sites integrity. The assessment of the significance of an effect should be undertaken in a structured and systematic manner with supporting objective scientific evidence.

Appropriate assessments are site specific analyses and need to be carried out on a case by case basis as each situation differs. The assessment must have regard to the characteristics and local environmental conditions of the site and must use the best current available scientific evidence. The following is a list of significance indicators:

- Reduction of habitat area
- Disturbance of key species
- Habitat or species fragmentation
- Reduction in species density
- Changes in key indicators of conservation value
- Change to hydrological or hydrogeological regime
- Climate change (e.g. mesoclimate)

Where significant effects are identified it will be necessary to design mitigation measures.

6.3.4. Mitigation

Mitigation is used to avoid or reduce identified significant environmental impacts. Under the EC (2002) guidance, mitigation is considered in terms of a hierarchy of preferences: avoidance of impact at source; reduction of impact at source; abatement of impacts on site; and finally abatement of impacts at receptor.

Where significant impacts cannot be mitigated, compensation, which usually indicates habitat creation or improvement away from the site, may be considered. Compensation is only applicable to Stage 4 of appropriate assessment and not to preceding stages. Such measures can only be considered where it is accepted that adverse effects will occur, no feasible alternative means of achieving the plan / project objective exists and the plan / project is considered of overriding public interest.

Mitigation may be an integral part of the proposal or they may be designed following completion of its design. Well-implemented mitigation measures are essential. Mitigation measures need to be sufficiently robust to reduce the significance of any identified impacts.

6.3.5. Assessment of Adverse Effects

Assessments need to demonstrate with supporting evidence and the relevant studies that there will be no adverse impacts on the integrity of a N2K site. The integrity of a site relates to a site's conservation objectives and is considered to be the quality or condition of being whole or in a dynamic way means the resilience and ability of a site to evolve in a favourable manner. The **integrity of a site** is defined as, '*the coherence of a site's ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the levels of*

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populations of the species for which it was classified'[7]. The integrity can be understood to refer to the continued wholeness and soundness of the constitutive characteristics of the site concerned[8].

The Waddenzee judgement case C-127/02[9] ruled that, '*all the aspects of the plan or project which can, either individually or in combination with other plans or projects, affect those [conservation] objectives must be identified in the light of the* ***best scientific knowledge*** *in the field*'. The Waddenzee judgement ruled that where reasonable scientific doubt or uncertainty remains as to the absence of adverse effects on the integrity of a site linked to a project, the competent authority must refuse authorisation.

The evidence presented to the competent authority must therefore be prepared by experts, be objective, leave no room for doubt as regards the significance of the effect. This test can therefore be quite onerous and difficult to pass.

Case study 2: N6 Galway City Outer Bypass road scheme

In a judgement (Case C-258/11) from the EC in relation to the proposal to develop the N6 Galway City Outer Bypass road scheme regarding the significance of an impact where a relatively small area of limestone pavement on the edge of a N2K site, a priority habitat, would be permanently lost, the court ruled that this would contravene the objectives of the directive. Paragraph 46 of the judgement states, '*if, after an appropriate assessment of a plan or project's implications for a site, carried out on the basis of the first sentence of Article 6(3) of the Habitats Directive, the competent national authority concludes that that plan or project will lead to the lasting and irreparable loss of the whole or part of a priority natural habitat type whose conservation was the objective that justified the designation of the site concerned as an SCI, the view should be taken that such a plan or project will adversely affect the integrity of that site*.'

In the opinion of the Advocate General (Case C-258/11) considered that the habitat under consideration was essential to the unity, coherence and integrity of the site and the permanent destruction of part of a site that constituted a qualifying interest was an adverse effect. She noted that contravening the objective of the directive in this way could result in the 'death by a thousand cuts' phenomenon where cumulative habitat loss would arise as a result of multiple lower level projects being allowed to proceed on the same site.

If the competent authority determines that the proposal will adversely affect the integrity of the N2K site and that the effect cannot be mitigated, they must withhold consent except where the certain tightly defined conditions are met in relation to the finding of no alternatives and considering the proposal one of overriding public interest. If this is the case the plan or project must proceed to the next test, Stage 3, and examine alternatives.

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[7] PPG Guidance 9: Nature conservation. UK Government.

[8] Opinion of the Advocate General Sharpston in case C-258/11

[9] Judgment of the Court of 7 September 2004 in case C-127/02, paragraphs 57 and 61

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Case study 3: Kaunertal PHES project, Austria (see Wänn et al. 2013 for full text)

TIWAG-Tiroler Wasserkraft AG is a state owned company in the West of Austria that was set up in 1924 to build the largest hydropower facility in Austria at the time. Shortly after that they cooperated with the state of Bayern, Germany to build the first cross-border 110 kV-line. Today the company own 9 large and medium sized hydropower parks (some including PHES facilities) and 36 small hydropower facilities. Currently the TIWAG are in the approval process for two PHES facilities, Kühtai and Kaunertal. This example will expand further on the Kaunertal project.

In Kaunertal a hydropower facility already exists at Prutz that uses the stored water in the Gepatsch reservoir situated 900m above. The Kaunertal project will add another hydropower facility at Prutz, the Prutz 2. Above the Gepatsch reservoir another reservoir will be constructed called Platzertal. Between the Platzertal – Gepatsch reservoirs is where the Kaunertal PHES will be located; it has a head of about 600m and will generate 400MW and be able to pump 390MW. The Kaunertal PHES will be a semi-open PHES facility according to the stoRE definition, due to significant water flow through the reservoir Gepatsch.

To increase the amount of water in the Gepatsch reservoir thus increasing generated power, the project is proposing to abstract and transfer water from the neighbouring valley Ötztal. There are two large and two smaller catchment areas associated with the two abstraction points. All four of the catchment areas are in the N2K site; the points of abstraction are just outside the N2K sites. The transfer tunnels will go through the mountains and will be constructed in a manner that does not impact on the ground water.

The Environmental NGO's (Non-Government Organisation) have stated their opposition to the entire project as they maintain that the rivers within the area of Ötztal have not been obstructed by dams up until now and therefore should be protected for their naturalness.

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6.4. Stage 3 – Assessment of alternative solutions

Assessment of alternative solutions is the process which examines alternative ways of achieving the objectives of the project or plan that avoid adverse impacts on the integrity of the N2K site.

Following a negative outcome, alternative means of achieving the objective must be identified for it to proceed to the next stage. The examination of alternatives requires that **the conservation objectives and status of the N2K site will outweigh any consideration of costs, delays or other aspects of an alternative solution**. The proponent must demonstrate that they have fully considered alternatives. The competent authority must also consider alternative solutions. If alternatives cannot be identified then the plan or project can proceed to the next and final stage where it will be decided whether it is an essential public plan or project. Alternatives that can be reasonably considered for PHES and CAES plans or projects can include:

- Alternative means of achieving the objectives of the plan or project e.g. alternative to energy storage
- Alternative locations
- Alternative scale and designs
- The do-nothing scenario

Alternatives means of achieving the objectives of a plan or project will depend on the services that the PHES is required to provide. PHES provides the electricity grid with electricity storage and ancillary services such as: grid balance, grid flexibility, supply smoothing, black start capabilities, spinning reserve, auxiliary reserve, peak shavings, regulation control, security, etc. For example, if the objective is to provide operating reserve then alternatives may include gas power plants or hydropower. However, if the objective is to remove excess power from the grid then alternatives could be demand side management or curtailment/constraining of energy sources. It should be noted that PHES can provide both of the services highlighted in the two examples.

For PHES there usually will be limited alternatives in terms of different locations though the scale and design of the project can be reconsidered.

If MS have acknowledged the need for PHES to achieve greater penetration of intermittent RES and utilize its grid services then the do-nothing scenario may not be feasible and services of PHES will have to be achieved by other means. These alternative means will have to be subject to Appropriate Assessment.

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6.5. Stage 4 – IROPI and Compensatory Measures

Assessment where no alternative solutions exist and where adverse impacts remain — an assessment of compensatory measures where, in the light of an assessment of imperative reasons of overriding public interest (IROPI), it is deemed that the project or plan should proceed.

With a negative assessment (i.e. a PHES or CAES project cannot demonstrate beyond reasonable scientific doubt that an adverse effect on N2K site/s will not occur) a project can only proceed once it has been determined that no alternative to the project exists (stage 3). The project may then only proceed on the basis of 'imperative reasons of overriding public interest' (IROPI), including social, economic or public safety, depending on the priority status of the habitat types or species affected (stage 4). For priority habitat types or species, the only considerations are those relating to human health and safety, as well as beneficial consequences of primary importance to the environment, or alternatively if a plan or project can be justified by other imperative reasons of overriding public interest following an opinion from the Commission. Only if these conditions are met can a plan or project affecting priority habitat types be justified and proceed to Stage 3. For non-priority habitat types or species social and economic considerations can be taken into account.

According to the EC (2000) it is clear that the IROPI of a social and economic nature refers only to public interests and not solely private interests, promoted either by public or private bodies; only public interests can be considered against the conservation aims of the directive. The word imperative suggest a project of vital or essential importance or that is indispensible. In the absence of viable alternative solutions (i.e. the services that a PHES can provide cannot be achieved by other means) to a proposed PHES, a project may be deemed of national public interest, however, the long-term advantages to the public would need to outweigh the conservation aims of the directive.

The "no alternative solutions" and IROPI tests are arduous and difficult to pass. One of the reasons is that conservation of a natural habitat types or species is preferable to compensatory measures as there is no guarantee of success.

Derogations from the requirements of Article 6 are interpreted in a restrictive way by the courts (MMO, 2011). If all alternative solutions have been ruled out and the project is deemed to be IROPI i.e. both test have been passed, the proponent will be required to provide compensatory measures. Such measures would be in addition to the proper implementation of the Habitats and Birds Directives and may be in the form of measures to mitigate the negative impact on the affected N2K site/s or may be independent of the project. The project proponent must bear the cost of compensation measures (EC, 2000).

Compensation measures need to fully offset any adverse impacts arising as a result of the plan or project. In such cases, the feasibility of compensatory measures should be assessed first, as many N2K qualifying features cannot, by their biological nature, be compensated at all. The Commission must be informed of the measures adopted.

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Case Study 3: Rotterdam Port Expansion

In 2002 the Dutch government sent a formal notification to the DG Environment according to Article 6(4) of the Habitats Directive regarding the plan, 'Project Mainport Rotterdam (PMR)'. The government made the case that in the face of continued economic growth a shortage of industrial space would develop in Rotterdam harbour and surrounding industrial areas. The project included land reclamation and would significantly affect the integrity of a number of N2K sites including a priority habitat, namely grey dunes.

Alternative proposals to the expansion were examined in detail.

The Dutch government declared the land reclamation project had to be executed for imperative reasons of overriding public interest other that those related to human health and safety or beneficial consequences of primary importance to the environment. To offset the expected effects the government proposed a package of compensation measures involving the creation of new dunes, beach habitats and a coastal marine reserve.

Considering the expected effects of the land reclamation project on the priority habitat type and the expected results from the compensatory measures the Commission held the view that in the long term the overall coherence of N2K would not be affected.

6.6. Summary of Appropriate Assessment Process

Article 6 of the Habitats Directive establishes the provisions governing the conservation and management of N2K sites (see Box 4). It plays an important role in establishing the relationship between conservation and activities (plans or projects) affecting N2K sites.

Article 6(3) sets out the requirement for a project to be subject to an **appropriate assessment** of its implications if it is likely to have significant effects, or significant effects cannot be ruled out, upon the N2K site.

There are four stages in appropriate assessment: (1) screening, (2) appropriate assessment, (3) assessment of alternatives and (4) IROPI and compensatory measures.

Due to the size, scale and nature of PHES and CAES developments, there will be a requirement for them to be screened for appropriate assessment in nearly all cases.

The purpose of the appropriate assessment is to consider the implications of a plan or project, in this case for PHES and CAES, for the N2K site in detail based on sound and objective scientific information. The aim of the assessment is to provide a sufficient level of information to the competent authority on which to base their appropriate assessment of the plan or project. Contrary to the screening exercise in Stage 1, this stage therefore requires the plan or project proponent to gather much more information. This usually takes the following format: desk study; consultation; and field study.

The impact assessment needs to consider all elements of the project, either alone or cumulatively with other plans and projects that are necessary to the ecological structure and functioning of the N2K site and focus on the target features i.e. the habitats and species for which the site was

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designated. Assessments need to demonstrate with supporting evidence and the relevant studies that there will be no adverse impacts on the integrity of a N2K site.

If the competent authority determines that the proposal will adversely affect the integrity of the N2K site and that the effect cannot be mitigated, they must withhold consent except where the certain tightly defined conditions are met in relation to the finding of no alternatives and considering the proposal one of overriding public interest. If this is the case the plan or project must proceed to the next test, Stage 3, and examine alternatives.

If alternatives cannot be identified then the plan or project can proceed to the next and final stage where it will be decided whether it is an essential public plan or project.

The project may then only proceed on the basis of 'imperative reasons of overriding public interest' (IROPI), including social, economic or public safety, depending on the priority status of the habitat types or species affected (stage 4). For priority habitat types or species, the only considerations are those relating to human health and safety, as well as beneficial consequences of primary importance to the environment, or alternatively if a plan or project can be justified by other imperative reasons of overriding public interest following an opinion from the Commission. Only if these conditions are met can a plan or project affecting priority habitat types be justified and proceed to Stage 3. Compensation measures need to fully offset any adverse impacts arising as a result of the plan or project.

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