The hydro pumped storage plant Pfaffenboden in Molln is essential for the further increase of renewable energy production in Austria, as well as the neighbouring countries, like Germany or the Czech Republic. The reason behind is that base load power stations (e.g. coal-fired power stations or nuclear power stations) are increasingly substituted by fluctuating renewables (e.g. wind or photovoltaic). Therefore the need for quick and flexible storages will further increase in the near future. As a result the stabilization of the electricity grid through hydro pumped storage plant is essential.

**Project 1000 - Hydro Pump Storage Power Plant Pfaffenboden in Molln**

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Austria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promoted by</td>
<td>Wien Energie GmbH</td>
</tr>
</tbody>
</table>

**Project Details**

- **Commissioning Date**: 2019
- **Hydro Pump Type of Storage**: Storage
- **Max Active Power (MW)**: 300
- **Storage Capacity (GWh)**: 1.8

**Storage Analysis**

In addition to the well known benefits of the hydro pumped storage technology the project in Molln has, due to the connection to the high level multinational transmission grid, positive impacts on the neighbouring electricity markets of Germany and the Czech Republic.

**Additional Information**

Besides the positive impacts on the environment due to the increased integration of RES, no significant impacts on nature conservation areas and the environment are expected, as a result of all necessary screening and permitting procedures.

**General CBA indicators**

<table>
<thead>
<tr>
<th>Delta GTC contribution (2030)</th>
<th>Turbine</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>[MW]</td>
<td>Pumping</td>
<td>326,4</td>
</tr>
<tr>
<td>Cost [Meuros]</td>
<td>340</td>
<td></td>
</tr>
</tbody>
</table>

**Scenario specific CBA EP2020 Vision 1**

<table>
<thead>
<tr>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>10 +/-</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>-10 +/-</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>200 +/-</td>
<td>100 +/-</td>
</tr>
</tbody>
</table>

**Capability for ancillary services**
voltage control, frequency control
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Austria enables saving in generation capacity of 10 - 13 Meuro/year

Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association for Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>Response time to activate Frequency Containment Reserves</th>
<th>+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to reach the available power</td>
<td>+</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>+</td>
</tr>
</tbody>
</table>
**Project 1001 - Kaunertal Extension Project**

Extension of the existing Kaunertal hydro storage power station by: the new pumped hydro storage power station Versetz and the new reservoir Platzertal including new water intakes, the additional power stations Prutz 2, Imst 2 and Haiming.

**Boundary**
- Austria

**Promoted by**
- TIWAG

### Project Details

<table>
<thead>
<tr>
<th><strong>Commisioning Date</strong></th>
<th>2028</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pumped Hydro</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Type of Storage</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Storage</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Max Active Power (MW)</strong></td>
<td>1076</td>
</tr>
<tr>
<td><strong>Storage Capacity (GWh)</strong></td>
<td>152</td>
</tr>
</tbody>
</table>

### Storage Analysis

Highly efficient (economical, technical) cross-Border, national and regional support of system stability security of supply RES-E integration as well as low cost RES-E generation and electricity storage improvement of power gen. efficiency (load shedding) reduction of energy dependency substitution of fossil energy demand CO2 reduction by market based products and contributing to the achievement of sustainability, climate and energy policy targets at national/regional level corresponding with EU policy.

### Additional Information

Meanwhile, RES-E share amounts more than 30 % EU-wide. In a longer run, Austria and Germany aim to reach a RES-E penetration of close to 100%.

All relevant strategy studies and policy papers expect an exponential increase of flexibility capacity demand from now on and an additional significant increase of storage capacity from 2025 on to meet energy shifting demand primarily in the longer time range (hourly, daily, weekly and seasonally) that cannot be met by decentralized storage technologies or flexibility technologies (DSM, ...).

### General CBA indicators

<table>
<thead>
<tr>
<th><strong>Delta GTC contribution (2030)</strong></th>
<th>Turbine</th>
<th>1076</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>[MW]</strong></td>
<td>Pumping</td>
<td>390</td>
</tr>
<tr>
<td><strong>Cost [Meuros]</strong></td>
<td></td>
<td>1254</td>
</tr>
</tbody>
</table>

---
### Scenario specific CBA EF2020 Vision 1

<table>
<thead>
<tr>
<th></th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B2 SEW (MEuros/yr)</strong></td>
<td>50 +/- 10</td>
<td>70 +/- 10</td>
<td>60 +/- 10</td>
</tr>
<tr>
<td><strong>B3 RES integration (GWh/yr)</strong></td>
<td>&lt;10 +/- 10</td>
<td>910 +/- 180</td>
<td>910 +/- 180</td>
</tr>
<tr>
<td><strong>B4 Losses (GWh/yr)</strong></td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td><strong>B4 Losses (Meuros/yr)</strong></td>
<td>70 +/- 10</td>
<td>70</td>
<td>70 +/- 10</td>
</tr>
<tr>
<td><strong>B5 CO2 Emissions (kT/year)</strong></td>
<td>-300 +/- 10</td>
<td>-200 +/- 10</td>
<td>-700 +/- 100</td>
</tr>
</tbody>
</table>

### Capability for ancillary services

1) all sorts of load frequency control reserves for  
   - primary control  
   - secondary control  
   - tertiary control  
2) U/Q-conrol  
3) black start capability

All sorts of (future) flexibility products for balancing in the steady state and the dynamic operational modus  
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Austria enables saving in generation capacity of 34 - 43 Meuro/year

### Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>Response time to activate Frequency Containment Reserves</th>
<th>++</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to reach the available power</td>
<td>++</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>++</td>
</tr>
</tbody>
</table>
iLand consists in building an innovative hydro-pumped storage facility on an artificial island off the coast of Belgium (approximately 5 km offshore with an imprint of 4 x 2.5 km). iLand should provide a total hydraulic storage capacity of ca. 2.2 GWh, i.e., a total net storage capacity of 2.0 GWh, assuming a 90% efficiency in turbine-mode, and a net annual electricity generation of approximately 750 GWh.

Flexible access is being considered due to the specific nature of iLand and its complementarity with offshore wind. iLand would be able to store energy during peak wind periods and inject energy into the grid when there is little wind. iLand is thus not dependent on specific grid enhancements, which could suffer delays. Flexible access also enables TSOs to better maintain security of supply and allows for more efficient grid management.

iLand will enable a significant increase in the regional balancing capabilities of the Belgian grid and the grids of the Netherlands and France. Even the UK will benefit from iLand’s balancing properties if it is connected to the pending “NEMO” interconnector between Belgium and the UK.

iLand is the industrial result of a process initiated by the Belgian Government to cope with the needs of market integration, flexibility, sustainability and secure system operation of both the European and national electricity systems. The project is especially necessary in light of the growing impact of RES integration to meet the European goal of 27% RES by 2030. Despite initially focusing on Belgium, iLand’s developers see potential in, and are committed to, developing iLand as a project of European significance: iLand is essential to achieving the European Energy Union objectives and its crossborder significance will continue to grow as other TSOs are involved.

iLand will significantly contribute, and is necessary, to the investment needs in the NSOG priority corridor as identified in the EIR. The projected installed capacity (250-1,000 MW) and net annual electricity generation (750 GWh/year) of iLand largely exceed the thresholds imposed by the EIR to confer upon a project a “significant cross-border impact”, even when located in a single Member State (like iLand).

iLand contributes to all three of the EU energy policy pillars. Indeed, iLand will enhance market integration by improving balancing capabilities both within the Belgian network and also, through indirect interconnections, within the overall NSOG area. iLand will also contribute to sustainability by allowing for increased integration of RES into the grid because its flexibility will help alleviate offshore wind intermittency issues. iLand will also contribute to security of supply by providing service for flexibility and black start capacity.

**Project Details**

<table>
<thead>
<tr>
<th>Commissioning Date</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumped Hydro Type of Storage</td>
<td>Offshore</td>
</tr>
<tr>
<td>Max Active Power (MW)</td>
<td>550</td>
</tr>
<tr>
<td>Storage Capacity (GWh)</td>
<td>2</td>
</tr>
</tbody>
</table>

**Storage Analysis**

iLand will significantly contribute, and is necessary, to the investment needs in the NSOG priority corridor as identified in the EIR. The projected installed capacity (250-1,000 MW) and net annual electricity generation (750 GWh/year) of iLand largely exceed the thresholds imposed by the EIR to confer upon a project a “significant cross-border impact”, even when located in a single Member State (like iLand).

iLand contributes to all three of the EU energy policy pillars. Indeed, iLand will enhance market integration by improving balancing capabilities both within the Belgian network and also, through indirect interconnections, within the overall NSOG area. iLand will also contribute to sustainability by allowing for increased integration of RES into the grid because its flexibility will help alleviate offshore wind intermittency issues. iLand will also contribute to security of supply by providing service for flexibility and black start capacity.

**Cost [Meuros]**

1327

**Scenario specific CBA EP2020 Vision 1**

<table>
<thead>
<tr>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>-100 +/- 200</td>
<td>200 +/- 200</td>
</tr>
</tbody>
</table>
**Capability for ancillary services**

As the need for flexibility will grow fast with increasing RES penetration in the power system, and as ancillary services offer an important market channel for the supply of flexibility to the grid, the iLand infrastructure is designed for maximum capability for the supply of ancillary services, as was indicated in the flexibility indicator. As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Belgium enables saving in generation capacity of 18 - 23 Meuro/year.

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>++</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>++</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>++</td>
</tr>
</tbody>
</table>
Chaira PSHPP has a generating capacity of 864 MW (4 units x 216 MW) and a pumping capacity of 788 MW (4 units x 197 MW). The upper reservoir of Chaira PSHPP is Belmeken Dam with usable storage of 141 million m³. The lower reservoir is Chaira Dam with usable storage of 4.2 million m³. The usable storage of Chaira Dam allows full capacity operation in a generating mode for 8.5 hours, and 10.7 hours in a pumping mode, respectively. The construction of Yadenitsa Dam will increase the capacity of the lower reservoir by 9 million m³ and thus will increase the possibilities of using Chaira PSHPP. The connection between the two water storages, the existing lower reservoir - Chaira Dam and Yadenitsa Dam planned for construction, will be done by a reversible pressure tunnel based on the principle of interconnected vessels. The increased volume of the lower reservoir of Chaira PSHPP will enable switching to a mode of weekly balancing of the waters processed by the power plant in both generating and pumping modes. The four hydro power units of the power plant will be able to operate at full capacity in a generating mode for 20 hours and in a pumping mode for 22 hours, respectively.

---

### Project Details

**Commissioning Date**: 2021  
**Type of Storage**: Hydro Power  
**Max Active Power (MW)**: 864  
**Storage Capacity (GWh)**: 5.2

### Storage Analysis

The increased operating potential of Chaira PSHPP by the construction of Yadenitsa Dam will enable optimization of the generating capacities structure, taking part in loads covering in the Electric Power System (EPS). On one hand, the part of base load in the load diagram will be increased, thus providing continuous round-the-clock operation of the NPP and the TPPs at optimal efficiency, whereas on the other hand the fluctuations in the loading of the most flexible TPP capacities will be reduced on the account of additional loading of Chaira PSHPP in generating/pumping modes. As before, Chaira PSHPP together with the installed capacities in the HPPs, will continue to participate in covering the peak loads of the load diagram.

### General CBA indicators

| Cost [Meuros] | 176 |

### Scenario specific CBA

<table>
<thead>
<tr>
<th>EP2020 Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>300 +/- 10</td>
<td>300 +/- 10</td>
<td>300 +/- 100</td>
</tr>
</tbody>
</table>

**Capability for ancillary services**

In a situation of reduced power generation from the conventional power plants and growing production from renewable energy sources, the construction of Yadenitsa Dam will increase the regulating potential of Chaira PSHPP, which is a key factor for a reliable management of the Electric Power System in real time. At present Chaira PSHPP is a major provider of ancillary services and will continue to play an important role for the EPS frequency control. As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Bulgaria enables saving in generation capacity of 28 - 35 Meuro/year.

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>+</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>+</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>++</td>
</tr>
</tbody>
</table>
Project 1004 - Muuga HPSP

Promoted by Energiasalv OÜ

Project Details

Commissioning Date 2023 hydro pump
Type of Storage storage
Max Active Power (MW) 500
Storage Capacity (GWh) 6

Storage Analysis

Privileged Location Near France, near 3 nuclear reactors within 60 km radius, near large consumption centres (minimize transport losses) Social And Institutional Support

Technically Feasible:
Enough water column in Ribaroja’s reservoir, independently of the evolution of climate change and alternation of dry/wet years. Enough backpressure in pumps. Few materials in suspension, which could wear impellers at pressures of 40 atmospheres.

Environmentally Viable
No effects to environmental protected areas, cultural or archaeological heritage, either residential areas in case of breakage of higher rafts. Minimum impact on the landscape.
ECONOMICALLY VIVABLE: M€ investment / Mw installed < 0,7

Additional Information

Ideal to future offshore wind farm project associated to the Zèfir Project, allowing energy de-nuclearization of the area.

General CBA indicators

<table>
<thead>
<tr>
<th>Delta GTC contribution (2030) [MW]</th>
<th>Turbine 500</th>
<th>Pumping 500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost [Meuros]</td>
<td>330</td>
<td></td>
</tr>
</tbody>
</table>

Scenario specific CBA

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>10</td>
<td>&lt;10 +/- 0</td>
<td>&lt;10</td>
<td>40 +/- 10</td>
<td>10 +/- 10</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>-200 +/- 10</td>
<td>100 +/- 10</td>
<td>+/-100</td>
<td>-100 +/- 10</td>
<td>300 +/- 10</td>
</tr>
</tbody>
</table>

Capability for ancillary services

Important role in secondary regulation in the System’s frequency.
According to ENTSO’s CBA analysis, the pumping / turbinate ratio will be approximately 2. To provide storage capacity in rafts, a continuous supply is raised at some time intervals to the main consumers at Petrochemical Polygon of Tarragona, as a closed network electric distribution (2009/72 / EC) thereby increasing their competitiveness by lowering the price of Mw.
Supply of Passive Safety to nuclear reactors Asco I and II, by having available 10 Hm3 of water at 45 atm pressure less than 10 Km of distance. Important role in secondary regulation in the System’s frequency.

According to ENTSO’s CBA analysis, the pumping / turbinate ratio will be approximately 2. To provide storage capacity in rafts, a continuous supply is raised at some time intervals to the main consumers of Petrochemical Polygon of Tarragona, as a closed network electric distribution (2009/72 / EC) thereby increasing their competitiveness by lowering the price of Mw.

Supply of Passive Safety to nuclear reactors Asco I and II, by having available 10 Hm3 of water at 45 atm pressure less than 10 Km of distance.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Estonia enables saving in generation capacity of 16 - 20 Meuro/year.

Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| Response time to activate Frequency Containment Reserves | +  
| Response time to reach the available power | ++  
| Total time during which available power can be sustained | ++  
| Power that is continuously available within the activation time | +  |
Compressed air energy storage using air storage caverns to be developed in salt deposits. Technical capability, per 24 hrs: 230 MW compression x 6 hrs, 268 MW generation x 6 hrs, 230 MW compression x 6 hrs, 268 MW generation x 6 hrs.

Envisaged operation over 24 hrs = 250 MW compression 4-6 hrs; generation 50-268 MW over 6-10 hrs

Boundary: Great Britain
Promoted by: Gaelectric Energy Storage Ltd

**Project Details**

- Comminising Date: 2022
- Type of Storage: air energy storage
- Max Active Power (MW): 268
- Storage Capacity (GWh): 1.608

**Storage Analysis**

Balancing of generation & demand profile. Provision of system services to support integration of variable renewables. Potential to provide balancing services to mitigate wind/solar forecast error.

**Additional Information**

Start-up time to full output: Compression, 5 mins; Generation, 10 mins. Min stable level: 10% of max MW output. Ramp rate: 20% of max MW output per minute. Additional: ENTSO-E regional/Europe system-wide CBA may underestimate substantially the benefits of the project as compared to project-specific, local system-specific analysis using industry-standard tools such as PLEXOS.

**General CBA indicators**

<table>
<thead>
<tr>
<th>Scenario specific CBA EP2020 Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>110 +/- 20</td>
<td>40 +/- 20</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>-100</td>
<td>+/-100</td>
<td>+/-100</td>
</tr>
</tbody>
</table>

**Capability for ancillary services**

Frequency regulation: Response time = approx 1 minute; Duration = minutes; Cycle = minutes. Spinning reserves: Response time = Seconds to <10 minutes; Duration = 10-120 minutes; Cycle = days. Electricity supply reserve capacity: Response time, Duration & Cycle = Varies. Load Following: Response time = Varies, within minutes; Duration = 120-240 minutes in increments as short as 5 minutes; Cycle = Varies. Black Start: Duration = Varies, hours to days; Cycle = Varies. Synchronous inertial response: Response time = within minutes; Duration & Cycle = Varies. Capable of providing Primary Operating Reserve, Secondary Operating Reserve and Tertiary Operating Reserve in both Compression and Generation Modes. Capable of providing Fast Frequency Response in Generation Mode.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Great Britain enables saving in generation capacity of 9 - 11 Meuro/year.
This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>Response time to activate Frequency Containment Reserves</th>
<th>++</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to reach the available power</td>
<td>+</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>++</td>
</tr>
</tbody>
</table>

### Project 1006 - Pumped Storage Complex with two independent upper reservoirs: Agios Georgios & Pyrgos

The project consists of two upper reservoirs, Ag. Georgios & Pyrgos. As lower reservoir of the complex, it is considered the existing, artificial reservoir of Kastraki (PPC ownership). The purpose of the project is to absorb wind, photovoltaic or thermal energy for pumping in order to store water to the upper reservoirs during low load consumption or renewables overproduction periods. Subsequently, energy is recovered via turbine mode during the peak load. The electromechanical equipment will be installed in two independent power houses, on the right banks of the Kastraki reservoir. Total installed capacity is 680 MW.

![Map of Greece showing the location of the project](image)

**Boundary**

Greece

**Promoted by**

TERNA ENERGY S.A

### Project Details

<table>
<thead>
<tr>
<th>Commissioning Date</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td></td>
</tr>
<tr>
<td>Type of Storage</td>
<td>(pumped storage)</td>
</tr>
<tr>
<td>Max Active Power (MW)</td>
<td>594</td>
</tr>
<tr>
<td>Storage Capacity (GWh)</td>
<td>3436</td>
</tr>
</tbody>
</table>

### Storage Analysis

1) Market integration

Pumped storage schemes play a key role in enabling energy systems develop low-carbon electricity production. They supply more flexibility and balancing to the grid, providing a back-up to intermittent renewable energy, facilitating the entrance of renewables, accelerating the de-carbonization of the electricity grid, improving the security and efficiency of electricity transmission and distribution (reducing unplanned loop flows, grid congestion, voltage and frequency variations), stabilizing market prices for electricity, while also ensuring a higher security of energy supply. This project offers significant assistance in the accomplishment of the above target.

2) Sustainability

Considering recent evolution of off-shore wind power, which together with solar are currently considered to hold most promise in the next few decades in Europe, an immense storage capacity is required. A solution enabling sustainability of future energy supply, is the construction of additional pumped-hydro storage.
Energy storage is a precondition for any sustainable energy policy in Europe, which has two main targets: a) Increase the share of RES, transmissions and Security of supply b) Reduce dependency on imported fossil fuels and CO2 emissions.

Pumped storage systems represent a giant rechargeable battery, able to store energy at any time, usually regardless of the weather. Pumped storage units can start up in a few minutes, in an emergency situation, to provide the necessary reserve capacity. Additionally, this pumped storage complex will assist the EU target of greenhouse gas emissions reduction by avoiding an estimate of 693,600 tons in CO2.

3) Secure System Operation

The Greek grid system is not flexible and stable enough, to accommodate large amount of intermittent RES penetration in the near future. The major production share is based on conventional thermal units (lignite and combined cycle) with high technical minima and inability of adaptation to frequent capacity fluctuations. In order to ensure efficient integration of RES and better adjustment of thermal plant operation, hydro pumped storage power plants are crucial for a secure supply of electricity and as a back-up for intermittent renewables, since they can provide large-scale storage capacity and several distinct ancillary services to the system.

<table>
<thead>
<tr>
<th>General CBA indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost [Meuros]</td>
</tr>
<tr>
<td>502</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP2020 Vision 1</td>
</tr>
<tr>
<td>EP2020 Vision 2</td>
</tr>
<tr>
<td>EP2020 Vision 3</td>
</tr>
<tr>
<td>EP2020 Vision 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B2 SEW (MEuros/yr)</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>10 +/- 10</td>
</tr>
<tr>
<td>&lt;10</td>
<td></td>
<td></td>
<td>230 +/- 50</td>
</tr>
<tr>
<td>&lt;10</td>
<td></td>
<td></td>
<td>650 +/- 130</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B3 RES integration (GWh/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
</tr>
<tr>
<td>&lt;10</td>
</tr>
<tr>
<td>&lt;10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B4 Losses (GWh/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
</tr>
<tr>
<td>&lt;10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B4 Losses (Meuros/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
</tr>
<tr>
<td>&lt;10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B5 CO2 Emissions (kT/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 +/- 10</td>
</tr>
<tr>
<td>100 +/- 10</td>
</tr>
<tr>
<td>100 +/- 100</td>
</tr>
<tr>
<td>+/-100</td>
</tr>
<tr>
<td>-200 +/- 100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capability for ancillary services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency control, voltage control, spinning reserve, standing reserve, black start, remote automatic generation control, grid loss compensation and emergency control action.</td>
</tr>
</tbody>
</table>

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Greece enables saving in generation capacity of 19 - 24 Meuro/year.

Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power             | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | + |
Project 1007 - MAREX storage

Store excess wind production sourced from EIRGRID, and that sourced directly from windfarms connected on the MAREX system, provide grid services to EIRGRID and UKNG, import- export power to and from storage as market dictates, net export of 7TWhr per year to UK from Irish wind

Boundary
Promoted by
Ireland
Organic Power Ltd.

Project Details

Commissioning Date
2020

Type of Storage
Pumping

Max Active Power (MW)
1500

Storage Capacity (GWh)
6

General CBA indicators

Cost [Meuros]
500

Scenario specific CBA

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10 +/-</td>
<td>20 +/- 10</td>
<td>30 +/- 10</td>
<td>40 +/- 10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10 +/-</td>
<td>320 +/- 60</td>
<td>410 +/- 80</td>
<td>460 +/- 90</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>20 +/- 10</td>
<td>20</td>
<td>20 +/- 10</td>
<td>20 +/- 10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>-100 +/- 100</td>
<td>400 +/- 100</td>
<td>600 +/- 100</td>
<td>-200 +/- 100</td>
</tr>
</tbody>
</table>

Capability for ancillary services

Conceived to store excess wind production in Ireland for export to UK, provide grid services to UKNG and EIRGRID, and to trade power between UK and Ireland

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Ireland enables saving in generation capacity of 48 - 60 Meuro/year.

Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |
Project 1068 - Battery storage in South Italy

The project consists in the installation of 250 MW of storage systems (Batteries) on critical 150 kV transmission network in South Italy. The battery energy storage systems allow a better integration of Renewable Energy Sources into the power system, avoiding RES generation curtailment in case of exceeding generation respect to grid transport capacities, by storing energy surpluses in security conditions. This energy will be released later, when this does not lead to network congestions. Batteries are characterized by removable, modular and flexible installations; these characteristics allow installations in a wide variety of sites and the possible replacement depending on the needs that could arise in the medium / long term.

**Project Details**

| Boundary Promoted by | Italy Terna |

**Commissioning Date** 2030

**Battery Energy Storage**

**Type of Storage System (BESS)**

**Max Active Power (MW)** 250

**Storage Capacity (GWh)** 1.7

**Storage Analysis**

The project hereby described will allow a better integration of Renewable Energy Sources into the power system, avoiding RES generation curtailment in case of exceeding generation respect to grid transport capacities, by storing energy surpluses in security conditions and releasing it later, avoiding network congestions. Moreover, the battery energy storage system may compensate the RES intermittent generation by increasing primary and tertiary reserve availability. The analysis performed has showed benefits in terms of SEW increase for the project, especially in the high RES scenarios.

The project has been included in the TYNDP in order to evaluate it in long term scenarios (2030), with RES penetration values much higher than the current ones. The commissioning date is in the long-term (2030) and the development of the project is subject to the positive completion of the pilot phase (35 MW) assessment and the actual evolution of RES scenario.

**General CBA indicators**

| Cost [Meuros] | 750 |

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>30 +/- 10</td>
<td>10 +/- 10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>250 +/- 50</td>
<td>90 +/- 20</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>+/-100</td>
<td>+/-100</td>
<td>+/-100</td>
<td>+/-100 +/- 100</td>
</tr>
</tbody>
</table>

**Complementary Information**
This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>++</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>++</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>++</td>
</tr>
</tbody>
</table>
Project 1009 - Kruonis pumped storage power plant extension

Currently Kruonis PSPP has 4 units with total installed capacity of 900 MW and provides generation, secondary reserve and system balancing services. However, it has only limited power generation and regulation flexibility (fixed 220 MW in pump mode), which will not be sufficient for the system stability in the future due to the increasing share of the intermittent generation in the system. To deal with this issue it is planned to extend Kruonis PSPP with an additional 225 MW asynchronous unit. The new unit will have pump mode ranging from 110 to 225 MW and the cycle efficiency of up to 78% (increase by 4%).

Boundary
Lithuania

Promoted by
Lietuvos energijos gamyba

Project Details

Commisioning Date
2020

Pure hydro

Type of Storage
pumping

Max Active Power (MW)
225

Storage Capacity (GWh)
10.8

Storage Analysis

• Integration of renewable energy generation in the region;
• Increase of flexibility and reliability of the whole Baltic transmission system;
• Expansion of new production capacities in the region.

Additional Information
The extended Kruonis PSPP will contribute significantly to the flexibility and reliability of the whole Baltic transmission system.

General CBA indicators

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta GTC contribution (2030)</td>
<td>Turbine</td>
<td>225</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>[MW]</td>
<td>Pumping</td>
<td>225</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Cost [Meuros]</td>
<td></td>
<td>160</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

Capability for ancillary services

It is planned that the new unit would operate within 110-225 MW range in pump mode (compared to fixed 220 MW of existing 4 units) and within 55-225 MW range in generation mode (compared to 160-225 MW of existing 4 units). Such increase of flexibility would enable the plant to offer additional regulation services for the electricity market by offering new range regulation capacities (e.g., regulations of minor fluctuations +/- 50 MW).

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Lithuania enables saving in generation capacity of 7 - 9 Meuro/year.

Complementary Information
This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>++</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>+</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>+</td>
</tr>
</tbody>
</table>
Compressed air energy storage using air storage caverns to be developed in salt deposits. Technical capability, per 24 hrs: 250 MW compression x 6 hrs, 330 MW generation x 6 hrs, 250 MW compression x 6 hrs, 330 MW generation x 6 hrs. Envisaged operation over 24 hrs = 250 MW compression 4-6 hrs; generation 70-330 MW over 6-10 hrs.

Storage Analysis
Provision of system services and capacity via the DS3 and Reliability Option processes. Addressing acute security of supply issues in Northern Ireland. Balancing of generation & demand profile. Provision of system services to support integration of variable renewables. Potential to provide balancing services to mitigate wind/solar forecast error.

Additional Information
Start-up time to full output: Compression, 5 mins; Generation, 10 mins. Min stable level: 10% of max MW output. Ramp rate: 20% of max MW output per minute. Additional: ENTSO-E regional/Europe system-wide CBA underestimates substantially the benefits of the project as compared to project-specific, local system-specific analysis using industry-standard tools such as PLEXOS.

General CBA indicators

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;100M€</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>60 +/- 20</td>
<td>90 +/- 10</td>
<td>50 +/- 50</td>
<td>140 +/- 50</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>-100</td>
<td>+/-100</td>
<td>+/-100</td>
<td>+/-100</td>
<td>+/-100 +/-100</td>
</tr>
</tbody>
</table>

Capability for ancillary services
Frequency regulation: Response time = approx 1 minute; Duration = minutes; Cycle = minutes. Spinning reserves: Response time = Seconds to <10 minutes; Duration = 10-120 minutes; Cycle = days. Electricity supply reserve capacity: Response time, Duration & Cycle = Varies. Load Following: Response time = Varies, within minutes; Duration = 120-240 minutes in increments as short as 5 minutes; Cycle = Varies. Black Start: Duration = Varies, hours to days; Cycle = Varies. Synchronous inertial response: Response time = within minutes; Duration & Cycle = Varies. Capable of providing Primary Operating Reserve, Secondary Operating Reserve and Tertiary Operating Reserve in both Compression and Generation Modes. Capable of providing Fast Frequency Response in Generation Mode.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Northern Ireland enables saving in generation capacity of 11 - 14 Meuro/year.
This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>++</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>+</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>++</td>
</tr>
</tbody>
</table>
The motivation for this Project responds to the possibility of storing the produced energy surplus in order to use it during consumption peaks. The pure pumping exploitation designed constitutes a flexible generator set.

The "Mont-Negre" exploitation will promote the three pillars of the European energy policy:

- 75108MWh of accumulated energy will ensure the market integration of the interconnected nations.
- The hydraulic system’s mechanical nature will guarantee the European network sustainability, since it is able to feed on both natural energy and energy produced with flat curve.
- The plant’s hydraulic nature will provide the system with an immediate response to its unexpected needs and it will increase its resilience. The plant, therefore, will contribute to the security and the continuity of electrical supply in the interconnected network.

This plant will play a key role in the achievement of Europe's target 20/20/20.

Additional Information

The "Mont-Negre" exploitation will surpass the 2850MW of the Lewiston/Niagara Power Plant (USA), which has so far been the first one of the world ranking for pure pumping exploitations. Said surpass would mean Europe's leadership in this field.

The "Mont-Negre" project meets the latter part of the last century’s need for energy storage in South-western Europe due to the adaptation of the production curve to that of the consumption.
There are 12 synchronous units of 275MW that operate with turbine or pump which enable both mains frequency control and safe settings of electronic parameters.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Spain enables saving in generation capacity of 106 - 133 Meuro/year

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>Capability for ancillary services</th>
<th>EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>10</td>
<td>20 +/- 10</td>
<td>10 +/- 10</td>
<td>10 +/- 10</td>
<td>50 +/- 10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>-10</td>
<td>&lt;10</td>
<td>80 +/- 20</td>
<td>20 +/- 10</td>
<td>190 +/- 40</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>20 +/- 10</td>
<td>20</td>
<td>20 +/- 10</td>
<td>20 +/- 10</td>
<td>20 +/- 10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>200 +/- 100</td>
<td>800 +/- 100</td>
<td>-200 +/- 100</td>
<td>+/-100</td>
<td>-200 +/- 100</td>
</tr>
</tbody>
</table>

There are 12 synchronous units of 275MW that operate with turbine or pump which enable both mains frequency control and safe settings of electronic parameters.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Spain enables saving in generation capacity of 106 - 133 Meuro/year

**Response time to activate Frequency Containment Reserves**

+  

**Response time to reach the available power**

++  

**Total time during which available power can be sustained**

++  

**Power that is continuously available within the activation time**

++
P-PHES NAVALEO in Leon, Spain, is pure pumped plant with an installed capacity of 552 Mw. (3 x 184 Mw.) in generating mode and 548 Mw in pumping mode and generate an annual capacity between 700 - 1000 Gwh. The projects consists in two reservoirs with a volume of 2,23 Mio m³. The total rated flow are 90 m³/s in generating mode and 70 m³/s in pumping mode. Normal static head is 710 m. The cycle efficiency is up to 79%.

Boundary Spain

CDR TREMOR
Promoted by S.L.

Project Details

<table>
<thead>
<tr>
<th>Commisioning Date</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure pumping</td>
<td>plant</td>
</tr>
<tr>
<td>Max Active Power (MW)</td>
<td>541</td>
</tr>
<tr>
<td>Storage Capacity (GWh)</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Storage Analysis

P-PHES NAVALEO use abandoned mine water that being the cause of the failure of "bad ecological status" under Directive 2000/60/CE Water Framework in the region of Castilla-León where more than 5.500 MW. of wind power are currently in operation with projects for another additional 1.500 MW. that can not be incorporated. P-PHES NAVALEO project reconciles energy storage with water purification. Furthermore has a guaranteed supply of 100% throughout the whole year.

Additional Information

The project has a high environmental force because all its elements (excavated reservoirs, roundhouse, ...) are located outside the rivers, so that they do not affect environmental flows or living fish species, neither detracts the necessary water from the rivers for other uses (water supply, irrigation, industrial, recreational, ...) and therefore it is not sensitive to periods in which it is necessary to modify the production/consumption to meet such uses.

General CBA indicators

<table>
<thead>
<tr>
<th>Delta GTC contribution (2020) [MW]</th>
<th>Pumping 541</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Turbine 541</td>
</tr>
</tbody>
</table>
Delta GTC contribution (2030) | Pumping 541 | Turbine 541
Cost [Meuros] | 258

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>10 +/-</td>
<td>10 +/- 10</td>
<td>10 +/- 10</td>
<td>&lt;10 +/- 0</td>
<td>20 +/- 10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>-10 +/-</td>
<td>&lt;10 +/- 0</td>
<td>40 +/- 10</td>
<td>10 +/- 10</td>
<td>80 +/- 20</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>10 +/- 10</td>
<td>10</td>
<td>10 +/- 10</td>
<td>10 +/- 10</td>
<td>10 +/- 10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>100 +/- 10</td>
<td>200 +/- 10</td>
<td>+/-100 +/- 0</td>
<td>-100 +/- 100</td>
<td>-200 +/- 100</td>
</tr>
</tbody>
</table>

Capability for ancillary services

Considering that the water starting time in the penstock of the power plant is lower than 2 s, and the plant will be equipate with frequency converters P-PHES NAVALEO will provide a very fast time response to activate frequency containment reserves, can participate in primary frequency control, helping to maintain the instantaneous balance between generation and demand and being used for both primary and secondary regulation in the electricity grid and can provide the full range of grid-stabilising services: Back-up, Black start capability, Load-frequency control (spinning and non-spinning reserve) and voltage control. Furthermore, the plant would be equipated with variable speed technology.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Spain enables saving in generation capacity of 17 - 21 Meuro/year

Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| Response time to activate Frequency Containment Reserves | +/-++ |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |
**Project 1013 - CAES Zuidwending, NL**

Compressed air energy storage using air storage caverns to be developed in salt deposits. Technical capability, per 24 hrs: 250 MW compression x 6 hrs, 330 MW generation x 6 hrs, 250 MW compression x 6 hrs, 330 MW generation x 6 hrs. Envisaged operation over 24 hrs = 250 MW compression 4-6 hrs; generation 70-330 MW over 6-10 hrs

<table>
<thead>
<tr>
<th>Boundary</th>
<th>The Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promoted by</td>
<td>Gaelectric Energy Storage Ltd</td>
</tr>
</tbody>
</table>

**Project Details**

<table>
<thead>
<tr>
<th>Commission Date</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Storage</td>
<td>Compressed air energy storage</td>
</tr>
<tr>
<td>Max Active Power (MW)</td>
<td>330</td>
</tr>
<tr>
<td>Storage Capacity (GWh)</td>
<td>2.64</td>
</tr>
</tbody>
</table>

**Storage Analysis**

Balancing of generation & demand profile. Provision of system services to support integration of variable renewables. Potential to provide balancing services to mitigate wind/solar forecast error.

**Additional Information**

Start-up time to full output: Compression, 5 mins; Generation, 10 mins. Min stable level: 10% of max MW output. Ramp rate: 20% of max MW output per minute. Additional: ENTSO-E regional/Europe system-wide CBA may underestimate substantially the benefits of the project as compared to project-specific, local system-specific analysis using industrystandard tools such as PLEXOS.

**General CBA indicators**

| Cost [Meuros] | 275 |

<table>
<thead>
<tr>
<th>Scenario specific CBA indicators EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>40 +/- 10</td>
<td>&lt;10</td>
<td>40 +/- 40</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>0</td>
<td>+/-100</td>
<td>+/-100</td>
<td>+/-100</td>
</tr>
</tbody>
</table>

**Capability for ancillary services**
Frequency regulation: Response time = approx 1 minute; Duration = minutes; Cycle = minutes. Spinning reserves: Response time = Seconds to <10 minutes; Duration = 10-120 minutes; Cycle = days. Electricity supply reserve capacity: Response time, Duration & Cycle = Varies. Load Following: Response time = Varies, within minutes; Duration = 120-240 minutes in increments as short as 5 minutes; Cycle = Varies. Black Start: Duration = Varies, hours to days; Cycle = Varies. Synchronous inertial response: Response time = within minutes; Duration & Cycle = Varies. Capable of providing Primary Operating Reserve, Secondary Operating Reserve and Tertiary Operating Reserve in both Compression and Generation Modes. Capable of providing Fast Frequency Response in Generation Mode.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of The Netherlands enables saving in generation capacity of 11 - 14 Meuro/year

Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>++</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>+</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>++</td>
</tr>
</tbody>
</table>
Project 1014 - Coire Glas

A pumped hydro project with consent granted for up to 600MW capacity and a storage capacity of up to 30GWh. Located at Loch Lochy in Scotland.

Boundary UK
Promoted by SSE

Project Details

Commisioning Date 2023

Hydro Pumped
Type of Storage Storage
Max Active Power (MW) 600 Storage Capacity (GWh) 30

Storage Analysis

Bulk storage such as that which could be provided by Coire Glass pumped hydro station would provide a number of important benefits to the UK and, through Project TERRE potentially the European, electricity system. These benefits include storing energy for long periods at times of excess supply for release at times of shortfall several days later; providing a range of energy security and system cost benefits and supporting a diversified electricity system at lower overall cost; providing a range of balancing and reserve services; and reducing the requirement for additional transmission investment. Inclusion on the TYNDP 2016 and subsequent status as a European Project of Common Interest will aid in raising the profile of the project and help in highlighting the numerous benefits that the project’s delivery could achieve. Further it would provide the project's developer with potential access to funding to support further investigation into delivering the benefits of large storage scale pumped hydro.

General CBA indicators

Cost [Meuros] 1100

Scenario specific CBA EP2020 Vision 1 Vision 2 Vision 3 Vision 4
### Capability for ancillary services

Coi Glas would be capable of providing a range of ancillary services including Frequency Response, Fast Reserve, Reactive Power and Black Start.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of UK enables saving in generation capacity of 19 - 24 Meuro/year.

### Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>B2 SEW (MEuros/yr)</th>
<th>B3 RES integration (GWh/yr)</th>
<th>B4 Losses (GWh/yr)</th>
<th>B4 Losses (Meuros/yr)</th>
<th>B5 CO2 Emissions (kT/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>-100 +/- 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 +/- 10</td>
<td>380 +/- 80</td>
<td>&lt;10</td>
<td>400 +/- 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60 +/- 10</td>
<td>470 +/- 90</td>
<td>&lt;10</td>
<td>600 +/- 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 +/- 10</td>
<td>380 +/- 80</td>
<td>&lt;10</td>
<td>-300 +/- 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60 +/- 10</td>
<td>470 +/- 90</td>
<td>&lt;10</td>
<td>-200 +/- 100</td>
</tr>
</tbody>
</table>

| Response time to activate Frequency Containment Reserves | +                  |
| Response time to reach the available power              | ++                 |
| Total time during which available power can be sustained | ++                 |
| Power that is continuously available within the activation time | ++                 |
Project 1015 - Cruachan II

Up to 600MW pumped storage facility at Cruachan, Argyll, Scotland

Boundary: UK - Scotland
Promoted by: Scottish Power

Project Details

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commissioning Date</td>
<td>2025</td>
</tr>
<tr>
<td>Type of Storage</td>
<td>Pump Storage</td>
</tr>
<tr>
<td>Max Active Power (MW)</td>
<td>600</td>
</tr>
<tr>
<td>Storage Capacity (GWh)</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Storage Analysis

Cruachan II is a proposed reversible pumped-storage hydroelectric power station which would be located west of Dalmally on the banks of Loch Awe in Argyll and Bute, Scotland adjacent to the existing Cruachan hydro-electric pumped storage generating station.

Cruachan II would generate up to 600MW of electricity, using water from an upper reservoir on Ben Cruachan to drive the turbines. The turbines to be used at Cruachan II, would operate both as pumps and generators, which would be housed in a new cavern located within Ben Cruachan.

Cruachan II would go from standby to full production very rapidly, thus it could used to deal with periods of peak demand on the grid, and intermittency of renewables.

Cruachan II power station would support effective energy management in the market by minimizing changes in output from conventional generating sets by in effect, storing the excess generated electricity when demand is low.

As a pressing energy issue is the fact that there is not enough capacity to store electricity. To meet global climate change targets it is necessary to double the current levels of renewable energy capacity. In order to make the most of those renewable energy generation, there is need for more storage capacity such as Cruachan II to be rapidly delivered.

Pumped storage hydro is the most cost effective form of large scale electricity storage, and Scotland has the landscape and resource potential to deliver a new generation of projects.

Additional Information

Scotland's National Planning Framework 3 (2014) (NPF3) has recognised that increasing the capacity of pumped storage hydro-electricity can complement Scotland's ambitions for more renewable energy capacity.

The NPF3 has identified a new pumped storage facility at Cruachan as a national development.
Initial engagement with key stakeholders (local and central government, various NGOs) has been positive.

**General CBA indicators**

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>40 +/- 10</td>
<td>40 +/- 10</td>
<td>40 +/- 10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>370 +/- 70</td>
<td>460 +/- 90</td>
<td>370 +/- 70</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>-100 +/- 100</td>
<td>400 +/- 100</td>
<td>500 +/- 100</td>
<td>-300 +/- 100</td>
<td>-200 +/- 100</td>
</tr>
</tbody>
</table>

**Capability for ancillary services**

The plant will be able to provide the following services:

(i) Balancing Mechanism (Bid & Offer instructions delivered within 60 seconds);
(ii) Frequency Response (Primary, Secondary, High); (iii) Reactive Power (MVar Lead & Lag);
(iv) Reserve Services (Spin-Gen, Spin-Gen with Low Frequency Relay, Spin-Pump, Spin-Pump with High Frequency Relay, Pump De-Load, Rapid Start); (v) Black Start.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of UK-Scotland enables saving in generation capacity of 19 - 24 Meuro/year.

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>+</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>++</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>++</td>
</tr>
</tbody>
</table>
The MSS system draws electricity from the grid, converts it into thermal energy stored in hot molten salt, and then later converts the stored thermal energy to electricity using a conventional Rankine cycle power plant. The TES system consists of a hot salt tank at 1,050 degrees Fahrenheit (°F), a cold salt tank at 560 °F, and the inventory of molten salt. The charging system consists of a collection of electric resistance heaters and a set of pumps to move the fluid between the tanks. During charging, cold salt is pumped through the electric heaters and into the hot storage tank. The electric heaters are connected in parallel and isolation valves allow specific heaters to be turned on/off. By varying the number of operating heaters, the charge rate can be easily varied.

In order to deliver electricity, steam is generated by pumping salt from the hot storage tank through the steam generation system (“SGS”). The cooled salt at the outlet of the SGS is returned to the cold salt storage tank. The steam is used to drive a conventional Rankine cycle power plant.

Charging and discharging are carried out by separate systems which allow each to be independently sized to optimally meet their respective needs.

**Project 1016 - ANGS: Abengoa Northern Germany Storage**

Boundary Germany
Promoted by Abengoa

**Project Details**

<table>
<thead>
<tr>
<th>Commisioning Date</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Storage</td>
<td>Molten salt</td>
</tr>
<tr>
<td>Max Active Power (MW)</td>
<td>140</td>
</tr>
<tr>
<td>Storage Capacity (GWh)</td>
<td>1680</td>
</tr>
</tbody>
</table>

**Storage Analysis**

1.- The German electric sector is the greatest in generation capacity. Furthermore, it is the sector with most renewable generation capacity, in terms of installed capacity, providing more than 25% of the energy consumed in the country.

2.- Electricity prices have suffered a progressive decrease in recent years, as shown in the following figure. This is due to the combination of factors such as excess of low cost generation capacity, with stable demand, due to the economic crisis, and increased efficiency in end-use energy.

3.- Aligning with the German plan called Energiewende, in order to reduce drastically fossil fuel generation with 2022 horizon.

4.- The plant would be connected at 400 kV, and it will support the new wind farms forecasted to be developed at Northern Germany, and will help to solve current and future the congestion problems in the North-South transmission lines.

**Additional Information**

MSS is a commercially available technology, technically mature and widely available. All major equipment and components are commercially available today. The technology has been demonstrated commercially in both parabolic trough and tower STE plants.

Abengoa Solar has been working on TES with molten salt for three years with a pilot plant at its R&D center in Spain where all major components for Abengoa Solar’s commercial solar plants are tested. Abengoa Solar’s commercial solar plants have been designed with a greater than 30-year lifetime. Abengoa recently commissioned the world’s largest parabolic trough plant, Solana, with six hours of TES, in the U.S.

**General CBA indicators**

| Cost (Meuros) | 350 |
**Scenario specific CBA**

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (Meuros/yr)</td>
<td>10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>10</td>
<td>10 +/- 10</td>
<td>&lt;10</td>
<td>90 +/- 20</td>
<td>60 +/- 10</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>200 +/- 10</td>
<td>200 +/- 10</td>
<td>-100 +/- 100</td>
<td>+/-100 +/- 0</td>
<td>-200 +/- 100</td>
</tr>
</tbody>
</table>

**Capability for ancillary services**

A MSS energy storage system can follow economic dispatch and provide a range of ancillary services including loadfollowing, spinning or non-spinning reserves, regulation up/down, frequency response, inertial response, reactive power, and voltage control. It combines operational flexibility with high capacity value, and is therefore well suited to provide the flexible capacity requirements needed in systems with increased intermittent generation.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Germany enables saving in generation capacity of 9 - 11 Meuro/year.

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>0</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>0</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>+</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>+</td>
</tr>
</tbody>
</table>
Inabensa propose a stand-alone Battery Energy Storage System (BESS), using Lithium ion batteries. It will be connected to the grid through the nearest MV/HV substation; voltage at connection 400 kV. The proposed BESS has 225 MW of rated power capacity that can operate for three hours. The useful energy capacity reach 625 MWh. The maximum reactive power will be 235 MVAr. Specific operating flexibility has been defined by Inabensa; the system shall be capable of discharging from 100% to 0% useable State of Charge (SOC) of its rated energy, then charging it to back to 100% SOC. The BESS is designed for performing 1 cycle per day, for up to 365 days per year, excluding time for planned maintenance and/or forced outages for a minimum of 10 years.

Each block – unit has one Power Conversion System (PCS) with four independent DC inputs of 1 MW. One battery container is connected to each DC input, so that the unit –block contains 8 battery containers.

A Control Center Container is added to the plant. These containers will include all communication and control equipment and a UPS to provide services to all containers auxiliaries’ services.

Boundary
Spain
Promoted by
Abengoa

**Project Details**

<table>
<thead>
<tr>
<th>Commissioning Date</th>
<th>2019</th>
<th>Type of Storage</th>
<th>Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Active Power (MW)</td>
<td>225</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage Capacity (GWh)</td>
<td>0.675</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Storage Analysis**

1.- The most significant benefit of a storage plant is the contribution to the security and continuity of the electricity supply, thanks to the capability of quick response of the Battery Energy Storage System (BESS).

2.- A storage plant will permit to integrate new renewable generation capacity due to meet three key challenges to accommodate: output variability, a temporal (time-related) mismatch between generation and demand, and undesirable electrical effects caused by renewable generation.

3.- ANSS is the increased efficiency of the system, among other reasons, due to:
   - The quick response of the ESS control permits to operate balancing the deviation of the renewable plant respect to the scheduled power, eliminating frequency fluctuation. The storage device will remain in operation in network undervoltage and overvoltage conditions. The BESS will be able to inject reactive power during the disturbance too.
   - It will be able to provide an immediate real power primary frequency response.
   - The BESS is able to control voltage in the interconnection point. This function used for the voltage control is similar to the way a conventional generation (AVR) works.

**Additional Information**

The Spanish electric system is currently immersed in a transformation process, with a trend to an increase of the share of renewable and natural gas generation, instead of coal and nuclear generation.

Abengoa Southern Spain Storage project will increase the reliability of the Spanish electric system, improving the security of the supply and the supporting the integration of current and new renewable generation capacity.

ASSS project is an achievable goal that would help to improve the performance of European Electric System.
**Cost [Meuros]**

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>20 +/- 10</td>
<td>&lt;10</td>
<td>20 +/- 10</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>100 +/-100</td>
<td>+/-100</td>
<td>+/-100</td>
<td>+/-100</td>
<td>+/-100</td>
</tr>
</tbody>
</table>

**Capability for ancillary services**

BESS is a source of power, with a low response time (0.2 seconds), which can be used for a large number of applications supporting power to the grid and support renewable energy included: Regulation, Spinning Reserve, Nonspinning reserve, Voltage support.

Ancillary services that can be included: Spinning Reserves, Non Spinning Reserves, Regulation up, Regulation down.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Spain enables saving in generation capacity of 14 - 18 Meuro/year

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>++</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>++</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>+</td>
</tr>
</tbody>
</table>
Inabensa propose a stand-alone Battery Energy Storage System (BESS), using Lithium ion batteries. It will be connected to the grid through the nearest MV/HV substation; voltage at connection 400 kV.

The proposed BESS has 225 MW of rated power capacity that can operate for three hours. The useful energy capacity reach 625 MWh.

The maximum reactive power will be 235 MVAr. Specific operating flexibility has been defined. The system shall be capable of discharging from 100% to 0% useable State of Charge (SOC) of its rated energy, then charging it to back to 100% SOC. The BESS is designed for performing 1 cycle per day, for up to 365 days per year, excluding time for planned maintenance and/or forced outages for a minimum of 10 years.

Each block – unit has one Power Conversion System (PCS) with four independent DC inputs of 1 MW. One battery container is connected to each DC input, so that the unit – block contains 8 battery containers.

Control Center Container is added to the plant. They will include all communication and control equipment and a UPS to provide services to all containers auxiliaries’ services.

Boundary
Spain

Promoted by
Abengoa

**Project Details**

<table>
<thead>
<tr>
<th>Commissioning Date</th>
<th>Type of Storage</th>
<th>Battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td></td>
<td>225</td>
</tr>
</tbody>
</table>

| Storage Capacity (GWh) | 0.675 |

**Storage Analysis**

1.- The most significant benefit of a storage plant is the contribution to the security and continuity of the electricity supply, thanks to the capability of quick response of the Battery Energy Storage System (BESS).

2.- A storage plant will permit to integrate new renewable generation capacity due to meet three key challenges to accommodate: output variability, a temporal (time-related) mismatch between generation and demand, and undesirable electrical effects caused by renewable generation.

3.- ANSS is the increased efficiency of the system, among other reasons, due to:

• The quick response of the ESS control permits to operate balancing the deviation of the renewable plant respect to the scheduled power, eliminating frequency fluctuations.

• The storage device will remain in operation in network undervoltage and overvoltage conditions. The BESS will be able to inject reactive power during the disturbance too.

• It will be able to provide an immediate real power primary frequency response.

• The BESS is able to control voltage in the interconnection point. This function used for the voltage control is similar to the way a conventional generation (AVR) works.

**Additional Information**

The Spanish electric system is currently immersed in a transformation process, with a trend to an increase of the share of renewable

Abengoa Southern Spain Storage project will increase the reliability of the Spanish electric system, improving the security of the supply and the supporting the integration of current and new renewable generation capacity.

ANSS project is an achievable goal that would help to improve the performance of European Electric System.

**General CBA indicators**

| Delta GTC contribution (2030) | Pumping | 225 |
**Cost [Meuros]**

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>20 +/- 10</td>
<td>&lt;10</td>
<td>20 +/- 10</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>100 +/- 100</td>
<td>+/-100</td>
<td>+/-100</td>
<td>+/-100</td>
<td>+/-100</td>
</tr>
</tbody>
</table>

**Capability for ancillary services**

BESS is a source of power, with a low response time (0.2 seconds), which can be used for a large number of applications supporting power to the grid and support renewable energy. Ancillary Services included: Regulation, Spinning Reserve, Non-spinning reserve, Voltage support.

Ancillary services that can be included: Spinning Reserves, Non Spinning Reserves, Regulation up, Regulation down.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Spain enables saving in generation capacity of 14 - 18 Meuro/year.

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>++</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>++</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>+</td>
</tr>
</tbody>
</table>
The two Pumped Hydroelectric Storage stations, GIRONES & RAIMATS, have their common take on the right bank of the reservoir named Riba-roja, at the EBRO river, 1.5 km upstream of the dam. They are located on the Terres de l'Ebre, Tarragona (Spain). Its online design will allow to build them in two phases depending of the demand scenario. Its online design will allow to build them in two phases depending of the demand scenario. The total flow requested of 762 m³/s comes to pump the volume of water between the elevation 70 (normal maximum level of the Riba-roja’s reservoir) and a decrease of 1.5 m over a period of 8 hours on continued operation. This is driven by two parallel low pressure galleries with 10 m indoor diameter, underground toward the Girones’s cavern. Two alternatives with the same 3 Gw installed power are developed: A) UNIQUE OPERATOR (selected layout): a single cavern in GIRONÉS is projected to house the teams of the two PHS with only one tunel for acces into it. Each of the 6 groups of GIRONES (90 m³/s, 370 Mw pumping / 300 Mw turbine) are connected to the bottom of the upper raft (Hm3 21,50; 22196 Mwh stored) by a high pressure water well of 6 m inside diameter. The 4 RAIMATS’s groups (55 m³/s, 295 MW pumping / 239 MW turbine) will do so at their upper raft (8,55 Hm3; 10179 Mwh stored energy) through a rack composed by 4 pipes of 4 m diameter each one. Budget without VAT: 2.007 M €. B) TWO OPERATORS: Each plant can operate independently of the other. One of the low-pressure galleries stretches 4.5 km underground until the second RAIMATS’s cavern, needing a second road tunnel as an access to it. With a total budget of 1.899 M€, the capacity of the GIRONES’s raft is reduced to 13,8 Hm3.

According to the preliminary and informative REE’s report, the GIRONES 400 kV network connection is foreseen in SE NEW MEQUINENZA from 2020 and RAIMATS (2nd phase) in the SE of PEÑALBA and OSERA

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Spain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promoted by</td>
<td>Grupo Romero Polo</td>
</tr>
</tbody>
</table>

**Project Details**

<table>
<thead>
<tr>
<th>Commissioning Date</th>
<th>2024</th>
<th>Type of Storage</th>
<th>Pure Pumping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Active Power (MW)</td>
<td>3400</td>
<td>Storage</td>
<td></td>
</tr>
<tr>
<td>Capacity (GWh)</td>
<td>24.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Storage Analysis**

**Privileged Location:**
Near France, near 3 nuclear reactors within 60 km radius, near large consumption centres (minimize transport losses)

**Social and Institutional Support Technically Feasible:**
Enough water column in Riba-roja’s reservoir, independently of the evolution of climate change and alternation of dry/wet years. Enough backpressure in pumps. Few materials in suspension, which could wear impellers at pressures of 40 atmospheres.

**Environmentally Viable**
No effects to environmental protected areas, cultural or archaeological heritage, either residential areas in case of breakage of higher rafts.

**Economically Viable:** M€ investment / Mw installed < 0,7

**Additional Information**
Ideal to future offshore wind farm project associated to the Zèfir Projet, allowing energy denuclearization of the area.

**General CBA indicators**

<table>
<thead>
<tr>
<th>Delta GTC contribution (2030)</th>
<th>Pumping</th>
<th>1470</th>
</tr>
</thead>
<tbody>
<tr>
<td>[MW]</td>
<td>Turbine</td>
<td>820</td>
</tr>
</tbody>
</table>
### Cost [Meuros]

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10 +/-</td>
<td>20 +/- 10</td>
<td>10 +/- 10</td>
<td>10 +/- 10</td>
<td>60 +/- 10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10 +/-</td>
<td>&lt;10</td>
<td>60 +/- 10</td>
<td>20 +/- 10</td>
<td>210 +/- 40</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>20 +/- 10</td>
<td>20</td>
<td>20 +/- 10</td>
<td>20 +/- 10</td>
<td>20 +/- 10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>-100 +/- 100</td>
<td>600 +/- 100</td>
<td>-100 +/- 100</td>
<td>+/-100</td>
<td>-300 +/- 100</td>
</tr>
</tbody>
</table>

### Capability for ancillary services

Important role in secondary regulation in the System’s frequency.

According to ENTSO’s CBA analysis, the pumping / turbinate ratio will be approximately 2. To provide storage capacity in rafts, a continuous supply is raised at some time intervals to the main consumers at Petrochemical Polygon of Tarragona, as a closed network electric distribution (2009/72/EC) thereby increasing their competitiveness by lowering the price of Mw.

Supply of Passive Safety to nuclear reactors Asco I and II, by having available 10 Hm3 of water at 45 atm pressure less than 10 Km of distance. Important role in secondary regulation in the System’s frequency.

According to ENTSO’s CBA analysis, the pumping / turbinate ratio will be approximately 2. To provide storage capacity in rafts, a continuous supply is raised at some time intervals to the main consumers at Petrochemical Polygon of Tarragona, as a closed network electric distribution (2009/72/EC) thereby increasing their competitiveness by lowering the price of Mw.

Supply of Passive Safety to nuclear reactors Asco I and II, by having available 10 Hm3 of water at 45 atm pressure less than 10 Km of distance.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Spain enables saving in generation capacity of 197 - 246 Meuro/year.

### Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>+</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>+</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>++</td>
</tr>
</tbody>
</table>
Project 1020 - GIBREX STORAGE

Provide storage to reduce/eliminate constraining off/curtailment of wind energy in Galicia Spain, and North Portugal. Provide grid services to REE and REN. Trade power as market dictates.

**Boundary**
Spain

**Promoted by**
Organic Power Ltd.

<table>
<thead>
<tr>
<th><strong>Project Details</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Commisioning Date</strong></td>
<td>2022</td>
</tr>
<tr>
<td><strong>PHES pure</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Type of Storage</strong></td>
<td>pumping</td>
</tr>
<tr>
<td><strong>Max Active Power (MW)</strong></td>
<td>1500</td>
</tr>
<tr>
<td><strong>Storage Capacity (GWh)</strong></td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>General CBA indicators</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delta GTC contribution (2030)</strong></td>
<td>Pumping 1500</td>
</tr>
<tr>
<td><strong>Cost [Meuros]</strong></td>
<td>800</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Scenario specific CBA</strong></th>
<th><strong>EP2020</strong></th>
<th><strong>Vision 1</strong></th>
<th><strong>Vision 2</strong></th>
<th><strong>Vision 3</strong></th>
<th><strong>Vision 4 indicators</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>10 +/- 10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>30 +/- 10</td>
<td>10 +/- 10</td>
<td>160 +/- 30</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>+/-100</td>
<td>-100 +/- 100</td>
<td>+/-100</td>
<td>-100 +/- 100</td>
<td></td>
</tr>
</tbody>
</table>

**Capability for ancillary services**
Black start, quick response demand/generation, frequency modulation via VSC
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Spain enables saving in generation capacity of 96 - 120 Meuro/year

**Complementary Information**
This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th><strong>Response time to activate Frequency Containment Reserves</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Response time to reach the available power</strong></td>
<td>++</td>
</tr>
<tr>
<td><strong>Total time during which available power can be sustained</strong></td>
<td>++</td>
</tr>
<tr>
<td><strong>Power that is continuously available within the activation time</strong></td>
<td>++</td>
</tr>
</tbody>
</table>
upper reservoir will be located in a natural glacial valley 5.5km long, with an average width of 1.3km. The reservoir will be formed by a 1.3km long rock-fill dam of average height 35m located 2.5 km from the Atlantic coast. It will provide a storage capacity between 90,000MWh and 120,000MWh subject to final design. A power house constructed over-ground will be located at the coast and contain 10 x 150MW reversible pump/turbine motor/generators. These will be connected to the dam by 10 penstocks laid in shallow trenches backfilled to minimise visual impact. The ocean will act as the lower reservoir. Although the project is planned primarily for Irish use. It will be connected by undersea cable through the UK to the main European grid. A direct interconnection from Ireland to France is planned for the future.

Ireland and Northern Boundary

Promoted
Pump Storage Energy Ltd.
by

**Project Details**

<table>
<thead>
<tr>
<th>Commissioning Date</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro Pump</td>
<td></td>
</tr>
<tr>
<td>Type of Storage</td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td></td>
</tr>
<tr>
<td>Max Active Power (MW)</td>
<td>1500</td>
</tr>
<tr>
<td>Storage Capacity (GWh)</td>
<td>120</td>
</tr>
</tbody>
</table>

**Storage Analysis**

The project topology is expected to result in a low capital cost in comparison to conventional pumped storage plants. Ireland currently has 2500MW wind turbine capacity. This is supplying close to 20% electricity generation from renewable sources, contributing to the 40% target agreed with the EU for 2020. This is already causing curtailment, which will increase as wind capacity expands. The Donegal plant will substantially reduce curtailment. Pumping energy will be supplied by both curtailed wind and off peak thermal generation. The increased pumping load will improve the load factor of thermal generation by permitting greater base load operation of thermal plant. This can contribute to reduced production costs and electricity prices. The resulting increase in efficiency, together with increased wind generation from less curtailment, will reduce carbon dioxide emissions. The low capital cost combined with the other advantages is planned to permit the Donegal project to trade competitively.

**Additional Information**

Donegal will be the first large scale sea water pumped scheme in the World. As such, it is expected to be a flagship project, which will attract considerable interest. It is planned to permit leisure water sport activities on the large reservoir. A number of considerable community benefits are anticipated from the project.

**General CBA indicators**

<table>
<thead>
<tr>
<th>Cost [Meuros]</th>
<th>0</th>
</tr>
</thead>
</table>

**Scenario specific CBA indicators**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;10</td>
<td>40 +/- 10</td>
<td>70 +/- 10</td>
<td>120 +/- 20</td>
<td>90 +/- 10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>590 +/- 120</td>
<td>660 +/- 130</td>
<td>1390 +/- 280</td>
<td>1110 +/- 220</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>40 +/- 10</td>
<td>40</td>
<td>40 +/- 10</td>
<td>40 +/- 10</td>
<td>40 +/- 10</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------</td>
<td>----</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>+/- 100</td>
<td>600 +/- 100</td>
<td>1000 +/- 200</td>
<td>-600 +/- 100</td>
<td>-400 +/- 100</td>
</tr>
</tbody>
</table>

### Capability for ancillary services

The project is capable of supplying extensive spinning reserve and reactive power. As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Ireland and Northern Ireland enables saving in generation capacity of 96 - 120 Meuro/year.

### Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>++</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>++</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>++</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>++</td>
</tr>
</tbody>
</table>
Transmission grid-scale energy storage innovative adiabatic Compressed Air Energy Storage (CAES). Our installations of 500MW, 6-21GWh with zero or low emissions, operate at 68-70% round trip efficiency, at a cost of £350m (€420m), and a levelised cost less than half that of gas-fired peaking plants, and use existing, off-the-shelf equipment. Addresses the entire energy trilemma: the world’s most cost-effective and widely implementable large scale energy storage technology, up to 100% clean, turning locally generated renewable energy into dispatchable electricity. Potential to store the entire continent’s energy requirements for over a week; potential globally is greater still.

<table>
<thead>
<tr>
<th>Boundary</th>
<th>Great Britain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promoted by</td>
<td>Storelectric Ltd</td>
</tr>
</tbody>
</table>

**Project Details**

<table>
<thead>
<tr>
<th>Commissioning Date</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adiabatic CAES</td>
<td></td>
</tr>
<tr>
<td>Type of Storage</td>
<td>(Compressed Air Energy Storage)</td>
</tr>
<tr>
<td>Max Active Power (MW)</td>
<td>500</td>
</tr>
<tr>
<td>Storage Capacity (GWh)</td>
<td>2.5</td>
</tr>
</tbody>
</table>

**Storage Analysis**

Sustainability: enables renewable energy to power entire grids by matching intermittent generation cleanly with variable demand.

Energy security 1: keeping electricity grids supplied with both baseload and renewable electricity when most generation will be renewable.

Energy security 2: enables locally generated energy from local resources (wind, sun, tides, waves etc.) to power grids independently of foreign countries.

Market integration: enables interconnectors to carry much more energy, and helps overcome grid bottlenecks by smoothing loads.
Reducing prices: profitable without subsidy in a level regulatory playing field; reduces subsidies for renewables as it enables all their power to be sold profitably.

Closing fossil fuelled power stations: unlike batteries etc., our long durations provide reliable power to enable power stations to close without risks at night or during major adverse weather patterns.

European potential: salt basins mean these plants can be built in most countries, and in future other geologies will be developed to extend coverage still further.

Environmental impact: by enabling closure of fossil fuelled power stations and improving the economics of renewables while reducing upwards price pressure on electricity, CARES enables entire grids to become clean – and then to replace fossil fuels increasingly in heating, transportation and industry.

Additional Information

• A novel configuration of existing technologies well proven at similar scales and similar load profiles, whose integration is considered by engineering partners to be simple.
• Partnered by Siemens, Balfour Beatty, PriceWaterhouse Coopers and others.
• Already received enquiries from Netherlands, Germany, North Africa (for providing solar power to southern Europe), the Middle East and beyond.
• CARES is a 2-plant project: a 20MW initial plant and a 500MW follow-on. The small plant will prove and optimise the technology, thereby enabling the large plant to be financed and built.
• Dozens of financiers have expressed interest in funding future plants after the first.
• Roll-out will be in special joint venture companies that will compete with each other within their markets, avoiding excessive market leverage.

General CBA indicators

| Cost [Meuros] | 560 |

<table>
<thead>
<tr>
<th>Scenario specific CBA</th>
<th>EP2020</th>
<th>Vision 1</th>
<th>Vision 2</th>
<th>Vision 3</th>
<th>Vision 4 indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2 SEW (MEuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>10 +/- 10</td>
<td>20 +/- 10</td>
<td>20 +/- 10</td>
</tr>
<tr>
<td>B3 RES integration (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>190 +/- 120</td>
<td>180 +/- 180</td>
<td>210 +/- 100</td>
</tr>
<tr>
<td>B4 Losses (GWh/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B4 Losses (Meuros/yr)</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
<tr>
<td>B5 CO2 Emissions (kT/year)</td>
<td>-100 +/- 100</td>
<td>100 +/- 100</td>
<td>200 +/- 100</td>
<td>+/-100</td>
<td>-200 +/- 100</td>
</tr>
</tbody>
</table>

Capability for ancillary services

CARES offers:
• All balancing services;
• All frequency response services over 10 seconds response time;
• Inertia;
• Reactive power;
• Demand turn-up and absorption of unwanted generation;
• Long term storage, even inter-seasonal.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment. This storage project of Great Britain enables saving in generation capacity of 33 - 41 Meuro/year.
This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

<table>
<thead>
<tr>
<th>KPI</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response time to activate Frequency Containment Reserves</td>
<td>+</td>
</tr>
<tr>
<td>Response time to reach the available power</td>
<td>0</td>
</tr>
<tr>
<td>Total time during which available power can be sustained</td>
<td>+</td>
</tr>
<tr>
<td>Power that is continuously available within the activation time</td>
<td>++</td>
</tr>
</tbody>
</table>