Magellang & Barents, S.L. Progress Report- 2020- Complete version.

2020 was of course hard. The best part is we continue to strengthen our project, with a great team and a swift, efficient path to verify the commercial viability of a clean, scalable and low cost energy storage system. We aim at using existing infrastructure and resources such as mines, solid dumpsite materials, abandoned tunnels, geological formations, as well as the expertise from many decades of mining, which might end up lost. Those experts play a large role in our project. Coal seams in NW Spain exist in sedimentary rock formations, but some of those rocks are strong and suitable as large geological pressurized caverns. For example, puddingstones and, occasionally, strong, compact limestone could be used.

This document has been prepared in two versions: A 2 page summary, and an expanded report.

Summary

1. **Heartful thanks.** The first year of any company is almost always challenging. For our innovative start-up in a pandemic, lockdown year, achieving our initial goals (and a bit more!) has only been possible because we got a lot of help from many people, almost always for free. Our main mechanical subcontractors Fluinor, our IP partners Horizon IP and several branches of the Government of Asturias have kept us alive. We truly appreciate the courageous investment of EUR 25,000 in April 2019, when we just had a project on paper. We also got two grants for a total of some EUR 170,000 and that helped us launch the company and finance our upcoming 80 m prototype, which thanks to Grupo Cárcaba, the owners of the quarry and mining company Hunosa, will be launched in February in an operational environment, that is, out of the lab, in a location very similar to that of a future commercial installation.
2. **Dense fluid developments.** We continue to improve the behaviour and cost of the slurries in our labs in Asturias and in the Netherlands. Our main strength is experimental development but we have enrolled fluid mechanics specialists Idonial to consolidate the theory, so we depend less on serendipity and trial and error. We have been using exotic minerals from Sweden and Australia, but we are switching to dumpsite materials to sabe costs and to qualify as a circular economy Project. We have been quite lucky:
   A) We ensured good flow of a dense fluid based on commercial mine products, even after a 7 day stop.
   B) We repeated the test with dumpsite materials which can flow in larger diameter pipes.
   C) Although it was not initially planned, we designed dense fluids which are very affordable because we use mainly dumpsite minerals blended with a smaller amount of additives. Flow parameters, especially long term stability) are better than those of competing pumpable dense slurries. Our slurries might find a market as ballast for ships and floating wind turbines, maybe through the innovative purchasing programs of offshore wind developers such as Iberdrola or EdP.
3. **Intellectual Property.** Beyond the PCT patent, we have filed patent applications in the main industrialized countries. We are searching for local partners who can help us develop and optimize the technology, Japan and the USA are our leading areas. We have synthesized innovative slurries that we will try to protect, our IP experts, Horizon IP from Singapore sensibly propose to get the first patent there, where they are the "home team", so patenting elsewhere becomes easier.

4. **Other inititiatives by Third Parties, harbingers of new paradigms.** The energy industry is entering a profound technological revolution. Suncable between Australia and Singapur, and Xlinks between Morocco and the UK show long distance transmission of power is coming soon. Strong government support for renewables in the border regions between Portugal and Spain helps, as well as the just transition funding mechanisms. Floating offshore wind is growing fast, we have a very competitive dense fluid that can be used as ballast instead of more costly options. Large scale energy storage is the crucial part that allows renewable energy to dethrone coal and gas, there are strong indications that unconventional pumped hydro can compete with conventional pumped hydro, not just environmentally but also in cost. Onkalo is a great example of what can be achieved when governments and companies get together. The nuclear repository in the Gulf of Bothnia, where EUR 800 million have been invested in a 520 meter deep cavern, will withstand the next glaciation, several millenia in the future.
5. **Demonstrator in operational environment, H=80 meter.** With the pandemic restrictions, we were unable to complete the installation. However, we did manage to improve our dense fluids, so much so that we will reduce the diameter of the penstock from 4" to 2", which will allow for a significant reduction in costs. Besides that, we just learnt we have been awarded a grant from the Government of Asturias, which helps our meager finances. We hope to have the installation ready in several weeks, that should mean reaching TRL 7-8. The main use for this demonstrator is as a stepstone towards a commercial project, but it will be used as a test bench for slurry in the meantime.
6. **Prototype-Demonstrator, Test Bench, commercial scale, H=300 m, 1000 m3.** Our aim is demonstrating technical and comercial feasibility with an investment of approximately EUR 1 million, so it can be financed within the scope of regional programs that support R+D in Asturias. Ideally, we could have an operational installation in late 2021 or early 2022. It is critical to use existing infrastructure to minimize costs. There are at least three options, with very distinct features:
   - **A) Mine or quarry.** This would be a very good operational environment. We are in advanced talks with a company that owns a suitable location.
   - **B) Coal power plant chimney.** Some chimneys reach close to 300 m. The necessary structural reinforcement is complex, but a successful solution could be replicated hundreds of times, so we are checking with specialist structural engineers.
   - **C) Hydropower plant.** At best, a decommissioned or end-of-life installation could mean sharply reduced costs.
7. **First commercial projects.** Because lead times are so long, we are already looking for sites that could host a commercial installation, ideally hybridized with wind power or PV generation, which in Spain might be financed with funds from the Just Transition Program. The underground mine in Cerredo might be a good location, with a long incline lined with shotcrete. Other locations are possible, including mine shafts and abandoned tunnels, some of which have electrical infrastructure in place and they could supply the power surges needed to drive high speed trains through new layouts.
8. **Web. Our offer to local industrial companies.** Most of our funding comes from the Government of Asturias, so we are encouraged to reach out to local companies that can supply penstocks, hydropower equipment, mining supplies and machines, as well as dumpsite materials and specialist engineering and Project management services. In Asturias, mines, chimneys and deep, hard rocks are also available, as well as privileged funding for projects in former mining areas and, last but not least, specialist underground technicians. We are very conscious that our project is innovative and inherently risky, so we will try to include industrial companies so they can benefit from our Project at minimal cost.
   In order to comply with the requirements of a previous grant, we need to launch our website soon. We will explicitely invite companies with an interest in the power industry and an appetite for low cost innovation. We have contacted some of those companies in the past, even joining ArcelorMittal in a consortium that got a large grant in 2019 but was cancelled because of unexpected contingencies. Now our Project has matured and is more focused, benefiting from support from the Government and from qualified experts from many companies. We have to make a better effort to listen to the managers so we can detect the opportunities that innovative projects must bring in order to succeed.

Expanded report:

1A – Heartful thanks:

Our humble project got support from dozens of persons. At every critical juncture we found people and companies who kept us afloat, with many hours of specialized, high quality work. Everything that is good about our project is owed to them, we have basically just asked for help. Thanks to them we could:

- Define the parameters and contours of the project, with free or very low cost expert advice.
- Exhibit with our own booth in international shows.
- Start the patenting process, with US provisional patents, then PCT and now national phase.
- Incorporate the company with a 12.5% share belonging to the Government of Asturias.
- Source samples from remote mines in Sweden and Australia for the initial tests.
- Source dumpsite materials for low cost dense fluids.
- Build a lab scale test installation at low and high pressure.
- Apply for grants and comply with business requirements.
- Find a location for an 80 meter prototype at almost no cost.
- Start the basic design for a 300 meter test site.

2A – Dense fluid.

This is a key component. Initially, we demonstrated fluidity in optimal conditions, with the very best minerals and additives. We found the slurry will flow again after a seven-day stop, and that it is not necessary to physically separate the slurry from the water on top of it:

https://youtube.com/shorts/a4VNrez5p6E

Then we tried to reproduce that flow with dumpsite material (inert and stable), suitable for large diameter pipes:

https://youtu.be/yH3ZZHdGRW0

Finally, we developed a dense from dumpsite material but with additives that allow exceptional fluidity. This is a product that can be used in many applications and can be marketed at a very competitive price. Our fluid is still a bit less dense tan other fluids but it is also much more stable, it will not bleed water. Compared with drilling mud, there are no heavy metals in the mix, so the problems with mining and disposal of barite are avoided.

3A- Intelectual Property.

In 2018 we applied for 4 provisional US patents, which are very affordable. Then we went to the PCT way, and we got an encouraging report from the International Searching Agency. Right now, we have applied for national patents in the most advanced areas:

Australia, China, Europan Union, Estados Unidos, Japan, Mexico, Singapur, South Korea, United States.

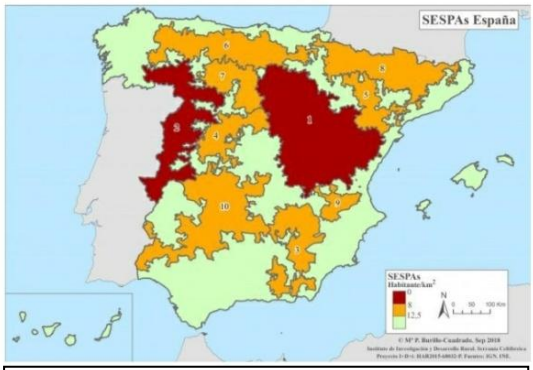
We intend to make available the IP (both patents and trade secrets) to international partners so they can launch innovation projects that are heavily subsidized by governments, so it will be easier to improve and optimize the technologies, and certainly, to split costs as much as possible. For example, we will request funding to complete the 300 meter test bench we are designing. It would not make sense to repeat that infrastructure in each geographic area, it´s much more rational to share ownership and transport the relatively small amounts of minerals or slurries to be certified. Additionally, in countries like the Australia, Mexico or the US, the permitting process might be much faster than in Europe, so we can launch the technology faster.

Singapore is particularly interesting because Horizon IP is local and can help us learn how to navigate the patenting process in other jurisdictions. Mexico can provide the clean power that southern California needs, and the Spanish government encourages R+D projects with Mexican partners, and there are strong links between Asturian and some Mexican companies.

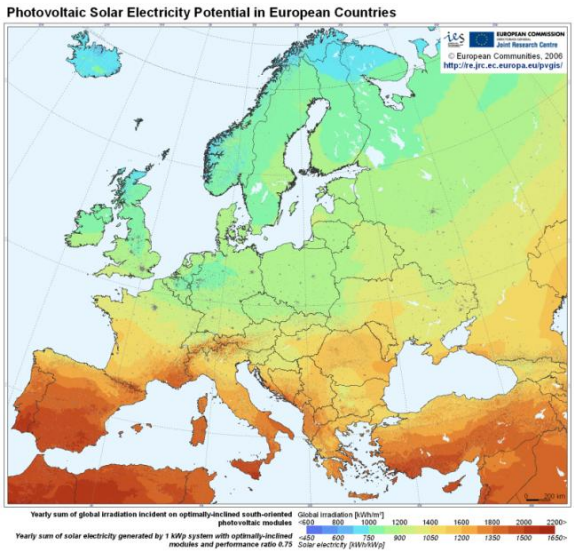
So far, we have chosen to keep the formulation and operation of the dense slurry as a trade secret, but we feel the latest innovations use new concepts and may well be patentable and enforceable, so we have started the process to obtain protection. Patenting costs are partially covered by the grants from the Government of Asturias - IDEPA (BOPA 30-XII-2019 y 5-I-2021).

4A- Other initiatives:

In the XXXI Spanish-Portuguese Summit, Oct. 2020 an agreement was made to develop infrastructure for renewable energy in the border area, which includes 62% of the Portuguese territory but just 15% of the population, and 17% of the Spanish land mass but just 7% of the people, so the PV and wind resources in that high insolation area could power all of Europe. As it happens, escarpments in the area and solid granite massifs are ideal for energy storage.



Map of areas in Spain with low population density. In red, density is less than 8 people/km2, in orange, less than 12,5 people/km2. Author: Pilar Burillo, estudio SESPAS



Xlinks: A British Project aims to export Moroccan energy to the UK by means of a subsea power cable several thousand miles long. A similar project is Australia/ASEAN power link. We think it is obviously much more competitive and safer to link Asturias with southern England.

Large scale storage allows export of very competitive solar PV in Europe and Asia.

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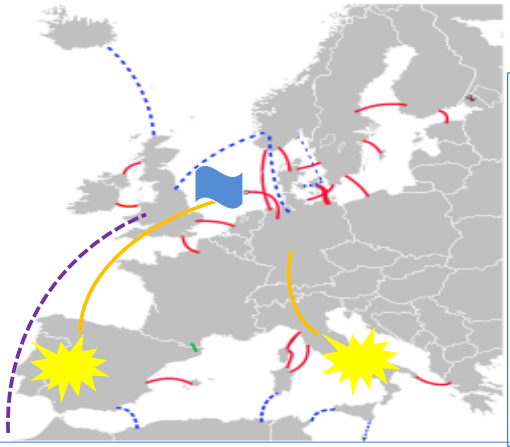


Xlinks is planning a 3.6GW subsea cable for PV export from Morocco to the UK, CEO Simon Morrish has raised GBP 30 MM.
www.Xlinks.co

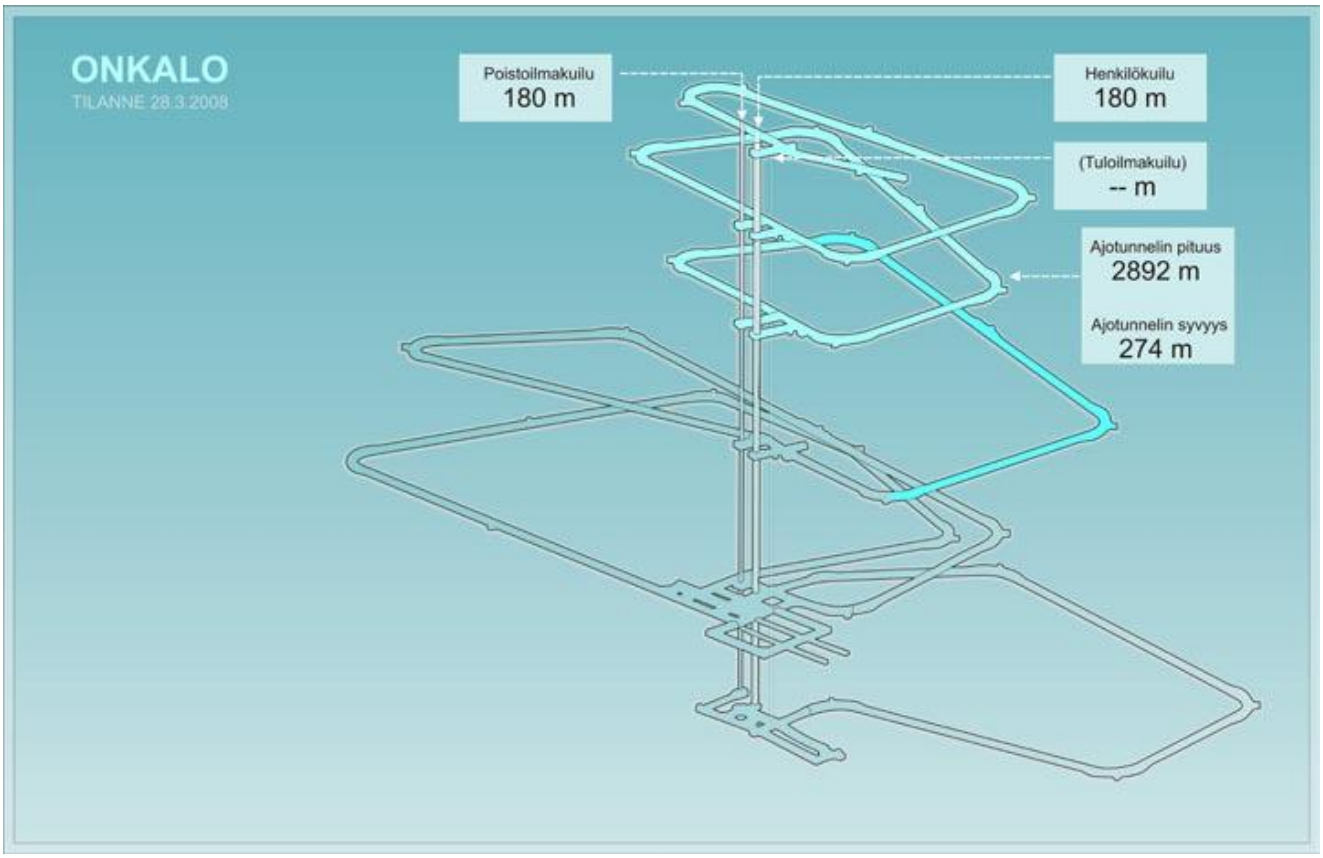
Australia-ASEAN Power Link is a 3GW - 3200 km subsea cable partly in very deep water, for PV export from Australia to Singapore, scheduled for 2027, promoted by mining and IT magnates Forrest (FORTESCUE) and Cannon-Brookes (ATLASSIAN).

Financial Times, 20.08.2020

Iberia to Britain would bring activity to the sparsely populated border AND:

1. **Cost a fraction, the cable is much shorter and the solar resource is similar.**
2. **Carry no geopolitical risk nor sand storm hazard.**
3. **Allow balanced two-way trade, bartering diurnal PV for nocturnal offshore wind.**

Onkalo (The little cave): Finland is a small country but with very high technology and good managers (though they are not free from making costly mistakes). The Finish Nuclear Energy Act requires that all nuclear waste produced in Finland must be processed and stored in Finnish territory. A location was found with adequate geology and popular support. Public utility Fortum (main shareholder) and a consortium of energy and industrial companies, including UPM and Stora Enso, established a company to develop the Project.



800 million Euros were invested in a rock mine 550 meter deep to ensure the nuclear waste remains buried after the next glaciation, withstanding the extreme erosion due to the ice mass. The necessary technology (mining, mechanical, geotechnical…) will be developed and possibly marketed abroad. Onkalo is the first project for final storage of high activity nuclear waste, a great example of what can be achieved, and also of deep mine construction for uses different from mineral ore extraction, namely the end cycle of an energy process that is no longer competitive. Although we aim at using existing underground infrastructure initially, we believe deep mines in competent rock, such as Onkalo, allow the least cost solution for very large scale energy storage of very competitive clean energy, such as Iberian and Global South PV. It is inevitable that, by designing and building Onkalo, many of the crucial problems that we face have been partially or fully solved, including site geological validation, mine construction, water tightness and mine plugging.

5-A. Operational Demonstrator, H=80 metros.

We have found a location in Central Asturias, with good road access, and we have already sourced the main components (pumps and pressure vessels), as well as the dumpsite material and additives for the slurry, which is of good enough quality to allow us use a penstock with a mere 2” diameter. We are renting the site for a token amount thanks to the kindness and generosity of the owner. If the weather and the pandemic are favorable, we should have the installation ready in February. We have enrolled fluid mechanics experts Idonial to simulate and optimize the flow and to strengthen the theoretical basis so we can reach the next step as soon as possible.

6-A. Prototype and test bench, H=300 m, 1000 m3.

This installation will be necessary to verify the technical and comercial viability of the technology. It will use a dense fluid made with dumpsite material, which will be verified in the previous installation.

We intend to build a very affordable prototype in Asturias, ideally with Asturian industrial suppliers, and finance it with grants from the Government of Asturias which are awarded competitively, and with “just transition” funds. There would be room for international partners who would have access to the test bench to verify the performance of the dense fluids for their installations. Commercial projects will have to use dumpsite minerals to be competitive, so they should be brought from every geographical area to the test bench. This is certainly cheaper than building twin installations in the different countries and allows partners to share the knowledge gained in each test. To minimize cost, it is very important to find and adapt existing infrastructure, and carry out tests only on innovative components. For example, we will generate a water jet and measure flow rate and energy, avoiding the cost of installing a complete turbine with ancillary electrical equipment, because the performance of the turbine is well-known. It is very important to check if the installation can find other markets, such as testing hydropower equipment or technologies for mine plugging.

7-A The first comercial project.

We are looking for locations for commercial projects because we are confident that we have solved a critical problema: Preparing cheap dense fluids that flow properly, composed of dumpsite materials instead of ores, and we are acquiring expertise in their operations. We suspect the owners of those locations will be interested in making money from depreciated or worthless assets, and developers can benefit from grants for innovative projects and buils hybrid installations with clean generation and clean storage. Searching for locations helps us meet owners of dumpsites, mines, hydropower plants, deep boreholes, etc. who could benefit from our technology and decide to help us in the earlier stages. We have already found that such contacts generate ideas that can help the financial health of our company.

8-A Web. Our offer to Asturian companies.

When we accepted our first grant in 2019 we agreed to launch our website. We will show a technology that, if it is even partially successful, could unlock powerful externalities, fanning the deployment of renewables and creating demand for new products and services, many of which can be sourced locally, from dumpsite materials and equipment to process them, to piping, pumps, turbines, rock surface treatment and conditioning… we are entering a stage in which new components will have to be developed, we propose new applications for infrastructure and materials that have not attracted expert attention previously. These developments will be useful for our projects, but also for new applications, so even if our project stalls, we can launch new products, procedures and technologies. In fact, this has already happened, we have prepared an innovative dense fluid which can compete in areas unrelated to energy storage. There sure is a way to include their capacities and add to the technological stock.