

XXL-REFRESH FINAL REPORT

EXECUTIVE SUMMARY

XXL-REFRESH has developed a modular technology for fresh water transportation by sea.

The concept is a breakthrough evolution of the so-called “waterbag” technology, examples of which exist since the 1980s. The new technology has built upon the lessons learnt from previous waterbag projects, overcoming all drawbacks that prevented past attempts from reaching commercial success. Unlike any other waterbag in the past, the new system is not made by a train of sealed containers or by a single huge monolithic container: the key innovation introduced is the use of modular, easily accessible and reconfigurable containers, that allow easy storage and sanitation, fast and inexpensive deployment and modulation of the payload according to clients’ requirements. The modular structure of the system is enabled by the use of extremely high strength watertight zip fasteners; the capacity of the system can be increased indefinitely by joining a number of modules.

The technological feasibility of the concept was proven with a test carried out in 2012 in Greece on a medium scale 200 m3 prototype (FP7 project REFRESH), which proved that the new design approach is able to solve all technical issues and provide a smoothly functioning product.

XXL-REFRESH has developed and tested a new full commercial scale waterbag system. The final demonstration voyage was performed in Spain in December 2015, transporting a payload of 2000 m3 of water. The test was fully successful as documented by the documentary produced by Euronews and available at <http://www.euronews.com/2016/01/25/the-big-bag-theory-a-cheap-and-innovative-way-to-transport-fresh-water/>.

Commercial exploitation of the system is presently starting, with the consortium already having received commercial requests coming from Europe, South America, and Middle East Countries.

PUBLISHABLE SUMMARY

Water scarcity and water stress are increasingly compelling issues at European and global level. According to estimates by European Commission's DG Environment at least 11% of Europe's population and 17% of its territory are affected by water scarcity, most of them being located along the Mediterranean shore. Water resources are on the overall still abundant in Europe, but their distribution is uneven; what's more, water-poor areas tend to feature the highest water demands in peak periods (i.e. summer); in addition, the action of climate change is slowly but steadily turning the Mediterranean coastline into a semi-arid region, with hotter and drier summers and more frequent droughts, adversely affecting water availability.

Together with more sustainable water management practices, water transport from water-rich to water-poor areas can be a solution for mitigating water stress.

Conventional water supply techniques available to Mediterranean coastal communities feature considerable drawbacks which often hinder their usage:

- Water pipelines have high costs of design, construction and maintenance; they are permanent infrastructures suitable only in case of constant need of large quantities of water. Typical costs for water pipelines are in the range of 4 million €/km. For example, the Western Pipeline in Turkey, with a length of 2.650 km has been estimated to cost approximately 11.2 billion €, while the Gulf Pipeline with a total length of 3900 km has been estimated to cost approximately 16.5 billion €. Water supply to islands requires the use of even more expensive underwater pipelines.
- Desalination is a complex chemical/physical process requiring several pre-treatments phases (e.g. to remove suspended matter in the source water) and additives (e.g. anti-scalants to lower the pH and improve the reverse osmosis membrane performance). In spite of all treatments, the quality of the desalted water is not excellent because the salt is not completely removed. Desalination plants requires high initial investments and operative costs (respectively, 15-20 M€ and 1M€/year for a 10.000 m³/day plant) ; moreover, high energy consumption and generation of brine are serious environmental concerns, presently discouraging the realisation of new desalination plants in the Mediterranean .
- Water tankers are generally small and only suitable for short routes; larger ones are usually reconverted old oil tankers. The conversion process is extremely expensive and operation is costly

An alternative means of shipping freshwater through the sea is represented by the "waterbag" technology – transporting bulk quantities of water across the sea by means of large flexible barges towed by tugboats, examples of which exist since the 1980s. Such systems can be used to transfer water from water-rich to water-poor areas even at long distance; however, despite the research efforts, none of the proposed waterbag concepts has up to now reached a commercial product phase.

Two main categories of waterbags had been proposed in the past, either being based on huge monolithic containers or on trains of smaller containers, each one being sealed on itself, connected via ropes or fabric sleeves. Each of the conventional designs – despite being technically sound – has intrinsic drawbacks that have prevented all past waterbag projects from reaching commercial success.

The FP7 project REFRESH (Grant Agreement n. 262494, November 2010 – October 2012) developed a technological solution able to overcome the drawbacks of past waterbag attempts. The key innovation introduced by REFRESH is the use of open modular containers. This new structure, enabled by the use of a unique watertight high-strength zip closure (one of the most notable results of the research project), has improved handling, reliability and time-efficiency by orders of magnitude with respect to previous waterbag attempts. Within REFRESH, the system was prototyped at small scale and a proof of concept was obtained.

XXL-REFRESH has brought the REFRESH to commercial scale. This has involved a partial re-design of the waterbag system and its components. The main technological advancements developed are:

- A strong but flexible PVC-coated reinforced fabric, featuring an inner side approved for food contact and an outer side with a specific coating to enhance the endurance to exposure to sea water and sun rays.
- A unique extremely strong, watertight zipper, used to join the modules to build the overall waterbag. With a cross tensional strength exceeding 20 t/m, it is the strongest watertight zipper in the world.
- A smart monitoring system coupling fibre optics sensors to the fabric, able to send a real time warning to the tugboat main deck in case of excess stress in the waterbag.

A 60 m long, 10 m wide and 5 m deep prototype was produced and tested at sea. The final demonstration voyage was performed in Spain in December 2015, transporting a payload of 2000 m³ of water. The test was fully successful as documented by the documentary produced by Euronews and available at <http://www.euronews.com/2016/01/25/the-big-bag-theory-a-cheap-and-innovative-way-to-transport-fresh-water/>.

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S & T results/foregrounds

Waterbag redesign

The design of the system started from the one used in the medium-sized prototype manufactured in REFRESH, updated and scaled-up to meet the full-scale prototype requirements.

A number of hints for improvements had already arisen from the demonstration voyage of the medium-sized prototype, in particular:

- shaping the bow to minimise wave formation and maximise hydrodynamic efficiency
- modulation of fabric stiffness near towage connection to avoid fatigue at steep turns

The seakeeping analysis developed by DAPP was corroborated by a hydrodynamic analysis of the system to better understand the interaction between seawater, the membrane and the freshwater inside it under different conditions (such as linear towage, turning, front wave, side wave and their combination): this was crucial to foresee force/stress distribution and take needed countermeasures.

A total of 40 different model shapes were numerically generated by varying a set of geometric parameters.

With the results carried out by the parametric analyses described above, four cases of interest were selected in order to be further analyzed through a more detailed model: the first two designs had a classical cylindrical shape, while the second two had a flattened shape with lower depth.

The second phase of the CFD simulation was carried out to investigate in a deeper way the four best design cases selected through the first phase analyses. A new numerical model, more detailed, was implemented to get a reliable precision on hydrodynamic drag forecast.

The calculated hydrodynamic drag values were in the range 40 – 55 kN at 5 knots speed.

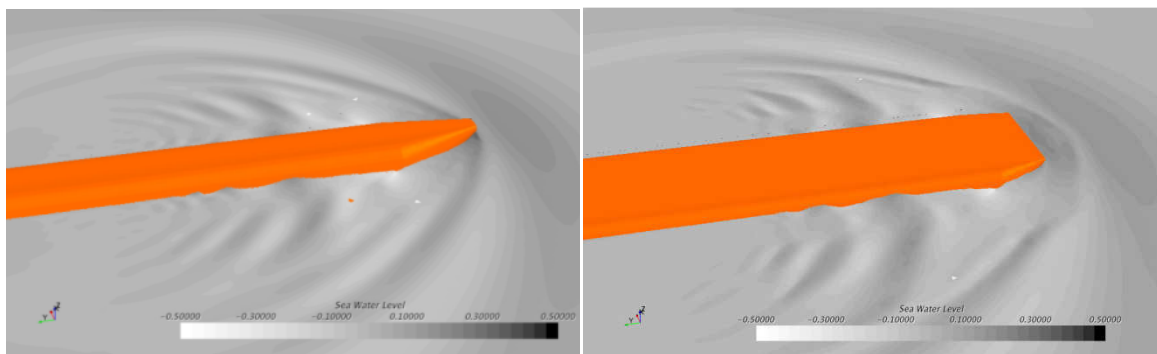


Figure 1: Computer-assisted Fluid Dynamic analysis by DAPP

These results allowed to perform the detailed design of the system, upon which the successive prototyping activities were based.

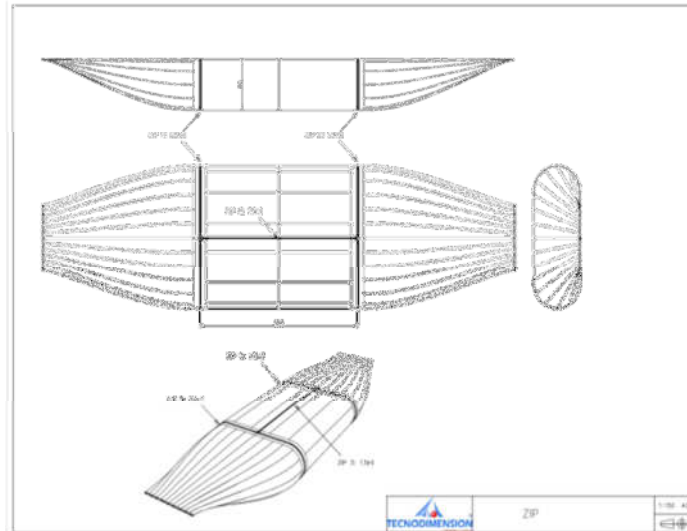


Figure 2: Design of the first 3 module assembly by TD



Figure 3: Detailed design of the final 5 module assembly, with indication of the fibre optics sensors and valves for filling (DAPP and TD)

Waterbag components

Fabric

The XXL-refresh waterbag is made with a strong but flexible PVC-coated reinforced fabric, featuring an inner side approved for food contact and an outer side with a specific coating to enhance the endurance to exposure to sea water and sun rays.

PVC coated fabrics are widely used in several applications due to low cost and optimal performance with a good combination of flexibility, toughness, extensibility and high ratio of strength to weight. They offer good chemical and weathering properties.

Coated fabrics are essentially polymer-coated textiles. As shown in figure 1, a reinforcing fabric is coated on both sides with a polymeric coating.

The properties of a coated fabric depend on the type of polymer used and its formulation, the nature of textile substrate, and the coating method employed.



Figure 4: Loom and plasticiser mixer at SEDO

The choice of PVC coating is essentially due to its low cost, excellent physical properties (good flexibility, toughness, extensibility and high ratio of strength to weight), good chemical and weathering properties, unique ability to be compounded with additives (i.e. plasticizers, heat stabilizers, antioxidants, UV absorbers, fillers, lubricants, colorants) and usefulness for a wide range of applications and processability by a wide variety of techniques.

Different modifications have been done in order to tune the properties of the plastic coated fabric developed within the original REFRESH project. Main improvements have consisted in manufacturing a reinforced polyester fabric with enhanced tear strength featuring a new woven architecture based in a pattern that combines a set of 3+3 yarns instead of the 2+2 pattern used in the previous prototype.

Basically the new weaving design combines 3 weft yarns of polyester interlaced with 3 warp yarns of polyester as depicted in figure 3. This new weaving pattern offers up to 55% increased tear strength.

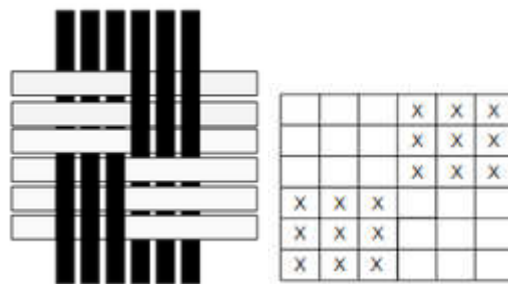


Figure 5. Reinforced fabric weaving patterns 3+3

Other developments have considered the reformulation of thermoplastic PVC-coating using alternative additives (mainly non phthalates plasticizers).

SEDO has produced 1000 m of fabric with a 2.5 m width, which have provided sufficient fabric for the 5 modules employed in the final prototype of the system.

AIMPLAS validated the characteristics of the fabric by performing mechanical, aging and sensory tests, as well as tests on migration of chemicals from the fabric to the water. The tests ensured that water transported with the waterbag is safe for human consumption.



Figure 6. Welding resistance essay, aging test, sensory analysis at AIMPLAS

Zipper

Modules composing the waterbag are joint by using a unique, extremely strong, watertight zipper. With a cross tensional strength exceeding 20 t/m, it is the strongest watertight zipper in the world.

The “REFRESH SEALING ZIP FASTENER” is composed by overmoulded elements individually screwed and also including a longitudinal extruded gasket made of TPU.

The zip is made by a total of 4 tapes, each of whom equipped with a quarter of the chain: more precisely, the zip closure is realised by two halfchains, each of whom equipped with a row of teeth; each row of teeth is realised in two halves in order to make it possible to insert a PU sealing profile in the middle.

One meter of complete and joined zipper chain contains n. 116 teeth, each one equipped with a stainless steel screw of mm. 3.9 x 19.

The zip is made on a mixed Vectran (weft)/polyester(warp) tape. In order to enhance adhesion to the PVCised fabric used to manufacture the waterbag prototype, the polyester yarns are PVC-coated. The teeth are directly overmoulded on the tape using a POM polymer injection.

The increased thickness of the PVC coated warp yarns needed deep adjustments both in the loom and in the creel. ZIPLAST has, therefore, added one more new weaving machine, dedicated solely to production of zips for XXL-REFRESH.



Figure 7: Loom weaving the tape, coupling of the cordon and overmoulding of teeth at ZIPLAST

A special automatic screwing machine was designed and assembled to fabricate the large quantity of zippers needed for the full scale waterbag.

The machine is equipped with sensors that guarantee a constant screwing torque. Production capacity of the machine is at present of 30 meters/hour of complete chain. The production capacity is still in progress. We estimate to reach a final production speed close to 60 m/h.

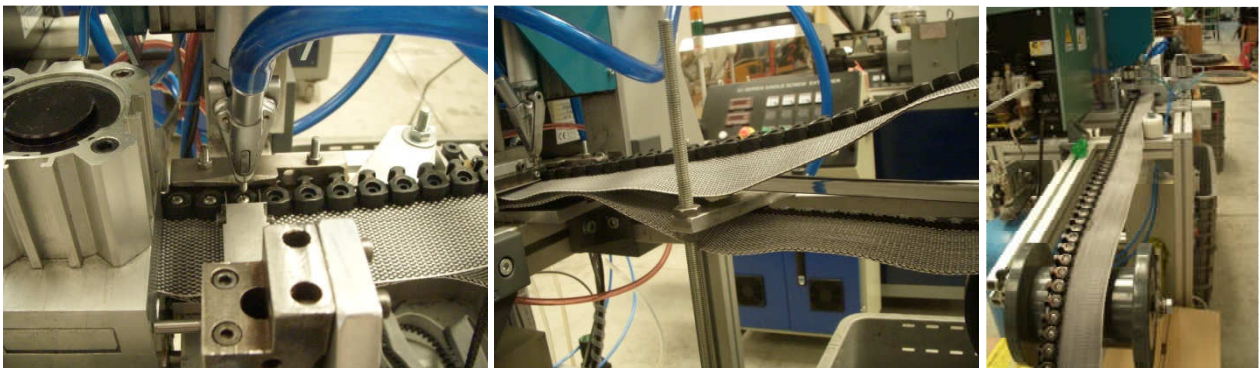


Figure 8: Automatic screwing machine at ZIPLAST

After many tests made in different seasons and temperature conditions, it has been demonstrated that following the cooling shrinkage into the deepest inner part of the moulded elements, the diameter of the screwing passage is sometimes too small in comparison with the screw's core. This condition can cause some breakage of elements during/after the screwing. A deep modification in the injection mould was then necessary, involving all the pins / ejectors, in order to increase of 0.3 mm the inner diameter of the element's hole.



Figure 9: Final zip prototypes and stainless steel cursor

Fibre optics monitoring system

Deformation of the waterbag during navigation is measured in real time using a smart monitoring system coupling fibre optics sensors to the fabric. The system, developed by SAFIBRA, is able to send a real time warning to the tugboat main deck in case of excess stress in the waterbag, enabling the crew to take countermeasures to avoid breakage of the waterbag and loss of the payload.

A special patch of fabric was developed, equipped with a 1 m long fibre optic sensor, in order to provide a quick means of attaching the sensor to the bag and enable a fast deployment and retrieval of the sensor. With respect to embedding the fibres directly in the waterbag fabric, this device enables to protect the fibre from excess bending when the waterbag is folded.



Figure 10: Sensor patch with glued fibre and attached fibre optic cable.



Figure 11: Fibre optics monitoring system during waterbag assembling.

During the final demonstration voyage of the waterbag the system was validated. Each unit is equipped with a radio antenna for communication with the tugboat. The monitoring units are to be switched on from the sleep mode by a multi-channel remote control. It means that each unit can be switched on independently. Both data transmission (Wi-Fi @2.4 GHz) and remote control radio are commercially available and has a range of several hundred meters in free space

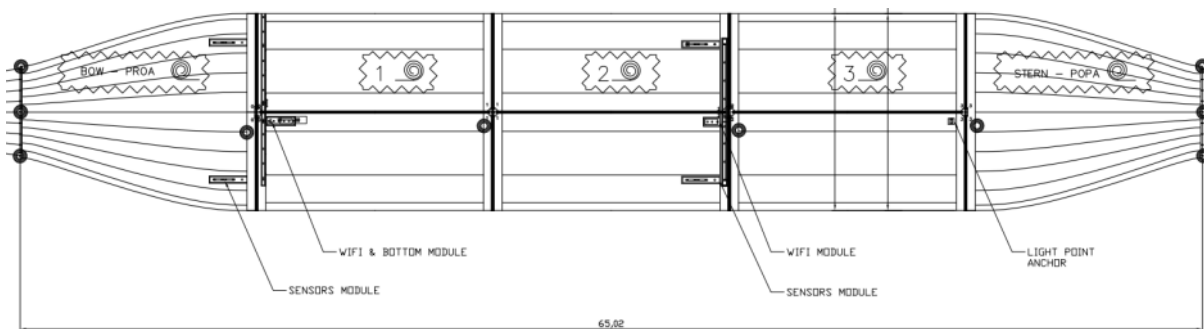


Figure 12: Final configuration of the bag with 2 sensors on the tip, 1 on the second module and 2 sensors on the third module.

Auxiliary components

Closure plates

Zipper ends are not terminated at intersections, but rather left free. This is needed in order to let the cursor slide out and in order to keep surface planar. A hole remains at the intersection of zips, which is exploited as inlet for the freshwater.

Each intersection of zippers is shut and secured by a closure plate, which features a water valve in correspondence of the hole.

The plates are made in inox steel, with a polyurethane foam liner for water tightness and protection of the fabric. Each plate is made in an upper and a lower part: screws on the lower part are engaged by knobs on the upper part through holes pierced in the textile. This ensures mechanical engagement of the plate with the fabric and water tightness. A 2" Storz valve is fitted on top of each closure plate for water filling.

Three way plates are used at links between a tip and a central module, while four way plates are used at links between central modules.



Figure 13: Three-way and four-way Closure Plates

Towing line connection

The two tips have got the same terminations, an assembly of steel bars equipped with steel cables. Steel cables join at a loop, where the towing line from the tugboat is connected.

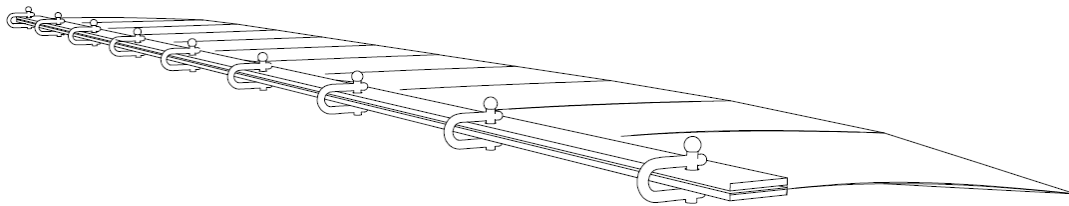


Figure 14: Towing line connection



Figure 15: Steel cables and connection of the towing line at dock

Manufacturing process for the waterbag modules

Due to high level of accuracy and large surfaces involved, the most delicate tasks in the manufacturing process, i.e. juxtaposing and welding the fabric pieces, must be performed manually by the highly skilled personnel of TD.

Automation was introduced in the first steps of the process, i.e. drawing and cutting.

TD Technical Department produced a 3D model of the modular system with the new shape; 3D drawings were converted again into 2D files to be sent to the digital cutting plotter station in order to cut the appropriate fabric pieces that would be assembled to manufacture each element of the waterbag.



Figure 16: Digital cutting plotter

After cutting, each fabric piece was prepared and numbered by modules, ready to be assembled and welded.

After the production of the fabric structure, the zip and valve slot were welded.

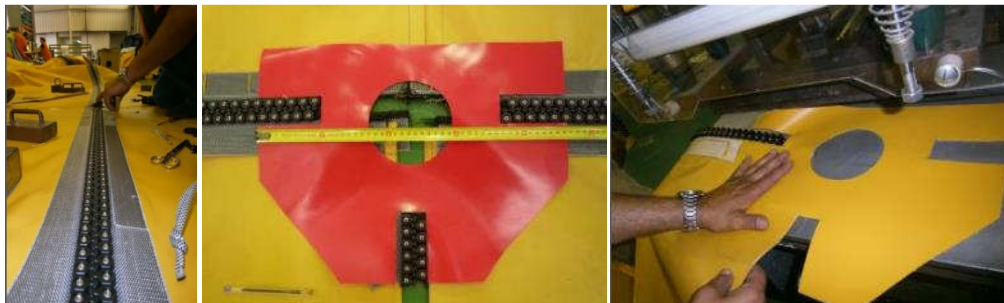


Figure 17. Zip welding (left), valve slot measurement (center) and welding (right)

Once the fabrics and zippers had been welded and the different components produced, the several parts of the system could be assembled in order to obtain the modular elements in the flexible waterbag.

Due to the dimension of the prototype, up to 12 persons were involved in welding to handle and align the 13 m long single pieces of fabric.



Figure 18. Modules assembling process

Fabrication of tip modules takes 4 days each; fabrication of central modules takes 2 days.

It is thus possible to manufacture a module waterbag, with a maximum payload of 2500 m³, in 14 days.

Technical, economic and environmental performance

Seaworthiness

A seakeeping analysis was performed by DAPP early in the project on the basis of the CFD validated design. The behaviour of the waterbag at sea was tested first on a small scale with the deployment of a 3 module system, then with a full scale demonstration with the complete 5 module waterbag.

The final demonstration voyage was organised in the dates 14 – 18 December 2015.

Weather was calm with no wind and calm sea. Departure from the port occurred at 12.15 and the final approach back to the port started at 15.36. The total route covered was approximately 14 nautical miles (26 km).

The waterbag was composed of 5 modules, in total 65 m long, approximately 8 m wide and approximately 5 m deep.





Figure 19: XXL-REFRESH Waterbag Moored at St. Carles de la Rapita South Dock. See Persons for comparing the Size of the Waterbag

Power of the tugboat was 2005 kW or approximately 2700 HP. It was certified with a bollard pull of 45 tons. The Captain reported that even when running at maximum speed the engine was not exceeding 60% of its power. Fuel consumption was estimated at 200 l/h.

The maximum speed reached during the test was 5.4 knots.



Figure 20: Waterbag in navigation seen from the tugboat (left) and support boat (right)

Data on elongation of the fabric were sent in real time to the tugboat main deck via a radio signal from the electronics box on top of the waterbag. Maximum strain measured by fibre optics system was close to the upper limit of the instrument (1%) but still within the acceptable range for the fabric and zippers.

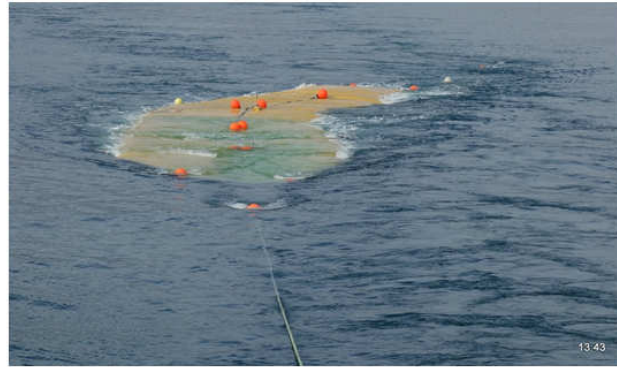
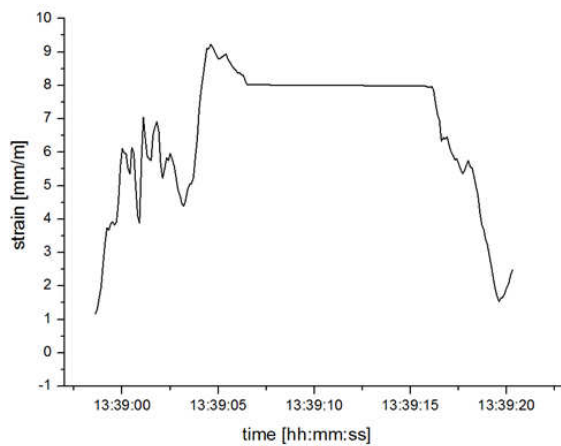


Figure 21: Short Record during the Towing procedure at Maximum Speed

The behaviour of the waterbag was according to forecast. No significant damage was observed in the fabric and zipper. The steel towing assembly was found bent at ex-post inspection, but this damage was attributed to mishandling during lifting of the waterbag out of the water, since no sign of it was observed at navigation or mooring.

A filming crew from Euronews documented the demonstration trial. The video is now publicly available online at www.euronews.com/2016/01/25/the-big-bag-theory-a-cheap-and-innovative-way-to-transport-fresh-water/ and aired on TV by mid January 2016.

Logistics and handling

The modular structure of the waterbag allows to perform all “dry” operations on ground at the level of a single module. This keeps the operations manageable by a small crew of people (5-6) even when building a macroscopic structure (60 m long in the case of the 5 module waterbag).



Figure 22: Textile Modules Folded and Rolled up



Figure 23: Rolled-up Modules Loaded on TECNODIMENSION's Truck

Each module, when folded, can be stored and shipped on standard pallets. In particular, for the 5 modules produced, the following dimensions were measured:

- 2 pallets for front and back modules, having dimensions $2.00 \times 1.10 \times 0.90 \text{ m} = 1.98 \text{ m}^3$, for a weight of 503 kg each (gross weight);
- 3 pallets for central cylindrical modules, having dimensions $2.00 \times 1.25 \times 0.90 \text{ m} = 2.25 \text{ m}^3$, for a weight of 640 kg each (gross weight).



Figure 24: Palletised Modules at TECNODIMENSION Workshop, ready for Shipment

The palletisation of modules allows a fast deployment of the system anywhere it is needed. This is critical in order to be able to propose the system as emergency device in response to extreme events as unforeseen drought.

Economic performance and commercial perspective

After acquiring data from the final demonstration of the waterbag, DAPP built a case study to compare its technical-economic performance against existing alternatives, namely an underwater pipeline and a service of transport with tankers.

The case study chosen as reference for XXL-REFRESH was, since the proposal phase, the route leading from Turkey (Manavgat) to Northern Cyprus.

Northern Cyprus is a semi-arid territory with little domestic water reserves, who depends on water import to replenish its aquifers. It being a self-proclaimed country recognized only by Turkey, it has traditionally been dependent on the “sister country” on the mainland for supply of several utilities, including water.

The original choice of Manavgat as source of the water was dictated by two main reasons:

Presence of a large scale near-shore water supply infrastructure, to become a hub for water shipment in the Eastern Mediterranean in the intentions of the builders (a description of the Manavgat plant is reported in D1.1);

This route was home to the only known case study of commercial deployment of waterbags for water transport, the service performed by Nordic Water Supply (NWS) in 1998 – 2002, enabling direct comparison of the XXL-REFRESH waterbag with the closest competitor.

The routes from Manavgat (or Anamur) to Girne (or Kumkoy) have been used for large scale water transport with conventional means (tankers) as well as non conventional ones (waterbags). Economic data are available from a number of studies.

Moreover, an underwater pipeline has been recently built between mainland Turkey and Northern Cyprus, making this route the only one known in the world to have been serviced by all of the three competing methods to transfer water by sea: waterbags, tanker ships and pipeline.

For all these reasons, the route from Manavgat to Northern Cyprus was the first choice for performing the final demonstration test. This would have enabled a direct, factual comparison between XXL-REFRESH and the competing technologies. However, as reported, this was not possible for technical and political reasons. In order to enable the comparison, a simulation of the performance of the XXL-REFRESH system on the Manavgat-Kumkoy route is elaborated on the basis of data acquired during the final demonstration test performed in Spain.



Figure 25: Routes for water transfer to Northern Cyprus

The target yearly volume of water to be transferred was set as the same that was requested to Nordic Water Supply in the only known example of commercial operation of waterbags from Turkey to Northern Cyprus, that is 2 million m³ per year.

The XXL-REFRESH waterbag is able to compete with comparable alternative means of water transfer such as tanker ships.

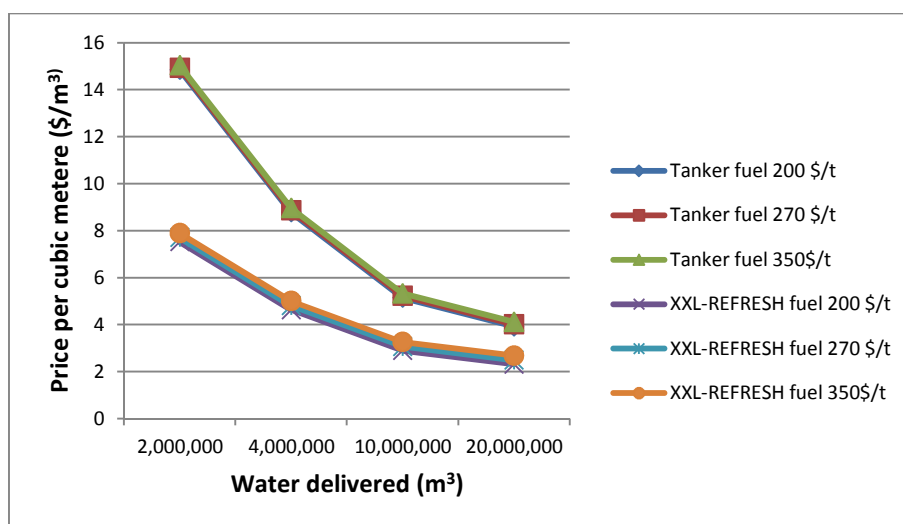


Figure 26: Comparison of breakeven water pricing for tanker and XXL-REFRESH waterbag in the use case in scope

This economic calculation allows the XXL-REFRESH consortium to foresee the creation of water transfer services across the Mediterranean with a final price of water well below the current market prices (that can reach up to 10 €/m³ in Italy).

Commercial contacts were established in the following Countries:

- Italy;
- Chile;
- Japan;
- Palestinian Territories;
- Saudi Arabia;
- China;
- Norway;
- Greece;
- Romania;
- Colombia;
- Malta.

One of these contacts already became a quite detail commercial opportunity. The contact is interested in performing a demonstration of the system in its own location, at its own expenses, and asked the consortium to provide a formal quotation for the rental of the waterbag. The consortium answered with a quotation, that is now being evaluated by the customer.

DAPP led the partners in the work of defining a suitable business plan for exploitation of the results of the project. Each company will pursue exploitation of its own developments (at the level of single components) on its own; the main result of the project, i.e. the waterbag itself, will be jointly exploited.

Environmental performance

On the basis of data acquired in the demonstration test, DAPP performed a Life Cycle Analysis of the system's fabrication and operation.

Three use cases, stemming from actual commercial contacts received by the project consortium. were prepared:

- Water supply from Piraeus to Aegina Island (20 nautical miles equal to 37 km), in Greece, that has an annual request of 120000 m³, through a barge with a capacity of 1000 m³, 120 voyages per year, for providing domestic potable water;
- Water supply from Puerto Aysen to offshore fish farm (38 nautical miles equal to 70 km), in Chile, that has an annual request of 130000 m³, through a barge with a capacity of 2500 m³, 52 voyages per year, for providing domestic potable water for workers;
- Water supply from Manavgat (Turkey) to Kireniya/Girne (Cyprus) (124 nautical miles equal to 230 km), that has an annual request of 525000 m³, through a barge with a capacity of 5000 m³, 105 voyages per year, for providing freshwater (not potable) for agriculture.

For each of the three scenarios a comparative analysis was performed, in comparison with a tanker ship of same capacity.

The energetic and environmental performances of the two different water supply services for three different scenarios, used as reference, have been compared, taking into account a series of hypothesis explained in the report.

Summarizing, the comparison of the XXL REFRESH system with a competing technology (tanker barge) has highlighted that this technology is highly promising in terms of reduction of energetic and environmental performances. The benefits are more evident, higher is the carried volume for each single trip.

For all the three scenarios and the two transport systems it is clear how service life represents the highest contribution to impact, while production, maintenance and dismantling are comparatively negligible.

Impact

Potential impact

Water scarcity is a global problem and is not confined to “poor” nations. Considering Europe alone, XXL REFRESH represents a cost effective and flexible technology for supplying fresh-water to coastal small cities and island with less than 300.000 inhabitants where about 45 million of European citizens live ¹. 65% of these communities, that double in size during summer with tourist presences², are affected by growing water scarcity³ due to several factors as climate change, growing urbanisation of coasts, tourism, sea water intrusion in aquifers.

Water scarcity is also a major concern in the Middle East, where most countries have only less than 500m³/capita/year of water available. The annual volume of actual renewable water resources per capita is 261m³ in Israel, approximately 90m³ in Palestine, and 164m³ in Jordan, while water-rich countries such as the United States have more than 10,000m³.

One of biggest challenge in the Arabic Gulf region is water, which may be everywhere in the Gulf but is undrinkable without desalination. Desalination plants produce emissions of carbon dioxide that have helped give Dubai and the other United Arab Emirates one of the world’s largest carbon footprints. They also generated enormous amounts of heated sludge which is regrettably pumped back into the sea⁴, causing environmental concerns.

For these communities XXL-REFRESH represents an effective solution for fresh-water supply service, especially where traditional technologies as water pipelines, desalinisation plants and large water tankers are not a feasible solution due to financial, environmental and technical barriers.

In addition to the clear social impact of the project when deployed at large scale, the use of the XXL-REFRESH waterbag will contribute to:

- **Reduce environmental cost of water industry:** REFRESH water supply system, consuming low energy and with practically no environmental impact due the use of solar energy and recyclable materials is an important improvement on developing a low environmental impact European industry, fully supporting the competitiveness of water sector on the international market.
- **Support the Tourism Industry,** one of the leading sectors in Europe, especially in Mediterranean seaside locations with an estimate of 235 million tourists per year⁵ and an occupation of 4 million people, which will benefit from increased water availability without environmental drawbacks thanks to the application of the REFRESH water supply paradigm, increasing the touristic appeal and marketability of European coasts and helping overcome the competition from extra European destinations;

Besides direct impacts stemming from the use of XXL-REFRESH as a freshwater transport system, further impact will originate from the commercialisation by consortium of the new components developed.

¹ EEA, 2001, Population density in the European coastal zone

² EUWI, 2007, Report: Mediterranean Water Scarcity and Drought

³ EEA, 2008, CLIM38 - Water and food-borne diseases - Assessment published Sep. 2008

⁴ A. Hashim and M. Hajjaj, 2005, “Impact of desalination plants fluid effluents on the integrity of seawater, with the Arabian Gulf in perspective”, presented at the Conference on Desalination and the Environment, Santa Margherita Ligure, Italy, 22-26 May

⁵ WWF, 2004, Freshwater and Tourism in the Mediterranean

In particular, the successful application of SAFBRA's fibre optics monitoring system to a flexible structure makes it possible to extend the application of such system beyond current applications in civil engineering to encompass monitoring of textile structures. This important niche of the market is substantially untouched by sensors providers.

In addition, the extremely strong watertight zipper developed by ZIPLAST enables the design of completely new structures, e.g. large scale flexible pipelines, that are not feasible with today's technology. The zippers make it possible to easily substitute a section of the pipe for repair of scheduled maintenance.

Extreme zippers have the potential to become a new standard to join textiles directly in-place, combining the benefits of current welding (water tight, in-factory) and hook-and-loop (in-place , not watertight) systems. This new possibility could open up new developments for the European textile architecture sector, in turn benefiting the European Textile sector, that in the latest years suffered by Far Est competition on low value products. Overcoming the limitations caused by current hook and loop joints could allow a substantial expansion of the textile architecture market, currently estimated at 13 billion €.

Moreover, a further development of the zip to make it gastight would enable creation of large inflatable structures with structural properties, for use in transport (airships) and architecture.

Dissemination actions

The project was represented in the following events:

- Even before the project officially started, most of the project team (namely SEDO, ZIPLAST, SAFIBRA, AIMPLAS and DAPP) was present at Techtextil in May 2013 to showcase the previous REFRESH project and receive the Innovation Award 2013 in the category "New applications". Techtextil Europe, held every two years in Frankfurt, is the largest and most important event for the technical textile industry and the Award is one of the most prestigious in the field. Even though the new project was not officially operating yet (it was actually in negotiation stage), the project team took the chance to put forward the will to continue developing the REFRESH concept. In that occasion, some interesting contacts were made with Asian and European potential customers.
- In the first stages of the project (October 2013) DAPP's Donato Zangani presented XXL-REFRESH in a national Italian conference, Nanoitaltex (devoted to innovation in technical textiles) and at European level at EURATEX conference.
- In May 2014 DAPP and TURGUTREIS participated to the International Conference on Water Resources and Environmental Management, conveniently located in Antalya (turkey), near the location chosen for the final Demonstration voyage. DAPP's Samuele Ambrosetti presented the project in the keynote speech of his session and answered questions from an attentive audience. The audience had a large representation of high level participants (from academia, industry and policymakers) from Middle East and African countries: this enabled creating links with important stakeholders in two potentially very interesting markets.
- DAPP gave a speech in one of the leading European events concerning water resources management, "IWA Water ideas", Bologna, Italy, 22-24 October 2014;
- AIMPLAS participated to CONAMA – Congreso Nacional del Medio Ambiente, held in Madrid 24-27 November 2014, Spain's prominent conference for environmental related issues, with a poster dedicated to the project;
- DAPP was present to BIAT – Borsa dell'Innovazione e dell'Alta Tecnologia, held in Naples 12-14 December 2014. BIAT is the leading Italian showcase and brokerage events, aiming at creating opportunities for commercial exploitation towards foreign countries. The 2014 edition was focused on investors from USA, Canada, Sweden, UK, France, Israel, Germany, Austria, Belgium, China, UAE

and Russia. Reception of XXL-REFRESH was positive but only one concrete contact emerged, from China;

- DAPP gave a speech, rented a booth and participated in a B2B event at Malta Water Week, held in Valletta 23-27 March 2015. Audience was composed of professionals, academics and policy makers from Europe and the Mediterranean countries. The event was fruitful for dissemination but also for potential exploitation, as contacts were made with Aqua Norway, who owns exploitation rights on water from a glacier in Norway and is looking into ways of exporting bulk quantities of it, and with Paragon Europe, Maltese company who expressed the interest in acting as local broker to turn Malta into a “water commerce hub” for the Mediterranean;
- DAPP, ZIPLAST and SEDO’ were present with booths at Techtextil 2015. Techtextil Europe is the largest fair for technical textiles in Europe, held biannually in Frankfurt Messe. The 2015 edition ran from 4 to 7 May and attracted 28500 trade visitors from 102 nations.

The project was featured in the following media:

- Due to REFRESH winning the EARTO Innovation Award in 2013, the old project and its continuation XXL-REFRESH were included in EARTO’s brochure “Impact Delivered”.
- AIMPLAS’s Vicent Martinez released a radio interview on the National Spanish radio RNE in February 2014.
- In March 2014 AIMPLAS included the project in its monthly newsletter sent to members of the association. April saw the publication by AIMPLAS of an article in the Spanish technical magazine FUTURENVIRO, concerned with technologies for environment. FUTURENVIRO has bimonthly issues with an outreach of more than 4000 subscribers in the industry.
- In June 2014 TECNODIMENSION arranged for coverage of manufacturing and dry trial of the first three module prototype by Spanish newspaper “El Punt AVUI”. Published daily in Catalan language, “El Punt” reaches around 75.000 persons. XXL-REFRESH was chosen as the daily cover story for the Girona edition and appeared in an internal page in the other local editions (including Barcelona and Tarragona).
- AIMPLAS published a four page article in the April 2015 issue of Spanish magazine Futurenviro, dedicated to innovation in environmental technologies;
- A box dedicated to the project was present on a special publication launched by Italy’s Federazione del Mare (Cluster of Italian marine economy operators). The publication, titled “Feeding the planet: the maritime economy contribution” was prepared by D’Appolonia and CENSIS and presented within the framework of the EXPO2015 in Milan on June 22nd 2015.
- In December 2015 the project was the subject of a documentary shot by Euronews during the final demonstration voyage. The documentary aired in January 2016. The format was a 4 minute documentary within the series “Innovation - Futuris”. Euronews is one of the leading all-news satellite channels in Europe, available in 350 million households in 155 countries worldwide and claiming an average of 14.1 million viewers each month. “Innovation” is a programme targeted specifically at EU research projects, whose aim is to show how projects can lead to products with good market potential. Clips from “Innovation” are also translated in a number of languages and given to national broadcasters for inclusion in their own programmes.

Exploitation

Each company will pursue exploitation of its own developments (at the level of single components) on its own; the main result of the project, i.e. the waterbag itself, will be jointly exploited.

At the moment there is a non-written agreement between partners to jointly pursue any commercial opportunity arising from the project. Each partner is scouting potential opportunities in its network. Every opportunity arising is brought to the whole consortium, who decides whether it is worth to pursue it or not. In case of affirmative reaction an offer is made covering production costs, plus a markup. The partner who

held contacts first continues liaising with the customer. Revenues are shared in variable proportion (according to the amount of work performed) and a bonus is given to the partner who brought the deal in.

The consortium will keep using this *modus operandi* to manage the first few commercial orders; when orders will grow and a more well-defined structure will be needed to address them, partners will decide whether to setup a newco (with shares to be agreed) or to appoint one partner as the commercial interface for everyone.

Regardless of the form that the partnership will take, the consortium has a clear view of the way in which they want to address the market. The exploitation strategy is focused on proving the effectiveness of the waterbag system and seeking commercial partnerships for its operation worldwide. The preferred option is retaining within the consortium the manufacturing stage of the system, so no licensing on the production will be implemented. Operation of the system at sea will be always conducted by local tugboat companies, wither directly contracted by the consortium (as service provider) or by a local service provider (in this case the consortium only acts as supplier of the waterbag).

Commercial contacts have been established in the following Countries:

- Italy;
- Chile;
- Japan;
- Palestinian Territories;
- Saudi Arabia;
- China;
- Norway;
- Greece;
- Romania;
- Colombia;
- Malta.

For confidentiality reasons, the names of the companies involved are not disclosed. One of these contacts already became a quite detail commercial opportunities. The contact is interested in performing a demonstration of the system in its own location, at its own expenses and asked the consortium to provide a formal quotation for the rental of the waterbag. The consortium answered with a quotation, that is now being evaluated by the customer.

A calculation of economic aspects of the system operation was performed, enabling the calculation of the breakeven point for the system in the case study of transporting water from the Manavgat river (Turkey) to Northern Cyprus. The case study allowed to fix a water price between 3 and 5 €/m³, favourable in comparison to transport with water tankers.