



GRUPE DE RECHERCHE SUR L'INVENTION ET L'ÉVOLUTION DES FORMES
unité de recherche habilitée par le B.R.A.U.P



INTERNATIONAL INTERDISCIPLINARY COLLOQUIUM

Call for papers and posters

Tidal energy yesterday, today and tomorrow

This call for papers and/or posters aims to address the way tidal energy was or is exploited by man regardless of the era or place. Let us begin by specifying that the papers will be about 'potential' tidal energy, i.e. based on the difference in water height on both sides of a causeway or dam as with tide mills or tidal power stations. Also, we will not concentrate on the exploitation of kinetic energy from tides which uses tide currents similar to offshore water-current turbines, even if they may be brought up in a paper for informative or comparative purposes. Although the committee deliberately chose to not focus on kinetic energy, that does not mean it is less interesting on the whole, and its presence in the energy mix of any territory is certainly positive and recommended. This form of energy presents undeniable advantages, for example bringing power to isolated populations such as island communities. One reason for setting it aside is that, contrary to 'potential' tidal energy, it is a very recent means of producing energy, which would therefore exclude inquiries related to history or archeology. Also, as they are permanently underwater, water-current turbines make surrounding land management and planning superfluous. They do not contribute, or only very little, to the land-sea relationship under consideration here, with issues related to architecture, surrounding landscape and land management, or usage along the coastlines. Another reason is that 'potential' tidal energy is radically different according to location and time. Some countries, once pioneers in the matter as France was, do not, or no longer support it even though it is the best-controlled renewable marine energy, and, at the moment, one of the most profitable per installed megawatt. Other countries are betting on this technology (South Korea, United Kingdom...) now more than ever before. Why should a country subject to tides choose between potential energy and kinetic energy? Wouldn't the presence of both at the heart of an energy mix be preferable?

[This colloquium will be held from June 20th to 22nd, 2017. It will include 2 days of papers at the École Nationale Supérieure d'Architecture de Bretagne and at l'Université de Rennes 1 as well as a day-trip to the Rance estuary.](#)

Authors are invited to submit proposals that fall within one or several of the following areas:

- **Tidal energy and heritage** - the heritage aspect touches on architectural qualities either artisanal (linked to flour production or another activity that uses a mill mechanism), industrial, cultural and/or natural;
- **Architecture, landscape and tidal energy** in order to address architectural opportunities and questions of how existing or planned tidal structures fit into landscapes;
- **Tide mill archeology** - this theme invites us to present the main findings of recent archeological digs concerning tide mills;
- **History of the use of tides** - preference will be given to papers with new or rarely published data concerning the use of tides in countries or regions where that history is scarcely recorded, or regards a forgotten tide mill, or one for which there has been little data up until now;
- **Tidal energy and conflicts of usage and occupation**, about the tensions involving tidal energy equipment (mill, factory...) that has retained its original function or not;
- **Tidal energy and coastal area land-use** notably through the role of tidal energy equipment in terms of the organization and land-use of coastal areas as regards solely the production of energy or as regards existing or planned multi-functional equipment;
- **Perspectives and planning ahead for tidal and renewable energies**. This point will deal with the possible future of tidal energy at the heart of energy mixes in general or within a particular territory;
- **Tidal energy and environment conservation**. Although it is renewable and does not emit greenhouse gases, the environmental impact of tidal energy is not necessarily neutral if one takes into account the facilities' functioning and footprint sometimes amid sensitive natural areas.
- **Tidal energy and the law**. This theme will emphasize that the creation, rehabilitation or exploitation of a tidal installation creates legal difficulties related to the regime of the site's location, the nature of the activity and its links with public interest, the predominant role of public authorities and the intermittent nature of the energy produced.

Tidal energy yesterday

Energy production with the help of tides is one of the most ancient means extant. Some rare tide mills, sometimes called sea mills (J.-L. Boithias and A. de La Vernhe, 1989), have been recorded as early as the Upper Middle Ages in Brittany (V. Bernard, 2013) and in Ireland (C. Rynne, 1992; T. Mc Earlean, 2007). This type of mill may even be dated as far back as the 2nd Century for the site in London built by the Romans (R. Spain, 2002). But in the current state of knowledge, it wasn't until the 12th Century that they developed considerably along the European coastline before appearing on the other side of the Atlantic with the first colonists during the 17th Century. The way they worked was based on the ebb and flow of tides: a causeway or dam equipped with a tide gate blocks a small estuary or bay creating a mill pond that fills up with water. Once the mill pond is filled, the tide gates automatically close through the inversion of the current. As soon as the tide has receded enough to clear the wheel or wheels of a mill located on, or at one end of the dam or causeway, and that the difference in water height is sufficient on both sides, a sluice is opened to make the wheel(s) turn. Most tide mills were for grinding grain, some were used for other purposes (rinsing salt, paper making, leather tanning, pottery works, saw mills, ice making, cannon-boring mills...), and some were dedicated to local particularities (crushing sugar cane in the West Indies).

Limited to the foreshore, tide mills were much less widespread than their river-based or wind counterparts with which they were sometimes coupled. They were however omnipresent in many coastal areas subject

to tides, preceded by shoals and where the coastline offered an adequate configuration with inlets that could make for potential reservoirs. At the height of their deployment during the 18th and 19th Centuries, there were some 750 tide mills in the North Atlantic. Throughout the ages on the same geographic area, there were over 1220 sites that certainly had, or once had, such a mill, with some 300 to 350 in North America, a hundred or so in Belgium and the Netherlands, 230 in the United Kingdom (D. Plunkett, 2014), 190 in France including 140 just in historical Brittany (E. Sonnic, 2016), over 260 on the Iberian peninsula with 155 in Spain and 109 in Portugal (L. Ménanteau, 2012), and in each of these countries, mills were particularly concentrated in certain places (Maine, Massachusetts, Nova Scotia, greater London area, Hampshire, at the mouths of the Rhine, Meuse and Scheldt rivers, the Rance estuary, the Gulf of Morbihan, Charente Maritime, the Basque Country, Cantabria, the Tagus estuary, Ria Formosa, the Guadiana and Tinto-Odiel estuaries, Cadiz Bay...). Other places also had some but in much smaller numbers, sometimes just a handful (Iceland, Germany, Russia, Italy, Australia, West Indies...). Very old tide mills have been reported in India and China. Others were attested to during the 10th century in the Tigris and Euphrates deltas in a text written by Arab geographer Al-Maqdisi Shams al-Din. The above numbers are from more or less precise inventories where the authors regularly underlined the difficulty of absolute accuracy and, consequently, the patchy and sometimes perfectible aspect of the obtained results. As such, this call for papers and/or posters is also an invitation to pursue this inventory process and aim for more comprehensive numbers for this or that coastal area.

Beyond the inventory, information regarding tide mills is vastly different according to country, region, or even mills in the same sector. Some are very well documented, while the existence of others is still in question. Sometimes, only the type of property (public or private) is known. In France, most medieval mills, be they tide mills or common mills, belonged to monasteries or lords and they became national property sold to private individuals after 1789, usually to important bourgeois or aristocrat bigwigs. Doubts also remain as to what type of mills they were. Is it intermediate, activated sometimes thanks to the tide and sometimes thanks to a river? In which case, it could be a part of the tide mill family when this specificity is pointed out. Is it a river mill whose tidal function is only possible with certain spring tides? Is it just a river mill whose location on the coastline may simply give rise to confusion? Classing them with tide mills is to be avoided in these last two cases, even more so in the last case.

Many tide mills are still very visible in the landscape. For countless others, only ruins remain and some have completely disappeared, particularly in regions that have undergone important urban, industrial or port development when demolition was systematic as at the mouths of the Scheldt, Meuse and Rhine rivers. Certain wars also led to the demolition of tide mills. Sometimes we know what they looked like thanks to historical illustrations or detailed descriptions. But others that were demolished centuries ago remain enigmatic. An element of both the coastline's history and rural history, the tide mill is an authentic example of the architectural language of coastal regions where they flourished. Regardless of its current condition (visible building, in ruins or totally disappeared) the tide mill deserves research and excavation, literally by way of archaeological digs and figuratively in the countless shelves of existing archives.

Tidal power and architectural opportunities

Several tide mills have been listed as national heritage sites, or have benefitted from preservation and rehabilitation projects aiming to rehabilitate the building, restore their mechanisms and the essential elements of the mill (causeway, dam, pond) in some cases concurrently with the creation of ecomuseums, or when mills are opened to the public during heritage visit days. Some have started to produce flour again but only for instructional purposes. These events are often paired with informational campaigns relayed by local or regional media; for the most part these mills are the ones best identified by the public as those selected for the travelling exhibit *Moulins à marée d'Europe occidentale (Western European tide mills C. Silveira, 2005)*. Others, more recently rehabilitated or still under restoration, are not (yet?) famous and could be the subject of papers. Each mill renovated more or less to its original condition presents an architectural opportunity that is not limited to just the structure, but to a three-part composition including causeways or dams from 10 to 100 meters long and a tide pond, all making up a characteristic feature of the coastal landscape in question. Including the tide pond, the tide mill in its entirety often covers an area of a few hectares directly on the foreshore.

Tidal power stations also constitute architectural opportunities. The Rance facility inaugurated in 1966, was designed by Louis Arretche who also rebuilt the privateer city of St Malo. The station is not limited to only producing electricity, or being a lock or bridge between two shores. It is now the first industrial tourism site in France: a site to visit and discover, especially as it offers a viewing of the machine room. The tidal lagoon project in Swansea, Wales, prides itself on being an integrated project combining energy production with other activities (sailing, oyster farming...) The project stakeholders spotlight the architecture and landscape integration of the equipment, this second aspect may have been somewhat overlooked for the Rance facility, the context was very different at that time when engineering was booming. One Swansea partner is *Cape Farewell*, a collective of artists and scientists whose slogan is "What does culture have to do with climate change? Everything". In the light of climate change and the risk of major flooding, protecting a bit of coastline with a tide mill's seawall is another often-highlighted argument.

Tidal power projects – abandoned or completed

With the Industrial Revolution, Western countries abandoned tidal power for fossil-fuel based power. Little by little, tide mills stopped turning except when they were converted into flour mills, either complementing tidal power, or by replacing it using steam, gas generators, fuel and later, electricity. Tide mills they were, in name only. Strictly speaking, tidal power was also set to pass into the Industrial Era. Tidal power projects were proposed at the end of the 19th Century on the Rance river near Saint Malo in France in 1897 (M. Chaigneau-Normand; 2002, M. Gasnier, 2003). Twenty odd years later, research about that type of equipment was done by the 'blue coal' commission, named as such because that was the term used for tidal power (and a nod to 'white coal' which was used for power produced by mountain dams). The first tidal power plant construction site began in northern Brittany on the 'Aber Wrac'h river in 1928. But in the context of the economic crisis following the Wall Street Crash and because there were not enough electric networks, it was abandoned in 1930. In the United States, in the middle of the Great Depression and within the framework of the *New Deal*, the construction of two tidal power plants began in the 1930's in the Passamaquoddy and Cobscook bays in Maine. There too, construction was never completed due to a lack of financing. And yet the development 'blue coal' had huge potential. In France, under the Vichy government, an organization was specifically created and dedicated to the question: the Société d'Étude et d'Utilisation des Marées (SEUM – Society for the Study and Use of Tides). After the war, it became a part of Electricité de France (EDF – the French electric utility) and it identified some thirty sites to install tidal power dams in (R. Gibrat, 1955), mostly in Brittany. Only one was built in 1966 on the Rance River; it was the first tidal power plant in the world and was actually a prototype for a mammoth project planned for in the bay of the Mont Saint-Michel, but it was eventually abandoned in favor of nuclear power. Elsewhere other tidal power plants were built but on a much smaller scale: Annapolis in Canada (19,1 MW), Jiangxia in China (3,2 MW) as well as half a dozen more, all less than 1,3 MW in the ex-USSR and especially in China. With its 238 MW, the Rance plant ended up holding the record for 45 years as the only industrial scale plant before the construction of the South Korean Sihwa plant in 2011 (254 MW) which took advantage of an existing dam to install its turbines. On the other side of the English Channel, a tidal power dam was considered several times throughout the 20th century to close the wide Severn estuary. For a long time, it was put off because there were not enough electrical networks, and especially to preserve British coal jobs and economy. Later, it was scrapped again due to concern over environmental impact, considering the issues reported around the Rance facility, and shipping or navigational issues that could arise. In the early years of this 21st Century, the idea of closing the estuary seems definitively abandoned, in favor of the lagoon type tidal power plants mentioned above.

From mini-plants to major power plants: current tidal plant perspectives

Since Sihwa, tidal power seems to once again hope to get past the project stage. In South Korea works on the largest tidal power station in the world are currently in progress at Incheon. With 1320 MW, the equivalent of a large nuclear reactor, it will have an installed capacity 5 to 6 times greater than the biggest

tidal power plants extant. In Wales, authorizations were granted so that works for a tidal lagoon in the Bay of Swansea may begin in 2017. Also in the United Kingdom, other projects are under study with the long-term objective of covering 10% of the energy needs for the British Isles.

If, alongside these industrial-scale tidal power plants, a few tide mills have been rehabilitated, in general they are meant to spotlight their heritage aspect on a purely symbolic level. However, the architectural opportunities mentioned above could also move away from restoring the mill's mechanism to its original condition. Couldn't some sites be turned into farms, or mini-tidal power plants like the mini-hydroelectric systems installed on some rivers? Could micro-turbines, mini versions of those used in existing tidal power plants, be used on the causeways or dams of some mills? Taking advantage of the support for renewable marine-based energy, and as more and more territories seek to diversify their energy mix, setting up micro-tidal plants could be a viable option for coastal zones that are often densely populated, even more so during the summer months when the population increases considerably in touristic areas. The equipment could also contribute to powering the multiple residential areas and amenities found on the coastline (lodgings, shellfish farming, marinas, etc.). As well as the old sites of tide mills, other options are worth considering in terms of micro-tidal power production: old salt manufacturing sites and abandoned fish-farming basins. In the context of declining port activity, docks, basins or dry-docks could be equipped with turbines as proposed a number of years ago at Boulogne-sur-Mer.

Tidal power, increased energy production time and energy storage

Like most renewable non-greenhouse gas producing energies¹, tidal power is intermittent. This intermittence is however totally predictable as it is linked to tide times that may be planned for several years in advance. If a tide mill can theoretically function 12 hours per day when operating one-way (operating only during the time when the basin empties), most would function for only 8 hours and a few for a maximum of 10 hours. Note that only very few tide mills have been equipped with two-way systems, which means they function not only when the basin empties but also when it fills up, albeit less efficiently. Two-way systems could increase daily output, but only a little bit. Nevertheless, two-way systems meant considerable work on infrastructure, synonymous with costs so large that most owners, even wealthy ones, were not able to commit to (J.-L. Boithias et A. de La Vernhe, 1989). Since it became operational, the Rance tidal power station also features the two-way system thanks to its "bulb turbine units" which work both ways. The station functions on average a little over 10 hours a day but only 6.5 hours at full power. It is important to underline that this two-way functioning is profitable only during high tides, or about one week per month. Moreover, production time is voluntarily limited by EDF in order to limit negative impact on the estuary's aquatic fauna.

Finally, let us mention the double basin systems that enabled a small number of tide mills to operate longer, as in Bishopston (Sussex) or Trédarzec (Brittany). The latter operated 15 hours a day thanks to that system. Today, tidal power projects seem to be able to produce power continuously and therefore solving the crucial question of storing energy. These are tidal lagoon projects with several basins so that there is always a sufficient difference in water height in at least two of them in order to make the turbines function.

¹Recall that some renewable energies emit greenhouse gases (wood logs, biofuel...).

Fates and destinies of tide mills

In the past, tide mills were built to use the energy from the tides, most often to grind flour, and those where the building is still standing have met various fates and destinies. Save for some exceptions, their current usage is sometimes very different from their original usage. Often turned into principal residences or holiday homes, either as individual residences, or collective ones as is the case in old, larger flour mills with several floors, these mills offer a variety of much more important reconversions for example in the case of tourist lodgings (holiday 'cottages' or B&Bs...), culture and heritage sites (ecomuseums, exhibit halls...), commercial spaces (restaurants, various shops), leisure activity centers (water sports bases), agriculture-

related spaces (farm buildings), etc. Over the course of inheritances, real estate transactions or choices made by successive property owners, a single building may have had several uses over time. Much like the mill building, the mill pond may have also evolved (natural reserve, fish farming, marina wet dock, swimming area, drinking water reservoir...). Some were dried out and, and here as well, the subsequent uses were many (pasture, urbanization projects, camping ground, sports fields, shipyard, sewage stations, etc.). Causeways or dams also underwent changes over time. Some are rather inaccessible by land and sea, others have become private roads or public ones subsequently integrated into road networks or hiking trails. Some are simply causeways to protect a marina, and some tidal ponds turned into polders.

Tidal power and conflicts of usage and occupation

The location of tide mills on foreshores may provoke complicated situations in part due to their status. Often, they are private properties that are partially accessible to the public (shops, B&Bs...) or on the contrary reserved for the exclusive use of their owners or renters in the case of residences. The situation is all the more delicate when the various elements of a mill complex (building, dam, pond, embankments) belong to several owners, entities or administrative frameworks. The area around tide mills may have various entities, uses and users with sometimes contradictory interests (private property, easement and right of way on the dam or causeway, protected wildlife areas...). When tide mills are located on or on the edge of public maritime property the situations become even trickier. Tide mill owners are sometimes in conflict with associations wishing to integrate causeways in hiking trails. Some businesses located near a tide mill may limit access to it in order to protect themselves as is the case with oyster farms which often face theft and any stroller or hiker becomes suspicious in this context. People regularly approaching tide mills because they want a closer look or want to take photographs may also be seen by the owners as intrusive, even more so when people request to see inside the building. On the other hand, people who wish to get closer to a tide mill may feel frustrated after being shooed away by pre-cautious owners or those who simply do not wish to be disturbed.

Tidal power stations may also experience tensions between various uses. The Rance station is regularly singled out by estuary locals or associations as the main cause behind accelerated silting in several areas. Mudflats have taken the place of old sandy strands suitable for bathing. It has also been blamed for the disappearance of the original ecosystem because it blocks the estuary. Indeed, a new ecological balance has been established and the ria has been once again recognized for the quality of its biodiversity. Taking this experience feedback into account, barring an estuary is no longer an option for most project stakeholders, even more so when potentially restrictive effects for pre-existing economic activities are added to environmental impact. That is one of the reasons why the decades-old project for a tidal power station on the vast estuary of the Severn was abandoned. It could have impacted the activity of commercial ports located upstream in the areas around Cardiff, Newport or Bristol. A tidal dam may indeed reduce the number of users of estuary ports as it was highlighted for the Rance tidal power station in terms of recreational boating (E. Sonnic, 2015). In South Korea, the tidal power stations currently being developed or planned for are criticized by NGOs for their environmental impact and by the local fishing sector which sees them as a risk for the sustainability of their activity (Y. Ko and D. K. Shubert, 2011).

Tidal power and the law

In France, from the Law of October 16, 1919 up to the Energy Code after the Energy Transition Law in 2015, the legal framework and contractual framework for the production of tidal energy have evolved remarkably. Located on a fragile, coveted and protected coastal area, tidal power plants, from the smallest mill to the Rance tidal power station, are governed by a set of rules drawn from laws governing the environment, energy, urban planning, coastal area management and public domain (G. Guéguen-Hallouët and N. Boillet, 2016). While tidal energy isn't currently under consideration in the framework of adaptation measures for the Renewable Marine Energies Law, this option remains quite interesting in light of projects in progress abroad. The prospect of creating micro-tidal power plants justifies looking at the existing legal framework and reflecting on adapting it to the new challenges regarding the promotion of this renewable energy. A comparative

approach to laws in different countries could be instructive. Reflection on the legal framework for tidal energy should also be enriched by an analysis of the role of local and regional authorities, who have become fully involved in the development of renewable energies by way of increased expertise in the fields of urban planning, energy, environment, tourism and natural and cultural heritage.

Procedures for submission

Proposed papers and/or posters in French or in English are to be emailed by **Monday 13 February 2017** to the following address:

colloques.recherche@rennes.archi.fr

They must not be longer than 3 pages (Arial font, size 11, simple spacing). They will include the author(s)'s name, email address, academic discipline(s), job title(s), institution(s) and research team(s) affiliation and will have a title in French and in English, 3 to 5 key words, a 6 to 8-line summary and 1 or 2 illustrations. Authors of chosen papers promise to send the slide presentation for their paper or their poster by Monday 12 June 2017 at the latest, followed by a more complete version of their paper in digital format for 20 July 2017 for collective publication in a book or proceedings.

Provisional calendar

- **13 February 2017:** deadline for submitting proposed papers
- **31 March 2017:** scientific committee will contact authors
- **20-22 June 2017:** colloquium in Rennes, France (20 and 21 June) and excursion to the Rance estuary (22 June)

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