PRO-TIDE

TIDAL ENERGY ON THE SCHELDT

Investing in Opportunities

This project has received European Regional Development Funding through INTERREG IV B.

INTERREG IVB

www.pro-tide.eu

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HELLO! I AM TIDAL TIM

As an energetic spokesperson, I will keep you personally up to date with all Pro-Tide news.

Do you have interesting information, case studies or questions about tidal energy? Let me know quickly by using one of the communication channels below. See you soon!

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NOT GREEN BUT BLUE ENERGY?

In recent years, the focus on renewable energy has increased greatly. In Germany, electricity from sun, wind, biomass and water provide a great part of all the energy consumed. Sadly, we are not as advanced in Belgium. Even worse, with 6.8% in 2012, we are still way below the European average (14.1%).

This is partly due to our landscape. Our region is highly populated, which restricts us from easily building wind turbines or hydroelectric dams. Our hours of sunshine are also limited.

Nevertheless, Waterwegen en Zeekanaal NV (Waterways and Sea Channels PLC) still wants to make more effort to reduce dependence on fossil fuels and nuclear energy. We will take a closer look at less apparent ways to achieve that. Energy generation on the Scheldt is one of them. The endless ebb and flood of the tides offers a chance to produce energy from the powerful blue stream.

Is blue the new green? We will look into that for you!

PRO-TIDE'S PARTNERS

Pro-Tide is a European supported collaboration, in which five partners from the North Sea region work together to investigate the power of tidal energy. Scientists and governments from Belgium, the Netherlands, UK and France want to find out if tidal energy has a place in our future energy policy.

This energy production method has many advantages:

- Installations are out of sight, meaning that they do not "disturb" the locality.
- There is no harm to fauna and flora. Even not underwater.
- The amount of energy produced is accurately predictable.

Yet there are still a lot of questions. Are technologies available that make cost-effective energy production possible? Could partnerships with private companies create possibilities? What installations best fit which circumstances?

Through knowledge exchange and sharing experience, a powerful network of European experts now exists. The blue pioneers of the future.

waterwheel

WHAT IS HYDROPOWER?

FROM WATERWHEEL TO HYDROELECTRIC PLANT

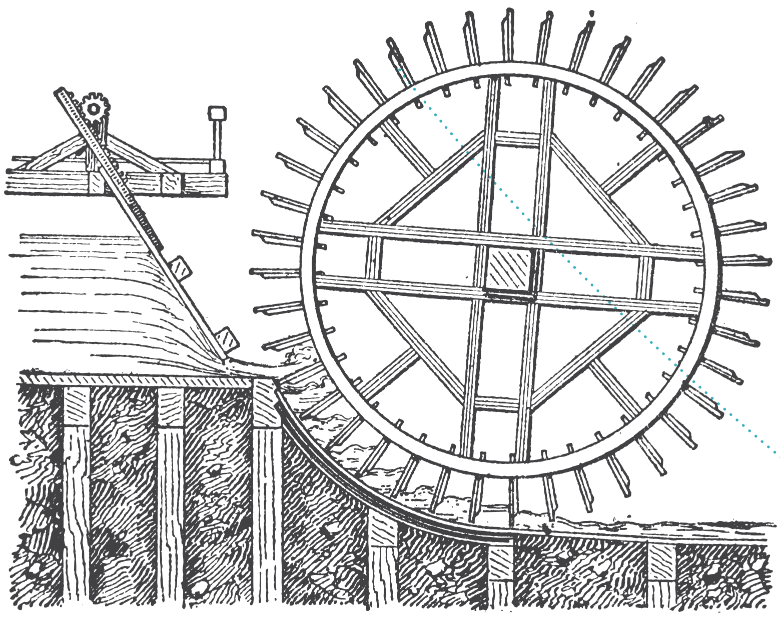
For centuries, we have used hydropower to make tasks lighter.

As early as the third century BC, people constructed waterwheels driven by hydropower.

Ingenious inventors harnessed waterwheels to a range of mechanical installations that helped people pump water, mill flour, press oils, etc. We find references to the merits of waterwheels in all the ancient cultures (Egyptian, Greek, Roman).

Through time, people's ingenuity increased. They built faster moving blades and millraces that delivered the water to the rotors more efficiently, resulting in increased energy production. The infrastructure around these watermills became more complex.

In the 19th century, we saw the first hydropower mills that produced electricity.



THE TWO SIDES OF HYDROPOWER

There are two important types of hydropower, potential energy and kinetic energy. Each type has its own output, application possibilities and techniques. Partners in the Pro-Tide project examine which solution is best suited to our flat landscape.

In view of the fact that our region has no great elevation difference and only a moderate tide on the river, we call it a low dynamic area. The research must show if energy production from water is cost-effective.

THE POWER OF FALLING WATER

Most Hydroelectric plants utilise a phenomenon known as “potential energy”. In the form of water flowing (dropping) downwards though turbines. The turbine blades begin to turn and produce mechanical energy. This provides energy to other installation or generators.

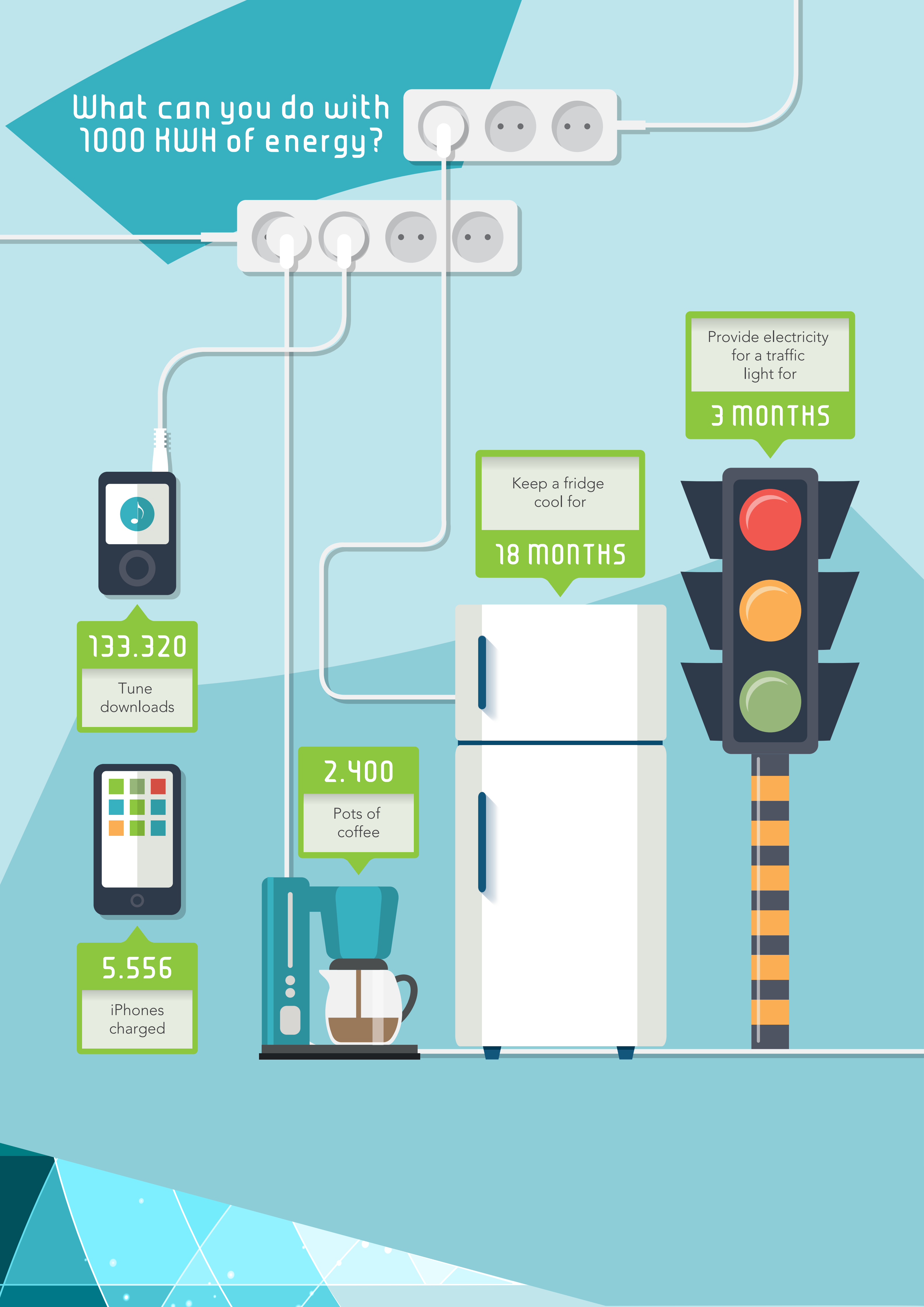
If one cubic metre (1 m^3) of water drops a distance of 1 metre through a turbine it produces 0.0027 kilowatt-hours. An average family uses 3,800 kilowatt-hours (kWh) of electricity per year. In order to produce sufficient energy, there are often a number of turbines installed next to each other. Obviously, the preferred location is where the largest possible volume of water flows down the greatest possible drop.

There are various types of hydroelectric plants:

- **RIVER PLANTS**
  Natural height difference in the landscape provides a powerful flow of water.
  The hydroelectric station at Niagara Falls is an extreme example, producing 4.9 million kWh.

- **HYDROELECTRIC DAMS**
  If a river has too little natural drop for effective energy production, we can give it a hand. Damming the river creates an artificial lake and holds it in check. One way you can produce energy is by installing a tube with turbines in the dam and allowing the water to flow through them.
  The Kariba Dam in Zimbabwe holds back the biggest reservoir in the World. Its surface area of 5,400 km^2 is as big as the provinces Flemish Brabant (2,106 km^2) and East Flanders (3,007 km^2) together. Annually, the hydroelectric plant generates 6,400 million kilowatt-hours. Quite impressive, when you think that you can drive an electric car ten kilometres on just 1 kWh.

- **PUMPED STORAGE PLANTS**
  This hydroelectric dam variant is especially common in mountainous regions, such as Switzerland. During low energy use periods, the system utilises the “excess” electricity to pump water to higher elevation storage basins. When there is energy demand, the water flows through turbines to lower-elevation collecting basins. Then a new cycle starts again. We can even find examples in the south of our country. The Coo-Trois-Ponts (Luik) is the most important pumped storage plant in Belgium. During periods with low energy use, the pumps utilise “excess” electricity from nuclear plants to move water to higher elevation storage basins.



What can you do with 1000 KWH of energy?
Provide electricity for a traffic light for
3 MONTHS
Keep a fridge cool for
18 MONTHS
133.320
Tune downloads
2.400
Pots of coffee
5.556
iPhones charged

WATER IN MOTION

There is still another form of hydropower. Flowing water has motion or kinetic energy. This technique is close to windmill technology. The flow of water turns turbine blades and produces electricity.

You can find tidal energy plants at a number places. The earliest tidal powered turbine construction dates back to the middle ages in Brittany. That is also where the first and biggest tidal energy plant was built, with twenty-four turbines, each 10 megawatts.

Through time, these machines became more ingenious. Thanks to smarter housings that steer the flow in the required direction, the blades start moving quicker. On top of that, there has been rigorous experimentation with blade shape and spacing. This did not only make them more efficient but also safer. Thanks to slow-turning rotors, there are no fish casualties and the impact on flora and fauna is minimal.

PRO-TIDE'S FOCUS

As you will have noticed, elsewhere hydropower plays an important role in the energy supply for the local population.

At home, this is still much less so. In view of the fact that our region has no great elevation difference and only a moderate tide on the river, we call it a low dynamic area. Partners in the Pro-Tide project examine which solution is best suited to our flat landscape.

Which techniques provide the best output? Which locations the most energy? Is it possible to recoup investment costs for these installations?

We are looking into it for you!

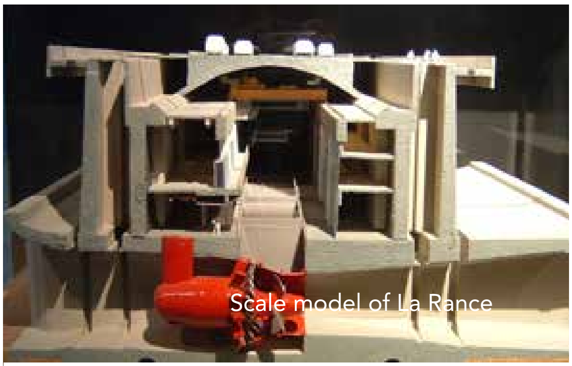
Hydroelectric plant

THE ROAD TO THE RIGHT TECHNOLOGY

There are a number of types of tidal turbines from entrepreneurs all over the World. In Pro-Tide we will look closely at a range of systems.

We will compare the most utilised and remarkable solutions.

POTENTIAL ENERGY TURBINES (SEE: THE POWER OF FALLING WATER)



Scale model of La Rance

La Rance France

• THE LA RANCE BULB TURBINE

La Rance is the first tidal energy plant in the World, and still one of the biggest. This installation is in Brittany.

The twenty-four 5.4 metre diameter turbines produce over 540 million kWh of electricity annually. According to the operator, the plant produces 90% of Brittany's electricity.

▸ *More info: www.bretagne-info-nautisme.fr/*

• SIHWA, SOUTH KOREA

In August 2011, South Korea opened the largest tidal energy plant in the World. The reservoir was built in 1994, for agricultural purposes but lost its function though industrial pollution.

With a 5.6-metre drop, 10 turbines produce 550 GWh of electricity annually.

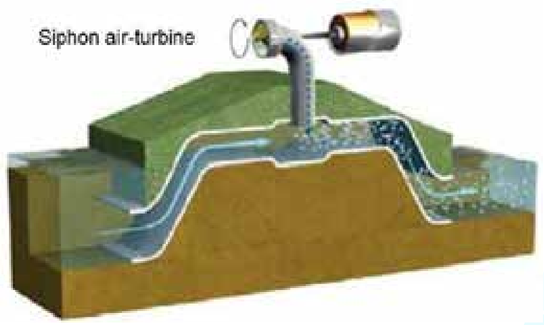
Realisation of this project set Andritz Hydro's reputation as market leader in hydro-energy turbines and generators.

▶ *More info: www.andritz.com/*

• FUTURE TECHNOLOGY

Besides these "known values" with proven track record, there are also experimental techniques and equipment that we do not want you to miss.

River plants recently gained an interesting new technique. The "Siphon Air-Turbine " has assistance from a second natural force, wind. The water does not flow through a normal turbine but a u-shaped tube. At the tube's highest point, the water pressure drops. Adding wind from the water at that point increase the water's rotation force, resulting in greater turbine speed. In this way, a lower cost installation can achieve the same output. The Pro-Tide lead partner, the Province of Zeeland, is considering use of these turbines at Brouwersdam.

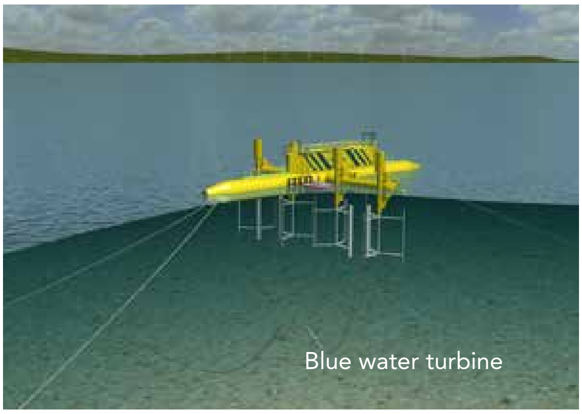


KINETIC ENERGY TURBINES (SEE: WATER IN MOTION)

• TOCARDO TURBINES

In the Netherlands since 2008, Tocardo has been building and improving turbines that can also be installed in sluices. They offer solutions in a variety of formats. Their blades operate in two directions, depending on the flow of water. Above all, they developed a patented low-cost rotor system that guarantees lower installation and maintenance costs. One of their installations has been running for 5 years at Den Oever in the Netherlands.

▶ *More info: www.tocardo.com.*


Blue water turbine

• BLUE WATER TURBINES

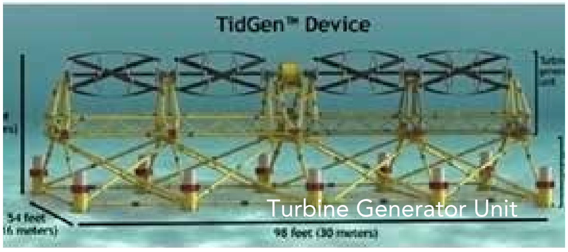
Cross-axis turbines can be installed vertically and horizontally. In both cases, the water flows perpendicular to the blades. This Dutch design is ideal for installation under existing infrastructure such as bridges, windmill platforms and pontoons.

▶ *More info: http://www.bluewater.com.*

• FUTURE TECHNOLOGY

This "Turbine Generator Unit" is developed as a brother to the diesel generator. They are for installation on the river bottom, with the blades perpendicular to the direction of current. The turbines are easy to couple and every unit produces 25 kW at speeds of 2.25 metres per second. If the river fails to produce enough electricity, the diesel generator fills in, resulting in a reliable and constant electrical supply that is independent from the national grid. A test installation with four units produced an average capacity of 600 kW.

▸ *More info: http://www.orpc.co.*



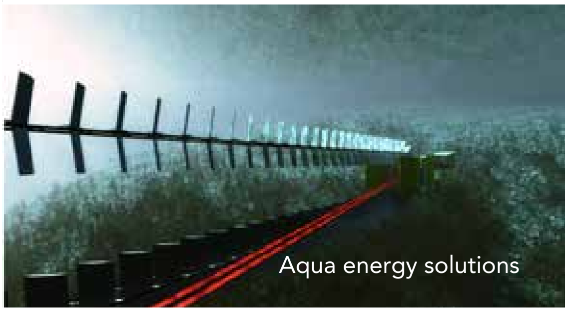
Turbine Generator Unit


Davidson-Hill

In the Davidson-Hill turbine, water runs through a tunnel known as a "venturi shroud". This makes the turbines up to three times more powerful. Mounting the tunnel on a rotatable platform enables it to find the most effective direction.

▸ *More info: http://www.tidalenergy.net.au*


Flumill


Aqua energy solutions

The Norwegian "Flumill" consists of two composite spirals, running in the opposite direction. They are flexible, so they automatically adjust to the most effective angle according to the current. This lightweight installation works with flow rates as little as 1 m/s, and it has survived all stress tests. There is now a plan to build the first installation in Rystraumen (Norway).

▸ *More info: http://www.flumill.com.*

This Aqua Energy Solutions application is another Norwegian design. The installation comprises a chain with blades mounted perpendicular to the current. The current in the water sets the blades (and chain) in motion. Generators convert the motion into electricity. The company has run successful tests and is now installing a life-sized prototype.

▸ *More info at: http://www.aquaenergy.no.*

Scheldt

ENERGY PRODUCTION ON THE SCHELDT?

THE SCHELDT A STREAM OF NATURAL TALENT

Since the Scheldt flows into the sea, it also has tides. Great volumes of water flow inland daily, mix with any rainwater runoff and flow back out.

Few rivers in Europe have a direct connection to the sea. Many plants and animals prefer a specific sweet and saltwater variation in their living environment. They find a new home along our riverbanks.

The Scheldt's natural riverbanks play a leading role in the Flemish biodiversity story. At the same time, the Scheldt gives strong support to the Flemish economy. This important waterway relieves our traffic system by transporting about 70 million tons of goods per year.

So much commercial activity and still a source of energy?

Maybe, but it is the least obvious. Through the importance of shipping, laying a dam is out of the question, and turbines cannot be installed just anywhere. The whole of the shipping channel must remain accessible for transporting goods. Even along the riverbanks, there is insufficient depth for turbine installation. Space for water holding basins, for prospective energy potential, is also in short supply.

Yet, reflection is worthwhile. Tides offer a constant "fuel" that will never disappoint. In contrast to wind and sun, ebb and flood allow perfect prediction. Read on!

TIDAL PREDICTABILITY

Obviously, tidal effect is a sum of innumerable factors, geography, wind, the Earth's rotation, etc. Yet the greater part of its explanation is within our universe.

The ancient Greeks noticed that the tides live with the rhythm of the Moon. Newton succeeded in explaining the phenomenon mathematically.

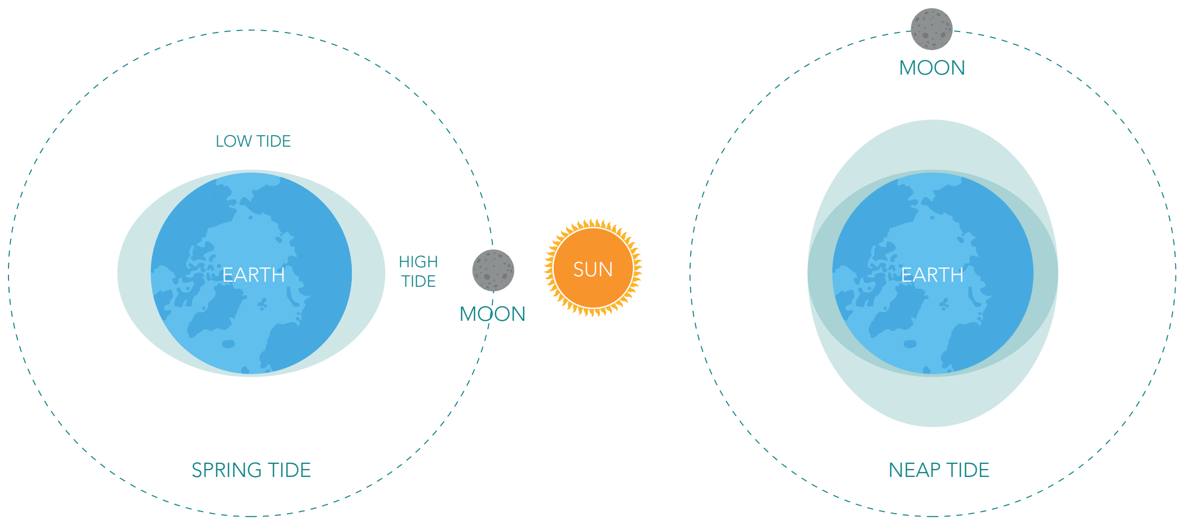
If you conveniently disregard the continents, you can propose that the water forms an even skin around the Earth.

The gravitational pull of the Moon pulls the water toward it. The globe changes, as if in the shape of a Rugby ball that protrudes more on the side the Moon is facing. The Earth's surface that is closest to the Moon has "high water"

On the riverbanks, we can see it is "flood tide". Yet, due to the Earth's rotation, the Moon's gravitational pull gets weaker at our location. This leads to lower water once again, and eventually "ebb tide".

The Moon completes a full rotation of the Earth every 29 days, 12 hours, 44 minutes and 28 seconds. When the Sun, Moon and Earth are all in line, the Sun and Moon both have gravitational pull on the Earth. That pulls the water surface higher, becoming what we know as a "spring tide". Then an exceptional high tidal flow runs up the Scheldt. When the Sun, Moon and Earth form a 90 ° angle, the forces cancel each other out and we call it a neap tide, there is a much smaller tidal difference.

Obviously, the "power" of the rising and dropping water level has a lot of influence on the amount of energy production that is possible at a location. Yet, so-called low dynamic areas have the hidden advantage of predictability. We can flawlessly calculate the amount of energy generation at any time. Sadly, that is not the case with solar and wind energy.



FROM VLISSINGEN TO GHENT

The Scheldt's total length from its source to the river mouth on the North Sea at Vlissingen is about 350 km. About half of the river is subject to tides.

At its mouth, the Scheldt is up to 5.2 kilometres wide at high tide. The more you travel inland the narrower the river gets. On the Belgian-Dutch border, it measures two kilometres, but the width is down to 500 metres in Antwerp, 100 metres in Dendermonde and only 50 metres in Ghent. There, a sluice brings a halt to the tidal effect.

Naturally, the size of the river has a great influence on the amount of inflow and outflow.

In Vlissingen, twice a day, an average of 1 billion m3 of seawater flows into the Scheldt. That volume reduces rapidly. In Antwerp, we measure only 70 million m3, and a meagre 6 million in Dendermonde. Even so, that is still the contents of 2,400 Olympic swimming pools.

The difference in water level between high and low water is then greater in Antwerp (average 5.15 metres) than in Vlissingen (average 4 metres)

The more water that flows by, the more energy it is theoretically possible to generate. Close to the Scheldt's mouth, there are numerous locations with theoretically favourable output. Other places in the Netherlands also have large areas of water that offer theoretical potential for energy production. For example, with Pro-Tide, the planned tidal power station in the Dutch Grevelingenmeer is coming a step closer to realisation.

Several years ago, there was great interest in the dream of a tidal power plant in Antwerp with sufficient capacity to supply 2600 households with energy. A comprehensive study report proved the feasibility of this train of thought. In autumn 2014, Waterwegen en Zeekanaal carried out practical tests on the Scheldt to test the research data in practice and to gain experience with this young technology. In this way, we know if the Scheldt can be an efficient source of sustainable energy.


Antwerp

THE TESTS AT THE SECOND SCHELDT BRIDGE

THE RIGHT LOCATION PUZZLE

Waterwegen en Zeekanaal ordered a study to find a suitable location for the first tidal power test on the Scheldt.
The project team applied various criteria for making a choice:

- The presence of the necessary infrastructure for tidal turbine installation
- High rate of flow in the water
- Good accessibility
- No disruption of shipping

Obviously, we considered a number of locations. During preparation, we reviewed the wharf in Lillo and the pontoon on the Steenplein in Antwerp. In the end, the choice became the second Scheldt Bridge (also known as the Temse Bridge). The Temse and Bornem municipalities seemed open for the plans, which meant that these got the green light very quickly. At the end of 2014, the first installations go into the water.

TURBINES IN THE CURRENT

From November 2014, 3 different turbines went into the water in succession.

1. WATER 2 ENERGY

The premier went to a vertical axis turbine with three blades, controlled according to the situation in the water.

2. AQUASCREW

Four weeks later, the second installation took over the test location. This test rig consists of a horizontal screw with increasing diameter.

3. BLUE ENERGY CANADA

In January, the last turbine took its turn. It has a special housing that forces water into a narrow passage, which boosts the speed and consequently the amount of generated power.

After completion, we can evaluate the extent to which energy from the Scheldt benefits Belgium and the effects of tidal energy turbine installation on the Scheldt, and vice versa.

THE TEST’S FUTURE

Thanks to the test results for various systems, we can accurately calculate which installations at which locations on the Scheldt could deliver good output.

There are Scheldt river charts showing in detail where the fastest currents are. In the tidal book (http://www.vlaamsehydrografie.be), you can easily look up the predicted water level.

In this way, we know how much energy we can expect from the tidal energy turbines. In addition, how long it will take to recoup the installation costs.

LOOKING TOWARD TOMORROW

In the short term, energy production from the Scheldt is not a viable solution.

Yet, with depleted fossil fuels and the risks associated with nuclear energy that may change in the future.

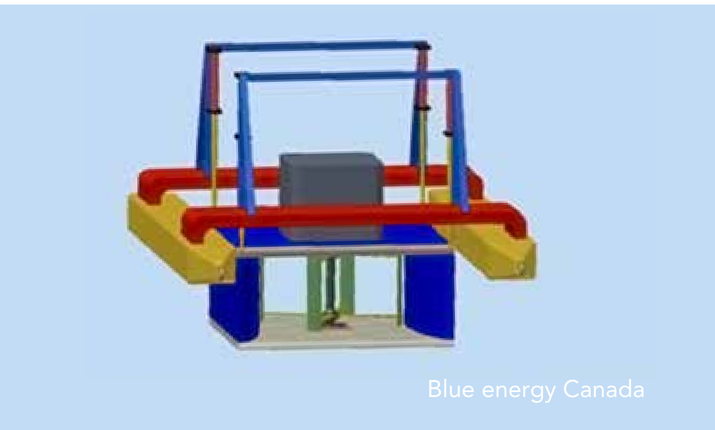
The technology is developing at a pace. More and more suppliers are offering smart, budget-friendly solutions.

In addition, the energy source (tidal current) is continuously available and (in contrast to other energy sources) very reliable.

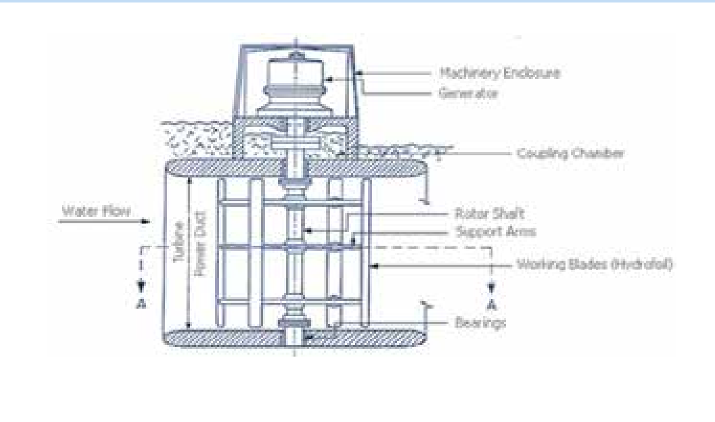
In its role as a waterways manager, Waterwegen en Zeekanaal NV wants to be prepared for the future. That is why we give our full support to this research.
Curious about the end-result?
You can read about it at
www.pro-tide.eu

Water2energy

Aquascrew turbine



Blue energy Canada



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Investing in Opportunities
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