

**SUBMISSION TO THE ROYAL SOCIETY OF EDINBURGH
FROM GREENHEAT SYSTEMS LIMITED
GENTEC venturi**

by

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INTRODUCTION

General

Hitherto, the generation of electricity from renewable energy resources has concentrated on 'real time generation' - this, in the opinion of the author, is a big mistake. It means that when the tide is flowing or ebbing or when the wind is blowing you get electricity. When it is not - you get nothing! **Scotland** should start building **GENTEC venturi** power stations now if we are to meet our energy needs over the next 5, 15, 30 and 45 years, and on into infinity. Using **GENTEC venturi** Scotland would be self-sufficient in very **cheap green electricity** and energy in general within 10 years. Exporting surplus electricity would be possible by **High Voltage Direct Current (HVDC)** ring main from Dounreay, through Orkney, Shetland, Norway, Sweden, Denmark, Germany and back across the English Channel to complete the loop. One thing that is certain is that imported oil and gas will not get any cheaper as supplies diminish.

EXISTING RENEWABLE ENERGY SUPPLY

The idea that **wind energy** will somehow replace conventional thermal forms of electricity generation is ridiculous in the extreme. The output from wind turbines is tiny, intermittent and therefore unreliable. The outputs are so low that the term load factor has been redefined to put **wind turbines** in a better light. Load factors are used to relay the percentage of the year that generators operate *at full capacity*.

For example, it is not unusual for a nuclear power station to have a load factor of 90%. This indicates that this power station can deliver electricity at its full capacity for 90% of the year. However, the **British Wind Energy Association (BWEA)** routinely suggests that wind turbines have a **load factor of 30%**. This is simply not true if the above definition of load factor is adhered to. The Vestas V66 2.75MW wind turbine operates at full capacity in near gale conditions with a wind velocity of 16m/s so that to have true load factor of 30% the wind must blow at this velocity for 30% of the year. It does not. In Scotland, even on high ground, the wind blows between 16m/s and cut out speed of 25m/s for no more than 8% of the year on average. So where does the 30% load factor come from?

Below is a copy and pasted part of the BWEA's Frequently Asked Questions

"How much of the time do wind turbines produce electricity?

A modern wind turbine produces electricity 70-85% of the time, but it generates different outputs dependent on wind speed. Over the course of a year, it will generate about 30% of the theoretical maximum output. This is known as its load factor. The load factor of conventional power stations is on average 50%."

The new generation of wind turbines as indicated above can generate at full, half, quarter and perhaps one eighth capacity to accommodate variations in wind speeds. These mixed capacity outputs are multiplied by hours and aggregated. The total output in MWh is then divided by the number of hours in a year and then by the wind turbine's capacity to give pseudo-capacity factors of anything between 30%. Clearly, this misleads the general public into believing that wind turbines can deliver electricity at full capacity for up to 60% of the year.

In Scotland, the Executive and the Forestry Commission are trying to drive forward the **biomass** agenda. Burning coal along with 75% of coppiced willow trees is seen under

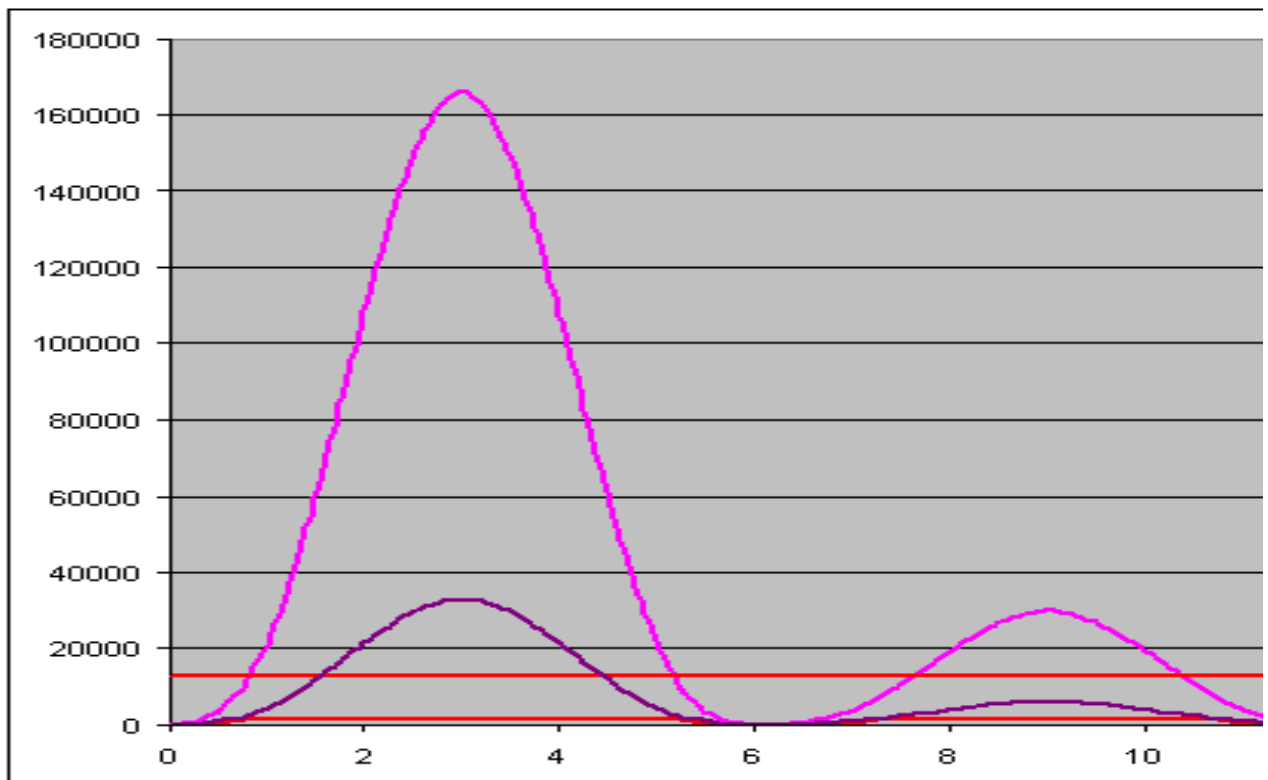
European renewable obligations as a 'renewable energy resource.' It would, in the opinion of the author be better to raise steam without burning anything. Last year, Scottish Coal planted over 1.5 million willow trees at nurseries in Mid Lothian, Fife and East Ayrshire.

In any event wind turbines, fossil fuel and nuclear thermal plants, hydro and all other existing forms of renewable energy have all been superseded by GENTEC venturi.

[GENTEC venturi](#)

Using **GENTEC venturi** over 550TWh of electricity can be generated using tidal stream energy as the prime mover in Scottish Waters alone.

The electricity from **GENTEC venturi** thermal plants will be synchronous and continuous 24 hours per day seven days a week at full capacity, yes, even at slack water. The electricity is generated using off-the-shelf steam turbine generator sets from a thermal store heated by tidal stream energy in a venturi shroud. (At this point all those with a degree in mechanical engineering will suck their teeth in a manner favoured by car mechanics and mutter something like "inefficiency"). However, the converse is true. Using tidal energy to raise steam by charging a suitably sized thermal store will generate more than 18 times more electricity in a year, at nearly 13 times the capacity continuously when compared to a conventional intermittent marine turbine alongside in the same high tidal regime. The tidal stream regime required to give these results, (8m/s Springs, 4.5m/s Neaps) is not available in Scottish waters but the graph below shows the potential for exporting this idea to, perhaps **British Columbia**.



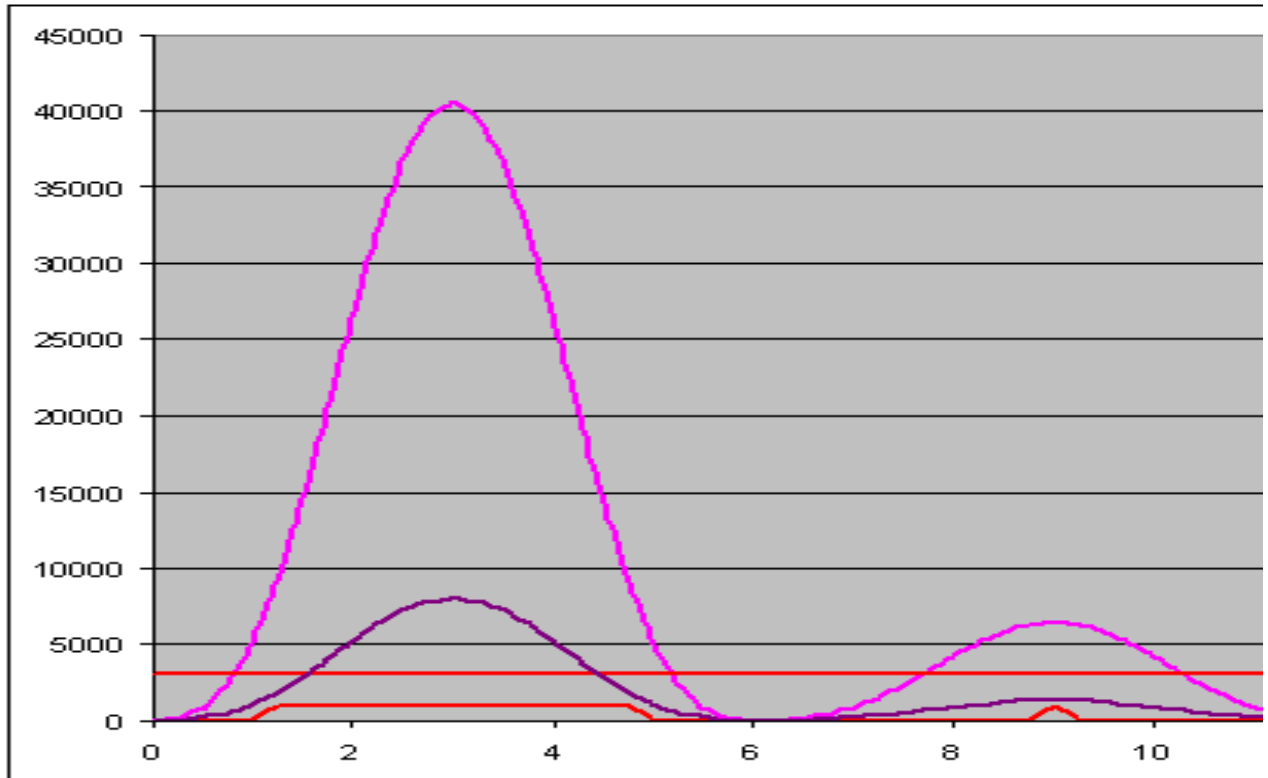
In the graph above:

- * The area under the **magenta** curve represents the energy in MWh (636MWh during Springs, 113MWh during Neaps) extracted from the tidal stream by GENTEC venturi (8m/s during Springs, 4.5m/s during Neaps);
- * The horizontal upper continuous **red** line represents the GENTEC venturi system's electrical power output; in this example 12.9MW
- * The area under the **violet** line, and above the **red** intermittent power line very close to

the x-axis, represents the approximate energy in MWh discarded by a conventional marine turbine (631MWh during Springs and about 110MWh during Neaps)

* The horizontal lower red line shows the intermittent electrical output from a conventional device varying between 0MW and 1MW (5MWh during Springs, 3MWh during Neaps)

The author will now use 5m/s Springs and 2.7m/s Neaps in this example to better reflect tidal streams available in Scottish Waters.



In the graph above:

* The area under the magenta curve represents the energy in MWh (155MWh during Springs, 24MWh during Neaps) extracted from the tidal stream by GENTEC venturi (5m/s during Springs, 2.7m/s during Neaps);

* The horizontal upper continuous red line represents the GENTEC venturi system's electrical power output; in this example 3.1MW

* The area under the violet line, and above the red intermittent power line very close to the x-axis, represents the approximate energy in MWh discarded by a conventional marine turbine (151MWh during Springs and about 23MWh during Neaps)

* The horizontal lower red line shows the intermittent electrical output from a conventional device varying between 0MW and 1MW (4MWh during Springs, 0.5MWh during Neaps)

Now the author realises that the idea sounds to pretty inefficient, using the electricity generated in the venturi to heat water, then to make electricity from the thermal store and the question that needs to be asked is "Would it not be better to put the electricity straight onto the grid?" Well, quite frankly, no, you would end up back at square one with intermittent power and a lot less electricity. The **system's efficiency** is about a third of the conventional extraction efficiency but GENTEC venturi has a lot more energy in storage available to work with to generate 8 and 18 times more electricity annually.

Find a calculator and do the maths yourself. Multiply 0.5 by 1030(density) x 153.953(area) x 11.25x11.25x11.25(velocity) (Note; 5m/s velocity is accelerated to 11.25m/s in the venturi).

You should get about 112.9MW. This is the energy in the tide at the venturi choke diameter of 14m (inlet 21m dia) but the tide would stop if you could find a way of capturing all this energy. **Betz's Law** states that the maximum energy that can be taken out is 59%. Using a very conservative 36% we can now multiply 462.4 by 0.36 to give 40.6MW - (see graph above). This represents the amount of energy available to heat the thermal store when the tidal stream is running at its maximum of 8m/s. Multiply 40.6MW by 12 (base: 6 hours x2) and then divide by pi (3.142) to calculate the area under the pure sinusoidal magenta curve. Therefore, 155MWh(m) over a six hour period is converted to heat the store. (In the same period just 4MWh(e) will have been generated by a conventional marine turbine alongside.)

DETAILS

The **GENTEC venturi** turbine itself is a bi-directional **Tidal Energy Converter (TEC)**. In this example and, in order to compare outputs with a conventional 1MW Marine Current Turbine, the TEC consists of a 14 metre diameter axial-flow rotor mounted in the centre of a pair of back-to-back venturi ducts with an intake diameter of 21 metres. Fixed-pitch rotor blades are used in order to offer the same capture efficiency in either direction of tidal flow.

One or more TECs can be deployed to feed to a system hub. TECs are connected to the shore by umbilical cables; each TEC venturi is mounted on a buoyant carrier platform and can be deployed or recovered for maintenance with just one anchor-handling vessel. Alternatively, TECs could be mounted on captive rails and lowered into the water. For cleaning they can be winched out at will. TECs are used in free stream mode and are capable of extracting almost all the available dynamic energy, subject to Betz's Law, for conversion from both high and low currents. Asynchronous electricity, directly proportional to the tidal energy present at any given time is converted into heat to raise steam that, in turn, will generate continuous synchronous electricity *at full capacity*.

The GENTEC venturi system is the only renewable that can provide base load capacity on the grid and replace all other existing generation methods. One 100MW GENTEC venturi plant will put 100 megawatts of electrical power, from thermal storage, onto the grid, 24 hours per day, 365 days per year. GENTEC venturi also has 'peak shaving' capabilities. (Say, 500MW to 1000MW for several hours subject to demand making Hydro and Pumped Storage schemes uneconomic.)

The GENTEC venturi turbine does not suffer from the two factors that limit the application of conventional 'submarine windmills' on a large scale:

* Conventional marine turbine farms require very large areas of moderately shallow waters - say, 30 to 100m depth - which are essentially free of major ship traffic. It is hardly surprising that most of the UK's energetic tidal stream sites are in relatively narrow channels that happen to be major navigation routes too.

* The second factor is impact from semi-submerged debris such as ship-borne containers and other similar objects. **GENTEC venturi** uses a ducted system with screens over the intakes to prevent the ingestion of large sea mammals and fish, as well as other damaging detritus. Shipping can therefore criss-cross over deployed GENTEC arrays unhindered. However, the dropping of anchors in their vicinity would have to be discouraged.

FEATURES

* The **GENTEC venturi overall system efficiency** can be tuned between 9% and 18% to suit; the lower the design system efficiency, the higher the volume of desalinated water produced pro rata.

* The **GENTEC venturi TEC(s)** is deployed in a free stream river or tidal current to heat water in a large well insulated thermal store.

* Power generated by the TEC is directly proportional to the flow. Multiple TECs would be clustered together into a 'farm,' feeding power back to the central hub's thermal store.

Using Marine Current Turbines' (MCT) technology as a benchmark against which to make comparisons:

Consider a 1MW 'submarine windmill' and an adjacent **GENTEC venturi** sited together with a mean 5m/s to 2.7m/s tidal currents prevailing. The 1MW-rated submarine windmill device, with a swept area diameter of 21m, can only extract mechanical energy at that rate when the current velocity is at 2.7 m/s or above. During periods of slack water there is no electricity generated at all. Over the course of a year, the conventional turbine will have generated 6.2GWh in this example. However, the GENTEC venturi turbine alongside it, with the same inlet dimension, will have generated 27.1GWh or 9.3 times more electricity over the same period, at a continuous rating of 12.9MW representing a 12.9 increase in capacity over conventional.

Four factors that rail against conventional marine current turbines:

* To avoid 'park effect' or turbulence affecting downstream conventional marine turbines, they must be spaced out by ten rotor blade diameters longitudinally and five rotor diameters laterally. Accordingly, each conventional marine turbine unit requires 2 hectares of seabed, to avoid interference between adjacent turbines;

* Installation of these units may be problematic and expensive in current velocities greater than 3.5 m/s. Tidal modelling suggests that changes in tidal range caused by current power extraction will be relatively small (except in tidal inlets). However, if the velocity of the tidal currents at the extraction site is reduced, this will have a significant impact on exploitable power available to conventional devices because the velocity term is cubed in the power equation.

* At the time of writing, the wholesale cost of 1 MWh of synchronous electricity is £46.176 per MWh (Press & Journal 9th June 2005); this means that a handsome profit can be realised without the value of a Renewable Energy Obligation Certificate being added.

Economics of [GENTEC venturi](#)

The projected cost per installed MW would be similar to on shore wind turbines - that is, about £1million per installed MW. The predicted annual output figures for 10MW of wind turbine energy is 26GWh which will turnover about £1,850,000. The cost of producing 1MWh from a wind turbine varies between £19 and £32. Assuming a mean cost of £25/MWh will cut margins by 650,000 to give an annual profit of £1.2million. However, a 10MW GENTEC venturi plant will generate 87.7GWh and turnover £7.9million on electricity sales alone @ a predicted cost of £3.23/MWh. Another aspect of the GENTEC venturi plant not yet touched on is that it can be engineered to desalinate huge volumes of seawater as well giving it two incomes streams. Sales in Potable Water, the most valuable income stream, would boost annual turnover to £96.5million if the plant was built in, say, Portugal.

With 7,500 TECs in the tidal stream locations in the same tidal stream regime around Scotland GENTEC venturi will generate 361TWh or all of the UK's electricity consumed in a year at a 'one-off' capital cost of £10billion. The British Wind Energy Association (BWEA), on the other hand, is proposing to spend £7.2billion on wind turbines that will supply just 7.5% of 360TWh required intermittently and at varying capacity *and because of that, conventional fossil and/or nuclear backup on top of the £7.2billion is necessary!*

[GENTEC venturi](#) requires no back up whatsoever because it will replace fossil fuelled and nuclear power plants within 10 years if the political will is there.

The supply of electricity is subjected to peaks and troughs in demand. GENTEC venturi is capable of meeting sudden peak demand as well as providing Scotland with base load electricity with a load factor at, or close to 1. The feedwater in existing fossil fuelled plants could be preheated to higher and higher temperatures using GENTEC venturi so that less and less coal is required to bring the water temperature up to operational levels. The existing steam turbine generating sets would continue to generate electricity as before albeit with a different heat source. A similar exercise could be done at decommissioned nuclear plants.

The cost to the UK of just £10billion is a small price to pay for a secure supply of very cheap green electricity with the additional option of desalinating water. The cost to ScottishWater of catching, storing, allowing contamination, pumping, purifying, testing, building infrastructure, treating and delivering safe potable water to our homes works out at about £60 per tonne. It

would cost about £2.00 per tonne to provide sterilised desalinated water straight into the water main using GENTEC venturi.

All over the world desalination of water accounts for large quantities of CO2 emissions although most of these plants are on the back end of power generation plants.

Conveniently, because **GENTEC venturi** can generate at full capacity 24 hours per day and there is little point in shutting the plant down, there is scope for making hydrogen at off-peak times. This hydrogen will, not only be 'green,' but very cheap and can be used in fuel cells and for transportation. Electricity will be very cheap too, so that electric vehicles and hybrids could run on a choice of both 'fuels'.

Alternatively, spare capacity during off peak periods can be used to raise the temperature in the **GENTEC venturi** Power Station's own thermal store in preparation for meeting large peak demands during the following day.

The steam turbine house will be a good neighbour and can be built close to in towns and villages. The temptation is to use the residual low grade heat to provide space heating for the local community. Better use of the heat could be used in heating large greenhouses or for cultivation using hydroponics. Electricity will be so cheap that homes and commercial properties could be heated using electric convectors 24 hours a day if necessary.

SUMMARY

All existing forms of renewable energy are intermittent and require backup. GENTEC venturi can generate all of the UK's electricity without backup.

Nuclear power stations have serious and costly waste issues that still need to be resolved. GENTEC venturi can replace all existing thermal power plants including nuclear

Globally, GENTEC venturi can desalinate or sterilise huge volumes of water and provide 'too-cheap-to meter' green electricity for the planet without burning anything

One day all electricity will be generated by steam using predictable tidal stream energy as a heat source.

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