Boosting the Output of Hydroelectric Generators

Peter Graneau

The idea of boosting the electricity output of a hydroelectric generator emerged slowly from a string of unexpected—and still comparatively unknown—experimental discoveries. The beginnings of this novel energy technology will be found in publications of research relating to the anomalously large force of water arc explosions. The relevant experiments were performed in an electrodynamics laboratory at the Massachusetts Institute of Technology (MIT). The project was funded by the U.S. National Science Foundation and its first publication was entitled "Electrodynamic Explosions in Liquids" (*Applied Physics Letters*, 1985).[1]

The first ten years of the program dealt with two questions: 1) Was it heat that exploded water arcs? 2) Was it a phenomenon due to electrodynamic forces set up by the arc current? The answer to the first question was a decisive "no." The answer to the second question was far more involved.

In 1994, high-speed photography in three laboratories (U.S., Canada, England) revealed the surprising finding that what exploded was not liquid water in the arc plasma, but cold fog in a collection of small water droplets. In several decades of research the fog jets that were emerging from the water arc column had not been noticed with the naked eye because they existed for only a few milli-seconds. The kinetic energy of the exploding fog turned out to be much greater than the stored energy in the capacitor bank which drove the arc current.[2] None of the scientists who observed the phenomenon then, and subsequently, have published any doubt that the fog jets proved the severance of hydrogen bonds which previously had joined the droplets together to form the coherent liquid.

Let us now look at the reasons why the existence of large amounts of hydrogen bond energy has remained concealed. Water scientists all know that liquid water molecules are bound by hydrogen bonds, but only some accept that these chemical bonds store energy and almost all would add that they have not come across circumstances where the energy, freed by the rupture of intermolecular bonds, has revealed itself in experiments. Therefore, the stored potential energy which causes the Coulomb repulsion between the nuclei of the separated water molecules is often ignored. The experiments just described have, however, demonstrated that liberated hydrogen bond energy from ordinary water could become a promising resource for reducing our dependence on fossil fuels.

Arc explosions have demonstrated the availability of chemical energy in the hydrogen bonds of ordinary water, but an electricity generator driven by these explosions would probably be of quite small volume and generate no more than a few kilo-watts of output power. To yield megawatts, the electric arc has to be replaced with another method of hydrogen bond rupture such as, for example, mechanical tension.

It is not obvious how mechanical tension can be applied to the bonds between water molecules. Researching this subject soon revealed, however, that water can be readily subjected to tensile stress near its surface by sliding another substance over the liquid. This would not only liberate internal water energy, but the additional energy would accelerate water droplets which become entangled with the medium which is already driving the water fracturing. The effect of high velocity wind dragging over a surface of warm water is the long-overdue explanation of the self-intensification of hurricanes.

That hydrogen bond energy drives hurricanes was first suggested three years ago in *IE* #74.[3] Meteorologists have still to comment on this suggestion which, quite unexpectedly, is something that has its origin in electric arc physics. Since 2007, when hurricane intensification was explained with hydrogen bond energy liberation,[3] another mystery of the behavior of hurricanes has been resolved by invoking the same bond energy liberation mechanism. Wind speed measurements have revealed years ago that, in the northern hemisphere, the hurricane force is greater on the right side of the circulating air flow than on the left side relative to the forward translation speed of the anti-clockwise rotating storm. If we distinguish between the cyclonic tangential circulation wind velocity and the translation wind velocity of the storm center, we find that absolute wind speeds on the right side are greater than wind speeds on the left side. The greater relative air velocities on the right are responsible for some additional breaking of hydrogen bonds between water molecules, which liberates more bond energy to accelerate the right hand side of the storm. On the left side the forward air velocity is reduced by the advance of the storm, leading to a reduction of liberated bond energy and storm force.

The foregoing argument directs attention to yet another aspect of hurricane behavior. It concerns the dependence of the strength of hurricanes on the existence and direction of

ocean currents. These currents vary the relative velocity between water and air and may, subject to the strength of the currents, exert some control on the often surprising and erratic behavior of hurricanes.

Unfortunately, agreement on the hurricane intensification mechanism does not immediately suggest a practical electricity generator which makes use of the storm energy and the vast reservoir of intermolecular chemical energy in the ocean. To this end, we are proposing to let large amounts of water flow over the metallic blades of a hydroelectric turbine. This should result in hydrogen bond ruptures by drag forces, due to boundary layer adhesion. In the turbine case the bond explosion, after bond rupture, should accelerate the turbine runner and generate additional electricity. The gravitational energy responsible for moving water through the hydroelectric turbine would thereby be augmented in a specially designed machine, relying on no additional civil engineering and dam building.

Existing water turbines will inevitably produce boundary layer drag and may very well rupture some hydrogen bonds, whether we want it or not. This is expected to contribute to the surprisingly high efficiency of existing hydroelectric turbines. To enhance the effect so that it could possibly double the energy output of a hydroelectric generator is an R&D challenge for mechanical engineers.

When a hydrogen bond between an oxygen atom in one molecule and a hydrogen atom in a neighboring molecule is broken, it causes the two previously bonded positive atomic nuclei to repel each other. This leads to a repulsion force between the associated water clusters or droplets and helps to drive the turbine. The work done in separating water droplets and pushing turbine blades in this way represents new energy. The smaller the droplets are, the more bonds have been broken and the stronger the observed overall repulsion (explosion) becomes. This was the important lesson learned from water arc explosions.

Hydroelectric turbines are amongst the most efficient energy converters known to man. Modern versions of these turbines are quoted to be 95% efficient. This excellent performance may already be the result of hydrogen bond energy contributions. Understanding this high efficiency has not been helped by the fact that the teaching of chemistry hardly makes any mention of the energy stored in intermolecular bonds of water.

Our attention was first directed to turbines when we tried to capture the kinetic energy of fog jets from water arcs. What struck us as strange was the low efficiency of steam turbines (35%) compared to the near 100% efficiency of water turbines. The question immediately became: do fog turbines behave like water turbines or steam turbines? The outstanding difference between the two is that steam collides elastically with the turbine blades while liquid water collides inelastically with metal. Experiment quickly established that fog (liquid droplets) impact is inelastic, like that of the liquid, and the higher efficiency of water turbines is likely to have something to do with the chemical bonds between water molecules which are absent in steam.

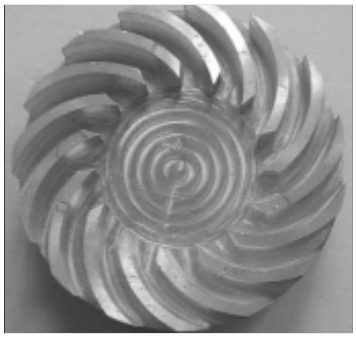
Experimenting with fog jets, it was further discovered that molecules of the vertical jet impinging on a horizontal metal plate are accelerated radially away from the impact area and gain kinetic energy from ruptured intermolecular bonds. The liberated energy acts in the direction of flow, as it should, on account of repulsion between the separated nuclei. On the assumption that liquid water behaves like fog, we have proved that bond rupture by drag force tension can accelerate water flow in a turbine as well as in the hurricane.

To learn more about the inelastic impact of water and fog on a metallic surface, an experiment was performed with a vertical fog jet, from a water arc explosion, striking a horizontal aluminum plate. Instead of bouncing back from the metal, the fog droplets sped away radially over the metallic surface. Details of the radial motion were revealed with a high speed camera operating at 30,000 fps (frames per second). The radial fog layer was about 2 mm thick. Over the first five centimeters, its front traveled with an average speed of 900 m/s. From other experiments it was known that fog leaving the barrel of the water arc accelerator traveled, typically, at 100 - 500 m/s.

The impression gained from this experiment was, therefore, that inelastic impact does not diminish the kinetic energy of the fog droplets. If anything, it seems the impact phenomenon accelerates the fog and increases its kinetic energy by 200 to 300% or more. On reflection, the investigators could think of no other explanation than the rupture of intermolecular hydrogen bonds and the liberation of the stored potential energy of the chemical hydrogen bonds. Details of the inelastic impact of a fog jet on a metal plate were first published in 2008.[4] The proposed liberation of hydrogen bond energy has not been denied in the past two years since the discovery has been made. Nor has any other explanation of the energy gain come to light.

Since then a turbine configuration has been invented which comprises a ninety degree flow impact deflection. In the invention a vertically downward directed jet of water strikes the center of a horizontal turbine flange and forces the flow of water radially outward over the flange disc. Some distance away from the flange center stand bow-like turbine blades which are welded to, or machined integrally with, the horizontal flange. Hence the accelerated horizontal (and radial) sheet of water will drive the turbine to rotate about its vertical axis.

This new turbine has been called a "spider turbine." A photograph of a small scale model (6 cm rotor diameter) of the spider turbine is shown here. This small model has been driven up to 2,000 rpm with fog jets from water arc explosions. In combination with the previously described horizontal disc experiment it has, in fact, been verified that liberated hydrogen bond energy from water can be added to gravitational water energy to greatly boost the output of hydroelectric generators beyond their gravitational potential. This can be done by replacing existing water turbines with suitably developed turbines without modifying water reservoirs and dams.



The addition of hydrogen bond energy to the gravitational energy of existing hydroelectric generating plants has obvious advantages for economical and environmental reasons. It is likely to encourage the exploitation of plants with less energy potential which have so far been considered to be

uneconomical. For the sake of a quantitative example it would not be unreasonable to speculate that the gravitational hydropower efficiency can be doubled.

An important aspect of the development of boosted hydroelectric generators is that experimentation can start in the laboratory with small machines. Even though hydrogen bonds may not rupture below a certain relative water velocity, we know from running water into the kitchen sink that this limitation does not arise with water velocities as low as 1 m/s.

In a simple kitchen sink experiment, the inelastic collision of falling water on the sink bottom results in a thin radial flow layer. The radial flow is swift and the liquid may even accelerate. But within a short distance from the impact area, the layer thickness suddenly increases, revealing an abrupt deceleration. This could well be the limit at which bond rupture stops.

The typical energy source of electricity in an industrialized nation is: 70% from hydrocarbon fuels, 15% from nuclear reactors, 10% from gravitational energy and 5% from all other renewable sources. By adding hydrogen bond energy to this mix, we possibly might increase the output of hydroelectric generators to account for 20% of all electricity and reduce the carbon fuel component from 70% to 60%. Apart from the environmental benefit, this should result in a noticeable saving in the cost of electricity. If in addition the bond energy capture leads to a 5% growth in hydroelectric plants, we may expect the hydrocarbon fuel contribution to fall to 50%. It is difficult to see how any other new energy development could be as effective.

In the U.S., the best sites of gravitational hydroelectricity have already been developed. But some of the existing plants could conceivably be enlarged to provide more electricity from gravitational energy. Today we have about 80,000 dams with water reservoirs in the U.S. Only 3% are provided with hydroelectric generators. Most dams are built for flood control and irrigation. It has been estimated that it would now be economical to add water turbines to many of the latter dams and thereby double our hydroelectric power component.

At the beginning of the 21st century, gravitational hydropower is the cheapest way to generate electricity. No other energy source—renewable or non-renewable—can match it. Gravitational hydropower is cheap because, once the dam and the reservoir are built, flowing water is free. Another economic advantage is the long life and dependability of hydroelectric generators. With the doubling of the existing tapped gravitational power and a further doubling with hydrogen bond energy, the hydrocarbon related input energy would fall from 70% to 40% of electricity consumption.

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