# Lunar Power

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In a remarkably short span of time – less than a decade – New Zealand has moved from an electrical power generation scenario of reasonable performance, to one of significant risk in the near future of demand exceeding supply, with a concomitant risk of blackouts in peak demand periods.

We are one of the lucky nations of the world in having both mountains and rainfall that has enabled the construction of a hydro power system of significant size in relation to our population and level of industrialization. Sixty percent of our electricity comes from the hydro power system, but there is an inherent problem in that the lakes hold, at best, only a few months of storage. We are now faced with an immediate future of electrical power generation that, in an average year, only marginally supplies the demand. In a "bad" year, one of low winter rainfall and dry summer, serious decisions eventually will have to be made on who gets electricity and who suffers blackouts in the following winter.

The Government policy decision in the early '80s to deregulate the electricity market has led to a reduction in investment for new generating plant. The resulting shortfall in generation has now initiated considerable efforts to reverse the effects. Simultaneous with this has come the realization that global warming is a serious threat to humanity and that the burning of fossil fuels has exacerbated the problem by adding to the atmospheric $CO_2$ levels that have acted beneficially as a thermal blanket, to the point of probably raising the global temperature beyond acceptable levels within a century.

One of the prime burners of fossil fuel – coal, oil and natural gas – is the thermal power station. These large $CO_2$ producers are being built all over the world to power the increasing population and industrialization of virtually all of the 192 nations that make up the global community. Research is underway to develop the technologies required to sequestrate the emitted $CO_2$, but no reliable technique for permanent sequestration has yet been demonstrated.

The emphasis, therefore, has been to identify and develop sustainable energy sources, and much attention is being directed to the potential of wind energy. However, marine energy is only now being publicly discussed as probably the most promising of all sustainable power sources in the New Zealand environment. Partly this is because, while wind turbine technology is relatively mature, only now are viable mechanisms being developed that convert the energy of waves and tidal flow into electrical power.

Fortunately, we are blessed with an abundance of sustainable marine energy resources. In particular, Cook Strait is one of the great Straits of the world, with an enormous mass-flow of water, equivalent to about 8000 Waitaki rivers. If we can tap this flow efficiently we will have a most significant resource for our expanding population and industrialization.

We, the Directors of Neptune Power Ltd., identified in 2003 a suitable turbine, adaptable for use in Cook Strait. SMD-Hydrovision Ltd, Newcastle-on-Tyne, England, is developing a design, called TidEl, that is ideally suited to operation in depths of over 80m. Calculations show that an array of such units should be able to generate more than 60 Megawatts per square kilometer of the ocean, provided that the tidal current is strong enough. A $^1/_{10}$-scale prototype has been tank-tested in the laboratory and proven.

SMD-Hydrovision says that the TidEl turbines offer several advantages:

- They are out of sight, invisible from above the surface, and in Cook Strait would be submerged below the navigable depths. The blade sweep diameter is 20m and the top of the sweep should be 40m below the surface to prevent navigation obstruction to the largest known ships. The minimum depth for operation is therefore about 80m.
- They are inherently quiet, rotating at only 4 or 5 revolutions per minute. They are inaudible outside the marine environment, which is already a cacophony of wave and surf noise. SMD-Hydrovision is investigating the gearbox noise effects relative to the ambient levels, but in the long term, silent low-speed direct drive generators would probably be used.
- They are buoyant, in that the generator module exerts an upwards force on the tether chains. There are only two anchorage points on the seabed, prealigned along the dominant flow direction, so they interfere minimally with the seafloor ecology. When the tide turns, only the upper generator module flips over.

Cook Strait is not the only significant location for tidal current power. Foveaux Strait, between Stewart Island and Southland, is strategically sited next to the Bluff Aluminium Smelter, which consumes nearly all of the power generated by the huge Manapouri hydro system – $^1/_6$ of all the electrical power generated in New Zealand. A number of turbine types are better suited to this shallow Strait than is the deepwater TidEl system. We are keeping a watching brief on those.

Tides occur because the Earth rotates beneath the gravitational influence of the Moon and Sun. The familiar ebb and flow of tides, visible as the sea covers and uncovers the seashore, is also present as tidal currents that traverse the oceans and can occasionally be seen as "rips" where the movement is fast enough to cause surface turbulence. In Cook Strait, the famous one is the Karori Rip, swirling around Cape Terawhiti, west of Wellington.

Tidal currents are totally predictable. The main component of the tide is the lunar gravitational effect, which will stop only when the Moon stops revolving around the Earth, some billions of years from now. A secondary component is the solar tide, which can add to the lunar tide at Spring Tide times, or subtract from it at Neap Tide. Another component is the Apsidal variation, caused by the significant difference in the Moon's distance from the Earth as it travels in its orbit from Perigee (closest to the earth) to Apogee (most distant from the Earth). These effects can be computed for any minute of any hour for centuries – indeed, millennia – ahead, making tidal currents the most reliable of all sustainable energy sources.

Marine turbines will enable hydro lake water conservation, because the turbines can, and should, be used as a base-load resource complementary to our hydro infrastructure. The predictability of the tidal flow allows blending of marine and hydro power outputs, so that the hydro output would be maximized only when necessary to fill in the periods when the tide turns and the marine units swing to the reverse flow.

Marine units are immune to the effects of weather extremes. A storm may turn the surface to foam, but in the depths it is hardly even detectable. Wave and wind power systems, on the other hand, are subject to significant maintenance requirements in extreme weather, and extreme weather is the main prediction of the effects of global warming and the ensuing climate change.

Marine turbines will eventually displace the need for new fossil fuel power stations. We will have to accept that coal will be the fill-in energy source until sufficient sustainable power generation can be brought into service, but thereafter the ongoing increase in power demand may well be met by expansion of the sustainable sources. Coal's ideal role is as a carbon source for the petrochemicals industries, not as a source of heat from burning it.

A great deal of work has to be done before we can expect the first installations of marine turbines. The Energy Efficiency and Conservation Authority is already addressing the processes involved in the establishment of sustainable generating systems. A new Industry Association has been formed – the Aotearoa Wave And Tidal Energy Association (AWATEA: loosely translated = New Dawn) that will coordinate the efforts of marine power generation companies. NIWA, the National Institute of Water and Atmospheric Research, has much essential information, but more research will be needed to define the best turbine locations and the operational parameters that will reduce the risk factors inherent in the establishment of a new industry.

Nor can the possible influence on the marine environment be ignored. There is no present knowledge of any untoward or even beneficial ecological effects of wave or tidal power systems, and research into such aspects will be mandatory.

SMD-Hydrovision has been 60% funded by the British Department of Trade and Industry, and is 40% self funded, to develop their TidEl design, benchmarked to the point of a test installation at a test site in the Orkney Islands, off Scotland, late in 2006, and followed by an extended test and development period, programmed to terminate in 2008 with the information required to create a production design. One aspect of the testing is that of investigating the effect of the presence of turbines on marine mammals. It is anticipated that the very slow rotation rate of the turbine blades will facilitate sonar detection and avoidance maneuvers by these intelligent animals.

Of the few designs of marine turbines in development worldwide, the SMD-Hydrovision TidEl system appears to be the only one suited to operation in Cook Strait. We expect to be able to install the first units sometime in 2009-2010 and be generating useful power immediately. Thereafter, installations will follow the demand imperative.

We see tidal stream energy as but one source in an integrated mix of sustainable power generation plants, with hydro, wind, wave and geothermal power continuously controlled to match demand. By 2020, we expect the New Zealand electrical power scenario to be back on track as a mature system, expandable to meet all future needs.