ENGINEERED ENERGY TECHNOLOGIES

THE ENGINEERS' REPORT

Micro-Sun-Bakeries: The Bright Alternative

The Water Beetle: Using the Sun to Purify Water

Geothermal Energy Plant Commissioned by Maori

Wind Energy Opportunities in Least Developed Nations

This material is based upon work supported by the National Academy of Sciences, under a grant to the World Federation of Engineering Organisations' Committee on Technology.

ENGINEERED ENERGY TECHNOLOGIES TO CREATE ECONOMICAL SOLUTIONS

THE ENGINEERS' REPORT

A United Nations Presentation Made Possible by
The American Association of Engineering Societies
The World Federation of Engineering Organisations

April 17, 2001

FOREWORD

Technologies that use renewable energy resources provide the subject for this report, the result of a jointly-sponsored panel presented to the United Nations Commission on Sustainable Development at its 2001 two-week annual meeting in New York. The international engineering profession, through the World Federation of Engineering Organisations, continues to participate in the UN's dialogue on sustainable development by sharing successful case studies.

The World Federation of Engineering Organisations (WFEO) represents in its membership over eight million engineers in 80 nations. It is pleased to have shared in this effort, through its Standing Committee on Technology (ComTech), along with the American Association of Engineering Societies (AAES).

Respectfully submitted by

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The American Association of Engineering Societies (AAES), the U.S. representative to the World Federation of Engineering Organisations, is proud to have supported the panel presentation during the United Nations Commission on Sustainable Development's two-week annual meeting in New York.

AAES represents 26 US engineering societies, each individually representing the disciplines within the engineering profession. AAES' primary goal is to identify common issues among its members and to facilitate activities to effect change for the good of the profession.

The U.S. engineering community looks to join its neighbors worldwide in working with WFEO to engage in dialogue at the United Nations.

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The World Federation of Engineering Organisations' Standing Committee on Technology (ComTech) is grateful to the U.S. Department of State for its invitation to present a meaningful event to UNCSD delegates. This event, *Engineered Energy Technologies to Create Economical Solutions*, provided a significant opportunity for delegates and representatives to the United Nations to talk with energy engineering professionals. This firsthand knowledge was of particular value to developing countries considering ways to incorporate principles of sustainable development in addressing their energy needs.

ComTech's primary interest is in emerging sustainable development technologies, as well as in disseminating information on simple solutions that address complex sustainable development problems. ComTech's 2001 achievements show a depth of service to the world community and success at bringing engineers into the public dialogue on sustainability.

ACHIEVEMENTS

- The establishment of a growing sustainability database, located at ComTech's website. http://www.wfeo-comtech.org.

- Publication of *WFEO ComTech News*, a quarterly newsletter to keep members informed of activities.

- At the invitation of The Earth Council, conducted a survey of the engineering profession's implementation of Agenda 21 principles into practice. The resulting publication, *The Engineers' Response to Sustainable Development,* was presented at the Earth Summit in Rio de Janeiro in March 1997. The production of an updated edition included a presentation at The World Congress on Sustainable Development under the sponsorship of the Institute of Engineers (India) and WFEO, in January 2000. A second edition of the publication is timed to Rio +10 events.

- Invited by the World Water Forum, ComTech provided an engineering dimension to the dialogue at the Second World Water Forum at The Hague, 2000 and the Stockholm Water Symposium in August 2001. Led by ComTech's Regional Vice President for North America, Dr. Joseph Delfino, ComTech is participating in a 25-year study to formulate a water vision.

- In 2000, at the United Nations Commission on Sustainable Development's annual meeting, ComTech presented a panel of engineering experts who spoke on case studies in best practices in agriculture and natural resource management. The written report, *Sustainable Agricultural and Natural Resource Management Engineering Practices*, was disseminated broadly. Presenters offered information on projects in microirrigation, animal-drawn implements for vertisol management and strategies for land use intensification, and weather data collection and climate prediction in management of agricultural production systems.

- At the UNCSD 1999 meeting, ComTech presented a panel of engineering experts speaking on the issue of production efficiencies. The resulting publication, *Production Efficiencies/The Engineers' Report*, was widely circulated. Speakers provided case studies of projects in developing countries to provide information on simple technologies to enable wider application.

- On April 27, 1998, ComTech presented a panel of engineering experts speaking on the issues of privatized water delivery systems to the UNCSD' s annual meeting. The resulting publication, *Water Financing/The Engineers' Report: Water Privatization Projects in the Developing World*, has been widely distributed and is being used as a primer by countries considering the feasibility to privatize delivery systems.

- ComTech's *E-Mail Pairing of Engineers Program* is a one-to-one information exchange program, introduced in 1997 when an engineer in Sri Lanka sought information on biomass gasification projects. Subsequent pairings include engineers in Brazil and Canada on sustainable practices in the mining industry. Follow-on activities in this particular pairing have incorporated joint participation in an international conference and in generation of several news articles.

- Engineering Exchange Programs, through the Institute for Leadership Development at York University, Canada, were launched to place intern graduate engineers in nine-month projects in developing countries.

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MICRO-SUN-BAKERIES: THE BRIGHT ALTERNATIVE

A case study in Minas de Oro, Honduras, presents the Micro-Sun-Bakery, a project begun in 1996. This capacity-building project in Latin America has led to the establishment of 20 similar bakeries, with an expected 301 projects within 20 years. The Minas de Oro enterprise utilized the ultimate renewable resource, sunshine, to cost-effectively provide needed food staples while combating the destructive forces of deforestation and reducing CO2 emissions.

The Micro-Sun-Bakery in Minas de Oro has been in operation since March of 1996 and was started by a group of Rotarians. Tom Burns, the inventor of the Sun Oven, led a group of Rotarians from Wisconsin, Illinois, and New York to Honduras to initiate the project, which was administered and operated locally. The program was developed to work towards alleviating poverty and enhancing the quality of life by empowering women to raise their standard of living through self-sustaining micro-enterprise. This program fills the need for fresh, locally prepared bread and other baked goods. Previously, bread was delivered to this area from the capital city of Tegucigalpa. The closer location of the bakery to its market area, and the use of the sun as the primary fuel source, allows baked goods to be sold for less.

The cost of energy for a bakery is very high. In rural Honduras available fuel is generally wood. There is significant fuel loss in oven operation, because regulating oven temperature calls for burning wood down to coals. In most of the developing world, the cost of fuel for a bakery averages 25% of gross revenue. When a bakery is operated with just sunshine, there are no energy costs. This allows baked goods to be sold at lower cost and creates a greater profit opportunity for a cooperative.

THE WATER BEETLE: USING THE SUN TO PURIFY WATER

Solar energy to purify water is shown to be a solution to water pollution problems. This case study describes tests carried out from July through September in 1999 as a part of the environmental improvement project of the Tomakomai River.

The case study shows the success of the Water Beetle, a solar-powered device that circulates water of a highly dissolved oxygen concentration in deep layers of the river through mechanical circulation to enhance the self-purification effect and improve water quality.

The Water Beetle is a floating body having a funnel-like structure that expands upward. A propeller is mounted at the lower end of the shaft extending downward from the floating body. The rotation of the propeller moves the deep river water upward to produce a circulating flow, which impels the surface high dissolved oxygen concentration water to lower depths. The floating body, which is subject to the rotational force of the propeller, is secured by an arm to the anchor and moves on its own in a circle by the turning momentum force, with the mooring point (anchor) as its center. This circular movement allows circulation of a larger volume of water covering a larger area.

GEOTHERMAL ENERGY PLANT COMMISSIONED BY MAORI

Following the deregulation of the New Zealand electricity industry, several medium- and small-sized projects have begun operation. The Mokai Geothermal Project is the largest privately developed geothermal project in New Zealand. The 60 MW development was undertaken by the Tuaropaki Trust in Taupo, New Zealand. The Trust, which owns the majority of the land at Mokai, operates its project through its wholly-owned project company, the Tuaropaki Power Company.

The power plant uses geothermal fluid captured from the production wells and reinjects the full capacity into the reinjection wells. The plant utilizes steam turbine and binary turbine technology to obtain maximum energy from the resource with minimal environmental impact. The electricity generated is delivered via a 20 km, 110 kV line to the Whakamaru national grid substation and is sold in the national pool. Financing of the development was undertaken on a non-recourse and long-term basis by a group of financing institutions with Westpack Banking Corporation acting as leader.

During the first 12 months of operation, the power plant has generated an average output of above 58 MW, with an availability of above 97%.

WIND ENERGY OPPORTUNITIES IN LEAST DEVELOPED NATIONS

Wind blows almost everywhere, 24 hours a day, 365 days a year, however wind conditions vary from one site to another. A case study in New Caledonia presents a capacity-building project to produce energy from the winds that blow across Pines Island. To make the best use of wind energy, the following two key points should be understood:

* The wind : It can be very powerful. This is the "fuel" of the system. Several parameters have to be taken into consideration before installing a wind turbine: intensity and regularity of the wind (daily, seasonal and annual variations), directional variations, and mean wind speeds. All these data depend tightly on the logging location and height. As a consequence, a pre-feasability study is necessary to carry out a wind project.

* The wind turbine: It is responsible for transforming wind energy into mechanical energy. It has to be robust and reliable. It will be chosen according to both the wind quality and quantity measured on site and the energy needs.

How does a wind turbine work? A wind turbine transforms wind energy into mechanical energy and/or electrical energy to produce power.

Wind turbines were developed in 1945 according to two technologies. They can be:

- slow and multi-blades, which are generally used for small flow pumping.
- fast and two-blade or three-blade and combined with an electric generator.

Manufactured by VERGNET SA of France, wind turbines are installed on a wireguyed tower that allows it to be pulled down very quickly (nearly 20 to 40 minutes), for maintenance or in case of high-speed winds (hurricanes, tropical storms...).

The wind turbine is able to work alone in remote areas, the batteries guaranteeing a continuous energy supply in case of a low-wind period; or it can be connected to the grid where it exists.

INTRODUCTION

The ongoing impact of human development on the environment is a fact of life and the most significant impact is from energy production, distribution and use.

—UN Commission on Sustainable Development

The economic growth and social development of all countries depends on energy consumption. The important issue for countries is how to address the need for energy and mitigate the environmental impact. And, as the world's population grows at its rapid rate, it is increasingly important for decision-makers to study all uses of renewable energy resources.

Agenda 21 suggests that a large portion of the world's energy supply is produced and used non-sustainably. The UNCSD proposes that energy futures become compatible with sustainable development. The engineering experts panel brought forward four successful case studies that demonstrate technologies that work toward this end.

WFEO was founded on the importance of bringing an engineering dimension to the sustainable development dialogue. The following resolution demonstrates the strength of its belief.

WHEREAS it is widely accepted that scientific evidence indicates that human activity is contributing to climate change through global warming;

AND WHEREAS it is widely accepted that a significant contribution to global warming is made by man-made greenhouse gases;

AND WHEREAS global warming could affect weather patterns by causing heavier rainfall and more frequent flooding in some areas, and more periods of drought in others;

AND WHEREAS global warming could significantly affect ecosystems, promote the spread of insect-borne diseases, and cause increases in human respiratory distress;

AND WHEREAS man has the obligation to be a steward of the Earth's resources for future generations;

AND WHEREAS engineers play a vital role in the implementation of global warming solutions;

THEREFORE, BE IT RESOLVED that WFEO encourages members of national engineering associations and all engineers, to recognize their leadership role by conscientiously addressing environmental concerns in all future engineering work and to participate in the evaluation and decision-making process as the issues of global warming are addressed.

FURTHERMORE, BE IT RESOLVED that WFEO requests all its national members, and the world of engineers so represented, to place a high priority on the more efficient production and use of energy, on research and development that will facilitate solutions, and on utilizing sustainable and renewable sources of energy.

—Approved 1997 WFEO General Assembly

As early as 1993, The American Association of Engineering Societies (AAES) thought to create a statement on sustainable development:

Sustainable Technologies and Processes

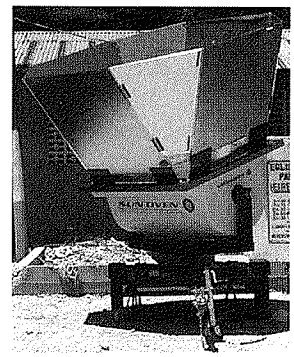
The creation of sustainable technologies and processes is perhaps the most practical and readily available tool to achieve the sustainable integration of the environment and technology in the foreseeable future. Technology focused on sustainable development is a key to solving problems created in the past and to prevent new ones arising in the future. Engineers must work with others to adapt existing technologies and create and disseminate new technologies that will facilitate the practice of sustainable engineering and meet societal needs.

—taken from the AAES Statement on The Role of The Engineer in Sustainable Development, 1993

MICRO-SUN-BAKERIES: THE BRIGHT ALTERNATIVE

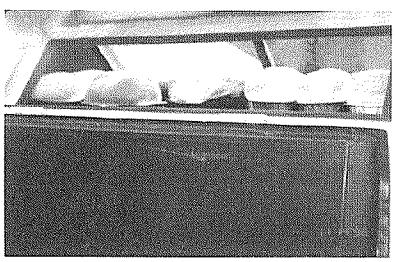
Mr. Paul M. Munsen

Minas de Oro, Honduras, might not be known as the hot-spot of Latin America, but it has become a landmark for a significant development in the energy and environmental communities. Minas de Oro is the home of the first Micro-Sun-Bakery. This enterprise utilized the ultimate renewable resource, sunshine, to cost-effectively provide needed food staples while combating the destructive forces of deforestation and reducing CO2 emissions.



The Micro-Sun-Bakery in Minas de Oro has been in operation since March of 1996 and was started by a group of Rotarians. Tom Burns, the inventor of the Sun Oven, led a group of Rotarians from Wisconsin, Illinois, and New York to Honduras to initiate the project, which was administered by three nuns from the Order of the Immaculate Heart of Mary in San-Igacio in Honduras and operated by a women's co-op. The program was developed to work towards alleviating poverty and enhancing the quality of life by empowering women to raise their standard of living through self-sustaining micro-enterprise. This program fills the need for fresh, locally prepared bread and other baked goods. Previously, bread was delivered to this area from the capital city of Tegucigalpa. This delivery increased the cost of the bread and, due to the distance of the bread makers from this rural village, there were days when bread was not delivered and the bread was typically not fresh. By locating the bakery in the market area that it served, the delivery expenses were reduced and fresher baked goods were provided to the consumer. The closer location of the bakery to its market area, and the use of the sun as the primary fuel source, allows baked goods to be sold for less.

The cost of energy for a bakery is very high. In rural Honduras available fuel is generally wood. There is significant fuel loss in oven operation, because regulating oven temperature calls for burning wood down to coals. Sixty-six percent of the wood is lost in the conversion to charcoal, thus adding to the cost of baking. In most of the developing world, the cost of fuel for a bakery averages 25% of gross revenue. When a bakery is operated with just sunshine, it then has no energy costs. This allows baked goods to be sold at lower cost and creates a greater profit opportunity for a cooperative.



The bakery was set up using large ***VILLAGER SUN OVEN***ä which my company, Sun Ovens International, manufactures. Prior to installing the Micro-Sun-Bakery, bakers in Minas de Oro baked bread in a stone oven that turned out abut 35 loaves of bread a day. The ***VILLAGER SUN OVEN***ä was able to turn out an identical size loaf of bread at a rate of 50 loaves per hour. It makes 400 loaves in a day, as opposed to 35 in the old system. Designed for long use and hard wear, the ovens are very durable and have been on the market since 1989. Currently 200 ***VILLAGER SUN OVENS***ä exist in 40 countries around the world.

Maintenance is simple. ***VILLAGER SUN OVENS***ä consist of only one part that requires maintenance-a shaft must be greased every few months. The oven features a crank mechanism and pivot that allows it to rotate 360 degrees and move up and down to follow the sun. Training to operate the oven is very simple. The written instructions that come with the oven include pictures. Anyone can learn how to use the oven in about two hours.

The oven, when it is not in use, can be folded down. In the storage mode, it is only 74 inches tall and it weighs 980 pounds (444 kg.) and is generally sold on a trailer, making it easy to push into a storage area for overnight storage. Setup takes 10 minutes and take down requires less than 5 minutes. ***VILLAGER SUN OVENS***ä are equipped with a propane backup system for cloudy days or for night use. The propane and sun can even be used in conjunction with one another.

The oven has also been installed without the trailer. In some instances, installation has been on building roofs. It is a very flexible cooking system and adapts well to individual requirements. The oven can make over 1,000 meals a day just using sunshine, therefore making it valuable in large scale feeding situations. In addition to bakeries, ***VILLAGER SUN OVENS***ä have been used successfully in a variety of applications including: large and small scale feeding

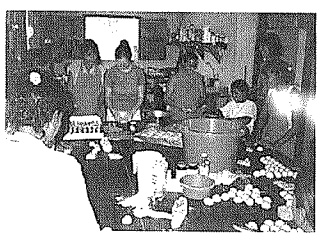
programs, refugee camps, sterilizing medical instruments, and water pasteurization programs.

The cooking chamber is seven cubic feet. Inside the oven there is a cooking shelf large enough to accommodate three standard baking sheets or a number of large pots. The reflective area is 91.75 square feet. Ovens can be used in areas where there is no electricity or fuels. Cooking temperatures of 500° F (260°) C can be maintained with no fuel costs. An optional 150 piece Micro-Sun-Bakery Package is available which includes everything from bread pans and an oven peel to an insect-proof flour container.

In the Minas de Oro project, the original intent was just to sell bread. It was noted, however, that many of the women would still travel by bus into Tegucigalpa, about three hours each way, to bring back cakes for special occasions. The bakery started baking pastries and cakes to respond to this community need. Now about 35% of the bakery's total revenue comes from the sale of cakes and pastries. In 1997, because this was turning into such a successful enterprise, they were able to purchase a display case for a small shop where they now can sell the baked goods.

The bakery project in Honduras did have some deficiencies. Because it was Rotary-financed, the condition for the project was that the bakery be given to the cooperative. The nun responsible for overseeing the bakery did an excellent job in helping the co-op to work through various things, but she became ill and had to leave Honduras for treatment. In 1998, when Hurricane Mitch struck Honduras, the nuns who remained on the project shifted their emphasis to other pressing relief aid. As a result, the bakery was left to operate on its own, without any outside oversight. One of the problems we recognized in lost oversight was that, without this support, sometimes conflicts arose. The bakery might be shut down for a week while a resolution was sought.

Most of our subsequent non-Rotary projects include oversight. Now, rather than making an outright gift of the oven, we lease the oven to the entrepreneur or co-op. They pay 25% of their revenue from bakery operation into a fund that goes to buy more ovens. It is therefore a project that is self-financing an overall expansion. The revenue stream allows the supervising NGO the opportunity to keep the project operating at its best potential. On several (non-Rotary) project sights a trained entrepreneur has been selected to be the boss. Putting someone in charge has helped alleviate some of the problems we experienced in the early project. Previously, the co-op decided that they did not require as much money as they were making and closed the operation down for a time. Another problem was that the cooperative did not monitor their supplies and ran out of flour, in which case it might take two or three days to replenish the supply. There was no good cost control; cakes were being sold for less than the cost of producing them. Having a single entrepreneur running the operation maximizes the bakery's success. In our newer projects, we also provide better training.



The Minas de Oro bakery is still in operation. It employs an average of 10 people, sales staff as well as bakers. It bakes about 50,000 loaves of bread a year and generates approximately $24,000 USD per year. It has been estimated that this sustainable fuel supply has saved 150 tons of wood a year, which translates into 277 tons of CO2 emissions.

The Micro-Sun-Bakery in Minas de Oro established a good model. As a result of this success, The Rotary Temple Solar Project was started in memory of one of the Rotarians who was involved in the initial project. The Temple Solar Project has opened up an additional 20 bakeries since 1996. There are 11 more in Honduras, operated by another organization that has done an excellent job. There are three bakeries in Haiti, two of which are located at orphanages that not only serve their own use but also sell to the local community to raise funds. Orphans are taught how to bake, which gives them a job skill that they can use in later life. There are two in the Dominican Republic; one is operated in a fascinating project with a school for the blind that teaches their students self-sufficiency by allowing them to earn their tuition by baking bread. The other is operated by a parish priest who feeds hungry Haitians who cross the border in search of food. We have one in Peru, one in Ethiopia, one in Ghana and one in Uganda. Currently the Temple Solar Project has nine more bakeries pending throughout the world.

By the end of the year we hope to have 20 bakeries open. Over a ten-year-period those 20 bakeries will increase to 301 bakeries, just by generating their own funds. This shows how much can be accomplished with just a little seed money.

We are waiting on project funding approval in which we are attempting to document what the exact CO2 emissions savings are. That will allow us to generate energy credits, and our hope is that, with proper documentation, we will be able to use the greenhouse gas emissions credits to fund future projects.

We also manufacture a home-use oven that can cook for a family of up to eight people. It is called the ***GLOBAL SUN OVEN,*** which is designed to meet up to 80% the cooking needs of a typical family, entirely with the power of the sun. Cooking temperatures of 360° F / (182° C) can be maintained in this easy-to-use unit. This ruggedly built oven weighs only 21 lbs. (9.5 kg) and it is able to bake, boil, or steam almost any local dish. Two billion households depend on wood and charcoal to prepare food and the worldwide supply of wood is rapidly disappearing. The demands of massive population growth, and the inefficient conversion of wood to charcoal, have outstripped much of world's forest's ability to regenerate. For example, the annual wood consumption for cooking throughout the African continent is 1,000 pounds of wood per person. A family of six using a ***GLOBAL SUN OVEN***™ for 80% of their cooking needs would save 4,800 pounds of wood per year. A ***GLOBAL SUN OVEN***™ has a useful life of at least 20 years; the wood saved by each oven would be 96,000 pounds. Each oven eliminates the need to cut down thousands of trees.

The sun can be used as the fuel source for the majority of cooking. Solar energy is the least polluting and most inexhaustible of all known energy sources and can be efficiently used for the cooking needs in the rural areas of developing countries. We have taken a concept that has been around for centuries and engineered into it more recently developed materials to produce the world's most effective solar cooking devices.

These ovens can have a positive impact on reducing deforestation and the resulting desertification. Sun Ovens International has developed a well-balanced, holistic, and integrated approach to sustainable development that combines solar energy and micro-enterprise to provide solutions to the problems of deforestation and global warming through economic empowerment. Every tree that is allowed to remain in place will help future generations. Every woman who gains entrepreneurial expertise will contribute to improving the quality of life for herself and the greater community.

We are most proud that our projects involve capacity-building in that ovens are built in the country in which they are sold The introduction of Micro-Sun-Bakeries in developing countries is a process that will alleviate poverty and enhance the quality of life by empowering women to raise their standard of living through self-sustaining micro-enterprise.

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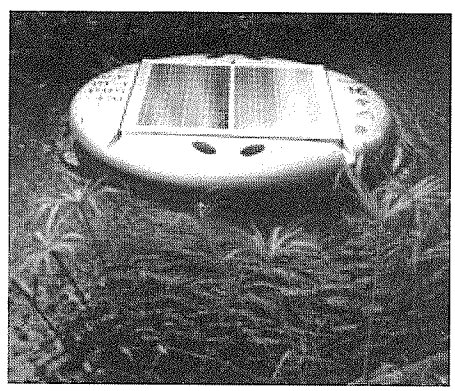
Mr. Paul M. Munsen is the president of Sun Ovens International, Inc., located in Elburn, Illinois, USA. The company is the leading manufacturer of high-quality solar cooking devices. Sun Ovens were developed to combat deforestation and show down global warming and are currently being used in 126 countries around the world. Sun Ovens International was formed in 1998 to take over the manufacturing and marketing of the Sun Ovens from the Burns Milwaukee Corporation, inventor and producer since 1986.

Mr. Munsen was formerly a partner in Competitive Advantages Inc. and assisted businesses and non-profit organizations in business and strategic planning. He serves on the boards of businesses involved in the energy/environment, factory automation, and food processing sectors. He is actively involved as a board member of two non-profit organizations and resides in the Chicago area.



THE WATER BEETLE

THE WATER BEETLE: USING THE SUN TO PURIFY WATER

Mr. Kenji Masaki

It is an honor to be able to introduce our solar-powered Water Beetle, which some people might think looks like a UFO. The Water Beetle performs water purification through aeration of water by mechanical agitation. It is a unit that can purify water in any pond, lake or river that suffers from large algae saturation. In 2001 the Water Beetle won the New Energy Grand Prize in Japan.

This case study describes tests carried out from July through September in 1999, as a part of the environmental improvement (river purification) project of the Tomakomai River.

Various river improvement works have been carried out on the River since 1950 when serious flood damage occurred. In 1966, a small- and medium-scale river improvement project was launched to control floods. The project was completed in 1984. The Tomakomai River has rubber weirs upstream, a fish-ladder weir in mid-stream, and a self-tilting weir downstream around the junction with the Usu River. The self-tilting weir was set up in 1978 to prevent ground subsidence in the area by the river improvement works. Between then and 1984, the peat soil layer was excavated upstream of the self-tilting weir as part of the Usu River improvement works. This led to the outflow and deposits of peat fiber (organic substance) in the stagnant waters around the weir. The result was generation of methane gas, odors and over-luxuriant growth of algae due to the summer heat. The community recognized environmental and hygiene problems. As a countermeasure for this problem, dredging works were carried out to remove deposits in stagnant water as a part of the Hokkaido Renovation Works in 1990, followed by the Tomakomai River Environment Improvement (River Purification) Works in 1991. The works were completed in June 1999.

In the meantime, the survey conducted from 1995 to 1998 showed the formation of poor oxygen layers and progress of anaerobic sediments deep on the river bottom, attributive to stagnancy of water upstream of the self-tilting weir. This is likely to lead to the repeated deterioration of the water environment, due to the occurrence of odors, over-luxuriant growth of water plants and the outbreak of water-bloom. Based on this survey, the adoption of an automatic aeration system, the solr-powered Water Beetle, was considered to be the best mechanism to address the issue of water purification of the Tomakomai River.

The Water Beetle circulates water of a highly dissolved oxygen concentration (hereinafter referred to as DO concentration) into deep layers of the river through mechanical circulation to enhance the self-purification effect and improve water quality.

To implement the program, two Water Beetles were set up for a test run in the stagnant water above the self-tilting weir. Continuous observation of water quality was made during the entire test period in order to evaluate the efficacy, operating range and aptitude of the Water Beetle.

As shown in Fig-1, the Water Beetle is a floating body having a funnel-like structure which expands upward. A propeller is mounted at the lower end of the shaft extending downward from the floating body. The rotation of the propeller moves the deep river water upward to produce a circulating flow, which impels the surface high DO concentration water to lower depths. The floating body, which is subject to the rotational force of the propeller, is secured by an arm to the anchor and moves on its own in a circle by the turning momentum force, with the mooring point (anchor) as its center (See Fig.2). This circular movement allows circulation of a larger volume of water covering a larger area.

The reasons for selecting the Water Beetle for this project were:
(1) To effectively increase and maintain the DO concentration in water
(2) Operated only in summer time when the DO concentration becomes lower. Can be transported and stored indoors while it is not used.
(3) Simple maintenance, just by operation checking. There is almost no need for cleaning.
(4) Low noises presenting no noise pollution, even near residential areas.
(5) Power consumption as little as 90W per unit. AC100V power supply is accessible anywhere.
(6) Circulation of water at a low speed to minimize the stir-up of sludge at the bottom
(7) Low cost operation

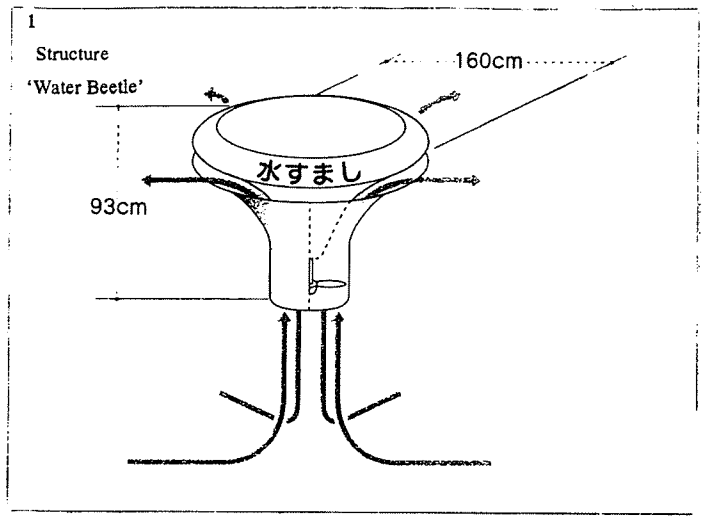


Fig-1 Structure of 'Water Beetle'

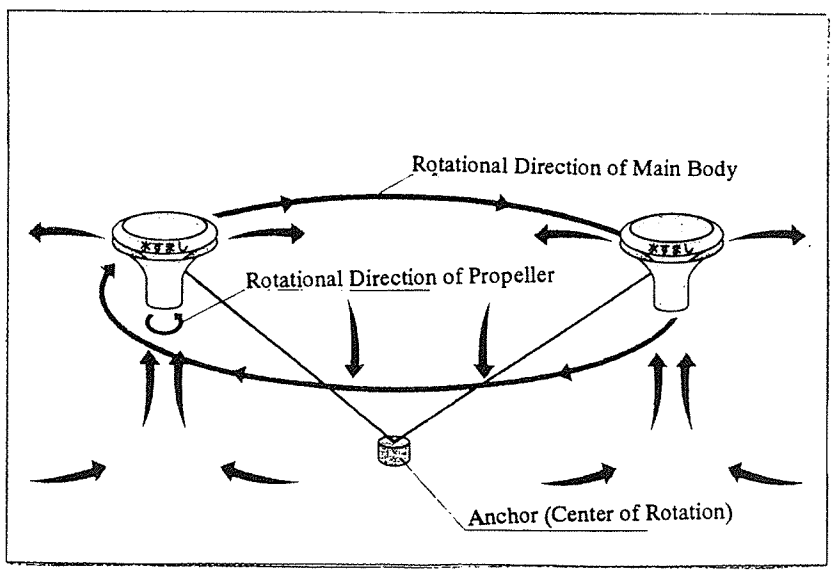


Fig-2 'Water Beetle' Operation Diagram

In this case study, two Water Beetles were installed in stagnant water of 2m depth upstream of the self-tilting weir. The test was performed for a three-month period from July 1 till September 30. In order to effectively compare water quality with or without operation of the Water Beetle, the Water Beetles were temporarily stopped for one week. Changes in water quality were observed during the period.

The Water Beetles were installed so that the center (mooring point) of the circular movement of each mechanism was located 52m (SP1262) and 152m (SP1362) upstream from the self-tilting weir (SP1210), respectively.

Fig-3 shows the survey area and Table-1 shows check items, purpose and details of the survey.

The four (4) check items and method used for the survey are detailed on the next page.

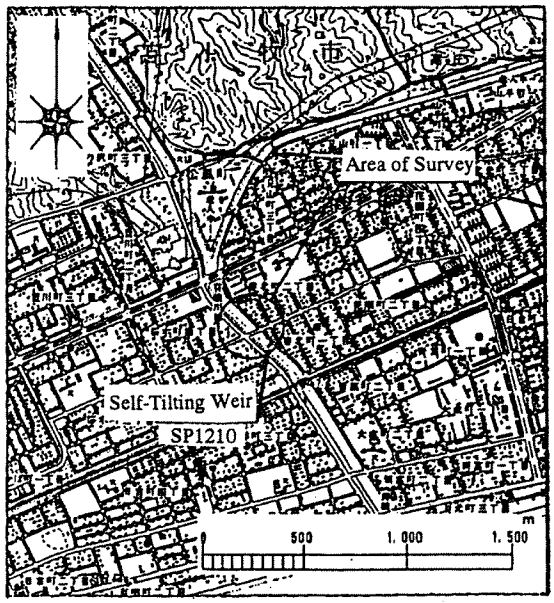


Fig-3 Area of Survey

Table-1 Survey Items

Check Item	Description	Purpose	Evaluation
Analysis on Water Quality	Periodical analysis of water quality at 4 fixed points	To evaluate changes in water quality after starting operation of 'Water Beetle'	Efficacy for water quality improvement
Continuous Observation of Water Quality	Continuous observation of water temperature and DO concentration at 2 fixed points (for each hour)	To evaluate time-series changes in water temperature and DO concentration after starting operation of 'Water Beetle'	
Cross-Sectional Survey of Water Quality	Cross-sectional observation of water temperature and DO concentration at 66 fixed points	To evaluate the range of effectiveness of 'Water Beetle'	Range of effectiveness of 'Water Beetle'
Noise	Check on noises while 'Water Beetle' is in operation	To evaluate noises while 'Water Beetle' is in operation	Noise prevention measures

(1) Analysis on water quality

Analysis on water quality was performed in the middle and deep layer at the center of the river at four points: 5m (SP1205) below the self-tilting weir (SP1210), 32m (SP1242), 102m (SP1312), and 252m (SP1462) above the weir. Measurements were made five times in terms of eight items including: the DO concentration, biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS), total nitrogen (T-N), total phosphorus (T-P), ammonium nitrogen (NH_4-N) and nitrate nitrogen (NO_3-N).

For analysis, water was sampled from the middle and deep layer at the center of the river at each survey point. Indoor analysis tests were conducted on the sampled water in accordance with JIS standards.

(2) Continuous Observation of Water Quality

Observation of water quality was made for the deep layer water at the center of the river at two points, 32m (SP1242) and 252m (SP1462), in terms of two items, including the water temperature and DO concentration. Measurements were made for each hour for a period of two months starting from August. For this analysis, continuous observation meters for water temperature and DO concentration were installed at two points to automatically record the water temperature and DO concentration for each hour.

(3) Cross-Sectional Observation of Water Quality

Analysis on water quality was made in three depths (surface, middle and deep layers) at the left-side, right-side and center of the river, at a total of 66 points; 2m (SP1212), 32m (SP1242), 52m (SP1262), 72m (SP1282), 102m (SP1312), 132m (SP1342) 152m (SP1362) and 252m (SP1462) upstream of the self-tilting weir. The cross-sectional observation was performed eight times on two items, including water temperature and DO concentration. For the analysis, a handy water temperature/DO concentration meter was lowered from a boat to the specified depth and fixed at each observation point to record the water temperature and DO concentration in a field note.

(4) Measurement of Noise

Measurement of noise was made at three points for each Water Beetle: at the noise source (No. 1), at the river boundary (No. 2) and a residence nearest to the Water Beetle (No.3).

The test was conducted using a normal sound level meter (JIS C1502) and a level recorder (JIS C1512) in accordance with JIS Z 8731 "Noise level measurement method". A microphone was installed level to the Water Beetle at the noise source point and 1.2m above the ground at other points.

RESULTS ON WATER QUALITY ANALYSIS

Table-2 shows the results of water quality analysis. Tomakomai River is classified as a Type-A river according to "Environmental Criteria for Preservation of Living Environment." The criteria of DO concentration, BOD and SS

Table-2 Results of Water Quality Analysis

SP	Criteria for Type-A River / Sampling Date / (Water Temperature °C)	DO (mg/L)	BOD (mg/L)	COD (mg/L)	T-N (mg/L)	NO_3-N (mg/L)	NH_4-N (mg/L)	T-P (mg/L)	SS (mg/L)
		7.5 or more	2.0 or less	—	—	—	—	—	2.5 or less
1205	H11. 6. 28 (14. 0℃)	9. 80	1. 2	3. 2	0. 74	0. 34	0. 22	0. 020	4
	H11. 7. 19 (15. 2℃)	10. 64	1. 3	3. 7	0. 53	0. 26	0. 17	0. 014	2
	H11. 8. 6 (13. 8℃)	8. 65	0. 9	3. 9	0. 47	0. 25	0. 17	0. 015	2
	H11. 8. 21 (17. 2℃)	9. 04	1. 0	2. 9	0. 63	0. 50	<0. 1	0. 026	2
	H11. 10. 9 (12. 5℃)	11. 79	1. 0	3. 2	0. 70	0. 32	0. 10	0. 018	2
1242	H11. 6. 28 (13. 2℃)	8. 40	1. 0	3. 0	0. 72	0. 36	0. 21	0. 019	3
	H11. 7. 19 (13. 5℃)	8. 60	0. 7	3. 7	0. 52	0. 31	0. 14	0. 014	2
	H11. 8. 6 (13. 8℃)	7. 47	0. 6	3. 5	0. 65	0. 33	0. 17	0. 018	3
	H11. 8. 21 (16. 5℃)	6. 44	<0. 5	2. 0	0. 67	0. 62	<0. 1	0. 015	4
	H11. 10. 9 (11. 6℃)	10. 04	0. 8	3. 1	0. 66	0. 33	0. 15	0. 016	2
1312	H11. 6. 28 (14. 7℃)	8. 73	1. 1	3. 8	0. 68	0. 31	0. 19	0. 020	4
	H11. 7. 19 (13. 3℃)	9. 70	0. 8	3. 5	0. 60	0. 34	0. 14	0. 018	4
	H11. 8. 6 (13. 8℃)	7. 38	0. 6	3. 7	0. 67	0. 34	0. 10	0. 020	5
	H11. 8. 21 (15. 6℃)	7. 23	<0. 5	2. 7	0. 66	0. 62	<0. 1	0. 013	4
	H11. 10. 9 (11. 5℃)	8. 06	0. 7	3. 2	0. 66	0. 33	0. 15	0. 017	4
1462	H11. 6. 28 (16. 7℃)	8. 52	1. 2	4. 3	0. 62	0. 26	0. 17	0. 022	4
	H11. 7. 19 (14. 0℃)	10. 60	0. 6	3. 4	0. 64	0. 34	0. 14	0. 017	3
	H11. 8. 6 (13. 7℃)	7. 15	0. 6	3. 5	0. 71	0. 34	0. 15	0. 018	4
	H11. 8. 21 (15. 9℃)	8. 10	1. 0	5. 0	0. 65	0. 62	<0. 1	0. 017	14
	H11. 10. 9 (11. 1℃)	8. 65	1. 3	5. 4	1. 10	0. 38	0. 12	0. 052	35

: Over the criteria

concentration for a Type-A river are listed in the table. Values that did not meet the required criteria are enclosed and highlighted by a thick frame.

The results of water quality analysis of the Tomakomai River show that there is no significant departure from the environmental criteria for Type-A rivers. Comparing measured values of the SS concentration before June 28, when the Waters Beetles were installed, and after show no significant change at all measurement points. The measured values are changed in a range between 2 and 14mg/L throughout the operation period (July 1 through September 30), meeting the criteria for the Type-A river. Noting little change in the SS concentration, the Water Beetle does not stir bottom sediments.

The measured value at SP1462 is 35mg/L after the shutdown of the Water Beetles, excels the criteria for the Type-A river. This is probably attributive to the fact that the depth to sample water was changed to a deeper layer after August 6. Since longer time has passed since dredging at SP1462 compared with other points, it is likely that more sediments have been deposited in the river floor at SP1462. For this reason, sludge was suspended in the deeper layer, possibly causing the contamination of suspended solids into the sampled water.

RESULTS ON CONTINUOUS OBSERVATION ON WATER QUALITY

In preparation for continuous observation on water quality, meteorological data in the Tomakomai area was gathered for the period of July 1 to September 30 of 1998 and 1999. This data was for the purpose of evaluating the measurement result in correlation with weather data. (Fig-4 shows temperatures alone from among the weather data.).

Comparison was made on the DO concentration measurement for 1999 and 1998, taking the Water Beetle shutdown period and operation period into consideration. While the DO concentration in the shutdown period is almost at the same level both years, the DO concentration in the operation period is generally higher in 1999 than in 1998.

The water temperatures are higher in 1999 than 1998, probably because of hotter temperature and longer duration of sunshine in 1999. In general, under the same oxygen saturation, the higher the water temperature, the lower the oxygen solubility is. From this, it follows that the DO concentration becomes lower with the increase in the water temperature. Without any countermeasures taken, the DO concentration would have been lower in 1999 if water temperature alone were taken into consideration. This will lead to the conclusion that the higher DO concentration in 1999 is attributable to the Water Beetle. This estimation is supported by the fact that the DO concentration in the Water Beetle shutdown period in 1999 is almost the same as in 1998.

Results of cross-sectional observation on water quality

A cross-sectional observation on water quality was made of the survey area one month after starting operation of the Water Beetles, then one week after the temporary shutdown, and finally one month after re-starting the operation.

(1) One month after starting the operation of the Water Beetle
The criteria for Type-A rivers (7.5 mg/L or more) is mostly satisfied in the survey area. The DO concentration distribution in the survey area is 6.44 – 8.75 mg/L in the surface layer, 6.39 – 9.24 mg/L in the middle layer, and 6.66 – 9.42 mg/L in the deep layer. There is no sign of drastic changes in DO concentration in the survey area with a tendency of increase in DO concentration with the increase in depth.

(2) One week after the temporary shutdown
The DO concentration is lower in the deeper layer and the upstream surface layer of the upstream-side Water Beetle. In particular, the DO concentration is decreased to 2.46 – 3.25 mg/L in the deeper layer in an area between the bridge pier and the upstream-side Water Beetle (SP1282) at the center and left-side areas of the river.

(3) One month after re-starting the operation
The DO concentration is 6.87 – 8.57 mg/L in the survey areas. There is no sign of drastic change in DO concentration in the survey area, with a tendency toward increase in DO concentration in the River's greater depth.

Examining the changes in DO concentration during the above periods, the DO concentration is decreased as a whole in one week following the temporary shutdown. The tendency is remarkable particularly in the deeper layer. In one month after re-starting the operation, the DO concentration tends to have a higher level of increase in the deep layer where there was a drastic decrease in the DO concentration during the temporary shut down. This increase in the DO concentration would not be possible without the action of the Water Beetle.

In regard to the DO concentration distribution in the first period, there is an area of significantly higher DO concentration between two Water Beetles installed 100m apart. The same effect is confirmed in the 50m-area between the downstream-side Water Beetle and the self-tilting weir. From the above observation, it is considered that the Water Beetle works effectively to increase the DO concentration in an area within a 50m-radius in this area.
When operation of the Water Beetle was halted, the DO concentration decreased in a deep layer just below the bridge pier. However, when the Water Beetle was restarted, the DO concentration was increased in any part of deep layers of the river regardless of the presence of a bridge pier. It is therefore clear that bridge piers do not negatively impact effectiveness of the Water Beetle.

Results of Survey on Noise

Table-3 shows measurement results of the noise level. The purpose of this survey is to evaluate the extent of noises that might affect the life of local residents. In measurement results in this survey, no significant difference is noted in terms of L50 and Leq values both in the background noise and in-service noise either upstream or downstream.

In measurement during the daytime, no particular change in the noise level is observed in any place upstream of the installation site. In the downstream area, the noise level is larger at No.2 (river boundary) and No.3 point than at No.1 (noise source). The downstream noise level is larger than the upstream noise on the whole. This is caused by the combined effect of noises from automobiles running over the bridge and noises of water running through the self-tilting weir in the downstream areas.

In measurement during the nighttime, the same tendency as for the daytime measurement is noted both in the upstream and downstream areas.

From the above description, it can be concluded that major factors of the noise level measured in this survey are noises from automobiles or noises from water running through the self-tilting weir and that the noise from the Water Beetle has little effect upon the noise level. As a conclusion, it can be stated that the noises from the operation of the Water Beetle has no adverse effect upon the life of residents.

The results of this survey are summarized below.
(1) The comparison between the water quality analysis and "Environmental Criteria for Preservation of Living

Environment" indicates that there is no significant departure from the Type-A Environmental Criteria in the water quality of the Tomakomai River. No stir-up of base sediments by the Water Beetle is observed.

(2) The continuous observation of DO concentration for1999 was compared with the DO concentration measured before the use of Water Beetle (1998). No notable difference in the DO concentration was observed between 1998 and 1999 while the Water Beetle is not in operation. In the meantime, the DO concentration for 1999 was higher while the Water Beetle was in operation than the measured value in 1998.

(3) Changes in the DO concentration after starting operation of the Water Beetle were examined. The DO concentration was decreased on the whole and particularly significant in the deep layer in one week after the temporary shutdown). The DO concentration distribution one month after restarting the operation of the Water Beetles shows the highest increase in the DO concentration in the deep layer where the largest decrease was observed during the temporary shut-down period. It was shown that the Water Beetle produces an effect to enhance the DO concentration over a range within a 50m-radius in the survey area.

(4) No significant difference was noted in the noise level in terms of L50 and Leg values around a residence nearest to the installation site, both in the background and in-service noise and in the upstream and downstream areas.

From all these results of measurements and observation, it can be concluded that the Water Beetle can enhance the DO concentration in deep layers by stirring and circulating river water and that the Water Beetle exerts effects in an area within 50m radius in the survey area. There was no notable observation of stir-up of bottom sediments and noise pollution by the Water Beetle in the test run in the survey area.

Acknowledgement: Mr. Masaki expresses appreciation to all who assisted and supported this case study.

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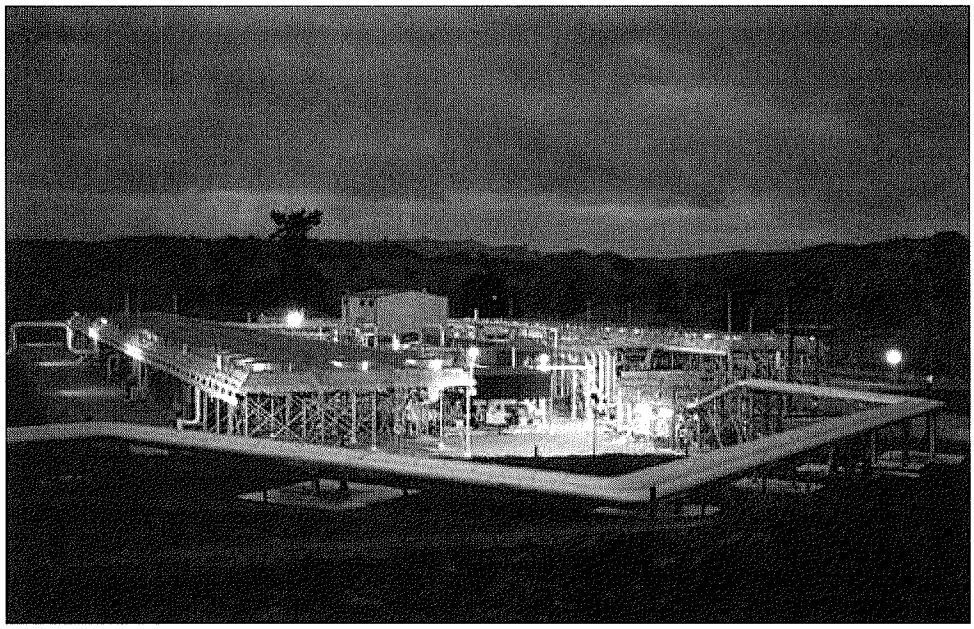
GEOTHERMAL ENERGY PLANT COMMISSIONED BY MAORI

A High Pressure, Sustainable and Environmentally Benign Power Plant

Mr. Hilel Legmann



The 60 MW Mokai geothermal project is one of a number of new geothermal projects being developed in New Zealand by the private sector, following the deregulation of the electricity industry. What makes the project unique is the ownership structure. The development is owned by Maori, indigenous people. The technology allows economic development of high-pressure geothermal resources.

New Zealand lies in the Southwest corner of the Pacific's "ring of fire"; the chain of volcanic activity which extends up through the Pacific Islands, Indonesia, the Philippines, Japan, Alaska, the West coast of the US, and down to the tip of South America. The main geothermal area is centred near the towns of Taupo and Rotorua, and the geothermal activity is of volcanic origin with some of the volcanoes still active.

Some of the world's early geothermal development was undertaken in New Zealand, with the Wairakei project (currently 156 MW) being the first large-scale development of a water-dominated geothermal field. Construction of the first station commenced in the mid 1950's, with the original layout allowing for the installation of a plant to produce heavy water for the British nuclear program. This was dropped before station completion, but its influence is still present in the multiple steam pressures of the older station.

The Rotorua-Taupo Geothermal Region

There is geothermal activity spread over both islands of New Zealand, with the main high temperature fields associated with the volcanic activity in the Rotorua-Taupo area. Most of the other geothermal activity in the country is of tectonic origin, and the heat flows and temperatures are not sufficient for commercial power generation.

The original settlers of New Zealand, the Maoris, who arrived about 800 years ago from the Island of the Central Pacific, used the natural geothermal springs for bathing and the very hot springs and geysers for cooking. There have been a number of major volcanic eruptions in the region, the most recent being the Tarawera eruption of 1886 which destroyed the world famous Pink and White Silica Terraces. The largest volcanic eruption, around 400 AD, formed Lake Taupo. The latter eruption was one of the largest known eruptions, with the ancient Chinese recording the impact of the emitted ash on their weather.

The major geothermal fields of the Rotorua-Taupo area are identified in Figure 1. The Wairakei, Rotokawa, Kawerau and Ohaaki fields have been developed for commercial power production as detailed in Table 1, and the Mokai field is currently being developed by an initial 60 MW plant.

Station	Location	Geothermal Field		Net Capacity MW	Output GWh	Year Commissioned
Wairakei	Taupo	Wairakei	156	1,300		1959-63
Tasman Paper	Kawerau	Kawerau	8	60		1959
TG1	**Kawerau**	**Kawerau**	**2.6**	**18**		**1989**
TG2	**Kawerau**	**Kawerau**	**3.8**	**28**		**1993**
Ohaaki	Reporoa	Broadlands	80	750		1989
McLachlan	Taupo	Wairakei	53	280		1997
Rotokawa	**Taupo**	**Rotokawa**	**27**	**200**		**1997**
Ngawha	**Wangharei**	**Ngawha**	**12**	**100**		**1998**
Mokai	**Taupo**	**Mokai**	**57**	**475**		**2000**
Totals			**323.8**	**2,625**		

Table 1: New Zealand's Geothermal Generating Plants

The Mokai Geothermal Resource

The Mokai geothermal field is a deep, high temperature field located approximately 25 km northwest of Taupo within the conspicuous western margin of a large volcanic-filled topographic depression. The investigation wells drilled in this field by the New Zealand government (the Crown) have encountered intracaldera volcaniclastics of significant vertical and horizontal permeability to a depth of over 160 m. It is generally held that the Mokai geothermal system occupies these volcaniclastic as an up flow of geothermal fluids in the vicinity of Mokai and a related northward outflow influenced by the regional groundwater hydrology. The surface hydrothermal manifestation in the vicinity of the Mokai wells is relatively minor, and is confined to features characteristic of steam heating. Warm chloride springs occur in the fault-aligned Waipapa steam gorge about 5 km north of the drilled area.

A northeast-trending fault system crossing the caldera's floor has been interpreted as a major source of vertical permeability. Enthalpies measured quickly stabilized at 1450 kJ/kg and the well chemistry indicated high temperatures for the production zones, as well as for the reservoir (350°C and 325°C respectively). The field has an estimated capacity of over 250 MW, with the initial development being a 60 MW station to allow for careful monitoring of the resource before any further development is undertaken.

The Project Structure

The project is unique in its structure and technology: the former brings the indigenous Maori people into the project as a developer and owner; and the latter provides effective use of the high-pressure steam from this resource. The Tuaropaki Trust administers the Tuaropaki E land at Mokai for the benefit of its owners. Initially the land was developed for pastoral farming under the direction of trustees and management of the Department of Maori Affairs. In 1979 development and sole responsibility for the land was vested in the trustees. The Trust purchased the Crown's interests in 1996 and decided to develop the field. After considering different options and project structures, including the lease of the land to developers or participation in a project together with other partners, the trustees decided that the Tuaropaki's best interests were kept when the Tuaropaki people, themselves, acted as owner and developer.

The Trust undertook a thorough review of various plant configuration and technology options, and decided finally in favor of the Geothermal Combined Cycle configurations using both the steam and brine components of the geothermal fluid. The plant configuration selected was the more flexible and modular Geothermal Combined Cycle technology, which uses a backpressure steam turbine and binary plant to capture the best features of each technology. The turnkey contractor and supplier of the equipment for the 60 MW plant was the ORMAT Group of Companies. Mighty River Power entered into an agreement with the Trust to provide a guaranteed minimum floor price for the electricity produced and for the supply of the Operation and Maintenance services for the plant. Additional production well and reinjection wells were required for the project and a contract for well drilling and testing was awarded to Century Drilling. Westpack Banking Corporation arranged construction and long-term financing for the development.

Project Design

The project has four production wells of approximately 2000-metre depth, producing a two-phase fluid, which is piped to a separator at the station. Steam is separated from the brine at 18 bar and both the steam and the brine are used for electricity generation. The condensed steam is pumped up to the brine pressure, combined with the high-pressure brine, and reinjected with no further pumping. There are three reinjection wells of around 500-metre depth, one of which was constructed using two of the original field exploratory wells.

To maximize benefits of the high steam pressure, a General Electric backpressure turbine of 32 MW output is utilized to reduce the steam pressure to approximately 1.3 bar. This low-pressure steam is condensed in four bottoming ORMAT® ENERGY CONVERTER binary units of 6 MW output each. This configuration, referred to by ORMAT as a Geothermal Combined Cycle Unit, has the advantage of the low capital cost of a simple backpressure turbine, and of condensing the steam in a tube and shell heat exchanger where steam wetness is not a problem. Two additional ORMAT® ENERGY CONVERTER binary units, also of 6 MW output, were installed, utilizing the hot brine flow and cooling it from 219°C to 150°C. The motive fluid in the binary units is pentane and cooling is effected by air-cooled condensers.

Station Parameters

Steam turbine output	31,1 MW
Binary bottoming units output	4 x 6 MW
Binary brine units output	2 x 6 MW
Net output	57 MW
Annual energy output	475 GWh

Heat and Mass Balance

The geothermal steam exiting from the separator and the brine flowing into and out of the brine binary unit have the following average conditions:

Steam flow rate	308 t/hr
NCG flow rate	4 t/hr
Steam quality ex separator	99.98%
Steam pressure; separator outlet	18 bar (a)
Steam temperature; separator outlet	208 °C
Brine flow rate	860 t/hr
Brine inlet temperature	207 °C
Brine outlet temperature	150 °C
Design ambient air temperature	12 °C

Main Equipment Description

The GE steam turbine is a backpressure, multi-stage, and reaction-type turbine. The turbine housing, shaft assembly and nozzle ring were designed to ORMAT's specification for operation with geothermal steam.

Level I Steam Turbine & Generator

Steam turbine type	GE multi stage, single cylinder reaction
Steam inlet pressure	18.6 bar(a)
Steam outlet pressure	1.3 bar(a)
Speed	3000 rpm
Construction	Horizontal split casing
Generator rated output	32 MW
Voltage	11 kV, 3 phase, 50 Hz
Power factor	0.85 (lagging)
Efficiency	97.5%

Manufacturer	GE

Level II ORMAT®Energy Converter

Organic vapour turbine type	Impulse
Speed	1500 rpm
Construction	Horizontal (overhung) vertical split casing
Number of stages	2
Motive fluid	Pentane
Generator rated output	6 MW
Voltage	11 kV, 3 phase, 50 Hz
Speed	1500 rpm
Efficiency	97%

The power plant consists of the geothermal combined cycle unit, the brine driven OEC unit, plus the following main systems:

- Power plant geothermal fluid gathering and reinjection system
- Auxiliary systems
- Electrical systems
- Main station control
- Fire fighting systems
- Auxiliary buildings
- High voltage T-line

The generator circuit breaker, control and auxiliary electrical equipment for each binary unit is housed in a container and was delivered to the site fully wired and pretested. This reduced construction time, and speeds up commissioning onsite. The overall station control is from a control room attached to the steam turbine building. The central station control computer utilizes software and graphics developed by ORMAT.

Construction Programme

The modular nature of this plant allowed a very short construction period onsite. All the binary turbines are mounted on simple low-level foundations. As the steam turbine has no attached condenser it too is mounted on a low level foundation, allowing a simple turbine building of modest size. The binary plant components were designed to be shipped in packages of standard container size, and, within days of the shipment arrival, the main components were bolted down and the air-cooled condenser erection was under way. The overall time programme for the plant development was as follows:

Notice to Proceed	February 1998
Delivery of turbine-generator	February 1999
Commissioned	December 1999

Environmental Impact

The station was designed to have minimal environmental impact. Under normal operating conditions, the geothermal fluid is completely contained from production to reinjection, with the only emissions being negligible quantities of steam emitted by the steam traps and the non-condensable gases emitted above the air coolers. The plant has a relatively larger footprint, but a much lower profile than a conventional condensing steam turbine, with an under slung condenser. The air cooler structures have a significantly lower profile than wet cooling towers and have the advantage of never producing a visible plume. In addition to its low profile, the plant has no water or chemical consumption and no blow-down of contaminated cooling tower water. The power generation technology implemented at Mokai fully complies with the

resource consents and is dedicated to the needs of a sustainable, environmentally benign and reliable geothermal power plant. Because the development is small, relative to the ultimate capacity of the very deep resource, it is expected that there will be little impact on the surface features. A comprehensive baseline-monitoring program was undertaken prior to project operation and an ongoing program monitors the field behavior.

Operation and Maintenance

Operation of the station was contracted to Mighty River Power to provide 24-hour operator coverage on a 12-hour shift basis. Only one operator is on duty during the day shift and one at night. Operators are required to undertake routine and emergency minor maintenance work as well as operational duties. An Operations Manager, who is also involved in the ROTOKAWA geothermal power station (a 27 MW geothermal combined cycle power plant supplied by ORMAT in 1997), supervises the station. During the first 12 months of operation the power plant and the geothermal resource fulfilled the owners expectations with an availability exceeding 97 % and a generated an output of over 58 MW.

Future Development

The Mokai field has been assessed as having a development potential of greater than 250 MW. This initial conservative development of 60 MW is not expected to have any significant effect on the resource, neither from a temperature/ pressure perspective nor from a surface environment perspective. However, before the joint venture partners embark on any further development, a program of environmental and reservoir monitoring is being undertaken to monitor reservoir and environmental changes. Subject to these impacts being within acceptable limits, the partners will look to the next stage of development.

Conclusion

The Mokai Geothermal Project is a working example of indigenous landowners developing their own resources through a partnership with a power company. In addition to the scientific resource modelling and resource behavior projections, there were two essential comfort factors, which were taken into consideration by the project developers:

- The use of a power generation technology which ensures the sustainability of the geothermal reservoir and avoids drainage of the resource and assures long term maintenance of the fluid level and characteristics of the field; and
- The option of a power plant configuration, which maximizes the use of the geothermal energy, minimizes the risk factors for the equity partners, and generates the highest possible income at the lowest possible operation and maintenance cost.

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http://wwwormat.com (URL)

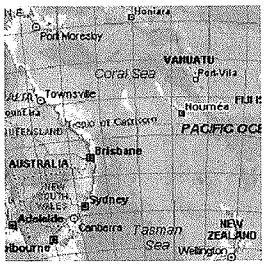
Mr. Hillel Legmann is a graduate of the Technical University, Aachen, Germany. He holds several patents for improvements in the industrial use of energy. He has written and presented papers on industrial waste heat recovery and on privately developed and owned geothermal power plants worldwide.

His accomplishments include: a 10 MW geothermal power plant in Iceland; the first 2.5 MW private geothermal generation facility at Kawerau, New Zealand; development of the first binary cycle heat recovery system for a city utility in the Peoples Republic of China; and a heat recovery concept for low temperature systems in the cement industry. Mr. Legmann developed and erected the world's first binary cycle heat recovery system for Heidelberger Cement in Germany.

WIND ENERGY OPPORTUNITIES IN LEAST DEVELOPED NATIONS

Mrs. Aurelie Fabre

Medium power diesel grids (50 kW to 1 MW) in remote sites show several limits: high fuel costs, difficult and costly operation and maintenance, and fossil energy dependence. Pines Island, New Caledonia, is one of these windy sites difficult to access.

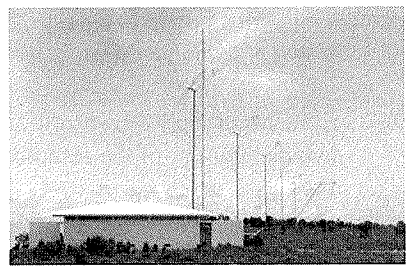


In 1999, to solve Pines Island energy problems and to meet ENERCAL New Caledonia Power Utility demand, French manufacturer Vergnet, installed three GEV15/60 wind turbines which are producing 60kW @ 14m/s. The three turbines (180kW) increase the autonomy and secure the quality of energy supply, thanks to an annual wind production of 350,000 kWh.

With a unique high-efficiency wind diesel system, which enables a maximized wind energy penetration rate, Vergnet wind turbines permit instantaneous wind power penetration, up to 70% into diesel grids (i.e. annual mean energy penetration up to 30%).

The maintenance and operation of the wind farm is entirely ensured by local technical staff, trained by Vergnet and its after-sales service team. Using a free and abundant local resource, the wind, Vergnet found an economic alternative to the diesel gensets, saving up to 115,000 liters of fuel per year. With this reliable and flexible solution, Vergnet supplies renewable energy for the island of 2,500 inhabitants.

The success of this project has been duplicated not only on remote islands, but also at many sites running diesel as a source of electricity. These are sites such as Guadeloupe (8 MW), French Polynesia, Cape Verde (150 kW), Morocco and other developing countries. Vergnet endeavors to supply energy to all remote areas, small villages that are not yet grid-connected or electrified with stand-alone electrification systems.



Wind blows almost everywhere, 24 hours a day, 365 days a year, however wind conditions vary from one site to another. To make the best use of this energy, the following two key points should be understood:

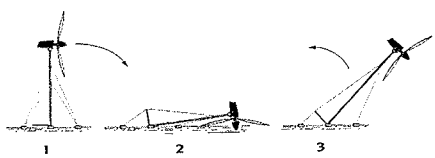
* The wind : It can be very powerful. This is the "fuel" of our system. Several parameters have to be taken into consideration before installing a wind turbine: intensity and regularity of the wind (daily, seasonal and annual variations), directional variations, and mean wind speeds. All these data depend tightly on the logging location and height. As a consequence, a pre-feasibility study is necessary to carry out a wind project.

* The wind turbine: It is responsible for transforming wind energy into mechanical energy. It has to be robust and reliable. It will be chosen according to both the wind quality and quantity measured on site and the energy needs.

How does a wind turbine work? A wind turbine transforms wind energy into mechanical energy and/or electrical energy to produce power.

Wind turbines were developed in 1945 according to two technologies. They can be:

- slow and multi-blade, which are generally used for small flow pumping .
- fast and two-blade or three-blade and combined with an electric generator .



Vergnet wind turbines are installed on a wireguyed tower that allows it to be pulled down very quickly (nearly 20 to 40 minutes), for maintenance or in case of high-speed winds (hurricanes, tropical storms...).

The French company, Vergnet SA, provides over 30 million people with its water or energy equipment. Vergnet wind turbines are economically viable solutions for power supply in decentralized stand-alone locations and adapted to wind diesel coupling. The wind turbine is able to work alone in remote areas, the batteries guaranteeing a continuous energy supply in case of a low-wind period, or it can be connected to the grid where it exists.

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Mrs. Aur?lie Fabre is a graduate of the European Business School of *Ecole des Praticiens du Commerce International* (EPSCI). As Projects Manager for Vergnet SA, the French manufacturer of wind turbines, she is working to develop the company's activities in Canada. Through partnership with Klimatair SA, Mrs. Fabre is involved in the development of renewable energy projects in Greece, where wind diesel systems, grid-connected farms and desalination demonstration projects are in progress. She has been selected by the European Commission to be evaluator in the framework of the Fifth Research and Development Program (5th PCRD), covering research technological development and demonstration activities for energy, environment and sustainable proposals.

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