The smart life

At the foot of Mt Taranaki a rural family is self-sufficient in energy. There's enough surplus to run a backpackers and a manufacturing business that exports hydro and wind turbines built around Smart Drives from washing machines.

Mechanical engineer Michael Lawley, his wife Linda and their two children are living their dream of a rural lifestyle based on renewable energy.

But they're not trying to scratch a living from a lifestyle-block smallholding.

The Lawleys run export business EcoInnovation from their four hectare property 18km inland from New Plymouth, employing one full-time and one part-time worker.

For a small charge and the cost of freight, Lawley ships crates of Smart Drives from Fisher & Paykel Appliances Ltd's recycling centre in Auckland.

He sets them up so that instead of converting electricity to mechanical energy for a washing machine agitator, they convert the energy of wind or flowing water to electricity.

The resulting generators are installed in off-the-grid applications in rural New Zealand and Australia and exported as far afield as India, Iceland and the United States.

Fisher & Paykel is happy because it disposes of unwanted Smart Drives collected as trade-ins, warranty claims or production seconds. Lawley gets top New Zealand technology

1 ECOINNOVATION'S **MICHAEL LAWLEY** WITH A FISHER AND PAYKEL **SMART DRIVE** STATOR (LEFT) AND ROTOR (RIGHT) THAT ARE THE CORE OF HIS **WIND TURBINE** AND **WATER TURBINE** POWER SYSTEMS.

THE DRIVES TRANSLATE THE **MECHANICAL ENERGY** OF A WATER WHEEL OR WIND TURBINE BLADES INTO **ELECTRICAL ENERGY**, THROUGH ELECTROMAGNETISM.

FISHER AND PAYKEL IS HAPPY TO **RECYCLE** ITS SMART DRIVES THROUGH ECOINNOVATION.

based on years of expensive research and development, which he can modify as a low-cost input for his products. And the customers get affordable generators.

Michael has visited Fisher & Paykel's engineers in Auckland and shown them the unanticipated uses to which their designs have been put.

The Lawleys supplement this business with the EcoInn backpacker accommodation where they host courses on setting up renewable energy systems. While attending the courses, the would-be system owners get a taste of what it's like to live with hydro, solar and wind.

Renewable energy saturates the Lawleys' lives. Their house, business and hostel are powered by a combination of hydro, solar and wind energy.

Michael Lawley says the first thing he impresses on his course participants is that if they live in town it's important to make their house as energy efficient as possible and get their average daily consumption and peak demand down.

Solar water heating is the most cost-effective household application of renewable energy, and anything beyond that is difficult to justify on economic grounds for grid-connected homes.

Rural dwellers should also be energy efficient and install solar water heating, but if they are ▶

2 THE HOUSE IS BUILT IN A **COMPACT SHAPE** TO MAKE THE BEST USE OF SPACE AND MATERIALS. DEEP FRAMING ALLOWED **EXTRA INSULATION** TO BE INSTALLED IN **WALLS AND CEILING.**

IT HAS TWO SETS OF **SOLAR PHOTOVOLTAIC MODULES** ON THE ROOF AND TWO ON FRAMES THAT HOUSE **BATTERIES**.

3 MICHAEL LAWLEY'S STUDENTS AT TARANAKI POLYTECHNIC MADE THE **3 METRE DIAMETER OVERSHOT WATER WHEEL** AS PART OF THEIR ENGINEERING COURSEWORK. IT SUPPLIES THE **BASELOAD** OF POWER FOR THE HOUSEHOLD AND STILL OPERATES EVEN WHEN **PARTIALLY SUBMERGED** IN A FLOOD.

4 THE THREE **WIND TURBINES** THAT INTEGRATE WITH SOLAR AND HYDRO AT THE LAWLEYS' FARM.

LEFT: A **1 KW SOMA WIND TURBINE**, WITH TWO BLADES AND A SPAN OF 2.7 MEETRES.

5 **CENTRE**: ECOINNOVATION'S OWN DESIGN, THE **SMART 400**, WHICH HAS FIVE BLADES AND 1.7 METRES SPAN.

RIGHT: A **LOW-COST CHINESE MODEL** THAT WORKS WELL AT **LOW WIND SPEEDS**. IT HAS THREE BLADES AND A 2.2 METRE SPAN.

6 A **HOME-MADE SOLAR WATER HEATER** SUPPLIES HOT WATER FOR THE THE **ECO-INN**.

faced with a hefty bill for connection to the grid, a full renewable energy system is worth considering.

Michael says if the property has a stream available with a good head and reasonable flows all year, hydro electricity is more cost-effective than wind, and solar photovoltaics come third.

Photovoltaics are continuing to come down in price, and in Michael's experience are totally reliable, with little difference in quality between solar arrays from China, India or France.

Hydro, solar and wind are complementary because when the waterways are depleted because of dry conditions, the sun is shining. When the skies are dull, wind and water are usually available.

Sustainable lifestyle

Michael was brought up in a city but had an inspiring uncle who "messed around with heat pumps and solar water heating." He has an honours degree in mechanical engineering from Bradford University in the UK. He and Linda moved to New Zealand from England during the Gulf War in the early 1990s, determined to strive for self-sufficiency in energy. Recent developments in the Middle East and closer to home have reinforced their decision.

At first Michael tutored at Taranaki Polytechnic. His students built the Eco Inn's three-metre diameter wooden waterwheel – which contains a Smart Drive and is mounted on a Holden rear axle – as engineering coursework.

He quit paid work to build the property's houses and for the last three years has concentrated on running the business.

The property has run on renewable energy for 10 years. The Lawleys began with a single wind turbine and now have 1.2kW of photovoltaics, which they plan to increase to 2 kW; wind power averaging 250W, with a maximum output of 2000W; and water output averaging 150-200W and supplying 3.6-4.8 kWh a day.

The photovoltaics are in four banks of 300W each: two on the house and two mounted on timber frames, one of which houses batteries.

The energy is stored in a large battery bank of 24 Volt batteries bought second-hand from Telecom. An inverter converts this into 230 Volt power for household use.

Home philosophy

The Lawleys' philosophy for building their home was to use recycled materials as a first option. If that wasn't possible, the materials should be sourced locally. Buying new from further afield was to be a last resort.

Before they built their present house, they built the home which is now the EcoInn Hostel. The lining and floors are plywood recycled from the floors of New Plymouth's TSB Stadium, giving it the ambience of a large tramping hut, and the cladding and framing are macrocarpa.

Downstairs the hostel has a a kitchen and dining area and a large open area with table tennis and pool tables, darts and table football . Upstairs are five bedrooms and an open plan lounge.

The Lawleys collected materials for the main house for a couple of years and waited for the timber to dry thoroughly before construction. "If you're not in a rush, things turn up," says Michael. They've even used some of the bearers that allowed the timber to aerate, as lintels above the doors.

The Tree House is a corrugated iron hut built into a large tree and approached on a scaffold made from a recycled transmission pylon. A flying fox makes it even more fun.

The property's water heating is mostly solar, but a third accommodation unit, the

7 A DEMONSTRATION **PELTON WHEEL-SMART DRIVE MICROHYDRO GENERATOR** SHOWS HOW MUCH WORK IT TAKES TO GENERATE THE POWER FOR A LIGHT BULB. PEOPLE WOULD NEED TO TURN THE HANDLES OF **10 MACHINES 24 HOURS A DAY** TO SUPPLY THE POWER NEEDED TO RUN A **TYPICAL HOUSEHOLD.**

8 A **TURGO** MICROHYDRO GENERATOR.

9 THE **SMART 400 WIND TURBINE**. THE ONE ON THE RIGHT SHOWS THE **SMART DRIVE**. THE **BLADES** ARE SPECIALISED IMPORTS BUT OTHER COMPONENTS – SUCH AS A STAINLESS STEEL SALAD BOWL – ARE **MASS-PRODUCED**.


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Eco Bach, has instant gas water heating. Michael says guests often don't want to wait till the woodstove heats the water for their hot showers.

The main house has a roof of zincalume previously used to wrap bundles of steel tubes. "It's got a few dents, but had no holes," says Lawley.

The floor rests on 100mm thick recycled polystyrene insulation. The wall and roof framing are double thickness to allow space for twice the standard amount of insulation. The Lawleys used fibreglass insulation because it was more affordable than their preferred material, wool. Piping laid into the tiled floor circulates solar-heated hot water, and a large woodstove has a wetback and heat recovery from the flue.

The stove runs on LPG, and the house has all the usual electrical appliances.

The windows and doors were cheap rejects from another house, and the Lawleys adapted the house design to accommodate them. The double-glazed skylights are recycled and locally milled macrocarpa has been used extensively, along with local river boulders.

The plumbing is all copper and recycled. The deck timbers came from a berry farm.

Wastewater from the bathtub goes to the washing machine, and Michael has made his own heat recovery unit for the shower.

The EcoInn's hot water is heated by an oversized home-made solar water panel made from recycled materials, and the outdoor spa pool – popular with guests on a starry night – is heated either by a fire beneath it or another large home-made solar panel. Small photovoltaic modules power fountain pumps to circulate water through the panels and feed it to the spa pool or hot water cylinder.


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The spa water is changed frequently rather than being heavily dosed with chemicals.

The Lawleys originally used a water ram for pumping water to a header tank. But when guests stayed the tapping noise was irritating, so an electric water pump now allows water to be pumped to a 35,000 litre header tank on an 18 metre hill. This gives the property a pressurised water supply using power that would otherwise be wasted.

The family doesn't operate a large vehicle – their car is an economical Suzuki Cultus – but they have a reliable network of couriers for the business. The Suzuki replaces an ex-ECNZ demonstration electric Toyota Starlet that cost $1 for 50 km-worth of charge (around 7kWh at 15 cents per unit) and gave more than 25,000 km of service on its original batteries.

Smart Drives and turbines

EcoInnovation sells three main products based on the SmartDrive: two types of hydro turbine (using a Pelton or Turgo wheel) and Lawley's own wind turbine design, the Smart 400.

What's special about the Fisher & Paykel Smart Drive?

Michael Lawley says the Smart Drive is ideal for his turbines because it is direct driven and is a good low-speed generator. It has no gearbox and has permanent magnets.

Fisher & Paykel designed the Smart Drive in the 1980s when they realised they had to come up with their own washing machine design if they wanted to be able to continue to manufacture cost-effectively. Their direct-drive motor design using plastic housing eliminated much of the weight of washing machines and got rid of the need for pulleys, gears and clutches, while providing a better more responsive wash for clothes.

Coupled with an intelligent water-cooled controller (later superseded), the patented Smart Drive produced a revolutionary new design for washing machines that has been patented in the US since 1991.

Fisher & Paykel's technical expert – product development Lindsey Roke says Smart Drive autowashers suit off-the-grid households because their power demand is smooth and they don't cause a large spike when starting up. They are also energy-efficient.

They sell 75 Peltons a year and fewer Turgos, but with a potential production output of one turbine a day would like to increase sales. The Pelton suits waterways with 5-130 metres of head and 0.25-8 litres per second of flow while the Turgo suits 3-15 metres of head and 5-20 litres per second of flow.

The Pelton works with standard black small-diameter pipe used on farms, while the Turgo requires larger more expensive PVC pipe.

The Smart 400 wind turbine uses standard mass-produced components. The fairing is a stainless steel salad bowl. The black five blades are off-the-shelf injection moulded plastics from the US that don't chip like fibreglass.

It is capable of generating more than 700W in high winds and 300-400W in 36 km/h winds.

The aluminium bearing holder that's a main component in all three EcoInnovation products comes from the outer bowl of Fisher & Paykel washing machines. Fisher & Paykel carves off most of the plastic around the bearing holder for recycling, then sends the holder to EcoInnovation. EcoInnovation then strips off the rest of the plastic.

Everything on site is done with an acute awareness of energy availability. The lathe operates to mill a batch of bearing holders when there's plenty of juice in the battery bank.

The Smart Drive stator rests on a bearing holder and the rotor goes on top to complete the assembly. Lawley says that by reconfiguring the windings he can make the motor 12 Volts, 24 Volts or 48 Volts and even 400 Volts.

With hundreds of thousands of Smart Drives made each year and millions operating worldwide, EcoInnovation is in no danger of running out.

Shelves in the workshop hold milled Smart Drive shafts stacked like firewood, and large wooden crates hold enough rotors and stators to meet years of demand.

The best-quality Smart Drives are Fisher and Paykel's "production waste" items that have never been used. EcoInnovation sells them to customers as part of a complete turbine.

Lawley packages those with cosmetic defects into an "inventor's kit" that he sells with a Smart Drive manual and EcoInnovation's test results to people who want to play around with the equipment and make their own applications at a reduced cost.

The Lawleys have found themselves becoming experts in Internet transactions and freighting goods worldwide.

Michael says the Pelton turbines have wide global appeal because the casing is light-weight, which makes the whole sub-20kg package cost-effective for export. Competitors' models made in China have cast-iron casings that make the cost of freight prohibitive.

EcoInnovation has a deal that if a customer buys two $1000 hydro generators, EcoInnovation pays the freight to anywhere in the world. This is equivalent to a $400 discount for buying two generators.

When selling to a worthwhile project in a developing country, Michael can supply say 100 turbines in a batch and freight them by sea, sending only the core components and leaving the final manufacture and assembly of the casing to be done by the recipient.

This means they can be sold at only $120 each, a fraction of the complete cost, and the local people get work.

Eco house energy features

- Deep timber framing allows space for extra insulation
- Underfloor is insulated with recycled 100mm polystyrene
- Walls and ceiling are insulated with two layers of high R-value fibreglass
- Compact house design is economical with space and materials
- Recycled materials are first priority; then locally sourced
- Underfloor heating is solar heated
- Double-glazed recycled skylights
- Waste heat is recovered from shower
- Second-hand wood fire has wetback and water-jacketed flue
- All electricity comes from renewable hydro, wind and solar
- Compact fluorescent lighting
- Water pump uses surplus electricity

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