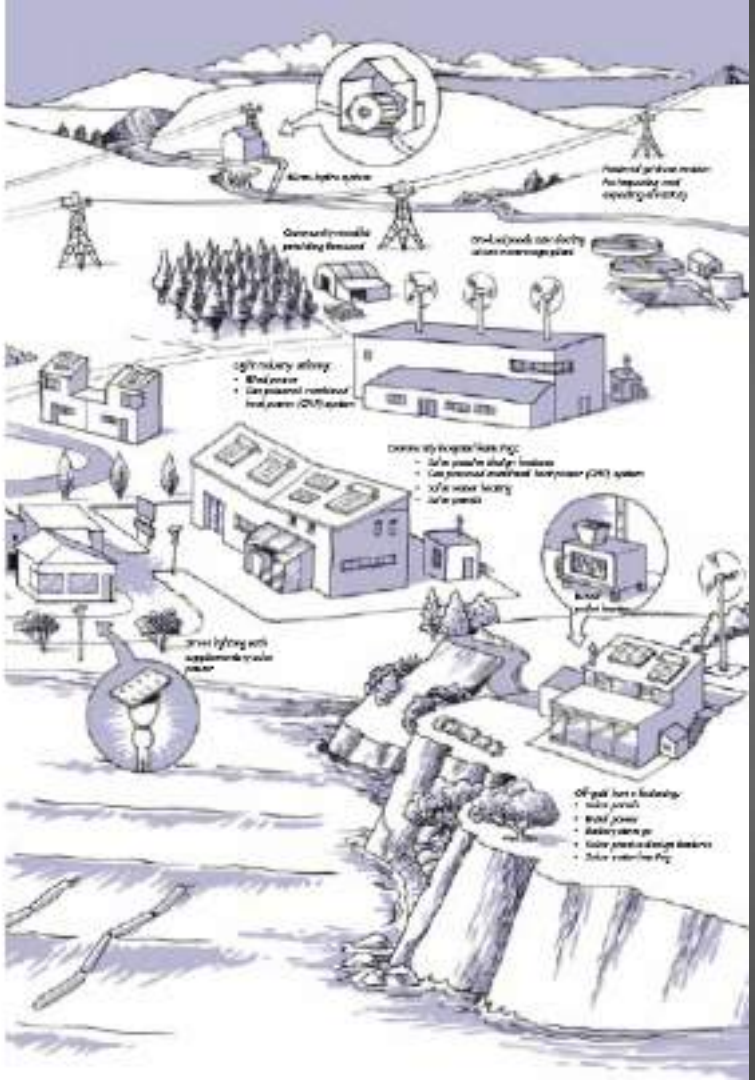
Small scale distributed wind: The Thinair turbine as a case study of the technical and commercial challenges of introducing an innovative renewable generation option.



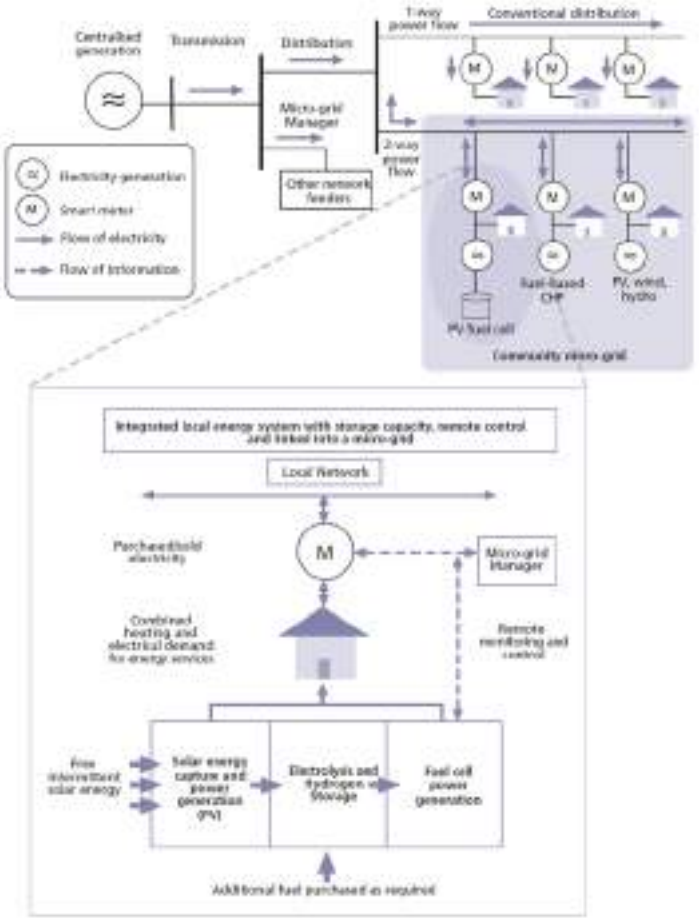


Figure 2.3 A micro grid within an existing electricity network

Source: Adapted from Gardiner, 2005

- We have designed a domestic scale wind turbine providing exceptional performance, reliability and potential for economic manufacture.

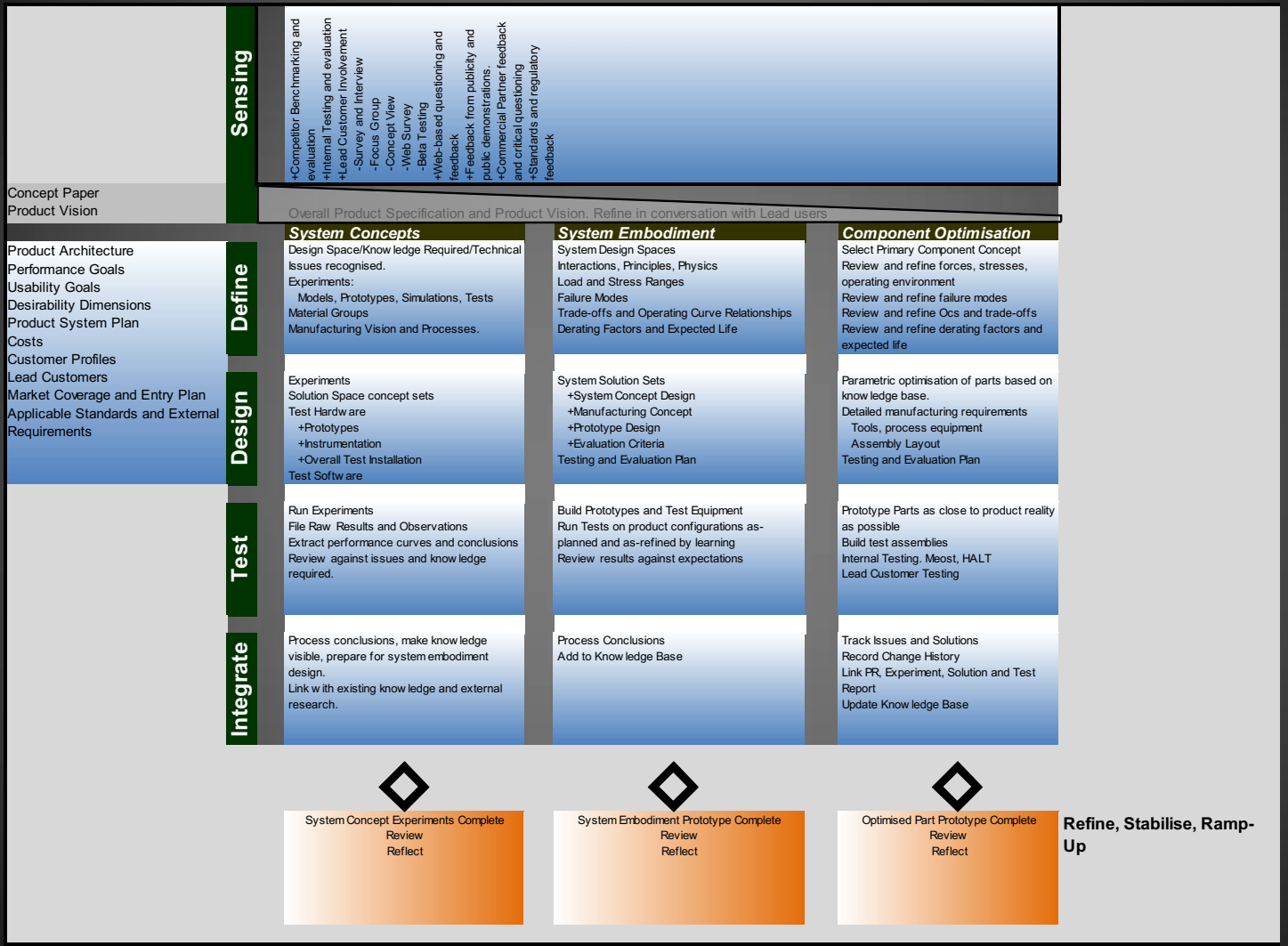
- Our aim is to give customers a viable complement to PV with the goal of facilitating houses and remote sites becoming net zero energy in all seasons and weathers.

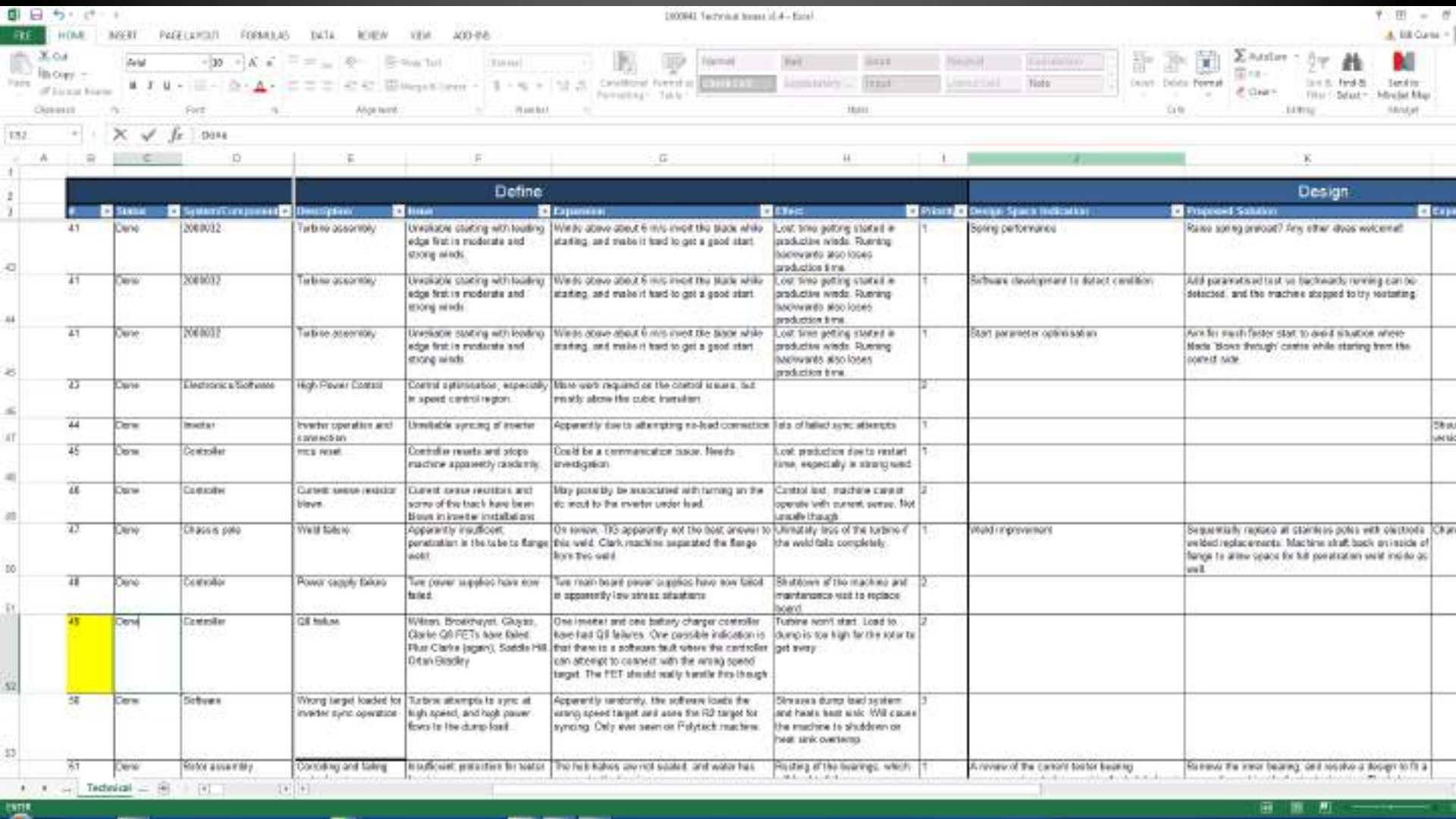
The turbine combines a high performance state of the art single blade rotor, a modular axial flux alternator and a proprietary control system – all carefully matched and designed for manufacturing and scaling.

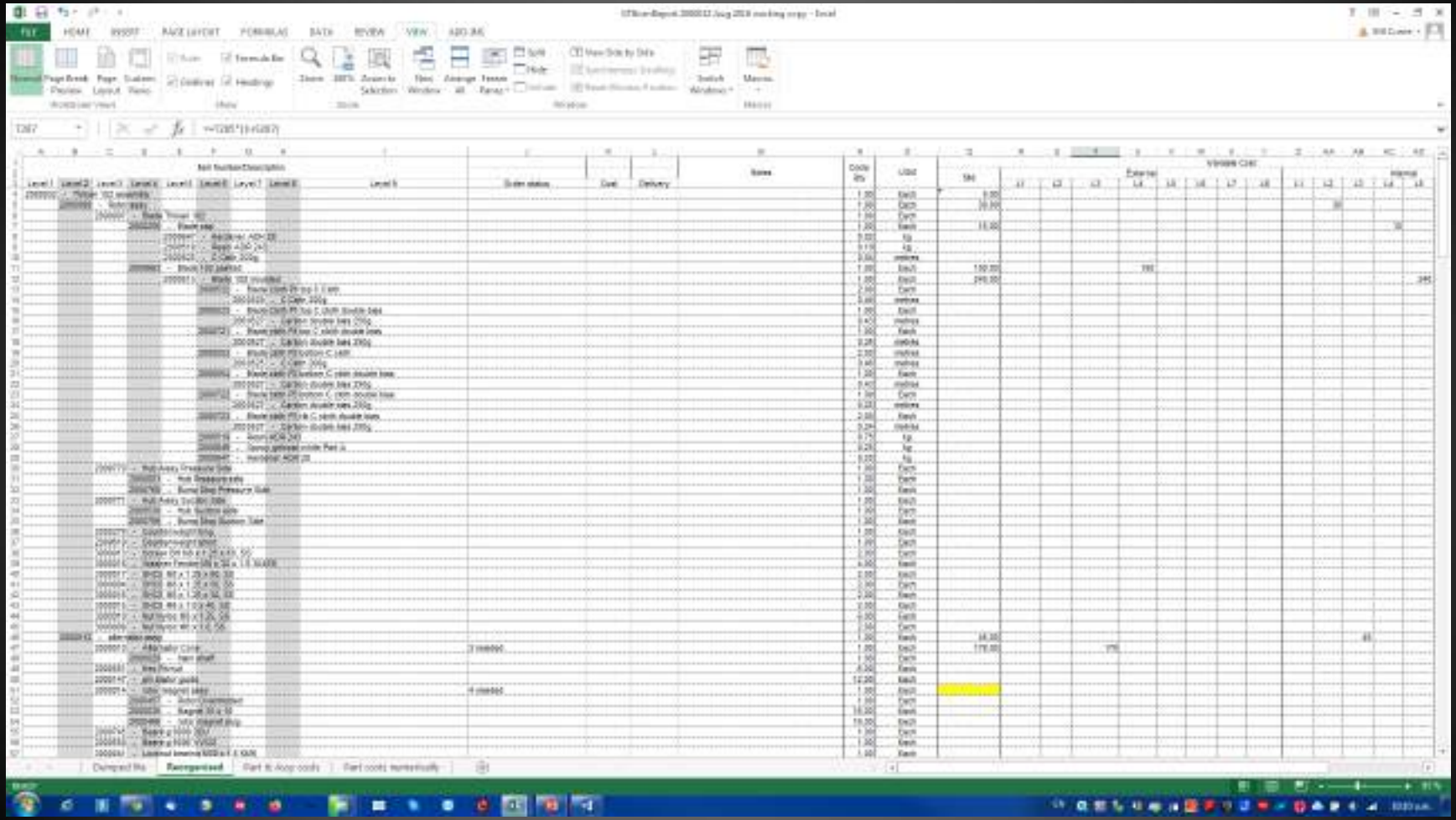
We have set the company up with methodical systems which should facilitate scaling:

- Solidworks for mechanical design with all parts modelled and stored in a pdm database.
- Pspice for the electronic design
- Sage for product BOMs and ERP functions.
- Careful problem solving for all issues from the field.
- ANSYS CFD modelling work done by the University of Otago to fill in our understanding of the flow and especially post stall flow behavior of the wing.

Figure 1: Product Development Process V1.0




Define
Design
| Status | System/Component | Description | Issue | Expansion | Effect | Priority | Design Space Indication | Proposed Solution
41 | Done | 2008032 | Turbine assembly | Unreliable starting with leading edge first is moderate and strong winds | Winds above about 6 m/s meet the blade while starting, and make it hard to get a good start | Lost time getting started in productive winds. Running backwards also loses production time | 1 | Spring performance | Raise spring preload? Any other ideas welcome!!
41 | Done | 2008032 | Turbine assembly | Unreliable starting with leading edge first is moderate and strong winds | Winds above about 6 m/s meet the blade while starting, and make it hard to get a good start | Lost time getting started in productive winds. Running backwards also loses production time | 1 | Software development to detect condition | Add parameterised test so backwards running can be detected, and the machine stopped to try restarting
41 | Done | 2008032 | Turbine assembly | Unreliable starting with leading edge first is moderate and strong winds | Winds above about 6 m/s meet the blade while starting, and make it hard to get a good start | Lost time getting started in productive winds. Running backwards also loses production time | 1 | Start parameter optimisation | Aim for much faster start to avoid situation where blade 'blows through' centre while starting from the correct side
23 | Done | Electronics/Software | High Power Control | Control optimisation, especially in speed control region | More work required on the control issues, but mostly above the cubic transition | | 2 | | |
44 | Done | Inverter | Inverter operation and connection | Unreliable syncing of inverter | Apparently due to attempting no-load connection | Lots of failed sync attempts | 1 | | |
45 | Done | Controller | mcu reset | Controller resets and stops machine apparently randomly | Could be a communication issue. Needs investigation | Lost production due to restart time, especially in strong wind | 1 | | |
46 | Done | Controller | Current sense resistor blown | Current sense resistors and some of the track have been blown in inverter installations | May possibly be associated with running on the dc input to the inverter under load | Control lost, machine cannot operate with current sense. Not unsafe though | 2 | | |
47 | Done | Chassis pole | Weld failure | Apparently insufficient penetration in the tube to flange weld | On review, TIG apparently not the best answer to this weld. Clark machine separated the flange from the weld | Ultimately loss of the turbine if the weld fails completely | 1 | Weld improvement | Sequentially replace all stainless poles with electrode welded replacements. Machine shaft back on inside of flange to allow space for full penetration weld inside as well
48 | Done | Controller | Power supply failure | Two power supplies have now failed | Two main board power supplies have now failed in apparently low stress situations | Shutdown of the machine and maintenance visit to replace board | 2 | | |
49 | Done | Controller | Q8 failure | Wilson, Brookmyer, Gluyas, Clarke Q8 FETs have failed. Plus Clarke (again), Saddle Hill, Orkan Bradley | One inverter and one battery charger controller have had Q8 failures. One possible indication is that there is a software fault where the controller can attempt to connect with the wrong speed target. The FET should really handle this though | Turbine won't start. Load to dump is too high for the rotor to get away | 2 | | |
58 | Done | Software | Wrong target loaded for inverter sync operation | Turbine attempts to sync at high speed, and high power flows to the dump load | Apparently randomly, the software loads the wrong speed target and uses the R2 target for syncing. Only ever seen on Polytech machine | Stresses dump load system and heats heat sink. Will cause the machine to shutdown on heat sink overtemp | 3 | | |
61 | Done | Rotor assembly | Corroding and failing | Insufficient protection for rotor | The hub halves are not sealed, and water has | Rusting of the bearings, which | 1 | A review of the current rotor bearing | Remove the inner bearing, and replace a design to fit a
Technical



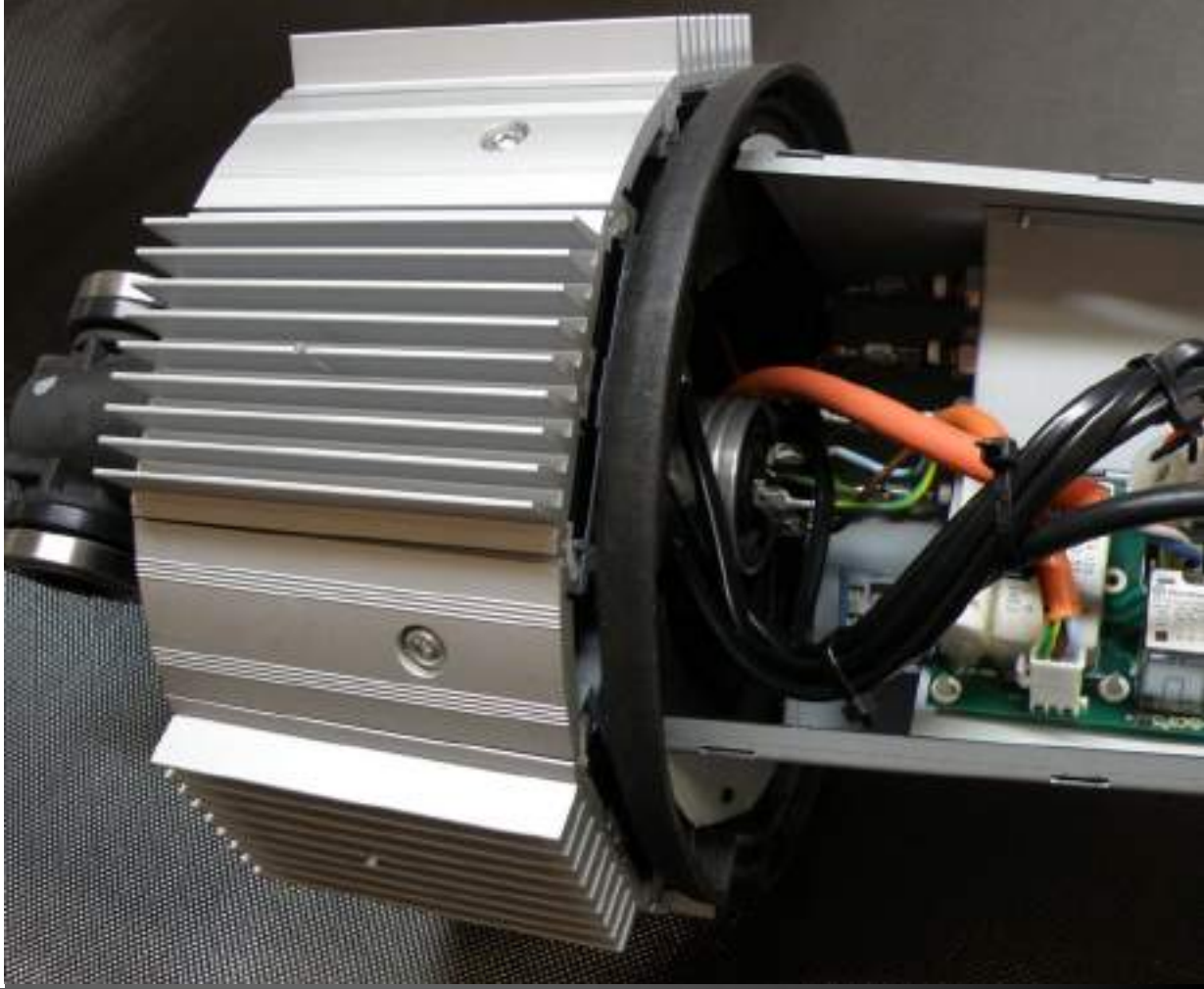
A lean approach to design results in a low parts count. The lightweight, single blade concept gives good material utilization. High voltage generation saves cable costs.

Potential to use high volume processes to manufacture major parts.

Potential to use common parts across a range of different sized machines.

Potential to adopt a distributed manufacturing model, where regional assembly sites produce turbines from a mix of local and centrally manufactured parts.

Potential to provide a ‘mass customised’ product range where a chassis frame size and blade wind speed rating can be closely matched to a customer’s requirements.



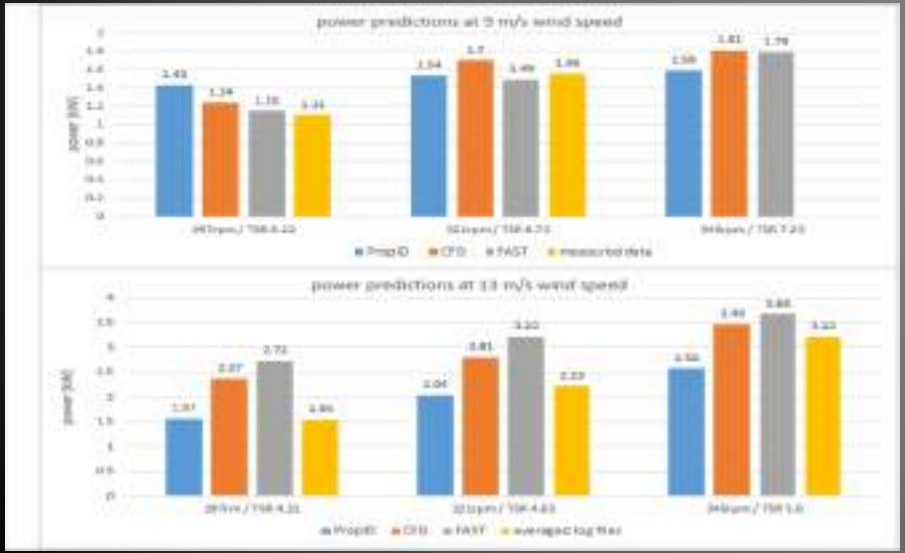
Another interesting benefit of the single blade design is that the tower top unit can be packed and shipped fully assembled.

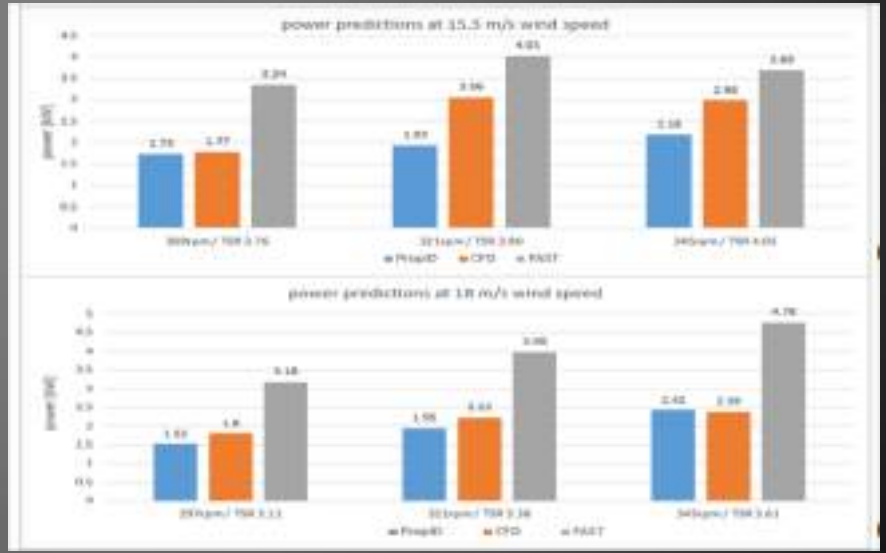
The simple mechanical design combined with sophisticated electronics and software create a system that once installed can be left to self manage by the customer or host.

Systems and components are designed for simple field replacement, with many examples of plug replaceable systems for fast repair with limited skills.

IP connectivity means problems can be remotely identified and alerted. Good for service plan managed installations.

Verification and Validation

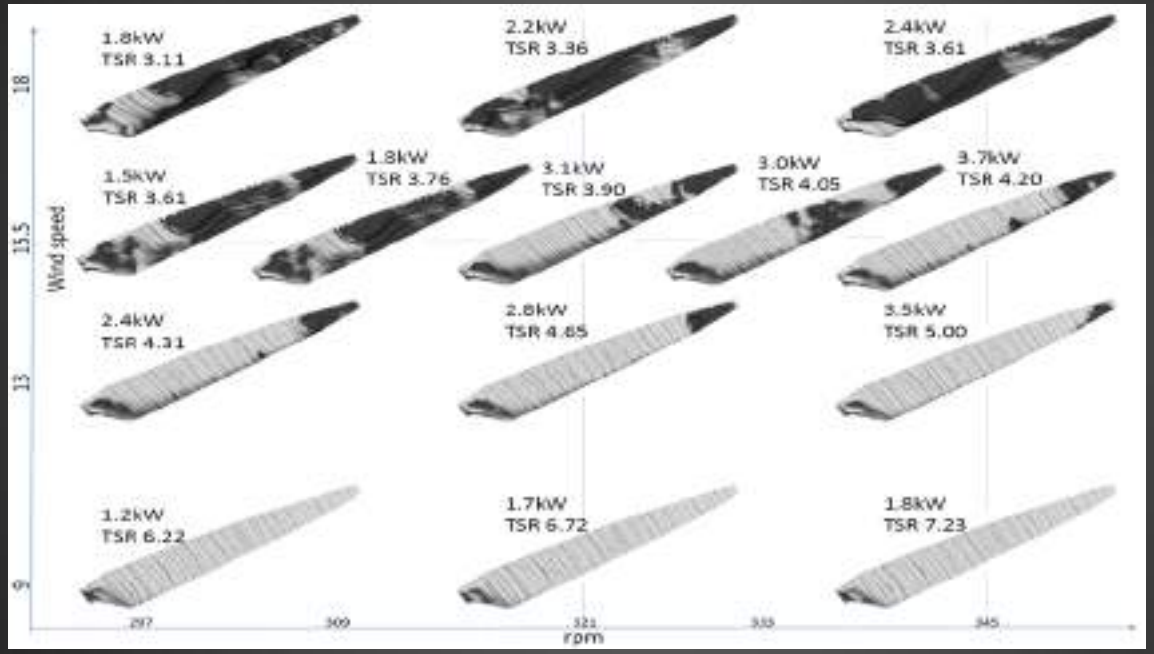


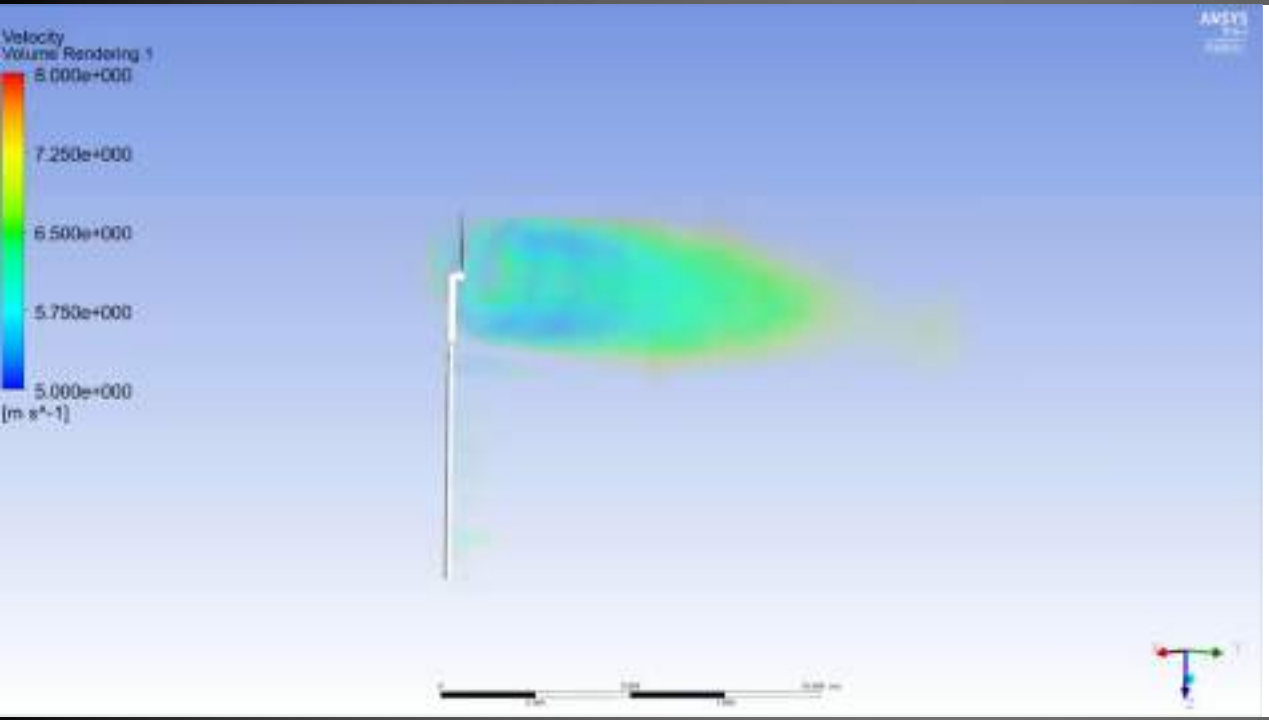


UNIVERSITY of OTAGO

Te Whare Wānanga o Otāgo

NEW ZEALAND





This clip shows the extreme lack of interference possible with a single blade.







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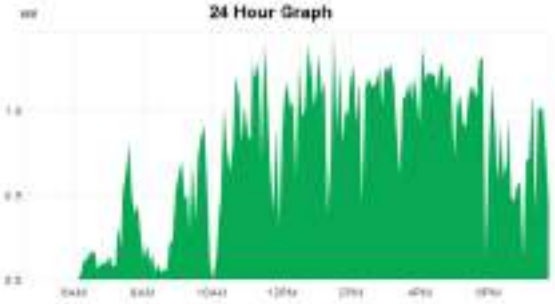
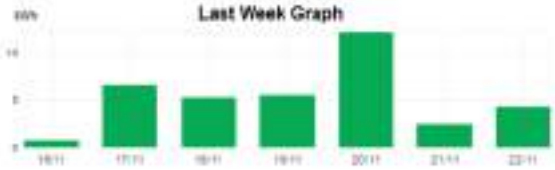
Yealands Est Thinair

Home
Charts
Settings

SOLAR GENERATING

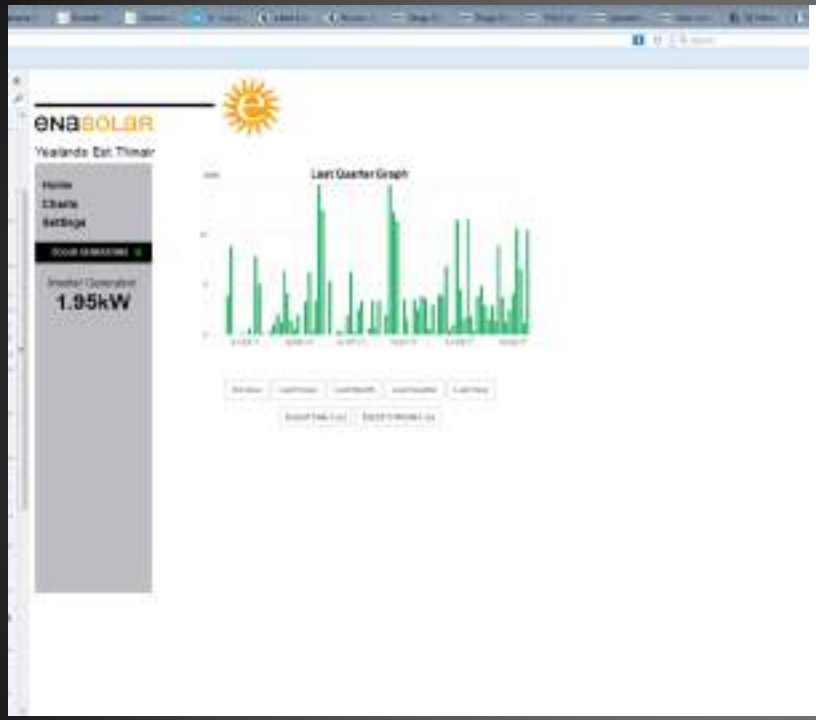
Inverter Generation
2.71kW



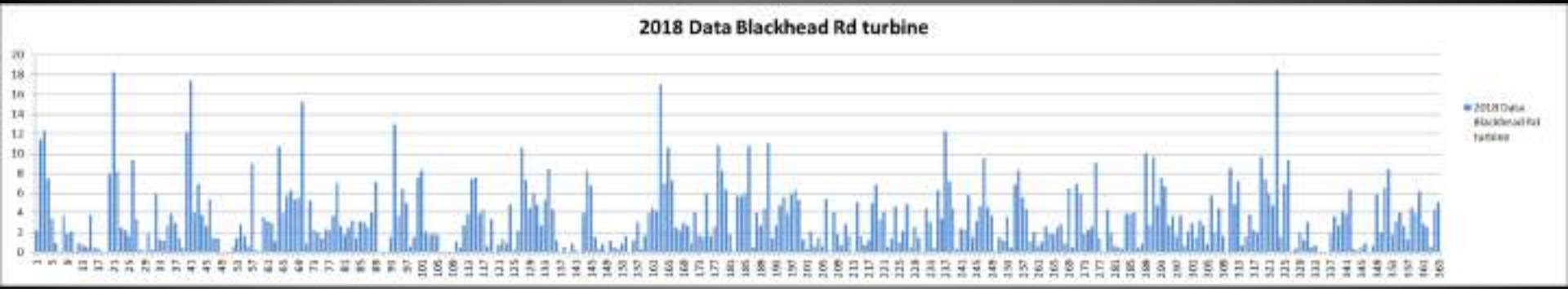


Total kWhs

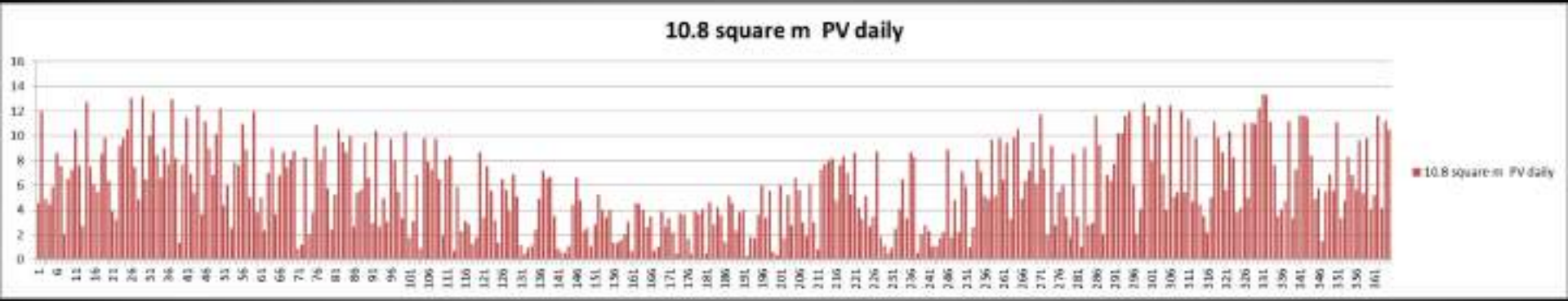
	Today	Yesterday	Average	Lifetime
Inverter Generation	10.58	4.36	3.58	1023



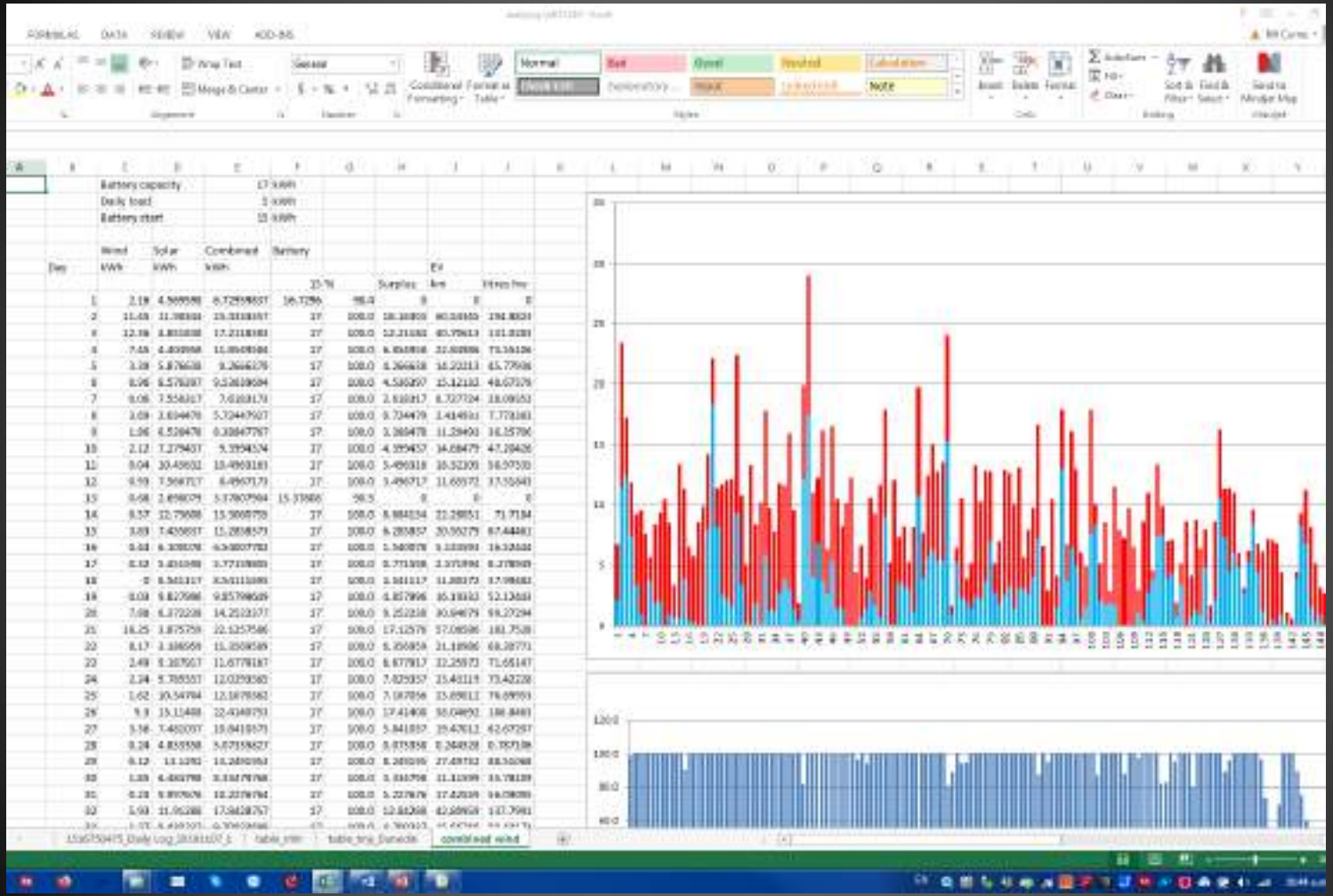
This screenshot shows the machine at 1.95 kW- and the daily record for the last 3 months.

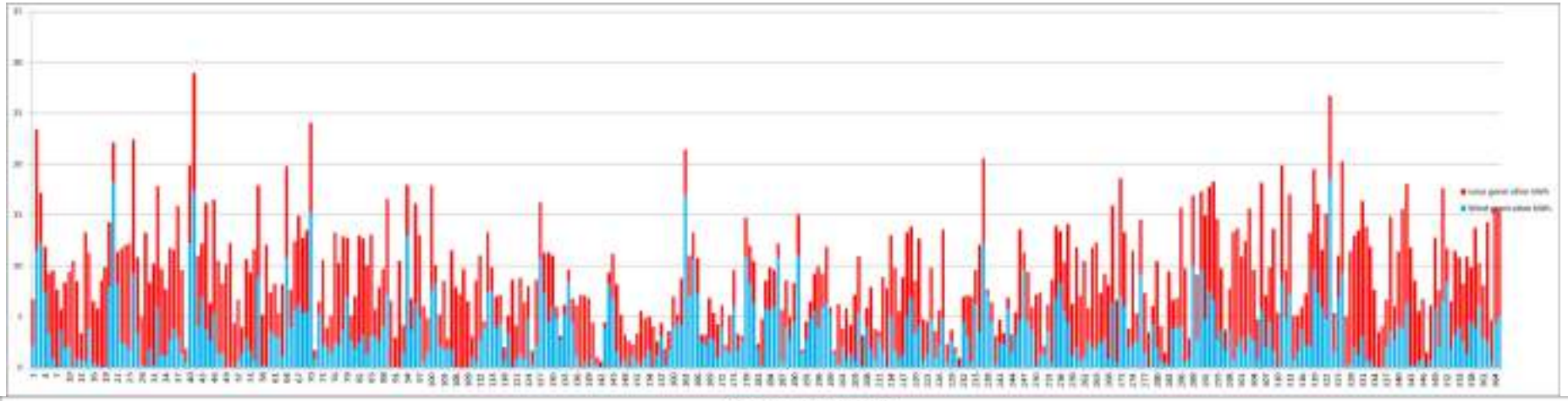

2018 Data Blackhead Rd turbine
2018 Data Blackhead Rd turbine

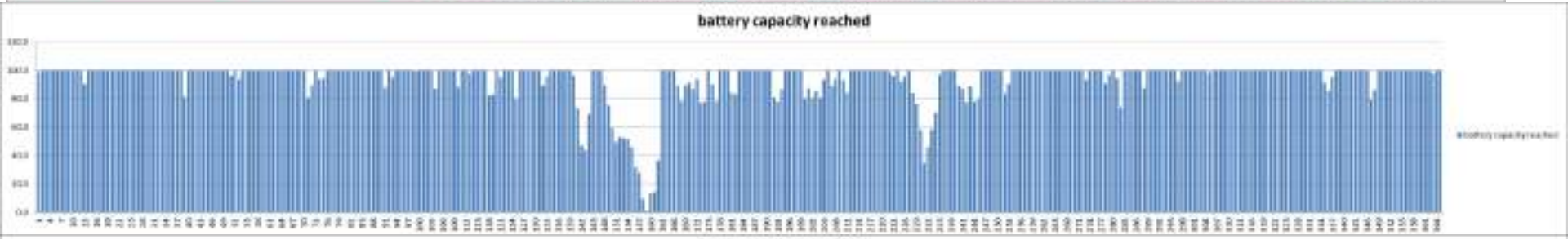

Oct-19
Oct-19

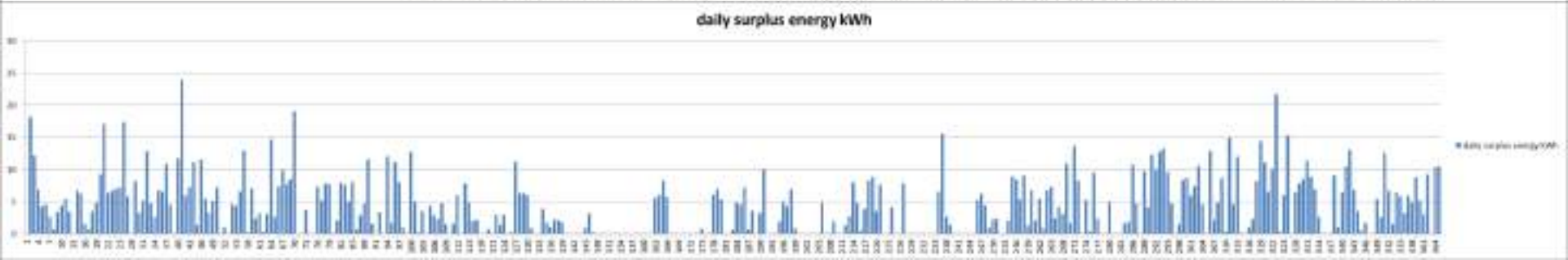


- Musselburgh data
- Typical days not a specific year
- Assumed 6 x 280 W panels, 46 degree tilt, bearing 0 degrees, ground albedo 0.1

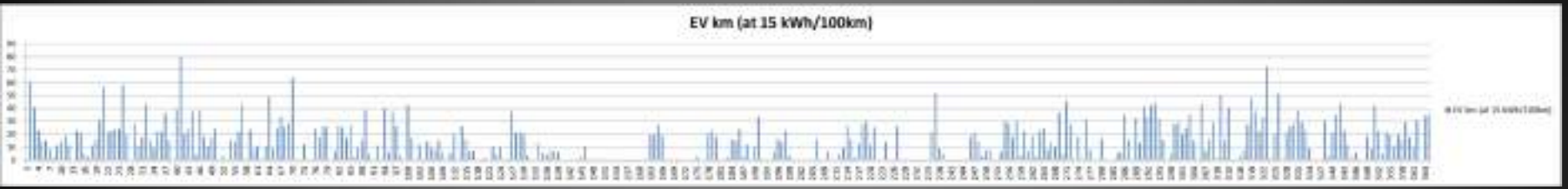

Battery capacity 17 kWh
Daily load 3 kWh
Battery start 15 kWh
Day
Wind kWh
Solar kWh
Combined kWh
Battery
Surplus
Deficit
combined wind

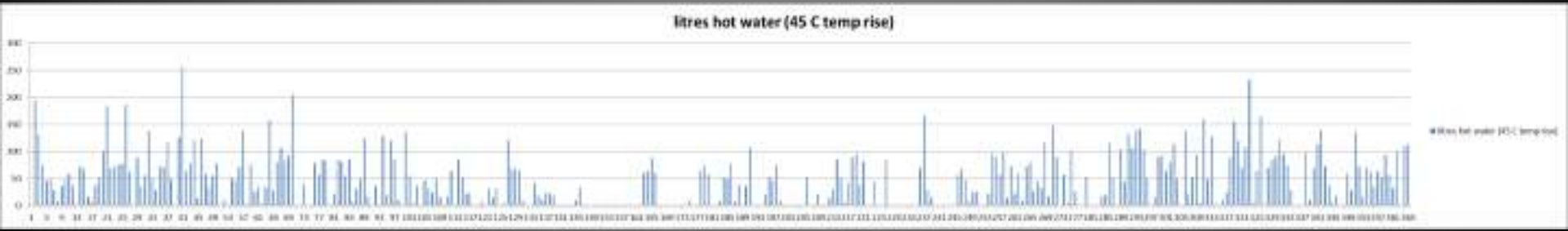



battery capacity reached


daily surplus energy kWh

Daily surplus shown split 50:50 into charging an EV and heating hot water (45 C rise)





Scaling strategy:

- Engage industry partners
- Sell machines directly
- Locate and engage reselling/installation agents
- Look for Pacific opportunities potentially with development agencies.
- Be open to good ideas from anywhere.