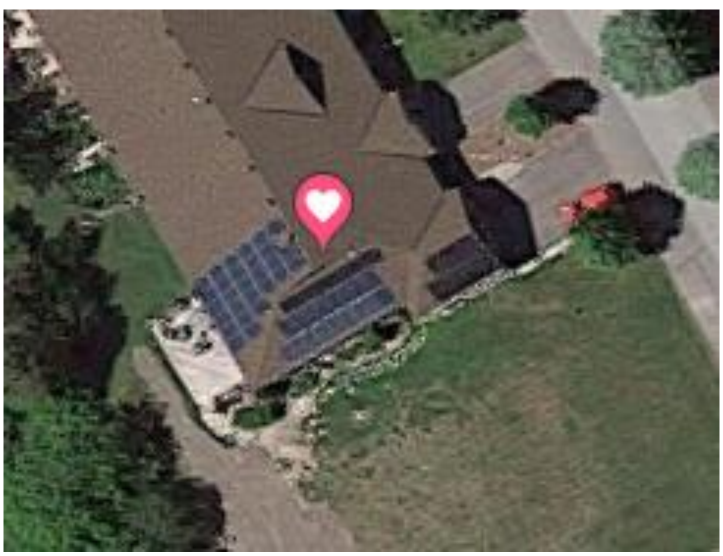
Net-Zero+ Home

Dr. J.A. Hunter

Jacob Nickerson – Summer 2019

For Steve Clarke
OMAFRA, Kemptville



About the Scientist

Dr. J.A. Hunter is an accomplished Engineer with a PhD in Hypersonic Aerodynamics. After graduating from the *Imperial College London*, Dr. Hunter was employed at several major satellite telecommunications companies – including a position at the National Research Council of Canada, managing the design, development, testing, and evaluation of the *Canadarm* Shuttle Remote Manipulator Arm for the International Space Station.

In 1989, following his success in the NRC, Dr. Hunter started looking towards low energy nuclear (cold fusion) and its association with climate change. For the last 30 years, he has run his own business (J.A. Hunter Inc.) in which he has designed, constructed, and continually experiments with a Net-Zero (or Passive) system for his home – Net-Zero referring to houses designed with a carbon-free, net-zero energy usage in mind.

Dr. Hunter opens his Net-Zero home open to tours in Manotick, Ontario, showcasing solar and geothermal energy sources, power and heat storage methods for routine use, and futureproofing for storms and bad weather, all working together in the absence of fossil fuels to provide sufficient energy for a cost-saving, carbon-free residential home; the future of living.

Net-Zero+ House Energy Production/Storage System

"Net-Zero" refers to a zero total energy usage; that is *energy generated minus energy consumed*. Net-Zero *plus* indicates more energy was generated than consumed, while Net-Zero *minus* means more energy was consumed than generated. Figure 1 shows the net energy usage at Dr. Hunter's house for one year (July '18 – May '19).

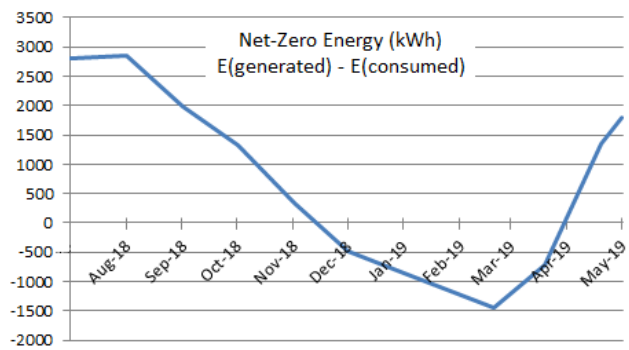


Figure 1: Net-Zero Energy Usage by Month

From figure 1, the Net-Zero energy was negative from December to April, as expected in the darker winter months, and positive the rest of the year, with the excess energy produced in the Net-Zero+ months being sold to Hydro One.

The system is designed for long-term, sustainable off-grid energy use; meant in part for energy and cost savings, but mostly as a reliable source of energy in the event of prolonged grid failure, and a testimonial to the viability and ever-decreasing cost of clean, renewable energy production and storage.

The system consists of an array of solar panels, geothermal coil loops and pumping system, three *Tesla* Powerwall batteries, and several driver boards and programs working together to maximize energy production and usage.

Solar Energy

Two systems of solar panels sit atop the roof: a 10 kW system on a FIT contract that supplies power to the grid (for which Dr. Hunter is paid 29.4¢/kWh), and a 5 kW NET-Metering system with which energy can be supplied to the house or stored on the grid for future use.

Figure 2: A Section of Dr. Hunter's Solar Panel Array

Three control boxes are located on the outside wall of the garage: a three-way switch to toggle between grid connection, purely solar connection, or disconnect from both, a second box passes both power sources to the boxes inside, and a third acting as an emergency shutdown box that shuts off power from the solar panels in the event of a fire – made mandatory in 2017 to protect firefighters from potential electric shock.

Figure 3: Enphase Microinverter Monitor Display

Each solar panel is equipped with a micro-inverter; a book-sized inverter that sits on the panel itself and converts the generated DC power to AC. Each one connects to a monitoring box (figure 3) that uploads real-time information for each individual panel to the Cloud, where you can monitor your solar system from your home computer. The display provides current power generation (13.1 kW), cumulative energy generation over the lifetime of the monitoring unit (32.9 MWh), and the number of online panels producing power (59).

The power generated from the solar panels is passed to another switch box, then through a gateway box. The gateway box contains logic boards programmed to divert power from the solar panels to charge the 40 kWh bank of three stacked *Tesla* Powerwalls (figure 5) when there is excess power (after the house's power consumption

Figure 4: Switch, Gateway, and Breaker Boxes

has been supplied). When the house draws more power than the solar panels can supply, the Tesla Backup Energy Gateway box automatically switches the Powerwall from charging mode to supply mode, making up for the power that the solar panels cannot supply.

Figure 5: Tesla Powerwalls in the Control Room

To illustrate, on a tour of the Net-Zero home, a visitor's Electric Vehicle (EV) was left to charge (figure 6) while Dr. Hunter conducted the tour. One of the displays in Dr. Hunter's control room showed the house drawing 4.8 kW, while the solar panels (due to shady weather) provided 3.7 kW, and the Powerwall supplied the leftover 1.1 kW. When that visitor left, the display showed an immediate drop in power consumption; the moment the EV was disconnected from the charger, the house's energy consumption dropped to about 1.8 kW. The solar panels – still providing 3.7 kW – were sufficiently able to supply the house's 1.1 kW power needs, and the gateway box diverted the excess 2.6 kW solar power to charging the Powerwall.

Figure 6: EV Charging Station

Geothermal Energy Collection & Storage

In tandem with the solar power system, Dr. Hunter, in collaboration with John Barton, president of *Bartonair Geothermal*, designed and assembled a geothermal system to draw and store energy underground. The system works by burying two loops of coiled PVC pipe 2.5 – 3 meters underground, and pumping a liquid 25/75 mixture of ethanol and water (termed *Loopanol*) through it. Ethanol is nontoxic and biodegradable, making it more desirable in geothermal systems than other, more toxic chemicals, as it will not harm the environment should a coil leak.

The coils are backfilled with sand and buried on all sides with dense Lada clay. This clay has an extremely low permeability, meaning a high resistance to water movement through the material – only a few orders of magnitude down from concrete. This permits an approximation of new heat loss due to water movement of almost zero, leaving only thermal conductivity as the heat transfer method. This is good for energy storage, as the heat will remain close to the coils, rather than dissipate rapidly.

Ground temperatures stay relatively constant at 12°C year-round, so by using a compressor and a pair of heat exchange coils, heat energy can be drawn out of the ground during the winter to heat your home, while storing the cool for use in the summer air conditioning season; the process can be reversed in the summer, capturing heat out of your home and storing it underground for use in the winter.

Figure 7: Dr. Hunter & his Geothermal System

Dr. Hunter has actually been able to store energy as heat underground and recover that energy later at 100% efficiency, provided he keeps the ground temperature under 12°C (above which the efficiency drops steadily). He describes this method of energy storage as a "geothermal battery" by which energy can be stored at and recovered perfectly. Though many in the geothermal business believe you cannot store energy effectively underground, some claiming that it is impossible, Dr. Hunter has been doing just that with exceptional results since this project began.

Most of the energy required to heat or cool your home can be collected from the ground, and can also be utilized in heating water. With smart energy usage practices and efficient means of collection and storage, Net-Zero energy can be achieved relatively easily. For example, domestic hot water typically uses 20% of home energy consumption but with a heat pump, this is reduced to about 5% and with heating only for a short time prior to showers, this drops to less than 2%.

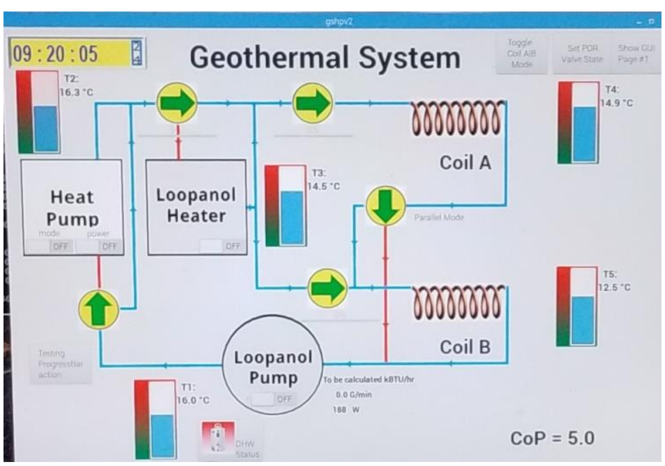


Figure 8: Geothermal Control System

The control system for the geothermal subsystem (figure 8) runs off a Raspberry Pi B+, displays temperatures at several locations along the system, and allows control of five actuator valves that control the flow of *Loopanol* through the coil loops.

With these actuator valves, the system can be set such that the two geothermal loops (coils) run in series (A + B), parallel (A || B), A only, or B only.

This allows Dr. Hunter to experiment with different setups and compare them for the best efficiency. The actuator valves also allow the choice between passing the fluid through the heat pump, to collect heat, or the *Loopanol* heater, to store it underground.

The *Loopanol* is pumped through the system by two pumps: one variable-speed 150-196 W, and one fixed-speed 230 W (figure 9). The variable pump runs at a speed calculated by the control program, based on data from a flow/runtime sensor. When the pump reaches its maximum speed, it switches off, and the second (fixed-speed) pump starts up, then the variable-speed pump returns to its minimum and speeds up as needed. This setup is energy conscious and highly controllable, as opposed to an energy-wasteful system running only a fixed-speed pump at all times.

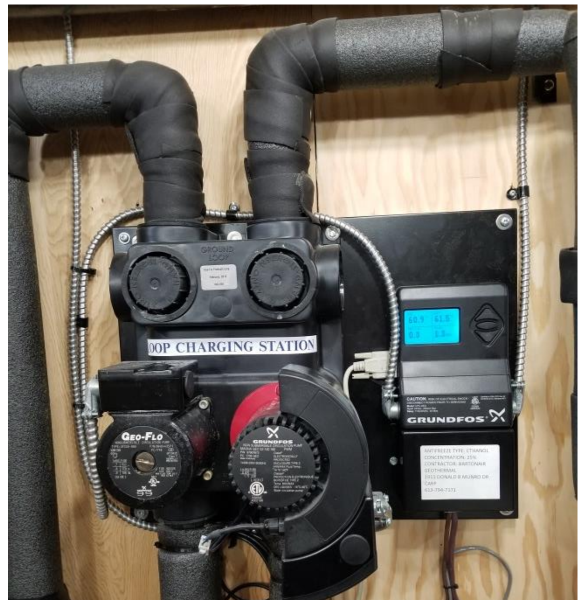


Figure 9: Loopanol Pumps and Meter

Costs

Dr. Hunter’s experimental Net-Zero house setup brags all the bells and whistles of renewable energy, and as such comes at a greater cost than may be feasible for the average homeowner. The system, however, can be recreated on a smaller scale, with alternative components that may trade a small amount of quality for greater affordability.

A geothermal system can cost between $19k to as high as $40k (system and installation), but with nearly 50% reduction in energy consumption, the payback period can be as short as 7.5 years. On the higher end, the payback may be closer to 20 years, but that is only considering monetary payback. Each geothermal heating system installed equates to planting an acre of trees, in terms of environmental effect. The use of geothermal removes the need for fossil fuel appliances, further reducing carbon dioxide levels and other greenhouse gasses. Renewable sources, such as solar or wind, can be used to power a geothermal system, allowing for a completely carbon-free method of heating your home with no negative effects on the environment [1].

A 5 kW solar system may cost close to $18k (see table 1) for parts and installation, generally paying itself off after 7-8 years [2][3]. Solar panel technology has improved greatly recently (2019), offering 22% efficiency in the market, with cells up to 46% efficiencies currently being researched [4][5]. With proper energy-conscious practices, a house need not consume more than about 3 kW at any given time (especially with geothermal heating the house’s hot water), allowing the solar system to provide all of your energy needs while storing excess energy in the ground and/or batteries for when the sun is not out.

A breakdown of the estimated cost for a 5 kW solar system mounted on a roof can be found in table 1. NOTE: This table provides an estimated cost breakdown, and is not meant to be exactly replicated in an actual system.

Table 1: Estimated Cost of 5 kW System (16 panels @ 315 W ea.)

# of Panels	16
Solar Panels (Hanwha Solar Q.PEAK DUO BLK-G5 315 W)	3981.6
MicroInverters (Enphase IQ6PLUS-72-2-US)	3015.68
Monitoring Box (Enphase Envoy ENV-IQ-AM1-240)	651
Roof Mounts	750.24
LDC fees (local distribution company) - to get hooked up	1500
Roof Engineering Analysis	700
Electrician Fees	2000
Permits	750
Installation	3000
Subtotal	16364.52
Total (13% HST)	**18491.91**

To store the generated energy, Dr. Hunter utilizes three *Tesla* Powerwall II batteries, each providing 13.5 kWh, and costing $9k each for a total 40 kWh system costing about $28k. Powerwall batteries have built-in inverters, smart charging technology, and boast top-of-the-line energy storage. If $28k is unreasonable, the system could be shrunk to one or two Powerwalls, which would cost less, but also limit the average household to about one day of power on a full charge. However, used responsibly, one day of charge can be more than enough, provided power consumption is curbed based on the weather forecast. Alternatively, deep-cycle batteries may prove cheaper for smaller projects where a Powerwall is overkill. Deep-cycle batteries have long been the most commonly used battery technology in solar systems, due to their durability and long life (if treated well). Currently (2019), researchers are coming out with more advanced and cheaper battery technology, predicting far lower prices and much higher storage capabilities (at least 70% higher) by 2025 [6][7].

Conclusion

With the ever-growing threat of climate change looming above, it is reassuring to see passionate scientists such as Dr. Hunter dedicated to proving the usefulness and viability of clean, green, renewable energy. His testimonial – and countless others like it – brings more and more people to understand and respond to the risk that carbon emissions and the current state of energy production pose on the future of our planet. With green energy production technology becoming more efficient and less expensive every year, projects like Dr. Hunter's Net-Zero home are on their way to become the future of household energy production. A green future.

Contact

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