Wilding Pines in Otago

A RESOURCE - NOT A PROBLEM!

An Alternative Viewpoint submission by:

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Executive Summary
I will argue in this submission that treating wilding pines in our area as a significant problem to be tackled at great cost and effort, and, inevitably, further levies and imposts to the struggling farmer whose land it often happens on, is entirely the wrong way to go about managing these trees. I hold this opinion because I happen to know a great deal about the field of Renewable Energy and that division of Renewable Energy known as Biomass. Firewood is the key component of biomass and this is an area I have just now returned from studying in Europe in some depth. I will argue that leaving wilding pines to grow to maturity and then harvesting them to be burned as biomass is a strategy that makes very much more sense than that which is currently planned.

I attempt to make this point by introducing the reader to the world of renewable energy production and energy efficiency. I explore our current crude oil based energy paradigm and demonstrate why it is in such trouble and cannot continue too much longer. I then turn to the alternative paradigm, Renewable Energy. I begin with a close look at the key area of energy efficiency within the built environment and explain its importance and show how abysmally the average Kiwi home fails every energy efficiency test we can impose. This ultimately means very much higher energy inputs than ought to be necessary if the home were properly constructed. I will compare New Zealand systems of building and insulation with those used in Europe to attempt to show what a difficult task we have created for ourselves in an energy sense if we only consider simply pumping ever greater volumes of conventional energy into such homes.

I will then review the key alternative/renewable energy production systems and explain their function and place within a properly configured low or zero energy home. I then move on to give an extensive review of the area known as biomass. I explain the multiple ways the fuel sources are processed and used and then explore the various biomass fuelled heating devices, explain their combustion systems, their heat exchange systems, their thermal storage mechanisms and how and why they burn so extraordinarily cleanly when compared to the totally outdated design of the typical Kiwi log-burner or even when compared to any other form of water or space heating. I then show how household scale, and larger heating systems that are fuelled by biomass can either stand alone as the prime energy source or act as the backup to other solar based energy systems.

The ultimate premise of this submission is that in our energy challenged world and our energy inefficient built environment, we have an utterly environmentally acceptable and viable energy source trying to establish itself right on our doorstep: biomass in the form of Wilding Pines. But because our understanding of how to burn firewood is based around a completely outmoded design - the Kiwi log burner - we are moving rapidly away from this sustainable energy source and directly towards an increasingly challenged and costly energy source, electricity, and it makes not the slightest degree of sense.

My credentials to speak to this issue.

Such ability as I have to submit in respect of this issue derives from a rather deep understanding of the twin arenas of alternative energy and energy efficiency within the built environment: two equally important sides of the same coin. I hasten to add however, that I am not a credentialed professional in this sphere. However, when I regularly see the elementary mistakes made by such credentialed professionals, especially in the buildings we inhabit and the ways in which we construct them, heat them and power them, I have to say I am not overly dismayed by my lack of official imprimatur.

What I am is a passionate and knowledgable amateur in the field of renewable energy. I am a generalist, not a specialist; I tend to see the whole picture rather than a fine slice as would a specific consultant. For a quarter of a century I have read deeply on the subject, visited many, many trade shows in the field in Europe and North America, visited several alternative energy demonstration centres in Europe and a number of homes and buildings that embodied the key principles. I think about and seek to better understand these concepts incessantly. I am joint patent holder, along with an American engineer (ex NASA shuttle program and Beale Aerospace rocketry program) of a paradigm shifting active solar collector that simultaneously produces Photovoltaic electricity, Solar Thermal heat streams and modulated daylighting through the same array. The concept was mine, the engineering and productisation by my American colleague and the current commercialisation is being done in the US as well.

Because of this broad background in the Renewable Energy arena, I automatically look at an issue such as this one - “Wilding Pines” - through the lens of Renewable Energy possibilities rather than in the manner dictated by conventional thinking. If one understands anything about renewable energy, then this issue, and many others, can be redefined from “Problem” to “Resource”, as stated in the title to this submission. The body of this submission will present background information and analytical argument to support that contention.

This issue runs very much deeper than a discussion of the extraordinary proposition of whether or not to spend significant public funds to poison pine trees. Everything that follows is germane to the topic under discussion and I guarantee the reader that time spent in a close study of this submission will not be time wasted. I advise however, that you are reading the conclusions of a thinking and analytical iconoclast, some of your current paradigms will be modified or demolished if you continue past this point.

The Current Energy Paradigm - Oil

Our society presently runs on combustable forms of energy, primarily Crude Oil. We are utterly addicted to it and each and every one of our everyday systems - food, transport, communications, building materials manufacture, industrial production etc. - would just grind to a halt without it. Quite simply put, when global reserves of crude oil are finally exhausted, our society, our civilisation, will collapse if we have put no other energy infrastructure in its place while we still have fossil fuels to create it.

A dramatic example of this simple demonstrable reality is electricity production. The vast majority of electricity production is presently powered by the burning of coal …. lots and lots of coal. The average coal fired power station burns at least one, but as many as five, 130-150 railcar train loads a day depending on size and season! Virtually all coal is mined, processed and transported by heavy diesel powered machinery, trucks, locomotives and ships. It is axiomatic therefore, that once crude oil is exhausted and diesel fuel is no longer available (bio-diesel, a division of biomass, doesn’t count), mining and heavy transport will stop and therefore electricity production on any meaningful scale will also stop. The point here is that once our civilisation has exhausted our one time global endowment of the perfect but totally non-renewable, finite and rapidly diminishing combustable energy source that is crude oil, we are also simultaneously out of all other fossil fuels (coal, natural gas, oil shale, uranium) because there will be no way to mine and transport the mind boggling volumes we require.

The simplest objective look at our civilisation, how it runs and what powers it, leads directly and inexorably to this ineluctable conclusion. No thinking person can deny that this is eventually going to happen - the question, classically, is not if, but when. The "when" of it is a big point of contention of course. Everything I have read points to a time around the middle to latter part of this century for the final exhaustion of world oil. Many refuse to believe such a near-term scenario and no one knows for sure of course. Recent exploitation of oil shale, oil tar sands and fracking extraction technology may now prolong that timeframe somewhat but this changes only the timing, not the ultimate outcome.

Some salient facts to ponder as you consider your position on this utterly crucial point:

1. The first oil well was drilled in Titusville, Pennsylvania in 1859. The oil age has lasted just one hundred and fifty seven years to date.

2. Global human population in the 1850's was just 1.25 billion.

3. Global population today is in excess of 7.2 billion.

    3.1. Therefore, the first 100,000 years of human occupation of the planet resulted in a global human population of 1.25 billion, while the next 150 years has multiplied that number by almost six.

    3.2. Our economic model demands this population growth (to power economic growth) and oil makes it possible.

4. For the early years of oil usage we were really just figuring out what to do with the stuff, so usage in industrial countries was nowhere near as high per capita as it is today. Today we know precisely what to do with it … absolutely everything.

5. Food production in industrialised countries is utterly dependent on oil. The ratio of oil energy inputs to food energy output is 15:1 - yes, incredibly and terrifyingly, for each joule of food energy we consume it takes fifteen joules of fossil fuel energy to bring it to our plates. This has risen from an 8:1 ratio in the 1970's.

6. Until recently it was unarguable that we were presently at or well beyond "Peak Oil" - that moment that we extract the most oil from the earth that we ever will on any one day. The oil production graph heads down toward zero from that point. The waters of that debate are now muddied somewhat by the potential increase in provable reserves due to oil shale/tar sands/fracking. Peak Oil is very real however, and is either with us today or in our very near future.

7. There have been no new discoveries of major fields of conventional oil in recent years. We have already found and put into production all there is to find.

    7.1. The continental United States peaked in 1970 - hence the Exxon Valdez and the BP Gulf spill. Not environmental disasters but screaming warning alarms attesting to our addiction.

8. We used that first half of world oil with a very small percentage of a far smaller global population using oil in consumer societies. We now have the former "Third World" countries joining the industrialised world and consuming at the same rate.

8.1. The first half of world oil was used by some 20% of 1.25 to 7 billion - the second half will be used by 50-60-70% (and growing) of a global population of 7 to 12 billion. End game scenarios are not difficult to derive from such a reality.

Most of us don't think about these issues other than peripherally because the places such thinking will take one are just too frightening and possible solutions are too unpalatable. I too wish this were not all looming on the horizon like a boxing day tsunami, but my analytical mind simply refuses not to go there and seek solutions for the sake of my children … therefore:

THE ALTERNATIVE PARADIGM
An Overview of Alternative Energy
Energy Efficiency / Energy Production

Preamble

If one accepts the basic premise of the foregoing, that at some as yet unknowable point in the future, but necessarily measured in decades rather than generations or epochs, global reserves of crude oil will finally be exhausted, then it clearly behoves us, issues of fossil fuel driven climate change and general environmentalism aside, to look at any viable alternative energy sources, strategic practices and management paradigms that both stave off that eventuality for as long as possible and, hopefully, move our societies toward a post fossil fuel age in time to avert what I call the coming *energy driven apocalypse*. Enter the realm of "Alternative" or "Renewable" Energy.

These principles and technologies provide the means of moving various energy consuming human activities and systems away from fossil fuel based energy sources and substitute energy systems that derive their power from renewable sources, principally the sun. In New Zealand, we are abysmally ignorant of the multiplicity, potential and implementation of these systems, and tend to lump them all together under the single erroneous title of "Solar". That word is arguably the correct terminology to describe ***all*** energy systems available to and used by industrialised societies, since all energy stored on our planet was originally derived from incoming electromagnetic radiant energy from the sun. Nonetheless, it is an inappropriate term to use as the blanket descriptor for the diversity of systems and concepts that are better termed "Renewable or Alternative Energy". Even that term is quite imperfect as it implies that only energy production is being described when the reality is that energy efficiency/conservation is considered to be equally as important as energy production when these concepts are being discussed and implemented. Nonetheless, one needs a workable terminology and Renewable or Alternative Energy is probably generally considered the most suitable candidate Perhaps however, one ought to throw in the occasional *"Renewable Energy: Efficiency and Generation"* for clarity and completeness.

"We are Concerned For The Environment So We Are Going To Put "Solar" on our roof"

This seemingly noble intention, that one hears repeated often by well meaning but ill informed people in our area of New Zealand and elsewhere, embodies two entirely fallacious notions:

1. The environment is in trouble and,
2. Putting in "Solar" (by which, without understanding it, they mean a Solar PhotoVoltaic system) is the best way they can direct funding to do something about their own negative impact on the environment.

A Word About 1) Above - Environmentalism and "Saving the Planet"

This planet of ours has been spinning on its axis for some 4.5 billion years and will continue to do so for a very long time to come. We homo sapiens, who have only been around for the last 100,000 years, make the grave mistake of seeing everything around us on a human timescale rather than the timescale that is actually in play. The dynamic and relentless forces that shape conditions on this planet's surface, determine weather patterns, atmospheric gaseous mixes, ocean currents, thermal balances and biological niches, continuously change the environmental conditions under which life must survive and have done so since life arose. The mechanism by which life adapts to those ever changing surface conditions is *Evolution via Darwinian Natural Selection* and it involves iterative physical changes in species over necessarily short individual lifespans. The planet has come back to the full flush of the astonishing species diversity seen today after volcanic events, meteor strikes and ice ages that have caused the extinction of over 99% of all species that have ever existed; it will do so again irrespective of how badly we stuff up this iterative version of its surface conditions and whether or not we voluntarily join the list of extinct species.

I have long felt it vitally important to try to spread the message that the planet is not in the slightest degree of difficulty from the things we humans do here on its surface. It is unarguable that our activities are causing changes to weather patterns via the mechanism of raising global average temperatures (caused by releasing vast carbon reserves formally locked away geologically as fossil fuels - and that is highly pertinent to my later arguments re biomass which is carbon neutral) and that we are causing species extinctions at an astonishing rate through habitat and biome destruction as our own populations grow at staggering and totally unsustainable rates. My point is that, as agonising to witness and dangerous to ourselves as this most certainly is, it is barely a blip on the radar screen of the planet compared to that which it has been through multiple times in the past and recovered from completely.

We are a grazed knee to the planet. ***On its timescale***, it will heal itself in a heartbeat from whatever damage we have done once we cease operations.

Therefore, unless you can disprove or ignore the following statements, please modify your understanding of environmentalism and the need for societal change and combine it with your new understanding of the reality of the impending exhaustion of global oil reserves:

- THE PLANET IS NOT IN TROUBLE - WE ARE.
- WHILST WE ARE VITALLY INTERESTED IN THE WELL BEING OF THE PLANET, THE PLANET IS ENTIRELY DISINTERESTED IN US.
- WE ARE AS SUSCEPTIBLE AND EXPOSED TO POTENTIAL EXTINCTION AS ANY OTHER SPECIES … ARGUABLY MORE SO BECAUSE OF OUR DEPENDENCE ON OIL.
- ACTION IS INCUMBENT UPON THIS GENERATION, NOT FUTURE ONES.
- YOU DO NOT NEED TO ACT NOW TO SAVE THE PLANET; YOU NEED TO ACT NOW TO SAVE YOUR CHILDREN.

<u>A Word About 2) Above - Putting In “Solar” On One’s Roof</u>

I talk regularly to people in our area who evince this worthy intention, and I regularly have to give them the bad news that they are on entirely the wrong track and that they would be wasting their money to do so. These people, by the very terminology they use, demonstrate that they know precisely nothing about what they are intending and are ignorant of the trap they are about to fall into.

I begin discussion by asking them the simple question, “what do you mean by solar”? The answer is invariably a slight hesitation and a degree of obvious confusion, followed by the words, “well, you know, solar panels”. Knowing full well they are thinking of a Solar PhotoVoltaic system (commonly known in the renewables world simply as PV), my next question is, “do you mean PhotoVoltaic or Solar Thermal and by the way, the correct term is collector/converter, not panel”. At that point discussion can begin because they suddenly realise they had not even contemplated anything other than electricity production via some sort of vaguely comprehended active rooftop solar system. This is where most people's knowledge of the subject of Renewable Energy begins and ends.

I have long since realised that people really do care about this stuff and that there is a real hunger for useful information on the subject; that subject, ultimately, is the supply, usage and loss of energy within, primarily, the built environment. The basics, which are in essence terribly simple to explain and comprehend, are not understood at all by most people or, incredibly and inexcusably, by the people making up the building codes within our bureaucratic consent authorities. People just do not understand this stuff and don't know where to go to get the information, how to put it together in their minds or how to best apply it in their homes and their daily lives.

Because they cannot hope to generate the entirety of their energy requirements from their own rooftop, without in any way comprehending it, what people who "put solar on their homes" are actually trying to accomplish is to minimise the conventional energy inputs to their home from the normal reticulated sources of municipal supply by generating some of it themselves. They invariably have a budget in mind (let's call this the Home Energy Reduction Budget - HERB) which is often dependent on ill-informed and entirely transient government subsidy. That budget will seldom buy them other than a very basic, entry level photovoltaic system; a system that will not be capable of generating more than probably ten percent of their total household energy requirements.

The question should immediately arise, but never does, "*is a solar photovoltaic system the use for these funds - the HERB - that will reduce this household's overall external energy consumption by the greatest amount"?* In other words, is there any other use in this building system to which this same Household Energy Reduction Budget could be put that would reduce energy consumption by an amount greater than the photovoltaics will generate. In a well built and highly energy efficient European residential building constructed in the last twenty years the answer may well be no, there is no higher use for the HERB funds and the PhotoVoltaics are a good idea. In the average Kiwi thermal-energy-colander home built at any time, including those presently being constructed, the answer is invariably a resounding yes. The average New Zealand home has energy efficiency characteristics built into its weather envelope that are so basic as to border on the primitive; in modern energy efficiency terms, our buildings are so appallingly constructed that they are one small step removed from a tent. Since up to 80% of residential energy usage in temperate climates is expended on water heating and space heating and cooling, the New Zealand home owner's HERB can ***always*** have a greater positive net energy effect if spent on energy efficiency improvements to the weather envelope of the building rather than if spent on a rooftop PhotoVoltaic system - it is that simple.

Add to this reality the embarrassing and insulting feed-in tariffs available in New Zealand for anyone with a grid-connected photovoltaic system and the economics of such a system become even more unviable. Sadly, governments all over the world have chosen to hoodwink voters by privatising electricity generation and reticulation and using the one-time funds so generated to pretend they have balanced the books over one single budget period when all they have in fact done is to sell the farm. This puts the national treasure that is any country's electricity grid firmly into the realms of the corporate world and the mad scramble to appease shareholders by magically producing quarter on quarter bottom line increases, thus maintaining management's six figure financial bonuses. It also makes impossible any sort of rational pricing policy that would support and encourage the uptake of renewable energy investment.

Storage of alternatively generated electricity in the national grid (which is certainly the best way to configure any such system) is part of the strategy known as *Distributed Power Generation* and is critical for uptake of renewable energy. A circa NZ$0.30/kwh grid charge for electricity and a NZ $0.07/kwh renewable energy feed-in tariff makes it farcical to connect to the grid and dictates immediate usage of renewably produced electricity on-site or some form of storage if no immediate on-site load exists. So, since it is pointless to connect to the grid and thereby use it as the battery bank for one's home photovoltaic system, we are forced to waste such power as we cannot use immediately by putting it to such stupid uses as heating water with electric elements (accomplished far more efficiently by other means) or expending half our HERB on a chemical battery storage system instead of putting it all towards generation. Governmental, bureaucratic and corporate madness to be sure, and an attitude that is going to come back to bite them at some point as current European industry responses to this same situation (if one considers parity pricing to be the same situation) are beginning to show. Mature, proven technologies exist today for individual or group grid-disconnection and self supply of electrical power and heating systems. Have a care for your customer attitude and relations Aurora, you really need to get out more and take a look around.

Energy Efficiency In The Built Environment

Thermal Opacity and the Weather Envelope

Consideration of Renewable Energy systems usage in relation to the built environment must ***always*** begin with attempting to make the energy consumption system, in this case we are considering residential buildings, as *Energy Efficient* as possible. By this it is meant that the building should be designed and specified in terms of materials, construction details, internal systems (HVAC, water heating, lighting, appliances) and constructed so as to require as little external energy input as possible to allow comfortable human habitation. It seems it is perhaps not redundant to explain that this is for the seemingly obvious reason that the less energy a building consumes the greater can be the contribution to its overall energy load from a given set of renewable sources; *energy saved is at least the equivalent of energy generated.*

In the case of the building fabric itself the primary area of interest is what is known as "The Weather Envelope": the outer walls, the floor and the ceiling or roof. This is the physical barrier between the prevailing external environmental conditions and the artificial internal microclimate that is maintained within the human thermal comfort envelope by energy consuming building systems. Since, as mentioned above, the largest residential energy load (by far) in a temperate climate is household water heating and space heating/cooling, the object of the exercise is to make that weather envelope as *"thermally opaque"* as possible in order to prevent unnecessary loss of the energy inputs now embodied in both the heated (or cooled) air and thermal mass of the building. It is in this regard that the average New Zealand home fails so miserably and forces the occupant to just keep on pumping more energy into the system to stay comfortable inside.

Any building that is not thermally efficient due to a badly designed and constructed weather envelope is the literal energy equivalent of driving the family car 24 hours a day with several holes punched into the fuel tank and trailing diesel or petrol along the road behind. We would not dream of allowing that to go on for long yet we do not even notice that the self-same thing is happening with our homes continuously during the heating or cooling seasons. The reality of this can be made visible and quantifiable, and therefore far more understandable, by two tests that are generally conducted in a *Home Energy Audit* (who has ever heard of such a thing in New Zealand). The first is a *Blower Door Test* and the second is *Infra Red Thermography.* These tests and the reasons they are so important and diagnostically illuminating are explained later.

How Thermal Energy Moves: Radiation, Convection, Conduction

An energy efficient weather envelope, as stated above, is one that allows the passage of the least amount of thermal energy (heat) possible; complete thermal opacity is the unachievable but striven for goal. It should be immediately apparent then that in order to design and construct such a system one need understand the mechanisms by which thermal energy moves and then attempt to include elements and strategies in the design to block, impede and redirect passage via those mechanisms. This list of mechanisms by which heat moves turns out to be very short and very simple. Nature is always seeking equilibrium and nowhere is this more apparent than in the movement of thermal energy, all of which originally arrived via electromagnetic radiation from the sun. Heat, thermal energy, moves toward equilibrium, travelling from hot to cold, and is transmitted by just three different mechanisms: *radiation, convection and conduction*. By contrast, the list of mechanisms, strategies, materials and products that have been developed overseas (primarily in Europe) to try to block these three thermal pathways is simply staggering; so different and so thermally effective are they, European building systems appear to be from a different planet to ours.

A good way of explaining these thermal energy transfer mechanisms is to describe heat loss through a double glazed window system during the winter heating period:

1. A heat source inside the house adds thermal energy to the the internal air mass creating atmospheric instability due to differential temperature zones which, in turn, create differences in air pressure.

    1.1. The result is convective currents within the air mass inside the building; the self same processes that create weather across the planet.

    1.2. These internal convective currents bring warmed air into contact with the inner surface of the inner glazing element and create effective thermal contact between air and glass, thereby allowing the warm air to give up part of its heat load to the glass by conduction.

2. The conductive pathway then carries the heat through the thickness of the glass, very efficiently as glass is a highly effective thermal conductor, until it reaches the outer face of the inner sheet of glass.

    2.1. Here it comes into contact with the air or gas captured in the cavity between the two glass sheets.

    2.2. It is this cavity, not the glass, that does most of the insulating within the system.

3. The thermal energy is now passed from the inner face of the inner sheet of glass to the air in contact with that face and gives up its heat to that cooler air by conduction.

    3.1. The layer of air so warmed has now gained energy, changed its relative pressure and so rises by convection up the inner portion of the cavity.

    3.2. This upward convective displacement of air effectively creates an area of low pressure in its wake and that is in turn filled by colder air from the outer half of the cavity. A circulating convective current has been formed within the cavity.

    3.3. Thus the thermal energy is transported across the cavity by convection and is then passed to the inner face of the outer sheet of glass by conduction.

4. It then duly passes through the body of the outer glazing sheet by conduction until it reaches the outer surface of that outer glazing element where it is lost by conduction to the boundary air layer and then carried away from the building by convection once again.

5. Meanwhile, as all this is going on through the glazing itself, the warmed internal contents of the building are emitting infrared radiation that travels through the internal air and then through the glazing, to be lost to the outside. Both air and glass are essentially transparent to radiant energy and so this pathway is unimpeded by anything other than a high-tech *anti-emissivity coating* that will certainly be on a European window but certainly not on a New Zealand window more than five years old or on the vast majority being installed today.

6. Then the framing system itself, which has also been heated by the same mechanism as the glazing, is vitally important since as much energy will be lost via the conductive pathway of a non thermally broken frame system as is saved by the double glazing unit.

7. In addition, any air exchange (convective loss) through ill fitting or poorly sealed sash closures will add dramatically to energy loss.

8. Finally, the installation methodology of the window into the building, if not carried out correctly, can leave an enormous convective air exchange gap around the entire perimeter of the window or door. European manufacturers have developed highly sophisticated and technical installation materials that act together as an *installation system.* Window installation with these systems completely eliminates this energy loss pathway.

<u>Airtightness - the Convective Pathway</u>
There exists a hierarchical ordering between known thermal energy loss pathways through the weather envelopes of buildings. Top of the list, the biggest offender by far as regards thermal transfer, is air exchange due to lack of airtightness. Air exchange is driven by pressure differences between internal and external air masses, hence this is a convective pathway. It can take place via many different routes. Some of the most common are through ill-fitting and poorly sealed doors and windows, around the perimeter of poorly installed doors and windows, reverse thermo-siphons in chimneys and flues, recessed down-lights are a notorious pathway, poorly designed and constructed wall systems, wall to floor or ceiling joints and through power points and other plumbing and electrical penetrations. If one attends to all such points of potential air exchange, which are regularly all open and flowing in the average New Zealand residential building, a dramatic and immediate improvement in energy efficiency can be effected.

<u>Thermal Bridges - the Conductive Pathway</u>
A thermal bridge is the name given to any thermally conductive pathway through the weather envelope. Even though heat is flowing out of the warm building and being lost outside (winter scenario) the tactile sensation inside is an obvious area of cold on internal surfaces that are affected by thermal bridges. For this reason they are often called “cold bridges” and it is these resultant cold spots in the interior of buildings that cause humid internal air to reach dew point on their surface and form condensation. Inevitably this results in mould. A conductive thermal pathway, a thermal bridge, is open anytime there is a very dense and highly thermally conductive material penetrating, or nearly penetrating, the weather envelope and thereby thermally connecting the warm interior to the cold exterior. Such things as non-thermally broken window frames, metal fixations (screws, nails, bolts, concrete reinforcing steel), uninsulated floor slabs, plumbing services, gas lines etc. can all go through the envelope and are all highly thermally conductive.

Then there are high thermal mass building materials (more on thermal mass later) such as any uninsulated masonry wall systems. These constitute a very effective means of continuously flushing the heat one has paid for in ever more costly energy prices, from inside to out. They also work very well in reverse, bringing heat inside in summer - especially if the sun is shining directly onto the outside of a solid dark coloured (low albedo) masonry wall as required by our local building codes on supposedly environmental grounds.

A classic design mistake involving thermal bridging is to extend an internal concrete floor slab out through the weather envelope to form a balcony, especially an upper floor balcony. If left uninsulated, the dense and therefore highly thermally conductive concrete, and the even more conductive steel reinforcing within, just firehoses heat out from the building on a cold winter night. This can result in cold-spot-condensation on the internal walls or ceiling nearby that is so significant that it is often mistaken for a leak and treated as such in remediation efforts. Such efforts obviously don’t work, leaving the owners baffled as to where all the water is coming from.

Infrared Emissions - the Radiative Pathway.
Of course, there is no perfect method of insulating any building and all materials are ultimately thermally conductive at some level. Any material that becomes warm is continuously emitting infrared radiation as it attempts to approach thermal equilibrium. This is true of the outer skin of the weather envelope as well as internal objects radiating out through the glazing. This form of thermal energy loss is mainly combatted by low emissivity layers in modern glazing systems and reflective foil layers on various insulation systems used in walls, ceilings and floors, that attempt, quite successfully, to reflect radiant heat back in the direction from whence it came.

Indoor Air Quality
It should be apparent from the foregoing that the ultimate objective of energy efficiency measures in the weather envelope of any building is to create a construction system that is highly resistant to the passage of thermal energy by conduction and radiation and is virtually hermetically sealed in terms of air exchange - an airtight “Chilly Bin”. One’s immediate question should then be, “what about indoor air quality, what do I do about ventilation?”

All building materials off-gas various volatile compounds (even natural materials) and air also becomes stale, oxygen depleted and laden with excess humidity. All of these problems are solved of course, by indoor/outdoor air exchange if one is lucky enough to live where the outside air quality is still good enough to help. Clearly however, simple uncontrolled ventilation via fenestration - just opening the windows - is not an option as one immediately negates all the insulating benefits of the highly energy efficient weather envelope one has created. If one is in the heating or cooling season, ventilation via fenestration is out of the question as the energy it took to heat or cool the internal air simply leaves with it through the open windows.

Thankfully there is another way that achieves all ventilation air quality objectives but has almost none of these energy negatives; controlled ventilation via a mechanical Heat Exchange Ventilation System (HEVS). There are three variants of this system now available - centralised, decentralised and decentralised push/pull, and every major electronics producer in the world, along with many specialist HEVS producers, make them. Once again, this is a system that is simply considered an essential part of any modern building in Europe. In essence the system consists of two small electrically powered fans (generally squirrel cage type) and a plate heat exchanger. Heat exchangers are something used frequently in renewable energy systems, especially heating systems, and we’ll meet them again later.

Think of the radiator in your car and you will quickly get the picture; excess heat generated by the engine is carried to the radiator in a water based thermal transportation loop that is driven by a circulation pump. The water passes through tubes in the radiator to which lightweight metal fins are attached. The heat transported from the engine and carried by the water is transferred to the metal of the tubes by conduction and then onward to the fins also by conduction. An airflow past the fins transfers the heat from the fins to the atmosphere. Interestingly, technologies are currently being developed in Europe to capture that waste heat in an onboard system within the exhaust pipes of the millions of heavy vehicles on Euro roads and using it to enhance engine power or for electrical generation, thereby significantly increasing the efficiency of the vehicle’s fuel usage.

A HEVS system simply utilises a highly efficient heat exchanger to pass two airstreams across each other without mixing them. One stream, in a winter scenario, is an outgoing stream of stale and humid but warm indoor air, whilst the other is an incoming stream of fresh but cold outdoor air. Each of the two fans controls one of the airflows and the heat exchanger extracts the heat from the outgoing air and transfers it to the incoming stream at levels of efficiency generally over 90%! It is important to achieve air exchange throughout the whole house. A centralised system achieves this with ducting that delivers the fresh air via bedrooms and extracts the exhaust air from the high humidity points of kitchen, laundry and bathroom. The newer decentralised and push/pull systems achieve the same result without ducting which makes for a far simpler installation.

The only energy cost here is the very minimal electrical power to run two small fans. This energy consumption is far less than the heating or cooling energy saved by the system. A HEVS system is an essential component of a modern energy efficient and highly airtight building. NB: at the time of last checking (2015 Christchurch Field Days show) the well known brand of ventilation system widely advertised in New Zealand, for reasons that are incomprehensible to me, does NOT include a heat exchanger and is therefore not a true HEVS system.

A Thermal Mass Primer

If one is setting out to build a truly energy efficient home there are two basic directions one can take - high thermal mass or low thermal mass. There are pros and cons to each and the choice also depends to some extent on how the building is to be used. Clearly, a good working knowledge of what is known in Renewable Energy circles as *"thermal mass"* is essential for a successful outcome.

All materials have the capacity, to a greater or lesser extent, to store heat. The precise analysis of this variation is the subject of physics and of detailed thermal energy modelling within buildings but a fairly simple working concept is to accept that the more dense a material, the greater its capacity to store thermal energy. As density increases so too does thermal conductivity and it is this parameter that ultimately defines a thermal conductor or a thermal insulator. This imbues a very dense material like concrete with two entirely countervailing properties: a wonderful capacity to store significant quantities of thermal energy right where you want it and where you may have intentionally placed it, along with the often not so wonderful capacity to conduct that same heat very quickly to somewhere you may not want it - like to waste outside the building. It is the understanding and utilisation of these properties of building materials, and attempting to impede, control and direct thermal energy flows in ways beneficial to the system and in accord with the dictates of the known properties of the materials in play, that provides all the fun and interest for me in building conception and design.

Thermal mass that is inside a building, or that makes up the fabric of a building, (the high thermal mass route) has the immense benefit of acting as a slow release/uptake thermal buffer. This results in a dramatic moderating effect on internal air temperature and diurnal temperature fluctuations. Much like the well known "Maritime Effect", where the vast quantities of stored thermal energy in the waters of the oceans (water being one of the best thermal storage mediums available) has a very considerable moderating effect on the temperatures and climate of the first few kilometres of the coastal interface. So too, if energy transfer into and out of the the thermal mass within a building are properly handled and building insulation properly placed, the same moderating effect can be achieved in the internal microclimate of a high thermal mass building, thereby creating one of the most comfortable and desirable of living spaces,.

Because of its thermal conduction properties, thermal mass internal to a building also has the ability to be thermally charged or discharged (an in-floor hydronic system - we meet another heat exchanger - being the perfect mechanism) on a seasonal basis. If warmed from a heat source in winter it will beautifully warm your home, if chilled in summer it will act as a heat sink and absorb excess internal heat from the air mass of the house providing very effective cooling - both winter heat and summer cooling can be readily supplied from renewable energy sources. All of this is done without any sort of forced air system with the only energy cost being small water circulation pumps and, possibly, a heat pump.

Any type of solid masonry structure can be defined as a high thermal mass building. To make use of the above mentioned mechanisms and concepts, as well as for general energy efficiency reasons as discussed earlier, the placement of building insulation materials is absolutely critical. Insulation in such a building ***MUST*** be placed ***external*** to the thermal mass so that it stops the flow of energy at the outer edge the highly conductive pathway intrinsic to such materials. If this is done correctly then the thermal mass of the weather envelope is transformed from an energy loss pathway into a thermal storage bank, thereby activating it as a temperature moderating element of the building. If the insulation is placed internal to the thermal mass of the building materials then the thermal mass is isolated from the internal air mass and becomes inactive and unable to act in the manner described above. In other words, the thermal mass in such an instance simply remains as a structural element when it could also fulfil such an important role in defining the whole internal thermal comfort envelope of the building.

This brings us to consideration of the other way to approach an energy efficient building; the Low Thermal Mass route. This concept is now exemplified by the revolutionary new building concept known as Structural Insulated Panels - SIPS. As ever, developed in Europe over the last ten to twenty years, SIPS have really changed the way buildings are constructed in many parts the world. In Germany today, most homes are completely factory constructed: wall panel by wall panel, windows and insulation installed, plumbing, electrical wiring, power points and switches, doors all in place, external and internal finishes set. The entire home is then trucked to site in individual panel form and craned from truck load bed directly into position in the home such that the building is constructed within a day or two. The panels used are enormously thick by our standards, seldom less than 300 to 400 mm, the vast majority of this system being rigid foam or other insulation material.

Such a building system results in very lightweight buildings in thermal mass terms, and in wall systems with very little capacity to absorb, store or conduct thermal energy. It also yields U-values (a measure of thermal conductivity - you want a low U-value figure) and R-values (a measure of thermal resistance - you want a high R-value) that are so far in advance of the requirements in New Zealand as to be something of an embarrassment. The point about a well insulated low thermal mass building is that, since the indoor heating or cooling system (whatever type it may be) is only really acting on the air mass in the building, and since air has very low thermal mass (water is some 800 times the density of air), the internal temperature responds very quickly to heating or cooling system inputs - this is quite the opposite of a high thermal mass response. Such a lightweight building system lends itself well to apartments for instance where the occupants are absent during the day and so there is no point in expending energy in keeping it at a comfortable temperature. Nowadays, with smartphone apps, the occupants can call the heating system from the bus or train as they near home and have the system turn itself on and bring the space up to comfortable temperature as they arrive home. Considerable energy savings can be gained in this manner.

Finally, thermal mass can certainly be added internally to a low thermal mass building in many and varied ways. It doesn't have to be part of the envelope of the building itself and adding it as a massive internal wall, staircase, fireplace and chimney, hidden "rock store", thermally connected solar heated indoor swimming pool, slab or earthen floor, or in any other manner that architectural imagination and ingenuity (or that of the well informed client) can contrive, will offer all or at least a proportion of the benefits described above. A significant amount of externally insulated internal thermal mass can always be considered as an absolutely positive element in terms of both energy efficiency and occupant comfort. As such, it should be a targeted objective of any new building project with the caveat that seismic consideration be also at the forefront of planning as well.

<u>So What is Wrong With the Good Old Kiwi Home Then?</u>

1. <u>The Window System</u>

The European window will be framed in a joinery system that is engineered to perfection, have two or more engineered EPDM sealing strips at strategic points and a multi-point positive locking system that renders the opening sash units completely airtight when closed. It will be triple glazed with argon filled cavities (now standard across Europe) and have low-emissivity coatings on the glazing. The frames will be made of UPVC, pultruded composites, aluminium clad timber or thermally broken aluminium to resist, insofar as possible, the conductive pathway for thermal loss through the frame itself. It will be installed to a level of airtightness and resistance to the conductive pathway that is completely optimised.

The average Kiwi window by comparison will be double glazed at best, air filled with desiccant spacer bar and with little chance of a low-emissivity coating. It will likely have one single ill-fitting and entirely ineffective fuzz-strip as a token air seal. It will have one positive closure/locking point which, when combined with the farcical weather seal and frame distortion, often yields open air pathways millimetres wide around the opening sash of larger windows and doors. It will almost certainly be of solid (as in not thermally broken) aluminium and therefore make no attempt to block the conductive pathway through the window frame system. It will then be mounted into the aperture in the weather envelope in the crudest possible manner that barely makes even a token effort at airtightness and just covers the open gap with a flashing strip so it cannot be seen. These four factors entirely overwhelm and negate the benefits of the double glazing system and make a mockery of the advertised thermal specifications (U and R values) of the the window system. In terms of thermal efficiency, such a window, despite being double glazed, is little better than a sheet of plastic stapled into the hole in the wall.

<u>The Wall System:</u>

Airtightness is often essentially non existent in a typical New Zealand timber framed home. First there are the problems with the window construction and installation methods mentioned above which means all three thermal energy loss pathways are routinely wide open through fenestration. Then we mostly build cheap to construct timber framed walls about one third as thick as their Euro analogues. Most of the difference in wall thickness is in insulation materials; a modern external wall in a Euro building is fantastically thick and it is mostly insulation. Not only is the thickness of the insulation dramatically more substantial than ours but it is also almost exclusively rigid foam sheets or semi-rigid mineral wool material. It is fitted precisely and accurately into the cavities within the timber framing and therefore in direct edge to edge contact with the timber on all sides. There are often compressive taped edges to achieve perfect edge to edge sealing. This means that the entire air cavity within the timber framing elements is completely filled allowing no possibility of convective currents forming as described earlier in the window cavity loss mechanism.

Then, over the inside face of that entire insulated timber frame wall system, another very thick layer of rigid foam insulation is placed that blocks the conductive pathway through the timber framing - timber is a poor thermal conductor but certainly not as good an insulator as foam or RockWool so they insulate between the structural timber framing to the highest degree possible and then isolate it to the highest degree possible with another insulating layer over the top. Into this system are inserted multiple air and water vapour barriers and any and all penetrations are individually and meticulously made airtight with specially designed manufactured systems. Then finally, there are now a vast range of non-conductive building fixation systems as well to minimise thermal bridges. The resultant wall system fulfils all the normal structural and weatherproofing requirements of any wall but is extraordinarily energy efficient as well.

The Kiwi wall by comparison, unless of a recently imported SIPS *Passive Haus* standard building system, is just a sad joke by comparison. Sound enough structurally but a thermal energy sieve. One layer of two by four timber framing filled (sort of) with some limp fibreglass bulk insulation material hacked roughly to shape with the good old Stanley knife and *flopped* into the cavity. Usually not as thick as the cavity it is attempting to fill and not capable of sealing edge to edge, even if cut accurately to shape, because of the nature of the material itself. It is not rigid or semi rigid and so sags somewhat under its own weight. Extremely poor at the performance of its sole job which is to prevent formation of convective currents within the cavity because the fibreglass material itself is so porous and riven with interstitial space; it is just open, unsealed material that allows air to pass quite readily through it. The exterior of the timber framing is covered with a building wrap, a thin layer of synthetic textile that is just stapled to the timber frame and never properly sealed at its edges or joins. Outboard of this is a ventilated cavity and then a weather facade that also makes no attempt at airtightness - weatherboards for instance. So it is the paper thin moisture vapour barrier building wrap, usually so poorly installed and with so many penetrations that it provides little impediment to air transfer, that is the sole barrier to air entry into and through the internal wall system: *good luck with that*.

The end result is a wall system that is usually capable of allowing dramatic levels of air transfer and also has very high levels of conductive transfer through its almost non-existent insulation barriers. Even the 1950's level of energy efficiency offered in calculated R or U value figures for such a wall system are seldom achieved because they assume that the problems of ill-fitting insulation, installation of building wrap, improperly fitted windows and air gaps around penetrations don't exist. They most certainly do exist and when one has the experience of feeling strong draughts of ice cold windy-day winter air flowing out of the plug-holes of an internal power outlet in an external wall of a ten year old home, as I have in several New Zealand timber framed residential dwellings, then one is completely justified in calling such a building "one small step removed from a tent" as I did earlier - in fact, a well made modern tent is significantly more airtight than most Kiwi homes!

Wall to Floor/Ceiling Joints

Here is another very significant energy loss pathway through the weather envelope that Europe goes to great lengths to block whilst we make no attempt at all. We just shoot the bottom plate into the slab with a bit of a waterproofing layer there but no thermal break or air transfer barrier and it is all much the same at the roof to wall interface. These joints are increasingly being seen in Europe as very important and new 3-dimensional thermal loss calculations have been developed to account for them in design and energy audit thermal analysis. As always, there are products readily available to provide airtightness and a thermal break.

The Ceiling and Roof

It is here that the average timber framed Kiwi residential building is generally just as bad as it can possibly be in energy efficiency terms. The lightweight timber framed walls are turned into a box with equally lightweight timber roof trusses. These triangular trusses form the pitched roof of the building along with the structural and support element of the internal ceilings. The roof element is universally left uninsulated and is very dark in colour (as mandated by planning ordinance due to "visual amenity" considerations - energy considerations never enter their thinking) which turns it into a large solar radiator blasting heat into the attic space below on a sunny day and allowing cold to penetrate almost as dramatically on a cold winter night. Below the roof is the internal ceiling; the visual and thermal dividing line between the internal temperature controlled (I use the term "controlled" rhetorically in the case of the Kiwi home as there is usually no attempt at real temperature control inside our buildings) microclimate of the house and the dramatic diurnal and seasonal temperature variations of the attic space. It is the ceiling that we in New Zealand choose to insulate rather than the roof which means that we actually have a split weather envelope on this face of the building. The roof is the weatherproofing element and the ceiling is the thermal barrier of the envelope.

Clearly, with the attic above alternating from freezer to furnace on a daily basis, logic would dictate that the utmost care be taken to ensure the thermal opacity of the vitally important thermal barrier that is the building's ceiling. Surely we find that such is the case? Well, actually, no. Quite the opposite. If it is physically possible, the symbolic attempts at insulating the ceiling of the average timber framed Kiwi home are even more embarrassingly inept and inadequate than the previously described wall system. The spaces to be filled are similar to those described for the wall, generally rectangular cavities between the framing elements. These cavities are bisected at random with all manner of electrical, plumbing and building services supply lines that make proper insulation very difficult. The ceiling then will more than likely have dozens of recessed down lights penetrating from below. If these are halogen or incandescent they must have a space clear of insulation and other combustible material around them of 200mm which negates much of the benefit of the insulation in any event. We then roughly fill these difficult cavities with insufficiently thick layers of the fibreglass insulation that is so ubiquitous in New Zealand that we tend to think it is the only insulation system available. This is not so of course, there are very much more more effective insulation materials available.

This results in a ceiling system with such severely compromised thermal credentials that energy loss via this element of the building envelope is, once again, dramatic. In the Euro building by comparison, it is usually the roof that is insulated rather than the ceiling. This means that the attic space is a semi controlled temperature zone and vastly less subject to wide temperature variations. If large enough, this area can also be easily converted into extra living space because the levels of insulation used are so significant, the same or greater in fact, as was described for the wall systems outlined earlier, that full residential thermal isolation is achieved. Because the roof is insulated rather than the ceiling, there is not the same difficulty trying to work around services lines and protruding down lights. Overall, a far superior end result.

A Word About Recessed Halogen Down Lights - the 'Mini Chimney"

One of the worst of all possible thermal loss pathways is the dreaded recessed halogen down light. Halogen light bulbs are enormously energy inefficient in themselves in that they convert a very high proportion of the power they consume to heat rather than to light. This heat is so intense, and the fitting itself becomes so hot because of it, that the fitting must be ventilated so that it can act as a heat exchanger and allow excess heat to be transferred to air and convected away from the fitting. Being installed through the ceiling means that there is a direct air pathway through the ventilation cavity of the fitting that connects the airspace in the house to the airspace in the attic. This air exchange pathway through the fitting is *always* open and active in some manner but it is at its worst in the winter heating season.

Clearly, the heat from the light fitting, if it could somehow be directed into the airmass within the house, could contribute very meaningfully to the heating of the home and lower heating energy costs. This effect is true of the heat output of all electrical appliances and, indeed, the 100-watt heat output per person of the occupants. Keep in mind that this waste heat from the light fitting has actually already paid for in electricity charges. Not only does the placement of the recessed light fitting into and through the ceiling obviate any possibility of productively using the heat the bulb is generating to heat the home, in fact, precisely the opposite happens.

The cooling air that must pass through the ventilation cavity within the light fitting can obviously only be drawn from the air mass within the house … the air mass one has already expended serious energy dollars to heat with the active heating system of the home! But wait, there's more. Within the vertical dimension of the internal air volume of the rooms of the house there is a high degree of thermal stratification caused by the buoyancy of rising warm air; the vertical air column is warmest near the ceiling. This warm air is still trying to rise convectively but is blocked by the ceiling - except of course, when it finds the open ventilation duct in every single recessed halogen downlight in the home. Here the warmed (warmest) air from the home does not merely "pass through" the ventilation cavity to be lost in the uninsulated attic space above, the convective force behind it *positively squirts it through!* This lost air from the house must of course be replaced and this is easily accomplished by drawing icy cold outside air in through the power points and other air exchange pathways in the wall system. It just doesn't get much worse than this, and this, sadly, from my observations, is the norm in many NZ homes.

The Floor Slab

I think I need not say much here, the reality should be obvious by now. If the highly thermally conductive concrete floor slab of any heated or cooled building is not correctly thermally insulated from the outside then it provides a direct conductive thermal pathway from the 25ºC internal temperature to the circa 6ºC to 10ºC ground temperature at its base or the 0ºC to -10ºC ambient winter air temperature at its perimeter. Uninsulated to-grade slabs have simply not been an option in Europe for decades, but are only just now being considered a problem by some architects, builders and home owners in New Zealand.

Home Energy Audit
A home energy audit is a process that can identify many different energy loss pathways and poorly performing internal building services and systems. The person conducting the audit must be a trained technician who understands all of the forgoing aspects of energy efficiency and much more. Two key diagnostic tools used in the investigation of energy loss through the building envelope are the Blower Door test and Infrared Thermography.

In the blower door test all known air exchange apertures in the weather envelope (predominantly windows and doors) are closed in the normal manner. One external door is left open and a specialised airtight fabric seal with a fan inset into it is placed into the aperture. The building is therefore sealed as well as it can be and the only air exchange pathways are those relating to all the problematic areas mentioned above. The fan is computer controlled and the computer linked to air pressure sensors both inside and outside the building. The blower fan is then activated and used to raise the internal air pressure of the building to a set level, generally around 50 Pascals above that of the outside; sometimes an under-pressure test is conducted as well. The system then measures and analyses the flow of air required from the fan to maintain the internal pressure at this preset level. Obviously the more air needed from the fan to maintain the 50pa the less airtight the building. Since we now understand that lack of airtightness is a key energy loss determinant, this test can give a very good overall picture of the magnitude of that loss and then go on to locate the sources.

Infrared thermography can be used either independently of the blower door or in conjunction with it. It utilises a highly specialised camera that is only sensitive to infrared radiation, as opposed to a conventional camera that only captures visible light. Radiant heat energy is carried by near, mid and far infrared radiation - not by visible light. As we have already seen, all building materials become warm to a greater or lesser degree and therefore radiate infrared energy differentially according to their relative temperatures. The infrared camera interprets these differences in radiant heat in the same way a normal camera interprets differences in reflected visible light, except the infrared camera displays the differences in arbitrarily assigned colours. Colder surfaces show up in the image as blues and greens and warm to hot surfaces as yellow, orange and red. Infrared thermography then, is literally a method of photographing heat energy loss through the weather envelope of a building. Such imaging makes the areas of thermal energy loss through the building dramatically visually obvious and can lead immediately to the regions of greatest loss so one can determine where that all important Home Energy Reduction Budget ought to be spent.

The energy audit consultant should also be capable of analysing (empirically and quantitatively) the relative energy efficiency of various building control systems (such as water heaters, home space heating, air conditioning and lighting) as well as appliances, and offering advice as to benefits of possible changeover to newer appliances or different systems. Something as simple as placing a small (30-40 litre) under sink storage water heater in the kitchen - the point of by far the most frequent hot water usage - can make a huge difference to water usage and water heating costs. With a thoughtlessly sited centralised water heater, one often has to flush an unbelievable amount of water down the sink, multiple times a day (in our home it was 8 litres), waiting for hot to come through. Then of course that same amount of heated water remains in the pipes up in the uninsulated ceiling going cold again. This is an example of what I mean when I talk of the elementary mistakes made by accredited “experts”; they have to site the water heater somewhere, why on earth not do it where it makes most sense in terms of occupant convenience and energy efficiency as opposed to being easiest for the plumber to hook up? Our homes are replete with such inexcusable errors made by those who we pay to know better (architects and builders) and consented to by those who tell us they are omniscient in all such matters (our local councils). Reality would seem to belie the claim to omniscience, but we all know for certain that they are most definitely completely omnipotent.

HERE ENDS THIS REVIEW OF ENERGY EFFICIENCY IN THE BUILT ENVIRONMENT.

I NOW TURN TO THE OTHER EQUALLY IMPORTANT SIDE OF THE SAME COIN

ON BOARD ENERGY PRODUCTION
PASSIVE SOLAR DESIGN AND ACTIVE SOLAR SYSTEMS

Passive Solar Design
It is often said that there is enough radiant energy falling on the earth each hour to supply all mankind's daily energy needs many times over. A true statement, but a rather simplistic and perhaps somewhat misleading one. The problem of course is gathering all that widely dispersed energy and converting it into a form able to be utilised by our various industrial and residential systems. Since so much energy is used in attempting to maintain the internal thermal conditions of our buildings at a level comfortable for human occupation, especially staying warm in winter, it has long been clear that getting heat from the sun, when it is available on clear sunny days, into the building has great benefit and worth. From previous discussion we know that this heat comes to us from the sun as the infrared component of the electromagnetic spectrum. Both the earth's atmosphere and the glazing of buildings are essentially transparent to this energy. The atmosphere is not heated directly by the sun but indirectly by the earth which either absorbs or reflects solar radiation according to its albedo. This is the mechanism that drives weather across the planet.

This same solar radiation also passes directly through glazing and enters our buildings. If it then strikes a dense, low albedo/high thermal mass substrate (such as a dark coloured concrete or stone wall or floor) then there is sufficient incoming solar energy to very quickly heat that substrate by a significant amount. This mechanism is unaffected by ambient external air temperature and so acts just as quickly in winter as in summer. Such a solar energy gathering mechanism can very easily be designed into any building in the form of a conservatory, an atrium or similar equator facing glazed sunspace. The thermal mass that is intentionally placed within, once heated by the sun, performs its moderating function and continues to give off its stored heat into the rest of the house (or to absorb excess heat from the air if so configured) for many hours after the sun has set. A problem can be that such a sunspace can become so hot when the sun is shining directly into it, even on the coldest winter day, that it becomes unusable by the homeowner. Deciduous trees are the age old mechanism used to offer seasonal control since they shade in summer and allow sun through when bare in winter. People often mistakenly believe placing blinds inside the glazing elements will stop the overheating. In fact, other than for direct re-radiation by reflection from light coloured blinds, this has no effect whatsoever as the heat is inside the glazing, converted from radiant to sensible heat, and therefore captured by the weather envelope. Certainly, *externally* arrayed sun louvres (brise soleil) offer a very high level of control over solar gain into such a sun space. Once again, it is Europe that leads the way in production and uptake of these systems.

All the energy efficiency measures discussed under the *"thermal opacity of weather envelope"* headings can certainly be considered as passive solar design elements. In fact an entire new building energy efficiency standard known as *the "Passive House"* standard has been formulated in Europe over recent years and effectively recognises this. These standards, that ultimately enable conversion of the building to a "near zero energy building" or a "plus energy" building, are in the process of becoming the new building standard across the EU. These *ultimate* energy efficiency standards (ultimate in the sense that it is difficult to conceive they can be improved upon) are now poised to supplant the already very stringent general European standards and will make the type of building I have discussed in this submission the mandated norm. In much the same way that Euro 6 vehicle emissions standards have replaced Euro 5, Passive House is now replacing former building standards. We in New Zealand have banned (in 2008) the importation of motor vehicles that do not comply with Euro 5 emissions standards but our regulators seem oblivious to the fact that similar standards exist across emissions from the built environment and from wood burning appliances.

All the energy efficiency measures I have discussed are far easier to design into a new build than to try and retrofit into an existing structure. It can be done however, and an additional "passive solar" sunspace is one key element that can often be added quite easily and can form part of a strategy known as *"double-enveloping".* One adds a functional thermal capture system and also simultaneously isolates a poorly performing section of the original weather envelope within the captured air mass of a new high performance structure. This also allows the air mass of the sunspace to act as a further thermal buffer zone to the interior of the building. Naturally this also adds to the overall footprint of the building, so all building codes and the Resource Consent process will militate strongly against approval. Coming up against such artificial and uninformed barriers to real world solutions to real world problems is intensely frustrating to those of us who know anything about these issues. Once again, time to investigate what others are doing and rethink our own building codes.

All the key site factors of solar aspect, general climate considerations, prevailing winds, site microclimate, seasonal sun angles, direction of weather systems and rain, shading from buildings/trees/topography, privacy from street or neighbours etc, can be considered and brought into the design concept to attempt to generate a building and landscaping scheme that best suits these unique aspects of any site. Then build a highly energy efficient Passive House standard weather envelope attuned to these site specific parameters, bring in controlled heating or cooling as required with passive design techniques and you will have produced a home with energy consumption requirements reduced by an amount in the order fifty percent or better over a conventional building.

Now, you can finally, meaningfully, consider the possibility of placing "solar" on your roof … but which kind?

<u>Active Solar Systems - an Overview</u>
We now come to the area of renewable energy where a manufactured system, generally, but not necessarily, arrayed on the roof or facade of a building, collects incoming electromagnetic radiation from the sun and converts it to another form of energy that is usable by building services systems and household appliances. This energy conversion will result in flows of thermal energy, flows of electricity or directed daylighting. The active solar systems that can be considered under this heading are:

1. Solar PhotoVoltaic - "The Sexy Solar": converts photons of visible light from the sun into a usable flow of electrical current via the magical alchemy of the PhotoVoltaic effect.

2. Solar thermal - "The Poor Relation": converts infrared energy from the sun into sensible heat.

3. Daylighting Systems - "The Special Case": captures and directs daylight from the sun but, strictly speaking, does not convert it to another form of energy.

It is also possible to think of most other forms of renewable energy capture under this "active solar system" banner, as all (except tidal power and deep-bore geothermal) are ultimately driven by energy from the sun. These need not be considered in depth in this submission as they are not generally arrayed on residential buildings. I list them below for completeness.

4. Wind - Captures wind energy in turbine blades to generate shaft power to turn an electrical generator.

5. Hydro - Captures water pressure in turbine blades to generate shaft power to turn an electrical generator.

6. Wave - Captures ocean wave energy in a system that generates shaft power to turn an electrical generator.

7. Tidal - Captures tidal flow in turbine blades to generate shaft power to turn an electrical generator.

8. Deep Bore Geothermal - uses heat from deeper within the earth's crust to capture heat and can produce electricity.

Intermittency is the simple, inescapable reality of most major divisions of active solar. The sun does not always shine, the wind does not always blow and the duration between can be significant at times. This reality need not and must not be seen as a barrier to uptake of these systems. Rather, intermittency must be seen in the same light as any limitation to any worthwhile system society wishes to make use of … as a challenge to be overcome by good engineering and good system design. Historically this challenge has been met by methods of energy storage, both electrical and heat. Increasingly, it is now also being met by concepts and methodologies of time shifting and "smart grid" uptake. Inevitably, intermittency also means that all solar systems must have back up … another system, a secondary energy source, to augment or replace the primary solar input when it is not available.

Daylighting - the Special Case

It is self evident that bringing daylight into a building when it is available displaces electrical energy usage for artificial lighting. Daylighting is therefore considered a major division of renewable energy. As cities become more densely populated and modern buildings become more tightly packed and multi-storied, daylighting through fenestration becomes less and less effective. As always though, clever engineering can often shed light onto the problem. Several systems have been developed that make a significant difference. Simple things like skylights and lighting down-tubes can be very effective but there are more lateral approaches than that. One system uses mirrored venetian blinds to intercept daylight at the window and reflect it deeply into a room at an upward angle so that it strikes the ceiling. Here are placed reflective panels set at a certain angle to receive the light. This diffuser panel, in turn, reflects this light vertically downward onto a work station below and lights it with a soft, shadowless diffused natural light that is very pleasant for the user of the area so lit.

Fibre optics provides a very promising method of bringing natural daylight deep into a building and channeling it to anywhere it is required. A two-axis tracking outdoor (generally roof top) receiver follows the diurnal movement of the sun in both altitude and azimuth and captures daylight in a series of lenses. These lenses then concentrate the light onto the end of a fibre optic connection. The fibre optic tail extends down into the building virtually as far as is desired and conducts the light down its length to the area designated for illumination. This light conducting tail is then connected to a special luminaire that is designed to spread the light in much the same way as a conventional artificial light fitting; in fact, LED lights are often included as part of the fitting so that the same lighting position can also provide artificial light when no daylight is available. These systems claim to only transmit visible light and to filter out IR and harmful UV. Very clever, very effective and only requires minor consumption of electrical energy to drive the simple tracking motors of the receiver.

Solar Thermal - 80% of the Remaining 50%?

NB: The following discussion deals with pumped closed-loop solar thermal systems that have indirect usage (heat exchange) storage tanks with a permanently captured volume of thermal storage media. I do not consider thermo-siphon systems where the storage tank is integrated with the collector array as a complete package and situated on the roof.

A solar thermal system can be sized to provide the primary energy source for both hot water requirements and for space heating as well. Whatever the remaining total energy requirements of the building, it remains true that a high percentage of it is for water heating and for space heating and cooling. It is also the case that a solar thermal collector has very much higher coefficients of conversion efficiency than solar photovoltaic. This means that a given rooftop display area of solar thermal will result in significantly more heat into the system than using photovoltaic electricity generated by the same size display to operate some form of electric water heater. Because of this reality it has long been accepted that a properly designed, sized and installed (installation is critical for success) solar thermal system, with appropriate back up from another source, makes the most sense for water and space heating. Technology advances in air-to-water and water-to-water heat pumps, reduction in feed-in tariffs, vast Photovoltaic and Wind power inputs in Europe on sunny, high-wind days and smart grid responses are presently muddying those waters. Future directions may change somewhat but solar thermal will certainly always remain a major sector of the overall Renewable Energy picture.

It is in solar thermal that we meet a plethora of heat exchangers. They are everywhere in a solar thermal system, in fact a solar thermal system can be thought of as a series of heat exchangers connected by transportation loops that move the heat from point to point in a working fluid. The collector is generally, but not necessarily, on the roof and it can be configured in several ways. We are talking low temperature solar thermal for residential use here, not high temperature CST or CSP systems (concentrating solar thermal/power) that involve mirrored heliostats or parabolic dish collectors generating extremely high temperatures for process heat or electricity production.

Residential collectors mainly fall into two categories: flat plate and evacuated tube. In the flat plate type, a copper or aluminium tube winds its way in a looped circuit through an area contained within an insulated enclosure that is glazed on its upper face. The tube is thermally attached to thin metal fins that face the sun and collect its heat - this is a heat exchanger from sun to metal - from radiant to sensible heat. This heat is conducted by the metal and transferred to the working fluid flowing through the tube - this is a heat exchanger from metal to the fluid.

The working fluid is being driven through the tube (carefully insulated once it exits the collector) by a small electrically driven circulation pump. This takes the heated fluid from the collector down into a service room within the building and into a water filled insulated thermal energy storage tank. The tube enters this tank and winds its way down through a section of its interior as a spiral. The spiralling tube is again given metal fins to increase surface area and conduction potential and so acts as a heat exchanger that gives up its heat load from the working fluid to to the water in the tank for storage and later use. The tube then exits the tank and carries the now cooled working fluid back to the collector to pick up another load of heat. This closed-circuit thermal transfer loop very efficiently transfers heat from the collection point on the roof into the storage fluid in the insulated tank in the plant room. There may be several other thermal transfer loops carrying inputs to the tank from other heat sources. Certainly there will be at least one more from the backup source which may be a gas, oil, coal or biomass fired boiler, or a water heating heat pump. There may also be a conventional electrical element inserted directly into the tank as a dump load to get rid of otherwise unusable photovoltaically generated electricity - highly wasteful of such a precious form of energy.

Evacuated tube collectors operate in essentially the same way within the system but the collector is configured in quite a radically different manner. There is a single copper pipe with attached collector fin inserted within a long glass tube very much like an overgrown laboratory test-tube. The glass tube is sealed around the collector pipe insert at the entrance and then a fairly strong vacuum is created within the sealed unit. An array of these evacuated tubes are mounted into a manifold that sends the working fluid through its loop. The vacuum has the effect of significantly increasing the thermal efficiency of the collector over the flat plate style because convection currents are eliminated within the evacuated space and there is almost no conductive thermal contact between the heated metal fins and the outside air. Whilst the increased efficiency of evacuated tube over flat plate collector is unarguable, there has been longstanding argument about overall efficiency and it seems to be true to say that there is not really any clear cut advantage of one system over the other - pros and cons, so one should do their homework.

Whichever collector type is employed, one ends up with a large thermally charged storage tank within the building. The tank is configured to receive heat from various sources, store that heat until needed by a load and then give up that heat to the load as required. The obvious loads within almost any building are hot water for kitchen, laundry or bathroom usage and heat for the space heating of the building during the heating season. Not so obvious are newly emerging heat-to-cooling units. Once again we meet closed thermal transfer loops, heat exchangers within the tank and heat exchangers at the point the of loads, at least, the heating system loads.

When a hot water tap is opened at any point, mains pressure water begins to flow through the system. The hot water system can be either open or closed loop. In an open loop system the mains water flows through a heat exchanger in the storage tank that is lengthy enough to heat the water to the desired temperature. The heated water then flows on to the open tap, but has to fill the intervening length of pipe before hot is available at the point of use. In a closed loop version, a heavily insulated pumped “ring-main” circles the house and passes each hot water usage point and then returns to the storage tank. At each usage point we find another heat exchanger that passes the heat from the fluid in the ring man to the water flowing from the tap. If the ring main is operating (they can generally be closed down when the home is unoccupied) then heat is available at each usage point immediately and so very significant volumes of water and thermal energy are saved. Such a system, as a side benefit, also obviates any formation of legionella bacteria within the hot water system.

The building heating system is handled in much the same way. Yet another heat exchanger extracts heat as needed from the storage tank and takes it to a manifold where it is directed to each heating zone via various loops. The two ways the heat so transferred is directed into the building is via in-floor hydronic pipes and via wall mounted radiators. In-floor hydronics, a radiant floor, is simply a labyrinth of flexible pipes set into a high thermal mass floor; an insulated concrete slab is ideal. The thermal mass of the floor is gently heated to a comfortable ambient air temperature by the hydronic system which then heats the room air. Hydronic heating is suitable for low-temperature base-load space heating. The wall mounted radiator system is heating the air of the room directly and so can be set to give off higher temperatures. This allows radiators to act as a rapid response heating system to quickly get the internal air of the building up to higher temperatures if necessary whereas low-temperature hydronics have a longer heating lead time. This is why these two systems work so well if integrated. It should be clear by now that both these systems, hydronic and radiator, are simply more examples of heat exchangers at work; the combination of radiant and gentle convective heating that results is by far the most pleasant method of heating a home one can experience.

<u>Solar PhotoVoltaic - 10% of the original 100%?</u>

Well, perhaps a bit more than that, but not much. A super energy efficient building has been created, energy efficient appliances and lighting fixtures have been specified and the lion’s share of the remaining energy load has been satisfied by a solar thermal system with some appropriate back up source. We are now left with a residual energy requirement that is as minimised as it can possibly be and is entirely electrical. We can therefore consider a properly sized and configured solar photovoltaic system really meaningfully. I trust I did not give the impression by my earlier comments that I do not in any way consider Photovoltaics not to be a worthwhile technology. On the contrary, PV is one of the key components of our energy future and its broad scale uptake is of absolutely critical importance if we are to have an energy future. But, in the privately owned residential context, PV must be deployed in the right manner and with the right philosophy or the investment and the opportunity will not be optimised. Electricity is difficult and expensive to generate, reticulate and store and it should ideally only be used for purposes that no other form of energy can satisfy.

A solar PV system does not begin and end with a chosen number of collectors on the roof of a home. Solar PV produces flows of DC (direct current) electricity generally at either 12 or 24 Volts. This form of current is unusable by virtually all home appliances and systems as they use 230 volt alternating current as supplied by the national grid. Therefore an essential and costly high-tech component of any solar PV system is an inverter or a series of string-inverters. Inverter is a word that is now becoming familiar to consumers as heat pumps and generators now all include some kind of “inverter technology”. In solar PV it is an electronic component that converts the direct current (DC) output of the solar collector or the battery storage system, into very high specification utility-grade 230V 50Hz power (except in US et al of course). The need for storage is the perennial nemesis of renewable energy and is caused by intermittency. Active solar systems create energy - heat or electrical power - when sun and wind are available, but the loads will certainly not coincide completely with the availability of the energy, so some form of storage is always necessary for such surplus energy.

With electricity storage there are a number of choices and all but one involve converting the electricity to another form; this always involves entropic conversion losses. The best option, and the one that leaves it as electricity, is storage in the national grid. However, as has already been discussed, government and corporate policy has made this option financially unviable so that leaves the energy conversion options. Some examples are compressing air, pumping water uphill, spinning a flywheel, conversion to heat or fractionating water by electrolysis to create hydrogen. Whilst hydrogen has great promise as an energy source (and is a whole subject in itself) the current norm is chemical storage in a battery system.

Battery storage has always been very expensive and rather fraught with complications but the Lithium Ion battery chemistry revolution is definitely changing that in recent years. This has been brought very much to the fore by the Elon Musk/Tesla phenomenon. Marketed on the back of his ultra high performance fully electric super car, the Tesla PowerWall PV storage battery has been styled as a piece of must-have living room wall art instead of the somewhat prosaic system component it actually is. Joe Public suddenly seems to think these people have invented the solar power storage battery and set us all free from the grid. The reality of course, is that theirs, and the dozens of other such systems by most major electronics companies in the world, is really just the latest iteration of a long established product category that has been steadily improving for many years. Nonetheless, their clever and astute marketing (sex really does sell) has done the whole sector a great service by bringing the capabilities and possibilities of renewables to the forefront of the public mind for a time. In addition to that, the mega factory they are building in the Nevada desert will almost certainly bring to this now key component of a functional solar PV system the economies of scale necessary to do to solar prices what Henry Ford did for automobile prices a century earlier. Ultimately, PV, and all other renewable energy systems, need moneyed visionaries like Mr. Musk to make it really happen big time … as it absolutely must.

The emasculation of existing smaller scale grid-connected PV systems brought about by the comprehensive world-wide semi-abolition of rational feed-in tariffs, mandated an alternative energy industry response. Several new battery technologies and radical new approaches to the use of the national grid, as embodied in the new and still evolving Smart Grid concepts being developed in Europe, are beginning to enable responses that grid operators are ultimately not going to be happy about. Individual and group disconnection and self-supply is possible today in certain circumstances and is on the horizon as a larger strategy in the near term. A home, configured in energy efficiency and solar thermal terms as discussed above, and then fitted with a large scale solar photovoltaic system, a significant new-generation battery storage capacity and backed up with some sort of stand alone generator, can absolutely disconnect from the national electricity grid today and enjoy all amenities of a modern home. This has long been the case of course, but dramatically cheaper Chinese built PV panel prices and the new battery technologies make it far more accessible today than in the past. … and the myopic policies of electricity utilities are pushing us closer towards it every day.

BIOMASS - HE COMES TO THE POINT AT LAST

What is Biomass?
There is an entire division of alternative/renewable energy that I have not yet touched on in this submission. Any organic material that can be dried, converted to a mechanically handleable form and combusted can be used as an energy source. These materials are known collectively as Biomass. Timber is the largest element of biomass, but a vast array of other materials can now be gathered (often are gathered anyway), converted, and - *like fossil fuels* - burned to produce energy. The absolutely key thing to understand about biomass is that, being gathered from materials that grow in soil, biomass is a *renewable* form of combustable energy. In fact, biomass is the only form of combustable energy of which this can be said … and, not only is it renewable but, perhaps most critical of all, it is *renewable on a human timescale*! As a final key benefit, these fuels are already caught up in the planet's natural surface carbon cycle of growth and decay. Other than the fossil fuels used in the harvest, gathering, transport and conversion of the materials, and of course the energy used to produce and operate the equipment that burns them … *they are carbon neutral*.

So here we have a form of energy that can be used in the same manner as fossil fuels, at least in static heat production energy systems, yet it is truly renewable and in a manageable timeframe.

Questions automatically arise:

1. Can this biomass be gathered, transported and converted into a usable fuel source economically?

2. Can it be combusted cleanly and efficiently and does the technology exist to do so?

3. Can biomass be harvested and regrown in a sustainable (in the true sense of the word) manner?

4. Can biomass energy systems be deployed at various scales: industrial, municipal, commercial, district, residential?

The really good news is that the answer to each of these questions is an unequivocal and resounding yes!

Modern biomass combustion devices are specifically designed to handle the material they burn in one of three different forms: log wood, wood chips or pellets. Chips and pellets can be bulk stored in a hopper/bunker system and then auger or vacuum (pellets only) fed, a few chips/pellets at a time, directly to the combustion chamber. These materials can therefore be thought of as continuous fuel sources able to be attenuated like diesel or gas. They are able to be precisely modulated in usage and the combustion devices have control, feed and heat exchange systems that accommodate their material handling characteristics and combustion properties to make them behave in just that way. Log wood by comparison is a batching fuel source and the clean burning log wood devices are optimised along those lines.

Clean Burning Biomass Appliances - Yes, You Can Burn Wood Without Air Pollution
Today's European biomass combustion devices are to the average Kiwi log burner what the Airbus A380 is to the rickshaw. I can only imagine that such devices are so difficult to get approval to install in New Zealand because none of our government rule-maker-uppers have ever been to the European biomass trade shows I have attended and been stunned and amazed by the complexity, maturity, sophistication and multiplicity of the offerings and the vast number of companies in the marketplace. This is big business and one cannot come away from these shows without realising that the answer to the problem of air pollution due to the burning of firewood is right in front of us, and it doesn't have to be conversion of the population to electricity consuming heat pumps. Heat

pumps are wonderful things (well, except perhaps the simple air to air versions we use) and they definitely have their place in many, many applications, but they are not the only way. While we have been busily making wood burning all but illegal as a method of heating our homes in NZ because of the problem of localised air pollution - and totally ignoring the vastly worse global air pollution/GHG emissions of electricity generation - Europe had already solved the problem thirty years ago and has been rapidly transitioning to the new ultra clean-burning wood fired systems ever since.

There are two broad categories of appliance: Kamine Oven and Boiler. The kamine oven is a German term that seems to have been broadly adopted although a semi-alternative is “Grundofen” which refers more to the very high thermal mass ovens with extraordinarily long and convoluted smoke pathways. These are a living room type fireplace with a dramatic modern twist and are the Euro replacement for the obsolescent standard log-burners we use. The designs available are simply stunning visually and the concepts used result in energy conversion efficiencies and flue gas output specifications that are difficult to comprehend when compared to those we are used to: to the point that it is my understanding that these appliances can be installed in any home or apartment in any location - country or city - in Germany and most other Euro countries without permission! Whilst the Kamine Oven is a piece of living room furniture that transfers its combustion heat to the thermal mass of the unit itself and then to the air of the room (more to follow on that concept) the boiler is a basement or utility room item of plant that transfers its combustion heat to water for distribution via hydronic heating loops and radiators.

Biomass boilers are somewhat cleaner burning than Kamine Ovens and have significantly higher coefficients of thermal efficiency. Kamines are generally a point source heating appliance whilst the boilers are always (in the residential context) part of a complex central heating/hot water system. The best (Wood Gasification) Boilers have conversion efficiencies (calorific content of the wood burned transferred to water) that are in the high ninety percent range, flue gas emissions that equal gas fired boilers and particulate emissions just very slightly higher than gas. So yes, it is absolutely possible to burn renewable firewood cleanly, so cleanly in fact that the efficiencies and atmospheric emissions directly rival the very best condenser gas or diesel fired boilers and makes the global pollution of coal fired power plants (to energise heat pumps) look positively Dickensian by comparison.

<u>So What’s Wrong with the Good Old Kiwi Log -Burner?</u>
How did those clever Euros achieve this decades ago when our manufacturers haven’t even thought about trying? The key concepts to understand are the relative efficiencies of combustion and the efficiencies of the heat exchangers involved - once again, in all such combustion systems, we meet heat exchangers. The centuries old design of the traditional log burner (a batching system) is monstrously inefficient and produces unacceptable levels of gaseous and particulate emissions. This is because there is no attempt whatsoever to ensure complete combustion and the heat exchange methodology is as crude and dysfunctional as the weather envelopes of our buildings. A simple steel box, a single air intake that draws the unit’s combustion air from the already heated air within the room it is attempting to heat (duh) and directs it to nowhere in particular within the flame column, a few semi-refractory bricks arranged around the interior of the box presumably as an attempt at some thermal mass, a thermal energy super-highway exiting the top of the box and going arrow-straight out through the roof, a heat exchange system that relies on a bit of radiant heat out through the glass front and conductive/convective exchange from the steel sides, no external thermal mass whatsoever to capture and slow-release excess heat over time, an air supply choke-damper to make it burn longer at night … and the result is stupidly incomplete combustion, uncontrolled emissions and in the order of sixty to seventy percent of the heat produced going straight up the flue to be lost to the outside. The only way to do it worse is an open fireplace.

WE CURRENTLY, AND COMPLETELY LEGALLY, HAVE TWO SUCH ANTIQUATED UNITS FIRED FULL TIME IN WINTER TO HEAT THE TWO LIVING ROOMS OF OUR NEWLY

PURCHASED HOME IN WANAKA WHILST 78 RECESSED HALOGEN DOWN LIGHTS FIREHOSE THE HEAT OUT TO THE UNINSULATED ATTIC AT A FRANTIC PACE.

So How Do They Do It Better?
All modern wood burning appliances start with the optimisation of combustion and then proceed to the optimisation of thermal exchange of the heat to a functional storage and distribution mechanism. The following is my understanding of how this is achieved. I'll describe the best first.

The Wood Gasification Boiler.
Primary combustion is always incomplete due to lack of oxygen. This results in an initial flame column that also contains significant amounts of unburned but combustable gases and unburnt but combustible particulate matter. The combustion chamber of the modern device is very carefully designed and shaped to guide and capture these materials in specific ways. The fire box of a log-wood gasification boiler has a fan induced downdraught drawn through it from top to bottom. This restricts primary combustion to only the lower 100mm or so of the log pile and the flame is then drawn away through the heat pathway. This means that the fuel load is burned slowly over time (hours) in a completely controlled and regulated manner rather than the manner in which the entire load within the firebox of the standard log burner furiously burns as one and can only be controlled by choking the oxygen supply. Initial combustion of these two systems could hardly be more different. In a chip or pellet boiler things are somewhat simpler as there is no need to batch load the firebox because the fuel is precision fed as needed.

Following primary combustion the unit then introduces further air inputs at strategic locations along the flame pathway. These extra inputs are known as *"secondary and tertiary air"* and it is the introduction of the extra oxygen this air carries with it that enables the final and complete combustion of the gasses and particulates. This secondary combustion process obviously has the dual benefits of converting far more of the embodied energy content of the fuel into usable thermal energy and of producing flue emissions - gaseous and particulate - that are dramatically more environmentally acceptable in a localised air pollution sense.

The supply of the secondary air, both volume and point of injection, is critical to the result and something each manufacturer wants us to believe they have cracked to perfection - the reality I suspect, is that all are exceptional. The key to the optimisation of this enhanced combustion process is controlled internal air pressure within the system and controlled air movement through the system. An non-pressure controlled fire (the Kamines) are known as *"an atmospheric system"*, whereas this pressure controlled system is *"a gasification system".* The internal pressure is governed and modulated by fans and vents that are microprocessor controlled with feedback from various oxygen content (lambda) and temperature probes within the flame and heat pathway. Once complete combustion has been achieved the next step is to capture as much of the heat as possible and to allow as little as possible to exit the flue to be lost to waste.

To understand this one needs to comprehend that the heat from a fire does not need to travel vertically from point of combustion to exit point from the flue. It is entirely possible to get a proper natural draw (atmospheric) with only twenty percent or less of the heat from the fire exiting the building via the flue outlet. In the case of the gasification boiler, the system controls its own speed of flue emissions. This is another demonstration of why the ancient log-burners we use are so shamefully wasteful - they need a triple-pipe ventilated flue system to prevent the heat load they are exhausting from setting the roof on fire! The reality is that the heat from combustion can be directed through a labyrinthine fire/heat pathway that winds around back and forth through a ceramic or stone channel (Kamine) or a steel duct and pipe network (boiler) that slows down the air movement and allows it maximum time to give up its heat load to the material of the channel and its particulate load to catchment. In the case of the boiler the steel is a pure heat exchanger with a pumped fluid thermal transfer loop on the other side to carry the heat away to storage in the buffer tank. In the case of the Kamine oven, although it can certainly be configured that way, most use the thermal mass of the ceramic heat path labyrinth (or a simpler high thermal mass stone cladding jacket over the exterior of the oven) to capture, store and give off the heat over a longer time.

WE WOULD INSTALL A WOOD GASIFICATION BOILER INTO OUR HOME IN WANAKA TO REPLACE THE TWO LOG BURNERS BUT THOSE WHO KNOW BEST WON'T ALLOW IT ON A SECTION UNDER TWO HECTARES IN SIZE.

Options
It can now be seen that modern biomass energy systems offer the residential building a range of heating strategies and a range of combustible materials. The lounge room installed Kamine Oven can be operated, always at maximum efficiency, with a continuous fuel type (generally pellet) to give off a finely attenuated heat to the immediate area on a 24-hour basis. Some simple versions of these are available in New Zealand but the pellet availability has been poor and not inexpensive. A log burning variant, inherently a batching process because logs cannot be automatically fed, also burns at maximum efficiency at all times (there is no banking/damping function) and stores much of its heat in on-board thermal mass to be given off over time (up to 24 hours depending on size of thermal mass and thermal efficiency of the building) thereby giving the benefits of banking with none of the deleterious drawbacks.

The Kamine Oven systems can be configured with an air to water heat exchanger (what we would call a wet back, although theirs are very much more efficient) and act as an input to a central heating and hot water system but that is the exception rather than the rule. The Kamines also have maximised combustion efficiency due to secondary and tertiary air injection but this is achieved passively. No electrical hook-up is required for the log burning versions of these appliances, although power is required for fuel feed and electronic control in the pellet variants. Kamine ovens are therefore not quite as clean burning or as thermally efficient as the far more sophisticated gasification boilers, but are light years in advance of a simple Kiwi steel-box log burner. As stated earlier, it is my understanding that these units are all in compliance with the very stringent European (even the German) clean air emissions statutes and can be installed anywhere. Just as one can no longer buy and install a crude, old fashioned NZ standard window system in Europe, so it is too with old style log-burners - simply not manufactured anymore, whilst there are literally hundreds of manufacturers of the new systems.

Central Heating
A whole-of-building managed central heating and hot water system is something almost unknown in New Zealand homes but considered the norm over most of the rest of the industrialised world. We tend to put a log-burner and an air-to-air heat-pump beside each other in the living room and a few electricity guzzling oil or fan/element heaters in the other rooms of the home and call it a heating system. Then we have a single centrally sited "instantaneous" gas water heater that is really "eco" because *"only heats the water you use"* - well, yes, except for the three to five second time lag between water flow and gas ignition in intermittent use and the 3-8-10-15 litres of heated water going cold in the pipe after shut off. Place one of these things at each point of use in the house, along with a tiny storage cylinder under the kitchen sink for normal intermittent kitchen use, and you have a fossil fuel based hot water system that makes some sense.

Europeans can't quite believe it when you tell them this. A Euro style central heating system is as described earlier in the solar thermal section. It has wall mounted radiators and in-floor hydronic loops gently and accurately warming both the thermal mass of the building and the air mass to appropriate levels in individual areas. The thermal energy input to this system can be from a wood gasification boiler just as easily as from solar thermal collectors. A biomass system of course, eliminates the cost of the rooftop solar thermal collectors but all other elements of the system remain the same. There are naturally continuing higher energy costs because now you have costly biomass as the primary energy source instead of free solar energy. It is self evident that a solar/biomass hybrid system - solar as the primary energy source and biomass as the back-up - can be considered the ideal, albeit the most costly, system.

The only benefits of the New Zealand norm of a log burner and an instantaneous gas water heater have is that they are very cheap to buy and install. To make the renewables based systems make sense financially one has to build in the expected cost of energy over the probable lifetime of the system, as well as, hopefully, considering the environmental and social costs of just throwing ever greater quantities of fossil fuels at the discredited systems of a rapidly failing paradigm.

WE WOULD INSTALL A CENTRAL HEATING SYSTEM AS DESCRIBED HERE IN OUR HOME IN WANAKA TO HEAT THE TEN ROOMS CURRENTLY HEATED AT ASTONISHING COST BY ELECTRIC ELEMENT RADIATORS OR ELECTRIC UNDERFLOOR HEATERS. WE CAN DO IT WITHOUT PERMISSION WITH A FOSSIL FUEL FIRED BOILER (OIL OR GAS) BUT IT IS NOT POSSIBLE TO GET PERMISSION FOR A BOILER BURNING LOG WOOD SOURCED FOR FREE FROM OUR OWN FARM. WE SEE NO BENEFIT WHATSOEVER IN SPENDING A VERY SIGNIFICANT SUM CONVERTING FROM ONE FOSSIL FUEL BASED SYSTEM TO ANOTHER.

BY INSTALLING A WOOD GASIFICATION BOILER AND CENTRAL HEATING WE WOULD HEAT OUR ENTIRE HOME AND BURN LESS WOOD WITH WAY LESS LOCALISED AIR POLLUTION THAN WE PRESENTLY DO TO HEAT JUST THE TWO LIVING ROOMS … BUT WE ARE NOT ALLOWED. NO DOUBT SOMEONE IN GOVERNMENT KNOWS AND CAN EXPLAIN PRECISELY WHY THIS MUST BE SO? PERSONALLY, I CAN'T IMAGINE ANY REASON OTHER THAN RULE MAKER UPPERS WHO DON'T GET OUT MUCH.

<u>How Big is the Biomass Sector Becoming?</u>
I have just had a very up close and in depth look at precisely this question. Much of this submission has been written as I travelled to seven different industry exhibitions (Trade Shows) in Europe during a period from mid February to the end of March this year, 2016. These shows were of interest for a project of my own that is in the planning stages and were themed in the areas of horticulture, biomass (harvest, processing and wood burning appliances), energy efficient building systems and products, window and facade systems, all aspects of active solar systems, and many other sectors pertinent to my areas of interest and, coincidentally, to this submission. For those interested, the shows were:

1. Horticultural Business Days - Gorinchem, Netherlands (Hi Tech Glasshouse systems) - 500 Exhibitors.

2. BauMesse (Solar Energy, Energy Efficiency, Renovation) - Gottingen, Germany. - 110 exhibitors.

3. EnergieSpar Messe (Biomass Show) - Wels, Austria. - 846 Exhibitors.

4. Ecobuild - Excel Centre, Docklands, London (Energy Efficiency in Modern Architecture) - Over 800 Exhibitors. My second visit to this show.

5. Salon Bois - Nancy, France - (Biomass and Forestry Exhibition): - 412 Exhibitors.

6. FensterBau Frontale - Window and facade Technology - Nurnberg, Germany - 1,319 exhibitors!!!

7. Building Holland - Amsterdam, The Netherlands - General Building Show - 175 exhibitors.

NB: I have also attended the world's largest solar industry trade show, InterSolar, in Germany three times. Most recently in June 2014.

A total of 4,162 exhibitors and seventeen days of walking every aisle in every hall of each show. There are few better ways to learn about a subject of special interest in the industrial arena than attending a series of large trade shows and talking to the engineers, managers, CEO's and technical sales staff who know their products better than anyone. These people are generally very generous with their time and knowledge and the enthusiastic and assiduous attendee can learn more about a large subject at one of these shows in a few days than could be gained in months of solo research.

Of course nothing concentrates the mind better than spending one's own time and money to be there. Since I was doing precisely that I simply immersed myself in this for six solid weeks; travelling in a small motorhome we keep in Europe, camping in the parking lots of the individual shows when possible, making notes on brochures at night and writing up notes on individual conversations. This has dramatically reinforced my previous twenty five years of study and research in these fields and shown me several new and developing trends, along with multiple sensational new innovations in several different fields. I talked to staff on well over fifteen hundred stands and have shipped home in the order of sixty kilograms of brochures and samples. I sincerely doubt that there many people in our region who have a greater insight into this field at present than I do and I am keen to share that knowledge and those insights with our local government and community if they are interested.

There are some very clever and innovative people out there working on this stuff and it really is invigorating and energising to see what they are coming up with. To give some concept of the present and coming scope and scale of Biomass Energy in Europe, the US and other countries, I offer the the following list of points that attracted my attention. In no particular order:

1. Amongst the 846 exhibitors at the biomass themed show in Wels, Austria (Austria being the epicentre of gasification boiler production) my estimate was that there were between thirty and forty different manufacturers of gasification boilers exhibiting.

    1.1. Of these, at least four are presently attempting to create a presence in New Zealand: ETA, KWB, Hargassner and Herz.

    1.2. Herz sent me a "thank you for stopping at our stand" email after the show that included a group photo of their on-stand show personnel … all thirty five of them! This was a five day trade show, one of several that all these companies attend each year, and I would characterise that presence as typical. Yes, this really is big business.

        1.2.1. Their newly acquired subsidiary, Binder, covers the industrial end of the range with high duty-cycle boilers. Their model range covers the sizes from 150kw to 10,000kw with 25 standard sizes in the range and modularity an easy option. My guess is that a unit from somewhere near the middle of this range could heat the Queenstown Swimming Pool complex, while one at the larger end could heat Queenstown itself if it had a district heating scheme installed.

    1.3. Before the show I visited the Hargassner factory in the town of Weng, Austria. As one arrives on the main road at the outskirts of town one has to navigate around the large stainless steel sculpture of the Hargassner flame logo in the middle of the roundabout that leads into "Anton Hargassner Drive". The very large factory is located in parklike grounds, has a huge showroom with all their equipment on display, a large and well appointed staff canteen and gym visible on the upper floors. A senior export manager was immediately available and spent close to two hours talking with me. Yes, this is really big business.

    1.4. I also cold-called at the corporate headquarters of an ultra high end German Kamine Oven manufacturer called Brunner. I was received by their export manager and shown their in-house showroom. It resembled a museum of modern art rather than the facility of an industrial manufacturer. A coffee and a chat followed in their reception foyer and restaurant area; stunning ultra high-end modern architecture in a fireplace manufacturer tucked away in the back blocks of a little German village. Extraordinary, and, yes, this really is big business.

2. Combustible pellets are much denser than wood chips and so taking the extra processing step to produce pellets from chips can make sense if long distance transportation is involved. The process also dries the material to a much higher level and so increases combustion conversion efficiency. Pellets can also be made from saw mill waste (sawdust), agricultural residue (straw, sugar beet fibre, olive pulp, nut shells), autumn leaves, roadside weeds, food scraps, forestry slash, waste cardboard and paper, old pallets and construction waste. Literally any organic material, if it is dry enough and not toxic, can be processed to feedstock in a hammer-mill, pelletised and combusted.

    2.1. On what scale does this happen? A recently commissioned mega pellet mill in the US is processing 30,000 metric tonnes of wood waste … A DAY!!!

    2.2. What happens to this quantity of pellets? They are loaded into bulk ore carriers and shipped to Europe.

    2.3. What happens to them in Europe? Believe it or not, they are used as the fuel source in former coal fired power stations that have been converted to biomass as their energy source!!! Personally, I find that mind boggling.

3. At Ecobuild in London I spoke to the British importer of a Czech Republic based producer of gasification boilers who was about to install a large capacity pellet boiler with an attached ceramic flue-gas filter into the heart of the Central London clean air zone. This system was to add heat to speed the composting process at the London organic material handling facility. All organic and food waste in Britain is collected separately from other waste and recycling and composted. The volume in London is so great that it is composted in a central London site to reduce the bulk and weight. This biomass boiler and filter is intended to aid that process.

    3.1. How cleanly will it burn … according to the company, the final stage air coming from the ceramic filter system had been tested to be cleaner in particulate content than the ambient London air going in to the boiler as combustion air!

    3.2. How stringent is the London Clean Air Zone standard? An excerpt cut and pasted from their website: "*If your vehicle doesn't meet the emissions standards, the Low Emission Zone (LEZ) daily charge is £100 for larger vans, minibuses and other specialist vehicles, and £200 for lorries, buses, coaches and other specialist heavy vehicles".*

4. The nation of Denmark, when we travelled there four years ago, had *65% of its household hot water and space heating supplied from district heating schemes burning biomass and municipal waste* - please think through the enormity of that statement. These are municipal heat production plants sited within or near a village, town or city that burn biomass on a large scale and then reticulate the heat so generated in water around the town in large diameter heavily insulated underground pipes. The heat arrives at each home and building (in smaller pipes insulated within the main underground pipe) in the same manner as water, electricity, gas and sewer. Hot water and space heating is just another reticulated service; produced centrally - *largely from biomass* - with utmost efficiency and minimum air pollution.

    4.1. Such district heating schemes are by no means unique to Denmark. They were a feature of many corporate offerings at several of the shows I attended.

    4.2. At an agricultural show in Denmark we attended there was an entire pavilion given over to biomass energy systems. These were centred on a different type of very large firebox capable of burning whole tree stumps and straw bales for larger scale process heat for factories, dairies and farms.

4.3. There were a number of consultants at this Danish show who helped farmers transition from growing food crops to biomass crops such as Miscanthus (elephant grass) ,Willow and Poplar. Yes, Willow and Poplar, two species we don't consider worthwhile converting into firewood in New Zealand, are being planted for precisely that purpose in Europe! Grown to broom handle thickness in coppiced groves, harvested with specialised machinery on a three to four year cycle and chipped for easy boiler feeding.

5. The seven shows I attended were widely distributed across Europe so I was obliged to drive quite extensively to attend, in fact 6,000 k's over the six weeks. Most of this driving was done on the autobahns of Germany. It quickly became apparent as I drove that a decision had recently been taken to clear the road reserves beside the nation's entire road and autobahn system of its woody roadside vegetation cover and to put this vast bank of totally unproductive land into use for biomass production. I drove past hundreds and hundreds of kilometres where the former tree, shrub and bush cover had been felled and was lying on the ground, aligned, bundled and drying, and waiting for the chipping crew. This enormous quantity of wood chips will not be used as mulch or landfilled as we would … every scrap of it will go into the nearest chip-fed biomass boilers (at homes, schools, municipal swimming pools, district heating schemes, farms or factories) and be converted to thermal energy. All the road reserve so cleared will, of course, now be replanted with appropriate biomass production species to be harvested again easily, quickly and directly from these existing transportation corridors in just a few years time.

6. Combined Heat and Power (CHP) is the term used to describe a system that recovers heat normally wasted during electricity generation. Site any combustion based power generation by itself in the country (as we tend to site our power stations) and the vast heat that remains after steam production and condensation cannot be utilised. Site that same power station near a city or factory and that heat can now be captured and utilised in a district heating scheme or for process heat in the factory. Apply that same concept to the scale of a single diesel generator (there are even compressors that offer this capability), house it in an insulating enclosure and capture the heat from both within the enclosure and from the water cooling system of the engine and the efficiency of the system is almost doubled. I have said above that the ideally configured grid-disconnected energy system needs to be backed up by a generator *"of some kind"*. I worded that comment very specifically because there are systems emerging just now with the capacity to offer viable small scale CHP *using biomass as the energy source rather than conventional fuels* … and that is game changing!

6.1. Seen at EnergieSpar Messe in Austria - A complex CHP system with a wood chip boiler that intentionally fails to provide secondary combustion air and so produces significant volumes of combustible gas. This gas is not directed to the atmosphere but through a complex series of filters and cooling vessels which capture the heat and clean the gasses. At the end of the system combustible gas is introduced as fuel into a modified diesel engine which has been fitted with electronic ignition and spark plugs. The engine then spins an electric generator in the normal manner: 15kw electricity output and 45kw heat output with virtually no air pollution … ***from wood chips!!!!*** The size of a 20' container, the cost of a large tractor, available today off the shelf as a drop-on-site plug-and-play CHP unit. Diesel fuel won't stay as cheap as it presently is for much longer.

6.2. Seen at Ecobuild in London - a very compact (refrigerator size - residential scale) Swiss made pellet fired CHP system that uses an *Organic Rankine Cycle* to generate steam in a low boiling point organic fluid. The steam then drives the vanes of a turbine and that drives a generator. Both electricity and thermal outputs are again the result. Again, this from a biomass energy source *and on residential scale!*

6.3. Seen at Salon Bois in France - similar to above but larger scale. Fired by pellets.

6.4. Seen at Building Holland in Amsterdam - A radical new approach. Not CHP as above but another important concept that perhaps fits best either here or in the solar thermal section - a _Heat to Cooling_ device. There are various heat to cooling devices available, usually absorption cycle cooling units rather like a motorhome gas refrigerator. This version was very different however in that it converted a heat stream, that could be supplied by either a biomass boiler or by a solar thermal system, into an "acoustic signal". Ultimately this acoustic signal was somehow reconverted into a stream of chilled water that could be used for direct cooling or air conditioning purposes. Again, as unconventional as it sounds, the company claimed that this is a market ready in-production unit. Any form of heat to cooling unit offers great promise in the field of solar thermal as they can potentially make use of the significant summertime heat streams still produced but not needed for space heating - air conditioning from solar thermal.

AND IN CONCLUSION

Are Renewables Viable and Acceptable?

"I'm not worried about all this because ***they*** will think of something." Well, ***they*** have already thought of it. It is called renewable energy and it is the only game in town. There are many negative things that have been said about the renewable/alternative energy technologies. Wind turbines take more energy to build than they create; they cannot provide base load power generation; they kill birds and bats; they are a blight on the landscape; they don't produce unless it is windy … yet the country of Denmark is electricity self sufficient _today_ from wind generation on high wind days and the rest of Europe is having to develop "SmartGrid" systems to cope with the renewables contribution. Photovoltaics are expensive, have low conversion efficiency, only produce when it is sunny and when they have a good direct view of the sun, require difficult and expensive storage systems if the generated power cannot be used immediately on site or rationally exported to the grid … yet in recent years European countries have installed thousands of grid-tied Photovoltaic farms that cover tens of hectares each and comprise tens of thousands of individual panels. Also, any decent sized farm, commercial or industrial rooftop in these same countries is PV covered if facing the equator. In calendar 2015 in Europe alone around 8 gigawatts installed PV capacity was added - the equivalent of 2 - 3 conventional coal fired power stations!! All the same objections were raised about rural electrification and horseless carriages a hundred years ago and yet here we are.

Reality check: if we like having electricity, the basis of modern civilisation, in our homes, hope to maintain private transportation, wish to maintain communication, refrigeration, water and sewerage reticulation, eat a diversity of foods out of season, have light in darkness, plastic bottles and packaging, music you are not making yourself, electronic (i-things) entertainment, modern building materials …. then we need to stop our fatuous, hypocritical maundering about alternative energy and its known shortcomings and learn to love the sight of wind turbines and PhotoVoltaics - and, yes, wilding pine trees - all around us. We need to embrace renewable energy techniques and infrastructure, recycle manically, eat, travel and live locally, retrofit energy efficiency into our homes, help try and fathom a way to transition from a growth based economic model back to a steady state model, think about population growth and immigration and many, many other very difficult and vexed questions that need answers.

In renewable energy however, there is just no single simple overarching answer to all society's energy needs as has been the case with fossil fuels for the last one hundred and fifty seven years … it is no longer that easy! Renewable energy involves a multitude of different strategies, technologies, systems and paradigms all working in some sort of harmony, all overlapping to some degree, all fulfilling some part of a new age energy mosaic. It also absolutely must have the enthusiastic and active support of an informed population and an integrated and proactive administration by both government and corporate sectors that are fully alive to the (real) issues in play. Hopefully it is now somewhat clearer to the reader that biomass is an utterly critical element of this new energy paradigm. We simply have to accept that reality and work with it …

BECAUSE, ULTIMATELY, LIKE IT OR NOT, UNDERSTAND IT OR NOT, RECOGNISE IT OR NOT, ***IT IS RENEWABLE ENERGY*** - WE DON'T HAVE ANY OTHER VIABLE CHOICE.

A word about Eco-Marketing and Sustainable Development

I call it *Ecobabble.* The relentless corporate con job that tries to convince us that we are saving the planet by purchasing the current version of their product with the "Eco" prefix and a drawing of a dolphin attached to whatever insulting to the intelligence and allegedly new "caring for the environment technology" their marketing department has dreamed up but their engineers and industrial chemists took no part in creating, unless it was to reduce the concentration from the old formulation by 20% … should be viewed with the utmost suspicion and seen through as the transparently disingenuous, manipulative, consumer level product pushing corporate Ecobabble that it is.

As for *sustainable development*, think through it; by definition sustainability and development are mutually exclusive terms. This terminology is just another marketing white wash by the corporate world and by government to allow us to think that mad population growth and business as usual is A-OK. Any and all development that uses non-renewable resources - both energy and building materials - to cover more species habitat and arable land with expanded human habitat is, by definition, *unsustainable* on a finite planet. All present human development in the western industrial model falls into this category and it really doesn't matter which shade of baby-shit-brown or inversion grey we paint it, how much recycled timber we use inside it or how non-reflective its outer surfaces. Such window dressing changes nothing and confuses subjective human aesthetic values with environmental design. What a tragedy and absurdity that we construct our building codes around such irrelevant fripperies instead of what really matters to the environment … energy usage and habitat destruction. Building better, as described above, counts enormously, but, as with "the planet is not in trouble, we are", this should be seen in its true light. Development is driven by growth, and in growth there is no sustainability, just greater or lesser degrees of damage.

A Word About Our Growth Based Economic Model

Even if the entire world began immediate and radical uptake of all the concepts and solutions that I advocate above, it sadly changes little in the face of a rapidly growing and rapidly developing/ industrialising human population. In the following thoughts I fear I am largely alone as one hears virtually no one in any position of power who does not consider "growth" to be a universal good. Those who speak of growth are generally speaking of economic growth, but, in my opinion, economic growth cannot be separated from population growth. The age of oil has provided the greatest period of economic growth and growth of individual wealth in human history. Our economic model demands growth and it is oil that has made it possible. We saw in the economic catastrophe of the Global Financial Crisis that the days of economic growth being driven by a general expansion of individual wealth are gone. That crisis was brought about by running out of nothing more substantial than confidence and credit. Dare you imagine what running out of something rather more real - oil for instance - will bring about?

We have completely realigned the world economy in recent decades by exporting most western manufacturing jobs to countries with cheap and abundant labour and so kicked off the industrialisation and oil consumption of those nations. This has led to the former manufacturing and exporting nations now being very top heavy with bureaucracies and service "industries" (is a wholly notional "product" the output of an industry or an artifice?) and having far less real output to sustain the individual corporate growth upon which our warped economic system places such emphasis. This means that the ways we can continue to drive corporate growth figures, quarter on quarter, are now very limited. Aside from cost cutting via product and employee emasculation, chief amongst them is to have a growing number of participants operating within a given economy … population growth … immigration!

Such a growth based economic model is a pure *"Frontier"* proposition. For it to keep functioning it constantly needs new land masses to move into and new resources to exploit. We have long since run out of those. On a finite planet, such a system could only ever operate for a limited period. The end of that period is clearly in sight but the death throes of a fatally flawed economic model keep propelling us ever faster down the road to societal self immolation. Without the ephemeral and artificial crutch of oil, the residual arable landmass of the planet cannot come even close to feeding the 7.2 billion people here right now, let alone the 9 to 12 billion who will be here when we run out of oil. We need to urgently find a way to *abandon our growth based economic model,* transition to a steady state model and reign in population growth … this, to me, really is the biggie. In the meantime however, if one wonders why the population of one's area is growing so fast, well, look no further than than this for the primary driving force.

<u>AND SO, AT LAST, WHAT ABOUT THE WILDING PINES - Now I Will Really Get Some Locals Offside?</u>

We live on a managed planet. There is no part of this planet and no species on it that we humans do not affect and, to some extent, often greater rather then lesser, manage. As we can readily see just in our little sphere of influence, from deer, to rabbits, to Didymo, to possums, to Largarosiphon, to broom, gorse, thistles, rats … once out of the bottle the genie is very difficult and very costly to try and get back in. In fact, it has never yet been successfully achieved with any feral species, either plant or animal. Yet here we are about to gird our loins yet again and take on another escapee from that already well and truly opened bottle. And on what basis? Well, from what I can see, the slimmest and most meagre of arguments are ranged against this energy source that is trying to establish itself right where we live and need it: slowing down water flows, displacing tussock grassland and affecting biodiversity and impact on visual amenity/landscape values.

First, I simply have to comment that this debate is certainly the first time I believe I have ever heard a community jointly argue that the local growing of trees is categorically a bad thing. A thing so dire in fact, that it must be opposed with a huge community effort and serious public finding. In an age where communities all over the world come together to plant trees to roll back habitat destruction, urbanisation, industrial ugliness, desertification, soil erosion, soil degradation, soil salinisation … and this is universally seen as a good thing, this local reaction to spreading pine trees certainly comes as rather a shock to me. At the very least I feel there needs to be much broader public discussion of these vague and highly debatable grounds of opposition to the presence of these trees; grounds for opposition that presently seem universally and credulously accepted at face value.

I am in no way knowledgable in the realms of resource management or biome protection, but one can think about the broad-brush overview and ask relevant questions. Would extensive lower slope coniferous forests really have a deleterious effect on water availability in our water challenged area or would they do what broad scale forests always do which is to significantly increase the general level of water retention and hydration in the soils and ultimately modify local micro-climates for the better? A local forestry consultant I know argues the latter. Need the trees established be a monoculture of pines? Whilst it is clearly conifers that do best in this area, surely other species, perhaps natives, could be interspersed? Could such alternative species perhaps utilise the conifers as pioneers aided and abetted by selective felling for biomass at appropriate times? Nor can I pass up comment on the mania for native only species (I seek cover from the inevitable onslaught) as I am in no way sold on the importance thereof. Once again, we live on a managed planet and I see no way any post colonisation New World land mass can ever go back to the environmentally halcyon days prior to first human settlement. We ought to do what we can to retain biodiversity wherever it is reasonable and possible to do so but, once again, the genies really are out of the bottle and it all becomes more and more difficult as our own population pressures increase - post the end of oil it becomes impossible to do anything at all and we will be turning the job over to evolution.

Visual amenity. Now there is a vexed question on which I have firm thoughts. We seem to manage the startling sight of giant swathes of brown tussock grassland turned into conjoined circles of emerald green by centre pivot irrigators with a fair degree of equanimity. Why should it be otherwise since, endangered paradigm that it is, this is presently how we are fed and what makes possible an industry that helps power the nation. Would the somewhat alien sight of dark green trees slowly manifesting themselves in our distant field of view really be so dramatically much worse than this? We seem untroubled by the same sight in the Rockies or the Alps. I have already stated that I think it absurd that in the regulations that govern the homes we can build to live in, we consider subjective human aesthetic values to be more important than that which truly affects the environment, that being energy usage. Once again, here we have human aesthetic values taking precedence over the possibility of the management of a new, highly exploitable and, ultimately, very environmentally benign energy system. Wilding Pines are pure biomass and offer us a potentially brand new and largely beneficial industry if we would only pause to consider it.

As well, whose aesthetic values are we most considering here in any event? I would venture to say those of the tourists to our area are those whose delicate sensibilities we are most at pains to protect. We feel we need to foster that *“Clean and Green Kiwi image*” at any cost, even our own and even if the protection is really not necessary. The seemingly obsessive preoccupation with the concept that when it comes to our buildings, invisible somehow equates to what I call “*eco, enviro and sustaino"* is a misplaced emphasis that particularly bothers me and is right up there with other kinds of similarly misinformed ecobabble. In other parts of the world one sees colour everywhere in the built environment, a homeowner needs no one’s permission to install a solar system and both the tourists and the neighbours just have to bloody well put up with five minutes reflection (and that is all it is with a moving sun and a static roof) from the PV covered building every so often if it is good for energy generation.

I do fully understand just how important tourism is to the economy of New Zealand and to our area in particular, but please consider the arguments put at the front of this submission relating to the probable rate of exhaustion of fossil fuels. Further reflection on that issue leads to thoughts on what changes will occur as we see that supply graph steepen into downward decline. Clearly the prices of all classes of fossil fuels will begin to rise, and, eventually, rise dramatically. Once that happens it becomes inevitable that activities that are somewhat superfluous will be dispensed with first. What could be more superfluous than two week trans-hemispheric jet travel tourism to a group of tiny isolated magical islands on the other side of the world. As the tyranny of distance reimposes itself on an increasingly oil challenged globe, international tourism will be one of the earliest casualties. If one accepts this as a basic premise then questions should arise as to just what prominence we should continue to give this sector in our long range strategic planning.

So here is that question posed in relation to Wilding Pines: ***“do we continue to favour the visual amenity of unproductive land preferentially to the renewable energy production potential of that same unproductive land in the unchallenged belief that because that visual amenity supports tourism (a demonstrably endangered industry) it is more important to the local community than its own energy future”?***

In any event, all of these contentious categories of argument can surely be put aside in the face of simple reality.

<u>BECAUSE</u>

- Given that the population of our area is growing rapidly due to forces totally out of our control.

- Given that we have spent over a century creating a building stock to house the bulk of our population that becomes thermally uninhabitable in winter post the end of oil.

- Given that more homes with appalling energy credentials are being built every day.

- Given that climate change and global warming are now a proven scientific fact and no longer a hypothesis.

- Given that snow lines are rising and glaciers are melting.

- Given that the level of controlled lakes such as Lake Hawea that are so critical to our electricity supply are constantly at low levels.

- Given that electricity for powering an ever increasing number of the most inefficient type of heat pump that are being used to heat an ever increasing number of energy inefficient homes will become ever more costly and ever more difficult to provide.

- Given that we live in the shadow of a potentially catastrophic seismic threat from the Alpine Fault and the certainty that “the big one” will shut down the national grid for days, weeks or months.

- Given that such a seismic event has at least 40% chance of occurring at a time of year when nights are cold enough to require heating of some kind, and with the population converted to heat pumps and the grid down there won’t be any heating because wood burning appliances have been banned.

- Given that the biomass sector is at such a dramatic stage of maturity and market penetration overseas right now.

- Given that the technology does exist to burn firewood cleanly right now.

- Given that there is not the slightest possibility of defeating wilding pines in the long term as that would entail eliminating the plantations from which they have so successfully made their escape and thereby eliminating a viable major national industrial resource.

SURELY

One must ask:

> ***“How much sense does it really make to be effectively banning the use of biomass fired home heating systems, and doing so with a regulatory regime based solely on the phasing out of existence of the 200-year-old log burner, the Model-T Ford of wood burning appliances, but being completely ignorant of its 21st century replacement? And then, in a final starburst of astonishing bureaucratic incompetence and communal myopia … burning fossil fuels to power helicopters to spray vast areas with hideous toxic substances to kill pine trees that are striving valiantly to establish themselves on our otherwise naked and degraded mountainsides when those very trees, if left to grow to maturity, could provide our homes with heat and hot water in a very productive and environmentally acceptable manner and all the while providing a significant number of new local jobs in a greatly reinvigorated local forestry industry and doing so from presently unproductive land”.***

Friends and neighbours - these trees are not going to be eradicated. They are going to be managed one way or another. Why on earth would we choose to do it in a way that is entirely negative in every respect when we could do it so positively, productively and maybe even sustainably instead?