terraintegra

ECO VILLAGE PROJECT

Chapter I
Energy for Life

(a) Introduction

At the beginning of the 21st Century, 15% of the World's people consumed 70% of the World's energy, generally using fossil fuels to provide that energy. This ratio of energy consumption is not static and will invert over the next twenty years, not because of a balancing of energy consumption but because new industrial giants are emerging to replace the old who drift towards service businesses and outsourcing. In consequence, the energy available today will be very inadequate in twenty years time. The economies of some Developing Countries are growing at an exponential rate. China and India, are leading the charge. Africa, Central Asia, most of South America and Oceania (excepting Australia and New Zealand) are being left further behind. The economic World is splitting into three divisions, Developed, Developing and Under-Developed. With modernisation, the per capita energy requirement of the Developing World will grow to four times that of the Developed World because of much larger populations and today's means of creating the required energy are inefficient and wasteful. As these Developing Countries are home to half the World's population, that energy requirement, using today's premier technologies, is neither achievable or sustainable by the Planet. Another two billion people (Africa: 1 Billion, Asia 600 million, South America 400 million) live within the Under-Developed World. Their populations will double in the next forty years, increasing pressure on energy, food, water and healthcare.

Fundamental to the continued development of the Developing World and the necessary trigger of development in the Under-Developed World, is the creation and use of energy. Energy and its sources have become popular news topics in the media and academia. But, accelerating economic development in the Developing World and population explosion in the Under-Developed World together make imperative a dramatic increase in energy generation. The only choice remaining is how to attempt to provide that extra energy. The 20th Century energy generating technologies are neither effective, sustainable nor healthy in the 21st Century. The answer lies in distributed electrical energy generation, efficient use of energy and its conservation. Distributed Electrical Energy generation using alternative energy resources and its consumption to power industrial and commercial development, societal quality of life, education and healthcare, communications and transport, presents the only realistic alternative to 20th Century energy solutions (oil, coal, nuclear and conflict).

(b) *terraintegra*

Terraintegra, is a socio-environmental entrepreneurial organisation. It is a consultant and advisor to various diverse groups (NGO's, Foundations, Commercial enterprises, Communities, Farmers e.t.c.) about the local generation, conservation and use of energy. Through constant research and enquiry, its team seeks out and identifies life quality enhancing and viable technologies. Terraintegra helps deploy these technologies where appropriate. In consequence, it has accumulated knowledge and know-how and has forged partnerships and associations in areas which help it achieve its goals. Its skills encompass alternative electricity generation, combined heat and power generation, distributed generation, fermentation technologies, water purification and desalination, passive housing, phase change materials, socio-environmental audit, healthy food and water and innovative efficient transportation for passengers and goods.

Every community should have knowledge about itself, its environment and its comparative quality of life. It should be aware of the larger World society, technologies, medicines, risks, successes and damage done. Knowledge is a cornerstone of society and an enabler of its quality of life. But, for a community to access sources of knowledge and having knowledge, to take action, that community must have access to energy. Where that energy is sourced is the greatest challenge of the 21st Century.

By definition, alternative and distributed energy supply is micro and mini as opposed to mega and giga. It is also locally sourced and can be locally owned. Terraintegra approaches the issue at local and community level.

Terraintegra is activating the roll-out of its Eco-Village strategy firstly in volunteer prototype villages and communities and from there to eventually encompass most of the un-energised parts of the World. Several communities in the Developed and Developing Worlds can also benefit themselves and the Planet by implementing an Eco-Village life strategy.

Eco-Village concepts are not new. Many such proposals have been disseminated before (*See UN Millenium Project, Jeffrey Sachs)*. There is one crucial difference between this proposal and its precedents. Terraintegra posits that for the residents of the Developing and the Under-Developed Worlds to advance societally, they must be powered by energy. Only when sufficient energy is available can the genius and motivation of the people of these Worlds be directed towards a standard of live that they desire and deserve. Therefore, energy and more specifically electrical energy, is the imperative of terraintegra's Eco-Village strategy. When cheap, reliable, efficient, adequate electricity is available and efficiently consumed the Eco-Village will step towards a better future.

(c) Electrical Energy

1.6 Billion people have no access to electricity

"Access to energy services is a key component of alleviating poverty and an indispensable element of sustainable human development. Without access to modern, commercial energy, poor countries can be trapped in a vicious circle of poverty, social instability and underdevelopment." International Energy Agency (IEA)

The United Nations Development Programme (UNDP) human development index (HDI) compares social and economic well-being in relation to per capita energy use. The HDI values demonstrate strong correlation between social and economic well-being and per capita energy consumption. Countries with high HDI values have high per capita energy consumption values and correspondingly high gross national income (GNI) numbers. Conversely, countries with low HDI values have low per capita energy consumption values and low GNI numbers.

Chart: Selected countries relationship between HDI, GNI, Electricity and Energy use.

Country Region	Human Development Index (HDI)	GNI at PPP per Capita	Electricity Watts per capita	Electricity kWh per capita 2005	Per Capita Energy Use (Gigajoules)
France	0.961	29,203	851.00	7,698.60	189.77
USA	0.956	41,557	1,460.00	13,635.70	327.38
UK	0.947	30,309	667.00	6,233.90	164.56
Germany	0.947	30,150	822.22	7,113.90	176.53
OECD Europe		30,000			142.00
EU	0.937	26,900	700.00		150.00
Latin America/Caribbean	0.821	6,549		1,526.10	46.00
Russia	0.817	11,209	785.00	5,786.40	185.77
Brazil	0.810	8,745	226.00	2,012.80	44.84
China	0.772	6,193	277.00	1,780.50	47.81
South Africa	0.683	11,035	581.00	4,847.60	109.07
India	0.612	3,262	50.50	480.50	21.52
Kenya	0.541	1,125	14.90	143.90	20.21
Papua New Guinea	0.540	2,414	66.60		
Sub-Saharan Africa	0.514	1,880			25.00
Asia				1,404.30	25.00
Congo DRC	0.389	675	10.50	93.00	12.44

It is not because they are Developing and Undeveloped that the people of these Nations have inadequate energy supply. Conversely, it is because they have poor energy supply that they languish in the lower quality of life divisions, unable to access the means to graduate to higher qualities. It is estimated that India loses up to €7 billion in productivity because of electricity shortage or to put it another way, India's GDP is lower than its potential by 1% because of electricity shortages.

The figures cannot account for internal imbalances. Industrialised South Africa, Sub Saharan Africa's most developed country, a middle rank energy consumer, gives misleading impressions. Though with 5% of the Continent's population, South Africa consumes 50% of the Continent's generated electricity. But 54% of its children (i.e. 10 million) lived in rural households in 2004. In 2007 less than half of these children (47%) had access to electricity. Only 27% had access to basic sanitation and only 15% had access to safe drinking water at home. *Children's Institute, University of Cape Town.*
(Note: These figures may be conservative as up to 65% of South Africa's rural and over 40% of urban children are not registered at birth, (the "invisible children" of South Africa).

(d) Achieving Quality of Life

In its "6 Questions towards Peace and Sustainable Development" the Global Network Energy Institute (GENI) ponders "how do we make the world work for 100% of humanity in the shortest possible time through spontaneous cooperation without ecological damage or the disadvantage of anyone? *(Question 1)*.
(See: http://www.geni.org/globalenergy/issues/overview/6questions-towards-peace-sustainable-development.shtml#1)

Question 2. *How do you define adequate quality of life -- a decent living standard for all?*
A: *Sufficient clean water, food, shelter, sanitation/sewage, health care, communication, transportation, education, security, economics.*

Question 3. *What is the technology that supports or enables each of the above systems to exist?*
A: *Energy, specifically electrical energy.*

Electricity supply is one cornerstone of a society which can provide a Quality of Life acceptable to its members. Electricity is the fuel which transports information, facilitates education, supports healthcare, produces potable water and hygienic food, creates labour, powers technology and industry. Today, electricity also promises to provide essential transport needs. Unlike oil, electricity can be produced in every town, village and community. It decentralises energy production, removes territorial disadvantage, vulnerable transport and security concerns.

Yet, 1.6 billion people have no access to electrical energy. Almost all live in a Developing or Under-Developed Nation. There is no UN strategy focused to bring electrical energy to the un-energised World. New York City consumes more electricity than all of Africa, from the Sahara, to the border of South Africa. Over 80% of people without electrical access live in South Asia and Sub Saharan Africa. 80% of Tanzania's people live within 5 kilometers of electricity transmission lines but only 10% have access to electricity. Without cheap, reliable, sustainable, local electricity, the Developing and Under-Developed Worlds will always be Developing and never Developed.

(e) Big Energy v Small Energy

Centralised electricity production reached the big population centres, suburbs and even remote rural regions of Developed Nations by the second half of the 20th Century. In 21st Century, Africa, Asia and South America its reach remains short and sparse. It is said that electricity takes time and expense to penetrate the poorer regions of the planet. This assumes centralised electrical distribution from giant industrial facilities pumping out megawatts of electricity or tonnes of transport fuels. Alternative electricity (and bio-fuels) do not have to replicate the fossil fuel era. Alternative or eco-energy need not share the same fate as oil: produced far from market, transported in bulk tankers, centralised distribution points, monopolised and politicised with security appendages.

Uniquely, alternative or eco-energy, in addition to having the potential to minimise planet resource depletion, can also be produced at community, village and individual level. The billions spent on oil, financial rescue of dinosaur banking companies and vehicle manufacturers which insist on continuing to make inefficient vehicles, could, if diverted, revolutionise the Developing and Under-Developed Worlds village by village. The benefit would also accrue to the Old World as new businesses in Africa will sell their goods to customers in Ohio or Bodyke and will use their newly achieved disposable incomes to buy the products of Ohio and Bodyke. Less calculable, but equally important will be the shared cultures, better understanding, histories, skills and lessons learned.

Distributed Generation is the cornerstone of locally produced electricity. Distributed Generation (like electric vehicles) has been with us since the early years of electricity production. At one time it was thought that Distributed Generation would become the dominant energy transfer and storage technology. But, when Ferranti completed the Deptford generating plant and distribution system in 1891, the first modern power station, supplying high-voltage AC power that was then "stepped down" for distribution to local homes, he launched centralised generation and encouraged the development of long range electrical transmission, to the detriment of Distributed Generation. Over a century later, Distributed Generation still supplies about 7% of World electricity consumption and is expected to make a comeback. It now can, like the mobile phone, allow Developing and Under-Developed Nations to skip the infrastructural and installation costs of centralised generation, moving instead to the low infrastructural costs and short installation time-scale of Distributed Generation. Alternative energy technologies are, by definition, distributed and do not easily scale up to centralised volumes. Newly developed synchronous generators and associated distribution technologies allow the commercialisation of Distributed Generation with efficient, reliable, micro grid control. Biogas storage and flow batteries promise efficient economical and indefinite electricity storage and distribution.

The argument as to the merits and demerits of centralised or distributed electrical generation are complex and many. A separate report is necessary to adequately address this subject but, in summary, certain aspects deserve mention in this document:

(i) We live in the 21st Century. It is almost 180 years since Michael Faraday discovered electromagnetic induction and built the first generator in 1831. A quarter of humanity still exists without electricity. This is the single greatest indictment of the predominance of centralised and affluent electricity generation.

(ii) By its nature, centralised energy is monopolised energy. Monopolisation encompasses economic, political, ethnic and class control. Energy control is a weapon. Distributed Generation is structured like the internet. Electricity contributes towards local energy needs and simultaneously can be transferred further afield as needed.

(iii) First mile, last mile. Utilities admit to losing over 7% of electricity in transit. But, losses may be far greater than admitted. About 65% of primary coal energy and 50% of primary gas energy, is lost as dumped heat. This can be observed at cooling towers which plume the lost energy as steam to the atmosphere. Transmission losses are calculated to be about 3% per 100km travelled with a further 7% lost in distribution. The end user may get less than 35% of primary fuel energy. Diverse industries recognise these losses. "Half the power gets lost between generation and the wall socket, and a lot of it has to do with the way the grid is operated and its efficiency, "*Justin Rattner, vice president and chief technology officer at Intel Corp.* And, "Electricity, on the other hand, measured from the point of generation to the wall socket, is much less efficient. In fact, only about 27 percent of the energy put into generating electricity is available by the time it reaches your home."
NaturalGas.Org, http://www.naturalgas.org/business/demand.asp.

Developing and Under-Developed countries which have electricity supply have greater transmission losses because of poor infrastructure, India loses 26% of its electricity during transmission and distribution. Further losses, due to theft and criminal damage, mean that only half of India's electrical generation is delivered to its customers. Uniquely, Distributed Generation can reduce these losses as generation is renewable, heat (normally lost) can be used to directly replace electricity consumption in heating buildings, transmission distances are shorter and supply and consumption, helped by good communication, are closely matched. It is probably not a coincidence that the countries with the most efficient electrical transmission and distribution systems and whose people universally have access to electricity, are small with small transmission and distribution infrastructures, which approach diversified grid systems in size and nature.
See: http://www.nationmaster.com/graph/ene_ele_pow_tra_and_dis_los_of_out-power-transmission-distribution-losses-output

(iv) Centralised grid systems must build a network of redundant lines to maintain the efficiency of the Grid. These redundant lines criss-cross the landscape, a costly inconvenience to the utility companies and an eyesore to many. Distributed Generation can help reduce redundant lines and bury lines economically over short distances. Distributed Lines become small, local and web-like with few transgressing high on pylons over countryside.

(v) Centralised energy production is heavy industry by its nature. It is largely fed by a mix of fossil fuels (80%); oil (34%), coal (25%), natural gas (21%), wood, other biomass and waste (11%), nuclear power (6.5%) and hydro-power (2.2%). Less than 2% of global energy demand is met by renewables. At least 35% of all Planet tapped primary energy is converted into electricity. Among Developed Nations an average of 42% of all primary energy is converted into electricity. Coal is used to generate about 40% of Planet electricity. Its consumption continues to expand as Developing Nations consume more energy. Natural gas meets 20% of electricity production, hydro 16%, nuclear 16% and oil 7%. Other renewables provide less than 2%.

Coal is a major emitter of greenhouse gas. A single kW/h of electricity produced from coal generation costs a single kg of CO_2. Natural gas, despite the implications in its name, also pollutes (0.206 kg CO_2/kW/h). Coal-fired plants generate 56% of U.S. electricity, emitting 1.5 billion tons of CO_2 per annum with varying volumes of sulphur (a major constituent of acid rain). Coal is the fuel voted most likely to succeed as the World anticipates a doubling of electricity production over the next 15 years to 24.7 trillion kilowatt hours *(Energy Information Administration (EIA))*. Much of this new generation will occur in China, India, Vietnam and South East Asia where some countries will quadruple their electricity production. "CO_2 emissions are projected to rise 55%--from 27 gigatons (Gt) in 2005 to 42 Gt in 2030." *International Energy Agency (IEA).* There are other dangers also. “In a 200 MW power plant in India burning about 9000 tons of coal per day leaching of a mere 15% of heavy metals from the surface of Ash will cause a nearby river to receive daily 208Kg of Iron, 56Kg of Zinc, 45Kg of Copper, 5Kg of Cadmium, 56Kg of Nickel, 4.6Kg. of Uranium, 16.5Kg of Thorium, 60.6Kg of Chromium and 11.2Kg of Cobalt daily.” *Dr. Yashpal Singh, Chief Environmental Officer, U.P.Pollution Control Board, Lucknow, India.*

Developed nations do not escape the consequences of coal burning either. The U.S. burns more than a billion tonnes of coal each year to generate 50% of US electricity. Over 130 million tonnes of coal waste (ash and sludge removed by power plant air scrubbers) is produced. An August, 2010 study by the US Environmental Protection Agency (EPA) revealed “that 39 sites in 21 states where coal-fired power plants dump their coal ash are contaminating water with toxic metals such as arsenic [cadmium, lead, selenium] and other pollutants ... [The pollutants are linked to cancer, respiratory diseases and other health and developmental problems.] Of the 39 sites analyzed, 35 had groundwater monitoring wells on the grounds of the waste disposal area. All of them showed concentration of heavy metals such as arsenic and lead that exceeded federal health standards. ... The other four had only water monitoring data from rivers or lakes where the waste sites discharged water. Scientists found contamination that damaged aquatic life.” *EPA*. Today contaminated coal waste sites in the US number 137 in 34 states. Smog which aggravates asthma and acute bronchitis and is linked to heart attacks is also caused by coal plants.

Oil burned to generate electricity produces nitrogen oxides, sulphur dioxide and particulates, carbon dioxide, methane, heavy metals including mercury and volatile organic compounds (which contribute to ground-level ozone). Sludges and oil residues not consumed during combustion become solid waste, comprising toxic and hazardous wastes.

(vi) Centralised electricity generation uses high transmission lines to transfer the electricity to market. Electromagnetic fields surround high transmission lines because the electricity literally leaks out of the wires to the Earth. While arguments, within and outside the medical professions, continue, some reliable evidence shows harmful health effects from exposure to these waves or radiation. The US National Institutes of Health (NIH) voted in 1998 (19 for, 9 against) that electric fields such as those around power lines should be considered possible human carcinogens. Of the dissenters, only one considered that there was no risk. The Bern University Institute of Social and Preventative Medicine in Switzerland found (2008) that the risk of developing Alzheimer’s increases the longer people live next to electricity pylons. “Anyone who lives within the immediate vicinity of high-voltage power lines for more than 10 years has a significantly higher risk of developing dementia or Alzheimer’s.” *Professor Matthias Egger Bern University Institute of Social and Preventative Medicine.* The University of Bristol has identified links between childhood leukaemia and proximity to power lines.

Distributed Generation requires fewer and smaller power lines. Lines near occupied areas can be reliably insulated. By using smaller insulated synchronous generators, electromagnetic waves will be less powerful and less prevalent. By using high quality electric machines and distribution technologies electromagnetic waves can be reduced at source.

(vii) Distributed Generation has historically been disadvantaged by technological complexity, higher costs and poor economies of scale. The green movement has fostered progress towards Distributed Generation by lowering the production and generation costs of alternative energy and its distribution. Today, embedded systems provide low maintenance, high efficiencies and automated operation. This facilitates the viability of smaller power plants. A couple of recent minor technological breakthroughs, the grid frequency setting capability of the BEM generator and the ORC expansion rotary pump/engine, promise to bring the costs of various micro generation technologies lower, to compete with fossil fuelled generation, without the environmental deficit.

(viii) Distributed Generation has the potential to match consumption with production. While storage does still pose problems (efficiency and high costs), progress gives greater control over the production of electricity and its storage for use during peak demand. And, just as important, the efficient use of energy and its conservation can be more easily integrated into a holistically designed, distributed energy strategy.

(ix) Perhaps the most enticing aspect of Distributed Generation and micro generation is localised ownership and responsibility for energy creation, consumption and conservation. Locally produced energy is consumed locally. A community's respect and appreciation of locally produced and distributed energy will transfer to support and co-operation both in production and in conservation. An Irish saying "níl aon tinteán mar do thinteán féin" translates as "there is no fireplace like your own fireplace".

(f) World Climate Change, Under-Developed World Climate Disaster

Climate is changing. It is almost academic to debate the causes. With the occasional exceptions (e.g. wine producing industry in Northern Europe and food production in Iceland) the climate changes now becoming apparent are bad for humanity and most animal life.

As with wealth, the changing climate's impact will not be evenly distributed. "Although climate change is a global phenomenon, its consequences will not be evenly distributed. In short, climate change can affect problems that are already huge, largely concentrated in the developing world, and difficult to control." *Dr. Margaret Chan, WHO Director-General.*

The environment and economic development are, today, inseparable. Before Global Warming became an issue, the then "Third World" ("ce Tiers Monde ignoré, exploité, méprisé comme le Tiers État" *Alfred Sauvy 1952*) paid a continuing and heavy price for the excesses of the First & Second Worlds. Perfidious colonisation, exploitation, manipulation were common in Africa, Asia and South America. The Developing and Under-Developed Worlds were always more vulnerable to viruses, bacterial infections, parasites, malnutrition and the less well understood "new diseases" AIDS, Nipah virus and Ebola. Environmental change has added to the distress. Drought and floods bring hunger and disease. Malaria and Dengue fever are spreading further afield. Progress and development in these circumstances are more difficult with the result that poverty is greater today than in 1995 as "277 million people still live on less than US$1 a day (compared with 265 million in 2000 and 245 million in 1995); while two-thirds of all people in those 50 [Least Developed] countries survive on just US$2 a day". *United Nations Conference on Trade and Development)*

It is perversely certain that Climate change will have an exaggerated impact in the Developing World and more so in the Under-Developed World. Dry regions will get dryer and wet regions will get wetter. As the World heats up, the consequences have already become severe. A 2°C rise in Global temperature will advance the threat of Dengue fever (no recognised cure) from its present position threatening 35% of the World's population to prey on 60% of the World's people. Already, Jakarta, population 12 million, has seen a dramatic all year increase in Dengue fever outbreaks due to extending rainy seasons. About 300 million people are at risk of contracting Malaria and it kills about 1 million people (usually the young) each year. The highlands of Bolivia are experiencing Malaria outbreaks for the first time in recorded history. By 2050 Malaria will have access to another 150 million people.

In addition to human suffering, climate change has economic impacts. "a 2°C rise in global temperature [will] cost about 1% of world GDP" *Stern Report 2006* . "the cost to Africa will be more like 4% of GDP and to India, 5%." *World Development Report, World Bank.*

"Even if environmental costs were distributed equally to every person on earth, developing countries would still bear 80% of the burden (because they account for 80% of world population). As it is, they bear an even greater share, though their citizens' carbon footprints are much smaller" *A bad climate for development Sept. 17th 2009 Economist.*

The Copenhagen Conference on Climate Change (2010) has been declared a failure by all but hardened optimists. The USA is resuming its retreat from a dalliance with Kyoto and not to be outdone Su Wei (who led China's negotiating team at Copenhagen) recently said that China "could not and should not" set an upper limit on greenhouse-gas emissions at the current stage. He seems to be at odds with the most recent official Chinese position. Britain's Prime Minister blamed the USA and China jointly for the Copenhagen failure. Meanwhile, villages in Africa, Asia and South America are once again faced with the prospects of being left in the dark. It is left to the villages and communities of the Developing and Under-Developed Worlds to roll out the technologies, know-how and skills that can enhance their own Quality of Life, village by village. The future well-being of the Developing and Under-Developed Worlds depends on it as does the well-being of the unwitting Developed World.

(g) The 10 Quality of Life Components

To enable a community to function, affording Quality of Life to its members certain resources are essential and imperative. GENI lists 10 essential "quality of life" components as (i) sufficient clean water, (ii) food, (iii) shelter, (iv) sanitation/sewage, (v) health care, (vi) communication, (vii) transportation, (viii) education, (ix) security and (x) economics. These ten components should become UN recognised and supported basic human rights, the absence of which keeps nations poor, nurtures disease and encourages conflict. Terraintegra, in defining its Eco-Village Project, places the attainment of these ten Quality of Life components as its targets and the criteria by which the success or otherwise of a project will be judged.

(h) Sustainable Supplies of Safe Electrical Energy

To achieve the Quality of Life targets, regular, reliable, sustainable, safe, economical electricity supply must be made available. Western society would cease to exist without a reliable electricity supply. It is pernicious to demand the societal norms of Western culture from the Developing and Under-Developed Worlds without ensuring that they have the opportunities and advantages enjoyed in the Developed World. Access to electricity, information, water, healthy food, security of person and property, e.t.c. are prerequisites to robust, long-lasting democracy and justice.

There is almost no place on the planet, which is habitable by humans, where electricity cannot be produced. Additionally, there are several areas where humans cannot survive (e.g. deserts, volcanic regions, oceans) which are eminently suited to electricity generation. Today, micro generation of electricity <500kW) is economically viable. Electrical energy can be generated in stations which output 100kW, 50kW or less, while maintaining cost-effectiveness and efficiency. As important, micro generation and Distributed Generation technologies can be implemented quickly. The long wait for centralised distribution to reach remote or politically disfavoured villages is no more. For many in the Developing and Under-Developed Worlds (1.6 billion people) micro electricity generation supported by Distributed Generation technologies offers the best and only hope of a better Quality of Life.

Energy self-sufficiency is normally viable whether the village enjoys lots of sunlight, rain, wind, river, tide, near surface geothermal heat, or grows extensive biomass. Photovoltaic and concentrating solar power (CSP) systems, wind turbines, hydro-turbines, geothermal systems, tidal turbines, bio-gas generation, PCM and passive building design all have a role to play in energising communities and villages by providing electrical energy, heat by-product, potable water and safe food.

Chapter II
Quality of Life
What can electrical energy achieve?

Try to imagine your environment with no electrical access. Electricity can provide the energy to improve the

(i) Sufficient Clean Water

1.1 Billion people have inadequate access to clean water

“70% of hospital visits in East Africa are due to consumption of contaminated water.” *African Medical And Research Foundation (AMREF).* In its 2010 report "Sick Water” the UN Environment Program attributes 3.7% of all deaths Worldwide to water-related diseases. Clean water will help reduce disease transmission and improve general health. It will support cattle and crops. Wild animals will also benefit. Water can be transported by pipeline and canal more cheaply than can natural gas. Clean potable water to sustain humans, fauna and flora must be ensured locally where possible and piped where practical. But, though the World has lots of water, only 2.5% is fresh water, about 70% of which is frozen in the ice caps of Antarctica and Greenland. Most of the remainder exists in soil moisture or in deep underground aquifers not accessible to humans. Less than 1% of the World's fresh water (0.007% of all water on the planet) is accessible to humans. The 2030 Water Resources Group estimates that World water demand will increase by 50% within 20 years, about 40% more than the planet can sustainably deliver. Already, about 35% of our fresh water consumption is not replenished. Agriculture accounts for 70% of World water usage. As Developing Nations industrialise (industry consumes 16% of fresh water supplies) and populations grow in Under-Developed Nations, the World must quickly take action to desalinate seawater, purify available supplies, conserve available water by efficiencies in agriculture and industry and pump water long distances. The alternatives are increased droughts, famines, mass migrations of people and animals, conflicts and accelerated climate change.

Direct access to potable water is essential to enhance quality of life. Water must be made available within the village or community. This will save considerable time and effort in transporting water long distances. This haulage work is usually undertaken by women and children. Readily available water also encourages better hygiene and facilitates local agriculture and industry. Technologies (e.g. pumps driven by electricity or directly by wind or heat) which deliver water to village homes, will free children to spend more time in school or at play and allow mothers greater time to self educate and manage their affairs.

In more arid regions it will be necessary to install desalination processes where sea water or other impure water is within reach. Simple technologies like rainfall collection, irrigation and pond dam building can be implemented or improved upon. These will reduce water volume requirements. Low cost long distance water pumping is feasible and increasingly necessary. There has been remarkably little research into the costs of long distance piping and canalisation of water. It will be much cheaper than oil and gas piping. Some studies suggest that water can be transported in open canals for about €0.06 per M^3 (1,000 litres) per 100km and elevated 100 metres for about the same price. In effect, it costs the same to transport water 100 kilometres as it does to elevate it 100 metres. This would make long distance transport of water from coastal desalination facilities into e.g. Northern Kenya (where drought is worst) relatively cheap. The distance is about 500km (Kenya route) from the ocean and the maximum elevation about 300M. CSP or wind turbines can be harnessed to assist pumping and reduce or eliminate energy costs.

Finally, water (like energy) can be used more efficiently. Low-flush toilets, special shower heads, grey water use, nighttime watering of plants and crops can help reduce water consumption. Drip hydration irrigation, Hydroponics and Aeroponics can dramatically reduce the water requirements of food cultivation.

(ii) Food

i. Food production

790 Million people are chronically undernourished

"Tell me what you eat, and I will tell you what you are." *Jean Brillat-Savarin, lawyer and gastronome (died 1826).* Nutritionists have long understood the necessity of food quality, balance and mineral content. More recently, research has shown connections between certain minerals and fatty acids and societal behaviour. Nourishing food can usually be grown in habitable areas, the seas and rivers. Innovative growing methods can change the nature of food production. Drip hydration, Hydroponics and Aeroponics have the potential to increase yields while reducing water consumption. Crops, grains and fruits can be selected for suitability to environment and nutritional value.

"Undernutrition steals a child's strength and makes illnesses that the body might otherwise fight off far more dangerous. Unless attention is paid to addressing the causes of child and maternal undernutrition today, the costs will be considerably higher tomorrow." *Ann Veneman, Executive Director, UNICEF.*

In the World today, 195 million children have stunted growth. 125 million are undernourished. The problem is not just insufficient food, it is inappropriate food. Knowledge about particular foods and their benefits for healthy growth, vitamin content, disease immunity, alertness e.t.c. is sometimes locally absent, even among Developed Nations. Education about food and minerals is essential. Food production can be focused towards healthier living, well nourished and alert children and healthier, less stressed adults.

The World's poor spend 75% of their disposable income on food so an understanding food nutrient value is essential. Biofuel production and natural disasters like Russia's (suspicious) wheat crop fires push even minimal volumes of food out of the reach of a billion people. With starvation imminent, drastic but positive action must be undertaken. Localised production will help reduce food costs and make more available. Trees and shrubs bearing fruits and nuts can be planted with the triple benefits of adding shelter, providing food and aesthetics. In arid regions, trees and shrubs help reduce soil erosion. Locally produced food can be both consumed locally and exported to market.

Carbon dioxide (CO_2), is a by-product of bio-gas fermentation (a technology that will be implemented near many eco-villages to generate electricity). Normally thought to be a greenhouse gas, CO_2 is essential to all living plants. The higher the CO_2 content of air, the better plants (trees, grasses, shrubs, herbs, vegetables, e.t.c.) grow. Air rich in CO_2 is toxic to humans, animals, insects, slugs and aerobic bacteria. CO_2 discharged by a fermentation process, can be pumped into glasshouses, thereby recycled to boost plant and crop growth (by up to 70%) while obviating the need for pesticides and nitrogens. Bugs and vermin avoid CO_2 rich environments while flora thrive on it. The CO_2 is thus further recycled to improve environmental return. Another by-product of fermentation, heat can be usefully employed in maintaining greenhouse temperatures at optimal levels. Finally, the residue, its pathogens destroyed by fermentation, rich in humic matter and humic acids which help reduce soil erosion, increase nutrient supply and soil hygroscopicity, is a valuable fertiliser.

Branding of food product for markets is important. As food, plants, flowers e.t.c., grown with the assistance of CO_2, require no pesticides or nitrogens, their marketability will be enhanced. With careful management, the food can be marketed as bio-food. With low cost, innovative transport technologies (e.g. the BladeRunner hybrid train truck) to transport village produce quickly and safely direct to market and (e.g. Aqua Salveo) to keep it fresh, the farmer gets best price for produce and the customer gets high quality fresh, nutritious, bio-food.

ii. Food preparation and storage

2.5 billion people use biomass, wood, charcoal and animal dung to meet their energy needs for cooking

Today about 2.5 billion people rely on biofuels (wood, agricultural waste and dried animal manure) to cook all their food. "The majority of households in sub-Saharan Africa still rely on fuelwood and charcoal for cooking. More than 95 percent of rural households in Angola, Benin, Cameroon, Chad, Congo (Kinshasa), Ethiopia, Ghana, Sudan, and Zambia among others still use fuelwood and charcoal for cooking. Some areas of China and India also rely heavily on fuelwood, wood waste, and charcoal for cooking. In China, about 55 percent of the rural population uses biomass for cooking, as does 87 percent of the rural population in India." *International Energy Agency (IEA)*

India is the World's second most populous country and averages 324 people per square kilometre. West Bengal is its most heavily populated state with a population density of 904 people per square kilometre. "Biofuels contribute 42 per cent of India's total soot emissions, while open burning (such as forest fires) produced 33 per cent and use of fossil fuels produced 25 per cent. The large quantities of soot produced by household stoves, especially those using wood, could have a negative impact on the atmosphere, particularly given the extensive use of biofuels in India. Airborne pollution such as soot could have important implications for agriculture and the economy by altering rainfall patterns." *Indian Institute of Technology, Mumbai*

"Indoor pollution caused by burning biofuels affects the health of hundreds of millions of people, and kills more children each year than malaria or HIV/AIDS. Among the diseases linked to stove use are pneumonia, lung cancer and respiratory tract infections." *Intermediate Technology Development Group (ITDG), UK.*

The situation is actually getting worse. "many people have been driven back to using wood, charcoal, animal dung and other traditional fuels for cooking because of rising liquid fuel costs and the global economic recession. Most of those are in sub-Saharan Africa and India. The allure to the very poor of seemingly cheap fuels is misleading. For example, the cost of light from florescent tubes in Bangladesh is actually less than two percent the cost of the same amount of light from old-fashioned kerosene lamps. Access to electricity accordingly can reduce total household energy costs dramatically, if upfront costs related to the connection are made affordable. .... Another cost from unclean fuels is damage to health and the environment, two issues that again reinforce poverty. In a country like India, where 90 percent of people in rural areas use biomass for cooking, simply a clean-burning stove would yield enormous gains in terms of health and socio-economic welfare." *IEA*

Small bio-gas plants can provide electricity or methane gas for cooking without the by-products of soot and smoke. CO_2 has been used to store nuts and grain safe from vermin and it also controls the growth of fungi. Electrical energy will allow, food cleaning, cooking, freezing and transport. Stanford University US has developed a simple fridge that only requires the Sun's heat to function. As previously mentioned, Aqua Salveo can be used to keep food fresher for longer.

(iii) Shelter

There are 640 million children without adequate shelter

"An estimated 900 million are living in inadequate housing and unsafe neighbourhoods. Individuals and families struggle to secure the resources they need for healthy and prosperous lives and this includes shelter. …..... Low-quality shelter compounds the problems of poverty. In particular, poor quality shelter is associated with significant health risks, with greater likelihood of morbidity and premature death. Poor health also increases the incidence of poverty, reducing the opportunities to improve livelihoods and hence invest in better housing. The adverse location of many low-income neighbourhoods increases the costs of securing livelihoods, adding to the difficulties of securing adequate incomes." *International Institute for Environment and Development (iied)*

Shelter affords far more than protection from the weather. In a comfortable home, family life can be enhanced, property can be protected, health will benefit, children can focus on education and on being children, communications can enhance information and business development. While shelter of some sort is generally available in all communities, adequate housing and sanitation conditions are lacking in many. Well planned "Passive Housing" can be quickly built, offering homes comfort levels suited to requirements. Heat dispersal, cold protection, and air circulating technologies can be integrated into a passive home, thereby dramatically reducing its energy requirement while improving its habitability.

It is essential that homes and public areas have access to heat and light. Without electricity, fuels (e.g. paraffin) for heating and cooking can become health hazards. Wood or dung fires can cause chest infections. Open fires can cause burns which are a common cause of injury and death, especially where healthcare is inadequate. 1.5 Million people die from indoor air pollution each year. Without fridges it is not possible to keep food fresh for long. Without clean water, food cannot be washed and cleaned.

The provision of shelter will extend to establishing a village or community meeting house, a medical clinic, a school, a communication centre, an energy unit, e.t.c. Villagers will be able to care for others in the community, communicate about cooperation, discuss internal and external disputes and function with social cohesion.

(iv) Sanitation & Sewage

2.6 Billion people do not have access to sanitation facilities

Over a third of the World's people have no access to toilet facilities. More than a billion people drink, cook with and wash in, water taken from sources polluted by human and animal faeces. Diarrhoea, cholera, typhoid, trachoma and parasitic worms are the direct, persistent outcome. There are less obvious but equally important consequences. The United Nations Children's Fund estimates that one out of every ten African school girls either stays away from school during menstruation or quits permanently because of lack of school sanitation.

Efficient management can remove these risks. Modern systems of waste removal and recycling have become highly sophisticated. Sewage can easily be treated for pathogen contamination and neutralised, (e.g. by fermentation to produce gases for transport and electricity) allowing its reintroduction to land as fertiliser. Solid wastes can be eliminated, domestic waste recycled, water purified, compost and bio-gas produced where appropriate. The UN and Asian Development Bank (ADB) currently support the use of the Indian Sulabh toilet technology to assist India's poor to have sanitary toilet facilities.

As part of a sanitation and sewage programme, the use and disposal of non bio-degradable materials (plastic bags, bottles, metal tins e.t.c.) should be considered. A recycling programme can be initiated. In the longer term, the production of starch-based bio-plastics can be developed as an industry. Thermoplastics are completely recyclable and should be used in the manufacture of containers and other materials. If produced using sustainable farming methods, bio-plastics can be carbon neutral. When used they can be fermented in a bio-gas reactor and used as fertiliser so that soil is not polluted.

(v) Healthcare

Physical and mental health is essential to individual and community wellbeing. Without exception, every village and community should have access to a minimum of healthcare. It may not be feasible or essential to have trained nurses in every village or community but a health worker should be available to facilitate a specific catchment area or defined number of people. Each village or community should have essential medicines and appropriate facilities. Education will also assist parents to quickly identify children's illnesses and take appropriate action. Internet and telecommunications will be able to facilitate medical knowledge, including by video communication (now feasible with smart phones) and allow access to urgent medical assistance.

Low cost ultrasound (mentioned above in another context) can be used in the field to treat wounds and reduce joint inflammation. Other innovative technologies and treatments are available to help treat many diseases now common in Under-Developed nations.

(vi) Communication

"The single most important reason why prosperity spreads, and why it continues to spread, is the transmission of technologies and the ideas underlying them. The beauty of ideas is that they can be used over and over again, without ever being depleted." *Jeffrey D. Sachs, The End of Poverty.*

Manhattan Island has more internet hosting servers than all of Africa. However, the Developing and Under Developed Worlds are abandoning fixed line for mobile. They are leapfrogging the infrastructural requirements necessary to deploy broadband wired services. Instead, cellular broadband services are used where affordable. The mobile phone has become ubiquitous. The advance of the smart phone and now smart tablet (i.e. iPad and its copies) together with the lightweight apps that can run on them, promises technological comparability with the best fibre-optic connected desktop computers.

Eco-Village work centres will provide high-tech information services. Commercial, home office and studio facilities will be available with broad bandwidth communication links. Schools will have internet access and classes can be connected remotely to teachers and other schools Worldwide if necessary. Farmers can determine local and international market prices for crops and animals. Sales can be contracted, delivery arranged. Husbandry and horticulture classes can be communicated via the web. The teacher and pupil can be on different continents.

Communication technology can go further and do more. Medical clinics can connect to central hospitals and doctors can view patients directly via video cameras. Bangladesh has already rolled out this system. Farmers can send photos of diseased crops or animals to national or even foreign agriculture advice centres and treatments can be prescribed. Precious time can be saved and so can crops, animals and humans. People can be empowered by the internet and its diversified siblings, complaints can be filed directly with government, bypassing often corrupt local bureaucracy. Shared political viewpoints can be organised and mobilised.

To effectively link rural communities with urban and international business customers and partners, a high speed (effectively instantaneous) data transfer transfer technology must be installed. WiMax is the most popular of several long range, relatively low cost, wireless data transferring technologies. Despite the hype, a well designed WiMax system can achieve ranges of 16 kilometres between cells. Longer ranges may be possible in open landscape and where there is little wireless traffic. While WiMax is a licensed technology in many countries, other competing technologies exist and new technologies are under development. UMTS, CDMA2000, HiperMAN, long range mobile Wi-Fi, G4, satellite dish and mesh networking all offer alternatives in data volume, range and costs.

3G cellular phone systems have entrenched infrastructure, having been upgraded from earlier systems. 4G is under development and may offer the cheapest access to high speed wireless internet. Redundant television radio frequencies can also be used to transmit high speed, high band-with, data over long distances.

(vii) Transportation

i. Roads, paths and tracks

Over 2,000 years ago, Roman armies built and maintained, for hundreds of years, over 85,000 kilometres of paved roads throughout Europe, North Africa and the Middle East. The routes of some still exist today. In 1997, Africa (excluding South Africa) had 171,000 kilometres of paved roads *(UN)*. Road quality in Africa is deteriorating. In 1992 about 17% of sub-Saharan Africa's primary roads were paved, but by 1998 the figure had fallen to 12%, (*World Bank)*. In 2010 80% of unpaved roads are only in fair condition and 85% of rural feeder roads were in poor condition and un-passable during the wet season. In Ethiopia, 70% of the population has no access to all-weather roads. Sub-Saharan Africa has approximately 700,000 kilometres of rural roads, 50% in rundown condition.

Studies show that a 10% drop in transport costs could result in a 25% increase in total African trade. *(World Bank)*. "Poor road access leads to higher transaction costs for many farmers when selling their produce. For example, high transaction costs are equivalent to a value added tax of 15% for Kenyan farmers (Renkow, et al., 2004). Transportation charges in rural Ghana and Zimbabwe are 2-2.5 times higher than in Thailand, Pakistan, and Sri Lanka (Torero, 2004)" *Shenggen Fan & Peter Hazell International Food Policy Research Institute, Washington DC.*

“Transportation bottlenecks and inefficiencies amount to an 80 per cent export tax on Ugandan textiles, making them far less competitive on world markets, discouraging greater investment in the sector and slowing job creation. The lack of modern storage and marketing facilities is a major contributor to food insecurity, with losses to spoilage accounting for as much as 30–40 per cent of grain harvests in some countries” *Commission for Africa (UK NGO)*

Poor road quality (together with poorly instructed and aggressive drivers) contributes towards accidents and fatalities. More than one million people die on roads each year, and 90% of fatalities occur in developing countries *World Health Organization (WHO)* "In a sample of African countries, 339 deaths per 10,000 vehicles were reported in 1996. In comparison, the average death rate in the world's 10 most highly motorised countries was 2.3 per 10,000 motor vehicles that year" *Global Road Safety Partnership*

Roads and paths leading to villages and farms in many rural areas are often tracks of local soil, sand and stones. Travel on such roads is hazardous, can harm the environment and degenerate efficiencies. Delivery of goods, parts, equipment and the export of village product to market is put at risk. Rain exacerbates the problem.

Roads carry essential water and food. They also allow the passage of urgent and emergency vehicles. The absence of infrastructure is most severe in Africa's rural areas, home to the majority of its 920 million people. Women literally carry the burden of poor infrastructure. Rural women walk an average of 6 kilometres per day to transport water from rivers and wells. They have no reliable roads and no piped water. They spend hours travelling to carry litres of water instead of more productive work at home or with children and families. Harvests cannot get to market, ill children cannot get to hospitals in time because of poor transport and roads.

Both "engineered earth roads" and "closed surface roads" can be economically constructed using easily available machines and materials. The costs depend on local terrain, climate and usage volumes. The US Transportation Research Board (TRB) describes methods of installing low cost roads in Africa using locally available materials, "a stabilized base and an asphaltic concrete made of calcrete/sand on in situ compacted sand". Alternatively, a Scottish development may be able to utilise waste construction materials to lay down low cost solid road surface. "TAYSET® is made from recycled construction waste. *See http://www.innovationportal.co.uk/main/case-studies/*
A South African road building technology compresses the underlying rock and clay into a solid foundation and overlays the surface with 3cms concrete. The compressed undersurface is sturdy enough to support heavy traffic while the light concrete covering protects the road surface against heavy rains. This technology can be adapted to build canals and rail track. A co-operative structure, especially if a number of villages co-operate to build and maintain low cost, high quality roads and paths linking them to each other and to main roads, can quickly extend transport links from home to home and village to village.

Roads can carry more than traffic. Properly planned, roads and paths can also carry water pipes, electricity and communication lines and can facilitate locally installed energy generating technologies to receive raw materials and to locate energy capture devices, e.g. wind turbines, CSP frames, bio-gas fermenters e.t.c.
The eco-village or eco-community will be offered control of the construction, maintenance and management of roads and paths. In doing so, the community acquires the relevant technical skills and organises labour sharing systems to facilitate progress. Low cost equipment and tools can also be introduced. Skills can be learned. Jobs can be created.

ii. Cars trucks, trains and boats

Electricity can provide the fuel to power local utility vehicles. Electrical modular transport vehicles can carry goods and passengers, become as and when necessary, an ambulance, a fire-brigade, a tractor, a truck, a bus or a dump truck. As several eco-villages and eco-communities begin to integrate and trade, redundant rail track and underused roads can be used to transport hybrid road rail vehicles like the Bladerunner (http://www.silvertipdesign.com/) to transport people and goods, economically and efficiently. Where canals are built to transport water, they can be simultaneously used to efficiently and economically transport goods to market.

(viii) Education

1 Billion people cannot read or write

"Education is not a way to escape poverty - It is a way of fighting it."
Julius Nyerere, former President of the United Republic of Tanzania.

"Education can contribute to economic growth, reduce poverty and promote stability. Every additional year of schooling for males can reduce their risk of becoming involved in conflict by 20 percent. Without continued investment in education in countries affected by conflict, there is potential for countries to fall back into a spiral of poverty and conflict." *Last in Line, Last in School 2009, published by Save the Children.*

With electricity, shelter and healthy food and water, attention can turn to education of young and old. This will be aided by better transport and access to modern technology, computers the internet, telephony, printers and scanners. Education will encompass school requirements and will extend to teach better agricultural cultivation, healthy living, food preparation, avoidance of dangerous products e.t.c. Education should be applied, that is students should be aware of more than academics but should know about their health, risks in society, treatments e.t.c.

Electricity must facilitate wide band internet access. The average US teenager enjoys more internet bandwidth than the average business in South Africa. Without internet access by the writer and the reader, this document might never have been created and the reader and writer might never know of the other's existence. To compete in today's market place, the next generation must be afforded an opportunity to experience the same technological progress as their compatriots in Ohio, USA or Wintrange, Luxembourg. They should be able to use technology to learn of and communicate with Ohio and Wintrange.

Teaching attitudes must advance also. The Education system must grasp the need to educate about and with technology.

“Our young people are growing up in a digital world. What is the education system doing to equip them to cope with life in a world driven by technology? Consider the current situation in South Africa:
Most schools lack computer facilities.
School principals are not taking a lead in promoting the use of available technology.
Teachers are reluctant to adopt technology as teaching and learning tools.
Education department officials are not encouraging and guiding teachers to embrace technology.
Computer literacy is not yet regarded as a critical skill and is excluded from the curriculum.
Are these not signals that our education system is on the wrong side of the digital divide? And sadly, that it is not helping our children to cross the divide?" *Kobus van Wyk (http://www.e4africa.co.za/)*

The irony is that, with less than 10% of South Africans having any kind of internet access, Kobus's intended audience cannot access his blog.

(ix) Security

Security encompasses far more than protection from attack and crime. "When Hurricane Mitch swept through Honduras in 1998, for example, poor households lost 15-20% of their assets but the rich lost only 3%." *Economist.* Security also protects individuals, families and communities from exposure to disease, pollution, predatory industrialisation and excessive mineral and resource exploitation.

Following the 1998 Tsunami which killed over 3,000 people along the east coast of Papua New Guinea, the Pacific Development Foundation, in anticipation of further such waves in the coming years, set about raising funds to install a Tsunami warning system and refuge centre on New Ireland. Nobody was interested at the time. The Foundation failed to raise the necessary funding. After the 2004 Tsunami which killed over 230,000 people in the Indian Ocean, the UN decided to implement an International Early Warning System beginning with an Indian Ocean System. It required the simultaneous deaths of almost a quarter of a million people to snap the Developed World into action. Tsunami are not the only risks. From natural hazards to human conflict, the villages of the Developing and Under-Developed Worlds are in constant peril. The Western media only report their plight when the body count mounts. The Eco-Villages will have to provide their own security and share their experiences with each other. New Ireland is still without its Tsunami warning system.

Simply having the downstream benefits of electricity (lighting, communications, alarm systems) and the general improvement in living standards (better health, local work and good payment for labour) mitigates against the perseverance of war, crime, unexpected hazards, new diseases and other predation. Communities with meeting halls will organise their affairs including provision for dispute resolution and the community's security. Once organised, a community can better protect its Quality of Life.

(x) Economics

Electricity is a necessary, clean, adaptable, transportable, efficient, energy delivery system to power economic growth. Economic growth will be evidenced by growing activity in industrial and commercial sectors. In consequence, electricity generation capacity must increase to anticipate and respond to economic growth.

Electricity will drive electric tools (drills, grinders, welders, saws, polishers, sewing machines, computers, printers e.t.c.). Electricity will facilitate the operation of fridges, ovens, freezing machines, bagging and packing machines. It will also facilitate transport (electric vehicles, buses, trains, tractors, cars, helicopters, boats e.t.c.) and communications (telephony, internet). With access to electricity a nucleus of enterprise will emerge.

The community can implement projects which foster self sufficiency, healthy environment, local energy, transport, e.t.c. A practical approach may be to form a co-operative comprising community, advisors and investors. Using the first project as a model, establish and adapt technology to other communities in the region.

A follow up plan will develop larger projects that involve a number of communities working in unison. Hydro generation, biogas plants, better roads, hospitals, commercial and industrial parks, tourism and transport can be implemented at this regional level.

Chapter III
Energy, Specifically Electrical Energy

Introduction (how much electricity is enough)

"per capita energy use beyond 70GJ/year *[1,945kW/h or about 40% of the EU average]* is associated with rapidly diminishing improvements in the quality of life and beyond 100GJ/year any additional gains virtually disappear. Excellent quality of life is thus possible with average per capita energy consumption at least 40% lower than the current EU or Japanese average, and less than a third of the extraordinarily excessive North American rate. Irrefutable historical evidence shows that energy use above that level is directed overwhelmingly toward wasteful, excessive (often outright ostentatious) personal consumption which finds its main outlets in amassing quantities of ephemeral possessions and in pursuing high-energy, and often environmentally destructive, pastimes (and, most recently, also in worrisome increases in obesity). *Vaclav Smil, Distinguished Professor, University of Manitoba, Winnipeg Canada. author of "Energy at the Crossroads" and "Energy in Nature and Society".*

A medium size family home in Northern Europe will, assuming it uses electricity to heat its airspace and its water, consume between 18,000 and 22,000 kilowatt hours (kW/h) of electricity per annum or about 2.3 kilowatts constantly, while a home in a warmer climate might use 8,000 kW/h per annum or about one kW constant. The discrepancy is due to the energy demand to heat a home's water and airspace which together consume about 60% of total energy load in Northern climates. This means that a European home must receive or be able to receive 2,300 watts on a permanent basis and a warm climate home might require 1,000 watts. [*Think of electrical supply as a water hose with multiple outlet taps on the hose.]* To drive the machines of a North European home, the hose must supply 2,300 watts of electrical pressure, instantly and for as long as it is demanded. 2,200 watts will cause household machines to run more slowly or stop. 3,000 watts is surplus to requirement which will blow fuses or trip switches if fed to the house and will normally be diverted elsewhere (i.e. to the grid or into batteries).

The home's electrical demand will also fluctuate. 2,300 watts is simply an average consumption figure. Washing machines, vacuum cleaners, kettles, lights, toasters, water and air heaters, power hoses, e.t.c. do not all operate constantly and do not consume a fixed amount of electricity. It is sometimes necessary to increase the electrical supply *(Think of increasing hose pressure to push more water in response to more taps being opened*). A European home could have a peak consumption of 5 or even 8 kilowatt for a time. As usually happens, peak demand can occur for all homes in a region simultaneously. The electricity grid is structured to be able to supply this "surge in demand" (e.g at dinnertime, half time in an important tv covered game, extreme cold or heat e.t.c. It does this by trying to predict demand spikes and by having callable energy reserves (e.g. hydrostation, nuclear or coal station backup generators) and by having reserves of electricity stored in "Grid Electricity Storage".

Electricity resists being stored in bulk and grid systems try to match production with supply. When this balance fails, "blackouts" and "brownouts" occur. It is suggested that alternative energy generation, especially wind generated electricity will further disrupt electricity supply. There is some evidence that some wind machines (in particular DFIG turbines) can disrupt a grid. However, smart grid technology will overcome grid fluctuations and as varying alternative energy technologies become common, the different methods and times of operation will help smooth out grid supply. Alternatively, off-grid or diversified energy systems, using e.g. expanding dome roofs on biogas plants or flow batteries fixed to wind turbines to store electricity, have become commercial and practical. Diversified Energy has been described as the "sleeping giant" of energy systems.

Because varying volumes of electricity are consumed by homes, offices, industry, farming, transport, e.t.c. in every country, a comparative methodology which helps identify comparable wholesale volumes of electricity is kilowatt hours (kW/h) per capita (i.e. per person). Germany is a major affluent economy which has an annual per capita electrical consumption of about 8,000 kW/h. The USA per capita annual consumption is 13,500 kW/h, almost twice the German consumption. Both countries are heavily industrialised. Germany is the World's second largest exporter (China is first) with the USA third. The Developing World will soon consume and exceed the per capita energy consumption of the Developed World while the Under-Developed World will consume even less electricity than today and suffer a further decrease in living standards, unless action is taken to bring electricity to its communities.

Terraintegra calculates that (taking into account increasing efficiencies in machines and buildings) annual per capita electricity consumption of 4,500 kW/h will adequately meet startup electrical needs in the Eco-Villages. If building design is incorporated into the project, passive buildings and passive technologies will reduce the energy requirement to about 1,800 kW/h per person annually. Demand will increase in time as commercial and industrial activity takes off. Some of the reduced electricity demand will be due to more efficient consumption technologies. Just as the mobile phone has allowed many in the Developing World to leapfrog incumbent telephony technologies, the eco-villages can leapfrog incumbent, energy intensive, technologies and choose new innovative technologies in energy generation, consumption and conservation. Once electrified, an Eco-Village will have the capabilities of regulating energy generation and consumption. Extra generation can be brought on-line as the local economy grows. Commercial parks and industrial zones, which cooperate to generate and use energy, can be developed by the communities working together.

Conservation

While the World's media focus on the impact of transport, in particular our vehicles, on the climate, buildings (homes, offices and industrial structures) are the elephants in the room. Buildings cause over 20% (10 billion metric tons) of global anthropogenic CO_2e emissions annually. Residential sector consumption, (defined as energy consumed by households excluding transport) accounted for about 15% of World delivered energy consumption in 2006. *International Energy Outlook 2009 (www.eia.doe.gov/oiaf/ieo/index.html).*

Our homes, therefore, present an obvious immediate opportunity to cost-effectively reduce global CO_2e emissions. By comparison, light duty vehicles (cars and light trucks) upon which the World's media is fixated, emit less than half that of residential buildings, somewhat more than 3 billion tons of CO_2e annually, or approximately 6% of total anthropogenic emissions, (IPCC).

As a result, the generation of adequate energy supply is greatly assisted by its careful and efficient consumption. Heating and cooling airspace consume 38% of an average home's energy. Water heating will consume 25%. Every effort must be made to reduce the energy consumed by these facilities. Luckily, the technologies and designs which can reduce the energy requirement of these and other facilities exist and are easily implemented. As housing is becoming more energy efficient (European homes and commercial buildings are increasingly built to "passive home" designs), the demand for domestic electricity will decrease on a per dwelling basis. Population increases (not an issue in Northern Europe) will counter this trend. But, a well designed passive home can reduce energy requirements to a quarter of the current average. This is good for the house-dweller and for the environment.

Climate will determine the energy needs of homes in the Eco-Villages. The energy requirement of Industrial, agricultural, commercial activity and public utilities (water purification, pumping, public lighting, communications e.t.c.) can be extrapolated by analysing these activities elsewhere and by consultation with the providers of the motors, machines, and technologies to be employed.

Several simple steps will reduce energy consumption considerably, some are;

(a) Energy efficient light bulbs cut lighting electricity consumption by 75% and last up to 12 times longer than normal bulbs. These can be simply installed in homes and in public areas to replace traditional lighting. With even lower electrical consumption, LED lighting is emerging as a further development in this area.

(b) Low energy consuming equipment. Computer and television manufacturers have made immense progress to lower consumption in energy use. Manufacturers of other products (e.g. washing machines, fridges and dryers) are now focusing on energy efficiency.

(c) Adequate wall and roof insulation can conserve heat losses. Up to 40% of generated heat can be lost via walls and roofs. Phase change materials (PCM) can retain daytime heat, keeping buildings cool by day and release it at night raising night-time interior temperatures, saving on active heating systems.

(d) Windows facing the Sun can harvest heat energy reducing the pressure on other heating methods.

(e) Heat, often a by product of industrial and generation activity, can be used locally to heat buildings and to facilitate the washing and preparation of food.

(f) Solar heaters and "envelope" building design will minimise the energy required to heat and cool a building.

Chapter IV
What are the alternative energy technologies that can be applied in an eco-village scenario?

UNCTAD´s **Trade and Environment Review 2009/2010** (1) (TER 09/10), contends that while conventional wisdom holds that economic crises are times for belt-tightening and cost-cutting, the opposite is true in the current case. The urgency of the crisis gives governments of the World´s poorer nations the chance to re-direct resources to economic growth that is more economically efficient, better for the environment, more socially equitable, and more promising over the long term.

"Steps to provide diversified "off-grid" renewable energy supplies, especially in rural areas, also hold great promise for the Developing world. The **TER** notes that such technologies as solar panels, windmills, biogas generators (using agricultural waste), and small hydro-power facilities can power homes and communities, increase agricultural production, improve health by reducing air pollution from indoor fires, and create jobs. .... Although the initial procurement and installation costs of renewable energy equipment are high (depending on how sophisticated the technology is), the running costs are very low, as there are no fuel costs. Furthermore, the decentralised nature of such energy supplies means that the high cost of building expanded electricity grids is avoided. For example, in the EmPower programme, power from local renewable energy sources is about 30% cheaper than grid-provided electricity. Such systems contribute to enhanced energy security and shield developing-country economies from both the escalating energy prices of conventional fuels and the notorious price volatility of fossil fuels." *(http://www.unctad.org/templates/webflyer.asp?docid=12668&intItemID=1634&lang=1)*

(a) Energy generating Technologies

Technology	€ Costs per kW (Nameplate)	Capacity Factor	Status	Comments
(i) Biogas	2,000 to 3,000	80.00%	Commercial	Uses raw materials, co-products
(ii) Water	1,500 to 2,500	60.00%	Commercial	In-stream low environment impact
(iii) i. Photovoltaic	3,000 to 5,000	15.00%	Commercial	High costs and low efficiency problems
(iii) ii. CSP	2,000 to 3,000	56.00%	Commercial	Downsizing difficult
(iv) Wind	1,000 to 2,000	25.00%	Commercial	Over hyped, low capacity factor
(v) Geothermal	2,000 to 4,000	90.00%	Commercial	Binary systems advancing
(vi) Human Energy	500 to 1,500	5.00%	Commercial	Humans can gen 100w on cycle gen sets

(i) Bio-Gasification Facility

Two kilograms of fresh manure will give one cubic metre (M^3) of biogas which can produce 1.7 kW/h of electricity and 7.7 MJ of heat. With an abundance of biomass and or slurry, a village can build and maintain a simple methane producing facility, which in turn can be used to generate electricity and heat airspace and water. In Germany alone there are over 4,000 commercially operative biogas plants in 2010.

Germany is the World leader in biogas technology and in kW/h electricity production by biogas fermentation. Electricity produced by biogas in Europe in 2006 was 17,272GWh annual, of which 7,338GWh was produced by German biogas facilities. By 2009 German biogas companies directly employed over 10,000 people. It is current German Government strategy to produce up to 20% of its electricity requirement from biogas by 2020. The average EU biogas plant is about 500kW nominal. Other EU Governments (Luxembourg, The UK, Austria) are increasing support for biogas by introducing attractive feed-in tariffs and grant assistance programmes.

In general, biogas technology is a simple technology and a facility is relatively cheap to build and operate, fed by chicken, cattle and pig slurry, crop waste, forest residue and general biomass. Careful bacteria selection will improve gas yields. The Technical University of Munich (TUM) has developed and commercialised advanced fermentation processes producing exceptionally high yields and broadening the range of raw materials to urban and industrial waste. Bio-gas processes can also reduce noxious smells. Heat co-product is a valuable resource for residential, commercial and public utility use. Another co-product CO_2 is used to improve greenhouse plant growth and obviate the requirement for pesticides.

The residue of the fermentation process is inert fertiliser, ready to be spread on the farm or to be dried and sold as fertiliser to market gardening companies. The biogas process actually removes pathogens from farm biomass and slurry. It enriches the soil with protein, cellulose and lignin, not normally delived by inorganic fertilisers. Humic matter and humic acids present in the residue help reduce soil erosion (by rain or wind) and increase nutrient supply and soil hygroscopicity. Humic soil content is essential to low-humus soils often found in tropical regions.

Modern electricity generating turbines (ORC Expanders), high efficiency engines and generators with few moving parts, give improved electrical yields and heat capture. Costs of these technologies have fallen in recent years and an economic biogas micro-electrical generation facility (e.g. <50kW) is now an economic proposition.

In summary, biogas fermentation is a holistic technology which benefits farm and environment management and saves the escape of methane (a "Greenhouse Gas") to the atmosphere.

(ii) Water (Hydro, tidal, wave, e.t.c.) generation

Water is 784 times denser than air at sea level. Hydro generation is far more effective, reliable and efficient than wind generation. Global hydropower production is about 680 GW. Of that 47 GW is small hydropower (i.e. <10 MW). The remaining non utilised global hydropower potential is estimated at 3,000 GW of which 180 GW can be produced at small hydro sites. 70% of untapped small hydro potential (126 GW) is in Developing and Under-Developed nations.

While major hydro schemes are long established and hydro provides most of the World's alternative energy, recent development has focused on mini and micro generation technologies. The emphasis has shifted to diversified electricity generation with a small footprint. Large dams and water diversions have fallen out of favour. Midstream, non invasive turbines which minimally interfere with water flow and with water animals, are commercialised.

The WindCatcher small wind turbine featured above (c) will also operate submerged in water (run-of-river or tidal stream design) to provide a high energy, low maintenance, micro-hydro system at very low cost. Its advantages will be (i) it does not encourage silting, (ii) it does not affect fish or debris flow, (iii) easy installation, exit and repair. A stream with 1.5 metres depth, 3 metres width and water speed in excess of 2.5 mps does have potential to generate useable electricity. Larger rivers allow daisy chaining a series of turbines together for greater generation.

(iii) Solar Energy

Solar energy reaching the Earth's surface ranges from 0,8 kW/h/M^2 per day in a Northern European Winter to more than 4 kWh/M^2 per day in Mediterranean climates.

Greenpeace, the European Solar Thermal Power Industry Association and the International Energy Agency's SolarPACES programme, anticipate that by 2025, the solar power industry will attract nearly US$20 billion a year in investment, employ 54,000 people, and will have avoided the emission of 362 million tonnes of carbon into the atmosphere or roughly what Japan emits each year. Sabry Abdel-Mottaleb, former director of the Photoenergy Center at Egypt's Ain Shams University agrees that solar power has the potential to contribute to sustainable development in the Middle East and North Africa.

The Sun's direct energy can be captured in two ways;

i. Visible light can be converted directly to electricity by photovoltaic cells, also called solar cells. New low cost Thin-Film Solar Cells (TFSC) or Thin-Film Photovoltaic Cells (TFPV) are being commercialised which promise to drive down production costs and improve energy yields. Photovoltaic continues to be relatively expensive and inefficient (9% to13%) but it produces direct current (DC) which can be fed directly to battery storage. Photovoltaic panels are useful to recharge telephone equipment, medical instruments, and other devices which use rechargeable batteries. However, the use of photovoltaic panels to power an eco-village of e.g. 1,000 occupants would be prohibitively expensive, require substantial real-estate and battery storage, ongoing maintenance (including constant cleaning of panels) and protection from extreme weather.

ii. An alternative technology, Concentrating Solar Power (CSP) uses the Sun's energy to boil a liquid, which expands as steam to turn a turbine which in turn drives a generator to produce electricity. CSP has developed rapidly in recent years and is cost effective even if scaled to micro-generating unit sizes. CSP retains higher efficiencies (>25%) than Photovoltaic and is more economical to build. Several low cost designs are in production. CSP adapts easily to co-generation with e.g. bio-gas. Again, ORC Expander technology promises downward scaleability while maintaining efficiency and economic production. CSP can reliably meet eco-village electrical demand if correctly deployed and appropriately sized.

(iv) Wind Machines

From multi megawatt machines to small rooftop units, turbines can capture the available wind to drive electricity producing generators. Wind machines (HAWS) have become ubiquitous and have achieved almost industry brand status in the alternative energy field. Perversely, wind energy is also controversial, machines are considered ugly by some, they interfere with wildlife and throw pulsating shadows across residential areas from afar. But, the greatest practical flaw of a wind turbine is the divergence between a machine's nominal output capacity and actual electricity produced. Wind has a low "Capacity Factor". Complexity is added by electricity's aversion to easy cheap storage. Wind can produce more electricity than a country's grid can handle one day followed by no supply at all the next. Denmark, reputed to be the World's largest consumer of wind energy per capita, often overproduces and has to export its surplus wind cheaply. The buyers, Sweden and Norway, then in turn reduce production from their own alternative generation systems i.e. hydro. So alternative energy is exported to replace alternative energy in another country while the Danes pay subsidies on the exported discounted production. Not an equitable situation and no fossil fuels are displaced as wind energy cannibalises hydro energy.

Wind energy has limited use in micro generation facilities but has its place in diversified generation as part of a holistic programme. Excess electricity can be stored in flow batteries, water reservoirs or even in pressurised air tanks. A village or community with average wind speeds in excess of about 12kph or 4mps can use available wind to generate electricity at low cost. Mini or micro wind machines do suffer efficiency losses (lower height, smaller blades e.t.c.) when compared with their bigger siblings. They also suffer higher per kW costs thanks to lower economy of scale and minimisation of complex parts. However, this area is receiving renewed attention (thanks to a shortage of multi MW suitable land in Europe) and the costs of practical reliable machines are falling. That said, wind remains highly effective in generating low cost electricity, torque lifting power (e.g. water from wells or pumping up slopes) and compressing air or other gases.

The WindCatcher Turbine (See WindCatcher Project) combined with the BEM generator (See Dealán Dé) has the potential to generate quality electricity, reliably, at low cost with minimal aesthetic impact. Its simple construction facilitates local servicing and production which reduces costs.

(v) Geothermal

"Geothermal is 100 percent indigenous, environmentally-friendly and a technology that has been underutilized for too long," *UNEP Executive Director Achim Steiner.*

From Djibouti to Kenya lies the Rift Valley. Djibouti, Eritrea, Ethiopia, Uganda and Tanzania could all generate substantial energy. Mongolia is rich in geothermal resources. Many Pacific islands exist as a result of volcanic activity. The potential energy stored in geothermal fields could, if harnessed and transported correctly (i.e. HVDC lines), supply electricity to all of Africa and much of Southern Europe, Central Asia and many Pacific Islands. So far, politics and lack of regional investment have ensured that production is limited.

Many developing countries may have geothermal potential but geothermal research is almost non-existent in Developing and Under-Developed Nations. Modern geothermal systems will operate at well-head temperatures between 120°C and 170°C. One US system operates at brine temperatures of 70°C. The use of liquids with low boiling points is being researched and they promise access to geothermal energy even where the well-head temperature is relatively low. Pratt & Whitney's "PureCycle® power system can operate on a wide range of resource temperatures starting as low as 195°F (91°C)".

At least one company is commercialising a heat expander technology which promises to micro-size geothermal sites to produce e.g. 50kW to 200kW electricity at very low cost. It is now possible to tap geothermal sources to generate several kilowatts of electricity for local village consumption and it is no longer necessary to build 10+ MW units to achieve economies of scale. The heat expander system is also highly effective under part load i.e. lower temperatures, which will bring marginal geothermal sites into production.

(vi) Human power

Humans have always converted biomass into energy by a biological process of respiration. Human power drives, bicycles, pushes wheelbarrows, carries rucksacks, e.t.c. A healthy human is easily capable of cranking a generator (e.g. fitted to a bicycle chain), outputting over 50 watts for 30 minutes. As an example, 6 people, each undertaking 15 minutes cycling would output 75 watt hours. This would be enough to power several low energy lights and a computer for some hours. Used in conjunction with a battery, enough electrical energy can be cranked over a couple of hours to run e.g. A washing machine, an electric drill, oven, e.t.c.
(See, http://www.los-gatos.ca.us/davidbu/pedgen/one_hour_pppm.html)

Wind-up lamps are an example of a cheap environmentally friendly lighting technology that can be immediately deployed. Several models are available and they cost about €30 each. Wind-up lights usually involve a minute's winding effort for a 30 minute light in return. The following url gives and example of a bedroom reading light that can be DIY made. *(See http://www.instructables.com/id/The-Wind-up-Headboard-Reading-Light/)*

Many useful tools, from lights to mobile phones can be energised by simply winding a handle.

Note: humans are inefficient energy converters. Humans produce as muscle power, via respiration, the energy equivalent of about 20% of the energy they have consumed by food and drink.

(b) Energy Conservation technologies

Technology	Costs	Effectiveness	Status	Comments
(i) Passive Building	OK	High	Commercial	Good planning ensures success
(ii) Phase Change Material	High	Very High	Commercial	Dramatic impact, passive air-con
(iii) A++ Products	Medium	Moderate	Commercial	Premium costs
(iv) Air Conditioning	High	Good	Commercial	Several technologies, Limited rollout

(i) Passive Buildings

Our homes consume more energy and effectively produce more greenhouse gases than our vehicles. Passive building construction and adaptation address the primary energy sapping deficiencies of buildings. A passive building can be at least 75% more energy efficient than a standard building. Passive buildings are positioned and orientated to directly avail of and control access to solar radiation. They employ efficient insulation in walls, roofs, doors and windows, effectively creating a controlled climate envelope. Solar water heating and passive heat recovery ventilation systems provide comforts while ensuring a healthy fresh in-envelope environment. If available nearby, biogas waste heat can be used to heat water and airspace. Passive buildings can be designed to fit the surrounding cultural environment and costs are comparable with standard building costs, with dramatically reduced energy costs.

(ii) PCM

Normally, the walls and roof of a building are simply there to block wind and rain (or excessive solar heat) and to retain some of the buildings internal heating but no more. If however, "Phase change material" (PCM) is blended into the plaster on the walls and laid on the ceiling, it will have a dramatic effect on maintaining the internal building temperature at a desired level (e.g. 20°C). This is achieved because PCM has the unique ability to keep its surrounding environment within a fixed temperature range. When the surrounding air heats up above this range, the PCM absorbs and retains the excess heat and when the temperature drops below the desired range, the PCM releases the stored heat. This has the net effect of keeping the airspace close to a desired level. PCM is effectively a passive air conditioning or climate control system. PCM allows occupants to take advantage of the usual building heat generating mechanisms, (e.g. heaters, lights, computers) and the natural element, the Sun. The average European building uses about 60% of its energy to heat airspace and water. PCM materials remain expensive but with volume production, costs will fall. Even if costs are high, PCM materials do directly reduce long term energy requirement and energy costs. The Eco-villages, wherever located, will be able to use PCM to heat or cool an airspace. The results will be efficient creation, management and conservation of heat, climate control, reduced energy requirements and costs, healthier occupancy environment with reduced humidity.

(iii) A++ Products

Pushed by regulation and environmentally aware consumers, manufacturers of machines, white goods and other products have improved the energy efficiency of almost all commercially and domestically used products. From electric drills to fridges energy ratings (e.g. A++, A+, A, B, C) are published to indicate the more energy efficient products.

LED lighting (still developing) will become a dominant low energy (5 watt bulb) lighting technology to facilitate nighttime reading, study and family sharing. LED lighting has a low energy requirement, does not contain mercury, is extremely robust, a low fire risk and can be powered by simple solar panels, micro turbines or even human power. LED is also emerging as low energy screen lighting for computers, phones and televisions.

Apple's new iPad, which does have a LED screen, consumes a remarkable 2.5 watt (one hour cycling on a generator bicycle could run an iPad for 40 hours). The iPad can be rubberised and shared between students (to help with studies) during day and made available to farmers (to learn about agriculture, cattle husbandry or get the market price of produce) in the evening. Apps can be built to facilitate Developing and Under-Developed Nation use.

We live in a digital World. Our children (when they have access) are natural and intuitive with smart phones and touch screens. Unless the children of the Developing and Under-Developed Worlds can access the came computer technology as children in the Developed World, they will fall further behind on the wrong side of the digital divide.

(iv) Air Conditioning & Climate Control

Traditional air conditioning is a heavy energy consumer. Several technologies which are energy efficient use alternative energy to work. Solar (both active and passive) systems are now commercial. Geothermal energy can be used to keep building interior temperatures balanced. Geothermal systems are common in northern Europe.

Much can be learned form ancient Arabia about keeping buildings cool. The medieval Arabs of North Africa and Moors of Spain employed various techniques (beautifully perfected in the Alhambra e.g. venturi, water pools and flow, draughts, windcatcher, e.t.c.) to cool and heat. The houses in Cordova were air conditioned in the summer by "ingeniously arranged draughts of fresh air drawn from the garden over beds of flowers, chosen for their perfume, warmed in winter by hot air conveyed through pipes bedded in the walls”. *Account circa 800 a.d.*

(c) Urgent need and emergency technologies

Technology	Costs	Effectiveness	Status	Comments
(i) Aqua Salveo	Low	High	Commercial	Effective water purification
(ii) Emergency Shelter	Low	High	Commercial	Fast, secure, solid shelter. Re-deployable.
(iii) Desalination	Medium	High	Commercial	Slow to install (9 months) unless pre-built

(i) Aqua Salveo

"Aqua Salveo" technology, developed in South Africa, purifies water by directly killing bacteria, viruses and other pathogens. It is harmless to humans and animals. This technology is directed for use in homes, public buildings, transport systems and medical centres. It will ensure that water is potable at the faucet. It will add minerals to distilled water enhancing the water's benefits. Aqua Salveo is effective against Salmonella, E-Coli, Dysentery, Cholera and other lethal pathogens. It will also ensure (by washing them with it) that stored food (meats and vegetables) stay fresh longer.

(ii) Emergency Shelter

To accelerate the provision of homes to those in urgent need, converted shipping containers offer a low cost, comfortable and easily transported dwelling. They can also be fitted out as clinics, storage rooms, communication centres e.t.c. They can be insulated with PCM material to keep the interior at a comfortable temperature. Shipping containers can be purchased for less than replacement costs because of market inefficiencies. Thanks to globalisation, goods travel (usually East to West) in containers on-board ships. Shipping companies try to fill the containers for the return journey but this is not always possible and the cost of transporting an empty container to where it can be reloaded is considered to be higher than the worth of the used container. Consequently many used containers are sold cheaply (e.g. €600). Retired containers can be recycled as architecture.

A container (or fleet of containers) can be transported quickly to a location and used as housing, medical clinics, offices, storage or even electricity generating and water purification stations. When permanent housing and services have been re-established in the disaster area, the containers can be stacked and stored ready for the next emergency.

(iii) Desalination and large volume water purification

A US development uses solar heat to desalinate by distillation while a passive pumping system gradually heats the water to allow the potential to generate electricity by using hot water to indirectly turn generators. Thus, the system is energy positive. The system can be installed in the sea, saving on real estate costs, can be scaled to provide a city with fresh water, has no membranes or other complex parts and has a long life expectancy. This technology promises to reduce energy consumption and lengthen plant life while providing distilled pure water, the only water purifying process that is pure H_2O. A pilot plant is operative in the USA and a second larger system is being installed in India.

Chapter V
Project Implementation

(a) The Eco-Village Projects

Terraintegra is convinced that the only realistic answer, the most viable solution, is the roll-out of electrically energised eco-villages where possible, where practical and where necessary. Electrical energy will bring the Quality of Life essentials which, in turn, will help the Developing and Under-Developed Worlds resist and counter the worst effects of economic imbalance and Climate Change. Innovative technologies will provide innovative solutions to societal needs. Problems will be encountered and addressed in real time. The technological solutions will provide blueprint precedents for all following projects. As lessons are learned and skills and technologies are honed, the process will become both more efficient and effective.

Terraintegra's practical approach on a case by case basis is:

i A village or community and surrounding region with the support and co-operation of terraintegra, its partners and associates mutually agree project implementation based on requirements.

ii A working committee involving community leaders and terraintegra team members is established.

iii The committee draws up a plan of action and secures community support by a consultative process.

iv A feasibility study and environmental audit to determine available resources (Sun, water, wind, biomass, geothermal, communications, transport e.t.c.) and the suitability of various alternative energy technologies for implementation, is undertaken.

v Then, with the co-operation of the community, the technologies suited to the circumstances are introduced, their effectiveness studied and refined. Local people are trained in manufacturing, installation, maintenance and electrical generation skills.

vi Once a technology is performing satisfactorily it will be deployed to another village or community. No two villages or communities are alike. Geography, society and climate will decide deployed technologies. Each will require unique technologies and solutions. Biogas may provide adequate electricity supply in one community, the Sun in another or a combination may be effective elsewhere. The soil and water resources may sustain biomass fermentation, horticulture, cash crops or animals in some areas but parched earth may prohibit green growth in others.

vii In time, the eco-villages themselves may begin to share and deploy sustainable technologies. Trade in alternative energies and bio-food may evolve. Resources may be pooled to undertake larger energy or food producing projects. A World within a World will emerge.

(b) Inception

i. Identify and secure backing of sponsors and stake-holders.
ii. Identify, contact and get support of key individuals in Government, business and communities.
iii. Set clear goals and achievable, objective deliverables, audit and checks and balances.
iv. Set expectations, allow for problems and disputes.
v. Ownership of project planning, build team, secure loyalty.
vi. Define process and methodology (include testing, implementation, communication lines, best practices, reporting issues, troubleshooting, back-out plans, e.t.c.)
vii. Ensure resources, financial, management, support, technology are in place.

(c) Application

i. Identify start point villages and communities.
ii. Commission a socio-environmental audit (include environmental impact) and feasibility study.
iii. Consult with village and community residents and explain strategy, plans, get support.
iv. Prepare budget, financial projections, schematics, set aside funding.
v. Get technology specialists on the ground to study location, infrastructure and geography.
vi. Develop situation plan, identify structural changes.
vii. Identify technologies required and suited to location, population, geography, climate.
viii. Acquire equipment, install, commission, operate.
ix. Teach residents to operate and service technology.
x. Establish, follow up, servicing, maintenance and repair procedures.

(d) Costs

Individual electricity requirement	kW/h Per Person per Annum	Required kW capacity per Person	X Capacity Factor	Capital Cost per Person *
Passive Home	1800.66	0.51	0.6424	€1,605.90
Germany	7202.65			
Median	4501.65			* Biogas

The figures are based on a roll out in a village of at least 1,000 people. Biogas has been selected as the chosen technology for example purposes. Preliminary calculations (subject to in situ feasibilities), anticipate capital costs of €3,200 per Eco-Village resident. The capital costs of electricity generation per capita will be €1,800 and the capital costs of establishing minimal Quality of Life structures will be €1,400. Maintenance costs will be about €230 per capita annually. For example, a village of 1,000 souls with no infrastructure or tapped source of energy will cost up to €3,200,000 to gain an acceptable Quality of Life.

To provide electricity (and its Quality of Life appendages, clean water, shelter, sanitation, education, e.t.c.) to the 1.6 billion people who go without today, will cost about €5.12 trillion. A not inconsequential amount. But, terraintegra argues that the gains far outweigh the costs as societal change comes to 25% of the World's population, benefiting the other 75% in the process. The financial costs and returns of establishing and maintaining the eco-villages are more fully dealt with in a separate individual project spreadsheet (Eco-Villages Calculations) which takes specific project data into account and is not available online.

The Prototype Eco-Villages will be more costly than later scaled up rollout costs which will benefit from economies of scale, as different technologies must be assembled and tested, processes must be streamlined, know-how learned, e.t.c. in the early prototype Eco-Villages. It is also necessary to persuade investors and consumers that while up front capital costs are necessary, the financial benefits will accrue downstream with investors, consumers and the environment all benefiting. The most economical and effective approach will be to win the co-operation of several connected villages (e.g. 5 villages, each with 500 residents) totalling about 2,500 residents with prototyping costs of up to €16 million (i.e. twice later rollout costs). A "rising tide" will see egalitarian development over a region. Thereafter success breeds success.

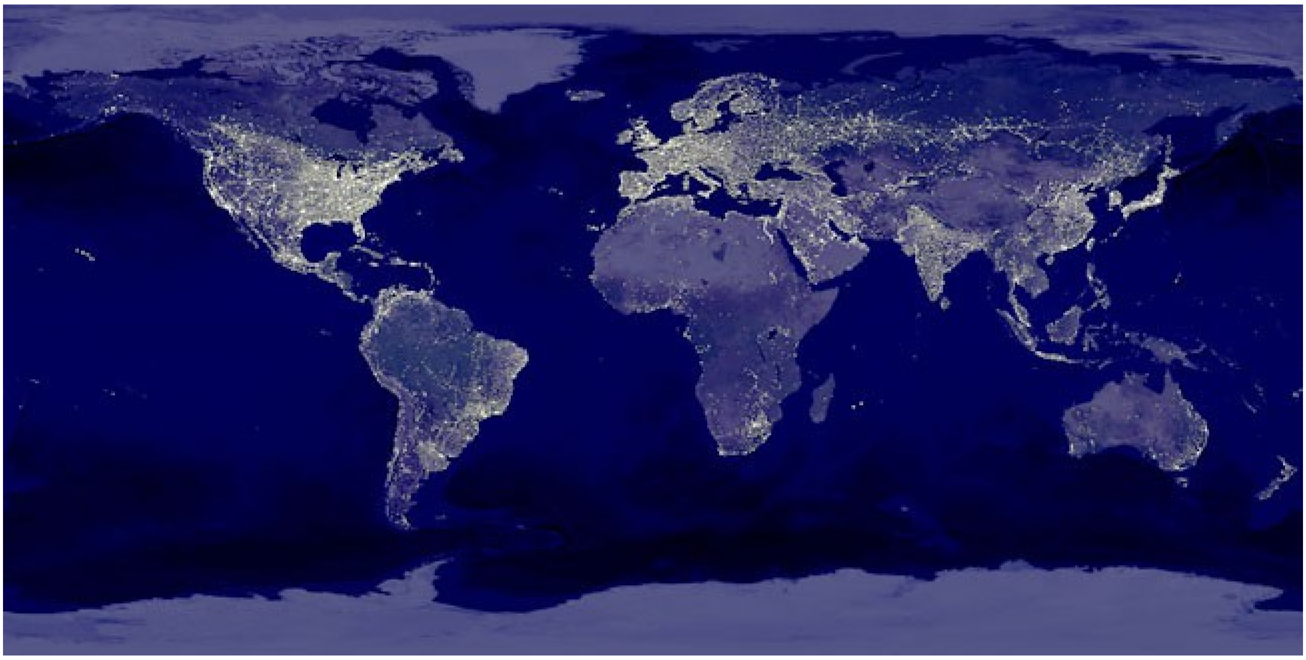
(e) Returns

Income	kW per Person	KW per Person per Annum	Price per Annum (€0.07)	Gross Return over 15 Years
Electricity	0.51	4,501.65	315.12	€4,726.74
Grants	0			0
Carbon Credit	0			0
Sales to Grid	0			0

A financial, return based on South Africa's electricity cost (the World's lowest) of €0.07 is used in the example. While several other income potentials, including grant assistance, carbon credits and feed in tariffs, will variously apply, they are not calculated into this example because of variability between countries and technologies.

Conclusion

An economic model to encompass and calculate the broad range of benefits that will emerge from electrification of the World's un-electrified regions is subjective and controversial. But, the economic model principle remains valid. Though not always readily quantifiable, the benefits that ensue, are real and measurable. The Eco-Villages will foster profitable businesses, well educated open minded youth, healthier workers, new markets, regional political stability, e.t.c. Cash returns to funders will be via electricity generation contributions based on kW/h, feed in tariffs and grant funding, lease payments for machinery and equipment, transport payments, marketing agreements, trade, e.t.c. (These returns will be quantified in Eco-Village business plans) Carbon Credits (CER) will also support investment recovery (*See Carbon Credits good and bad*). Indirect returns will emerge via healthy, educated village residents, entrepreneurship, education, dignity, equality, trade e.t.c. And, with every village that opts for an eco-friendly energy supply, one more step is taken on the long and winding road towards a healthier planet.


Earth at night (Composite) NASA

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