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Sustainable technologies and products

The electric powered assisted bicycle; a clean vehicle to reduce oil dependence and enhance the mobility of the elderly,

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ABSTRACT

There over 300 models of powered electric bicycles sold throughout the world today and in most countries they are legally classified as bicycles. In 2003 most of them were produced in Asia, 200,000 in Japan and 3 million in China. There are two main types. (1) The electric power assisted bicycle (E-PAB) weighs only a few kilograms more than a bicycle and is used mostly in Japan and the EU, with a maximum of 250 watts of power assistance from a small electric motor and a rechargeable battery. State of the art versions have electronically controlled power assistance via sensors in the cranks linked to a computer chip, which automatically fade out power assistance at 25 km per hour. (2) The E-Bike is around 10 kg heavier and has around twice the power output and only needs to be pedalled on hills and against strong headwinds. It is used mostly in China but in 2003 was classified as a bicycle in US and Canadian traffic law. Both types can enhance the mobility of the elderly, and when used by the able bodied are a practical substitute for many car trips of less than 10 km .This paper describes their development and how their use in New Zealand is constrained by poor legislation which classifies them as mopeds:-

1. Product development since 1950; from the early petrol powered models to “state of the art” E-PABs and E-bikes
2. Present and future markets in Japan, China, Canada, the US and the EU.
3. How E-PABS that reduce physical effort by 50% makes is easier for the able bodied to cycle in hilly cities, and enable the elderly, some of the lame and partially disabled to continue cycling or to generally improve their mobility.
4. How E-PABs, coupled with roof mounted solar PV panels for recharging, have been trialled in Japan.
5. Suggests that there is an opportunity to sell imported or assembled E-PABs in New Zealand using batteries recharged from roof mounted solar cells.
6.It is concluded that when E-PABs with up to 250 watts output are classified as bicycles in New Zealand a start can be made on realising their potential for reducing greenhouse gas emissions, air pollution, petrol consumption and traffic congestion in cities. E-Bikes of more than 250 watts but less than 500 watt power output, when used by the lame, the disabled. and the elderly (over 50) to also be classified as bicycles.

Abbreviations:
PAB = General term for all "Power assisted bicycles"
IC-PAB = Early model "PAB" with a polluting two stroke internal combustion engine.

E-PAB = Power assisted bicycle with a rechargeable battery and electric motor with a maximum power out put of 250 watts.
E-Bike = Electric bicycle with a motor rated at around 400 to 500 watts that does not need to be pedaled except on hills and against heavy winds.

1. INTRODUCTION

Both the IC-PAB and the E-PAB, when they are legally classed as bicycles, are very economical for consumers. There are no compulsory registration and insurance fees and they have very low running costs. This is why IC-PABs were popular in post World War 2 Europe and are used widely today in China and India. However the difference in quality and sophistication between the early model IC-PABs and "state of the art" Yamaha and Panasonic E-PABs is like the difference between a post war Holden car and a Toyota petrol/electric hybrid car. The rated power output of the Japanese E-PAB motor is mostly between 210 and 245 watts. In N.Z. they cannot be purchased as bicycles because they are classified as mopeds which means that NZ consumers are denied access to the safest E-PABs on the world market which is an unwarranted restriction of trade.

A "state of the art "Japanese E-PAB is a bicycle that is pedal powered for most of the trip but power assisted when starting off, climbing hills, overcoming strong wind resistance or when carrying a heavy load. The power assist is completely automatic after a key is inserted it is switched on; it is designed to maintain a safe cruising speed and to halve the effort required to get from A to B on an average trip. The batteries are designed to provide for around 30 km of travel before a recharge. The crucial safety feature is automatic speed limitation which fades out from 20 to 25 km per hour. Their silent operation and lack of emissions makes them very suitable for use on both shared footways and local residential streets, especially those with 30 kph limits.

In Japan their use is relatively safe as a substitute for car trips of less than 10 km. This meets the needs of an ageing population, many of who have health problems that prevent them from driving cars. Many of the elderly use E-PABs, electric wheelchairs and tiny low speed three and four wheeled electric vehicles on shared footways and local roads (Cycle Press Yearbooks 2001/02). The Japanese are now reviewing the 50% power assistance with a view to increasing it to around 70%.

The "state of the art" E-PAB and E-Bike have the potential for making urban transport systems far more energy efficient, reducing greenhouse gas emissions and reducing air pollution. The next generation of these vehicles will be powered from renewable energy resources and will be the most energy efficient form of motorised transport ever invented. For all practical purposes tomorrow's electric two wheelers are destined to join the bicycle and walking as the only forms of transport that emit no greenhouse gases. Some of the car companies that are producing fuel cell concept cars and petrol/electric hybrid cars are also developing E-PABs and E-Bikes with solar PV battery rechargers for public and domestic use. The ecological footprint of tomorrow's solar powered E-PAB and E-Bike is so small it could enhance the mobility of billions without irreparable environmental damage and resource depletion.

In Asian countries (with the exception of Japan and Singapore) IC-PABs, mopeds, scooters, motorcycles and three wheelers with two stroke engines are a major health hazard because up to 70% of the petrol used ends up as exhaust fumes. In Asia the production of petrol and diesel powered two wheelers exceeds 25 million per year. A similar number of motorcars and commercial vehicles are produced but they are less of a problem because new cars have 4-stroke engines and catalytic converters (CSE India 2002). China has ten of the world's most polluted mega cities in some of which the use of mopeds and IC-PABs has already been banned. By July 2000 37 cities had stopped issuing motorcycle licenses and from 2002 all new motorcycles made in China have been legally required to have much cleaner engines. The Chinese National Environment Protection Agency has issued regulations that encourage Chinese industry to produce E-PABs and E-Bikes and around 3 million of them will be produced in 2003.

The situation is far worse in India where 70% of the motor vehicles on the roads are two and three wheeled vehicles with two stroke IC engines (CSE India 2002). Despite the existence of emission standards no coordinated action is being taken by the government, other than in New Delhi. India, Thailand, Taiwan and Vietnam are likely to create a regulatory environment in which all new motorcycles and scooters will have four stroke engines from around 2005. Even the latest IC-PABS are polluting but new technology could be used in the form of more efficient engines powered by biofuels such as ethanol or hydrogen.

The Orbital Engine Corporation (OEC) in WA has expertise in the design of small clean engines (Leighton et all 1993). A bio-fueled PAB would be a very efficient user of ethanol, which could be produced from waste in many countries (Parker 2002). In the long term, when the cost of fuel cells is greatly reduced, hydrogen power assisted bicycles maybe a practical option according to one future 2050 scenario (Shell International 2001).

2. IC-PAB PRODUCT DEVELOPMENT SINCE 1900

The IC-PAB evolved from the development of the earliest European and British motorcycles, which had pedal start engines and were very slow. The oldest relatives to the modern IC-PABs were the 1900 Singer motorised back wheels that were fitted into heavy-duty bicycles. IC-PABs were popular for touring before 1906 but their use declined after World War 1. After World War 2 the economic necessities of post war reconstruction in Europe encouraged the production of lighter weight IC-PABs and mopeds as economical means of mass transport. The British IC-PAB, the 1952 BSA, was exported to N.Z. (See Figure 1).

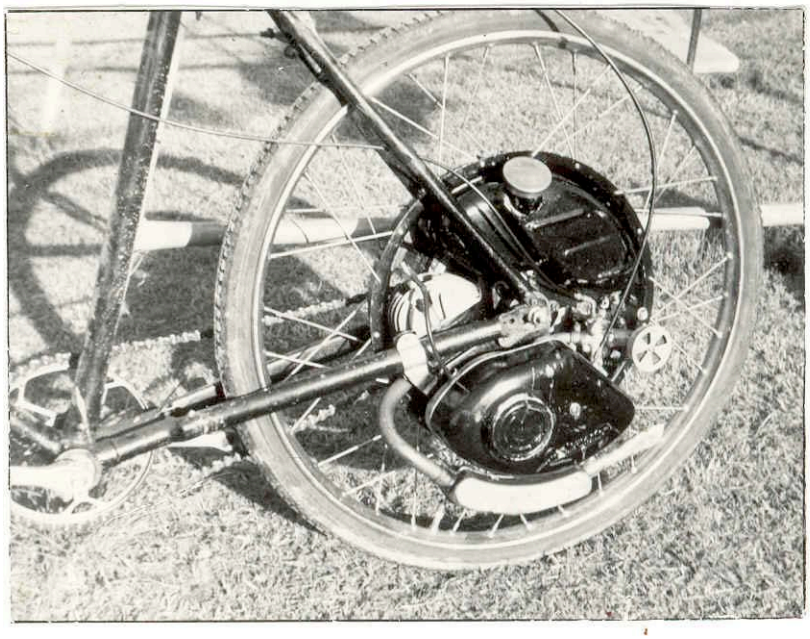

Figure 1. *The BSA "Cyclemaster" motorised back wheel had a 32 cc cast iron engine built into a 27 x 1.5 inch rear bicycle wheel. It had a fuel consumption of 1.1 litres per 100 km on long runs, delivering its maximum power output at low speeds going uphill. It was safer than many PABs because it powered the back wheel and the engine's centre of gravity was low.*

The 1952 BSA was typical of the models available which were designed to be bolted onto or into an existing bicycle frame. They were PABs in the sense that it was necessary to pedal to go uphill, to get the engine started or to overcome strong head and crosswinds; however there were no automatic electronic controls and speed limiters. Front wheel drive IC-PABs were also popular in Italy but were dangerous on England's icy roads in the winter.

Usage of petrol powered IC-PABs and mopeds in Europe grew steadily in the post war years and by 1965 there were thought to be a total of 15 million in use. The number of these that were IC-PABs is not known, as they were all legally classified and counted as mopeds. After 1965 their use declined as the sales of motorcars increased.

In 1984 Honda introduced the 'People,' an IC-PAB with a 24cc petrol engine weighing 26 kg. In the 1980s several Taiwanese companies were making IC-PABs, mainly for the domestic and Chinese markets. The technology did not change much and was mostly based on a motorised back wheel, or on a 30 to 40 cc two-stroke engine driving a small wheel on the top of the tyre. There were a million or so IC-PABs in use in Europe in the mid 1990s.

In Japan, Taiwan, and Australia IC-PABs with a power output of 200 or 250 watts are classed as bicycles but in most other countries they are classed as mopeds.

Since 1997 there has been a growing range of E-PABs on the world market with sophisticated electronic controls and there are around130 companies producing E-PABs worldwide. Many of these companies use Japanese made drive units and electronic control systems. Over 300 models of E-PABs and E-Bikes dominate the retail market today. In 1998 there were 17 Taiwanese companies researching and developing new models for the Chinese and European markets.

There are also some better quality IC-PABs available on the world market; the German Sachs IC-PAB with a 30cc engine and power limiter is available in Australia. In 2002 new regulations for E-PAB and E Bikes were passed in the EU, Canada and the US which are expected to greatly increase their use.

3. JAPANESE E-PAB PRODUCT DEVELOPMENT SINCE 1989

The development of E-PABs in Japan grew out of the large domestic market of around 8 million bicycles a year and the high level of bicycle use amongst the elderly. E-PABs were originally designed as an industry initiative in the late 1980s to make pedaling easier for elderly cyclists. In 2002 10.7 millions bicycles were sold. The population was 126 million and 74 million owned a bicycle. 19 million Japanese were over 65 years of age in 2002; this will double by 2040.

Consumer surveys by Yamaha in the 1980s showed that most E-PAB users were women or elderly males. From an ergonomic viewpoint the lower power to weight ratio of these groups was taken into account in formulating the 50% power assist concept for the second generation E-PAB which was released in 1989: the *'PAS Prototype'* with a maximum power output of 235 watts. The Yamaha *'PAS Prototype'* was a major design breakthrough with torque sensors in the cranks which are linked to the motor controls for automatic power assistance.

The basic design concept was that only half the normal pedaling effort would be necessary for most trips. Figure 2 shows *The PAS Little More,* which evolved from the *PAS prototype* and has a retail price in Japan with exclusive battery charger of NZ $1,600.

The Japanese government was concerned about pedestrian safety because only 2% of cycling is done on separate bike paths; 98% is done in areas shared with pedestrians. According to the Yamaha engineers the most difficult problem in addressing these safety concerns was designing the control system so as to integrate human pedal power and the power available from the motor in the safest way possible (Cycle Press 1997). The smart computer chip developed by Yamaha prevents aggressive riders winding their E-PAB up to more than 25 kph and terrorising pedestrians on the shared footways and narrow side streets. Above 25 kph the extra weight of the power unit and batteries also makes it more difficult to go faster than on a bicycle. Another advantage is that the precision power unit is connected to the chain and does not get clogged up with mud in wet weather, as did early models with drive wheels running on the top of tyres.

In 1995, after six years of development, the Yamaha E-PAB was sold nationwide. From then on many companies in both Europe and Japan became involved in E-PAB design and production; many built their own bicycle frames around Yamaha's 'PAS power unit'. By 1997 Japanese E-PABs, which were designed for different purposes, were coming onto the market in various wheel sizes and frame configurations. In 2001 Japanese E-PAB industry leaders were still focusing on improving the quality of their products and the two leading manufacturers in the field, Yamaha and Panasonic, made major gains. Sales for 2002 went up to 200,000 (See Figure 3). Panasonic produced a compact lightweight drive unit and produced its "ViVi" E-PAB with an all up weight of less than 20 kg. Yamaha broke another

barrier and brought production costs down. Honda also produced a lightweight E-PAB that folds up for carriage on other vehicles and weighs only 17.8 kg.

Figure 2. The PAS Little More has (1) a stable child seat, (2) ease of control and operation with a new keyless switch design and battery remaining indicator, (3) dynamo lighting control from handle bar mounted lever, (4) battery charging time of only 2.8 hours; on a single charge will travel 38 kms over flat roads. (5) It has a 3 speed integrated gear.

In Taiwan, which makes E-PABs for the Japanese market the Industrial Technology Research Institute has a major material research project to develop lithium rechargeable batteries which may produce high performance low weight batteries to reduce the weight of E-PABs and E-Bikes (Cycle Press 2004). Further more there are still some battery recycling issues to address. The non-profit European company Extra Energy tested 17 E-PABs and eight E-Bikes, most of which where made in Europe. Hannes Neupert of Extra Energy seeks to promote the benefits of electric/human power hybrid vehicles through product testing and by raising concerns about battery use and disposal. He states that:

"PAB technology is still far from perfect. The issues of battery recycling, solar recharging and the need for 'smart or smarter chargers', and considerable information on these subjects, including the full test results, are on our web site; www.extraenergy.org." (Neurpert, 2002)

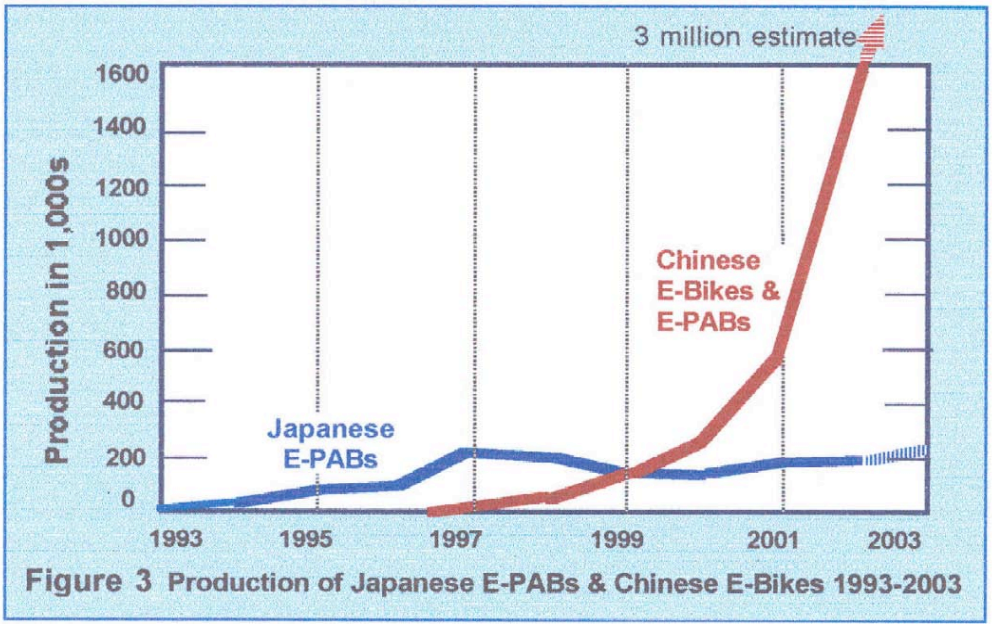

Figure 3 Production of Japanese E-PABs & Chinese E-Bikes 1993-2003

3.1. Today's niche markets for the E-PAB in Japan

In Japan there are 1.5 bicycles per household. While the level of bicycle use has declined in the last 20 years 14 % of all trips and 17.5% of commuter trips were made in 1996 by bicycle. The E-PABs that hit the market from 1993 to 1996 were very successful. 70,000 Japanese women over 50 years of age purchased them and it is likely that most of them found that pedaling the E-PABs was as easy as riding bicycles had been when they were young. Of the 1.4 million Japanese who bought E-PABs in the five years from 1997 to December 2002 70% were sold to women. The three large niche markets were: -

- People over 50 years of age who bought 66% of all E-PABs, mostly women over 50 and men over 60.
- Women under 40 who bought 9.4% of all E-PABs; growing numbers are now using E-PABs fitted with specially designed child passenger seats (see photograph 2) or shopping baskets that are very stable.
- Business men in their forties who bought 7.6% of E-PABs and value the time saved moving around congested central business districts; most of them do not want to "work up a sweat" on a bicycle and have found the E-PAB easier and more convenient to use and park than a car (Cycle Press 2001).

In 1990s the main problem for most E-PAB users was that they were too heavy for lifting up stairs into a typical Japanese home or into other vehicles. Even the small-wheeled models weighed 24 to 27 kg and the large wheeled models weigh between 24 and 31 kg. The three-wheeled shopping E-PABs were much heavier at 36 kg to 39 kg (See photograph 3). The weight problem was particularly troublesome for the elderly so a lot of design effort is going into reducing the weight without increasing the price.

Figure 4 This Yamaha electric shopping tricycle has excellent stability and load carrying power. Battery charging takes 2.8 hours and it will carry the rider 35 km on flat roads. Electronic indicators show battery levels and a dynamo light is fitted that stays bright at low speeds. It comes complete with a built in front wheel lock, comfortable sprung saddle and front basket. Retail price in Japan A$3550

3.2. Tomorrow's niche markets for the electric PAB in Japan

Since the Japan government signed the Kyoto Protocol in 2001 they have become interested in schemes to use E-PABs instead of cars to reduce greenhouse emissions. Japan is completely dependent on imported fuels with very high electricity prices. They have been implementing an energy security policy since the mid 1970s that focused on reducing oil consumption.
This explains the massive investment in the rail network and the very high percentage of trips made by public transport. Five million people cycle to the rail system every workday and around 15% of the population cycle all the way to work. It is not an accident that many motor vehicle manufacturers also have electric bicycle divisions. Reducing emissions and oil consumption are an integral part of the National Energy Security Policy.

Japan has been exploiting renewable energy resources since the early 1990s and now generates half the world's solar power. The Japanese solar power industry is expected to grow fivefold by 2010 when over one million homes will generate their own electricity from solar electric panels. In the last three years there have been several experiments using solar electricity for the recharging of batteries of E-PABs and other domestic appliances. A long-

term vision is emerging of E-PABs charged from roof mounted solar electric panels as an ecologically sustainable means of transport, used by people of all ages even in hilly cities.

One innovation is the use of E-PABs to solve environmental problems, in Shimonoseki City in the prefecture of Yamaguchi. Yamaha designed a project for the charging of batteries of 30 Yamaha "PAS" E-PABs using solar power. Yamaha plans to promote E-PAB solar energy charging parking lots in many other areas (Cycle Press 2002).

Honda has been at the forefront of these environmental innovations and provided 200 "Racoon 24 Lx"E-PABs in April 2000 to Koga City in Ibaraki Prefecture, which has built an extensive network of bike paths. The bikes are assigned to different groups of people every 3 months and user comments are gathered to assist in developing E-PAB use. The objective is to find out how to reduce car dependence, particularly for short trips. Since 2002 battery charging stands have been provided that use solar PV panels to provide the electricity.

Another of Honda's environmental initiatives is the concept of "Intelligent Community Vehicle Systems"(ICVS). This is based on moving individual vehicle ownership to "shared vehicle use". Honda's vision is of a transport system that is "kind to people, the city and the planet" The ICVS aims to provide a solution to environmental conservation, co-existence with nature, better use of public space, smoother traffic flow and insufficient parking space. The basic concept of this system is based on moving from the individual ownership of vehicles to the shared ownership of environmentally friendly vehicles. This includes energy efficient cars, microbuses and E-PABs for door-to-door trips and to access an efficient rail system.

For the future there are four niche markets that can reasonably be expected to grow and contribute to a more passenger sustainable transport system:

1. People of all ages using shared E-PABs at solar charging stations and apartment and office E-PAB charging and storage facilities.
2. Employees using E-PABs to access rail stations and modal interchanges.
3. Young male and female bicycle riders using E-PABs to take the extra physical effort out of riding in hilly cities so that they are as mobile as cyclists in flat urban areas.
4. The elderly: as the proportion of the elderly in the Japanese population increases more of them will use electric bicycles, electric tricycles and fully powered 3 and 4-wheel scooters.

Honda and the Japanese government are improving on the European concept of using "Car Clubs" to discourage car ownership and encourage car sharing. Five million Japanese park bicycles at rail stations every workday. E-PABs will progressively move into that niche market for multi-modal travel, as many users need a bicycle at both ends of their rail journey. Lightweight fold-up E-PABs are allowed on bullet trains and easily fit in the boot of a car.

4. CHINESE PRODUCTION OF E-PABS FOR EXPORT AND E-BIKES FOR DOMESTIC USE

In China a combination of manufacturing policy and environment policy, designed to reduce air pollution, provides a secure market for E-PAB and E-Bike manufacturers. China has slowly built an industrial base to enable it to become the "manufacturing plant" of the world. In 1979 China became the world's leading maker of bicycles and by 2002 it was manufacturing 60 million bicycles a year with 46 million being exported. This is not an entirely home grown effort because Japanese companies like Shimano and Taiwanese companies like "Giant " and many other component makers have large factories in China. This in time may wipe out bicycle manufacturing in the US which produced 7.5 million bicycles in 1991 but only 900,000 by 2002. Meantime, in the US Chinese imports increased from 1.3 million to 18 million bicycles. This has also happened in Australia and may happen in other developed countries.

China wants to build up an industry base that in the next few years can produce E-Bike replacements for the millions of polluting IC-PABs in Chinese cities. Some heavy Chinese E-PABs which comply with the 200-watt (1/4 HP) regulations were being sold in Australian bicycle shops in 2001 and 2002 however the major export markets of the future will be the US and Japan. The production of E-PABs and E-Bikes in China increased to 1,590,000 by 2002 and is expected to reach 4 million in 2004 (Cycle Press 2003). This greatly exceeds Japanese E-PAB production, which is expected to stabilise at around 300,000 (see figure 3). In just a few years it is likely that China will be making at least 10 million E-Bikes to much higher quality standards than is done now.

The scale of the Chinese urban air pollution problem and the future market for E-Bikes within China is indicated by a GDP growth rate of 9.1% in 2003. Car production is growing rapidly and is expected to reach 5 million in 2004; around 13 million scooters and lightweight motorcycles will be produced. Given the high and growing health costs of urban air pollution and road accidents in China, it is likely that more environmental legislation will be introduced to constrain car use in cities and increase the demand for both E-PABs and E-Bikes (CSE India 2002).

A specific example is Shanghai which has a population of 20 million people. In Shanghai there were nearly a million licensed IC-PABs with dirty engine emissions so the city government decided not to issue new licenses for them but only to issue them for E-Bikes, as was done in Beijing. 37 Chinese E-Bike brands are now being produced in Shanghai.

According to the Chairman of the China Bicycle Association there is likely to be a large increase in the domestic demand for E-Bikes:

"the majority of demand is for fully battery powered machines capable of self propulsion. These will provide the bulk of sales for the domestic market. As far as the development of Japanese style "intelligent" PABs is concerned the development of such models will be geared mostly to export sales" (Cycle Press 1998).

The domestic E-Bike market will be dominated by the better-paid workers in the new industrial parks and office complexes, most of whom will be male. In 2001 there were 450 million adult bicycle users of whom 250 million lived in cities.

This will happen first in the 10 cities of more than 10 million population and then in the provincial cities servicing rural areas as the standard of living increases. Many of these urban workers are upwardly mobile and wanting to enhance their mobility, but will not be able to

afford a car so that the production of E-bikes is predicted to exceed 4 million in 2004. Housewives and the retired are only a small part of the E-Bike market at this early stage of Chinese economic development.

5. DEVELOPING MARKETS FOR E-PABS AND E-BIKES IN EUROPE

From 1998 there has been a resurgence of E-PAB research and development in Europe. 11 manufacturers are already involved including Mercedes Benz and four other German companies. This occurred despite the legacy of the 1970s moped legislation which required that PABs be classified as mopeds and subject to compulsory registration and insurance (Wigan 1979).

EU member states, which previously had a chaotic array of legislation for E-PABs and E-Bikes, will replace their individual regulations with the EU regulations. This will result in stable free market conditions for all producers of E-PABs both inside and outside of Europe. On March 18 2002 the European Union (EU) reclassified electric bicycles with a maximum power output of up to 250 watts as bicycles. For safety reasons the EU requires that all E-PABs be fitted with electronic controls that progressively reduce the power output with increasing speed and cut off the electric power assist when a speed of 25 km per hour is reached. E-PABs meeting these EU requirements are now being produced in quantity in Japan, Taiwan and Europe. Sales of E-Pabs increased from 70,000 in 2001 to 90,000 in 2002. Many of the models had sophisticated drive systems and batteries with a good travel range. (Brusch 2003). One review stated that E-PABs are sold under 53 brand names (Neurpert 2002). There are 17 different electric motor systems but most systems are sold by Yamaha, La Prima, Merida, Sanyo, and Shanghai Elite. E-PABs sales reached 55,000 in 2001.

The largest use of bicycles in southern and Eastern Europe is for sport and recreation and this also applies to use of E-Pabs. In Northern Europe bicycle culture is somewhat different as bicycles and E-Pabs are used primarily for transportation and to a lesser extent for fitness by the elderly. It is predicted that an EU market for 2 million E-PABs per annum is possible in a few years (Neurpert 2002). NZ regulations should allow European made E-PABs to be available to consumers just as it is for European cars.

6. NEW MARKETS FOR E-PABS AND E-BIKES IN NORTH AMERICA

The USA and Canada are major potential markets for electric bikes. The high level of bicycle ownership indicates the size of the market. In the US in 1999 120 million bicycles were owned when the population was 272 million, and in 2002 there were 22 million bicycles sold. In 1999 31 million Canadians owned around 13 million bicycles. Canada and the USA recently amended their regulations to facilitate greater use of E-bikes or electric bikes. These countries now have higher-powered output limits than in Australia.

6.1. United States legislation

In the USA legislation was introduced in May 2003 which allowed for a 750W power limit, a 20mph (32kph) assisted speed limit and functioning pedals on E-bikes and E-PABs. The passage of a new Federal Act (HR 727/SR 1156) recognizes an electric bike as a “bicycle” in Federal law thereby allowing them on the street without a license and registration and onto bicycle paths. This allows youth below driving age and adults who have lost their driving licenses to ride them. (Bejamin 2003)

The Consumer Products Safety Commission (CPSC) is now the Federal agency responsible for E-Bikes, which will have to conform to CPSC safety requirements. E-PABs and E-bikes are not regarded as a means of transport in the USA and most are used for recreation. Due to the lack of effective marketing most consumers are not familiar with the features of E-PABs and E-bikes (Bejamin 2003).

Today the major source of information about E-Pabs and E-bikes is the Internet; there is very little television advertising. There is no monitoring of E-PABs and E-bike sales in the USA but it appears that most that are sold are made in Taiwan.
The Taiwan government reported that 37,000 E-PABs were sold in the USA in 2001/2. Light electric scooters are the most important electric two wheelers sold in the USA with estimates of 270,000 sold in 2001/2. Distribution channels for E-Pabs, E-bikes and electric scooters remain disorganized but the future appears promising for the new E-Bikes (Bejamin 2003).

6.2. Canadian Legislation

Canadian Legislation was passed in late 2002 which allows a maximum power output of 500W, maximum assisted speed of 32kph, and a stipulation that the motor not be engaged until a speed of 3kph is attained on E-bikes and E-PABS, this is not sound legislation because starting the motor after 3 kph is reached disallows most Japanese E-PABs which are switched on like a car with an ignition key and a major handicap for many of the elderly lame or disabled wanting to use them because of the physical effort involved (Rose and Cock 2003).

However, the Canadian approach to regulating these vehicles is based on Performance Based Standards (PBS), which have been used for other vehicle types.

The legislation includes requirements that:

1. Active pedal power is present for the vehicle to be classified as a bicycle.
2. The maximum speed at which the power assistance should cut out be 32 km per hour
3. Vehicles meeting these limits continue to be classified as ‘bicycles’ and require no registration
4. Vehicles which do not have pedals and/or exceed the above performance standards should not be classified as ‘bicycles’ and therefore be subject to specific regulations

The type of E-Bike allowed for by both the USA and Canadian legislation is the 400-watt Lafree E-bike made by the Giant Bicycle Company which this author considers to be a state of the art machine. Paraparaumu-based CycleTech New Zealand Ltd, which imports and distributes Giant cycles, is reluctant to market and support the Lafree because LTSA regulations create such an overwhelming barrier to the electric bicycles use.(EECA 2003 B) The Lafree E-bike would sell retail for around NZ $2000.

7. BIKEWAY NETWORKS FOR THE USE OF PABS IN HILLY URBAN REGIONS

The economic justification for using bicycles and E-PABs in OECD countries is to make better use of car fleets. The Dutch car fleet is much more efficient than Australia’s partly because bicycle trips substitute for around 8 billion kms of short car trips. 28% of all trips made by people over 11 years of age in the Netherlands are made by bicycle. This level of bicycle usage is partly due to Dutch cities being flat and partly due to the safe bikeway

networks in all Dutch cities (Parker 2001). There were 17 million bicycles in the Netherlands for a population of 16 million in 2001. There is a growing market for E-PABS amongst the elderly.

Most cities elsewhere in the world are not flat and have grown much bigger than Dutch cities, with growth along motorised transport corridors and longer trip lengths. In these cities the use of bicycles is limited by the physical effort required to get from A to B. Most cities have sprawled beyond the plains and valleys and are spread across hilly terrain. If bikeway networks existed E-PABs could overcome these constraints and could be used to enhance personal mobility in much the same way as bicycles do in flat cities. Modern multi geared bicycles are a help in climbing hills but, as recent experience in Japan shows, housewives and elderly cyclists start to give up cycling when it becomes too strenuous. However, they will use E-PABs.

If safe back routes to rail stations, secure bicycle parking at stations and modal interchanges were available E-PABs and E-Bikes could make it much more convenient to use public transport and effectively enlarge rail catchment areas. From a strategic transport planning perspective investing in bikeway networks would be cost effective in hilly N.Z. and Australian cities if they enabled E-PABs and E-Bikes to be safely used of instead of cars (Parker 1999).

8. THE END OF THE AGE OF CHEAP OIL 2010 TO 2020

A few years ago N.Z. was far more self sufficient in energy than it is now. The future is not very promising because of the depletion of 'conventional oil' reserves (i.e. cheap oil). About 35 % of N.Z. energy is provided by oil and the growth in oil production from the 1980s peaked in 1997 (APEC 2002). This stemmed from a decline of new oil discoveries and is similar to the situation in Australia. Woodside Petroleum's Managing Director said recently that:

"*Australia has been consuming oil three times faster than it has been discovered. Projections by Australian Government forecasting agencies indicate that Australia is facing a rapid decline in liquid petroleum production over the next decade. Liquid petroleum self-sufficiency is expected to decline from an average of 80-90% over the past decade to less than 40% by 2010."* (Akehurst, 2002).

The general view within the oil industry is that Australia and N.Z. have low oil prospectivity. Fields yet to be discovered are of small to medium size and are becoming more technically demanding, e.g. heavy oil or deep-water reserves.

The general view of the international oil industry regarding world oil reserves is even more depressing (Laherrere, 2003). For several years for every new barrel of cheap oil discovered worldwide four barrels of oil have been consumed. Once peak oil production is passed, as shown on figure 5 costs rise and quality tends to decline. The world oil market is expected to become a seller's market as early as 2006 and at the latest by 2016. Temporarily the balance of power will shift towards OPEC, but even Middle East production is expected to start falling around 2010 (Robinson, B 2002)(Robinson, B 2003). A crisis in supply-demand balance is likely to emerge within 12 years as the impact of the growing demand of the

developing economies competes with the high demand from developed countries for a dwindling supply.

The May 2002 Uppsala University International Conference on Oil Depletion and the May 2003 Association for the Study of Peak Oil Conference held in Paris evidenced a growing consensus on the reality of oil depletion (www.hubbertpeak.com.) Overall there emerged a scenario of world oil depletion of 5-10% per year; a recognition that oil reserves had been deliberately overestimated by the oil industry and that there are unlikely to be more major significant reserves to be found. Middle East and American oil representatives issued warnings on the absence of any more major frontier regions except the Polar Regions and the increasing incidence of "dry holes".

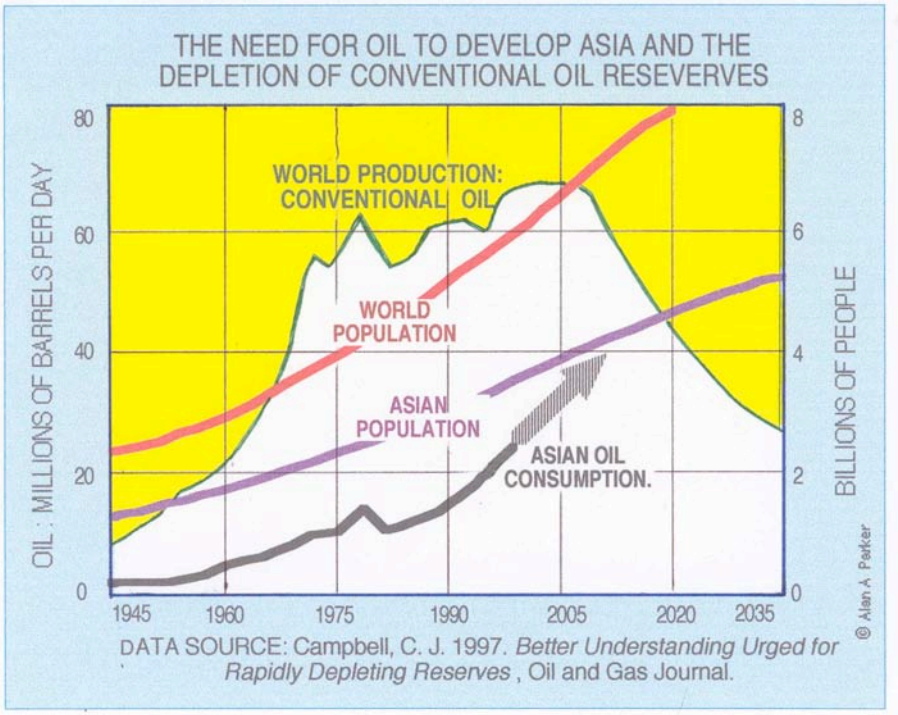

Fig 5

The historical record shows that oil based agriculture is primarily responsible for the world's population exploding from 2 billion in 1938 to 6.3 billion at the turn of the 21st century. For example figure 5 shows the consumption of oil in Asia from 1945 to around 2010 and it relation to world production of conventional (cheap oil').

Oil powers the farming implements such as tractors, food storage systems such as refrigerators, and food transport systems such as trucks. Most pesticides are petroleum (oil) based, and all commercial fertilisers are ammonia based. Ammonia is produced from natural gas. As oil production went up, so did food production and the worlds population. We are now at a point where the demand for food/oil continues to rise, while our ability to produce it in an affordable fashion is about to drop. Within a few years of cheap oil production peaking , the price of food will skyrocket because of the cost of fertiliser will soar. The cost of storing (electricity) and transporting (gasoline) the food that is produced will also soar. Substantial alternatives to current cheap and abundant petrol and diesel transport fuels are unlikely.

Future risks to the N.Z. economy from oil depletion are much worse than for Australia because N.Z. has only one sixth of the per capita oil reserves of Australia (World Oil. com 2000). By the time that the current N.Z. buyer's market becomes a seller's market and as world oil production begins to fall N.Z. will be vulnerable to increasing costs of imported oil and serious oil shortages. To produce the petrol, diesel, aviation fuel, plastics and other oil products 133,000 barrels of crude oil per day are needed. The option of using gas as a transitional fuel for motor vehicles, as proposed by the Western Australian Government, may not be an option for N.Z. because N.Z. had only one fourth of Australia's per capita gas reserves in 2000. (World Oil. com 2000)

A more comprehensive industrial transformation towards sustainability is needed in developed countries like N.Z. and Australia. An all-of-government approach to decoupling per capita economic growth from per capita oil consumption is being tried with some success in the Netherlands (NEPP 3 1998).

In N.Z. the necessary change processes will have to emphasise oil conservation as the key risk management strategy as there appear to be no technical panaceas to enable the current oil consumption patterns to persist. These changes will need to involve lifestyle changes; oil and transport demand management measures; congestion pricing; new "energy-lean" technologies; integrated land use and transport planning and the use of electric bicycles. To date the end of the age of cheap oil has been an overlooked factor in transport policy in NZ and there is no study setting out both the problems and the solutions as there is in Western Australia. (Robinson, B. 2003)

9. THE FUTURE FOR E-PABS AND E-BIKES IN NEW ZEALAND

Energy Wise News an Energy Efficiency and Conservation Authority journal stated: -

"New Zealanders are missing out on one of the most energy efficient forms of transport - the electric bicycle - because the Land Transport Act defines it as a moped motor vehicle, needing registration and number plates with a light to illuminate them at night, a motorcycle helmet and a driver license." (EECA 2003 B).

The LTSA's Fact sheet 43 defines a moped as a motor vehicle, which can have an engine that does not exceed 50 cc and 2000 watt power output...the LSTA is aware of the devices (E-PABs) and their appeal, but their use requires a change of the definition in the Land Transport Act. There is work afoot to class them as bicycles, providing they have less than a certain power output; discussions have revolved around 200 W." (EECA 2003 B) This of course is due to the influence of Austroads which recommends a simplistic 200 watt limit which excludes state of the art E-PABS a mere 10 to 45 watts above the limit but has allowed dangerous scooters to be legally classified as bicycles with up to 1000 watts in excess power output.

Some scooters now used on Australian roads have dirty two stroke engines (1,200 watt) bur fitted are fitted with easily removable 200-watt speed limiters that salesmen show buyers how to remove. They are potentially dangerous on roads (Paine, M 2001) and pollute the shared footways used by cyclists and pedestrians. The Australian Transport Council (ATC) which is responsible for introducing amendments to the Australian Road Rules (1999) and has been conducting a review of the Safety of, and Associated Rule for, Scooters and Other Wheeled

Recreational Devices since 2000, it had still not decided what to do in March 2003. NZ should learn from Australia's mistake not copy it.

What is needed in NZ is a proper performance based standard as adopted by the EU, Japan. and Canada (Rose and Cock 2003). To copy the simplistic 200-watt rule would ignore world best practice, be a denial of N.Z. consumers right to choose the safest and best products available; it would also be an unwarranted restriction on free trade. As a minimum requirement it would be prudent for New Zealand to bring their regulations into line with the new EU regulations so that consumers have the choice of buying safe "state of the art" E-PABs with a power output of up to 250 watts. Feedback from the Australian bicycle industry suggests that E-PAB users are predominantly males aged over 50 years. It is likely that these older riders will represent a growing market particularly as mobility issues for older drivers are magnified with the ageing population. Initial research conducted at Monash University has confirmed that E-PABs can provide health benefits to them (Rose and Cock 2003).

In NZ there are compelling reasons for adopting the Canadian Legislation allows a maximum power out put of 500 watts:

9.1. Urban densities are far lower than in Europe with many day-to-day destinations being further apart and far fewer of them within convenient walking distance. However, many are within easy cycling distance except when there are lots of hills. In the hilly parts of Auckland and Wellington the more powerful 500 W limit would enable people of all ages to cycle much more than they do now. It would enable them to be more active as part of their daily life, increase their mobility, reduce isolation and improve health.

9.2. an important safety consideration is having enough power assistance to ride up hills without weaving and to reduce the speed differential with motor vehicles. The 200 W E-PAB is underpowered for N.Z. elderly males, who are much heavier than the elderly females who make up the majority of Japanese users. Even a 250-watt E-PAB would rapidly run down batteries on the hills of Auckland and Wellington.

9.3. There is a stated government interest in providing more extensive bikeway networks in the N.Z. Transport Strategy, (NZTS 2003) and the promotion of E-PABs and E-Bikes as part of Travel Smart programs (EECA, 2003 A). The more powerful E-Bikes with a 500W limit would be an attractive alternative for many of those "drive alone commuters" who create the most congestion and air pollution

9.4. Many people are limited in where they can go because walking is painful. For example riding a bicycle, E-PAB or E-bike can be less painful than walking for people with osteo-arthritis in the hips, knees or ankles. This is so because the saddle and not the legs carry the body weight (Parker 1992 B). Today around 2.6 million Australians and around 520,000 New Zealanders are afflicted with some form of arthritis. There are also 3.2 million Australians and around 650 New Zealanders with vertebral disk problems or unspecified back trouble for some of whom using an E-bike would be helpful (figure 5).

9.5. The N.Z. EECA could create marketing incentives for imported E-PABs and E-Bikes to be sold as part of a package, complete with a PV 24 Volt or 36 Volt DC battery charging system coupled to solar panels. The efficiency of the total package in substituting for car trips would justify the higher kW hour cost of solar PV because only a small area of solar panels is required with a low installation cost. The development of domestic solar power

systems for DC powered appliances (as well as for recharging the E-PAB DC batteries) within ten years is feasible in both urban and rural areas. There is no necessity to connect these appliances to the AC grid; this will reduce the demand on it and reduce the need to use more gas or coal powered generators.

E-Bikes with a power output of up to 500 watts should be available to those with medical conditions that limit walking without the need for registration, number plates with a light to illuminate them at night, a motorcycle helmet and a driver license. At the very least it would be prudent to make the LSTA regulations in line with the new EU regulations on E-PABs.
Also the LSTA website document "Disabilities and driving in N.Z" which recognizes the need to provide vehicle modifications specifically for the disabled, and needs to be revised and should state the following:

> *E-Bikes with a power output of up to 500 watts should be available to those with medical conditions that limit walking without needing registration, number plates with a light to illuminate them at night, a motorcycle helmet and a driver license.*

The assertion that 250 watts is not enough power for those wishing to use an E-PAB safely and without too much effort on the hills of N.Z. cities may be disputed. Should this occur it can be resolved by the LSTA commissioning a consultant or CANA to study and test an E-Bike with a 400-watt power output and a quality Japanese made E-PAB to compare their capability for safely riding up hills in an urban environment by elderly male and female test riders, one of whom should have osteo-arthritis of the hip that restricts walking.

The models which are recommended for testing, are based on what was commercially available in the 2002/3 financial year and are the "Lafree" E-Bike made by Giant weighing 29 kg with 400-watt power output and two Japanese E-PABs that weigh around 20 kg; the Panasonic "ViVi" and the Yamaha "PAS Super Light U". (designed for women wearing skirts). However, this is a rapidly evolving market and there are sure to be some new models introduced in 2004 that are worthy of testing.

The author's purpose is not to recommend specific models as such but to recommend these models as representing three classes of machine that need to be selected from the best available on the world market next year, or whenever tests take place.

10. CONCLUSIONS AND RECOMMENDATIONS

There is a need to enable N.Z. to survive the predicted depletion of the world's conventional oil reserves (cheap oil) between 2010 and 2020. Using bicycles, E-PABs and E-bikes, instead of many 'drive alone car journeys' is a practical option for conserving oil in passenger transport. Changing the Land Transport Act to encourage green products like the E-PAB and E-Bike and reduce car and oil dependence has a lot to recommend it as a risk management strategy. It should be noted that The Energy Efficiency and Conservation Authority has stated that:

"New Zealanders are missing out on one of the most energy efficient forms of transport - the electric bicycle - because it is defined in law as a moped and not a bicycle as it is in the EU, Canada and the US". (EECA, 2003B)

It is recommended that:

10.1 As an optimum solution NZ should adopt the Canadian approach to regulating E-PABs and E-bikes by having a Performance Based Standard (PBS). which allows a maximum power output of 500 watt, maximum assisted speed of 32kph. that fades out from 25 km per hour. However, the speed control system can be fully automatic (actuated with a starting key with no throttle), or semi automatic with a throttle but power assistance fading out from 25 to 32 kph.

10.2 Vehicles which do not have pedals and/or exceed the above performance standards should not be classified as 'bicycles' and therefore not the subject of these regulations. Which should exclude; scooters with electric motors above 200 watts and without automatic speed limiters that cut out at 15 km per hour. Powered scooters with dirty two-stroke petrol engines should also be excluded and banned from using Shared footways shared with pedestrians.

10.3 Powered bicycles with dirty two stroke petrol engines with a power output of less than 500 watts should be classed as bicycles but required to have power assistance faded out with electronic controls at 32 kph and banned from using Shared footways shared with bicyclist and pedestrians. Powered bicycles using clean fuel in advanced internal combustion engines (i.e. made by the Orbital Engine Company) should be covered by 10.1 above.

10.4 The N.Z. Energy Efficiency and Conservation Authority (EECA) creates marketing incentives for imported E-PABs and E-Bikes to be sold as part of a package, complete with a PV 24 Volt or 36 Volt DC battery charging system coupled to solar panels and Commissions a study to develop a prototype solar PV battery recharging installation for E-PABs, and E-Bikes, test the recharging installation over a period of one year and produce a feasibility study and detailed costing for factory production.

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NOTE
Cycle Press is a Japanese publisher serving the information needs of Asian manufacturers and distributors of around 80 million new bicycles and over 2 million E-PABs and E-Bikes

per year. It produces their power assisted bicycle (Pedelec) International Year Book; monthly journal *CyclePress* and catalogues in English and Japanese. Publications available from the publisher. URL http:/www.cyclepress.co.jp