SOFTWARE OPTIMIZES MOTOR-ASSIST 1-WD CARCYCLE, SANS REGO/LICENCE

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"The supply of sola energy is both without limit and without cost. Sola energy will pour down on us long after we run out of fossil fuel" --- Charles Fritts 1886 who with Becquerel discovered that sunlight can produce electricity in 1839 and who also developed the first selenium sola panel.

ABSTRACT

Completed and used regularly since 1995, albeit occasionally improved, this simple private project is an optimized low energy, motor-assist, non-polluting value-engineered and cost-effective shot at the ultimate mass transit passenger/freighter trike requiring no registration, license or insurance for all ages by virtue of its pedals (3-speed geared), and < 200watt motor-driven, lever-steerable 12" hub-geared wheel.

Bikes are notoriously off-putting as freighters, tandems or for mounting a motor to safely help weaker, infirm, timid, unbalanced, portly or elderly riders over hilly distances. The view from recliner bikes is restrictive. Even mopeds need expensive paperwork, suffer costly unreliability, can't be lifted or repaired easily and are over pollutant compared to this ultra reliable alternative.

All weather performance was vital as was: lively speed, tiny rolling resistance and CD (drag coefficient), use of standard low-technology bike and hardware shop components, substantially failsafe (for a flat tyre if alone, change seats to continue) and backup redundancy with long MTBF, comfort and driving ease by either rider, street maintainability, plus a nifty appearance. Multifunction bolted structure, whilst needing no welding, precision, turning or machining is largely a flat horizontal dirt-cheap braced-aluminium frame plus 2-abreast heavy-rider superb cushioned marine-ply aft seating. Footprint for storage sitting on its rear end is only 45*90cms possible since Hawker Energy battery is dry.

Additional design criteria were: 7-speed Sachs hub gears to save power, amplify motor performance. 46ah Hawker Energy dry battery (+ another for range) charging is by 42watt home-based solar panel, by heavy mains at garage or at home, if not by other renewables. A freight trailer can also carry solar panels - same could also be vehicle canopy-mounted - or hybrid power such as micro engine/generator driven by steam, grain alcohol, woodgas... Light animals (dog, goat, llama, sheep) are motor alternatives.

SOLACAR software, incorporating our light vehicle performance algorithms, models and predicts dynamics (depending on electronic controller setting) of such vehicles, in substantial agreement with that measured. Best solar panel sun angles are also calculated. MOTORS software predicts, optimizes and displays motor performance from merely two measurement sets rather than from dozens. Parameters tend to be universal and applicable to all ultra-economy designs whether sola, battery or fuel-engine.

INTRODUCTION

BackYard TEch is successfully committed to redesigning all 150 Home Lifesupport Systems for Sustainability including this our expandable, environmentally friendly and safe, easily-assembled and dismantled multi-use vehicle which, being lighter and smaller than 2 bikes, is ultra-compact and light enough to carry onto public transport, some buses, station wagons, ferries, rowboats etc.

Dimensions = 125cm L x 90W x 60 (current model slightly bigger).

Weights: Battery 10kg + trike 40kg = 50kg + us 2 chubby pensioner riders = 200kg gross.

MODE can be Pedal Assist (PA) where the electronically controlled motor + battery + chain and so on are continuously being 'worn out' en route, assisted by geared pedals up steep hills or for extra speed; or our favored economy Motor Assist (MA) in which, because freewheeling and pedalling is so effortless unlike the usual bike foetus position, motor power is only necessary on hills or for speed.

Motor alone speed in 7th gear = about 25km/h according to the little speedo computer, which can also be calibrated to read wheel revs. Flat unassisted, single battery motor range is figured at 60k++.
Freewheeling in which speed soon reaches 20km/h down slight hills (50km/h if courage doesn't give out when steeper) - especially before strong tail winds, to fast-assist the next hill or on long flat bottom coasting -

seems much better than regenerative braking complexity.

APPLICATIONS

Mass personal utility transport/freighter, shopper, races, sporty invalid carrier, taxi, rickshaw, ambulance, power walk-beside trolley or barrow...

Reconfigurable as: Bike, boat, hanglider, steam/IC hybrid, light animal power... Bigger motor could replace pedals (but needs registration, license, insurance). Customize, lengthen, widen, cover, add solar...

CONFIGURATION

Not as good at puddle jumping, but to save kilos of hardware, 9.1% less drag and consequently about 12.5% less power, 3 wheels were chosen over 4 (the author enjoyed years of safe driving a British 3-wheel Reliant van). Riders sit back-supported over a pair of rear 16.75" hub-geared and pedal-braked bike wheels. No springing needed other than by tyres, being 'critically damped' when so loaded. Front/rear tyres serve as bumpers. Feet-forward makes ride yet safer for aged, infirm, disabled, lazy, timid, weak, overweight or those of poor balance - also best crash resistance. The backpedal doubles for parking brake when spring-hook connected. Powering the stable 12" lever-steerable and spring-return front castor wheel saved on a differential, steering linkages... All inner tubes are "thornless".

Unpainted frame consists of flat horizontal low-slung light alloy |_| sections(doubles as mudguard) bolted on 2 corners + wide marine-plywood cushioned seat securing rear end to provide extra storage and battery space under, see 1st figure. 4 wheel-posts are aluminum cross-braced to ply which rigidizes frame and avoids metal bolt hole fatigue. Fancy shells were rejected as a complex ego-irrelevancy.

Cheap bike + nuts/bolts hardware shop technology + unskilled Meccano-style hand tool and drill assembly make trike easy to road-repair, decommission, recycle, or pack into small flat crate. Hardwood blocks on pedal + steering column safely distribute shocks into channel aluminum. Use is made of industrial standard components, including: threaded rod (for motor adjusting and U bolts), pipe clamps, angle and flat stock, rope, wire, nylock nuts...

ACCESSORIES

Many are12v: Swivel multi-use head/rear lights, speed/odometer/clock, solar radio, pocket TV + computer, fan, wheel/pedal/seat reflectors, mobile phone, satnav, 1/2 milliohm 50amp meter, compass, an on-board 3amp regulated mains unit and a basic home 42watt solar panel charges the battery to 14.3v before auto-cutout in less than a morning for typical trips. Also: squeeze horn, antenna flag, rear mirror, tool/medical pouch, hand signals, freight trailer... Big shopping crates and bags are easily carried. Plywood freight tray over passenger space permits much extra cargo area especially long items.

Leather blocks are recommended for the other (caliper) brake. Gently switch-reversing the motor enabled it to torque on a back-pedal hub brake (=electric brake): but proved too violent without interlock! Aluminium paint is perfect all-weather wood sealant/primer - or leave bare. There's no reverse; simply lift and wheelbarrow... Assembled solar panels still too heavy for safe on-board use.

12V, 46AH BATTERY, CONTROLLER, CONNECTIONS

Can't speak too highly of these over-priced Hawker Odyssey/Genesis 46ah longlife, high energy density, dry and hence invertible miracle lead batteries. We solar trickle-charge to 14.4v while connected before cutout, but charge can be restored after flattening 400 times by a 40a zap - as from another battery or switched capacitors. Heavy current use to 1000a barely changes rated ah, volts whilst using, or life! All top-connected cells are accessible (handy for other uses if a single cell dies years later). We had to rewrite their pathetically misleading documentation. All electrics are frame-insulated.

Measured as highly efficient, the Independence Tech chopper 'Fat' Controller has pot speed control, enjoys years of belting and has 30a limit, which necessitates a micro-loss 'hyperdrive' DPDT knife switch to bypass controller for 40a on steep hills. Best amphour economy for starting is to ramp up voltage pot gradually. Must battery-disconnect when stopped as 0.1a still drawn.

Check all cable volts drops. Connectors, terminals, plugs, switches, fuzes and usual meters... are out because 1v is soon lost at 20a. Our .0005ohm, 50a junk car meter worked well. Massive, short, fine-strand flexible speaker cable heavy-soldered everywhere (even to terminals) is OK. An essential trick seldom revealed is to lightly sand and smear a Vaseline-moistened finger all over every contact and terminal - especially where they electrically connect. One battery clamp doubles as prime switch.

Our exclusive 12volt home and solar wiring uses cheap standard heavy mains wire/plugs.

MOTOR AND TRANSMISSION

Wheel-mounted motors were rejected as they magnetically drag when coasting. Years of perm-mag, brushes and ball bearing Preslite invalid carriage power were good, but at 3200rpm necessitated a 20:1 double chain reduction - albeit far more efficient than belt, tyre-roller or gears. Thus we recently switched to a heavier EMP motor having about 1000rpm and 3 times torque. The 7-speed Sachs Preselector hubgear is phenomenal, forgiving and essential at these low powers, though could have a wider ratio range than its 2.83:1, especially at the low end to help on extreme hills. Fitting the wide hub with short spokes to the 12" wheel and into a widened fork was tricky. 9-tooth motor sprocket is a Reynolds Co. special and ideal for driving the big 50-tooth sprocket, which is just smaller than the front wheel to avoid road-grind if its tyre goes flat. Long molecule chain saw oil is preferred lube. In use the exposed motor barely gets warm, so intermittent hills are no overcurrent drive problem.

"MOTORS" PERFORMANCE MODELLING SOFTWARE

Typically, motor manufacturers tabulate over 20 sets of data for T(torque nm) versus V(volts), N(rpm), I(amp), mechanical Powerout(w), Efficiency%, electrical Powerloss(w), and electrical Powerin(w) which = V*I. From this table they plot composite graphs albeit only 3 simultaneously. Probably not much new, but it was observed that with N, I, Pin all linear wrt T to 3 or 4 decimals, the other variables are derived as simple polynomials. Thus the entire table and graphs (all at once on the author's no-frills embedded Maths Algorithm Library MAL PLOTFUNS routine) are precisely deduced from the 2 data sets taken at T=0 whence No=1544, Io=1.36, to T1=8 when N1=26, I1=110.45 .

Unfamiliar 18th century Smeaton, in studying how to optimize load and gearing for maximum power transfer from waterwheels, tidal mills, horse whims and windmills... concluded that if unloaded revs is N, then load and/or gearing should be adjusted until working revs is N/2, analogous to maximum power transfer in circuits. Applying to the motor: unloaded half max revs N/2 = 1544/2 = 772, at which point the maxpower is seen on the graph near 328.6w. Actually 328.91w from the software.

T at N=0 is linearly related to V (and I) to hence deduce and optimize motor performance at lower controller settings, especially power as in previous paragraph. Our menued "MOTORS" software carefully assembles, outputs and plots as in the second diagram, all material in this section - a substantial saving in measurement effort. Grey areas for intermittent or forbidden use can be highlighted. Max Pout and max Eff% are not at the same torque T or current I.

"SOLACAR" SOFTWARE MODELS AND OPTIMIZES VEHICLE DYNAMICS

This software is based on the following vehicle power/drag model which seems to fit well - see the author's text ECO-LOGISTICS. Thus motor shaft power Pout(w) is given by:

Pout=.00823Av^3+.000211Wv^2 +.034Wv (1+/-80.06 SIN(ARCTAN(B/100))),

where v=speed in km/h; W=gross vehicle weight kg (=200); A=effective frontal flat area sq.m (=.5); B%=hill angle, negative sign = downhill, B = 0 for level.

From this formula, with the help of embedded MAL, one can evaluate: Speed, revs and ratio for any motor power up/down hill or flat; Coasting speed downhill; Range on full battery; Time to accelerate from a standing start to desired speed. For the latter, v/(1-av^3 - bv^2- cv) is integrated 0 -> v.

The inverses of these are also available. Initial acceleration is so rapid that with 2 riders, about 6km/h was attained in a garage length! Both brakes + convenient dragging shoe were all needed to halt.

CONCLUSIONS

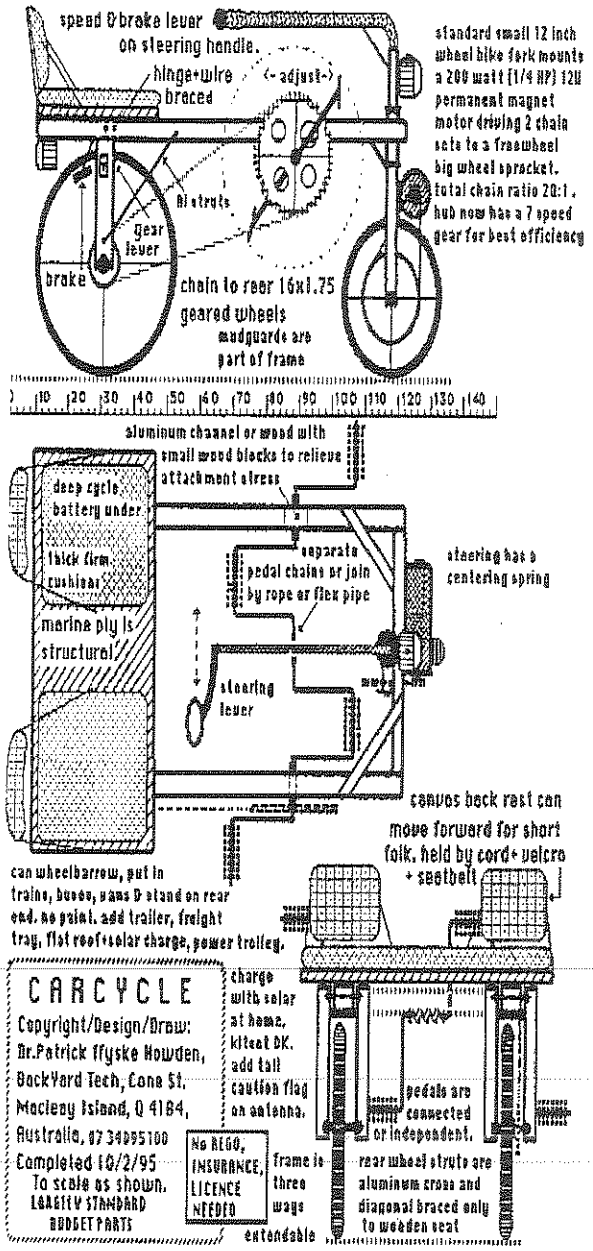
Described is a serious satisfying and simple, versatile, customizable, failsafe, pollution free, zero running cost, optimized performance and trivial maintenance answer to: global transport needs, air pollution reduction, an exerciser for the indolent, plus developing and western world budget commuting, yet needing only hand tools for assembly from a tiny flat kit. Doubtless the frame etc. can be much simplified, even largely wood. Mass production by anyone out there promises still better price slashing.

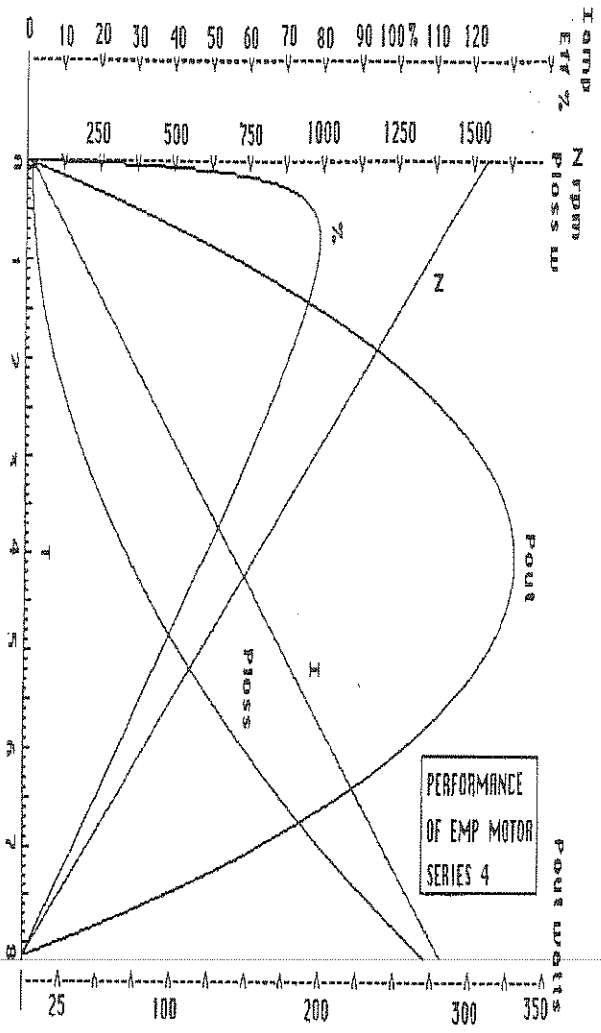
The legal power restriction to avoid registration is ludicrous because 200w is only used going slowly up steep hills! A 750w no-rego limit could popularly save green house gas by millions of tons annually!

We are still tying motor geometry, number of poles, magnetics, materials and wiring characteristics into the above motor variables.

High reliability means the CARCYCLE always starts in any angry weather.

Sincerest gratitude to all named producers for their magnanimous hardware grants and support.





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