Pedal power: the future of urban transport?

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Engineering Materials

Abstract

The need to develop non-motorized transport is based on the following premises:

1) Many urban transport systems depend on oil, whose global production has probably peaked.[1]
2) Obesity is projected to cost the UK £45.5 billion per year by 2050.[2]
3) Geological, technological, and economic constraints limit the growth rates of alternatives to the internal combustion engine.[3,4,5]

If each premise is correct, sustainable, non-motorized transport systems may be necessary for continued high mobility. This poster explores pedal-powered options.

Pedal power has the potential to reduce the UK's reliance on imported petroleum products at low cost. Policy should respond accordingly.

Policies

Cycling rates vary significantly internationally (Fig 1).

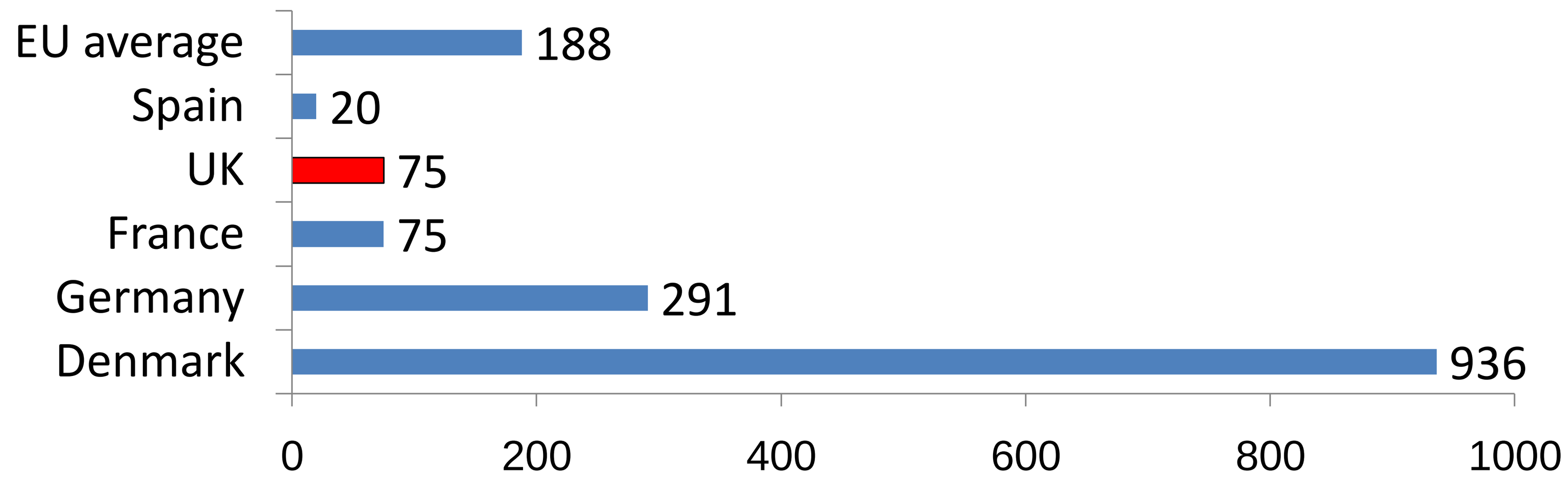

Fig. 1: Cycling rates in a selection of EU countries (km/p/yr)

High rates of cycling can be achieved by: 1) provision of separate cycling paths along major routes;[9] 2) encouragement of cycling to school;[8] and 3) restrictions on car ownership and use.[9]

Energy analysis

Energy consumption per vehicle-meter (e_{vm}) can be calculated as a function of manufacture (e_v), infrastructure (e_i), and fuel (e_f) costs:[6] $e_{vm} = e_f + \frac{e_v}{l_v} + \frac{e_i}{l_i}$ where l is vehicle/infrastructure lifetime in km and vehicles respectively. Other metrics of energy use can also be derived: energy use per passenger km, $e_{pm} = \frac{e_{vm}}{p}$ and potential efficiency, $e_{sm} = \frac{e_{vm}}{s}$, if values of p (occupancy) and s (n. seats) are known. Inputting UK data[7] yielded the following results (Fig. 2):

1) Bicycles use 1/5th of the total energy of cars per passenger kilometer.
2) Cars could halve their energy use by increased occupancy (currently 1.58).
3) Walking is the lowest energy form of transport, requiring no embodied energy.

Of course, the results rely upon assumptions: estimates of embodied energy and vehicle lifespan vary. One thing is clear however: if cycling rates in the UK rose to 936 km/p/yr, as in Denmark, ~10% of car journeys could be replaced.[7] This would reduce the UK's petroleum requirements by ~5%.[7]

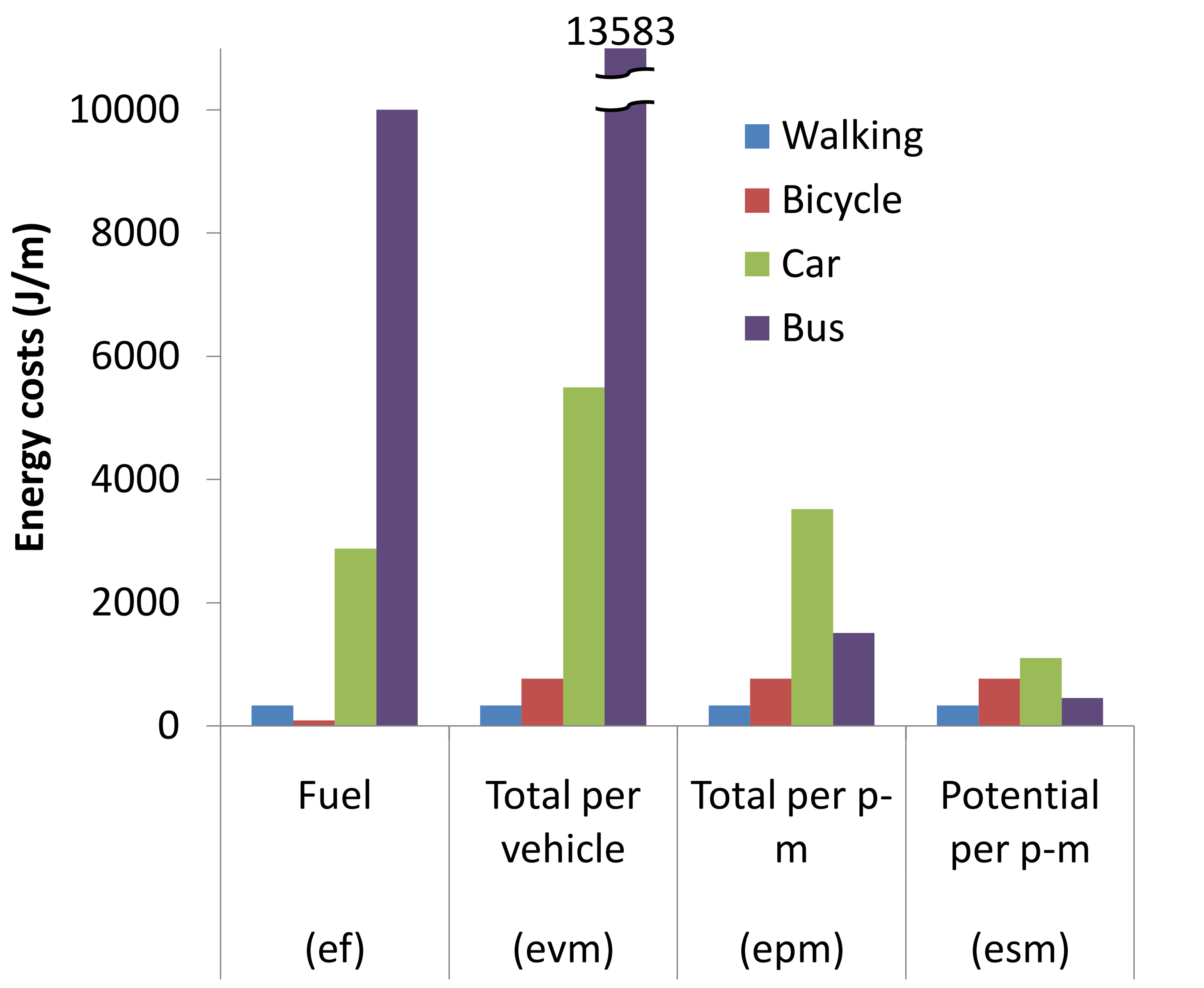

Fig. 2: Four metrics of energy use for four transport modes

Technologies

Technology can increase the range of tasks for which pedal power is appropriate. The range and speed of cycles could also increase significantly:

Tech-nology	Groups who may benefit	Approximate costs and stage of development
Panniers	People carrying loads < 50 kg	\$30 - \$200. Mature technology, advances in materials
Bicycle trailers	Parents, small businesses	\$50 - \$500. Mature technology
Recumb-ent bikes	Elderly, people with back pain	\$200 - \$2000. New, rapidly advancing
Tri/quadri cycles	Elderly, frail	\$500 - \$2000. Mature technology, little R&D funding
Electric hybrids	Elderly, frail or obese people	\$500 - \$2,000. Tested technology advances in batteries and motors
Emerging materials	Commuters, sportspeople	Advances in materials science are filtering into bicycles
Freight bicycles	Businesses and small farmers	\$500 - \$5,000. Mature, but rapidly advancing technology

Images

Load-carrying bicycles

Adventures by bicycle

Old Dutch freight bicycle

Conclusions

Cycling is a highly efficient form of transport, even accounting for the energy costs of manufacture and infrastructure. Pedal power could reduce the UK's dependence on oil, the most rapidly depleting of the fossil fuels. If rates of cycling approached Northern European levels, this would yield the following benefits:

1) Increased energy security in preparation for declining oil supplies.
2) Improved health and "social cohesion" of citizens.[8]
3) Reduced local and global air pollution.

Fortunately, the policies and technologies available to incentivise cycling are generally cheap and easy to implement.

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