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Social Factors in Household Energy Consumption

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SUMMARY

Energy use in Australia faces three major challenges: air pollution arising from fossil fuel combustion, depletion of our modest oil reserves, and global warming contributions from greenhouse gas emissions. Energy conservation is a means of responding to all three challenges. This paper focuses on conservation of residential and passenger transport energy. These are directly controlled by households, hence social factors are likely to be important in energy conservation. On the basis of an analysis of energy consumption patterns from 1950 to 1995, it is argued that greater emphasis will need to be placed on enhancing social efficiency, that is, the effectiveness with which a given output is used to satisfy human needs. To date the emphasis has been on increasing technical efficiency. It is found that in certain important cases, promoting technical efficiency can be detrimental to social efficiency, leading to an overall rise in household energy use. Finally, the various policy options available for achieving energy savings are analysed, and it is concluded that in general non-price policies are more equitable and usually more effective.

INTRODUCTION

Energy use in Australia faces three major challenges: air pollution arising from fossil fuel combustion, depletion of our modest oil reserves, and global warming contributions from greenhouse gas emissions. Energy conservation is a means of responding to all three challenges. This paper focuses on conservation of residential and passenger transport energy. These are directly controlled by households, in contrast to freight transport or industrial energy use, for example. Social factors in energy conservation are therefore likely to be more important.

An extensive and growing literature over the last two decades has stressed the large potential for technical energy efficiency improvements in both the residential sector (e.g. 1,2,3,4,5) and the transport sector (e.g.1,2,3,6,7,8). A much smaller literature has examined the scope for what we term "social efficiency", that is, the effectiveness with which a given output is used to satisfy human needs. The terms for it vary. Starr (1), for example, calls it "sociological conservation", while in its recent appearances in the transport literature it is usually termed "travel demand management" (9). Most researchers favour technical solutions, not only because of their mainly technical background, but also because of the undoubtedly large gains in technical efficiency that are theoretically possible. Policy makers prefer these technical "fixes" also. They see them as having fewer political costs because lifestyle changes are not required, as they are for social efficiency gains. However, technical efficiency gains are often difficult to achieve in practice, and even when improvements are recorded, do not always translate into overall reductions in energy use.

This paper recognises that if the above problems are serious, significant reductions in energy use will need to occur. How to achieve such reductions is the main focus of this paper. To this end, the paper first analyses the changing patterns of primary energy consumption over the years 1950-95. It next uses these findings to discuss the various approaches possible for cutting domestic energy use. The key finding is that not only is social energy efficiency important, but that it cannot be simply tacked onto a primary effort at technical efficiency improvement, since in important cases the two work at cross-purposes. Finally, using this insight, the paper discusses policies for energy reduction, concluding that non-monetary measures to promote social efficiency are the most effective approach.

TRENDS IN HOUSEHOLD ENERGY USE

Tables 1 and 2 show residential and travel energy use, both on a per capita basis, for Australia over the period 1950-1995. Because it is more relevant for greenhouse gas emissions--and to a lesser extent air pollution--primary energy has been used as the basis for calculations. Electricity has been converted to primary energy using estimated average power station efficiencies for each relevant year. For all other fuels we have assumed that primary energy is a nominal 10% higher than secondary energy. It is clear that in contrast to the very large increase in travel energy use, that for residential energy has been modest. Residential energy use per person fell 1950-70, and in 1995 was only about 30% higher than in 1950. Personal travel energy in 1995, however, was 370% higher than in 1950. There have also been changes in the type of fuel used. In 1950 wood dominated residential energy. The big changes since then have been the decline in the use of wood and the near-disappearance of coal and town gas, together with major increases in natural gas (not available until the late 1960s) and especially electricity. Oil products have declined overall, but since about 1980 there has been a shift from heating oil to LPG. For residential energy use overall, the main change over time has been the drop in home fuel supplied *intermittently* (wood, coal, heating oil), and a vast rise in *reticulated* energy (electricity and natural gas).

Table 1. Residential primary energy consumption (PJ) in Australia 1950-1995.

Fuel type \ year	1950	1960	1970	1980	1990	1995
Wood, coal & solar	146.3	143.0	101.8	77.6	84.8	92.7
Natural & town gas	13.2	15.4	22.7	56.5	99.0	110.2
Oil products (inc.LPG)	26.4	27.5	38.5	39.4	18.3	18.2
Electricity	48.0	108.0	165.0	338.8	416.4	445.0
Fuels total	233.9	293.9	328.0	512.3	618.5	666.0
Population (m.)	8.17	10.42	12.51	14.70	17.10	18.05
Fuels total GJ/capita	28.6	28.2	26.2	34.9	36.2	36.9

Sources: References 10,11,12.

The fall in rail energy shown in Table 2 from 1950-70 was partly caused by the closure of urban tram and trolley bus systems and the decline in heavy rail passenger services. More important, however, was the replacement of steam locomotives by the much more efficient diesel ones for non-electric passenger services. Road travel energy grew rapidly after 1950, with growth slowing in the 1990s. Nearly all this energy was for private travel as buses used only about 2% of this energy in the 1990s. Growth in domestic air travel energy has been strong over the entire period (the drop in 1990 was the result of the pilots' strike).

Table 2. Transport primary energy consumption (PJ) in Australia 1950-1995.

Mode \ year	1950	1960	1970	1980	1990	1995
Rail (inc. tram & trolley)	25.2	12.3	9.6	10.1	9.6	10.0
Road (inc. bus)	61.6	165.0	302.5	494.5	664.8	701.4
Air (inc. private planes)	4.7	9.1	22.7	28.3	25.9	36.1
All modes	91.5	186.4	334.8	532.9	700.3	747.5
All modes GJ/capita	11.2	17.9	26.8	36.3	41.0	41.4
Pass.-km/capita	4230	5690	9200	12010	13410	13750
MJ/pass.-km	2.65	3.15	2.91	3.02	3.06	3.01

Sources: References 11,12,13,14,15.

Why did travel energy use grow so much more rapidly than residential energy use? For residential energy two opposing factors were at work. The shift to more efficient fuels tended to reduce energy use, but these same fuels--reticulated gas and electricity--were very convenient to use, which encouraged greater use. For electricity, the rising number of different appliances available since 1950, including TVs, VCRs, personal computers, freezers, and automatic dishwashers, also helped increase consumption. For transport the shift to more efficient fuels (coal-to-diesel and more efficient electricity generation for rail, petrol-to-diesel for buses),

had only a minor impact on total fuel use. The main cause of the more than three-fold rise in GJ/capita was growth in travel itself, since except for the period 1950-60, Table 2 shows that MJ/ pass.-km has been fairly constant, as have been seat occupancy rates. The dominant trend since 1950 has been the shift from slower and less convenient public transport to the faster car and air travel. Such greater travel *convenience* directly promoted much greater use of vehicular travel (16).

APPROACHES FOR REDUCING HOUSEHOLD ENERGY CONSUMPTION

There are three ways in which energy consumption can be reduced. First, change the method used to solve a given task, or alter the fuel mix used. Second, improve the technical efficiency of whatever equipment is currently preferred, regardless of whether it is the most energy efficient method of solving a given problem. This is, of course, the favoured approach. Thus we have fuel economy standards (and exhaust emission standards) for cars, and energy ratings for domestic appliances. Third, improve social efficiency. The first two approaches are briefly examined in the next two paragraphs, followed by a more detailed look at social efficiency.

Although the small drop in per capita residential energy consumption from 1950 to 1970 was mainly caused by the shift away from wood for domestic heating purposes, further scope for wood replacement by more efficient natural gas is not large. In transport, as already noted, the shift from steam to diesel locomotives for non-electric passenger trains led to gains in efficiency, as to a lesser extent, did the introduction of diesel buses. But any further fuel changes, for example from petrol to natural gas for cars, will bring only marginal energy savings. The main potential for transport lies in a shift back to more energy efficient public transport, which in 1995 only accounted for about 6.5% of total travel.

Many researchers have identified the potential for large gains in technical energy efficiency, and seen this as a means of cutting both residential and transport energy use (1,2,3,4,5,6,7,8). Technical energy efficiency might be measured, for example, as MJ of fuel per seat-km for vehicles, or kWh per hour of operation for TV. Indeed, to date the main emphasis has been on increasing the technical efficiency of existing equipment, from cars to refrigerators. Compact fluorescent light bulbs, for example, are about four times more efficient (in lumen/watt) as the more common incandescent bulbs (2).

If technical efficiency is defined as obtaining more output from a given input, social efficiency is concerned with getting more social "value" from each unit of that output. For transport, social efficiency has two components: the seat occupancy ratio i.e. passenger-km/seat-km, and the "access" to out-of-home activities obtained from each passenger-km. Improving seat occupancy will be much more difficult for private travel than it is for public transport (or air travel). If patronage is expanding, public transport operators can to a large extent *choose* the occupancy rates they want, by how fast they expand service provision. Further, for trains they can also adjust the number of carriages to match likely patronage--Melbourne's rail system, for example, uses a mix of three- and six-car "consists". Within limits, bus sizes can also be varied. Matters are very different for cars. Many attempts have been made to improve occupancy ratios, especially during peak hours, mainly in the hope of reducing congestion. The results have been disappointing (9,17). In Melbourne, for example, the occupancy ratio for commuting has fallen steadily, from 1.37 in 1951 to 1.11 in 1994 (18,19). Rising car ownership and the long-term decline in household size makes it difficult to maintain, let alone increase, the occupancy ratios for any given trip type. The reasons for the failure of car-pooling are easy to understand. Different people have different standards of punctuality and proper degree of driving caution, let alone different tastes in music and conversation.

Some see today's higher levels of personal travel as no more than a sign of improved living standards. But travel is mainly a *derived* demand, not an end in itself. We endure the time and money costs of vehicular travel in order to take part in out-of-home activities. Given these costs, reductions in vehicular travel are desirable. Table 2 shows that personal travel levels have risen more than three-fold since 1950. Yet in 1950, Australians went to work, schools, shops, sporting and entertainment events, and visited friends--just as we do today. Nor can the travel increases be put down to today's larger cities, since personal travel levels are higher in smaller cities and rural areas. Without suggesting that we return to the low travel levels of the 1950s, there is clearly scope for reduction without compromising our quality of life.

Social efficiency considerations are also important for residential energy conservation. All private travel energy expenditure requires a traveller's presence, but such is not the case for domestic energy use. This point concerns not only such obvious cases as refrigerators or automatic washing machines, but also equipment such as TV sets

and radios, where there can be no social benefit if no one is attending. It is not always easy to define social efficiency for appliances, but for TV, for example, a suitable measure would be total viewer-hours per hour of TV operation. Even without quantitative indices it is clear that behavioural changes can greatly reduce the energy used for washing, room heating and cooling, refrigeration and lighting.

Overall reductions in energy use appear, at first glance, to be best served by employing all three approaches together. However, in certain cases, improving technical energy efficiency may work at cross-purposes to social energy efficiency. Conflicts can also exist, for example, between different methods of improving social efficiency. The potential for these conflicts means that policies for energy reduction will need to be very carefully thought through. A classic example of such "unintended consequences" from another field is the introduction of Humphrey Davy's safety lamp in 1815. Mining deaths in the northern U.K. actually *increased* following its introduction, since, it is conjectured, mining was now more often carried out under conditions where methane was present (20).

Many examples of such conflicts can be found in private energy consumption. With electric lighting, for example, Starr (1) has documented the progress in technical efficiency (in terms of lumen per watt) that occured when fluorescent lighting replaced incandescent bulbs. Further gains are promised with the introduction of compact fluorescent lights in homes (2), but it is quite possible that should such widespread replacement occur, households will relax whatever care is presently taken to turn off unneeded lights, and also increase the level of night-time security lighting. Indeed their high initial cost but low operating cost may well encourage such extra use. With travel, increasing the seat occupancy of aircraft improves cost recovery, which can lead to lower fares--and more air travel. Attempts to improve traffic flow and fuel economy by building additional arterial road capacity increases traffic speeds, which in turn, by increasing travel convenience, promote higher levels of travel and overall fuel consumption (16).

Clearly, a single-minded stress on technical efficiency, even if successful, may be of little help in cutting energy use overall. In fact Gellings (21), who works for the Electric Power Research Institute, has even argued that increasing energy efficiency can *boost* electricity sales. Although discussing industrial energy use, his point has general validity: efficiency improvement in a given area may reduce sales in the short run, but help them in the long run.

POLICIES FOR ENERGY REDUCTION

The various measures which can be implemented to curb private energy use can be grouped under two headings: market-based policies and non-market policies. Market incentives can be used with each of the three approaches discussed in the previous section. Petrol price increases, for example, could be used to shift travel from cars to public transport, to improve car fuel efficiency, and to increase private vehicle occupancy ratios and/or combine trips. Although price increases for petrol, electricity and gas are obvious solutions, they are ineffective unless they are large. Petrol cost is a small part of the total costs of car ownership and operation--about 15-20 % for a car over the first five years of its life (22). Similarly, gas and electricity costs are a minor share of total household expenditure (23). This means that the price increases needed for effectiveness would be inequitable--lower-income households would bear the brunt of energy reduction.

One policy which largely avoids this equity problem is to change the structure of motoring costs, and of gas and electricity bills. In Victoria, at present, gas bills carry $74 annual fixed costs, and electricity bills $136, which could be added to direct fuel costs. Similarly, the structure of motoring costs could be altered, with registration, driver's licence and insurance costs all added onto petrol prices. Overall, the total cost of energy or motoring costs would, for the average consumer, remain unchanged. Oil companies, however, may not wish to act as tax collectors, especially as petrol sales would fall as price rose.

A variety of non-market policies are also available for cutting domestic energy use. Those with the greatest potential, we think, are policies aimed at increasing the social efficiency of energy use. For private travel, possibilities include significant lowering of speed limits, more priority for street public transport and non-motorised modes, introducing other "traffic calming" measures, restricting parking, especially in the CBD, and ending further arterial road-building (8). The advantage of all these policies is that they can be introduced rapidly and cheaply, and are equitable. Parking restrictions and lower travel speeds would apply to all motorists, regardless of income. Furthermore these measures, although primarily aimed at social efficiency improvements, would also help shift people onto more energy-efficient public transport. It would even improve technical

efficiency, since lowering the speed limit would reduce air resistance, while the fall in traffic levels with social efficiency gains would help reduce fuel consumption caused by congestion.

Implementing these policies would not be easy, especially in the short term. The motoring public would probably regard restrictions on speed, parking and street access as infringements on their basic freedom. But increasingly after the year 2000, Australia will have less choice in reducing transport energy consumption. Depletion of our indigenous reserves means that after the year 2000 the oil import gap will grow rapidly, unless oil demand is curtailed (24). As global (and Australian) greenhouse gas emissions continue to grow, international pressures will build for their reduction --and Australia has high per capita emissions. Urban air pollution may become a serious problem as well, particularly in Sydney.

Environmental and resource problems are thus likely to get progressively worse by the end of the decade. The best solution is to reduce energy use, but the key component of this approach, improved technical efficiency, has failed to deliver overall energy reductions, and has been shown in a number of cases to increase energy use. It is the progressive realisation that the problems, far from going away, are intensifying, while present remedies are not working, that will eventually convince both governments and citizens that we will need to impose more effective policies on ourselves.

CONCLUSIONS

Energy conservation is a means of simultaneously tackling the problems of air pollution, greenhouse gas emissions, and Australian oil depletion. This paper has focused on energy savings in the residential and passenger transport sectors, where social, as distinct from technical factors, are also important.

Technical efficiency has been the main focus for energy conservation efforts, in both the residential and passenger travel sectors. It is undoubtedly true that very significant efficiency gains are possible. But such improvements do not always save energy, because technical efficiency can conflict with social efficiency. Much more emphasis should be placed on social efficiency for household energy conservation. In transport, for example, this means both an increase in seat occupancy and also getting more “access” from each passenger-km of travel. Policies based on social efficiency improvement can also encourage both technical efficiency and a shift to more efficient modes.

Although price rises for fuel, if sufficiently high, will eventually lead to any desired level of reduction, such an approach would be inequitable, with the burden falling mainly on lower income households. We advocate instead, a change in the structure of gas and electricity pricing and motoring costs, together with a range of non-monetary policies to encourage social efficiency. Such policies may today seem unthinkable, but the progressive realisation that the existing emphasis on improving technical efficiency is of little help in tackling the worsening problems facing energy use, will lead to grudging acceptance of the alternative policies proposed here.

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