Copenhagen 3

The behavioural wedge

reducing greenhouse gas by individuals and households

When nations fail to agree, can individual citizens make a difference? The third of our post-Copenhagen features is by **Jonathan Gilligan**, **Thomas Dietz**, **Gerald T. Gardner**, **Paul C. Stern**, and **Michael P. Vandenbergh**. They look at the effects that voluntary actions by individuals can have, and at the policies that can best encourage such actions.

The Copenhagen summit on climate change failed to produce binding commitments from the assembled nations to reduce global emissions of greenhouse gases. The nations of the world have repeatedly agreed to a goal of limiting global warming to 2°C, but there is a widening gap between this goal, or even the more modest one of limiting greenhouse gases to twice their pre-industrial concentrations, and the actions nations are willing to undertake to achieve it. Voluntary energy conservation by individuals and households could produce significant rapid reductions at low cost and without intrusive and politically controversial government regulation. While these measures could not come close to solving the entire problem of climate change, they offer rapid emissions cuts that could buy time to implement more difficult measures.

Human activity emits 8000 million tonnes of carbon (MTC) per year as carbon dioxide; without measures to restrain them, these emissions are likely to double by 2050. To limit greenhouse gases to twice their pre-industrial concentrations while allowing developing nations a reasonable measure of economic growth, the fully industrialised nations would need to cut their emissions by 35% or more below today's levels by 2020 and by more than 70% by 2050[1]. These cuts can seem impossibly large, especially if we want to make them without stifling economic growth. However, as Stephen Pacala and Robert Socolow have pointed out[2], we can reduce emissions by this much over the next 50 years if we divide these large reductions into a number of smaller "wedges", each representing reductions achievable using a currently available technology such as solar or wind energy. Each wedge would gradually expand so that after 50 years it would save 1000 MTC per year. Implementing eight or nine of these wedges could reduce emissions enough to buy time in which to develop and deploy the revolutionary technology we will need to fully decarbonise the global energy supply.

Most discussions of policies to reduce greenhouse gas emissions focus on large industrial polluters and

Actions by individuals could significantly reduce emissions without intrusive and controversial regulation

comparatively little attention has been paid to the individual and household, even though several analyses have demonstrated that in the United States the energy used directly by households and personal driving (not counting indirect emissions, such as those from producing household goods and transporting them to the store where the consumer buys them) is responsible for around 38% of national carbon dioxide emissions (almost 630 MTC per year) and constitutes the largest sector of emissions – more than the manufacturing, commercial (office and retail), or commercial transportation sectors and more than the total emissions of any nation other than China[3].

Although individual and household actions have great potential to reduce greenhouse gas emissions and there is a large body of research on individual behaviour and decision making around energy use, policy analyses have failed to draw upon this work to identify the most effective measures (programmes by government, utility companies, and/or communities, which might include financial incentives, information campaigns, and other measures) to induce people to take a broad range of such actions or to estimate the emissions reductions we might reasonably expect from such measures[4]. We have estimated the emissions reductions that could be achieved through a wide range of voluntary actions by individuals and households in the United States if there were effective programmes to encourage those actions[5]. Because we were interested in actions that many people would adopt voluntarily, we chose actions that can be performed using readily available technology and which do not require significant change of lifestyle. Most of these actions either save money or have low net cost when we balance the cost of taking the action against savings from reduced energy use. We considered 29 specific actions, which we grouped into 17 types:

1. Choosing a fuel-efficient model when buying a new vehicle – this action refers to buying a high-efficiency model within the same weight class, so someone planning to buy a large sedan would buy a fuel efficient model of a large sedan, not a subcompact hybrid car.]
2. Weatherising the home: insulating, sealing, and installing high-efficiency windows.
3. Replacing household appliances, such as refrigerators, clothes washers, and televisions, with high-efficiency models.
4. Replacing older heating or cooling equipment with high-efficiency models.
5. Adopting efficient driving practices, such as slower highway speeds and reducing acceleration and braking.
6. Installing low rolling-resistance tyres on personal vehicles.
7. Reducing driving by carpooling and combining shopping errands.
8. Replacing older water heaters with high-efficiency models.
9. Setting back thermostats and using programmable thermostats to reduce heating and cooling when no one is at home.
10. Performing appropriate routine maintenance on personal vehicles.
11. Regularly changing air filters in home heating and cooling systems.
12. Reducing consumption of electricity by standby mode of appliances not in use.
13. Line drying laundry five months a year.
14. Regularly maintaining home air-conditioning systems.
15. Installing low-flow showerheads to reduce hot-water consumption.
16. Reducing the temperature setting of hot water heaters.
17. Washing laundry at lower temperatures.

Although compact fluorescent lights are probably the most publicised measure for voluntary emissions reduction, we omitted them because existing laws will phase out incandescent bulbs too fast for an additional voluntary programme to have much impact.

We estimated how many people might be expected to adopt these actions in response to well-designed programmes and concluded that US households could be induced to reduce their greenhouse gas emissions by roughly 20% within ten years. This would reduce US emissions by over 120 MTC per year, which is more than the total national emissions of France.

We assessed the emissions reductions from individual and household actions in six steps. First, for each action we assessed the reduction if a single household takes that action. Second, we estimated *current penetration*: the number of households already taking each action. Third, we calculated the *potential emissions reduction* (PER) if everyone not already doing so took each action. Fourth, we estimated the *plasticity* of each action: the fraction of people not currently performing each action who would take that action in response to an optimal programme to encourage energy saving. Fifth, we used the plasticity and the PER to calculate a *reasonably achievable emissions reduction* (RAER): the actual emissions reduction a well-designed programme could achieve. For any single action, RAER = PER × plasticity. However, when multiple actions are considered, it is necessary to correct for *double-counting effects*, which occur when the emissions reduction from taking two actions together is less than the sum of the two actions taken separately. These corrections are the sixth step of our analysis and are described in detail below.

Figure 1 shows our estimates of the PER and RAER for the 17 types of action. The RAER estimates of should help policymakers distinguish those actions, such as weatherisation or purchasing fuel-efficient vehicles, that have the greatest potential to

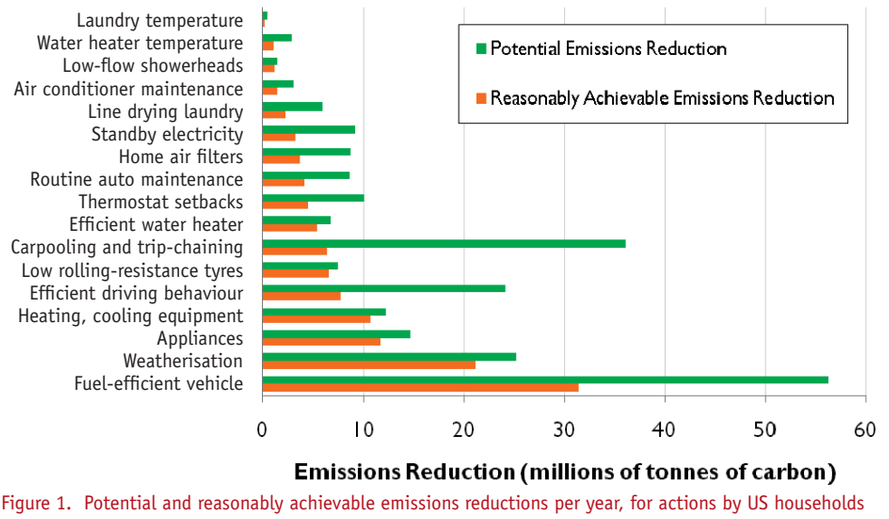

Figure 1. Potential and reasonably achievable emissions reductions per year, for actions by US households

produce large emissions reductions with feasible policies from those, such as carpooling and trip-chaining, which might produce significant reductions in principle (large PER), but which are hard to bring about in practice (small plasticity).

Most policy-oriented analyses of household energy efficiency either only calculate the PER or estimate achievable reductions on the basis of simple economic assumptions about behaviour. Our analysis of plasticity reflects a much broader set of behavioural influences, non-financial as well as financial, and is based on empirical studies of actual behaviour. We believe this approach provides a much better estimate of what a well-designed policy might achieve.

Past studies of energy-efficiency programmes by governments or utility companies have documented behavioural plasticity most thoroughly for actions related to weatherising houses and installing high-efficiency heating and cooling equipment. For weatherisation we estimated 90% plasticity, meaning that that a well-designed programme would lead to 90% of poorly weatherised homes being weatherised within 10 years. For installing high-efficiency heating and cooling equipment we estimated 80% plasticity. For other actions, particularly those that require regular attention rather than a one-time repair or upgrade of equipment, there is much less information; several studies have estimated plasticity of in-home energy consumption, and we can draw analogies from studies of interventions to promote health maintenance behaviours. However, further work is needed to better characterise plasticity and to distinguish short-term from long-term behavioural changes.

One lesson we learn is the importance of using multiple types of intervention. Many current proposals for emissions reduction focus on a single intervention. One of the most familiar is a tax on emissions, which would provide an economic incentive for all actors – from large industrial emitters to individuals – to reduce emissions by conserving energy or switching to energy from less carbon-intensive sources. However, field experiments and studies of past programmes to encourage energy efficiency have found that although financial incentives can be important, particularly where the action requires a large purchase, financial incentives alone are often inadequate or inefficient for producing the desired behavioural changes and that policies that combine several different measures can have much more impact for the same budget[6].

Ingredients of a successful policy include providing reliable, credible, and easily accessible and understood information so that the public can make informed choices; removing obstacles that make it inconvenient to take an action that a person would otherwise want to take; and engaging social networks and communities. Information and marketing are necessary because financial incentives will go nowhere if the public does not know about them. Information in the right form can significantly reduce the financial incentive required to achieve an emissions reduction: several studies have demonstrated that simply providing frequent feedback about energy use can induce households to reduce their energy consumption by around 10%[7]. Convenience matters: when compact fluorescent light bulbs are sold only at specialist stores or by mail, as opposed to stores where people habitually buy incandescent bulbs, it is much harder to persuade people to buy them[8].

Engaging people's social networks and communities, so that they receive messages not only from government or media but also from their friends and neighbours, appears to hold great promise, but the results seem to vary from one action to another and more research is needed to identify how best to engage these networks.

In addition to research on behavioural plasticity, we identified large gaps in the data on current behaviours. In estimating current penetrations, we were able to draw for some on national surveys of energy consumption, such as the US Department of Energy's Residential Energy Consumption Survey. However, the data reported in these surveys was sometimes ambiguous because the questions asked did not exactly address our concerns. To estimate current penetration of sealing air leaks in the home, we had to rely on a question asking whether the occupant experienced unpleasant cold drafts during the winter – even though a home can lose a lot of heat to leaks that do not produce unpleasant drafts. For other important behaviours we could find no published data and had to rely on indirect estimates: to estimate the fraction of households that regularly change the air filters in their central heating or cooling systems, we interviewed representatives from major air filter manufacturers to estimate the number of air filters sold per year and compared this to the number of households using central heating or air. Where there were ambiguities in the data, we chose estimates toward the conservative (small reduction) side, so we could be confident that our estimate of RAER would be a reliable lower bound. The data were too sparse to use formal statistical methods, so we relied on a combination of our subjective judgement and sensitivity tests in choosing estimates of current penetrations.

Even for more basic technical questions about the efficiency improvements from tak-

US households could reduce their emissions by 20%, more than the total emissions of France

Line-drying laundry can make significant savings in emissions. © iStockphoto.com/Maurice van der Velden

ing actions, we were surprised to find that for some actions there were few if any good measurements of their effects: while the importance of regularly changing air filters for maintaining the efficiency of home heating and cooling systems is emphasised in numerous advisories to homeowners, we were only able to locate a single study, in an obscure engineering journal, that actually measured the savings from doing so.

More comprehensive surveys of energy-saving behaviours, using more uniform methods, would improve our ability to identify behaviours with a combination of low penetration and high efficiency gains that would yield large PER.

Another complication arises from the interactions among different actions – the double-counting problem mentioned earlier. Although there are many ways different actions can interact with each other, we made a simplifying assumption that actions either combined additively or multiplicatively: if two actions would reduce emissions by factors of x and y if performed separately, then performing them together would produce a total reduction of $x + y$ if they combine additively and $1 - (1 - x)(1 - y)$ if they combine multiplicatively.

To a first approximation, adding insulation to the attic of a house does not affect the heat loss through inefficient windows, and installing efficient windows does not affect heat loss through the roof, so adding insulation and installing high-efficiency windows would combine additively (the total reduction is the sum of the parts). These actions pose no double-counting problem.

It is different when changes in equipment are combined with changes in its use. For example, the emissions from driving are roughly proportional to the distance driven multiplied by the average carbon intensity of the vehicle in emissions per unit of distance, so improving the fuel efficiency and driving less combine multiplicatively: we estimated that on average, carpooling would reduce the annual distance driven by 14%, replacing a vehicle with a top fuel efficiency model in the same weight class would improve fuel efficiency by 32%, and taking both actions would reduce emissions by 42% rather than 46%.

In calculating emissions reductions from all 17 of the behaviours we considered, we performed detailed calculations of the additive and multiplicative interactions. Some interactions fall somewhere between pure addition or pure multiplication, so it might be useful to consider a wider range of interactions, but we lack the detailed data to assess such cases. Overall, our double-counting corrections reduced the PER by 25% and the 10-year RAER by 17%.

A more subtle problem is that taking certain actions may affect a household's propensity to take others. There could be positive correlations, if once people start performing emissions-reducing actions they find it more attractive or easier to perform others. Psychologists call this the foot-in-the-door effect. There could also be negative correlations, called takeback: if installing a more energy-efficient furnace reduces energy costs, people may set the thermostat to a higher temperature and/or use the saved money to purchase goods and services that raise emissions. Understanding the interactions between the plasticities of different actions would improve our estimates of RAER. Both positive and negative correlations have been demonstrated in some situations, but the available research is not sufficient to estimate these effects for our list of actions so our calculations assumed correlations of zero. More accurate estimates would require more research on the correlations between different actions.

The available data limit how precise or certain we can be about the impact of policies to encourage voluntary emissions reductions, but even so there is sufficient empirical data on energy efficiency, current penetrations, and behavioural plasticity to clearly demonstrate that such policies, if they followed identified best practices, could reduce individual and household emissions by roughly 20%, around 120 MTC per year. Despite the uncertainties discussed above, our efforts to choose numbers towards the conservative side of the ranges reported in the research literature and to use sensitivity analyses to identify particularly sensitive parameters give us confidence in these results as a conservative first estimate.

Targeting individual behaviour can provide rapid reduction in emissions at low cost and without extensive new regulatory apparatus. Individual behaviour change cannot solve the entire problem of greenhouse gas emissions, but it has the potential to reduce emissions very quickly, and thus play an important role in buying time for slower, more expensive and technologically intensive measures. We have estimated the reasonably achievable potential of such programmes and established that non-financial aspects of household behaviour and decision-making are very important to the success of those programmes, but more research to quantify and characterise those behaviours and decisions would be invaluable for optimising those programmes. In addition, of course, governments and others need to employ the insights from available behavioural research – which they have rarely done in the past – if the reasonably achievable emissions reductions are actually to be achieved.

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