information. As mentioned, participants were randomly assigned to the non-prompt or prompt condition. A prerequisite for participation was that the individual had lived in the area during the previous winter. The temperature on the day of the study registered a relatively high 80 °F, compared with a normal high of 70 °F. The previous winter was the coldest in the last 30 years and led to a number of school closings, atypical for the area. The use of a single sample/location on a particular day has the advantage of ensuring control over actual temperatures, thereby offering a test for the conditions of the local warming effect. Future work, however, should explore the impact of different prompts with distinct samples and locations where the daily temperature is not clearly high.

I present the results in Table 1, with a column for each condition. The first row reveals that, not surprisingly given the warmth of the day, the average for both groups on the 'today's temperature' (TT) question was near 4 on the scale. No participants rated it as 1 and only six rated it as 2. The next two rows reveal differences in the percentage of warm days (PDW) last year, and more importantly, the correlation between PDW and TT. Today's temperature substantially correlates with past year's estimates for the non-prompt group (0.38) at a level similar to that reported by Zaval *et al.*[6]. This relationship does not exist in the prompt group. The next two rows reveal strong relationships between global warming belief and concern with PDW, with similar correlations for both groups.

As explained, PDW is higher in the non-prompt group — because it is driven by the high TT on that day — and the consequence is higher belief and concern scores. In other words, PDW drives beliefs and concerns, regardless of the prompt, but the prompt severs the connection that lead TT to drive up PDW. The downstream effect of the prompt is to vitiate global warming beliefs and concern. The final four rows show that TT correlates with beliefs and concern in the non-prompt condition but not in the prompt condition; and then, in multiple regressions, PDW affects beliefs and concerns rather than TT (even for the non-prompt condition). The findings show that (1) without a prompt, temperature on the day of survey shapes the perceived number of warm days last year, which in turn affects global warming beliefs and concerns; and (2) with a prompt, this temperature has no effect on the perceived number of warm days last year. Perceived number of warm days shapes global warming beliefs and concerns, but beliefs and concerns are not influenced by today's temperature.

That PDW continues to have an influence across conditions is intriguing, and may suggest relatively salubrious processes involved in opinion formation given that perceptions of local weather trends tend to be accurate[15]. The results indicate that science communicators who are troubled by the fleeting nature of the local warming effect[2] can counteract it with rhetoric that emphasizes temperature deviations over time. Similarly, when writing survey questions, researchers might consider alternative phrasing that minimizes the inadvertent usage of attribution substitution processes[13]. In both cases, it is unknown whether variables — such as partisan identity and cultural worldview — become increasingly impactful as the local warming effect dissipates[16]. ❐


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COMMENTARY:

# US climate policy needs behavioural science


Amanda R. Carrico, Michael P. Vandenbergh, Paul C. Stern and Thomas Dietz


**State implementation of new Environmental Protection Agency climate regulation may shift behavioural strategies from sidelines to forefront of US climate policy.**

In a rare move, the US Environmental Protection Agency (EPA), in a new draft rule known as 'The Clean Power Plan', has signalled that it will allow states and utilities to meet emissions standards by reducing electricity demand. The details of this regulation will have a substantial impact on its effectiveness[1], creating a tremendous opportunity to put integrated, multidisciplinary science to the practical end of mitigating climate change. Huge untapped potential exists for using knowledge about how the public responds to new technology, financial incentives and regulations[2]. Financial incentives for home weatherproofing, for example, have varied tenfold in their impact on rates of adoption, depending on a range of features of programme implementation beyond the financial incentives offered[3]. Incorporating insights generated from such integrated science could reduce compliance costs and achieve emissions reductions with minimal intrusion. But achieving these objectives will challenge the thinking of regulators who have more experience with mandating best available technologies than with programmes that target decision-making and voluntary behaviour. It will also challenge behavioural scientists to engage seriously with the practical issues of energy policy development and implementation. Finally, it will require a coordinated research agenda and greater collaboration between industry and academia.

## Opportunity

Programmes and policies that draw on social and behavioural science to support reductions in energy demand have gained widespread attention in the United States and around the world for their potential to contribute to climate change mitigation[2,4,5]. A recent estimate suggests that energy efficiency improvements in the United States could reduce end-use demand by 23% by 2020, avoiding 1.1 gigatonnes of greenhouse-gas emissions per year[6]. Others have estimated that, given historical responses to evidence-based programmes and policies, a 7% reduction in US emissions is possible if targeted efforts to reach the household sector are expanded[2].

Behavioural programmes — those that promote both behaviour change in how energy is used and the adoption of products that reduce carbon footprints — have been successfully used by national and subnational governments[7,8], non-governmental organizations[9] and energy providers[10]. But they are often viewed as minor adjuncts to more traditional regulatory actions, not as a core part of the response to energy and climate challenges[11]. The implementation of the EPA's proposed Section 111(d) 'Clean Power Plan' rule could change this. By enabling states to meet federal emissions targets with programmes for electricity demand reduction, including those integrating behavioural knowledge, the regulation has the potential to lower compliance costs by stimulating the design of innovative programmes, improved assessment methods for behavioural interventions, and new investments in basic and applied behavioural research.

## Incentives and compliance

The EPA's draft 111(d) rule[12] seeks to reduce 2030 power-sector carbon dioxide ($CO_2$) emissions by 30% from a 2005 baseline. The rule, which is scheduled to be finalized in mid-2015, will create incentives for states to submit compliance plans that include switching from coal-fired electric generating units to natural gas. But the draft rule also enables states to meet their targets through beyond-the-plant demand-reduction programmes, including actions involving consumers. The draft rule proposes an overall state goal of 1.5% annual electricity savings from demand-side energy efficiency efforts between 2020 and 2029. Given the results of well-designed behavioural programmes, this goal is very modest; more could be achieved. States will be required to submit the first phase of their compliance plans a year after the rule is finalized and will have a first compliance deadline of 2020, so substantial time remains to ensure that states exploit the full potential of demand-side reduction initiatives.

The proposed carbon rule recommends the inclusion of both technological and behavioural programmes, including programmes that "accelerate the deployment of both energy-efficient technologies and behaviours by addressing market and cultural barriers"[12]. The social and behavioural sciences have documented a range of strategies and programme design features that can achieve these goals[8,10], such as providing enhanced energy-related information to the user, social communication, real-time energy feedback, and targeted information that simplifies the task of weighing complicated and sometimes expensive alternatives when making choices about household technologies. State decisions about what demand-reduction programmes to include in compliance plans will be critical to realize the potential of behavioural strategies.

## Evaluation, measurement, verification

Although legal challenges will affect the role of demand reduction, much will also depend on the EPA's decisions about acceptable evaluation, measurement and verification (EM&V) plans. States will be required to develop EM&V plans that explain how -demand reduction will be measured[12]. The draft rule states that these plans must be "rigorous, complete, and consistent" with forthcoming EPA requirements and guidance. These requirements may determine the fate of some behavioural programmes.

The EPA has expressed concern that behavioural programmes may pose quantification and verification challenges, specifically citing information-based and targeted behavioural programmes as potentially problematic[12]. For a variety of reasons, the effects of behavioural approaches require evaluation methods different from what has historically been used to capture the effects of policies and programmes[13,14]. Accurate estimates can, however, be achieved with rigorous approaches common within the behavioural sciences, such as randomized controlled trials[13,14] and 'state of the science' analysis of data over time[15]. These evaluation methods are relatively new to utilities, and partnerships between researchers and industry may help to ensure success as EM&V standards are set and adopted[13].

These approaches also have the potential to improve the accuracy of evaluations of more traditional programmes that incentivize specific technological improvements, for example consumer rebate programmes to promote heating, ventilating and air-conditioning retrofits. Traditional estimates of annual energy savings are often based on the estimated demand reduction achieved by an equipment upgrade multiplied by the number of customers who upgrade. But actual demand reduction can differ substantially from these estimates because of usage changes (that is, rebound effects, spillover effects)[16].

In addition, some programmes may feed consumers into other programmes and that may amplify the effectiveness of the other programmes, leading to the possibility of either double counting or extra benefits from spillover. Improved EM&V techniques can more accurately estimate these results and also provide insights into how to design programmes that complement one another to maximize results. As behavioural programmes become more common and standardized approaches are developed, the challenges associated with EM&V will be substantially reduced. New research can accelerate the development and implementation of effective and easy-to-evaluate behavioural programmes. Improved communication between industry, government and the scientific community will be critical to ensuring that future research is designed in a way that will generate results but is also sensitive to the regulatory environment within which states and utilities operate.

To address EM&V concerns, the EPA is considering including a pre-defined list of well-understood programmes in the final rule, and requiring greater documentation and explanation when state plans include programmes with less well-understood features[12]. If a pre-defined list is adopted, the breadth of the list will be important, as will opportunities to modify the list as research in this area advances. The EPA is also considering limiting eligible demand reduction to this pre-set list[12]. This is unfortunate, as a zealous effort to eliminate phantom reductions from the list can also limit states' opportunities to innovate. It is critical for decision-makers to be aware of cost-effective, scalable and verifiable behaviour-based programmes when these decisions are made. Behavioural scientists can assist in filling knowledge gaps by synthesizing results from rigorous evaluations of behavioural programmes that are candidates for inclusion in compliance plans. Research by industry and academia is rarely integrated into more robust meta-analyses, but substantial insights could be gained if it were.

### Research agenda

If the final rule is friendly towards the inclusion of programmes engaging behavioural science, and if states respond by including robust demand-reduction efforts in compliance plans, much research will be needed to expand the current knowledge base. States should be encouraged to follow the lead of the Northeast Energy Efficiency Partnership, which has provided a forum for public utility commissioners and air-quality regulators to act collectively to share research results and reduce the costs of EM&V and other 111(d) compliance issues.

Behavioural scientists should include as research targets metrics of success that are relevant to EM&V requirements, once such metrics are defined. Collaborations with industry, a coordinated research agenda within the scientific community, and the establishment of 'best practices' guidelines for researchers can ensure a more streamlined transition from research into practice.

Much of the success of the rule will be determined by the decisions of federal and state regulators in the months and years to come. If the rule is too restrictive in its requirements for states to demonstrate effects, it could discourage the use of cost-effective approaches, inhibit innovation and result in a rule that fails to capitalize on the immense opportunity to reduce greenhouse gas emissions through behaviour change[2]. The response of the EPA and the states on issues such as the scope of acceptable behavioural programmes, and the level and type of documentation required, may determine whether demand-reduction approaches achieve their full potential or whether concern about phantom demand reductions induces the EPA and the states to throw the baby out with the bath water. ❐

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COMMENTARY:

# Key threshold for electricity emissions

Christopher Kennedy

**To reduce greenhouse-gas emissions in the short term, and catalyse longer-term cuts, countries should reduce the carbon intensity of electricity generation to below a universal target of 600 $tCO_2e\,GWh^{-1}$ by 2020.**

When faced with critical global challenges affecting the wellbeing of human society, the nations of the world come together to pursue concrete, measurable, evidence-based goals. Examples include the Millennium Development Goals[1], economic measures for growth or stimulus, and targets for environmental protection. Many numerically expressed global goals have been achieved or partially achieved, while others unfortunately have failed[2]. Key requirements for successfully achieving global goals, expressed in United Nations documents, include the use of robust, relevant measures that are broadly consistent with other global agreements and based on international standards, with well-established data sources[3]. Furthermore, numerical targets should be: ambitious but achievable; quantifiable and time bound; and set in consultation with country teams[4]. Others have pointed to the importance of additional needs: