Memorandum

To: Participants and Invitees to EIA Behavioral Economics & Energy Efficiency Workshop Held on July 17, 2013

From: Jay Ratafia-Brown, Jonathan Nunes, and Navid Nowakhtar, SAIC

Subject: **EIA Behavioral Economics & Energy Efficiency Workshop – Meeting Follow-Up and Summary**

Date: September 12, 2013

The U.S. Department of Energy's Energy Information Administration (EIA) conducted a technical workshop on July 17, 2013 in Washington, D.C. to assess recent methodological developments in the field of *behavioral economics as applied to energy demand analysis and energy efficiency programs*. The meeting was jointly planned and facilitated by EIA and SAIC staff. This memo is being distributed with the authorization of Jim Turnure, Director, Office of Energy Consumption and Efficiency Analysis, Energy Information Administration.

This meeting supports the EIA goal of updating its analytic assumptions and methods associated with the modeling of changing energy markets for purposes of public information and policy analysis. The National Energy Modeling System (NEMS) is the primary technical system used by EIA for domestic, long term forecasting and analysis. Ultimate objectives include enhancing the quality of EIA products through improved consumer behavior and policy representation in NEMS and maintaining relevancy and consistency with developing best practices in energy economics. Enhanced capabilities will support the Residential Demand Module (RDM) and Commercial Demand Module (CDM), which are major components of NEMS that project energy consumption for marketed energy sources plus distributed solar and geothermal energy. Both the RDM and CDM include projections of energy consumption by end-use service through 2040.

The purpose of this memo is to summarize the general discussions and salient conclusions of the meeting. An Executive Summary of the most critical meeting discussion areas and outcomes is provided first, followed by the more detailed set of meeting notes in the Detailed Meeting Summary subsection. Attachment 1 contains a list of meeting attendees. Attachment 2 lists the meeting agenda. Several presentations were also presented as meeting background information. These are attached as separate files.

EXECUTIVE SUMMARY

The current economic landscape appears to suggest that consumer behavior is influenced by behavioral economics principles in a much bigger way than what may be suggested by the existing EIA energy demand framework. The EIA is interested in feedback on and experimentation with alternative aggregate demand specifications which are underpinned by the behavioral economics literature. The main intent of the Technical Workshop was to build a foundation from which to

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further explore such alternatives in an isolated, "sandbox" environment that is removed from the inner workings of NEMS.

While the feedback from meeting participants was varied and covered a wide range of perspectives, there was, in general, overarching agreement reached with respect to the following:

- Behavioral economics in the academic literature can help to modify and tweak the traditional neoclassical framework;
- There is no fully fleshed out alternative model in the behavioral economics literature that is cogent enough to supplant the existing EIA framework, which is a combination of rational agent model elements and certain behavioral elements;
- While there may be some behavioral variables omitted from the structure, there appear to be avenues within the model for updating or creating additional parameter values; if key variables can be extracted from the literature and appended, that is a good thing;
- If what is absent is nascent or slow moving in terms of its impact and things change gradually, then the underlying historical trends are also self-informed and self-updating, and the modeling structure implicitly captures these movements through the estimation/specification process. The burden of proof in terms of whether changes are more drastic is a function of working to further our understanding of how the existing literature can help inform the current modeling framework;
- There may be certain policies that are anticipated to have a significant short-to-medium term impact on demand for energy efficient products and that are worthy of further analysis and review; and
- Further examination of adjustments must carefully balance the cost of gathering additional data with the perceived impact on the modeling structure from a forecasting perspective, as resources at EIA are not unlimited.

Given the above elements of consensus, specific ideas for technical steps that could be taken both in the short-term and long term that were predicated upon adjustments to the existing framework were focused on (i) generating alternative interest rate premiums based on behavioral factors, (ii) informing the RDM bias parameters (operating and capital cost related modifiers) with recent studies in the behavioral economics realm, (iii) performing further review on behavioral elements of price response in order to adjust the fuel price elasticity parameters within RDM and CDM, (iv) embedding behavioral economics into the current framework by introducing additional constraints, and (v) prioritizing behavioral factors worthy of focus given resource constraints by performing review of existing studies. The EIA intends to pursue multiple avenues of further research, and will

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consider the above ideas in concert with a set of alternative demand specifications for experimentation.

In the immediate future, further feedback will be sought from meeting attendees through the distribution of these notes, and the EIA will work with SAIC to engage in the development of a technical report that, as its top research priority, further investigates *alternative aggregate demand specifications for "sandbox" experimentation*. The report will seek to identify behavioral economics concepts and modeling frameworks that are most suitable for incorporation as improvements in the NEMS Residential and Commercial energy demand modules and/or those that may require further research or empirical study. In parallel with that process, an emphasis will be placed on the prioritization of key behavioral elements of demand that are recurring themes within the literature.

DETAILED MEETING SUMMARY

Below are SAIC's combined meeting notes that have been organized in chronological format to capture the flow of the discussions. Since the meeting notes are intended to be reviewed in a "not-for-attribution" context, emphasis has been placed on the specific perspectives and insights provided without identifying the speaker. To the extent that the EIA team presented specific views or provided feedback to the group regarding a certain topic or question, we have noted that herein. We have excluded information relative to the EIA's presentation materials and collateral introducing the meeting topic and outlining related energy demand modeling challenges. Finally, these notes do not delve into technical issues unless they served as a catalyst to specific feedback or workshop discussion.

Additional feedback received subsequent to the meeting has also been summarized below in the "Follow-Up Feedback" section of this memo. Potential next steps are presented in the "Next Steps" section of the memo.

MEETING SUMMARY NOTES

- The Energy Information Administration (EIA) conducts occasional technical workshops that are focused on a relatively bounded technical topic with an aim at generating "not-for-attribution" feedback, as a friendly and open mechanism to get external input. While there is currently no predetermined path for how behavioral economics will or will not be incorporated into the existing EIA modeling framework, the expectation is that the process of investigating these issues will be a longer, broader analytical effort, and that this meeting is just a starting point to help drive the direction of future efforts. There is no "silver bullet answer" being sought from the workshop, but rather, the objective is to begin to formulate insights and generate momentum towards either a working group of interested parties and/or further direct investigation by EIA.

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- The current economic landscape appears to suggest that consumer behavior is influenced by behavioral economics principles in a much bigger way than what may be suggested by the existing energy demand framework, and there have been statements such as "the war is over, neoclassical economics is dead, etc.". If it is indeed the case that the neoclassical paradigm is being challenged, what could one replace it with? What is the new aggregate demand paradigm, and are there papers or studies on behavioral economics that define an alternative paradigm with sufficient rigor to be implemented as alternative aggregate demand equations? There is interest within EIA regarding the theoretical basis of the existing demand models, and feedback and insight is being sought to get external input on viable alternatives.
- Alternative modeling constructs will be experimented with in a "sandbox" environment (i.e., divorced from the actual inner workings of the NEMS model) in order to stress test and scrutinize the implications of any technical adjustments in a parallel path. Adjustments within NEMS will not be made without a careful, extended, and deliberate review and experimentation process. These demand specifications will likely be tested along with more detailed representations of demographics and regional variability.
- NEMS is very much a modular equilibrium model that reaches agreement iteratively; changes to a given model may have significant system-wide ramifications, and consequently, initial investigations must be made separately. For example, an adjustment to the diesel fuel usage assumption has dynamic impacts on the petroleum market module.
- The NEMS RDM and CDM contain weight parameters and behavior rules, respectively, which drive technological adoption of energy efficient or new end-uses. The RDM is based on a pair of weight parameters for two key factors (capital cost and operating cost). The CDM is based on the least cost, same fuel, and same technology type behavior rules. These rules are paired with *hurdle rates* to drive longer term projections. One potential outcome of the entire process is to have either the weight parameters or the hurdle rates be in some way informed by behavioral rules or factors that incorporate societal trends/issues beyond the traditional cost-benefit/payback approach. An example would be the level of environmental conscientiousness of the incremental adopter, and the extent to which such a behavioral issue can be quantified.
- Hurdle rates are used to differentiate consumers, and are informed by surveys of commercial managers and estimates of consumer preferences for future energy savings; the most notable survey that was mentioned was the Johnson Controls annual survey of energy indicators, which tracks customers' propensity to undertake "green" measures or adopt new efficiencies. Hurdle rates are adjusted/adapted to map to the survey results. The survey generally asks for payback periods, and the payback period data is used to create a premium over the simple

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interest rate. *This avenue may be an additional pathway to infuse alternative interest rate premiums based on more behavioral factors.*

- It was asked whether hurdle rates are segmented by end-use or by type of building. Currently, hurdle rates are segmented by end-use. In addition, hurdle rates can be adjusted based on known legislation. One example that was used to illustrate this point was a potential law that could be passed, say, in 2015 requiring all Federal Agencies to make purchases in the top 2% of energy efficiency (EE) state of the art, which would be taken into account as part of the forecast.
- The RDM bias parameters were previously based on shipment data by efficiency level and a goal seek exercise; more recently, data is harder to find, and reliance upon alternative sources has been necessary. *There may be potential to inform the bias parameters with recent studies in the behavioral economics realm.*
- Both the RDM and the CDM have a group of fuel price elasticity parameters that capture an allowance for the "rebound effect", which postulates that as the efficiency of a given end-use increases, so does service demand (albeit the impact is usually small). Higher hurdle rates are reduced if energy prices increase. In addition, there is a parameter in the model that pushes more efficient technologies based on price, but that parameter is not currently active in the EIA reference case. *Activating or performing further review on behavioral elements of price response is one possible avenue for further study.*
- With regard to combined heat and power (CHP) and distributed generation (DG) penetration, analysis is generally based on a discounted cash flow/internal rate of return or IRR analysis, with some accounting for interconnection policies, and specific known future factors, such as the expiration of renewable tax credits in 2016. While the EIA is open to looking further into demographic or social factors with regard to DG and CHP, and there are currently efforts to examine trends in key weather variables (such as heating and cooling degree days) as assumptions to use in the future period, the central focus of the workshop and downstream efforts is on major end uses, such as heating, cooling, and lighting. The EIA placed a re-emphasis on alternative aggregate demand representations, and on the fact that any new modeling would be safely done outside of NEMS in a step-wise fashion.
- The question of the current accuracy of the NEMS model was brought up. The EIA Annual Energy Outlook (AEO) retrospective looks at how the forecasts compare to outcomes. EIA noted that in general, quantities [of fuel] are more accurately projected than [fuel] prices (which the group agreed was not atypical). The EIA modeling framework "lags macro", in the sense that the reference case does not model business cycles or economic shocks, but

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rather a longer term equilibrium view. Variances from the model are typically anywhere from 3% to 5%, and normally under 10% for quantity variables.

- There was discussion around whether EE programs impact the NEMS model and how. While no specific EE programs are explicitly captured, and there is no policy lever in the model, such issues are captured to the extent they color the underlying technologies being modeled. *The comment was made that, as historical demand side management (DSM) has impacted appliance stock and consumption, the "momentum" of existing programs was implicitly captured.* EIA seeks feedback from technology experts on such changes.
- The discussion was refocused on the notion of a theoretically defensible alternative aggregate demand representation, and this issue was expanded on as follows:
    - Is there a continuing basis for the notion of utility maximization?
    - If not utility maximization, is there another unifying framework for how decisions are made at the micro level?
    - The existing modeling framework is pragmatically convenient, in the sense that the modeling structure works and is based on data that can be collected within a reasonably constrained amount of time/resource dedication. But is pragmatic convenience coupled with a theoretical framework that is potentially unsound ultimately problematic?
- It was suggested that the challenges with the current framework may best be handled within the macroeconomic level and then transferred to the micro level, i.e. the NEMS end use consumption modules. While EIA has such debates internally rather frequently, the general consensus is that coverage of the macroeconomic drivers is good and well-captured. When thinking about how to deal with variables that may be impacting the future in a new way, the issue is predominantly a "micro" one, as it pertains to either an individual or a firm's behavior, and whether such agents actually maximize utility, have transitive preferences, etc., and if they don't, to what extent such deviation is grounds for a completely new framework and/or modifications to the existing framework.
- There was discussion as to the priority that should be placed on forecasting the future as opposed to understanding strategies that will cause agents to change their behavior. It was noted that strategies to encourage or engage agents to adopt new technologies may be less important/relevant if they are not expected to occur in the future (i.e., if we don't expect certain strategies, then they become irrelevant from a forecasting/modeling perspective). *Embedding behavioral economics into the equation may be more a function of additional constraints within the existing framework, as opposed to trying to encourage agents with*

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particular strategies, which is an external policy issue rather than an issue affecting EIA's tangible forecasting needs.

- One meeting participant espoused the following high level view:
    - No customers have total information and seldom make rational economic decisions;
    - The vast minority make rational economic decisions;
    - As a result of a long tenure of EE program evaluation, it is fairly clear that various levels of information and financial stimulus can get people to invest in or procure particular end use measures such as technologies with "good certainty;"
    - What is less clear is how the information flow and content impacts behavior – information flow can be thought of as the various types of information exchange mechanisms (e.g., types of media, word of mouth, etc.), and
    - Commercial sector dynamics of information flow are hazier than residential sector dynamics, as residential profile data does exist (demographics, psychographics, etc.) on individuals that will adopt energy efficient products.
- Another participant countered that we do not have a good handle on behavioral change as it relates to EE/DSM programs, and that behavior is a function of three overarching issues:
    - Psychological issues such as predisposition to efficient appliances, location on the adoption curve (early adopter, laggard, etc.); innovators are typically not looking at the economics of the decision.
    - Market issues such as direct incentives, program information, education, etc.
    - Cultural issues such as day-to-day interaction with others, word of mouth, and other "extra" trends within a given cohort that are beyond the individual but not as pervasive as to be characterized as a macroeconomic issue; customers may value an attribute that can have a significant impact that no one has measured. There is a significant regional aspect to some cultural behaviors.
- Consumption behavior can change rapidly. An example was made relative to home stereo systems, which have all but disappeared from the marketplace in the traditional sense, having been displaced by home theater, small electronics and other audio devices. The fact that EIA's Residential Energy Consumption Survey (RECS) no longer seeks to explicitly track stereo ownership was cited as evidence. Since the RECS survey has been conducted every four years since 1993 and future periodicity is unknown, there may be somewhat of a gap in understanding where demand is headed as a function of intermittent information (which is a

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resource constraint on the extent to which behavioral issues can be infused into the Annual Energy Outlook development process).

- It was noted that people are different, and behavioral economics has demonstrated this somewhat obvious notion. However, given the right amount of information, issues such as payback and IRR are valid substitutes for elusive and subjective issues or alternative variables that may not currently be measured. *It is possible that some of these behavioral/non-economic issues are "in the noise"*.
- While it is true that innovators are purely innovators and may not examine costs as rigorously as others, there are also cultural issues at play. For example, thermal comfort studies have demonstrated that winter & climate are not as good at predicting energy use as more personal issues such as proclivity for warmth/cold.
- It was noted that the heterogeneity of the human condition is not in question, and this is not as much due to behavioral economics as it is common sense. However, when devising a model or an equation(s), you must, by definition, homogenize. Furthermore, there will always be some amount of omitted variable bias. Consequently, the combative characterization of neoclassical and behavioral economics in the literature must be replaced with a more complementary approach that attempts to infuse what data does exist on behavioral issues into the existing framework, which, as an abstraction of reality, for all practical intents and purposes, "works". Additional caveats were made as follows:
    - Limited interval surveys, anecdotal evidence, and isolated studies have limited tractability over an annual modeling cycle, since you cannot easily aggregate or synthesize disparate data elements. Such work is nonetheless extremely valuable, and EIA hopes to provide feedback about which specific end uses, consumer segments, etc. would be helpful for future research.
    - EIA already performs a significant number of "what-if" cases that should not be ignored, despite the reference case tending to be the main focus of stakeholders.
    - There is a cost-benefit issue intrinsic to this pursuit itself, in that the EIA and other agencies have limited resources, and the incremental improvement to forecast accuracy resulting from such efforts must be weighed against the cost, much like the "rational agent" paradigm being stress tested; *therefore, in the long run, behavioral factors worthy of further study should be catalogued and prioritized*.
- It was again reemphasized that we must move beyond merely observational contradictions to the rational agent model, and delve deeper into the microeconomic dimension.

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- With regard to how one might consider adjusting the current model, reference was made to Slide 6 of the EIA presentation, and the following observations were made:
    - The RDM allocates shares of different equipment types based on a weighted formulation of capital cost and operating cost. This is not strictly neoclassical economics, since the model is not simply computing an NPV based on a discount rate. The weights are chosen in part based on behavioral issues.
    - With regard to the microeconomic issues and notions of aggregate demand, the elasticity parameters embedded in the model, if statistically estimated, are informed by the behavior that has occurred historically. More broadly, an important notion to keep in mind is that historical data has within it the embedded behavioral trends and issues previously discussed. If behavior were otherwise, that would in theory impact the historical data (i.e., what we see in history has the "how people do what they do" within it); as the model is calibrated to history, is it not capturing these behaviors?
    - Furthermore, the *hurdle rate structure is a potential avenue to incorporate behaviorally based risk premiums into the analysis*, although what the mechanics of that would look like will take work.
- It was noted that during the course of the meeting thus far, there appears to be more feedback and sentiment towards making adjustments to the existing EIA framework than abandoning it; additionally, it was noted that the EIA model is in part "behavioral" already in terms of some of its structure.
- Additional comments on ways to make adjustments were offered:
    - Can we examine the extent to which the weights in the RDM compare with the evidence that we have?
    - Should we simply look for other factors to be included in the existing structure (assuming there are reliable data on those factors) or combining these factors in a different fashion rather than making massive changes to the model?
    - Whatever formula you end up with, it was generally agreed that capital cost and operating cost are critical modeling elements that need to be retained.
- It was observed that transportation-oriented researchers should be involved in the discussion process, since the demand determinants in transportation studies may be helpful cross-checks against RDM and potentially CDM. In particular, consumer behavior in the transportation sector could perhaps be characterized as more mature than the data from the building sector,

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and it could be argued that the NEMS transportation module has benefited from this additional information.

- Given a good basis for the current AEO Reference case, the challenge remains to understand market segments, and the attributes that could enhance or improve upon what currently exists. A given attribute, call it "gamma", if theoretically sound and pragmatically tractable (i.e., has good data behind it), can coexist within the existing framework, and the "sandbox" can be the warehouse from which to uncover plausible and new alterations.
- The discussion turned again to how and if behavioral economics could tangibly impact forecasting. It was noted that the current model imposes constraints on human/economic behavior, and the model works pretty well. Assuming that forecasting is important, the issue is whether any of the structural assumptions or constraints misses something important.
    - One participant suggested that the model may work well only in describing the current situation but not in forecasting, as it can be calibrated to current data but miss the long-term.
    - With regard to behavioral economics, one opinion was that the discipline is impactful in terms of policy design, as it can help shape how incentives and programs associated with purchase of durable goods are designed due to insights regarding subjective rates of time preference. However, at the aggregated level at which EIA is tasked with making long term projections, where more macro-level variables such as income tend to swamp heterogenic nuances, we end up with models that rationalize behavior well. Consequently, with regard to forecasting, it is hard to see how things would vary that much as a result of the existing state of behavioral economics. EIA may utilize an essentially neoclassical model that has been roughly modified to handle behavioral concepts.
    - A participant suggested that, as NEMS is at essence a policy evaluation tool, it should address (or incorporate) behavioral issues.
- The issue of the estimated impact of behavior-based programs on consumption/demand was raised. Are we on the cusp of a huge paradigm shift? Are there policy or cultural changes that will have material impacts, and how significant are they? Are the changes protracted or rapid? Feedback from participants was as follows:
    - One participant suggested that perhaps significant adjustments to address behavioral economics should not be in the Reference Case; less than 1 percent impact on consumption (further comments were made suggesting as much as a few percent of

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total EE/DSM program impacts) was from behavioral programs that focus on market outreach with some form of incentive.

  - If changes are long and protracted, then they will bear themselves out in the historical data over time, and the current model and forecasts may be adequate. However, if changes are rapid, then EIA may be ill-equipped to do much other than make analyst judgments and calibrations.
  - A certain provider's behavioral EE program is currently penetrated into 5 million homes (aiming for penetration into as many as 50 to 70 million homes) and is estimated to achieve between 1 and 3 percent annual savings on a persistent basis.

- Facilitation brought back the central framing topic of NEMS and whether it is amenable to accepting behavioral factors. In distinguishing between (i) throwing the existing framework away and building something new or (ii) adding more detail and structure to the existing framework, the working group was in general agreement that the latter approach appears more reasonable. Specifically, it was noted that behavioral economics can help most immediately by *relaxing constraints* or *adding constraints* (or both). If neoclassical economics is the rational agent framework, then the initial rational hurdle rate may be subject to further research on what other factors may drive higher or lower hurdle rates (i.e., retain the utility maximizing agent, but add constraints). One caveat to this consensus is that the workshop group, if expanded to a larger contingent, would likely find some stakeholders who may argue for a complete repurposing of the existing structure (but who may or may not be able to articulate a viable alternative).
- There is an academic conference in November (the Behavior, Energy, and Climate Change Conference) that is a research workshop/gathering on behavioral factors that have been identified as critical in terms of having a longitudinal view on them. As the EIA continues to pursue this path, it may be helpful to attend the conference, as some of this research may help inform the weights assigned to capital costs versus operating costs, allow EIA to digest more of the rising evidence, and help to amalgamate existing societal evidence so that we can peel back individual elements of the market and better understand them. The two "betas" within RDM (the operating and capital cost related modifiers) clearly have behavioral drivers behind them in terms of the individual adoption decision.
- There was a comment made that the RDM weight structure implicitly assumes a Weibull distribution and there was a question as to whether this was an appropriate way to think about residential demand. It should be noted, however, that the weight structure uses a logistic functional form weighting either capital and operating costs by Beta1 and Beta2 respectively. "B1 and B2" is not the actual notation in the model, and was used in the EIA slide deck for

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simplicity. Although the model discussion was simplified for the workshop, there is an optional "bias" parameter that can be used for weighting life-cycle costs when the parameterized logistic function is insufficient to describe choices. This bias parameter is currently turned off. The ratio of Beta1 to Beta2 is characterized as an approximate implicit discount rate, and the RDM technology menu has two beta parameters for every item on the menu. The RDM model documentation is available on the EIA website for further review by interested parties.

- Data sources for behavioral information were discussed. The Energy Efficiency Information Initiative is attempting to understand factors that determine who gets energy audits and why/what factors drive that behavior. This may be a good source of intelligence regarding what communities are doing; however, cross-sectional data without a longitudinal view of that factor may not be very useful in a vacuum. Another potential source is any existing evaluation, measurement, and verification (EM&V) reports (EIA has published a database of studies, available on its website), although the source of the reports and the data contained within them that could be useful was not directly discussed. A participant brought up a new research effort on consumer behavior regarding EE that will be underway later in 2013 and is intended to cross check current assumptions to the evidence in recent literature and dissect the EE "gap".

- With regard to adjusting the current modeling framework, another comment was made surrounding the potential to adjust the current modeling framework with interventions intended to tweak the weights for the capital cost and operating cost variables. Such an adjustment could be based on further research related to the impact of "information" or a related program that increases awareness of an energy-using piece of equipment. The specific weights could be adjusted based on expectations for increased information/awareness by specific technology. Furthermore, upper boundaries for markets may need to take into consideration certain logistical constraints, much like power flow constraints on the transmission system, wherein transfer limits cap flow regardless of the economics.

- In similar fashion to above, short-term price elasticity could be adjusted to account for a broader set of behavior-based programs. The EIA currently adjusts for the impact of the Smart Grid demonstration programs, and could, with further research, continue to make adjustments to price elasticity as a function of other factors. With regard to such adjustment, it was noted that it sometimes can be challenging to make elasticity adjustments, as you are dealing with a parameter that falls back to analyst judgment. Such considerations generally also apply to the hurdle rate parameters, which influence initial purchase decisions as opposed to ongoing use of existing end use equipment.

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- One participant suggested examining the technology diffusion models used in the DOE Solar Program for other factors that could be used in the NEMS building demand modules.
- Policy experimentation in the sandbox will likely be a valuable tool for mapping the literature to actionable changes. For example, the impacts of carbon policy can easily be addressed in that framework. However, it should not go unnoticed that EIA routinely produces a number of alternative cases, and this is done to provide forecast options beyond the reference case.
- It was asked whether, in light of the overwhelming feedback on adjusting versus major reworking of the existing framework, it was valuable to begin to catalogue and prioritize behavioral factors worthy of further study. While it was recognized that this is a key step in the process, it was agreed that this initial workshop may not be the best forum for this activity.
- The meeting turned back to data sources and reliance upon survey work. It was noted that reliance upon direct survey data may not be a good idea, since people may not know exactly what motivates them and do not always provide accurate answers. There are certain "cryptic relationships" that must carefully be explored beyond simply relying on a direct survey instrument. Current behavioral dynamics may change, and some sort of longer-term view may be needed on certain relationships. However, it was noted that, outside of limited survey data used in the CDM, surveys that support the NEMS modeling such as RECS are focused on capturing data on building characteristics and energy use, and not as much on behavioral questions.
- The meeting transitioned into the concluding phase. One summary of the overarching meeting theme was provided as follows:
    - Behavioral economics in the academic literature can help to modify and tweak the traditional neoclassical framework;
    - There is no fully fleshed out alternative model in the behavioral economics literature that is cogent enough to supplant the existing EIA framework, which is a combination of rational agent model elements and certain behavioral elements;
    - While there may be some behavioral variables omitted from the structure, there appear to be avenues within the model for updating or creating additional parameter values; if key variables can be extracted from the literature and appended, that is a good thing;
    - If what is absent is nascent or slow moving in terms of its impact and things change gradually, then the underlying historical trends are also self-informed and self-

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updating, and the modeling structure implicitly captures these movements through the estimation/specification process. The burden of proof in terms of whether changes are more drastic is a function of working to further our understanding of how the existing literature can help inform the current modeling framework;

- There may be certain policies that are anticipated to have a significant short-to-medium term impact on demand for energy efficient products and that are worthy of further analysis and review; and
- Further examination of adjustments must carefully balance the cost of gathering additional data with the perceived impact on the modeling structure from a forecasting perspective, as resources at EIA are not unlimited.

- The workshop concluded with miscellaneous final comments, generally aimed at identifying further partnerships that may be valuable, data sources, etc. as follows:
  - There is continuing (and in many respects increasing) interest in EE, and preparing the current modeling structure for more policy levers should be explored:
    - At the Federal level, policies must be incorporated (in the Reference or in Side Cases).
    - Given that the geographic detail of the model structure is at the Census division level, EIA currently only captures state EE programs implicitly in cases where programs have existed long enough to impact consumption; at the state or local level, how must such additions be prioritized?
  - There is a lot of new detailed and adjusted modeling in NEMS for the most recent AEOs (biggest period in terms of adjustments in the last 10-20 years).
  - Smart meters enable the capture of more detailed energy consumption and cost data but the application of such data is still very uncertain.
  - If we are to make adjustments, we need to catalogue and prioritize the factors that will be subject to further investigation.
  - Analysis will be done in parallel in a sandbox initially.
  - Solicitation from the group and others will be made in terms of who wants to be involved downstream as investigations continue.
  - The Polk database was cited as a good source for data on consumer choices, as it provides empirical evidence on behavioral issues related to energy use in the realm of automobiles use/purchasing decisions.

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- Generational shifts in demand profiles and attitudinal issues surrounding demand and usage, if present, should somehow be studied – when is the signal going to "sift through the noise"?
- The "hybrid" of neoclassical and behavioral economics should lead to further study to devise potential modifications that take into account behavioral factors. However, from a forecasting perspective, the NEMS model should be focused on forecasting performance just as much as understanding what people are doing. If incorporating behavioral economics into NEMS does not lead to improved performance (i.e., forecast accuracy), then it should not be pursued.
- Do not lose sight of the numerous side cases the EIA does every year – these are done for a reason.
- The University of California is currently undertaking endeavors that may yield some interesting perspectives – for example, the Behavior, Energy, and Climate Change Conference, if attended by members of the EIA team, may be a good forum for getting further input.
- The residential sector dynamic may be more subject to behavioral impacts than the commercial sector, based on program management and implementation experience. The commercial sector may be less "scalable", in the sense that a more varied number of incentives and programs may be at play than within a residential context.
- Organizational behavior theory may help us better understand how the commercial and industrial sector incorporates behavioral factors into their decision making regarding energy use.

- Participants were invited to participate in the upcoming Buildings Energy Group meeting (Mon, 7/22 at 11a).

FOLLOW-UP FEEDBACK

Below we present direct follow-up messages from participants with minor adjustments to preserve the not-for-attribution framework of this memo.

- When thinking about how behavioral economics can influence the modeling done in NEMS, it's useful to break it down into two parts:
  - What behavioral economics means for accurately forecasting consumer decisions and thus aggregate outcomes, and

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- What behavioral economics means for modeling a variety of informational policies

- As was discussed during the meeting, since the NEMS coefficients weighting operating cost and capital cost are not straight from a rational economic consumer model, one could easily interpret them as coming from a behavioral economic model. So in this sense, NEMS is already incorporating behavioral economics into the forecasts. There may perhaps be better ways to do this, but the main idea is already implicitly incorporated.
- NEMS is not as well suited for looking at informational policies that may come from the behavioral economics discussion. This would require some careful thought and modeling, perhaps by bringing in some of the latest insights in the behavioral economics literature as it evolves.
- Do not to throw out the current framework, but be open-minded about new developments and willing to consider changing the framework if it appears that a superior framework arises. It is likely that the parameters in the current NEMS model do a reasonable job at modeling how consumers make decisions.
- Behavioral economics is most useful in informing the framing of models designed to understand the likely result of particular policies, e.g., policies to improve information about EE. These models tend to suggest more flexible models than found in a static neoclassical model, but don't depart from them in terms of the variables that matter. When it comes to forecasting, though, it's very unlikely that standard, flexible models used in economic analysis – e.g., models that recognize that the purchase decision for an energy efficient appliance depends on the price, the rate of time preference (i.e., the customer's discount rate), the expected value of reduction in energy use, demographics (which capture heterogeneity in preferences) etc., are likely to be replaced wholesale by alternatives. This is because most of those alternatives rely on the same variables, with behavioral economics suggesting they matter relatively less or more than indicated by neoclassical models, not that they don't matter at all.
- A participant mentioned that they "don't believe in rational choice", but it seems that the statement was intended merely as a point of departure, not as a black and white statement. It cannot be readily disputed that on average a higher income generates a higher consumption of energy nor that a higher price of energy yields less energy use on average (all else equal). In other words, most of the predictive aspects of neoclassical models are pretty mild, ones that we all accept, and so everyone would accept that these variables should be in any sort of forecasting model. This leads to the impression that behavioral economics probably won't have a drastic effect on modeling intended for forecasting, especially since such models are

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low-structure, "reduced form" models that already are only loosely tied to standard neoclassical models.

- It seems that the 'behavior' component we were talking about - and incorporating those into the energy models - is similar (if not identical) to the conversations regarding free riders. Free riders are individuals who reap the rewards of behavioral incentives even though they would have engaged in the measure/act of their own volition (i.e., taking a "free ride" on the incentives). See comment below.
- Some currently claim a net-to-gross ratio of one, even if the "true" ratio is less than one. This has long bothered me, as it has the potential to mess up our adjusted load forecast and thus our Integrated Resource Planning (IRP).
    - To the extent that free ridership is reflective of behaviors outside of program influence, free ridership is already embedded in our load forecast. That said, if the claim is that the net-to-gross ratio is one, but it is not actually one (something less than one, because our 'actual' realization rate net of free ridership is less than 100%), and we use that ratio of one when we adjust our load forecast for conservation, we over adjust our load forecast for conservation and we under plan for both supply-side and demand-side resources. I have drawn several pictures and graphs of what happens if we assume that 'behavior/naturally occurring conservation' isn't in our load forecast, and we then adjust for it. I can send you one of those graphs if you would like.
- Essentially, I think we are worried about a sudden "CHANGE in behavior"; not necessarily behavior itself. However, unless those changes in energy behavior are sudden and drastic, they will be reflected in your historical energy usage, which will be used in your forecast, so the issue is taken care of already. The only way I see a problem is if there's a drastic, sudden change in behavior from some external factor that you are not already planning for in your forecast, and I just don't see that happening.
- From the evaluations we have conducted on behavior programs, I would say that "changes in behavior" accounts for a very small part of our energy profile (and we are a fairly large utility); I just don't see energy related "behavior" as being significant enough (even on a drastic change level) to not just be noise in the background at this point. Specifically, marginal changes in behavior, year-after-year, are even smaller than pure "behavior change" change. So, I think you are fine with what you have, unless you expect some sudden, drastic change to occur. Given that "changes in behavior" are small for our utility, I don't see it being a large component on an aggregate level.

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- I can see wanting to understand how much of energy usage is related to behavior, as it is a large factor in how much energy a house uses, but if you account for this in your forecast then you run the risk of "double counting" in essence, because those behaviors are reflected in historical usage.
- The inclusion of behavioral factors into these existing models should be considered, but in a manner that maintains the existing model structure. It is recommended that these could be best done at present through establishing modifiers to the existing Beta and Hurdle factors. Some additional ideas to implement this could be as follows:
    - Build a matrix of behavioral modeling factors that can be used to "feed" the existing parameters. The matrix could accommodate various behavior-describing factors without directly impacting the base models, and thus provide the freedom to be a "test bed" for various behavioral modifiers.
    - The impact of behavioral models on end results should be tested to gauge the relative potential impact on various energy factors in the Residential and Commercial models. For example, minimum and maximum possible ranges of the behavioral model factors should be tested to gauge impact on the ultimate energy model results. This approach could provide a screening on which behavioral factors and which energy metrics in the NEMS model should be focused upon for the greatest improvement through incorporation of behavioral factors.
- One thing we did not discuss much in this meeting is the idea of not only hurdle rates but long lags, which sort of lead to a "capitulation" effect in the market. For example, one thing we have begun seeing in our demand forecasting work has been a sudden shift away from electricity in home heating and a precipitous drop in winter electric demand. The rational consumer has had limited and untimely information that natural gas is expensive, but has suddenly realized how (i) inefficient supplemental electric heat is and (ii) how much natural gas prices have fallen (even though they haven't come down at retail back to the historic levels). It's a classic overshoot situation due to information lags. We readily represent that with lags in standard econometric equations (as estimated); many people's econometric MODELS miss this and/or simplify this effect too much. What can happen is that behavior that appears to reflect a hurdle rate is merely lagging the real time information by a couple years or more (the classic example is the way many markets work in a way that is much more volatile than the underlying economics).

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ATTACHMENT 1

EIA Workshop on Behavioral Economics as Applied to Energy Demand Analysis and Energy Efficiency Programs – Final Participants List

#	PARTICIPANT	AFFILIATION	E-MAIL ADDRESS	ATTENDANCE LOCATION
1	Richard Newell	Duke University Energy Initiative		TELECONFERENCE
2	Annika Todd	Lawrence Berkeley National Laboratory		TELECONFERENCE
3	Bruce Ceniceros	Principal Demand Side Specialist Customer Strategy - SMUD		TELECONFERENCE
4	Bobbi Wilhelm	Evaluation Analyst at Puget Sound Energy		IN-PERSON
5	Bill Provencher	Navigant Consulting		TELECONFERENCE
6	Tom Giffin	SAIC		IN-PERSON
7	Nick Hall	TecMarket Works		TELECONFERENCE
8	James Sallee	Assistant Professor, Harris School of Public Policy Studies, University of Chicago		TELECONFERENCE
9	Meredith Fowlie	Assistant Professor of Agricultural and Resource Economics, University of California, Berkeley		TELECONFERENCE
10	Karen Palmer	Resources for the Future – Research Director and Senior Fellow		TELECONFERENCE
11	Kenneth Gillingham	Assistant Professor of Environmental & Energy Economics, Yale School of Forestry &		TELECONFERENCE
12	Miriam Goldberg	KEMA Inc.		IN-PERSON
13	Nancy Hersh	Opower, VP of Consumer Marketing and Analytics		IN-PERSON
14	Susan Mazur-Stommen	Behavior and Human Dimensions Program Director, ACEEE		IN-PERSON
15	Linda Schuck	Senior Advisor, Behavior and Decision Making, California Institute for Energy and the Environment (CIEE)		TELECONFERENCE
16	Erin Boedecker	EIA Office of Energy Consumption and Efficiency Analysis		IN-PERSON
17	Jim Turnure	EIA, Director - Office of Energy Consumption and Efficiency Analysis		IN-PERSON
18	David Peterson	EIA Office of Energy Consumption and Efficiency Analysis		IN-PERSON
19	Mark Schipper	EIA Office of Energy Consumption and Efficiency Analysis		TELECONFERENCE

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#	PARTICIPANT	AFFILIATION	E-MAIL ADDRESS	ATTENDANCE LOCATION
20	John Meyer	SAIC		IN-PERSON
21	Bob Lorand	SAIC		IN-PERSON
22	Jay Ratafia-Brown	SAIC		IN-PERSON
23	Navid Nowakhtar	SAIC		IN-PERSON
24	Jonathan Nunes	SAIC		IN-PERSON
25	William Comstock	EIA Office of Energy Consumption and Efficiency Analysis		IN-PERSON
26	Kevin Jarzomski	EIA Office of Energy Consumption and Efficiency Analysis		IN-PERSON
27	Mitch Rosenberg	DNV KEMA Energy & Sustainability		IN-PERSON
28	Sam Napolitano	EIA, Director - Office of Integrated and International Energy Analysis		TELECONFERENCE
29	Adam Cohen	EIA, Solar Program – Science/Technology/Policy Fellow		IN-PERSON

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ATTACHMENT 2
BEHAVIORAL ECONOMICS AND ENERGY EFFICIENCY FINAL EXPERTS MEETING AGENDA

WELCOME AND INTRODUCTION BY EIA (15 minutes)

- EIA Staff and Attendees Introduction
- Workshop Purpose and Objective
- Workshop Format and Facilitation Approach

ORIENTATION/PRESENTATION: OVERVIEW OF EIA RESIDENTIAL AND COMMERCIAL DEMAND MODELS AND CURRENT METHODS FOR INCORPORATING ENERGY EFFICIENCY/EFFICIENCY PROGRAMS (30 minutes)

- Model Framework Description and Model Inputs and Outputs
- Equipment Retirement/ Replacement and Technology Choice Methodologies
- Implementation of Incentives and Credits to Promote Energy Efficient Choices
- Use of Price Elasticity Functions and "Rebound Effect" Factors for Behavior Modification
- Description of EIA's Need for Enhanced Approach to Account for potential "Deviations" from the Existing Economic Methodology used in the NEMS Demand Models
- Questions/Answers/Discussion Focused on EIA's Modeling Requirements

ORIENTATION/PRESENTATION: BEHAVIORAL ECONOMICS GENERAL OVERVIEW AND DISCUSSION (45 minutes)

- Behavioral Economics Background Information
- What is Behavioral Economics (Comparison with Neoclassical Economic Models of Choice Behavior – Maximization, Equilibrium, and Efficiency)?
- Current Applications of Behavioral Economics to Energy Demand/Efficiency Programs and Decision-Making
  - Key Principals of Behavioral Economics as Applied to Energy Efficiency Programs
  - Behavioral Economics/Energy Efficiency Case Study Examples
    - Presentation and review of perhaps two case studies, showing the translation of BE theory into practice - this would also provide a basis for discussing recommendations for implementation techniques.
  - Other Recent Behavioral Modeling Examples
- Current Status of this Discipline (Focus on Consumer Decision-Making)

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EXPERTS ROUNDTABLE DISCUSSION/BRAINSTROMING: HOW CAN EIA BENEFIT FROM APPLICATION OF BEHAVIORAL ECONOMICS TO RESIDENTIAL AND COMMERCIAL ENERGY DEMAND MODELING? (2 hours)

- Efficacy of Utilizing Behavioral Economics to Satisfy EIA Modeling Requirements
- Application of Behavioral Economics Theory and Experience to Energy Demand Modeling
  - Lessons-Learned from EE Program Designs and Outcomes
  - Lessons-Learned from Ex-Post Modeling of EE Programs
  - Insights from EE Program Results Interpretation
- Methods for Adding Behavioral Assumptions to the Existing Demand Models
- Future Behavioral Research and Empirical Data Required to Support EIA's Needs
- Existing Research Groups or Networks on Behavioral Economics

MEETING SUMMARY AND CONLUSIONS (30 minutes)

- Summary of Salient Discussion Items
- Conclusions
- Recommendations for EIA

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