Summary of the "DOE Workshop on Indicators of Energy Intensity in the U.S. Economy"

[Adapted from summary prepared by David Ortiz, RAND]

Introduction

On January 11, 2002, the Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy and RAND sponsored an expert workshop in Arlington, Virginia. At the workshop, participants discussed the desired features of a system of indicators of energy intensity in the U.S. economy. During the "Workshop on Indicators of Energy Intensity in the U.S. Economy," experts examined the methodological underpinnings of a new system of energy intensity indicators for the U.S. economy and the major energy-consuming sectors: residential and commercial buildings, industry, transportation and electricity. The participants reviewed technical information and provided input to the DOE project team. Topics included the appropriate use and structure of energy intensity measures, technical issues of calculating and indexing measures, and detailed discussions of sector-specific measures. The Workshop Agenda is found in Appendix A. This is a summary of the ideas put forth by the workshop attendees.

Invited to the workshop were dozens of experts in energy and economics. The experts had reviewed a draft project team report regarding a proposed energy intensity index. Below is a list of invited experts and the members of the project team. The full list of workshop attendees is provided in Appendix B.

The workshop addressed a number of key issues and questions regarding the development of an energy intensity indicator system:

1. Reasons for creating a system of energy intensity indicators.

2. How to best approach making the energy-gross domestic product(GDP) link.

3. How far back in time should the calculations go and which base year is most appropriate.

4. How best to calculate an index of energy intensity.

5. How to treat the difference between delivered and primary electricity

Invited Experts:

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Dave Belzer, Pacific Northwest National Laboratory
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Jeff Dowd, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

In addition, detailed discussions were held on issues related to the buildings, industry, transportation and electricity generation sectors. In these sessions workshop attendees addressed questions including:

- The appropriate level of sector and sub-sector detail.
- How to measure activities in the sector.
- Data-collection issues.

Opening remarks by David K. Garman, Assistant Secretary for Energy Efficiency and Renewable Energy, included the following vision and charge to the group:

"We envision a new set of energy intensity indicators that will,

- *allow changes in energy intensity to be annually tracked at the National-level and within the key energy consuming sectors of transportation, building, industry and electric power;*

- *be accessible and understandable to public and private sector decision makers, energy policy administrators, NGOs and analysts in the research community;*

- *make the information available to all; and*

- *be suitable for being maintained in a user-friendly, web-based environment."*

The DOE project team presented the principles guiding development of the indicator system. The team felt that the indicators needed to be:

1. Useful and provide information on changes in energy intensity and contribute to a range of different analysis applications.

2. Clearly defined, practical and interpretable by intended users.

3. Technically sound so that basic principles and methods are theoretically appropriate and accepted by outside experts.

4. Updated regularly using primary data or by interpolating between benchmark years with transparent procedures.

General Comments

In particular, the energy intensity indicators system should have the following characteristics:

- It should be widely accessible. The group of energy and economic experts believe that the indicator system needs to be accessible to a wide audience of both researchers and non-researchers.

- The energy intensity indicators system should strive to be similar to statistics compiled by the Department of Commerce and other Federal agencies.

- The indicators should be transparent. Calculations should be clear so can be duplicated easily.

- The indicators should be disaggregated and sector-specific, where applicable. The group felt that aggregate numbers, while useful for some policy purposes, needs to be supported by significant sector disaggregation.

- A supporting system of data collection should be established.

- Attention should be focused on the ultimate use of an energy intensity indicators system. If the main use is to examine trends, absolute precision is less of an issue than in other analyses. The precision of the change from year-to-year, however, is important.

Uses for an Indicator System

Workshop participants identified ten uses for an indicator system:

1. Assessing changes in energy security: Changes in certain aspects of energy use have implications for energy security: the use of imported petroleum is an example.

2. Evaluating changes in environmental impacts of energy use: Air pollution and acid rain are directly related to energy use and an energy intensity indicators system that disaggregates by energy type can help to track and evaluate trends in pollution and other environmental effects.

3. Assisting energy planning of governments and companies: Government and private sector programs regarding energy use require information about trends and patterns in energy use that have an impact in supply, reliability and prices.

4. Establishing a common foundation for policy evaluation: Analysis of the implications of different policies requires transparent indicators of success.

5. Distributing results to the public: The energy intensity indicators system needs to be accessible to a wide audience so that public opinion may be immediately solicited.

6. Helping to measure performance: An indicator system can help to determine options for

improvements in energy use.

7. Understanding trends: An energy intensity indicators system can be useful in analysis of trends in energy use.

8. Providing inputs to other analyses: A successful energy intensity indicators system will produce inputs to broader economic analyses of the U.S. economy.

9. Providing consistency in the reports of energy use: Too many calculations regarding energy use are made by different organization resulting in inconsistent reports on energy use and trends.

10. Helping to forecast energy consumption: An energy intensity indicators system can help improve energy demand and supply forecasts

The long list of potential uses of indicators reflects the feeling of many participants that the energy indicators system should be as broad as possible and appropriate for application to many sectors.

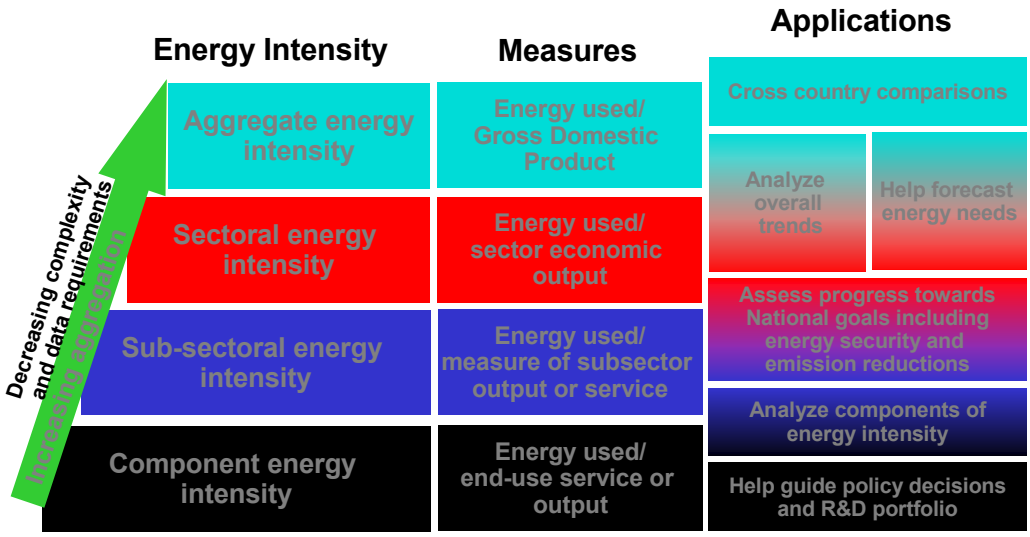
Relationship Among Aggregation, Data Requirements and Application

Mark Bernstein (RAND) presented the figure below that illustrates the relationship among aggregation, data requirements and the application of an energy intensity indicator. The important tradeoffs faced by the project team are illustrated in the figure. As disaggregation increases, data complexity and requirements also increase while the direct applicability of the measure increases. Hence, there is a tradeoff between complexity and usefulness of energy intensity indicators.

In light of these tradeoffs, participants felt that it is imperative that limitations in applicability and data be clearly stated. Participants emphasized that the energy intensity indicators system include some measure of the uncertainty of the indicators.

The Energy - GDP Link

Technical discussions began with the relationship between energy and economic growth and possible adjustments to GDP to reflect energy consumption. Participants concluded that traditional GDP be used so that it is consistent and compatible with other government agencies. The project team presented the following options to the group:



1. Develop an indicator system independent of GDP accounts.

2. Use a simple method to disaggregate sectors for energy use and GDP.

3. Use a more complicated disaggregation method that better matches energy data to GDP, identifies separate influences of compositional shifts of GDP (i.e., manufacturing vs. service industry) and rationalize issues like the link between business transportation use and GDP accounts.

4. Revise the energy GDP ratio by imputing household production of energy services.

The group agreed that option (3) was an appropriate method for addressing the energy to GDP link.

Period of Analysis and Determination of Base Year

Workshop participants addressed the issues surrounding the choice of a base year and the period over which historical trends should be calculated and presented.

The team presented six options for base years:

1. 1972 or 1973: This year is used in previous studies and would yield a long-term perspective. It might however be expensive to compile and validate data.

2. 1980: Initial EIA building surveys are available for this year though it also represents an

economically turbulent time.

3. 1985 or 1986: In these years began a long period of stable energy prices and corresponds to the first year of the Manufacturing Energy Consumption Survey (MECS).

4. 1990: This is the base year for Kyoto targets and facilitates comparison with other countries. Unfortunately, it was an abnormally warm year.

5. 1996: This year matches the National Income and Product Accounts (NIPA) base year and is the mid-point of an economic expansion; it was also abnormally cold.

6. 1997: This year corresponds to the last economic census, Residential Energy Consumption Survey (RECS) and was blessed with normal weather patterns.

Most workshop participants felt that energy intensity indicators system should be calculated as far in the past as possible because a historical perspective is needed. It also believed that the base year should be as current as possible and coordinated with the Department of Commerce and other agencies. The use of a chained index may mitigate sensitivity to a base year.

Three key considerations dominated the discussion:

- The base year depends on the goal and application of the energy intensity indicator system.
- The indicators need to be insensitive to the base year; hence, that year must not be an economic or climatic anomaly.
- The choice of a base year might be data dependent.

The first issue is critical and instigated significant discussion.

The group discussed the tradeoffs:

- If the concern is the effect of changes in price, then the base year should be in the 1970s.

- To reflect recent trends, 1985 or 1986 is an appropriate base year.

- If a ‘future’ focus is required, then 1990 or 1996 may be advisable base years.

There were a variety of other issues and sentiments discussed. Some suggested that the base year should match the base year used by the Commerce Department. Some suggested setting the base year at the most current year, but only if data for previous years is included. In the end it was felt that the base year was not as critical as having a sufficient number of years of data, and a rigorous method for changing the base year.

Anomalous years present a problem in terms of energy prices and weather since both have an

impact on energy use: 1990 was abnormally warm and 1980 experienced high prices. In the end, a recent base year, such as 1996, or an historic base year, such as 1972, seemed most appropriate. However to prevent error with respect to drift, the most recent year might be the best choice.

Method of Index Construction

The next session focused on technical issues related to the method of index construction. A number of options were presented and two were most extensively discussed -- the Log Mean Divisia and Fisher Ideal index.

The project team proposed to create an index like the Consumer Price Index that is common, easily reported and understood. The questions focused on whether to use a chain approach, and within that, whether to use a Fisher index, which is used in the US NIPA, or a log mean index, which has more flexibility.

The general consensus was that the most important consideration was how the index was to be used and that the type of index was relatively unimportant; more than one index should be reported. The Department of Commerce representatives felt that the approach should be consistent with their methods and should use 'superlative indices', like Fisher. However, it was noted that the drift problem associated with chain indices remains to be solved.

Participants questioned if the method of construction made any difference; in general it would not. However it was suggested that analysis verify the assertion. The final index should be the one most consistent with other Federal agencies' data and indices.

Buildings Sector Discussion

This sector comprises residential and commercial buildings. Given the variety of different uses in the building sector it is hard to choose a small set of activities to construct an index. What does energy consumption per capita represent? Many factors such as house size, house type, location, household income, existence of air conditioning or heating and fuel type are important for understanding the components of energy use in the residential sector. The type of building is an important structural variable: energy use can vary significantly among mobile homes, apartments, attached homes and single-family homes. Commercial structures exhibit similar differences. There was considerable discussion regarding the integration of physical measures and non-physical measures like population. Additional analysis regarding determinants of household energy use is needed.

Disaggregation by end use was perceived as highly valuable to the usefulness of the indicators system in buildings. The group raised the following fundamental points:

- For the buildings sector in particular, the energy intensity indicator system needs many different normalizing factors. For example, there are a variety of ways to measure activity in the buildings sector – by population, income, square feet, type of housing – and each activity measure presents a different interpretation of energy intensity index.

- The more aggregated the index, the less useful it is. Many felt that aggregate measures are not useful for policy purposes. Total energy use per capita for the buildings sector is not a value that has much meaning.

- Physical measures are critical. While income and economic growth are useful measures, type, vintage and size of the building also determine building energy use.

- Careful consideration is necessary to determine the measures that can best serve policy and programmatic initiatives especially in consideration of the previous points.

- Data quality and availability are obstacles. The depth and breadth of the energy intensity indicator system, at least initially, will be dependent on available data. An effort within the DOE to collect relevant data is required.

Industrial Sector Discussion

The energy intensity indicator system for the industrial sector needs to be consistent with other classifications. In particular it should match the MECS and Standard Industrial Classification (SIC) groupings. The participants were critical of the DOE team's proposal to use a different classification.

Additional classification issues include:

- Incorporating sub-classifications for comparison purposes. There are differences in industries, but these are not necessarily easily compartmentalized into the general classifications. Suggested sub-classifications include the following: durable and non-durable goods; high energy and low energy consuming industries; fast and slow growing industries.

- For common energy uses across very diverse industries, electric motors for example, there should be some consideration on those end-uses. A participant suggested the inclusion of satellite accounts.

- The incorporation of industries that do not appear in MECS, such as agriculture and mining.

- Cogeneration energy consumption data is poor and presents an analysis problem. One suggestion was to include cogeneration only for sectors in which it is currently

significant, adding additional sectors in the future.

Though more detail is generally preferred, participants expressed concern regarding the quality of the data. In general, physical measures are better than economic measures. However, even physical measures do not capture the 'quality' of production, which can have an impact on energy consumption. There exist different qualities of products and adjustments to account for quality are difficult. Many participants suggested that value measures should be adjusted for inflation using industry specific price deflators.

Transportation Sector Discussion

It was suggested that the DOE reconsider categories of vehicles and transportation service types. With respect to vehicles, some 14 participants felt that it is important to disaggregate by vehicle type: SUVs should be separated from other light trucks. Vehicle types and sizes are structural variables, but data quality remains an ever-present problem. Another suggestion was to split highway and non-highway uses. There needs to flexibility in the energy intensity indicator system to incorporate emerging technologies and fuels.

The transportation activity is important to measure, and it was suggested that the DOE team:

- Consider value measures for weighting freight. Data are available, but there are exogenous factors that have an effect on value and lead to incorrect interpretations of changes in intensity: shipping diamonds is not comparable to shipping steel. The use of ton-miles or kilometers to represent freight presents difficulties due to enormous variation in value of service in this measure (two orders of magnitude).

- Consider adding load factors: a full truck is more efficient than a half-full truck.

- Consider fuel disaggregation to reflect differentiation in efficiency of different fuel and emergent engine types such as electric hybrid and alternative fuels.

- Tackle freight by air despite the difficulties.

- Consider separating passenger activity by trip purpose thus distinguishing between activity and access.

- Fix data problems: vehicle miles of travel data, for example, are notoriously inaccurate.

Finally, there was a discussion about what different energy intensity measures mean in transportation and how behavioral changes can change energy use. As illustrated by one participant, moving farther away from your job increases the miles driven, but improves average fuel economy. The vehicle is the same but has efficiency increased, decreased or stayed the same? The participants encouraged the DOE to address changes in land use and demographics

with respect to energy intensity in transportation.

Electricity Sector Discussion

Electricity generation should be considered independently because efficiency gains in that sector are attributable to improvements in the generation and delivery of electricity.

Structural components are an issue in this sector. Structural differences include the generation technology, electrical 'products', and load factors in generation. There was interest in indicators that disaggregate the technology mix and region to differentiate energy intensity changes in the type of generation, the weather and other exogenous factors. A participant noted that greater electrification does not necessarily cause overall energy intensity to rise or fall.

The group focused their discussion on the following three issues:

- Cogeneration requires significant engineering and economic study to determine the proper industry and sector for the energy use.

- Renewables present problems in comparison to fossil fuel-based technologies. Blind inclusion of renewables in the energy intensity indicator system could mask changes in the underlying efficiency of conventional technologies. Perhaps renewables should be isolated.

- Site versus source energy, and transmission and distribution losses pose problems. There is a difference if one reports end-use electricity or the amount of energy needed to convert and deliver the electricity. Participants agreed that both measures should be presented.

Appendix A. Workshop Agenda

DOE Workshop on Indicators of Energy Intensity in the US Economy
Location RAND, 1200 South Hayes Street, Arlington, Virginia

Date: 11 January 2002

Objective: Conduct a detailed review of alternative approaches and data/methodology issues of indicators of energy intensity

8:00-8:30 Breakfast buffet

8:30-9:00 Welcome, introductions, objectives and agenda

9:00-9:45 Background

Presentation 1 Why create an energy indicator system?
Presentation 2 Methodology paper highlights and issues

9:45-10:30 Roundtable
< Is the general direction for creating an indicators system on point?
< Are there better approaches?
< What issue areas need to be added or expanded?

10:30-10:45 Break

10:45-12:15 Discussion: How do the key issues help to define an energy intensity indicator system?
< What are appropriate methods for refining the measure of E/GDP?
< What period of analysis and base year should be used?
< How to treat the difference between delivered and primary energy?
< What is the appropriate subsector breakdown?
< How should the measures for activity, structure, and intensity be defined and constructed?

12:15-1:00 Lunch

1:00-2:45 Breakout
A. Industry
B. Buildings

2:45-3:00 Break

3:00-4:30 Breakout

A. Electricity
B. Transportation

4:30-5:30 Reports: Highlights of sector breakout discussions

5:30-5:45 Closing remarks

5:45 Adjourn

Appendix B. Complete List of Workshop Attendees

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