2020 Review Panel Workshop on Energy Intensity Indicators

Summary Findings and Meeting Notes

March 2020

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January 28-29, 2020
Battelle Washington Office,
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Washington, D.C.

Acronyms and Abbreviations

ACS	American Community Survey
BLS	Bureau of Labor Statistics
CFS	Commodity Flow Survey
DER	Distributed energy resources
DOE	U.S. Department of Energy
EERE	Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
EII	Energy Intensity Indicators
FAF	Freight Analysis Framework
GHG	greenhouse gas
LMDI	Log Mean Divisia index
MECS	Manufacturing Energy Consumption Survey
OSU	Oregon State University
NAICS	North American Industrial Classification System
ORNL	Oak Ridge National Laboratory
PNNL	Pacific Northwest National Laboratory
REC	Renewable energy credits
RECS	Residential Energy Consumption Survey
T&D	Transmission and distribution

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Introduction

On January 28-29, 2020, the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE), in coordination with Pacific Northwest National Laboratory (PNNL), sponsored an expert workshop focused on energy intensity indicators. The intent of the workshop was to support a comprehensive review of the EERE Energy Intensity Indicators (EII), a national system of indicators used to track changes in the energy intensity of economic sectors. One goal of the workshop was to gather input from a panel of experts who have experience and knowledge related to the EII methodological approach and key data sources used to calculate indicators for each of the end-use sectors of the economy—transportation, residential, commercial, industrial, and electricity. The current EERE EII methodology is documented in a 2017 PNNL report, *A Comprehensive System of Energy Intensity Indicators for the U.S.: Methods, Data and Key Trends,* which is available online. The workshop also included a presentation by Dr. Beng Ang, who discussed the Log Mean Divisia index (LMDI) approach to decomposition analysis, which was followed by a discussion concerning the methodological approaches that could be applied to future EII efforts.

Workshop Participants

Workshop participants included the following people:

- David Belzer, Advisor (retired Senior Research Economist), PNNL
- Gale Boyd, Professor, Duke University, formerly Argonne National Laboratory
- Mark Curtis, Assistant Professor, Wake Forest University
- Olga Livingston, Senior Economist, Cybersecurity and Infrastructure Security Agency, U.S. Department of Homeland Security
- Stacy Angel, Analyst, Energy Information Administration (EIA)
- Erin Boedecker, Team Leader, EIA
- Colin McMillan, Researcher, Strategic Energy Analysis Center, National Renewable Energy Laboratory (NREL)
- Ookie Ma, Project Manager, DOE/EERE
- Jeffery Dowd, Project Manager, DOE/EERE
- Dave Anderson, Senior Economist, PNNL
- Sadie Goulet, Economist, PNNL
- Katherine Cort, Senior Economist, PNNL
- Sumitrra Ganguli, Senior Associate Economist, PNNL

Background

The primary purpose of EII analytical efforts is to inform policy-makers and the public of ongoing progress being made to improve energy efficiency in the United States. The intensity indicators were originally developed in response to the May 2001 National Energy Policy that directed DOE to support the improvement of energy efficiency as a national priority. An initial review of possible approaches to developing energy intensity indicators was conducted by a panel of nationally recognized experts in 2002.[1] The indexes of historical energy intensities were constructed to provide measures of the change in energy intensity over time. In particular, the indexes are viewed as providing a detailed look at energy efficiency across various sectors of the U.S. economy. The sector-level indexes are aggregated into an economy-wide metric that can be compared to the more simplistic energy-to-gross domestic product ratio.

The EERE system of energy intensity indicators includes an ongoing activity to maintain and consistently track changes in the energy intensity of the U.S. economy and specific economic sectors over time, and to disseminate such changes via a public website. Because it has been nearly 20 years since the energy intensity indicators methodology and process was implemented by EERE, this 2020 workshop provided an opportunity to review the process, its applications, supporting data sources through the years, and to gather input about recommended refinements to the process from a panel of experts in the field.

Workshop Agenda

Day 1

I. Introductions and Overview (Ookie Ma)
II. EERE Energy Intensity Indicators Overview (David Belzer)
III. Transportation Sector
IV. Manufacturing & Industrial Sector
V. Electric Generation
VI. Commercial Buildings Sector
VII. Residential Sector
VIII. Revisit/Open Discussion

Day 2

I. Presentation by Dr. Beng Ang
II. Open Discussion / Q&A with Dr. Ang
III. Broader Methodology Discussion / Revisit

Sector Summaries

Discussions largely followed the topics outlined in the workshop agenda (see text box) and the meeting was moderated by Dave Anderson, PNNL. The discussions centered on the electric generation sector and four end-use sectors—transportation, manufacturing/industrial, commercial and residential buildings—are summarized below. Detailed meeting notes for each day of the workshop follow the discussion summaries.

In the context of the **Electric Generation** sector, the discussion was confined to questions concerning the treatment of distributed energy resources (DERs), treatment of renewables (if they are construed as being an improvement in efficiency), and accounting for transmission and distribution (T&D) losses. It was generally agreed that DERs could be treated similar to cogeneration, i.e., as an efficiency improvement. Distributed renewables could potentially also be treated as an efficiency gain. A shift to renewables for central generation could be captured as a structural shift in the electric generation sector.

The sectoral discussions identified gaps in the analysis and offered ways to address them. Specifically, in the context of the **transportation** sector, the discussions were focused on how to define efficiency (we

[1] The findings from this workshop are documented in the 2002 Research And Development (RAND) Corporation report.

need to understand whether we are talking about a system-level measure) moving forward and how to measure the service that transportation provides. The offered solutions called for careful consideration of the available data to support the chosen activity measure. The starting point of this exercise would be to address the discrepancy between national highway statistics and Oak Ridge National Laboratory (ORNL)[2] transportation analyses. Further, it was suggested that ORNL's Freight Analysis Framework (FAF) data derived from the Commodity Flow Survey (CFS) could be used to address confounding variables and improve the final estimates. The FAF and CFS data also include information about North American Industrial Classification System (NAICS) codes and route information, which can facilitate sectoral and spatial disaggregation.

In the context of the **Industrial and Manufacturing** sector, the discussions were focused on a few key issues: (1) the treatment of (imported) intermediate inputs and final goods and the embodied energy (if an additional sector, trade, is included in the analysis); (2) the disaggregation of some of the more energy intensive sectors to the six-digit level (chemicals being a case in point) to separate opposing trends blended at higher aggregations; (3) the treatment of cogeneration; (4) the treatment of mining; and (5) additional data sources for estimating energy use. It was agreed to table the discussion of mining such that more time could be allotted to discuss manufacturing. It was also advised that DOE investigate, but hold off on attempting to implement fully, any immediate analytical exercises related to intermediate imported inputs, because this is a methodological question that is currently being debated by experts in the field. Instead, it was suggested that some additional analysis could focus on disaggregating some of the more energy intensive sectors like chemicals, steel, paper, and some food sectors (e.g., corn refining and sugar) in order to acquire more robust statistics. It also was noted that it may be possible to use the national accounts or an input-output framework to examine the scale of the trade-related issues (change in shares of imports used in manufacturing).

In the context of the **Commercial** sector**,** the discussions centered around the need for an activity measure for the commercial space that has supporting data. Although no solutions to these data challenges were revealed, exploring the possibility of making a special request to the economic census or using purchased private data from organizations such as Costar were suggested.

In the context of the **Residential** sector, the discussions centered around available options to account for activity measures and whether they were worth exploring. Some discussion focused on other activity measures, such as energy per capita, but there was tentative agreement that if you had to choose just one activity measure, the square footage of occupied housing units was still the most appropriate physical measure for capturing energy efficiency. However, the American Housing Survey is eliminating this question, thereby increasing the difficulties of developing annual time-series data. The detailed meeting notes on which these Sector Summaries are based are found in Appendix A of this report.

Overview of EII

David Belzer, a retired Senior Economist with PNNL who served as the principal investigator for EERE's EII efforts since its launch in 2002 through 2017, provided an overview of the process. Mr. Belzer's overview included information about the current EII methodological approach and the corresponding rationale for selecting the LMDI approach for developing the index. He also presented preliminary economy-wide EII results through 2017, which imply that U.S. energy intensity in all sectors has declined

[2] Note that Stacy Davis, lead analyst for ORNL's Center for Transportation Analysis, was not able to attend the workshop. Her input was solicited via e-mail.

by 18% since 1985. Selected slides from Mr. Belzer's overview presentation are provided in Appendix B of this report.

Key Take-Aways

Key workshop decisions and take-aways were related to activity measures, selective data aggregations and refinements, treatment of renewables, base year changes, international trade, and electrification, as described below.

Activity Measures

The energy intensity indicators, in their current form, provide indexes of sectoral energy intensities based on physical activity measures (with the major exception of the use of a deflated value of production as the activity measure in the industrial sector). Each of these activity measures (e.g., commercial building square footage) was reviewed in terms of its appropriateness and data availability. No specific changes were recommended for these measures, but alternative categories of metrics that could be considered when measuring efficiency were noted, as follows:

- economic measure using some disaggregated GDP metric
- physical measure, like tons of steel or paper production
- service measure, like population or occupied housing units.

Future efforts could examine the interplay between these types of measures in more detail.

Selective Data Aggregations and Refinements

A number of refinements related to data aggregation approaches and sources were recommended:

1. A lower level of disaggregation for some NAICS data in the manufacturing/industrial sector was recommended for some of the more energy intensive sectors, including the chemical and steel industry. Lower-level disaggregation could be considered for paper and some food-related sectors as well.
2. Use the Manufacturing Energy Consumption Survey (MECS) to develop the relationship between plant-level fuel costs to examine how much error is introduced into the model. The U.S. Environmental Protection Agency's plant-level greenhouse gas (GHG) database may offer a source of methods of imputations.
3. Gross output versus value-added data could be examined to see if there are trends in heavy industry with regard to its purchases of inputs from other sectors that may be influencing the final numbers.
4. ORNL's freight analysis data, based on the CFS, might be useful to answer questions like whether energy consumption is a function of long haul or short haul.

Treatment of Renewables

It was recommended that growth in the share of central generation renewables could be captured as a structural shift in the electric generation sector.

Base Year Changes

It was noted that if modifications of the intensity indicators were going to be implemented, then this would be an appropriate time to consider implementing a new base year. A new base year would allow us to add geographic granularity and other new considerations without having to "go back" to the 1960s. Several participants suggested using the year 2010 for the following reasons: (1) it would be a good post-recession starting point, and (2) picking 2010 would allow us to focus on current issues and facilitate the data-collection effort going forward.

International Trade

There was agreement among workshop participants that consideration of trade (i.e., imports and exports) could have important implications with regard to how we think about energy intensity. However, although this is an interesting and important topic, experts in the field cautioned DOE about making an immediate move in this direction, because this is a very dynamic field and methodological questions around this topic are currently being debated by experts in the field. Changes in the value added vs gross output in material-intensive sectors could answer the question regarding importing relatively more energy intensive materials.

Electrification

There was some discussion regarding how/if the move toward electrification could be explicitly accounted for as part of the intensity indicators. Eventually, this will become a more important issue in the development of intensity indicators related to vehicle transportation. This trend could be captured as a structural shift in the electric generation sector, but no firm decisions were made in this regard.

Appendix A – Detailed Meeting Notes

Meeting Notes from Day 1 (Tuesday, January 28)

Attendees in the room: Dave Belzer (DB), Olga Livingston (OL), Ookie Ma (OM), Gale Boyd (GB), Mark Curtis (MC), Jeff Dowd (JD), Collin McMillan (CM), Stacy Angel (SA), Erin Boedecker (EB), Dave Anderson (DA), and Sumitrra Ganguli (SG)

Attendees on the phone: Sadie Goulet (SG) and Katie Cort (KC)

I. Opening Remarks (provided by OM)

Ookie Ma (OM) provided the opening marks and introductions focusing in on the following key questions: (1) What can we do to adjust the methodology to match the trends that we are currently seeing? (2) Should we be radically changing our approach?

Recognizing that Energy Use/Gross Domestic Product (EU/GDP) is not very representative, he asked:

- What are some of the alternative measures?
- What specific units should be considered to measure intensity?

OM also emphasized that there are three important components of the current methodology that we want to address during this workshop: activity measures, structural factors, and units of energy consumption.

II. Energy Intensity Indicators Background Presentation (presented by DB) and Ensuing Open Discussion

David Belzer presented information on the current EERE EII approach and provided background on how the approach was conceived and how it's evolved. Some of the key topics are listed below and a selection of slides from his presentation are found in Appendix B of this report.

- The EERE system of energy intensity indicators was initiated in 2002 in response to interest in tracking overall progress in U.S. energy efficiency.
- An initial expert workshop focusing on methodology development was conducted in 2002-2003.
- Both EERE and the Energy Information Administration (EIA) currently maintain efficiency indicators in the U.S.
  - Key differences: The DOE/EERE system (1) develops annual estimates with diverse data, and (2) applies a decomposition method to separate structural elements from efficiency. EIA focuses on metrics from its own end-use surveys, where the end-use surveys are typically completed at intervals of three to four years (intermittently completed for the Residential Energy Consumption Survey [RECS] and Commercial Buildings Energy Consumption Survey [CBECS]). In addition, the EIA does not perform decomposition analysis.
  - EERE took on the analytical challenge of developing EII because the data needs, particularly at an annual frequency, were beyond what EIA was able to use in meeting its own standards of data quality. (JD)

Some general discussion and questions were raised after the presentation including:

- Should productivity be reflected in an efficiency measure? There is a need to decide what to include and not include. (DB, GB, OM)
- Could we consider capital intensity or capital productivity as an alternative measure of efficiency? (GB and OM)
- Energy use intensity declines as a function of building size. Does this introduce an undesirable bias in the intensity trends, particularly in the residential sector? (OM)
- Do more energy-efficient firms grow faster?
  - What data can be used for this type of analysis because reported data are tweaked/altered; how does one highlight these trends and questions? It all depends on the level of the granularity of the data that you have. In this context, is plant-level data useful? Yes, but you will be answering different questions; the goal of these indicators is not just about energy efficiency in and of itself but also about what other questions might they answer about the economy. (GB, MC)
- Who is the end user for this research? To increase public awareness about energy efficiency, i.e., track trends, the objective is to see if DOE energy efficiency goals that were set have been/are being met (i.e., to inform high-level policy-makers and the public) and allow us to make international comparisons. (OM, JD)
- Should we consider resource Intensity beyond energy? (GB)
  - The Environmental Protection Agency (EPA) maintains carbon intensity indicators (GHG inventory). Can we use their input to improve our metric? (GB)
- In the context of index numbers, it is important to note that picking a different denominator means asking a different question. For buildings the service of a building could be measured by something physical or value based. It depends on what we want to be measuring as efficiency. (GB)
  - For example, in the residential sector one could use rental value of home, which could be assigned a GDP or $ value. When compared to using square feet, this does not imply a home's value is based on size. Compared to using occupied housing units the rental value approach does not "favor" homes that have more occupants. The rental value measure approach is a way of measuring the service of housing and could include all the values of housing like size, quality, and location. (GB, OM)
  - Physical metrics were decided on a per square foot basis during the last workshop (in the early 2000s). (DB)

III. Transportation Sector Discussion

The first sector discussed was the transportation sector. DB indicated that activity measures in transportation lead to a data problems because overall vehicle miles are obtainable, but passenger miles have to be imputed. Other points and questions brought up during the transportation discussion include the following:

- We need to talk to ORNL (Stacy Davis) about the difference between their implied miles per gallon and the highway statistics. ORNL shows fuel use going down and the highway stats show it going up. (DB)
- Activity measures should be reconsidered based on how we define efficiency. What do we really value going forward in transportation? There was a consensus that the activity measure needs to be

able to be supported by data and an acknowledgment that in transportation there are limited occupancy data.

  - Is it miles that we are valuing or trips? (OM, GB)
  - Airlines were mentioned as an example. Should load factor be affecting what we consider air transport efficiency? (GB, DB, DA)
    - Available sources may be able to provide occupancy data and this would allow us to address the extent to which planes are full/empty—information that is critical in assessing efficiency in the context of not only a single airplane but the system (airlines) in general.
    - We need to understand what the question is: system-level efficiency (airline system) vs individual efficiency (just one plane). Once the question has been framed relative to what we are trying to address, there will be no need to decouple demographics from the activity measure. Note: It is possible to isolate load factors from structural factors. (GB)

- In the existing EII, what are the current air travel and transport handled? How are we currently capturing domestic vs international? (OM)
- Should demographic changes be included within the transportation structure? Factors like an aging population or people having children later in life could affect the miles driven, but not necessarily mean that we are getting less out of the transportation sector. (OM)
- There is a need to account for flexibility in terms of the modes of transportation. The flexibility provided by trucking may be the reason its share of total transport ton-miles has increased over time. Typically, flexibility in modes of transportation is affected more with higher value commodities, so there may be a need to disaggregate transportation modes further to understand what is contributing to these shifts/changes. (GB)

IV. Industrial/Manufacturing Sector Discussion

The industrial/manufacturing sector discussion was primarily centered on the following four questions/points.

1. Are we outsourcing our energy use within the accounting for intermediate inputs? Should the U.S. EII only account for domestic energy used in the production of final goods?
    - Trade could be an additional sector that would be difficult to include but would capture this effect. (MC)
    - Components of final and intermediate goods would have a different energy intensity. Explain the structural component by focusing on trade as a driver, an example being the steel industry. (GB)
    - Input-output data/accounting approaches separate financial flows between domestic and imports in high sectoral detail, but significant effort is required to further convert these financial flows into energy measures. (OL, GB)
2. Resource prices drive a lot of what is happening in manufacturing. Because of natural gas prices, the U.S. produces ammonia now after 20 years of manufacturing dormancy. Does this mean that we are less efficient? No. (GB)
    - For future efforts, look into regional fuel prices to do identify regional trends and shifts in manufacturing at a high level. (GB)

3. Would a lower level of disaggregation for some series help isolate EII trends?
    - Going from a three- to six-digit NAICS for some of the more energy intensive sectors was suggested. The first priority would be chemicals, then steel, then maybe paper or food-related sectors like corn refining or sugar. (GB)
    - We could obtain activity measures for industrial sector from the U.S. Bureau of Labor Statistics (BLS) price deflators. (GB)
    - To implement industrial sector analyses at a micro level some researchers have used regression-based imputation model. (GB, MC)
4. Which data should be used for electricity consumption?
    - Purchased energy should be the focal point for purposes of this study. (GB)
    - Use of self-generated biomass should be included. If the production process generates byproducts like bio-waste, they should be treated as an improvement in energy efficiency. Cogeneration is an efficiency, because you are taking out less electricity from the grid. Cogeneration is explicitly accounted for in EIA, so it should be included in the analysis. (GB)

V. Electric Generation Sector Discussion

The electric generation sector relies on analyses and data from the EIA. The discussion for this sector centered primarily on questions concerning the treatment of DERs, the treatment of renewables (if they are construed as being an improvement in efficiency), and accounting for T&D losses.

- Distributed generation could be treated similar to cogeneration—as an efficiency improvement. Does this approach really address improving efficiency in the use of electricity?
    - Distributed generation is handled in this sector, and not as a reduction in the residential/commercial sectors. What about T&D losses? Onsite generation would have less loss, and it would be captured in the difference between site and source intensity within the commercial and residential sectors. (DB, GB).
    - DER generation should be handled within this sector and not treated as site efficiency. (DB)
- Adding renewables improves efficiency because of the avoided use of non-renewable generation. There is no need to de-couple efficiency and renewables. (GB)
- EIA has small-scale solar estimates now available. (SA)
- EIA publishes statistics that use both the fossil fuel equivalency and captured energy approaches to convert noncombustible renewable electricity in from kilowatt-hours to British thermal units in Appendix E[3] of the Monthly Energy Review. A *Today in Energy*[4] article also discusses these conversion factor approaches. (SA)
- Since renewables are not using non-renewable "resources" could we reflect their usage as a straight-line improvement in efficiency?

[3] See https://www.eia.gov/totalenergy/data/monthly/pdf/mer_e.pdf.
[4] See https://www.eia.gov/todayinenergy/detail.php?id=41013.

  - There is agreement that renewables do not deplete a resource to produce electricity, but no agreement on treating it as a 0. Assign some different way of treating electrons made using fossil energy or not?
  - Should the shift to renewables be a structural change? Should only the actual generation equipment improvements be captured as improvements in efficiency?
- EIA's small-scale solar estimates are monthly and annual, starting in data year 2014. (SA)
- There is a need to capture the efficiency of the generation technology itself; it needs to be included within the accounting scheme. (GB)
- Do we need to attribute T&D losses to end-use sectors? The current approach using source energy does this.[5]

VI. Commercial Sector Discussion

Commercial sector discussions centered on the following topic areas:

- Delivered energy can be used for the end uses and include T&D losses in the electric power sector. (DB)
- An alternative to using floorspace as an activity measure could we use the ratio of gross commercial product to floorspace as an activity measure? (GB, OL)
- The census may have information that could be used; there is an option to make a special request for the economic census. However, OM noted that obtaining this level of census data may not be a viable option because there are legal complications involved with a request like this (from DOE to Census Bureau).
- Costar data gives floor space numbers by geography. (OM)

VII. Residential Sector Discussion

Residential sector discussions centered primarily on how to best capture the activity measure for this sector.

- It would be more representative to disaggregate single-family detached housing from all housing; however, the data are not available to break out these housing features, and it likely not a significant quantitative issue. (DB?)
- Renewable energy credits (RECs) end-use data could be used to disaggregate space conditioning and other end uses. (GB, OL)
- There may be better activity measures to use than square feet; this again points back to the question of what we value as the service of housing.
  - Alternative activity measures are included in the current approach. Intensity indexes based on occupied households and residential floor space are available from the indicators framework. (DB)

[5] Note that this topic was tabled for further discussion, but time limitations prevented an in-depth discussion of this topic.

- Imputed rental value is an activity measure worth investigating, because it should be representative of what is valued as a service within housing. (GB, DB)
    - Imputed rental value can be implemented in the commercial and residential sector because the market exists, but not in the transportation sector.
- We could use demographic data from the American Housing Survey to the determine impacts of various demographic factors on energy use. The American Community Survey (ACS) – household size data (i.e., number of persons in household), for example, could be used to impute information about demographic groups to refine analysis. (GB)

Meeting Notes from Day 2 (Wednesday, January 29)

Attendees in the room: Dave Belzer (DB), Ookie Ma (OM), Mark Curtis (MC), Collin McMillan (CM), Erin Boedecker (EB), Dave Anderson (DA), and Sumitrra Ganguli (SG)

Attendees on the phone: Gale Boyd (GB), Olga Livingston (OL), Jeff Dowd (JD), Sadie Goulet (SG), and Katie Cort (KC)

I. Presentation by Beng Ang

See selected slides in Appendix B.

II. Open Discussion

Renewable Generation

- OM agreed with Ang's approach to how he treats renewables. At some point we will have to decide how to treat renewables.
- Current EII methodology remains consistent with EIA's treatment of renewables. If renewables were to become more efficient over time, this would just be captured in the current model (DB).
- GB thinks, as does Beng Ang, that the shift to renewables should be captured in the structural shift and this could be sufficient, but is still bothered by the inability to capture the functional improvements (changes in total factor productivity) in renewables as part of this trend. There are big changes in wind and solar coming and this should be captured in this system.
- OM: If we calculated indicators on a pseudo-GDP basis—where the activity measure was in dollars—would this capture some of these system improvements?
- How do we treat changes in the electricity sector? (GB)
    - GB has thoughts about this and is going to try to work out calculations on this, but sees a potential alternative to what we and Ang have been doing, and would like to produce another option for this so that we can capture the improvements of renewables.

Imports and Exports

OM: Should we do a side case study for imports and exports where we can see the order of magnitude on the impact? Should we be adding a trade sector? Is there a simpler way to adjust the national accounts data to strip out the imports? The input-output data would break these financial flows apart so

we could separate imports and exports clearly. Is looking at value added as the activity measure the answer to get around this question?

- Changes in the value-added vs gross output in material-intensive sectors would answer the question, have we been importing relatively more energy intensive materials? (GB)
- There are tools (e.g., IMPLAN) that have these data; we just have to be consistent in treating the data throughout the analysis (OL).
- Accounting for imports/exports and outsourcing takes more to address than a small tweak in the index number approach (GB).
  - For example, consider how we might account for something like hotels outsourcing laundry to make energy-efficiency improvements within the hotel business. (OL)
  - We might see the flip side about to occur in the chemical industry as we have a trend toward "onshoring" certain lines of production. (GB).
- According to MC, this issue of how to deal with imports/exports and the possibility that we are outsourcing energy-intense production is currently being addressed by top trade economists. We might do a little research to see who is looking at embodied energy intensity in trade and track the progress in this area.

Distributed Generation

GB: To model DERs, we need to account for some stylized facts. Specifically, (1) Do we have reason to believe that DER's share is changing in the mix of energy sources? (2) Is DER energy intensity increasing or decreasing and (3) How does the growth rate of DERs compare with the growth rate of central power? So, a preliminary analysis is suggested to answer these questions so that we know if we need to include [what], and then tackle how to include it. If cogeneration is treated as efficiency, should DERs also be seen as an efficiency improvement?

2010 Base Year

- DB mentioned that if we are going to add a lot of new things then we should definitely consider implementing a new base year; e.g., 2010 post recession would probably work as a good base year. Implementing a new base year would address how we are doing lately and allow us to focus on addressing the new questions and new phenomena facing us now. We hope different issues today, compared to 1980s–1990s, and EII will shed light on current issues. Picking 2010 will allow us to focus on current issues and those going forward. We can add geographic granularity and other new considerations without having to "go back" to the 1970s.
- OL thought 2010 is the last calibrated (i.e., not estimated) year for the Annual Energy Outlook.
- It might be worth looking into starting with a new base year and looking into what factors might be considered when setting up a new post-recession base year.

Forecasting

Include forecasting as part of considerations relative to budgetary concerns. (OM)

III. Recap and Unresolved Topics Discussion

Sector-Related Recap

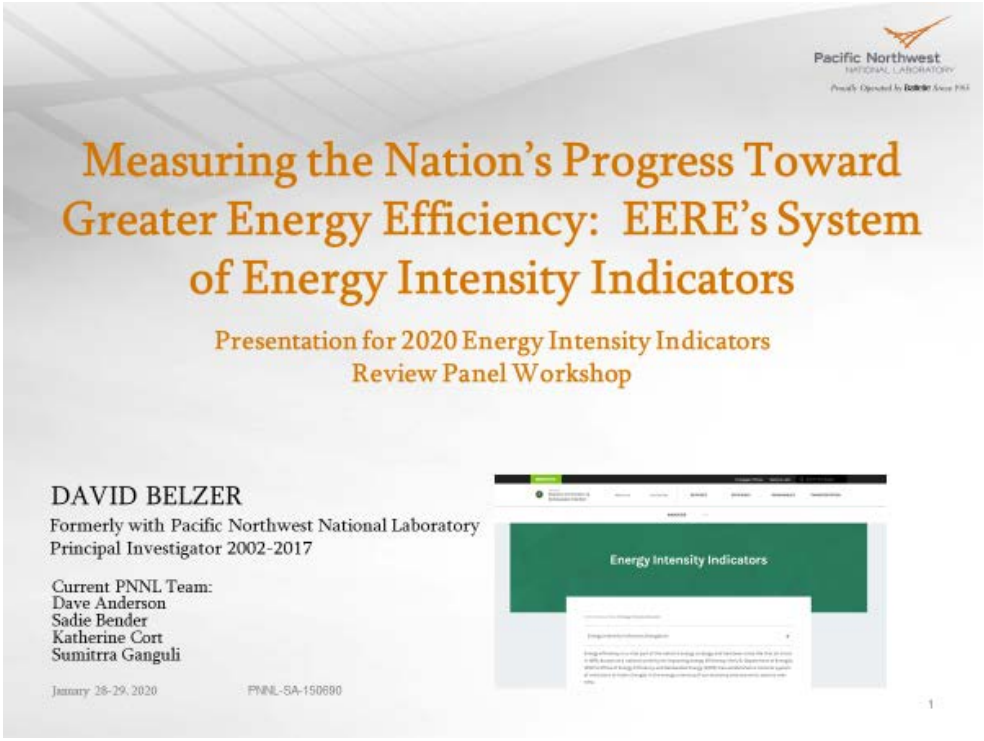
- **Residential:** In the context of the residential sector it was generally agreed that if one activity measure needs to be chosen, floor area is the best proxy for energy efficiency (question addressed to Beng Ang after his presentation).
  - GB: I am interested in seeing what can come out of ACS vs RECS; we should be looking at what we can get out of ACS. ACS would be helpful with the new 2010 base year.
  - OM suggested that the residential sector analysis should try to isolate fixed energy and weather-dependent energy, using the weather data and the EIA monthly data and on a per capita basis (not on a square foot basis) (Data Source: Oregon State University (OSU) maintains the prism database with weather data and a state-wide temperature map.)
  - OSU does collect **climate data** across the U.S.; their database is the current best option for weather data, but it does not include Alaska or Hawaii. DB mentioned he had tried to use the OSU database in the past. Should we consider changing the standard degree-day baseline of 65 degrees?
- **Transportation**: Truck Freight – DB suggests before doing something new we need to reconcile the Oak Ridge and Highway department fuel efficiency discrepancy.
  - GB said that the CFS has data that might be useful to answer questions like whether energy consumption is a function of long haul or short haul, and that accounting for these confounding variables might improve the final estimates. These data also include NAICS codes and route information to facilitate further sectoral and spatial disaggregation.
- **Manufacturing:** Mining – disclosures and withheld data. DB says we should table mining and focus on manufacturing. The general recommendation was to look at gross output vs value added to see if there is something there worth exploring further; are we importing energy intensive intermediate goods?
  - Is it possible going forward to use the level of aggregation that National Energy Modeling System uses? Chemicals and a few other sectors might need more disaggregation, but everywhere else aggregation could be left at the three-digit level. Disaggregate the more energy intensive sectors to the six-digit level. (GB)
  - BLS price deflators for industrial – We could get activity measures from them. Chemicals would be of first priority to break out, then steel, maybe paper next, or a couple food sectors like corn refining or sugar? (GB)
  - MECS has information only for 2010 and 2014. To extend the series, take the MECS data, add three-digit energy consumption, and link it to the BLS output and purchased fuels from the Annual Survey of Manufacturers. (GB)
  - Other general suggestions related to the manufacturing sector:
    - (GB) Do everything at the micro level.
    - (GB) Do multiple imputations.
    - (GB and MC) Develop a regression-based imputation model.

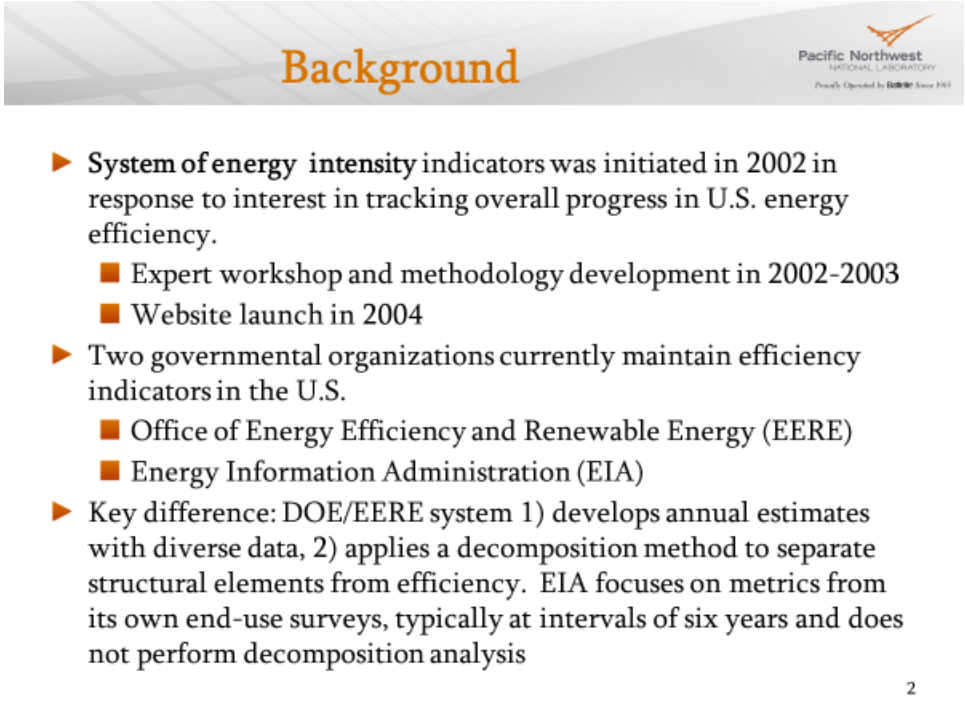
- (GB and MC) Determine how much error to introduce into the model; use MECS to develop a relationship between plant-level fuel costs.
- Collin McMillan's work on GHGs is a source for a method of imputations. (CM)
- Investigate gross output versus value added to see if there are trends in heavy industry that are influencing the final numbers. See if growth rates across sectors are having any effect on the final numbers. (OM, GB)

Other General Comments/Unresolved Questions/Concerns

1. A different approach to constructing the index could use "consumption" of goods and services, but the residential sector would pose the greatest problem in this case, because residential consumption of energy is difficult to isolate. However, Canada has come up with a method to identify and isolate energy use by device type in each home.
2. According to DB, energy losses ought to be treated as consumption of energy.
3. There is a general consensus on not accounting for the capacity utilization factor in the numbers; the time and effort it will take to isolate the cyclical components from the trend are not worth it.

Appendix B – Selected Slides from the Energy Intensity Indicators Overview





Who Has Used the EERE Indicators?

- Highest profile user has been Council of Economic Advisors, leading to display of economy-wide intensity index in the 2013 *Economic Report of the President*
- Other users have included non-governmental research groups, such as:
  - Federal Reserve Industrial Output Index
  - Climate change advocacy group in California
  - Sustainability organization in the U.K.
- DOE has used supporting data estimates or savings derived from the indicators
  - AMO office has sought to estimate autonomous energy efficiency improvement for total manufacturing
  - EERE used indicators to estimate quantity of U.S. energy savings from specific points in time

4

Methodological Approach

- **Energy Intensity** measures are developed first at a disaggregated level (Ex: Energy/ton-mile water freight)
- As the indicators are built up to more aggregate sectors, the multiplicative version of the Log Mean Divisia Index (LMDI) method is employed (*Energy Journal*, BW Ang & KH Choi, 1997).
- The LMDI provides an exact decomposition of Total Energy into three separate factors throughout the hierarchical system: Activity, Energy Intensity, and Structural Factors
- Total energy is converted to an index with a specified base year: *Total Energy Index = Activity Index x Component-based Intensity Index x Structural Index*
- The LMDI indexes are all "chain weighted": 1) independent of choice of base year, 2) the weights are based on energy use, so that indexes can combine very different types of activities

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Structural Change: Key Points

- Defined as any factor that does not reflect underlying change in energy efficiency at a detailed level
- The most common source is from compositional changes among specific activities with very different intensities
  - Examples: 1) average energy per ton-mile increases with greater share of freight hauled by trucks, 2) fuel use per sq. ft. (for heating) declines with greater share of U.S. population in South census region
  - Key point: this element of structural change is only an artifact of ability to aggregate activities into like units

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Major End-Use Sectors

Economy-wide

Transportation	Passenger: (Energy/passenger-mile) Freight: (Energy/ton-mile)
Industry:	Energy/Gross output ($2012 chained dollar)
Residential:	Energy/Square foot of occupied housing area
Commercial:	Energy/Square foot of building floor space
Electricity:	Energy/Kilowatt-hour of generation

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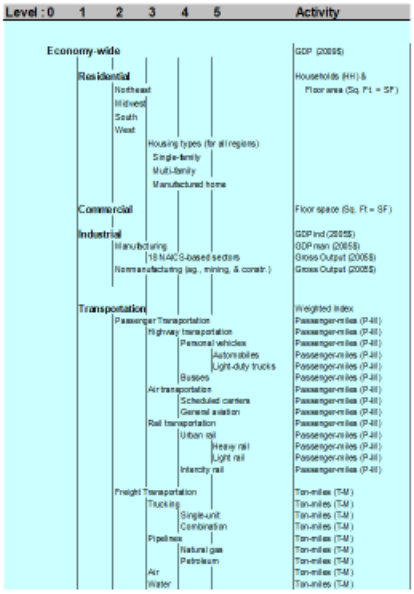
Hierarchical Organization

- The framework develops disaggregate energy indicators at the sector/sub-sector level. These indicators are nested upward to estimate an economy-wide indicator
- LMDI approach ensures consistency among levels of hierarchy
- The structural and intensity indexes from a lower level are used in constructing the indexes at the next highest level



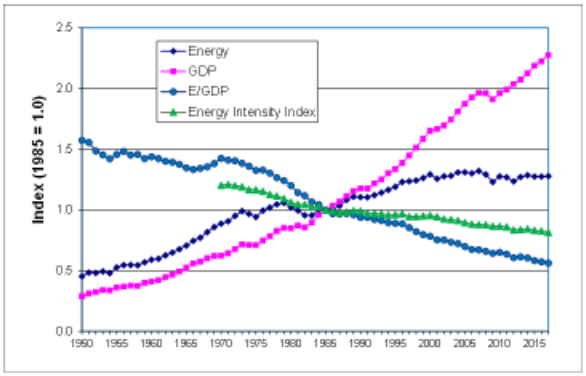
Multiple Energy Measures Used to Define Energy Intensity

- *Electricity (retail sales) Intensity*
- *Fuels (including renewables) Intensity* (= "primary" in AER, MER)
- *Delivered Energy Intensity*—uses *delivered energy* = electricity sales + fuels for major sectors (the four major end-use sectors—transportation, industrial, residential, and commercial—as well as electricity generation)
- *Source Energy Intensity*— uses *source energy,* which attributes both electricity sales *plus electricity* generation and transmission losses to the four major end-use sectors ("source" rather than "total" or "primary")
- *Adjusted Source Energy Intensity with Electric Utility Intensity Held Constant*— holds the electric utility intensity (losses/sales) constant, providing a more accurate indicator of the source energy intensity change that can be attributed *solely* to efficiency improvements within the end-use sectors

Economy-wide energy efficiency change: Preliminary Update to 2017

Pacific Northwest NATIONAL LABORATORY

- Economy-wide intensity index in 2017 shows 18% decline in energy intensity, since 1985
- Simple E-GDP ratio would suggest a decline of 44%
- Preliminary Update for Discussion Purposes Only



2015-2017 Results are Preliminary
NOT FOR CITATION

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Issues with Energy-GDP Ratio as Basis for "Energy Intensity Index"

Pacific Northwest NATIONAL LABORATORY

- E-GDP ratio contains a myriad of structural factors pertaining to the composition of GDP and geographic shifts.
- Major "apples and oranges" problem: Household use of energy for buildings and personal vehicles not included in GDP
- Service sector intensity influenced by productivity improvements linked to computerization and internet – no direct linkage to "building services" energy efficiency as normally defined by EERE (commercial sector energy use per square foot).
- Energy in E-GDP ratio includes energy for materials (e.g., asphalt, petroleum feedstocks) and military jet fuel

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