U.S. Energy Intensity Indicators: Overview and Key Data Challenges

Presentation to the IEA Workshop on Energy Efficiency Indicators

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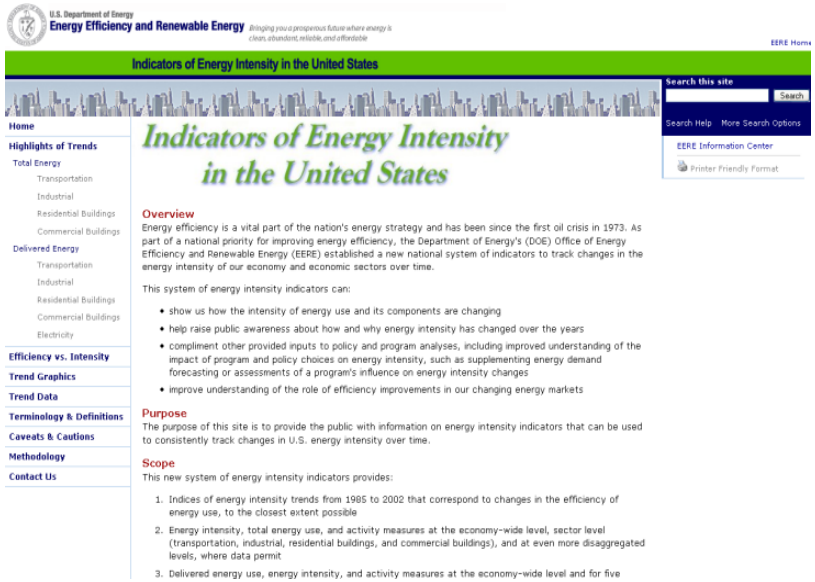


Background

- **System of energy intensity** indicators was initiated in 2001 in response to the new Bush administration's interest in tracking overall progress in U.S. energy efficiency.
  - Expert workshop and methodology development in 2002-2003
  - Website launch in 2004
- Two governmental organizations currently maintain efficiency indicators in the U.S.
  - Office of Energy Efficiency and Renewable Energy (EERE) in the U.S. Department of Energy (DOE)
  - Energy Information Administration (EIA), U.S. Department of Energy
- Key difference: DOE/EERE system develops annual estimates with data from many sources and applies a decomposition method to separate out structural elements to provide a more accurate measure of intensity associated with energy efficiency improvement; EIA focuses on metrics from its own end-use surveys, typically at intervals of three to four years and does not perform decomposition

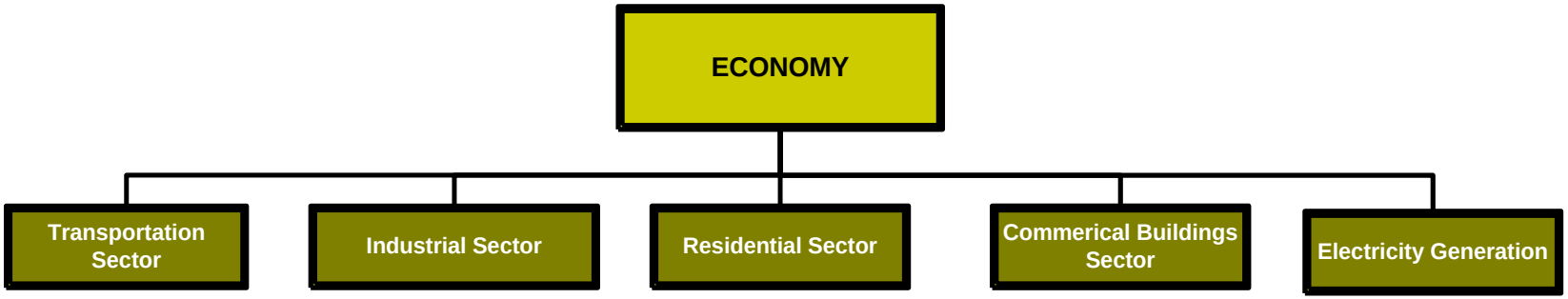
Methodological Approach

- **Energy Intensity** measures are developed at a disaggregated level, limited by the availability of consistent historical and currently published data. (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 (Ang & Liu, 2001).
- The LMDI provides an exact decomposition of total energy into three separate indexes throughout the hierarchical system: Energy Intensity, Structural Factors, and Activity
- Intensity indexes are energy-weighted averages of indexes from lower levels of aggregation (termed "component-level")

U.S./EERE system provides energy intensity trends by major end-use sectors

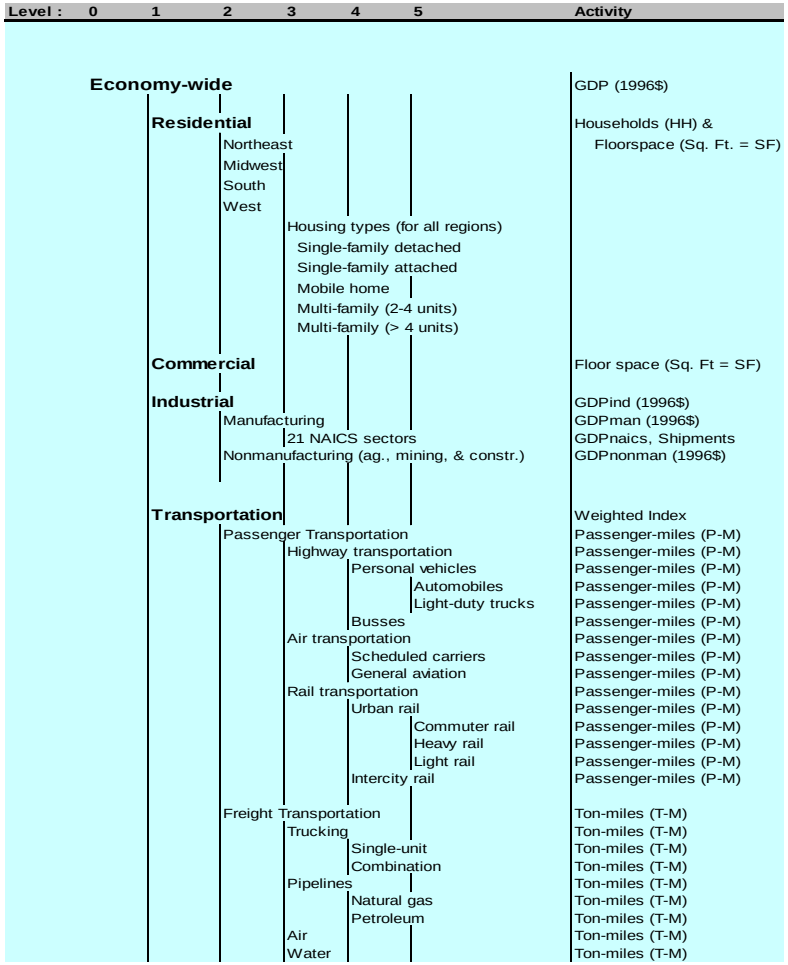
Economy-wide

- Transportation: Passenger: (Energy/passenger-mile)
- Freight: (Energy/ton-mile)
- Industry: Energy/Gross output ($2005 chained dollar)
- Residential: Energy/Square foot of housing area
- Commercial: Energy/Square foot of building floor space



U.S. energy intensity indicators are organized in a hierarchical manner

- The framework develops disaggregate energy indicators at the sector/subsector level. These indicators are nested upward to estimate an economy-wide indicator
- LMDI approach ensures consistency among levels of hierarchy

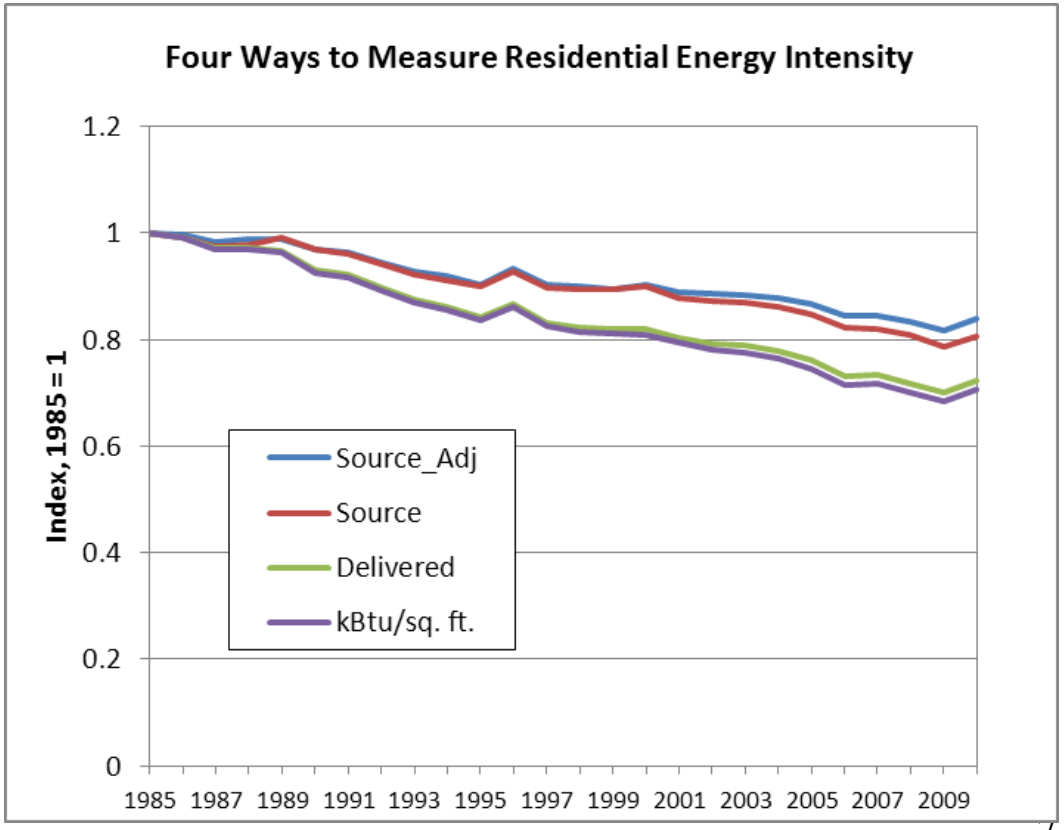


Multiple energy measures are used to characterize energy intensity, providing comparative insights of intensity changes by sector

- ***Delivered Energy Intensity*** —employs *delivered energy* which excludes electricity generation and transmission losses . Intensity indexes are constructed for five major sectors (the four major end-use sectors—transportation, industrial, residential, and commercial—as well as electricity generation)
- ***Source Energy Intensity*** — employs *source energy* which attributes both electricity sales *plus electricity* losses to the four major end-use sectors
- ***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

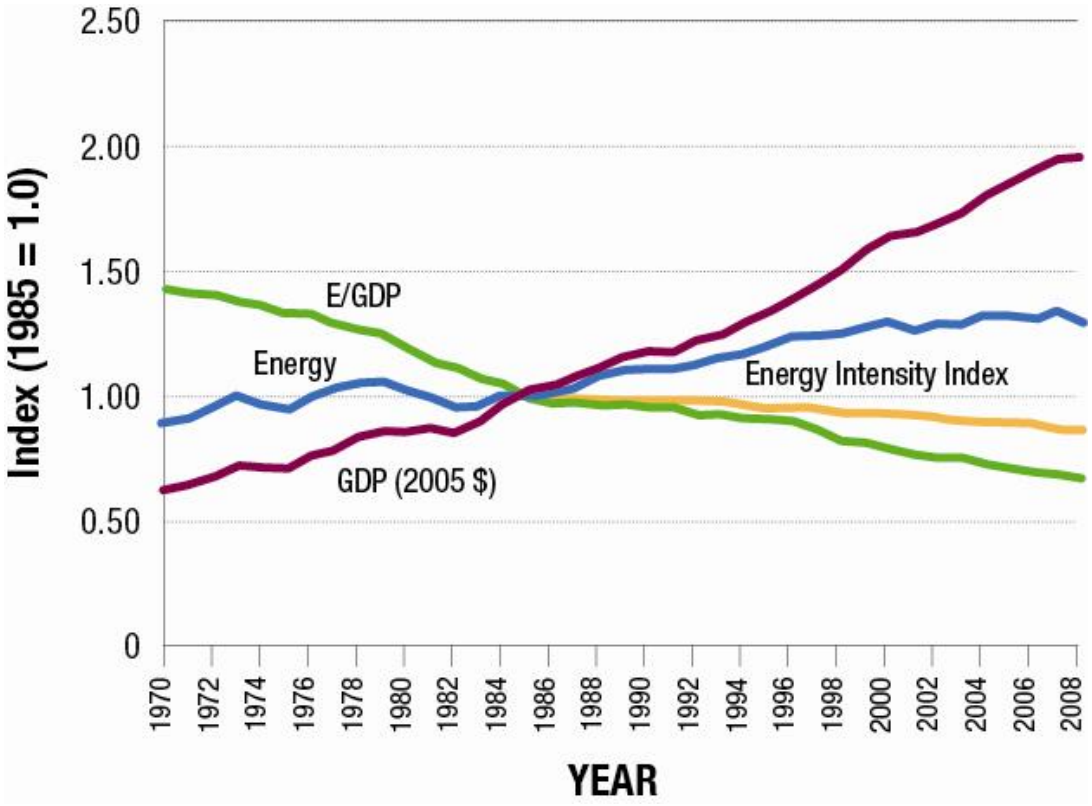
How energy is measured is important for knowing the true change in energy intensity

- Intensity measure based on simple E/A ratio could be misleading (lowest purple line)
- Most accurate measure is factorized intensity index based on source energy and adjusted for electric utility efficiency improvements (top blue)



Economy-wide energy efficiency change (simple E/GDP ratio vs. Intensity index)

- Economy-wide intensity index shows 15% decline in energy intensity, since 1985
- Simple E/GDP ratio would suggest a decline of 33%
- But 15% is a more accurate measure of the intensity change tied to improvements in energy efficiency; the intensity index excludes structural factors unrelated to efficiency



Overall Data Challenges Related to Intensity Indicators

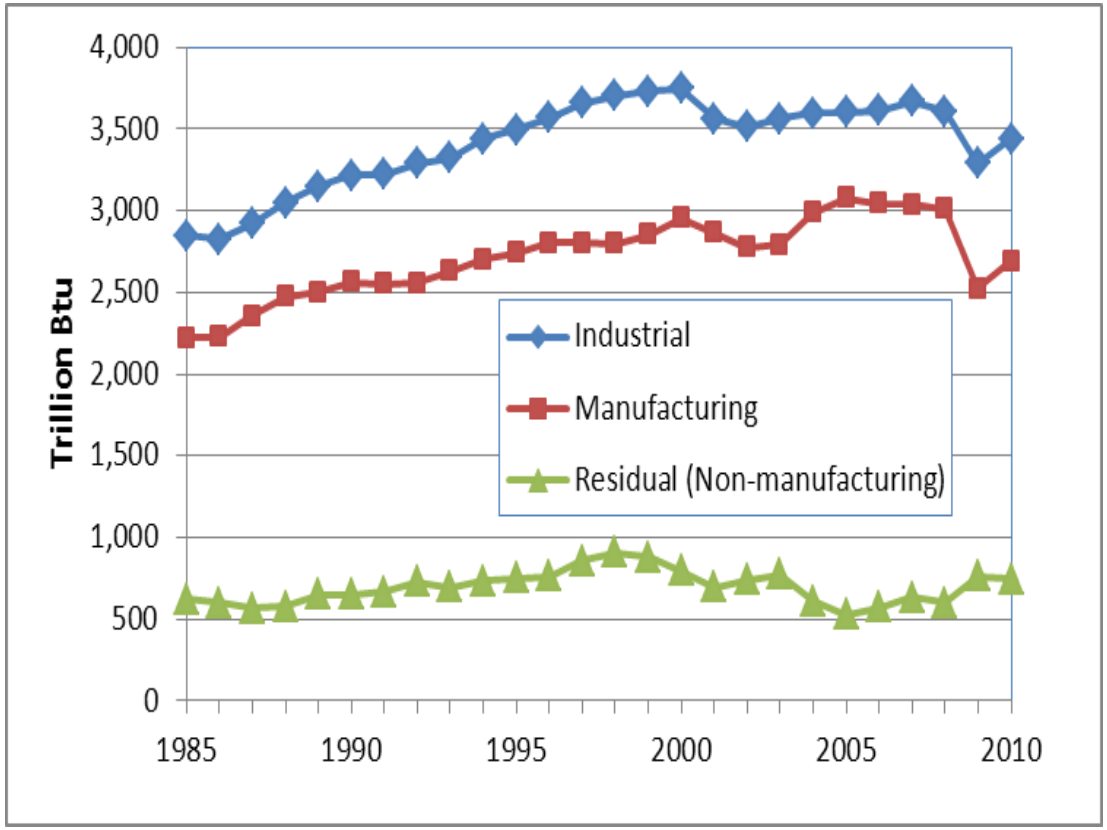
- Incompatible sources for energy consumption, generally supply-side ("administrative") vs. end-user reporting
- Lack of annual *quantity* data for energy consumption at desired level of detail
- Unavailable or inconsistently-measured levels of activity from which to construct intensity measures
- Appropriate methods of weather adjustment are challenging

Consumption Data Issues

- Statistical data collection system in U.S. related to energy consumption involves four basic sources:
  - Energy Information Administration – Periodic end-use surveys
  - Energy Information Administration – Supply-side sources (e.g., utilities)
  - U.S. Commerce Department – Periodic census and annual data related to general economic activity, but includes collection of some energy data
  - Other: Other regulatory agencies (primarily transportation), and private trade associations
- Scope: Energy intensity intended to measure energy as production input. Thus, exclude: 1) non-fuel use in the industrial sector, and 2) military consumption of jet fuel, 3) non-building commercial energy use
- Sector-level boundaries: Industrial vs. Commercial

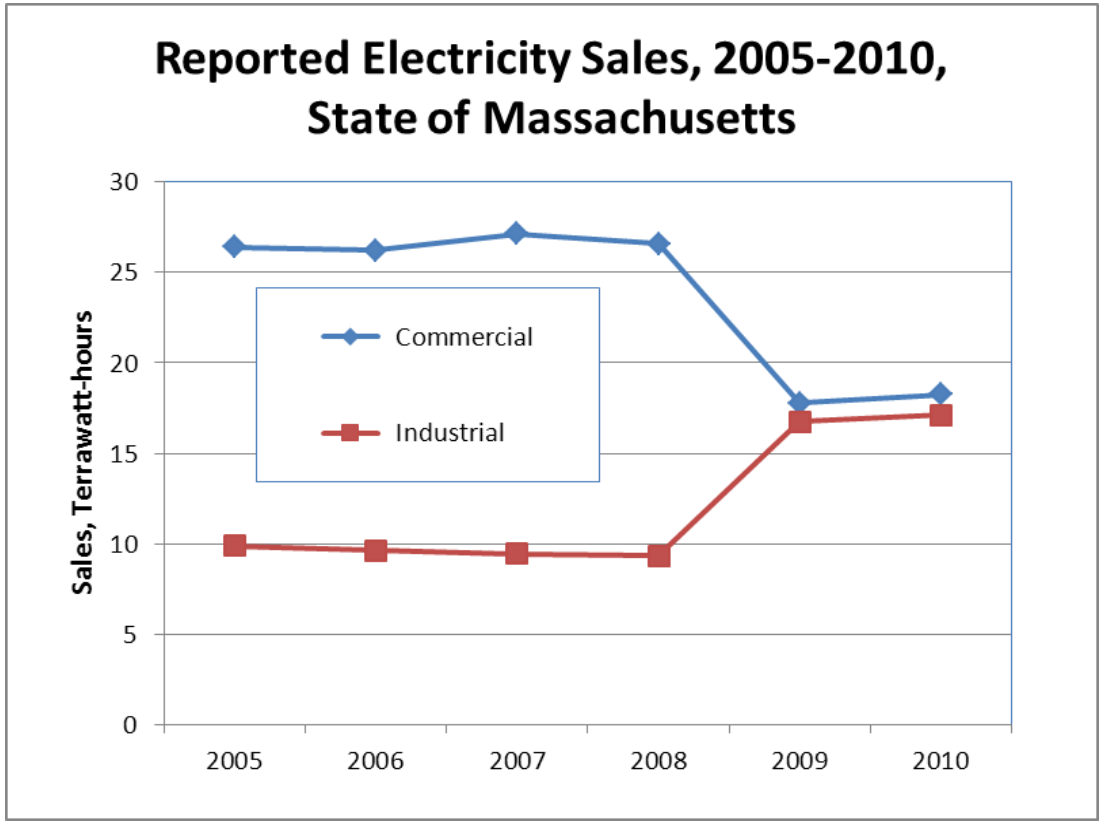
Supply-side vs. End-user Reporting:
Electricity Use in Nonmanufacturing

- U.S. EIA reports industrial electricity use from comprehensive electric utility survey
- U.S. Census Bureau data for manufacturing electricity use – reported by establishment
- No annual data for non-manufacturing: agriculture, mining, & construction
- Residual approach yields implausible values



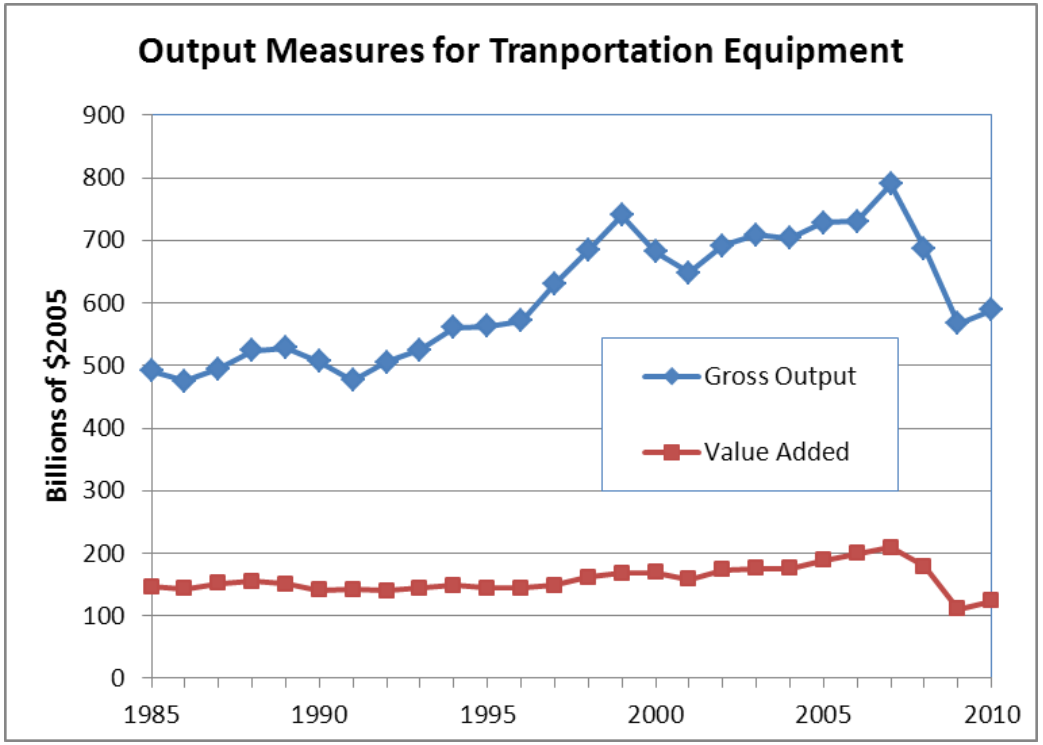
Customer Reclassification by Utilities

- EIA annual survey of all U.S. electric utilities, with reporting of sales by end-use sector
- Issue is reporting by rate class, rather than economic activity of customer. Rate structures change (e.g., from utility mergers), moving customers generally between industrial and commercial classes.
- Reclassifications may lead to bias over time (add ~4.5% to 2010 industrial electricity use now reported as commercial)



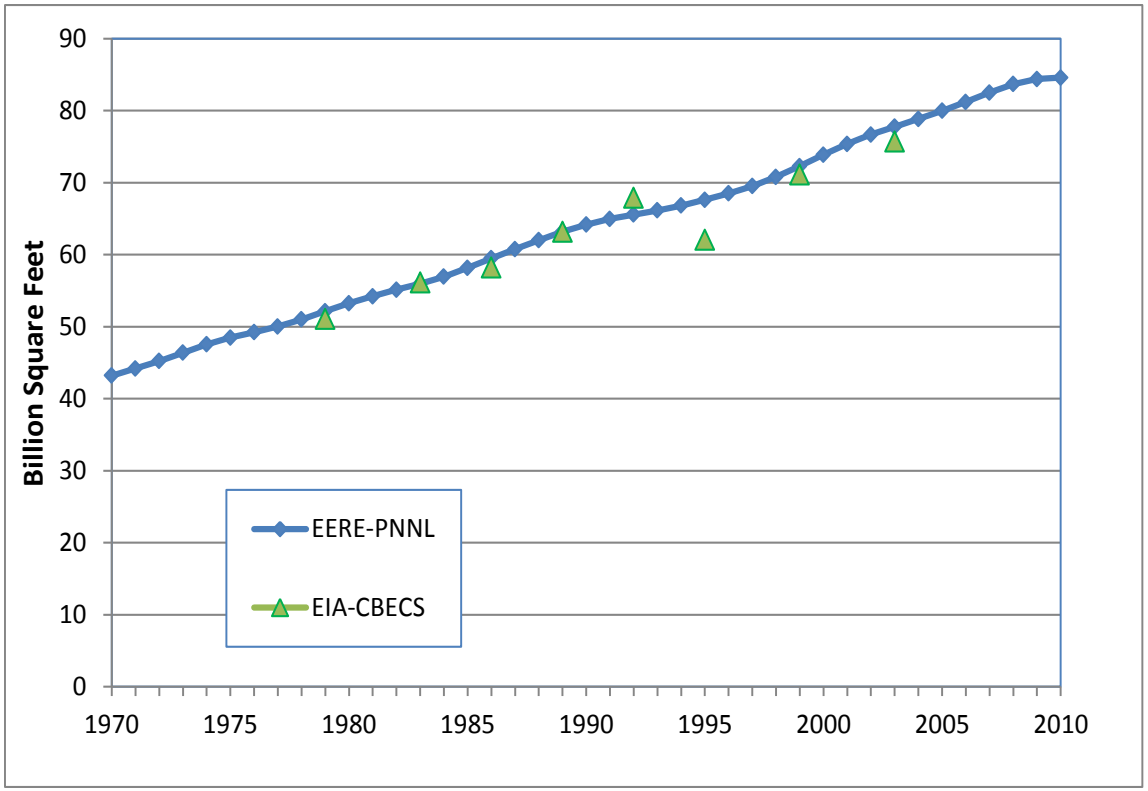
Value Added vs. Gross Output

- U.S. Bureau of Economic Analysis (agency for U.S. National Economic Accounts) develops sector-level estimates of value added and gross output (converted to real measures)
- Intensity measures in manufacturing relate to gross output (GO)
- However, value added (VA) is related to GDP; here GO/VA is treated as structural change



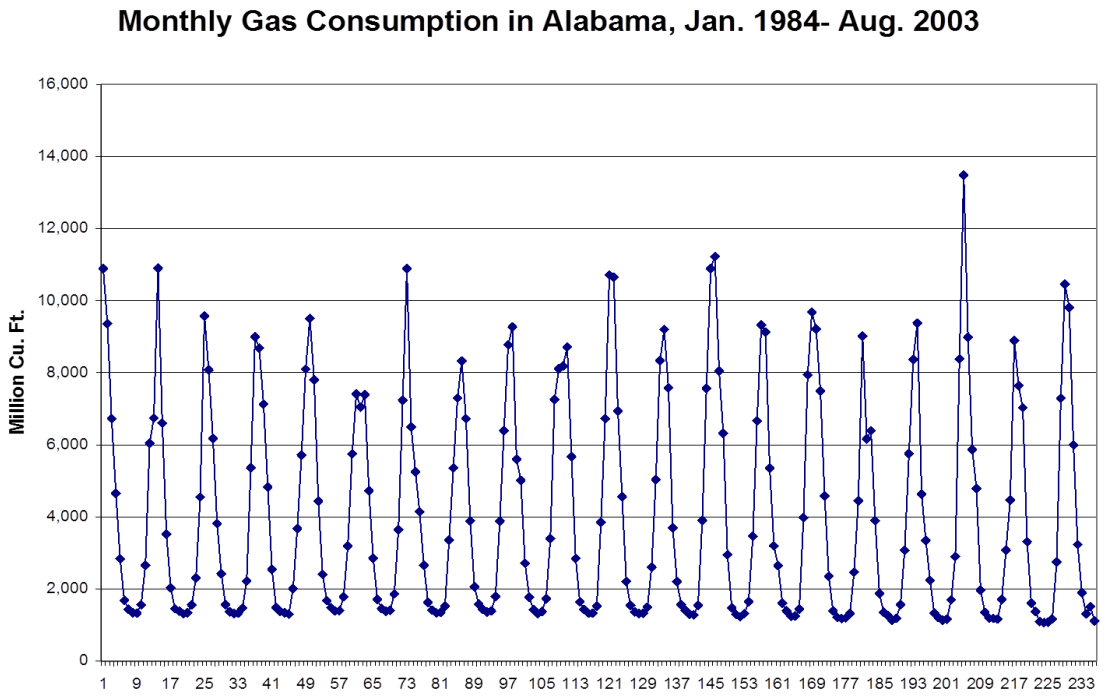
Historical Estimates of Commercial Floor Space

- No publicly available source of annual commercial building floor space in U.S.
- Historical *estimates* based upon additions from McGraw-Hill publishing, and retirements estimated from survival function (based on 1989 and 1999 building surveys)
- No new end-use survey (CBECS) estimate before 2014.
- Current approach lacks detail and corroboration

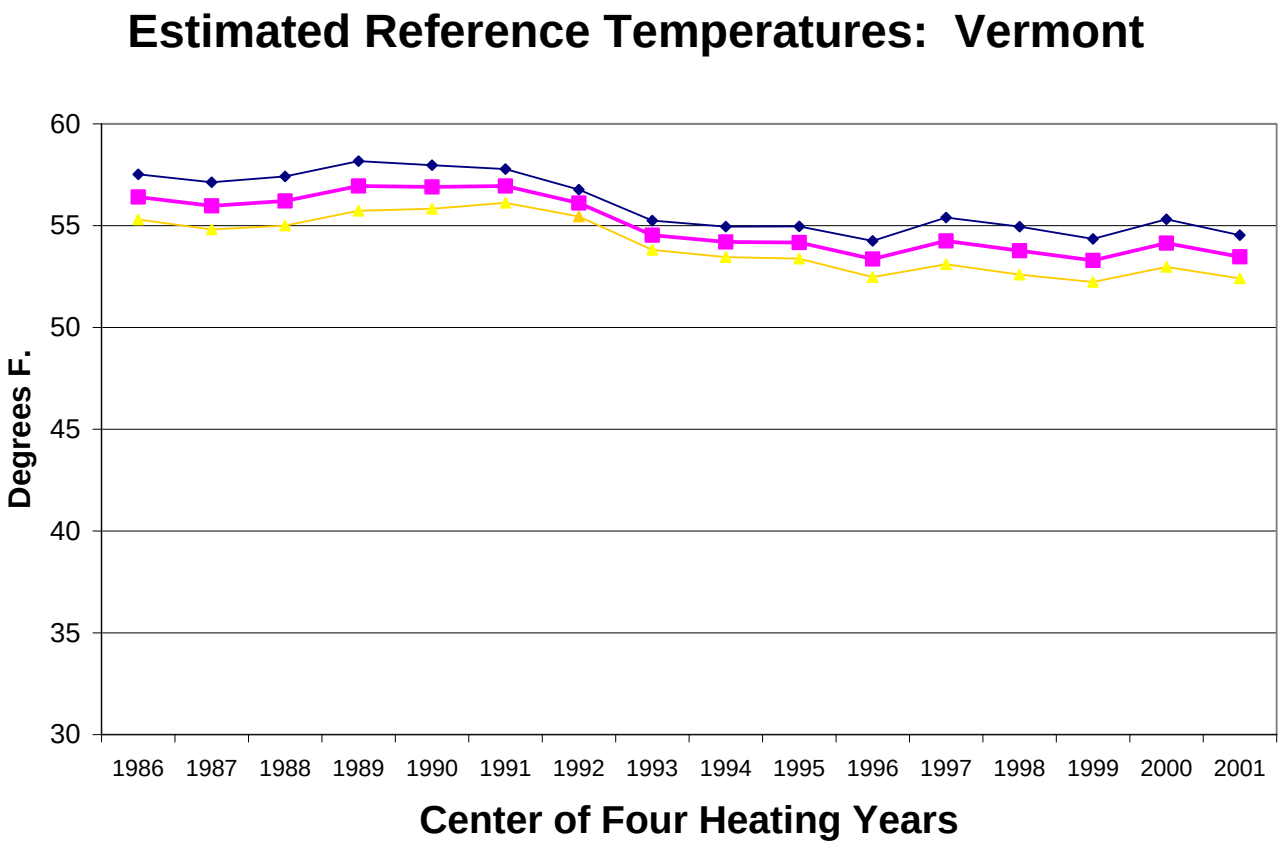


Weather Adjustment Using a PRISM-Type Approach

- Weather adjustment using reported HDD and CDD can bias results if the thermal integrity of the building stock has changed. Published estimates of HDD and CDD rely on fixed reference temperature (e.g., 18° C).
- PRISM (Princeton Scorekeeping Method allows flexibility in reference temp.)
- 2004 Paper to ACEEE Summer study describes application to state-level U.S. monthly energy data
- Complex procedure, but may identify heating/cooling use



Declining Reference Temperatures Suggest Greater Building Thermal Integrity



Additional Slides

System of indicators includes set of three indexes constructed at economy, sector and sub-sector levels

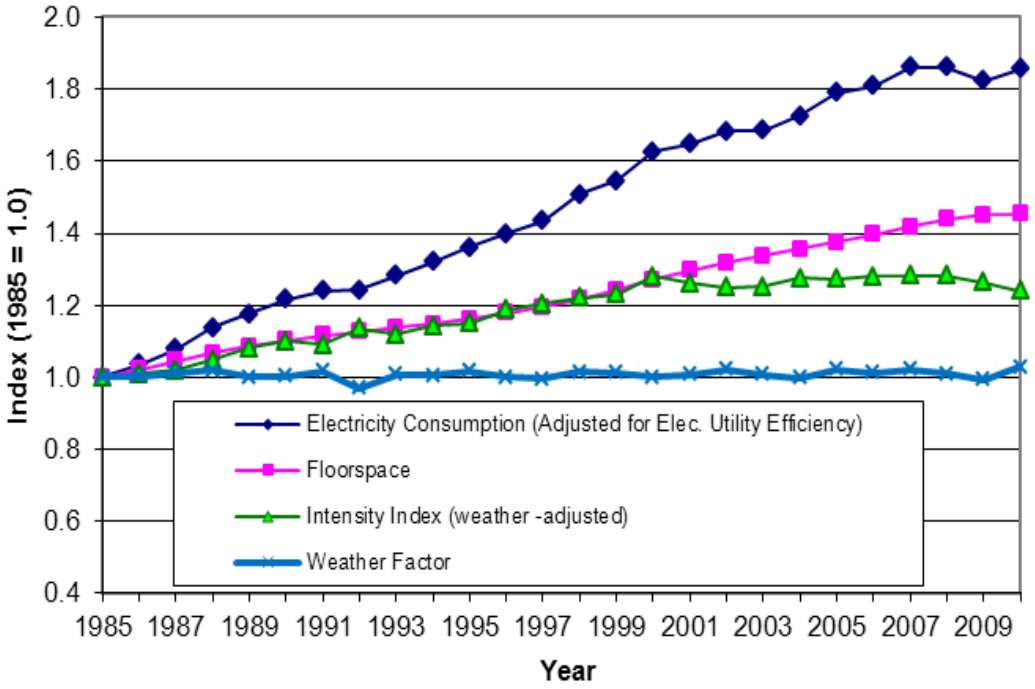
- ***Activity index*** — shows the changes in the level of activity. The units used to measure activity differ by sector (e.g., square footage of floor space, industrial GDP or gross output, passenger-miles, etc.)
- ***Component-based energy intensity index*** — represents the effect of changing energy intensity for sectors or sub-sectors, after controlling for structural factors. Answers the question:

  "How has energy intensity tied to efficiency changed?"
- ***Structural index*** — represents the effect of changing composition of activities within the economy or sectors, as well as other factors not related to efficiency changes
- System employs methodology to ensure that *Total Energy* =

Activity Index x Component-based Intensity Index x Structural Index

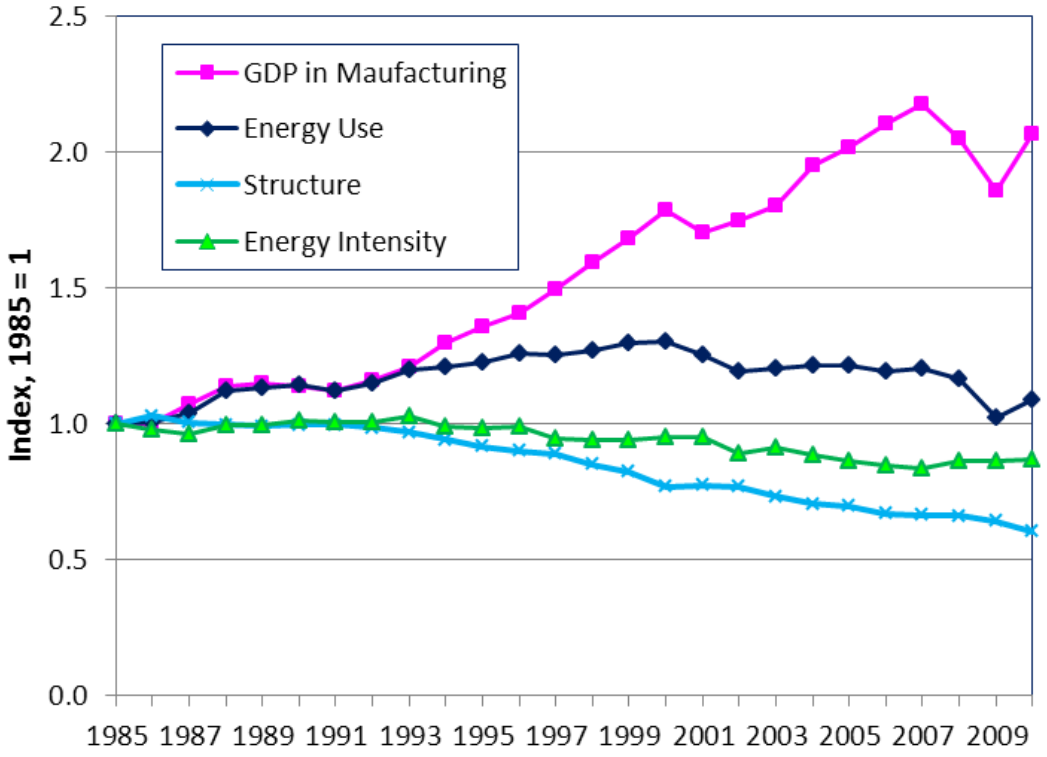
Commercial Energy Intensity Index Adjusted Source Energy/Sq. Ft.

- Intensity measure adjusted for electricity utility efficiency, and weather
- Intensity increased 1.0%/yr from 1985 and 2000. 0.6%/yr decline from 2000 to 2010. Improved controls, lighting, and building codes are likely major factors (+ 2009-2010 recession years).

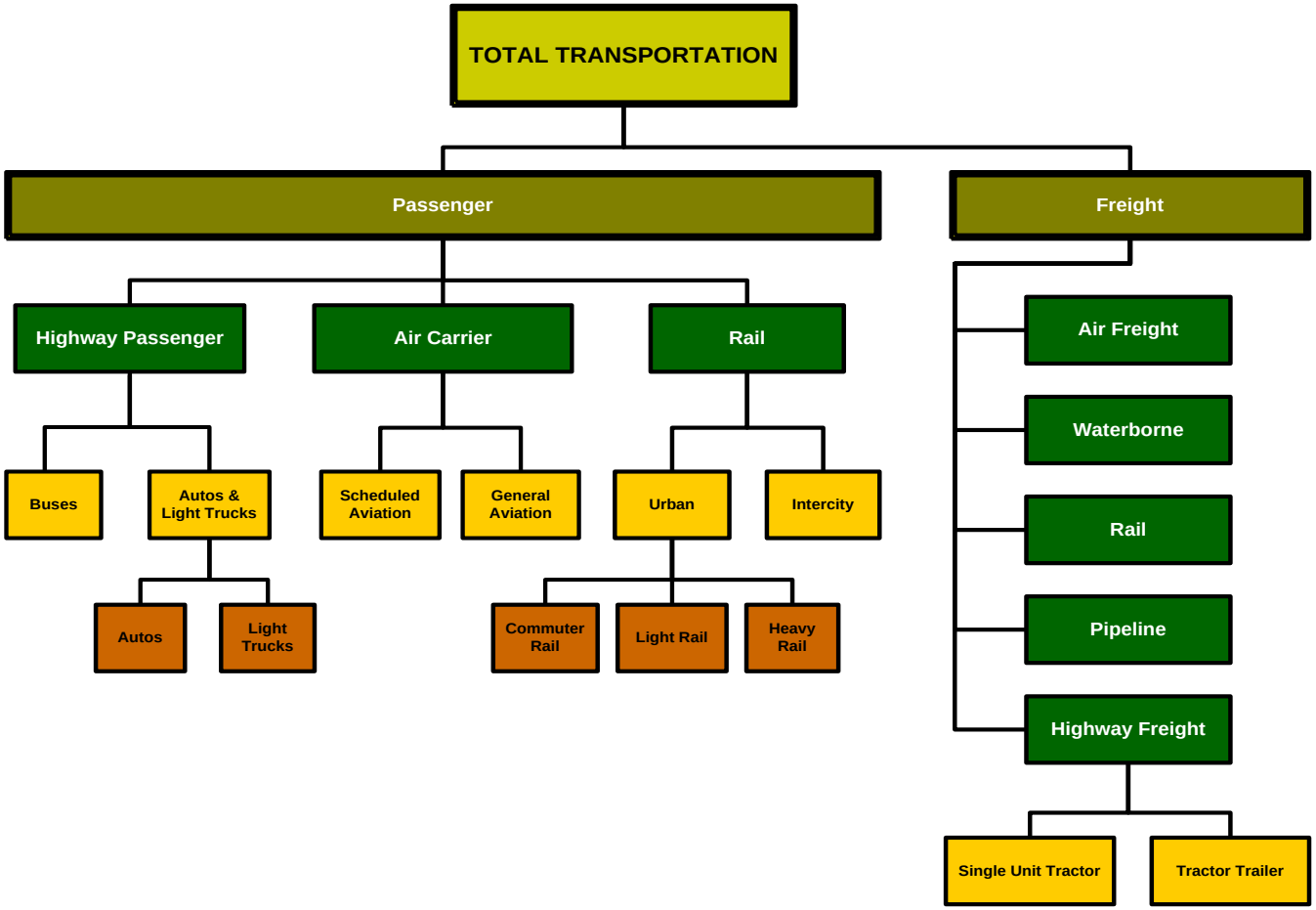


Manufacturing Intensity Index
Source Energy for Heat & Power/$ Gross Output

- Intensity measure adjusted for manufacturing mix of 3-digit NAICS, and VA/Gross Output
- Aggregate intensity (E/GDP, not shown) fell by nearly 50% but majority is due to structural factors. Intensity index declined 17% between 1985 and 2007, last pre-recession year.



Has extensive sub-sector level drill down capability (e.g., drill down structure for transportation)



Electricity generation sector drill-down