Energy Efficiency and the Supply Chain

Leaders for Environmental Assessment and Performance Webinar (Part 1)
September 2nd, 2011

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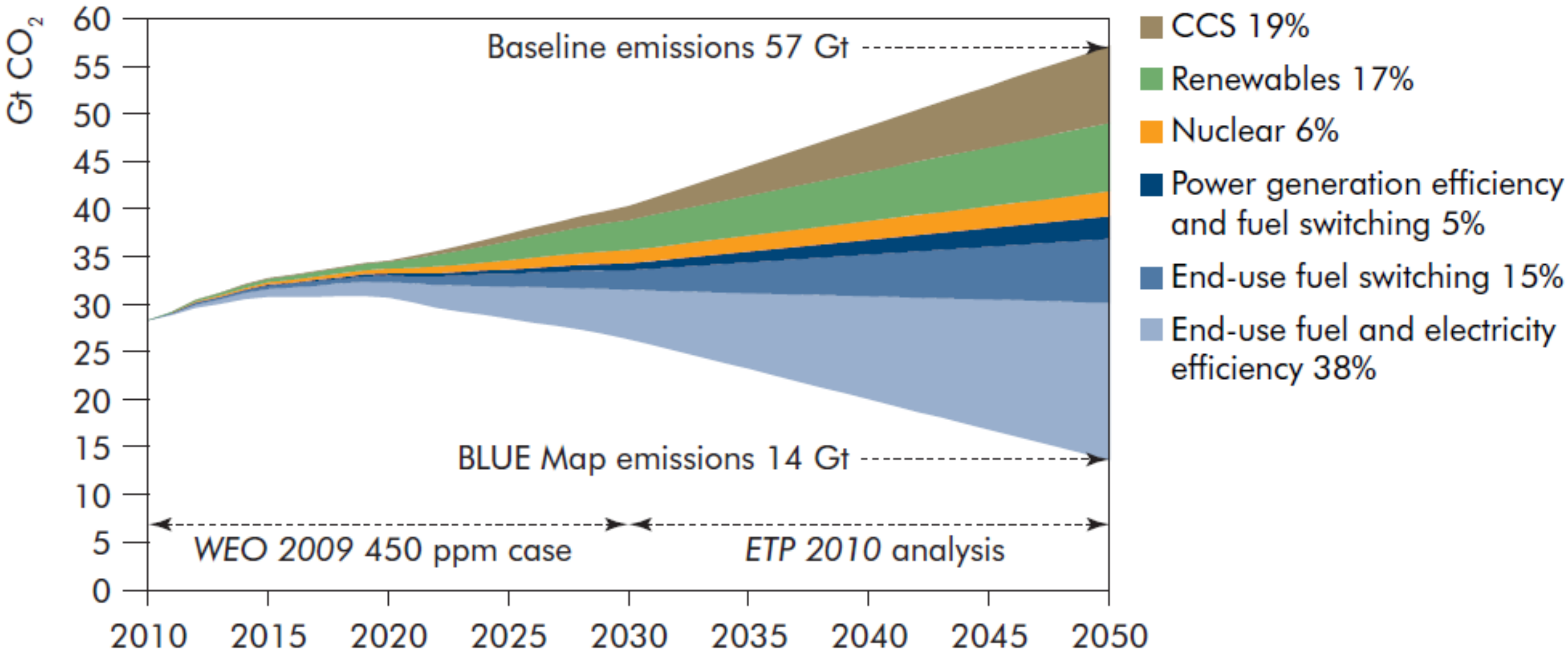
Importance of Energy Efficiency

International Energy Agency Energy Technologies Perspectives 2010:
Key technologies for reducing global CO2 emissions

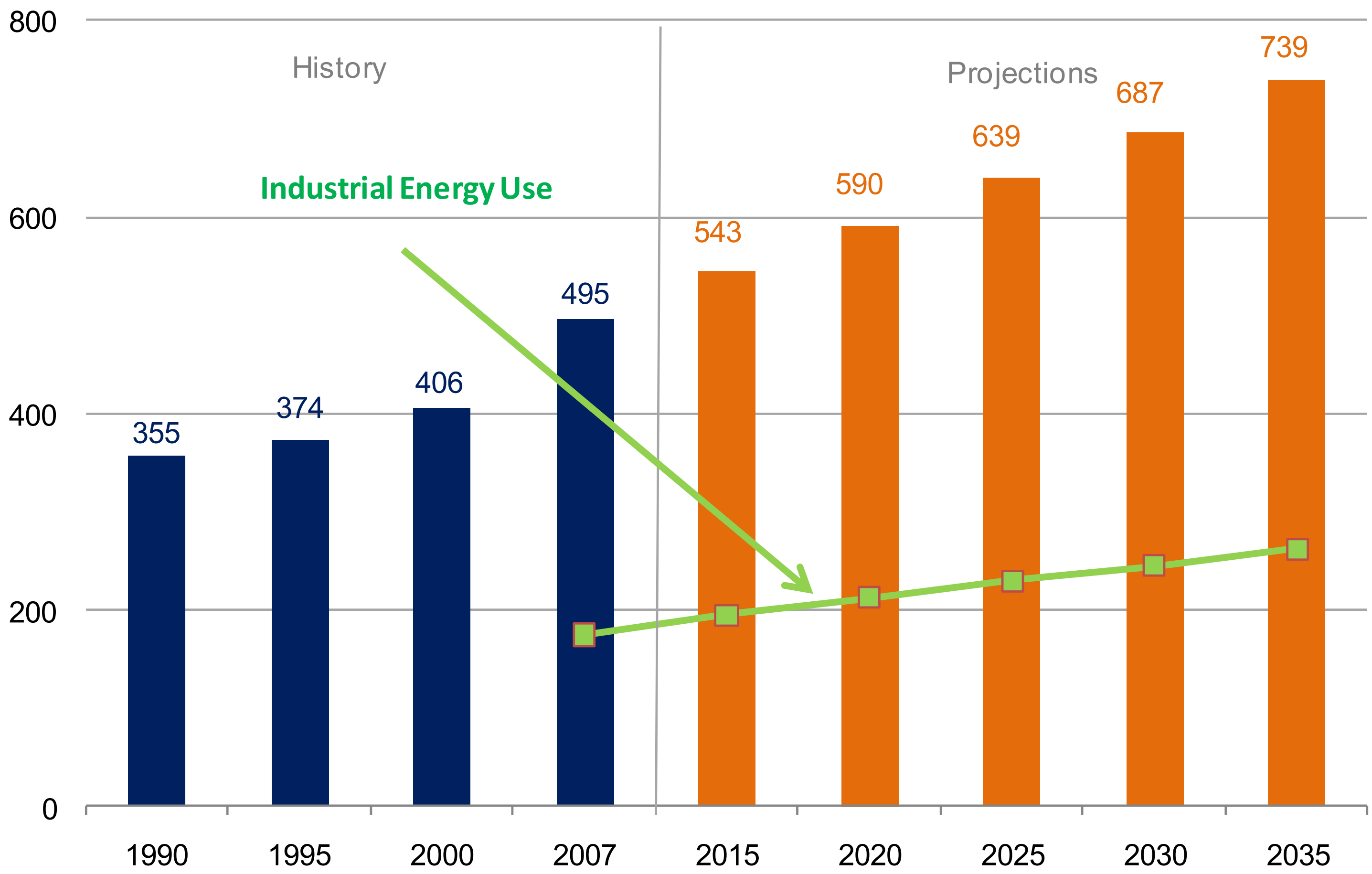


Source: International Energy Agency (IEA) (2010)
Notes: WEO = IEA World Energy Outlook; ETP = EA Energy Technology Perspectives

Global Energy Use Projections

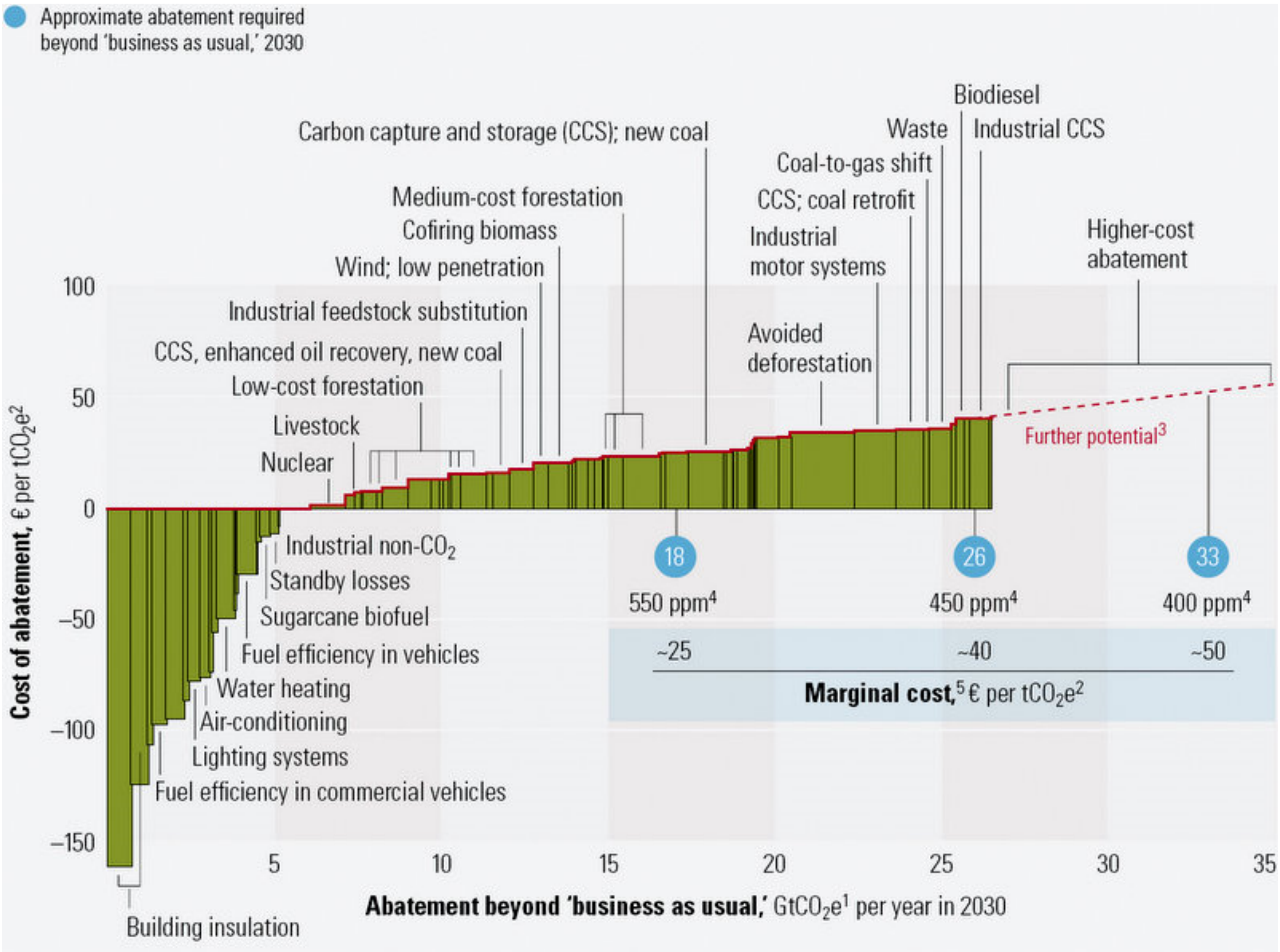
Figure 12. World marketed energy consumption, 1990-2035

quadrillion Btu



Source: Energy Information Administration, International Energy Annual 2009

U.S. CO2 Abatement Potential



McKinsey (2007)

Untapped Energy Efficiency Potential

Evidence from the U.S. Department of Energy (DOE) Industrial Assessment Center (IAC) Program:

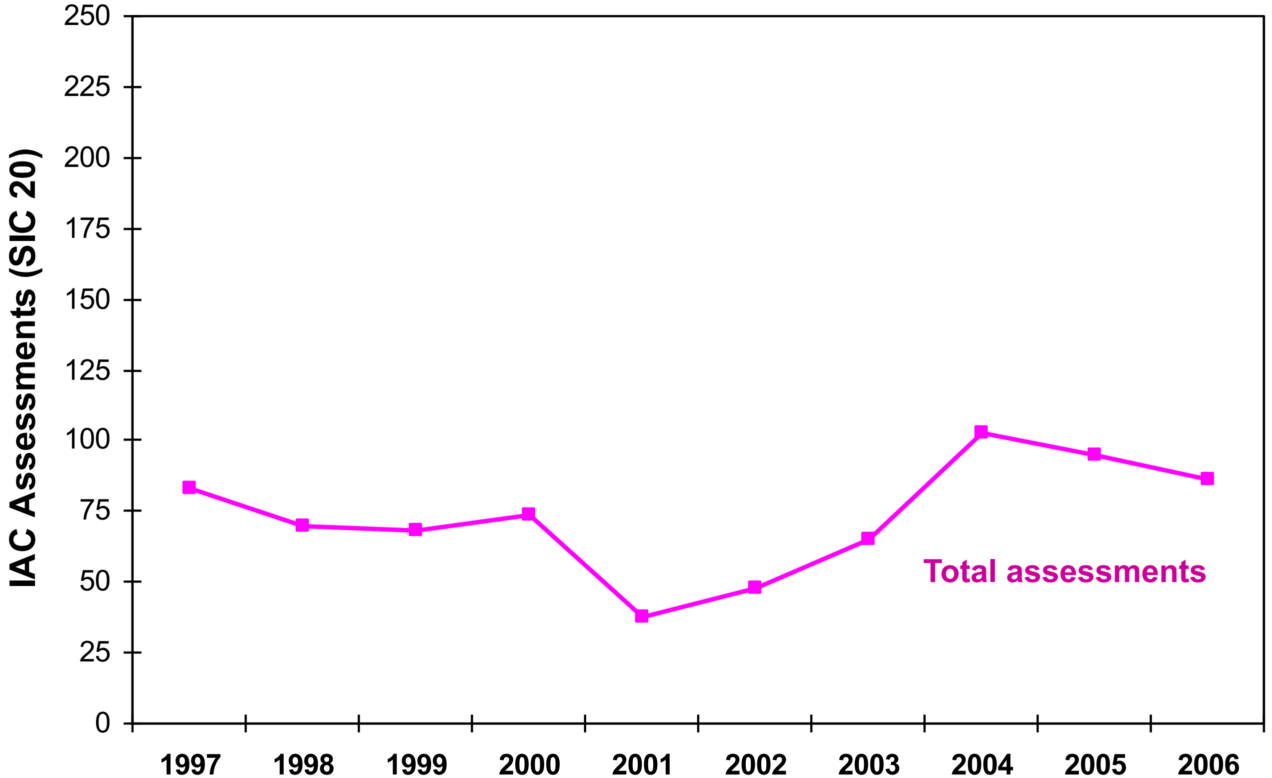
- **The IAC Program provides small and medium sized manufacturers with no-cost energy assessments carried out by professors and students at 26 U.S. universities**

- **590 facility assessments performed in 2001:**
  - **3,350 proven energy efficiency recommendations <u>with known results</u>**
    - — only 1,550 recommendations implemented (46%)
    - — only 24% of total recommended cost savings achieved
  - **Average simple payback of all recommendations = 0.9 years**
    - — average simple payback of implemented recommendations = 0.5 years

Source: Muller, M. (2001) IAC Annual Report: Savings Generated by the Industrial Assessment Center Program: Fiscal Year 2001. http://www.iac.rutgers.edu/technicaldocs.php

U.S. Food Processing Industry Example (i)

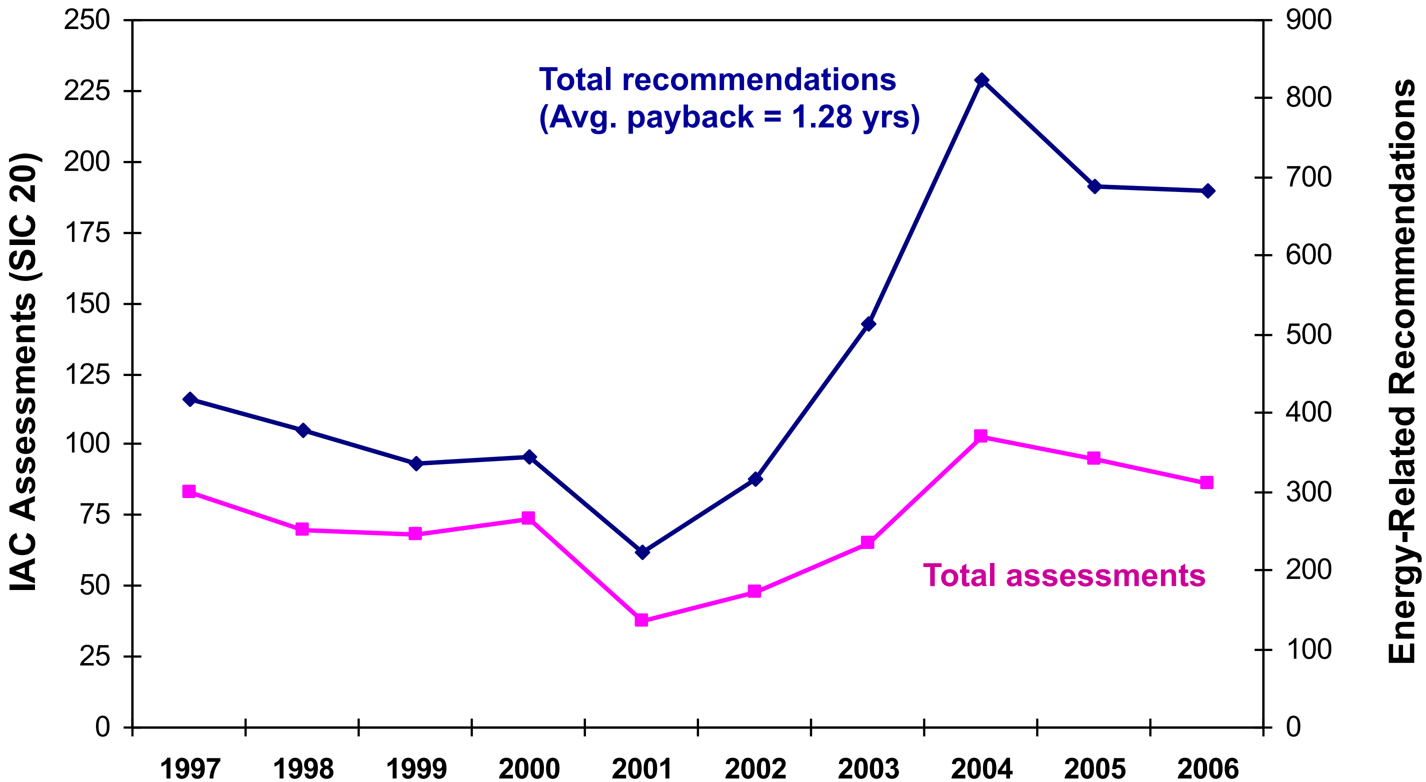
Summary of IAC Assessments and Recommendations for SIC 20 (1997-2006)



Source: Industrial Assessment Center (IAC) Database, http://www.iac.rutgers.edu/database/

U.S. Food Processing Industry Example (ii)

Summary of IAC Assessments and Recommendations for SIC 20 (1997-2006)



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U.S. Food Processing Industry Example (iii)

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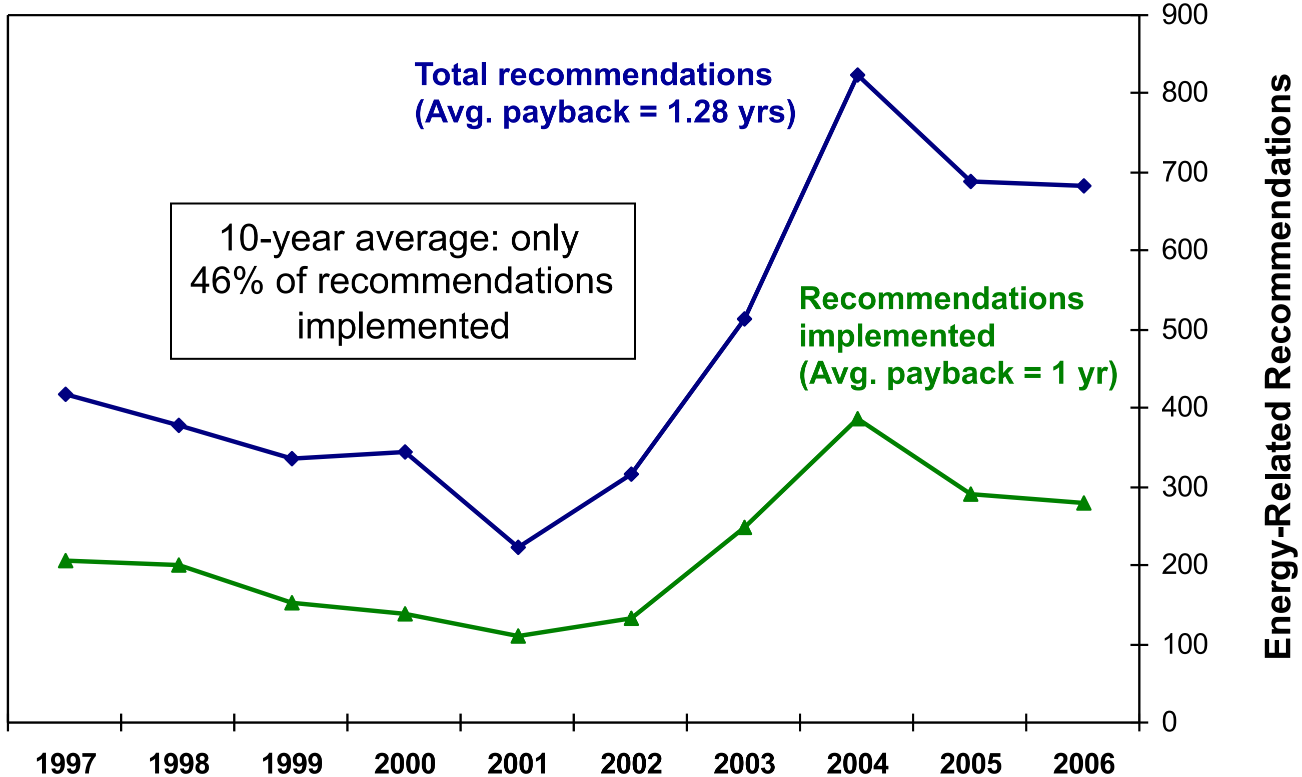

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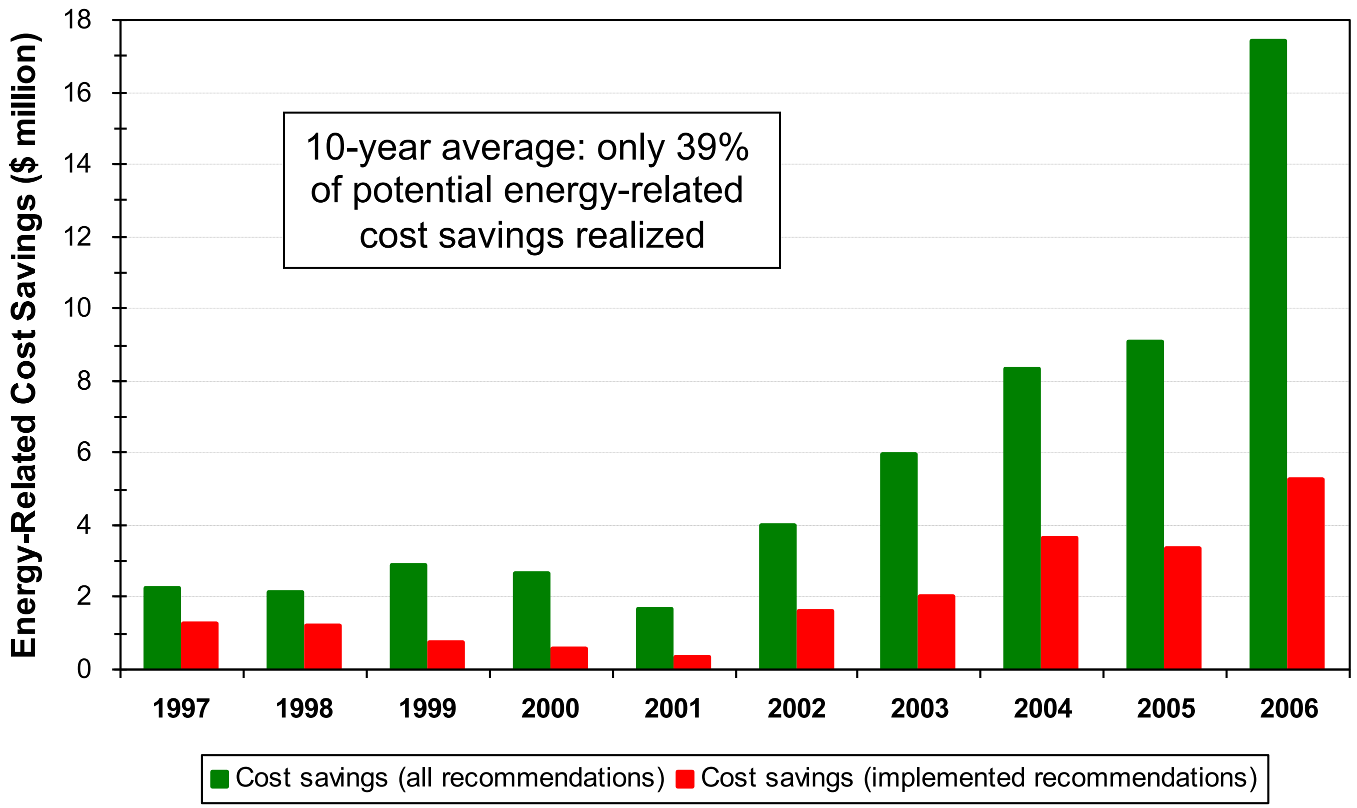
U.S. Food Processing Industry Example (iv)

Summary of IAC Recommendations for SIC 20 (1997-2006)



Source: Industrial Assessment Center (IAC) Database, http://www.iac.rutgers.edu/database/

Key Barriers

Common barriers to industrial energy efficiency include:

- Restrictive budget and fiscal criteria

Financial

- Energy costs might represent a small fraction of production costs
- Short-term revenue generation often takes priority
- Lack of cross-departmental cooperation
- Lack of staff and management awareness

Information

- Lack of resources (time, money, and skills) to identify and pursue energy efficiency opportunities
- Lack of information on key opportunities for government and utility company policies and incentive programs

Source: Russell, C. (2005). Barriers to Industrial Energy Cost Control: The Competitor Within. Chemical Processing. June 8th.

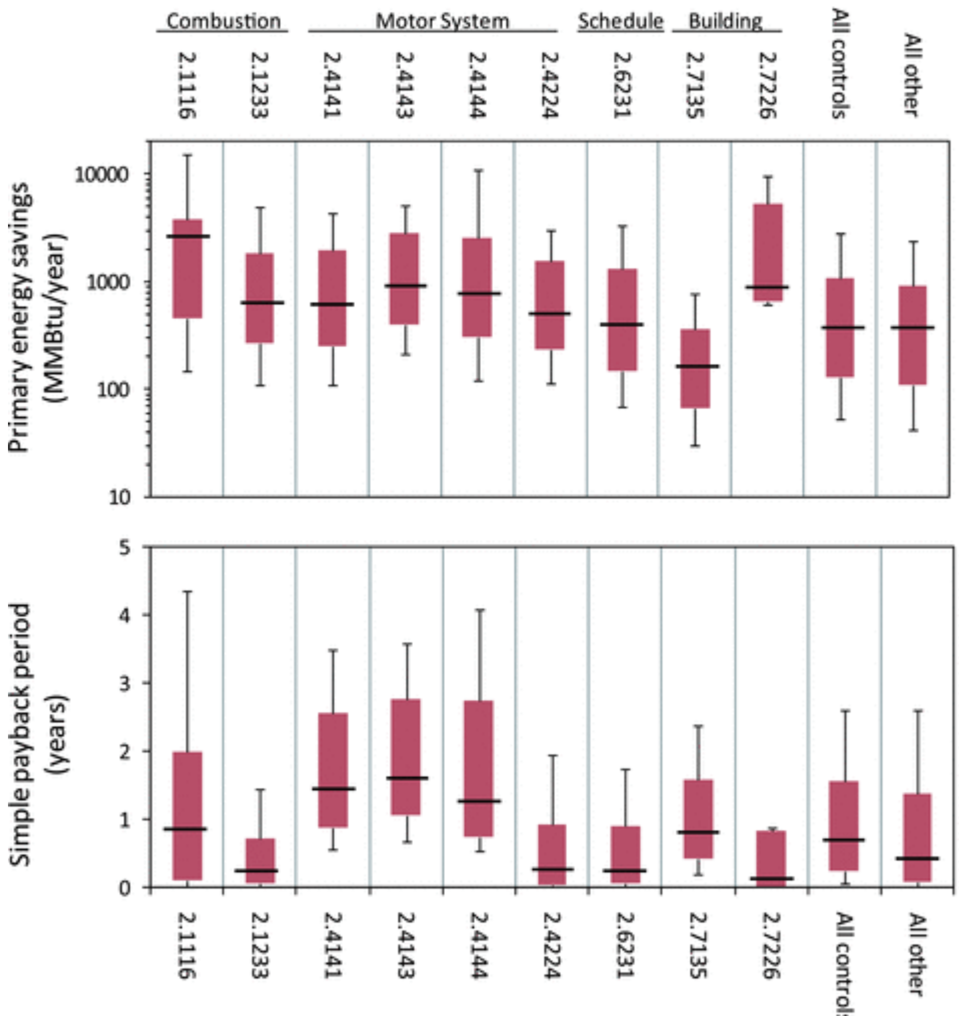
Industrial Controls (i)

Energy savings from one SME control system installation =

-1,400 efficient refrigerators, or

- 2,150 CFLs, or

- 20 upgrades to a Prius.



Source: Masanet, E. (2010) "Energy Benefits of Electronic Controls at Small and Medium Sized U.S. Manufacturers." Journal of Industrial Ecology. Volume 14, Issue 5.

Industrial Controls (ii)

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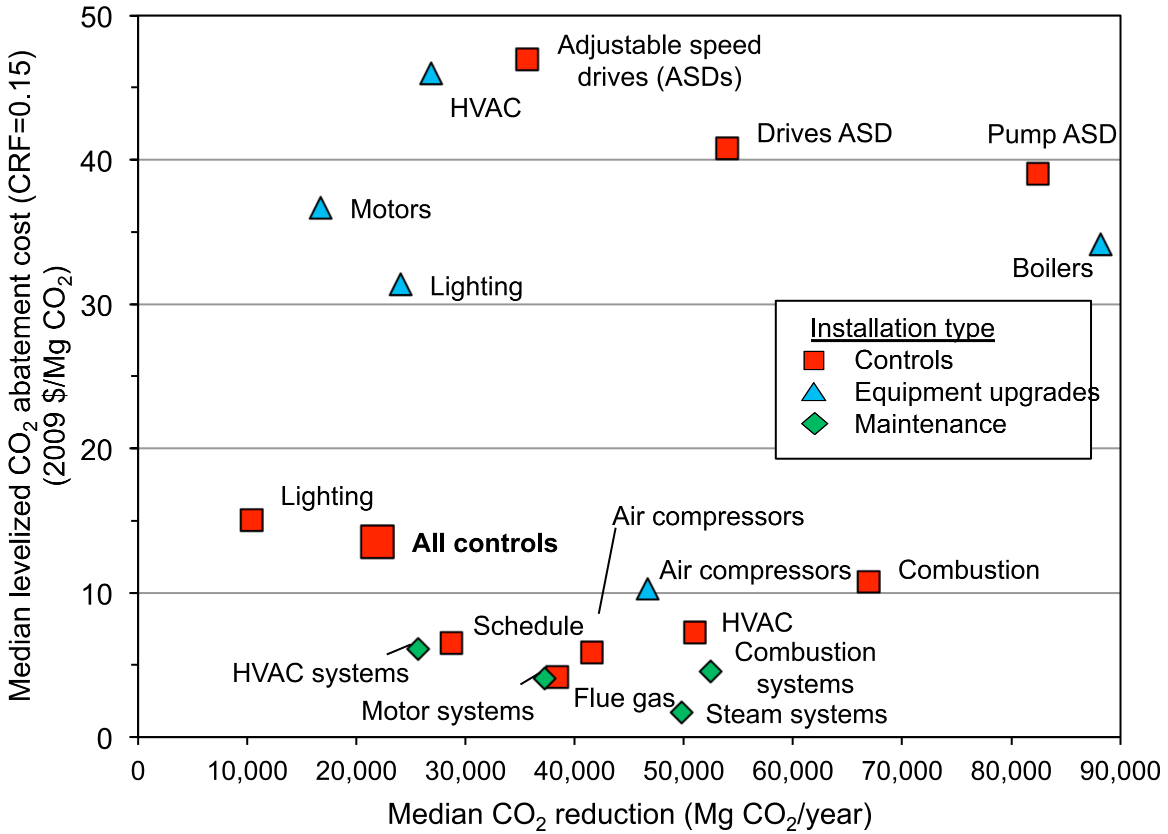
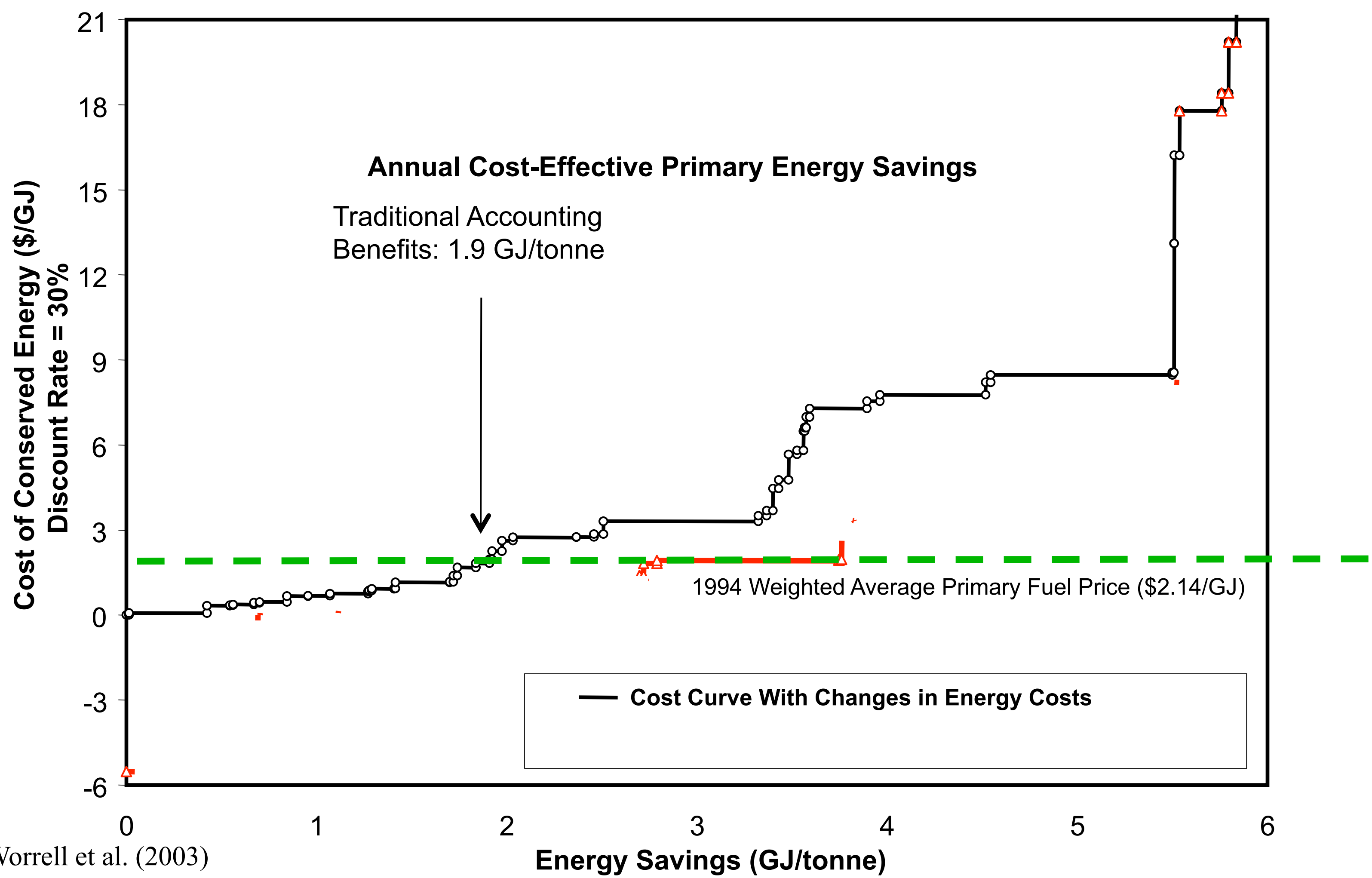


Source: Masanet, E. (2010) "Energy Benefits of Electronic Controls at Small and Medium Sized U.S. Manufacturers." Journal of Industrial Ecology. Volume 14, Issue 5.

Overcoming Financial Barriers: "Getting the Cost Numbers Right"

Energy Efficiency Cost Curve for the U.S. Steel Industry



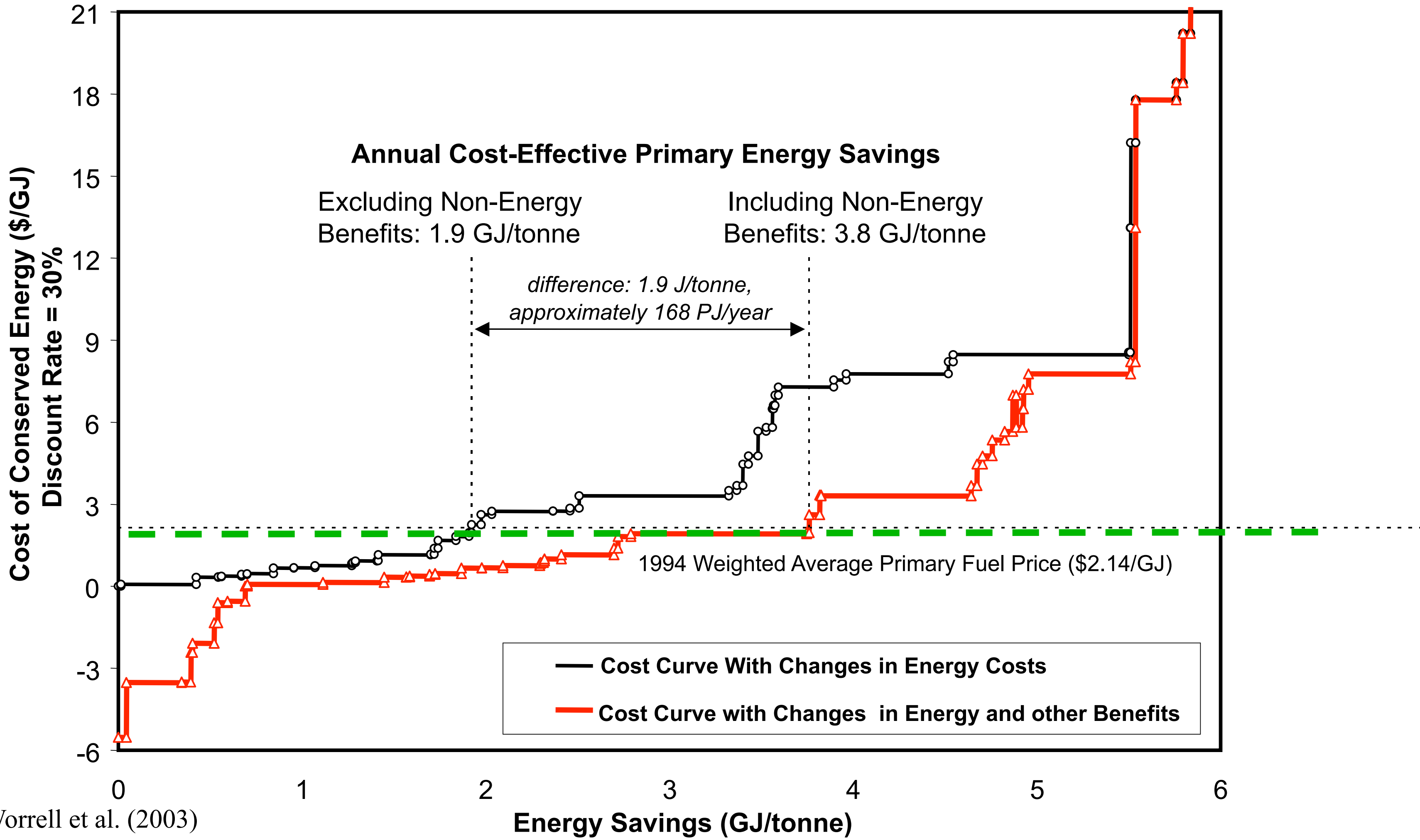
Source: Worrell et al. (2003)

US Steel Industry Cost of Conserved Energy: Other Benefits

Waste	Emissions	Operation & Maintenance
Use of waste fuels, heat, gas	Reduced dust emissions	Reduced need for engineering controls
Reduced product waste	Reduced CO, CO2, NOx, SOx emissions	Lowered cooling requirements
Reduced waste water		Increased facility reliability
Reduced hazardous waste		Reduced wear and tear on equipment/ machinery
Materials reduction		Reductions in labor requirements
Production	**Working Environment**	**Other**
Increased product output/yields	Reduced need for personal protective equipment	Decreased liability
Improved equipment performance	Improved lighting	Improved public image
Shorter process cycle times	Reduced noise levels	Delaying or Reducing capital expenditures
Improved product quality/purity	Improved temperature control	Additional space
Increased Reliability in Production	Improved air quality	Improved worker morale

US Steel Industry Supply Curves: Accounting for Changes four categories of benefits (previous slide)

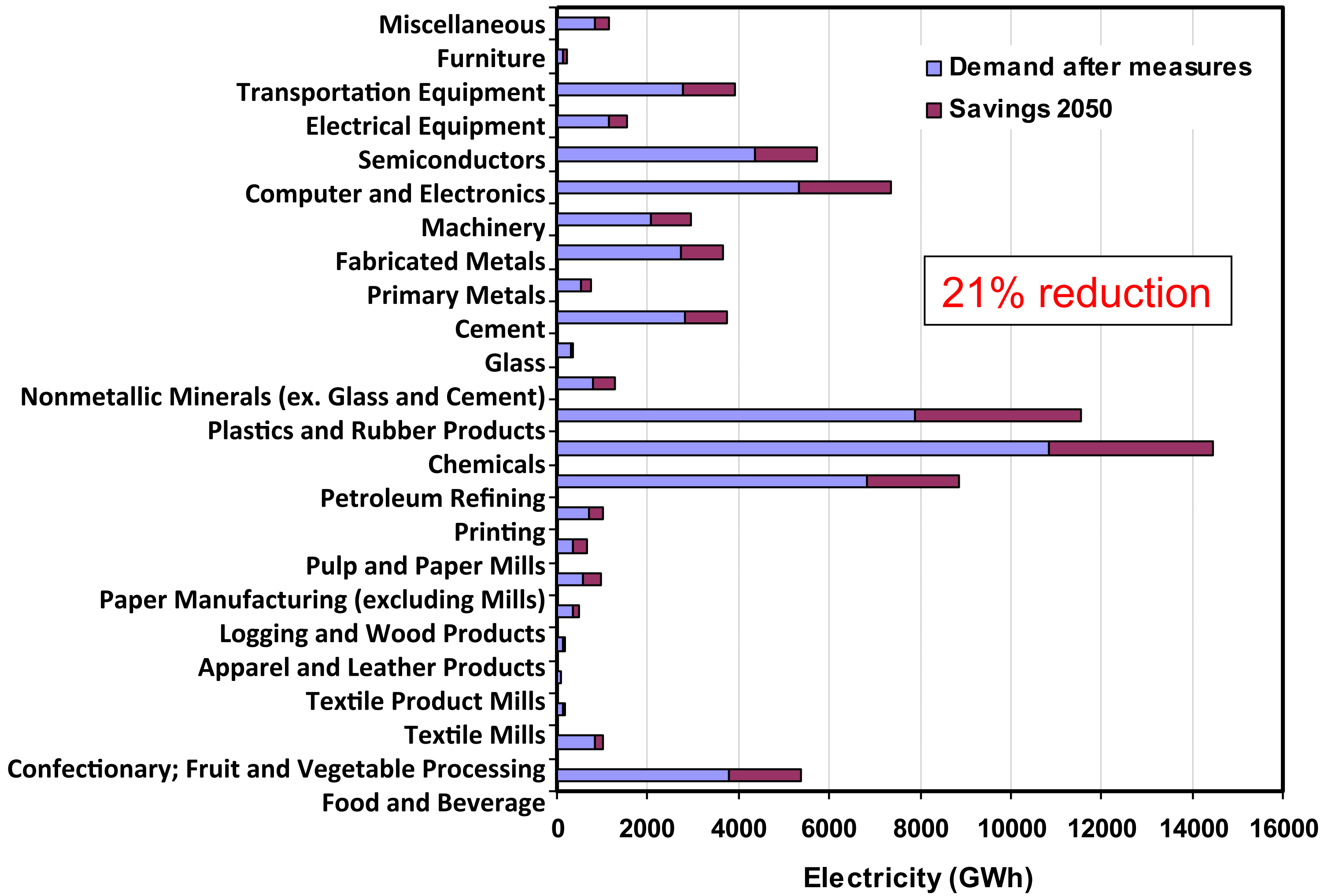
Benefits double cost effective energy efficiency potential to 19%



Source: Worrell et al. (2003)

2050 CA Industrial Electricity Demand

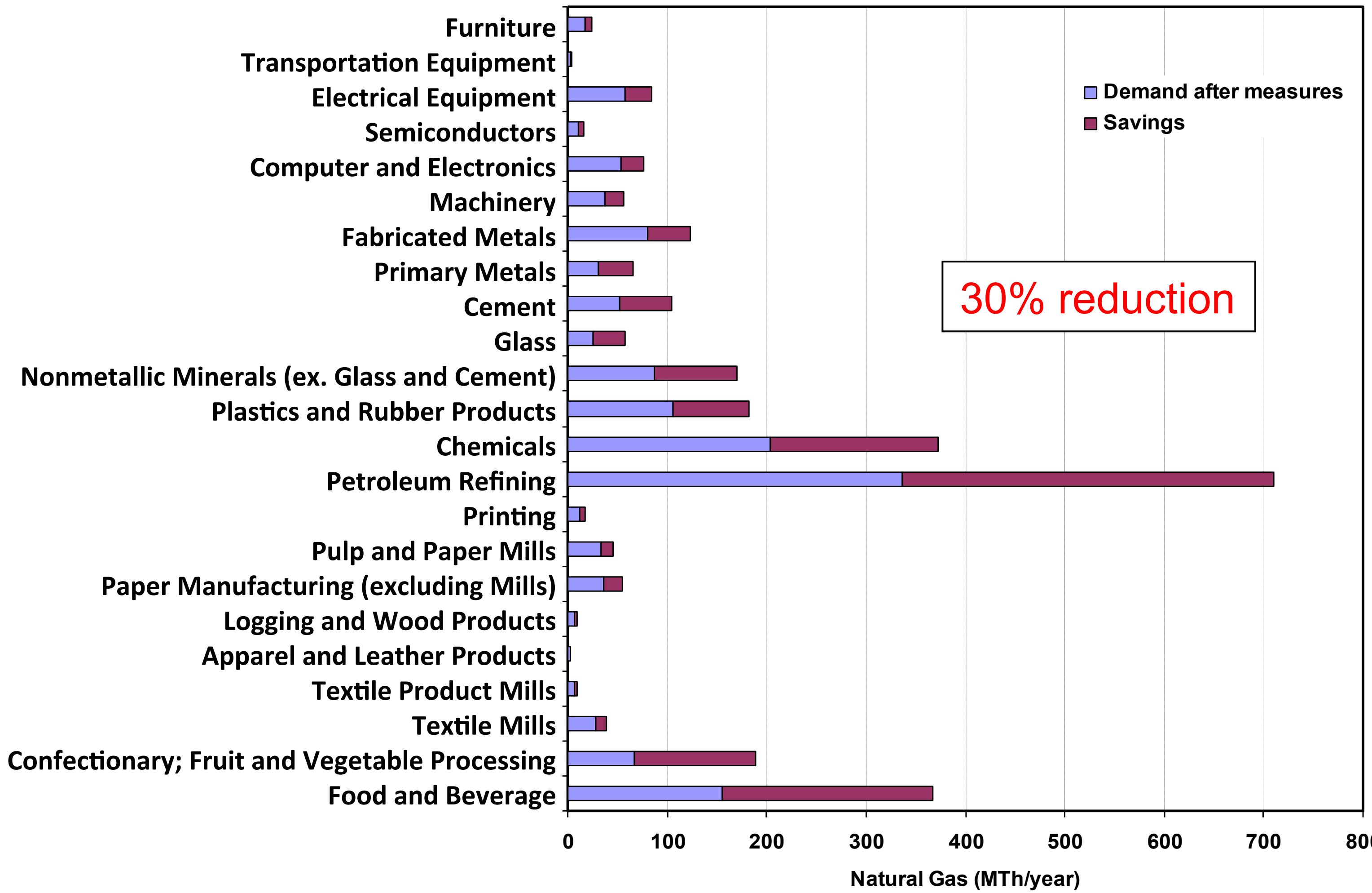
Projected Electricity Demand by Industrial Sub-Sector
(Savings are Relative to Frozen Efficiency in Benchmark Scenario)



Source: Masanet, E., M. Ting, E. Worrell, A.H. Sanstad, M. Marsidi, R. Bharvirkar, and M. Rufo (2009). Estimation of Long-Term Energy Efficiency Potentials for California Buildings and Industry. California Energy Commission, PIER-Energy-Related Environmental Research Program

2050 CA Industrial Natural Gas Demand

Projected Natural Gas Demand by Industrial Sub-Sector
(Savings are Relative to Frozen Efficiency in Benchmark Scenario)



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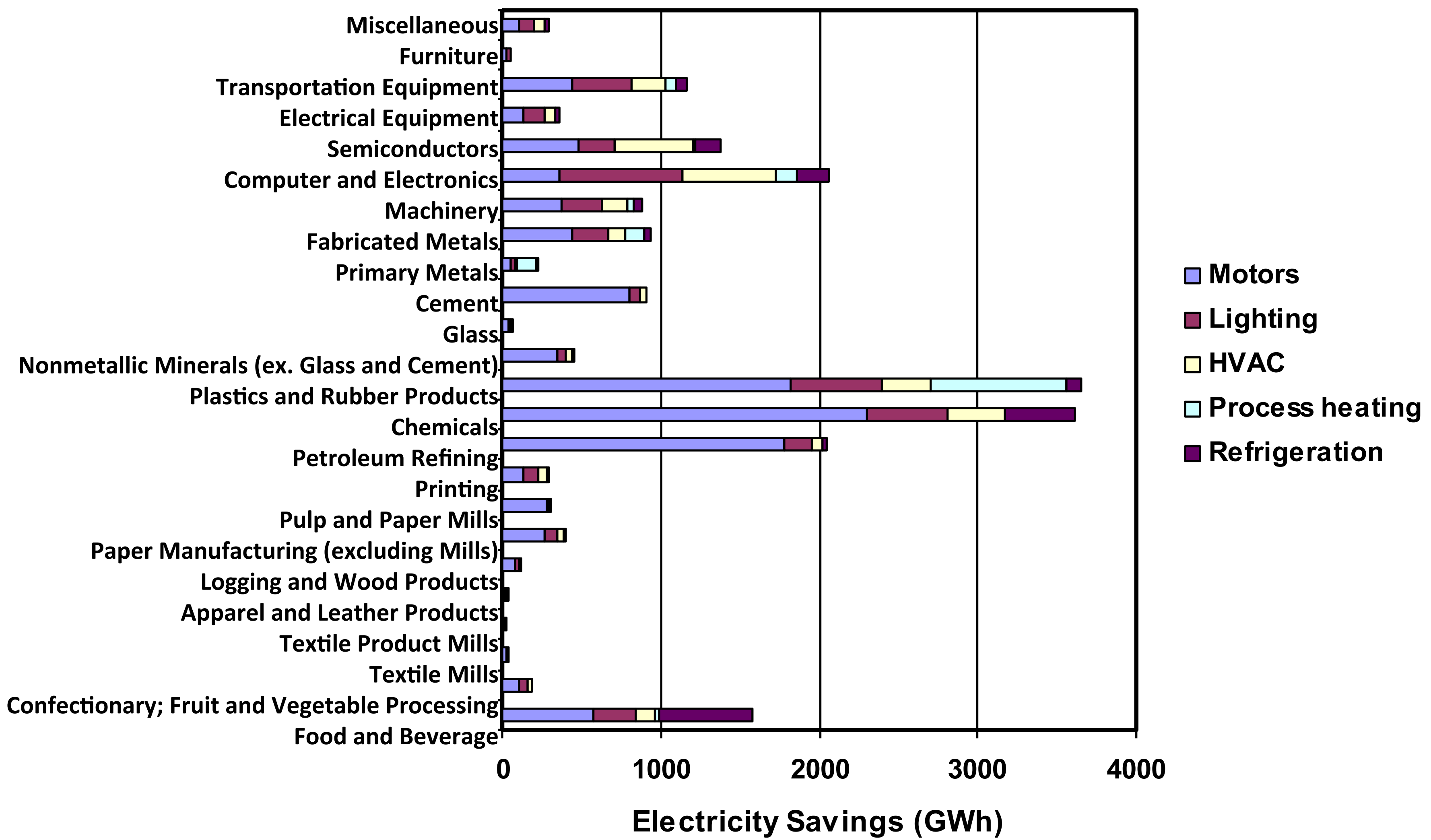
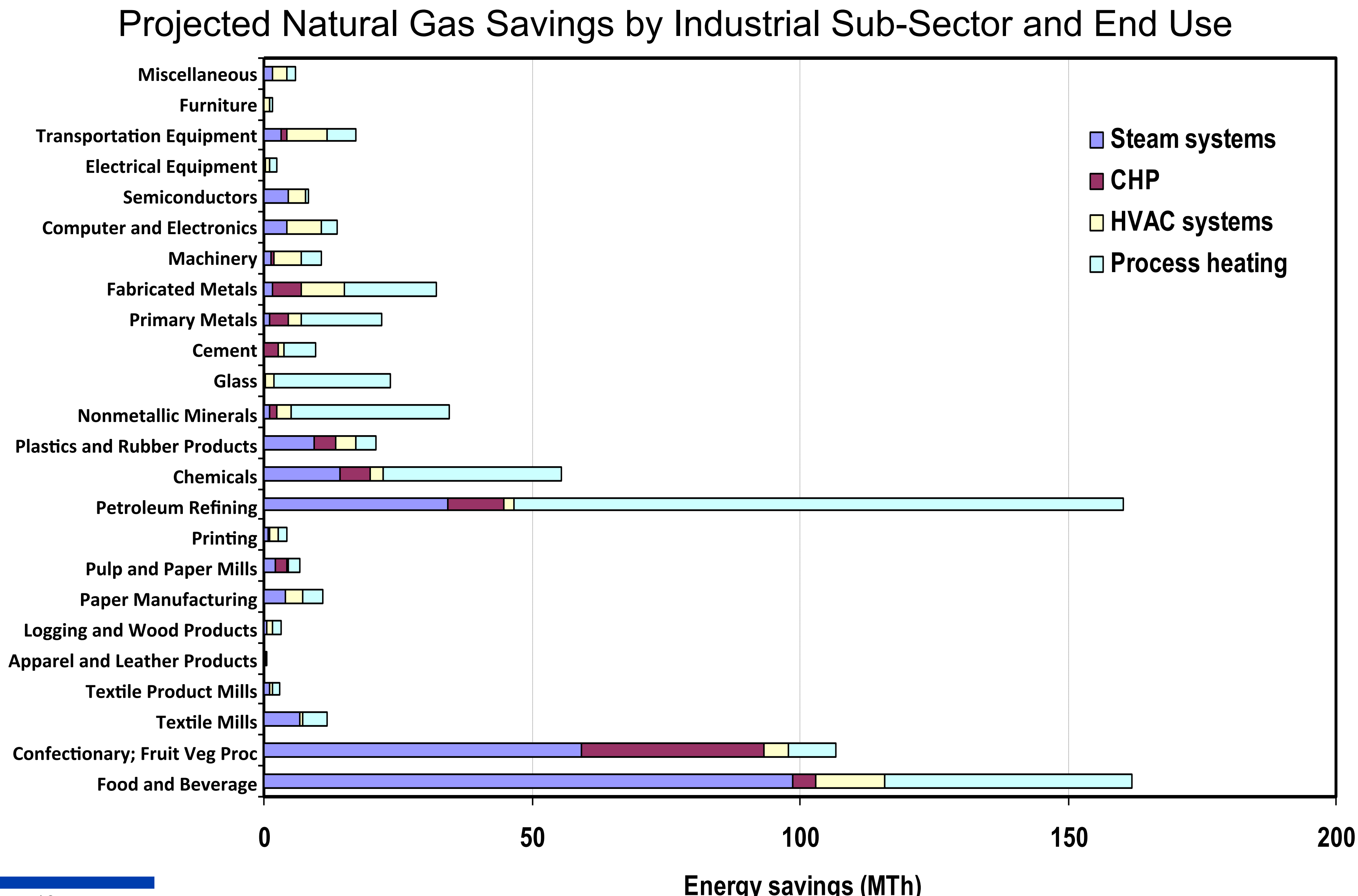
2050 CA Industrial Electricity Potentials

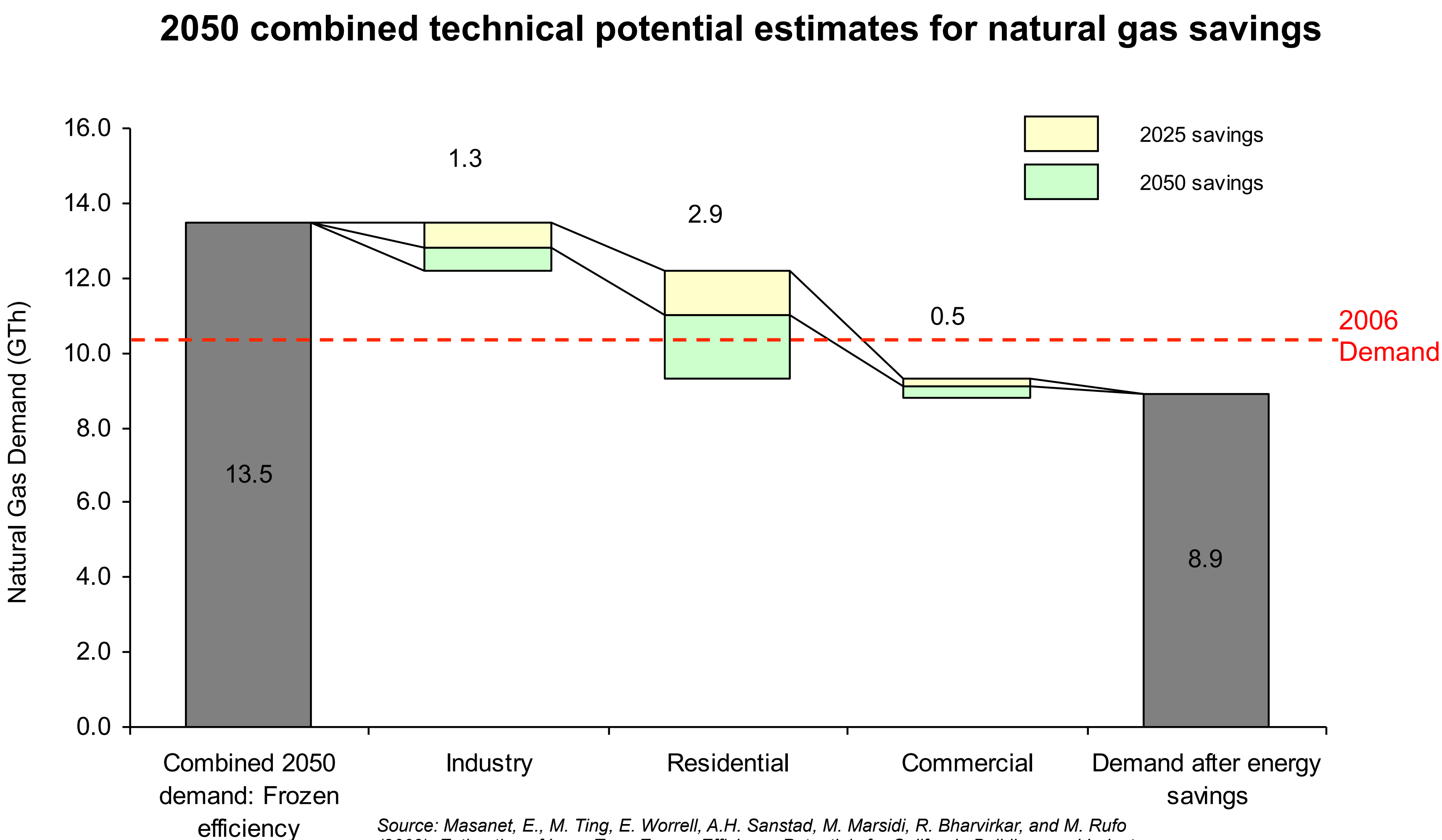
Projected Electricity Savings by Industrial Sub-Sector and End Use



2050 CA Industrial Gas Potentials



Technical potential: natural gas



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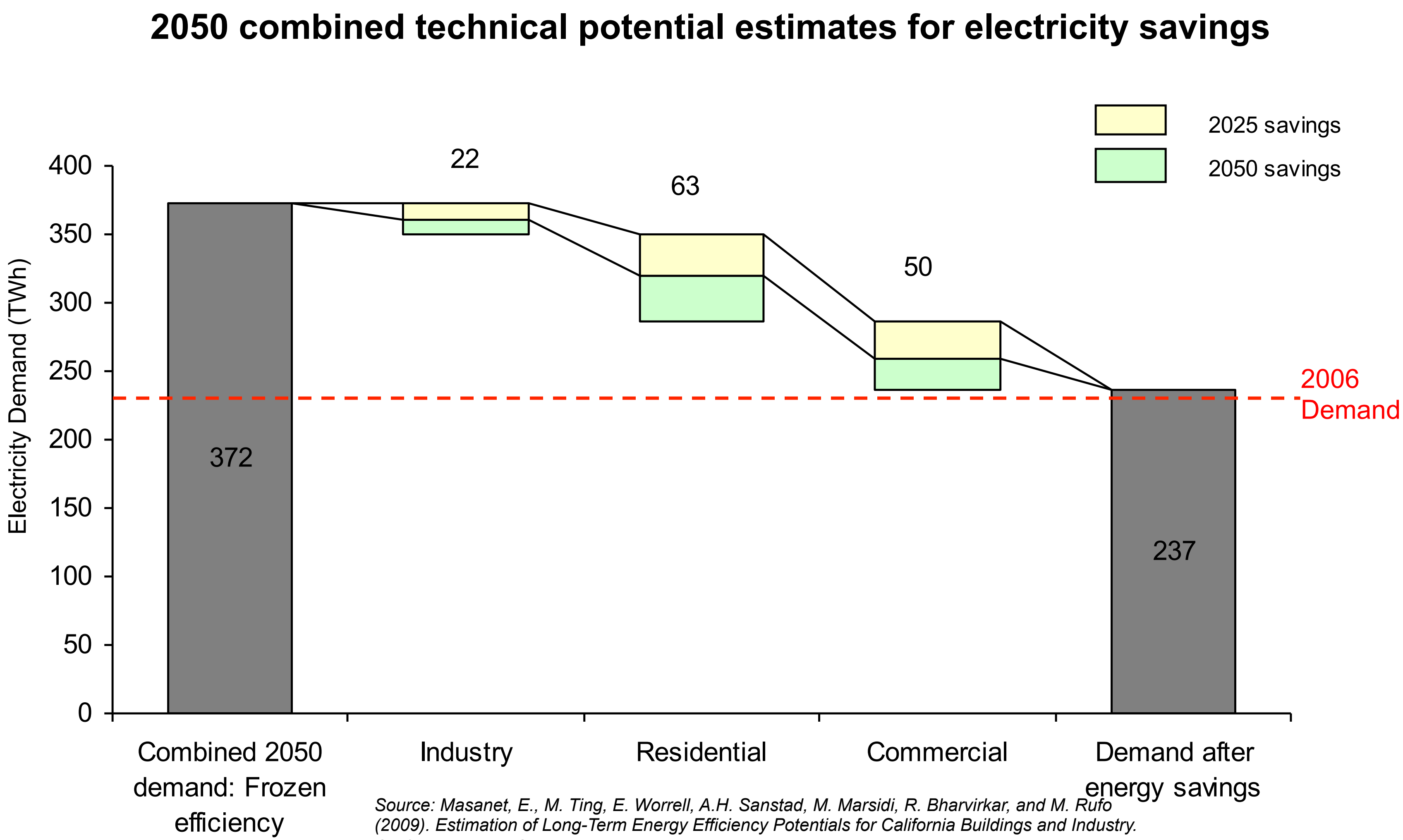
Technical potential: electricity



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Moving beyond efficiency

- Shift to low-carbon and renewable electricity sources can play a significant role in reducing California's industrial GHG emissions

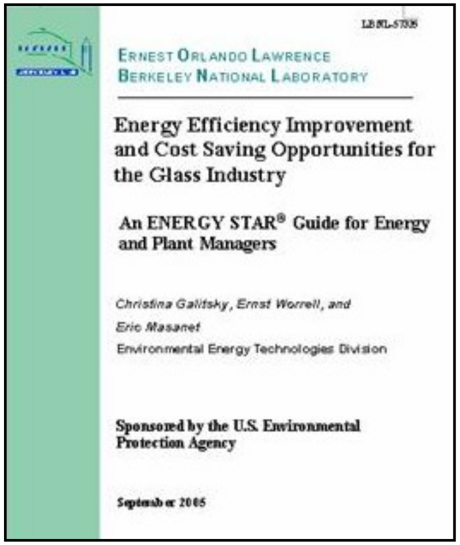
- Process electrification, coupled with low-carbon electricity sources can lead to additional GHG emissions reductions
  - Membrane separations in the food, chemicals, and petroleum refining industries
  - Electric boilers (many industrial sectors)
  - Electrified cooking, baking, and drying (e.g., microwave and RF technology) and pasteurization (e.g., pulsed electric field) the food and beverage industries

- Carbon capture and sequestration
  - Important to consider net systems-level effects (energy, water, etc.)

- Dematerialization of consumption, longer-lasting products, and shift from products to services
  - Electronics and appliances

U.S. EPA Energy Star for Industry Program: LBNL "Energy Guides"

- **Single report summarizing current state of knowledge on *best practice energy use and energy efficiency* in a given industrial sector (12 to date; see web link below)**
- **Written specifically for plant and energy managers**
- **Reviewed by industry professionals and experts**
- **Energy Guides:**
  - reduce information barriers
  - identify energy efficiency opportunities
  - quantify potential energy and cost savings
  - serve as a checklist for energy managers
  - highlight industry success stories
  - inform industrial energy policy


Ernest Orlando Lawrence Berkeley National Laboratory

Energy Efficiency Improvement and Cost Saving Opportunities for the Glass Industry

An ENERGY STAR® Guide for Energy and Plant Managers

Christina Galitsky, Ernst Worrell, and Eric Masanet
Environmental Energy Technologies Division

Sponsored by the U.S. Environmental Protection Agency

September 2005

http://www.energystar.gov/industry

… save energy, money and the environment…

Assessment of Techno-Economic Potentials for Low-Carbon Supply Chains

Leaders for Environmental Assessment and Performance Webinar (Part 2)
September 2nd, 2011

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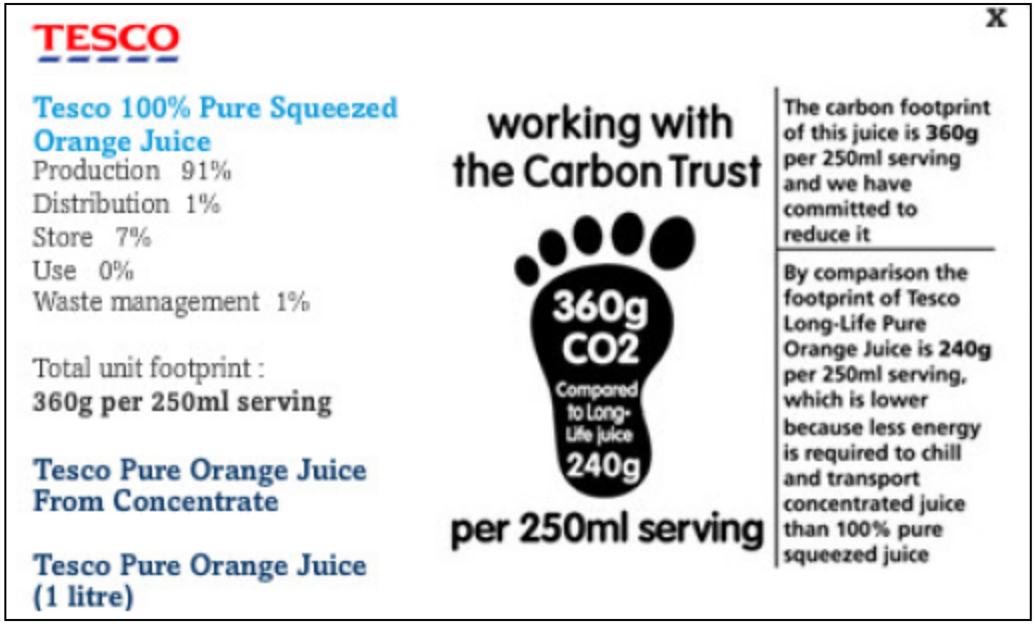
Background: Supply Chain Carbon Management

- **Initiatives are emerging globally to estimate and report the carbon footprints associated with goods and services**
  - — Carbon Trust (UK) Carbon Reduction Label and British Standards Institute PAS 2050
  - — Tesco (UK) and Wal-Mart (US) supply chain reporting initiatives
  - — Industry-led initiatives (breweries, dairies, others)
  - — California Assembly Bill 19
  - — Waxman-Markey Bill

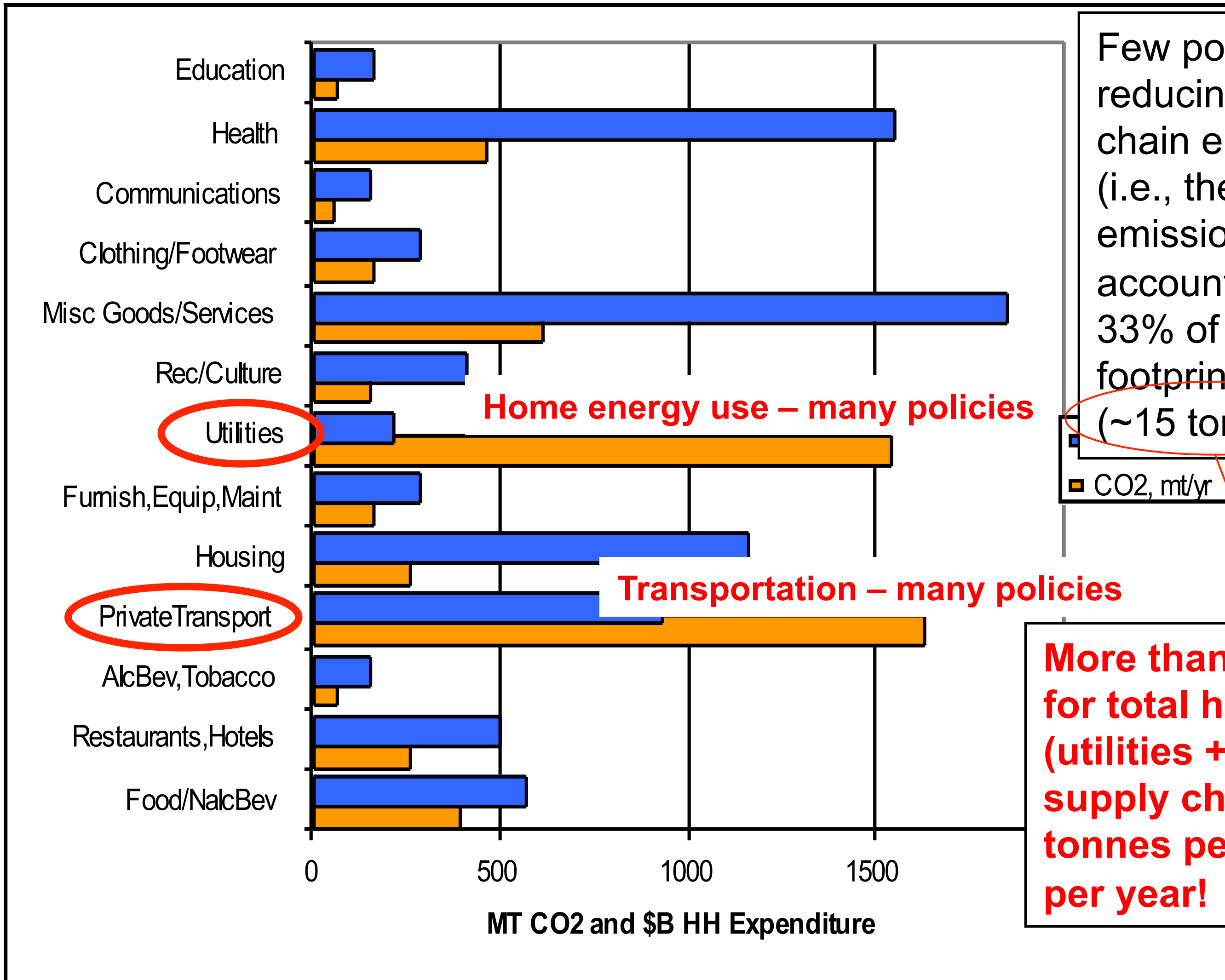


http://www.carbon-label.com/

- **Challenges**
  - — Cost, complexity, reliability
  - — Data gaps and uncertainties
  - — Singular focus on carbon
  - — Will market adopt?

- **Opportunities**
  - — Increased supply chain accountability
  - — Improved supply chain energy and emissions management
  - — Long-term corporate culture change toward continuous improvement

Aim: Reduce Supply Chain ("Embodied") Emissions



Few policies for reducing supply chain emissions (i.e., the remaining emissions), which account for around 33% of carbon footprint (~15 tonnes)

More than global average for total household (utilities + transport + supply chain) = 5-10 tonnes per household per year!

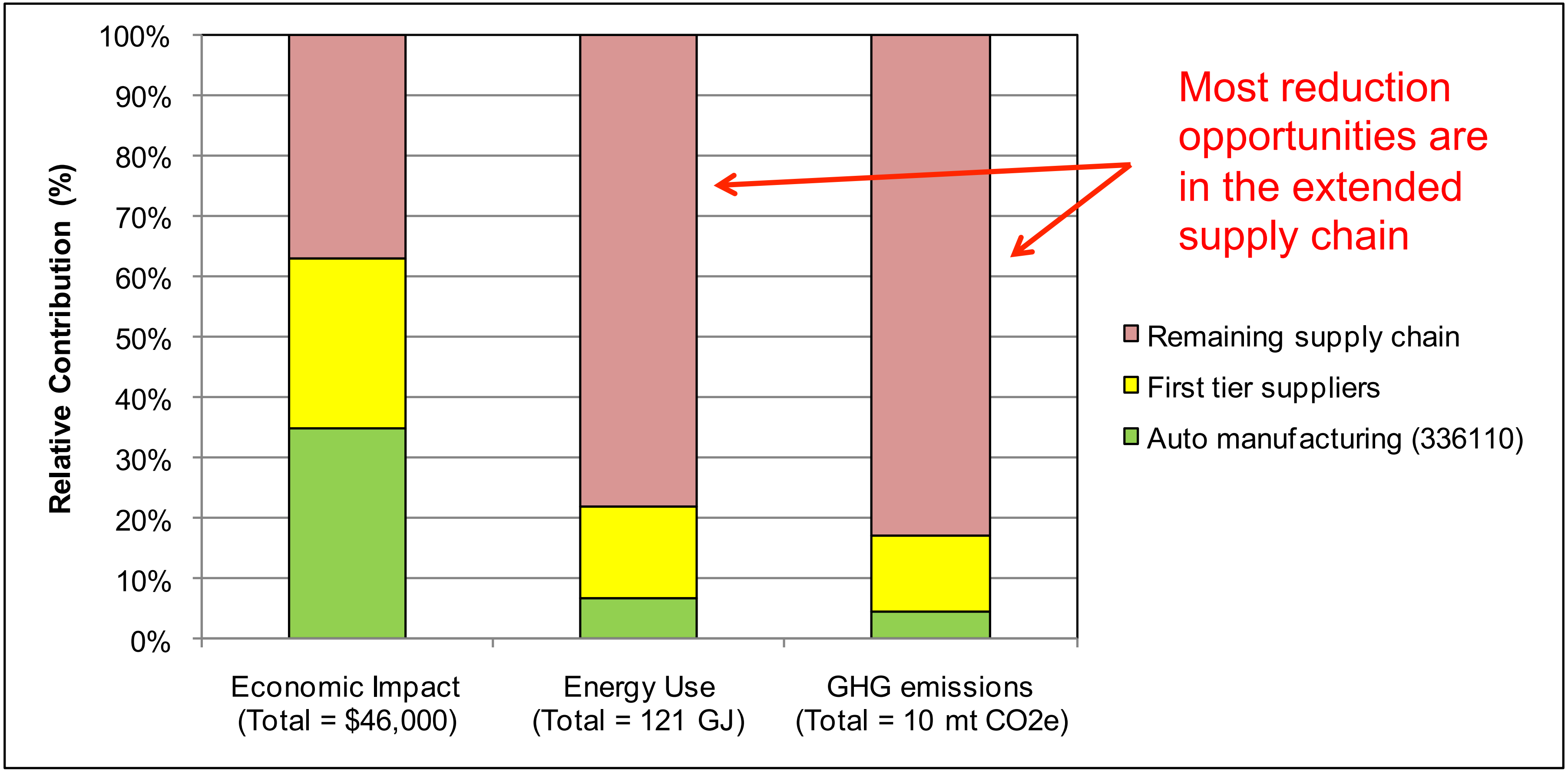
Total: 50 tonne/household including direct and indirect emissions

Source: Weber, C.L. and Matthews, H.S. (2008) "Quantifying the Global and Distributional Aspects of American Household Environmental Impact" Ecological Economics, 66(2-3), pp. 379-391.

Mechanism: Manufacturer Leverage (i)

Example

Economic Impact, Energy Use, and GHG Emissions Associated with the Manufacture of an Average Midsize U.S. Passenger Car (IO 336110)



Sources: Derived from (1) Hendrickson, C.T., Lave, L.B., and H.S. Matthews(2006). Environmental Life Cycle Assessment of Goods and Services. Resources for the Future Press, Washington, DC. and (2) Carnegie Mellon University Green Design Institute (2008) Economic Input-Output Life Cycle Assessment (EIO-LCA), US 1997 Industry Benchmark model [Internet], Available from:<http://www.eiolca.net>

Example of Manufacturer Leverage (ii)

Electricity Use and Motor System Electricity Savings Potentials of Selected Sectors in the Manufacture of an Average Midsize U.S. Passenger Car

Potential savings from efficiency upgrades

Fraction to plant's pumps, fans, drives, etc.

Auto plant electricity use

IO Sector	Description	Total Electricity Use (kWh)	Motor System Electricity Use (kWh)	Motor System Efficiency Potential	Potential Electricity Savings (kWh)
336110	Automobile and light truck manufacturing	727	313	15%	47
			Auto manufacturer total		***47***

An auto manufacturer might increase savings by a factor of 4 by replicating motor system efficiency best practices across just 10 key suppliers

Source: Sathaye, J.A., Lecocq, F., Masanet, E., Najam, A., Schaeffer, R., Swart, R., and H. Winkler (2008). "Opportunities to change development pathways towards lower greenhouse gas emissions through energy efficiency." Journal of Energy Efficiency. Forthcoming.

Unique Research Questions and Goals

- **Research questions:** So we have a supply chain energy and carbon footprint … now what? What and where are *specific* opportunities for reducing this carbon footprint along the supply chain, and at what level of cost?

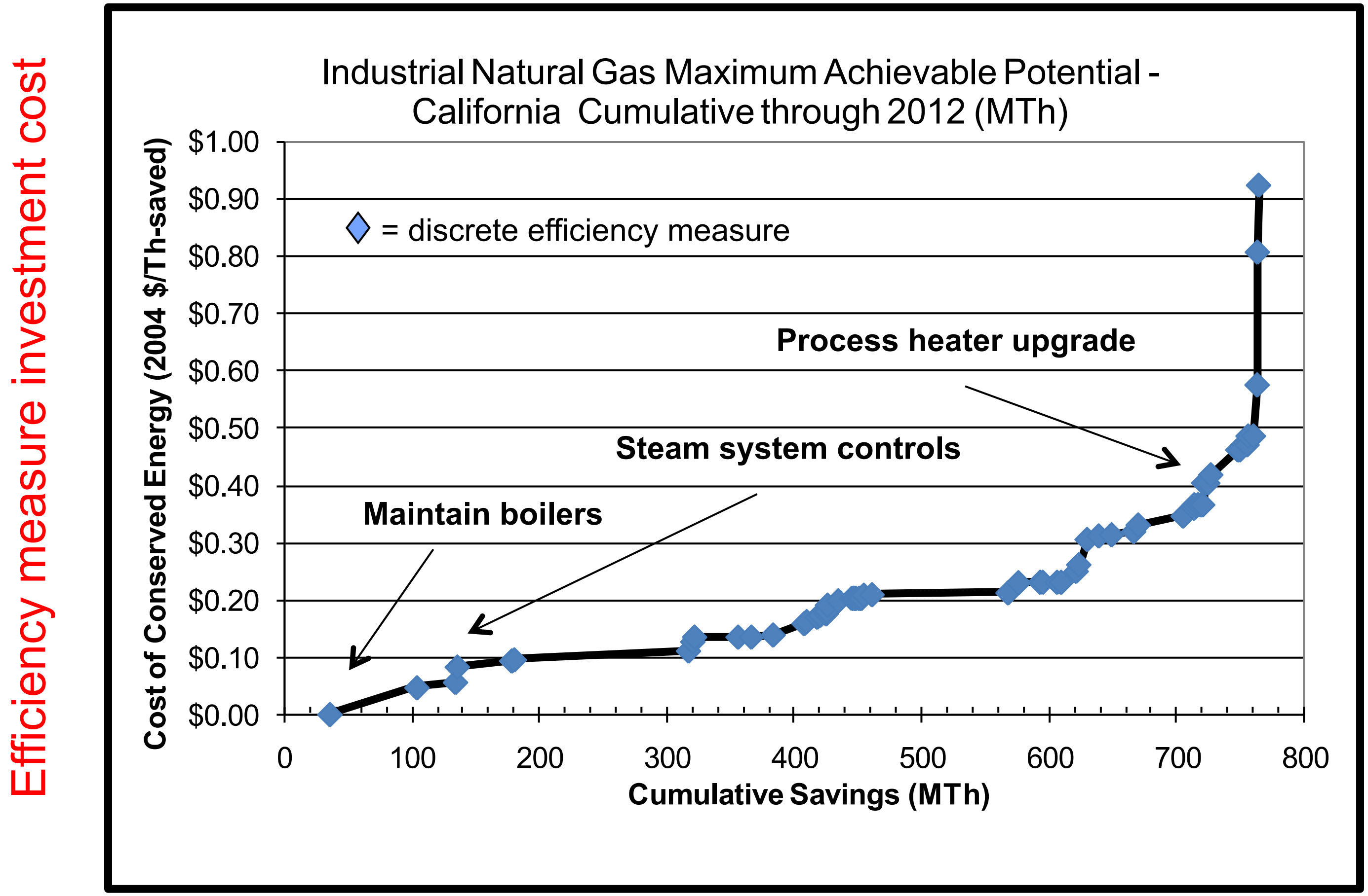
- **Research goals:** to develop a carbon footprint modeling framework that facilitates:
  1. disaggregation of supply chain energy use and GHG emissions by discrete processes, technologies, and fuel uses across the entire supply chain
  2. Techno-economic modeling of alternative processes and technologies by supply chain sector and fuel use
  3. identification of areas of actionable <u>energy efficiency</u> opportunities to inform the decisions of <u>policy makers, utilities, and energy/climate analysts</u>

→ Hybrid modeling approach: input-output LCI + techno-economic potentials modeling

Background: Techno-Economic Potentials Analysis

- **Which efficiency measures can reduce sector-level energy and carbon emissions, and at what cost?**

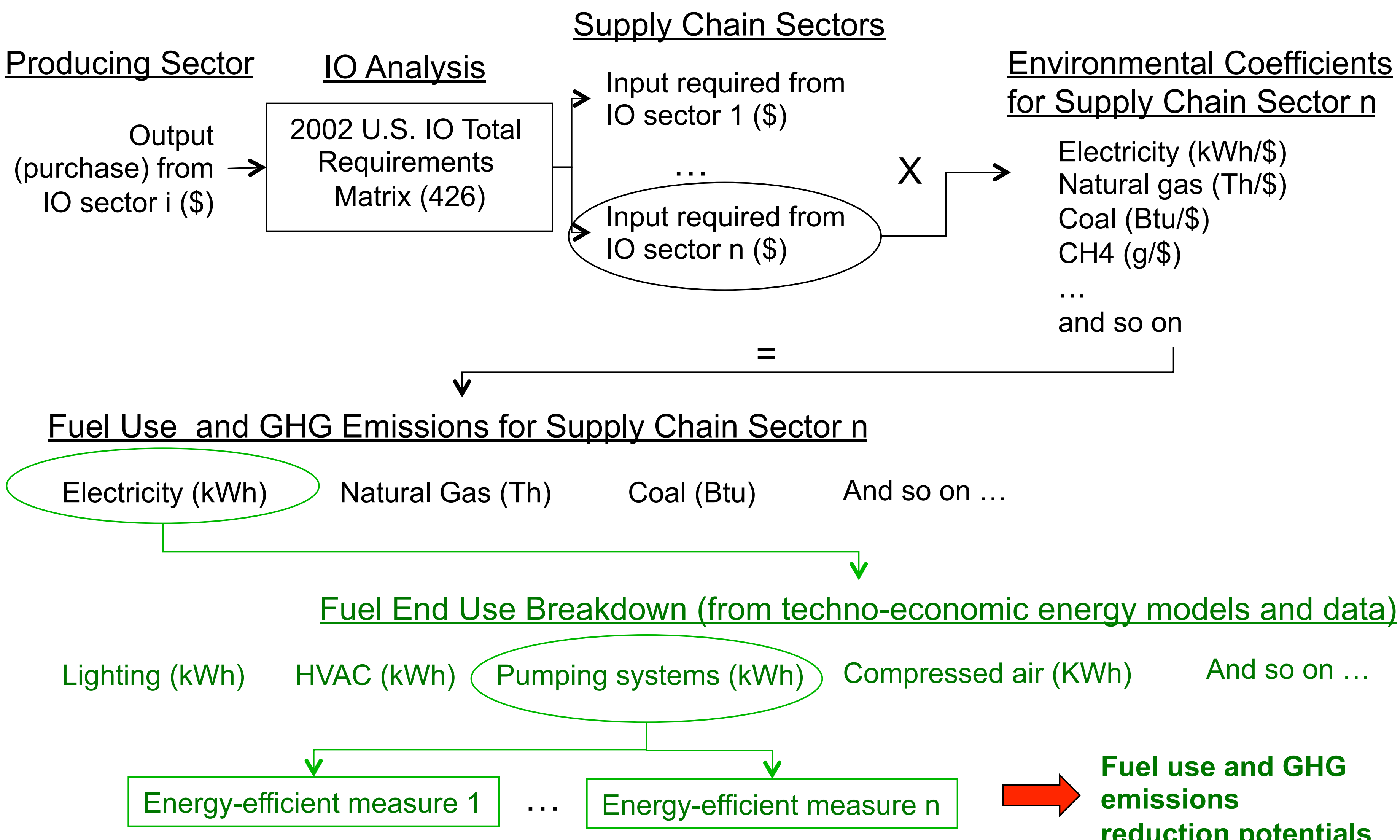
Example



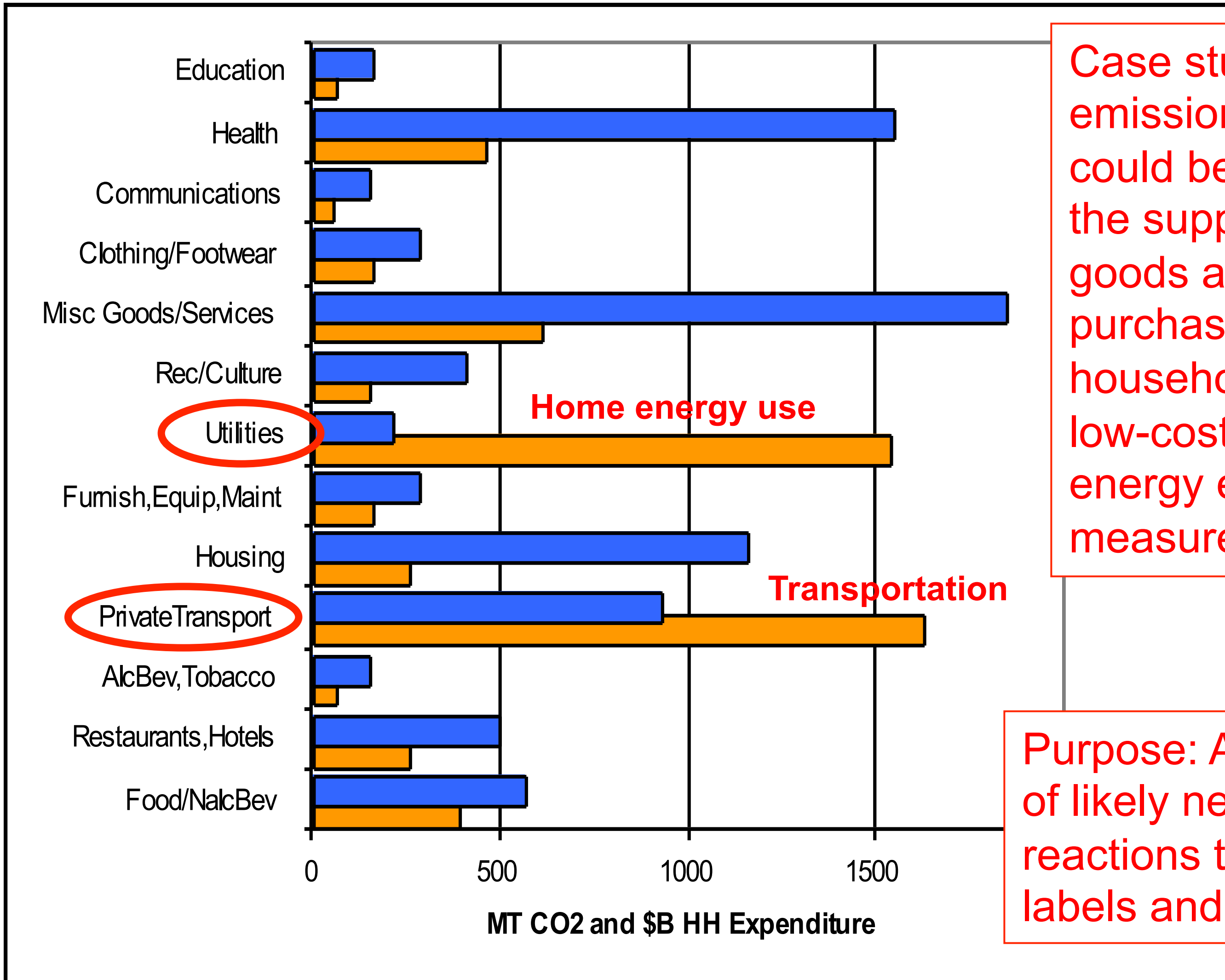
Friedmann, R., F. Coito, E. Worrell, L. Price, E. Masanet, and M. Rufo (2005). "California Industrial Energy Efficiency Potential." Proceedings of the 2005 ACEEE Summer Study on Energy Efficiency in Industry, West Point, New York, ACEEE.

Supply Chain Technology Potentials Model for Energy, Emissions, and the Environment

Black = CMU EIO-LCA model   Green = LBNL techno-economic potentials models



Sample eSTEP Analysis: Carbon Footprint of U.S. Households



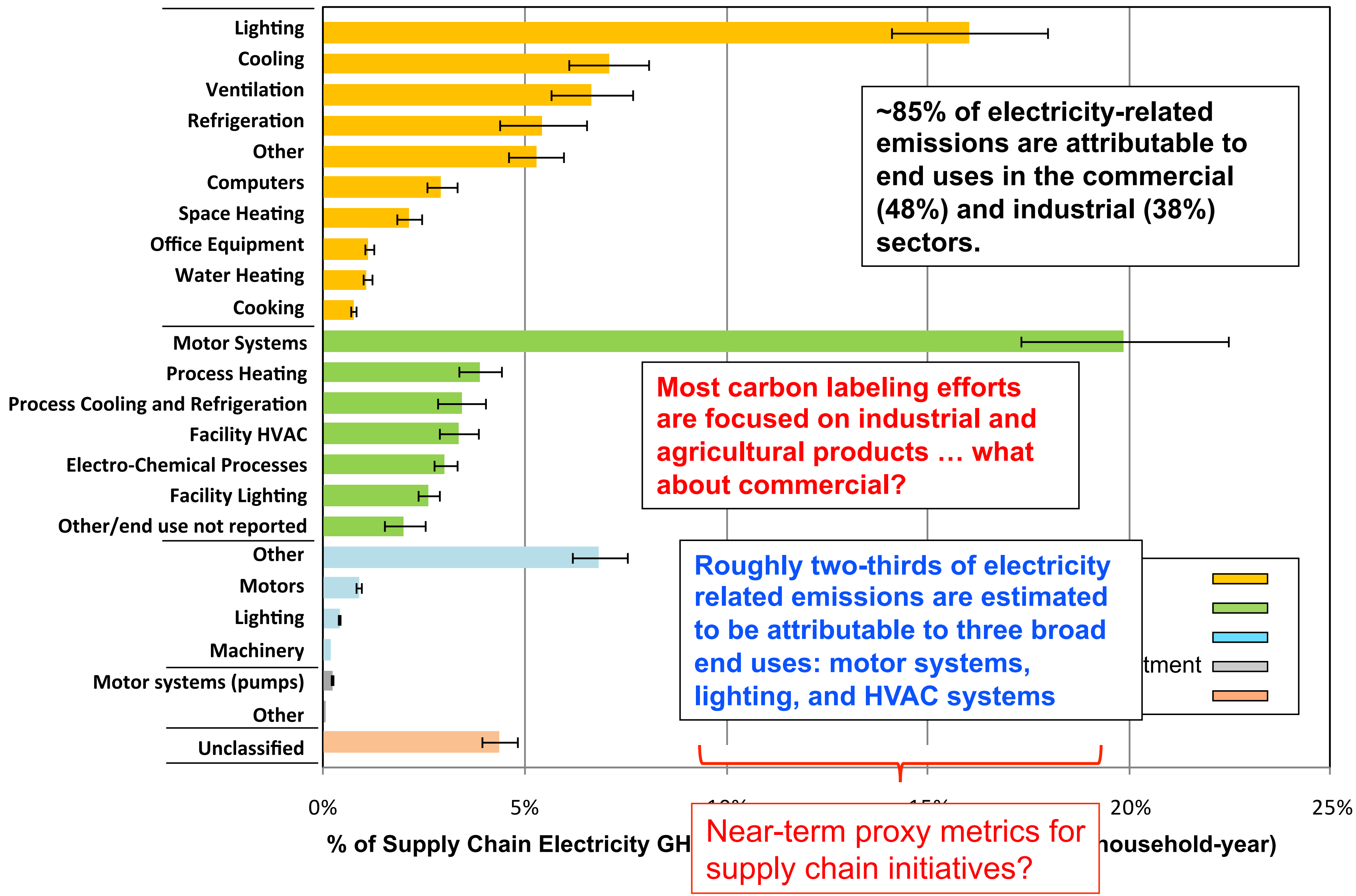
Case study: What emissions reductions could be achieved if the supply chains for goods and services purchased by U.S. households adopted low-cost, best practice energy efficiency measures?

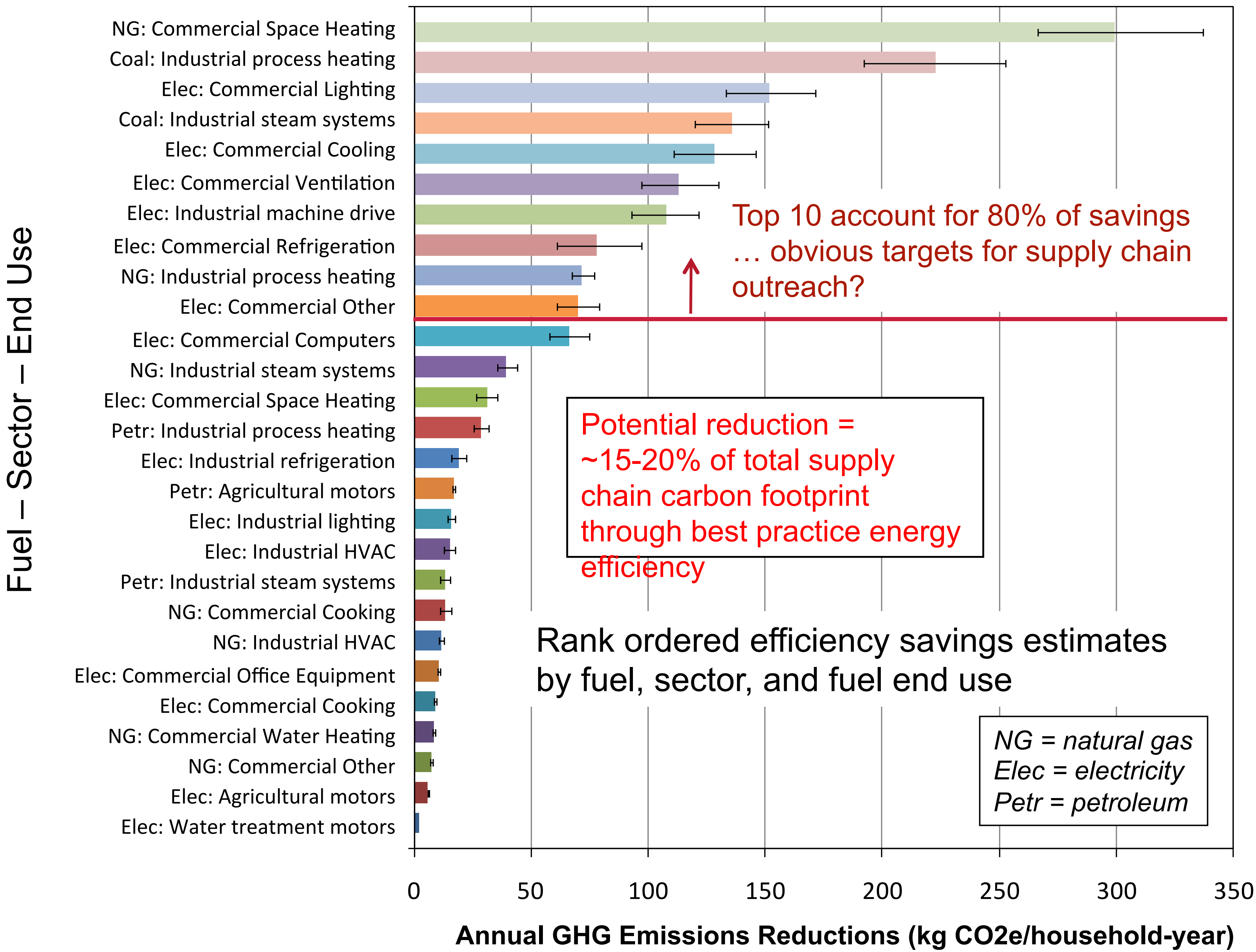
Purpose: A rough "test" of likely near-term reactions to carbon labels and standards

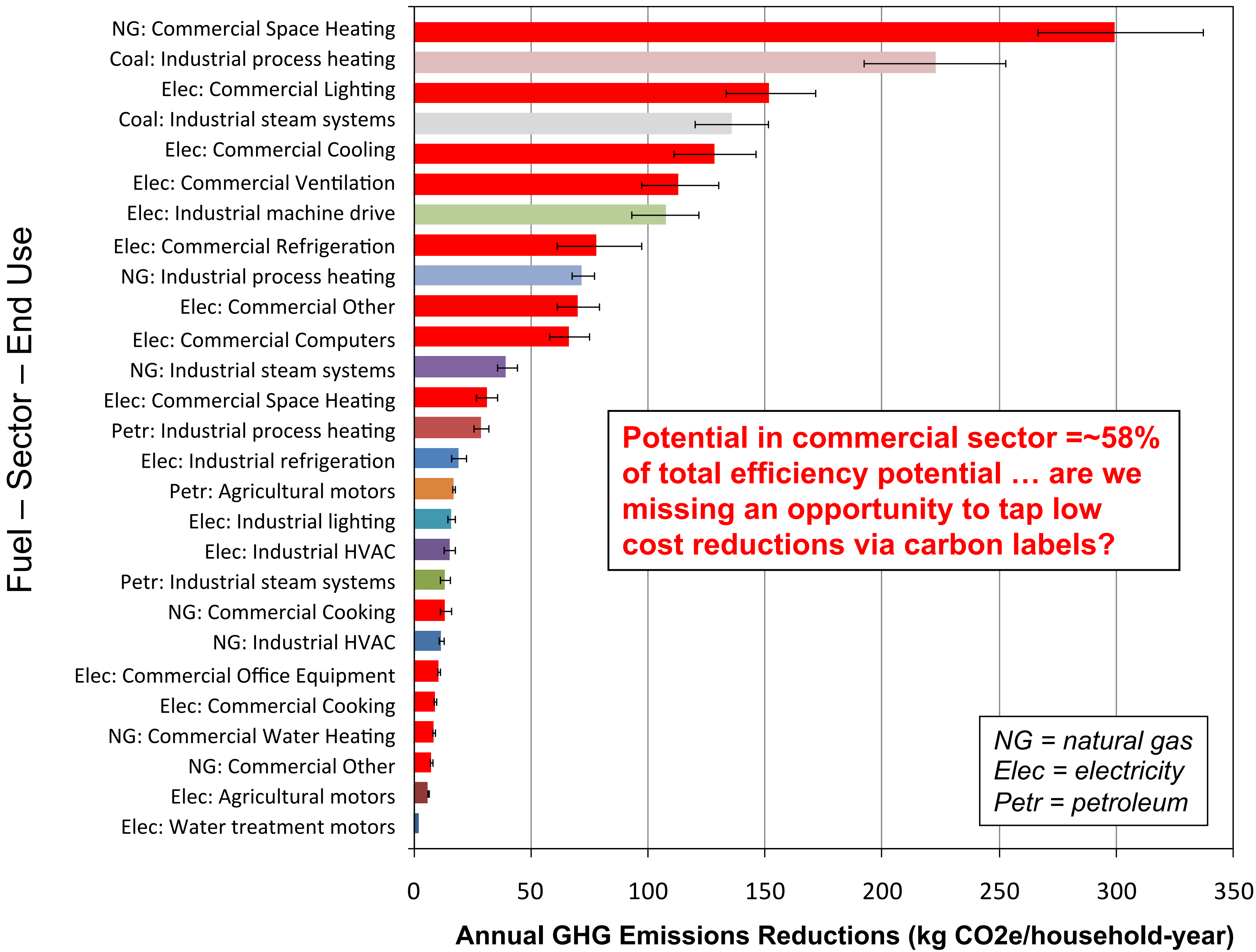
Total: 50 tonne/household including direct and indirect emissions

Source: Weber, C.L. and Matthews, H.S. (2008) "Quantifying the Global and Distributional Aspects of American Household Environmental Impact" Ecological Economics, 66(2-3), pp. 379-391.

End Use Breakdown Results for Supply Chain Electricity-Related GHG Emissions




Fuel – Sector – End Use
NG: Commercial Space Heating
Coal: Industrial process heating
Elec: Commercial Lighting
Coal: Industrial steam systems
Elec: Commercial Cooling
Elec: Commercial Ventilation
Elec: Industrial machine drive
Elec: Commercial Refrigeration
NG: Industrial process heating
Elec: Commercial Other
Elec: Commercial Computers
NG: Industrial steam systems
Elec: Commercial Space Heating
Petr: Industrial process heating
Elec: Industrial refrigeration
Petr: Agricultural motors
Elec: Industrial lighting
Elec: Industrial HVAC
Petr: Industrial steam systems
NG: Commercial Cooking
NG: Industrial HVAC
Elec: Commercial Office Equipment
Elec: Commercial Cooking
NG: Commercial Water Heating
NG: Commercial Other
Elec: Agricultural motors
Elec: Water treatment motors
Top 10 account for 80% of savings … obvious targets for supply chain outreach?
Potential reduction = ~15-20% of total supply chain carbon footprint through best practice energy efficiency
Rank ordered efficiency savings estimates by fuel, sector, and fuel end use
NG = natural gas
Elec = electricity
Petr = petroleum
0
50
100
150
200
250
300
350
Annual GHG Emissions Reductions (kg CO2e/household-year)



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Potential in commercial sector =~58% of total efficiency potential … are we missing an opportunity to tap low cost reductions via carbon labels?
NG = natural gas
Elec = electricity
Petr = petroleum
0
50
100
150
200
250
300
350
Annual GHG Emissions Reductions (kg CO2e/household-year)

Summary/Key findings

- eSTEP's bottom-up technology details by end use, fuel, and IO sector provide valuable new carbon footprint modeling capabilities:
  - New insights on underlying technologies, processes, end uses, and fuels contributing to the supply chain carbon footprint
  - Facilitates assessment of supply chain carbon mitigation potentials and optimization studies
  - Result = enhanced decision making for policy makers, manufacturers, and designers

- While much focus is on the industrial and agricultural sectors, the commercial/services sector represents a large fraction of supply chain emissions

- Results may provide much-needed proxy metrics for low-carbon supply chains

- Next steps include expanding efficiency and GHG abatement measures, ranking products by low-cost reduction potential (i.e., the wisest initial targets for carbon labels!)