

Using IAC Database for Longitudinal Study of Small to Medium Sized Automotive Industry Suppliers' Energy Intensity Changes

S. Chaudhari

Deepak Gupta
Southeast Missouri State Univ.

Bhaskaran Gopalakrishnan
West Virginia Univ.

ABSTRACT

Industries related to automotive manufacturing and its supply chain play a key role in leaving a carbon footprint during an automobile's life cycle. Per the report from Lawrence Berkeley National Laboratory (LBNL) in March, 2008 [1], "motor vehicle industry in the U.S. spends about \$3.6 billion on energy annually." The proposed research will focus on energy savings opportunities in automotive manufacturing and its supplier network. The US Department of Energy (DOE) funds 24 Industrial Assessment Centers (IAC) throughout the U.S. that conduct energy assessments at many of these facilities. The results of these assessments are summarized in a database maintained by Rutgers University which acts as the central management body for all the IACs. This research will present key concepts summarized from this database. These concepts include:

- (1). top 10 energy saving recommendations,
- (2). top 10 energy savings implemented measures,
- (3). comparison of energy efficiency investment in small-and mid-sized automotive industry supply chain in pre and post economic slump,
- (4). impact of major federal incentives on energy efficiency investments and its correlation with the implementation of recommended measures from database, and
- (5). energy savings potential across the automotive industry.

CITATION: Chaudhari, S., Gupta, D. and Gopalakrishnan, B., "Using IAC Database for Longitudinal Study of Small to Medium Sized Automotive Industry Suppliers' Energy Intensity Changes," *SAE Int. J. Mater. Manf.* 6(3):2013, doi: 10.4271/2013-01-0833.

INTRODUCTION

The US automotive industry can be considered as an unofficial indicator of market conditions portraying economic growth and personal achievement. Automobile industry's performance directly affects steel, aluminum, glass, plastic, and rubber as well as petroleum refineries, road construction, and maintenance and repair industries [2]. The US auto industry came under extreme economical pressure due to economic slump after financial meltdown and has been

undergoing restructuring since 2008. In October of 2011, the industry directly employed approximately 700,000 workers at 43 working hours per week [2]. The automotive supply chain that manufactures electrical and electronic equipment, engines, transmissions, brake systems, seating, interior trimming, tires, steering, suspensions, air-conditioning systems, and body parts such as fenders, body etc. employ 415,000 workers [2].

Increasing level of greenhouse gas (GHG) emissions are a primary concern in consideration of environmental and sustainability impact of automotive sector. A study carried out by Toyota found that up to 28% of CO₂ emissions generated during the life cycle of a typical gasoline-powered vehicle can occur during its manufacturing phase and transportation to dealership [3]. There are consistent efforts from industry to reduce their carbon footprint and boost sustainability which is evident from the product advertising. According to federal register, 40 CFR (part 85, 86, and 600), the minimum fuel economy standards for passenger cars will be raised gradually and will be at a level of 34.7 mpg in 2016 [4]. The direct, intermediate, and spin-off jobs associated with original equipment manufacturer - related operations provide 2% of the employment in the US economy [5]. The study carried out by Center for Automotive Research (CAR) also showed that the industry and the supply chain contribute \$500 billion to the economy through compensations to the workers. The automotive supply chain is very wide and includes different industries such as metals, metal working, electrical and electronic parts, plastics, etc.

The US DOE Advanced Manufacturing Office (AMO) is the leader in efforts to reduce industrial energy intensity, improve energy efficiency, and environmental performance. AMO works with industry to improve energy efficiency, increase productivity and bottom line profits, and reduce environmental impacts through research and development, commercialization of technologies, providing access to existing technologies and software [6]. The Industrial Assessment Centers (IACs), sponsored by AMO, provide eligible small- and medium-sized manufacturers with no-cost energy assessments. Additionally, the IACs serve as a training ground for the next-generation of energy engineers. IAC assessments provide a no-cost, on-site visit to plants to identify potential energy and cost savings opportunities. Teams of engineering faculty and students from the centers, located at 24 universities around the country, conduct energy audits or industrial assessments and provide recommendations to manufacturers on improving productivity, reducing waste, and saving energy.

A typical energy efficiency study can be classified as a walk through, survey level and cost analysis, and detailed energy study. The ASHRAE refers to the classification as Level I, Level II, and Level III respectively. The IACs conduct level II assessments at the manufacturing clients' sites. The typical methodology of the study is shown in [Figure 1](#) in the appendix.

The results from all the IAC assessments are stored in a database which hosts wealth of information in terms of recommended opportunities, potential savings, cost of implementation, and payback periods along with SIC or NAICS information from the plant [7]. This data has been analyzed in this study.

The North American Industry Classification System (NAICS) has classified code 336 for transportation

equipment manufacturing. There are approximately 30,000 businesses registered under this classification. This classification also includes marine as well as air transportation which is irrelevant for this study. The considered automotive suppliers according to NAICS with corresponding mapping to Standard Industrial Classification (SIC) are presented in [Table 1](#) in the appendix.

The 2006 Manufacturing Energy Consumption Survey (MECS) found that the transportation equipment manufacturing industry (NAICS 336) consumed a total of 479 Trillion Btu (TBtu) in 2006, out of which automobiles manufacturing, and light trucks and utility vehicles accounted for 39 and 43 TBtu respectively. The highest energy use was for process heating followed by facility HVAC and motors (shown in [Table 2](#) in the appendix) [8]. The preliminary findings released by Energy Information Administration (EIA) on MECS 2010 suggest that the US manufacturing industry energy consumption exhibited 10% overall from 2006 to 2010 [9].

STUDIES OF AUTOMOTIVE SUPPLY CHAIN

Several Studies in literature document theories and findings on the automotive supply chain. The studies have contributed to enhance and strengthen the supply chain network and integrated the industry further. An expert fuzzy rule based system was designed by Olugu and Wong to study Closed Loop Supply Chain (CLSC) performance assessment of automotive industry and found it to be effective, efficient, and an economical strategy towards sustainable practices. A study published by Galitsky and Worrell of LBNL found that in vehicle assembly industry, the practices that could contribute to energy efficiency were spread among the process and non-process measures [1]. The process measures mostly included paint practices such as new paint powders, powder slurry coats, carbon filters and VOC removers, high pressure water jet systems for washing, and variable voltage controls during stamping while non-process measures included energy systems of compressed air, process heating, lighting, HVAC, and motors. The study found that the assembly plants could save energy by reducing air leaks, load management, monitoring and control of air compressors, upgrading lighting systems, and making steam systems efficient. Gopalakrishnan, et al. published a paper on common compressed air energy efficiency measures [10]. The large part of auto industry's supply chain energy consumption is attributed to process heating systems in the auto supply chain. It is estimated that automotive supply chain spends more than \$500 million on steam systems annually [11]. The energy efficiency for steam systems can be improved through combustion control and use of economizers [1]. At part load steam, HVAC and motor systems do not operate at optimum energy efficiency [12].

A report prepared by Driving Workforce Change for US Department of Labor found that 30% of the plant managers

implemented at least one energy efficiency measure and 10% plant managers said they implemented three energy efficiency measures. In the survey, 51% plant managers conducted an energy audit to improve energy efficiency, 42% installed more efficient lighting, and 28% installed insulation [13]. The information on energy efficiency potential in auto supply chain in the US is scarce; especially so for the small to medium sized manufacturers. This study has attempted to extrapolate the assessments conducted by Industrial Assessment Center program over thirty years to the auto supply chain.

A study conducted by US DOE and USCAR estimated that the automotive supply chain accounts for 800 TBtu of annual energy use in the US economy [14]. The study also notes that the energy estimate does not include energy used by the basic tier suppliers such as primary metal manufacturers. It also does not include the energy used for vehicle transport to the dealerships. Energy intensity is defined as the energy required to produce a unit (dollar) of GDP, or E/GDP [15]. According to the data from economic census of 2006, the transportation equipment manufacturing industry (NAICS 336) shipped goods worth of \$699.03 Billion [16,17]. In the same year, the subsector of automobile manufacturing (NAICS 336111) accounted for \$94.23 Billion in value of shipments and subsector of light truck and utility vehicles (NAICS 336112) accounted for \$138.24 Billion in value of shipments (Table 3). The transportation equipment sector has an energy intensity of 685.2 Btu per USD value of shipments from the manufacturers.

Table 3. Energy Intensity for Automobile Industry in Comparison with Average of US Manufacturing Sector

NAICS	Energy Consumption, TBtu	Value of Shipments, Billion Dollars	Energy Intensity, BTU/USD
336	479	699.03	685.2
336111	39	94.23	413.9
336112	43	138.24	311.1
31-33 US Mfg Industry	21,098	5,011	4,210.3

ENERGY EFFICIENCY RECOMMENDATIONS

The Industrial Assessment Center database hosts a wealth of information which is mined for this section of the paper. The authors present insights in terms of what are the key energy efficiency measures that were thought to be beneficial as opposed to the measures that proved beneficial. The data was also used to compare pre- and post-economic slump energy efficiency investment characteristics of the industry. The data manipulation was carried out using SQL queries, the details of which are not presented due to space limitation. It was found that lighting, compressed air motors, and process heating system improvements were recommended most frequently. The measures included replacing lights with higher efficiency lamps and ballasts, occupancy sensors,

reducing air leaks, and utilizing premium efficiency motors (Table 4). The higher efficiency lamps and ballast recommendation would save the most as 411,200 MMBtu annually for the assessed 1,447 manufacturers (Table 5). However, based on implementation surveys, the manufacturers implemented air leaks programs more frequently than the lighting upgrades which saved 218,600 MMBtu of electricity annually as compared to 189,100 MMBtu saved by lighting upgrades (Table 6).

Table 4. Most frequently recommended energy efficiency measures in auto industry supply chain

Sr.	ARC2	Description	Freq.
1	2.7142	Utilize higher efficiency lamps and/or ballasts	1082
2	2.4236	Eliminate leaks in inert gas and compressed air lines/valves	793
3	2.4221	Install compressor air intakes in coolest locations	527
4	2.4133	Use most efficient type of electric motors	420
5	2.4231	Reduce the pressure of compressed air to the minimum required	378
6	2.7135	Install occupancy sensors	361
7	2.7143	Use more efficient light source	360
8	2.4111	Utilize energy-efficient belts and other improved mechanisms	299
9	2.2511	Insulate bare equipment	238
10	2.2434	Recover heat from air compressor	214

Table 5. Top ten energy efficiency measures in auto industry supply chain

Sr.	ARC2	MMBtu per year*	Description
1	2.7142	411,200	Utilize higher efficiency lamps and/or ballasts
2	2.2411	296,000	Use waste heat from hot flue gases to preheat combustion air
3	2.4236	282,500	Eliminate leaks in inert gas and compressed air lines/ valves
4	2.2437	245,900	Recover waste heat from equipment
5	2.7261	224,400	Install timers and/or thermostats
6	2.2424	196,100	Use heat in flue gases to preheat products or materials
7	2.6218	190,500	Turn off equipment when not in use
8	2.1233	182,500	Analyze flue gas for proper air/fuel ratio
9	2.7231	178,000	Use radiant heater for spot heating
10	2.2511	157,400	Insulate bare equipment

*savings rounded to upper 100 value