

# SEVERE WEATHER AND MANUFACTURING IN AMERICA:

COMPARING THE COST OF DROUGHTS, STORMS  
AND EXTREME TEMPERATURES  
WITH THE COST OF NEW EPA STANDARDS

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# INTRODUCTION

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On June 2, 2014, the Environmental Protection Agency (EPA) published draft greenhouse gas standards for existing U.S. power plants. Each state must meet the standards, but they may choose from a variety of options to do so, including energy efficiency investments and relying more on natural gas or renewable energy.

The EPA estimates that utilities will increase their rates by 6.2 percent (in 2020)<sup>i</sup> to pay for the investments these new standards require. The standards' true impact on rates will not be known until they are finalized and each state produces its own implementation plan. Even then, electricity prices will vary from state to state. Moreover, they will be subject to much larger forces, such as whether our economy continues to improve (increasing demand).

Critics of the EPA standards argue that increasing manufacturers' electricity costs will encourage them to move production overseas. The merits of this argument depend largely on a simple question: ***How much of a manufacturer's cost does electricity represent, and how will a 6.2 percent increase affect its global competitiveness?***

Proponents of the EPA standards argue that they are a necessary response to the immediate and long-term costs of severe weather caused by climate change. This argument raises a second question: ***How much does severe weather affect manufacturers' costs?***

**In answering these questions, we compare (1) the cost of reforms intended to address severe weather with (2) the costs manufacturers face from severe weather itself.**

For specific examples, we examine America's largest industrial sector: automotive manufacturing. Electricity represents 0.9 percent of an automaker's costs and 0.75 percent of a parts supplier's total costs, on average.<sup>ii</sup>

By comparison, their supply chains represent approximately 75 percent of their respective total costs. We explain why the industry's massive, global supply chains are at risk, largely because the improvements that have made them so efficient have also made them highly interdependent and vulnerable to even small disruptions.

# EXECUTIVE SUMMARY

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Automakers and their parts suppliers have built a massive supply chain that is highly specialized, fast moving, and global. But these advancements also make supply chains highly interdependent, which makes them vulnerable to climate change.

Severe weather has hit our highways, ports, rails and shipping channels, shutting down assembly lines for days and weeks at a time. For an auto assembly plant, those disruptions cost \$1,250,000 per hour.

When compared to the hours of production auto assembly plants and parts suppliers lose each time severe weather disrupts their supply chains, the cost of EPA standards to address severe weather (from steel and glass through final assembly, less than \$7 per car) are minute.

## MANUFACTURERS AND SUPPLY CHAIN RISK

American manufacturers rely on massive, highly specialized, global supply chains, which represent about 60 percent of the average manufacturer's costs. These supply chains operate on a "just in time" basis that requires factories to operate with as little as two to four hours of parts inventory on site.

"Just in time" delivery saves manufacturers money on overhead, but it also makes supply chains more vulnerable to disruptions, like severe weather. A plant with only two hours of parts on site shuts down if a shipment is delayed more than two hours.

Because supply chains are global, disruptions on the other side of the planet can slow down or shut down an American factory. For example, in October 2011, severe floods in Thailand affected more than 1,000 industrial facilities. Production by consumer electronics manufacturers in the U.S. dropped by one-third.

Automakers and auto parts suppliers are America's largest manufacturers (by revenue and by employment). Their supply chains are the largest, most complicated, and most important to our economy. For automakers and their suppliers, supply chain expenses are 75 percent of their total costs.<sup>iii</sup>

SEVERE WEATHER COSTS AN  
AUTO ASSEMBLY PLANT MORE

IN ONE HOUR

THAN EPA STANDARDS WILL  
COST IT OVER AN ENTIRE  
YEAR.

A typical American assembly plant purchases more than \$3 billion worth of parts each year. These are delivered to the plant in such volumes that a truck arrives every three to five minutes, nearly 24 hours a day. The assembly plant turns those parts into 500 cars or trucks per shift, 300,000 per year.

Shutting down an auto assembly line costs the plant \$1,250,000 or more per hour. For this reason, auto-makers penalize suppliers as much as \$10,000 for every minute their shipments are late. Faced with these penalties, a supplier whose trucks are delayed will often hire a helicopter to deliver a substitute shipment.

Historically, manufacturing plants (all industries) have experienced four unexpected disruptions each year, costing them 20 hours of total downtime.<sup>iv</sup> These are typically caused by equipment failures, power outages, absence of key personnel, and severe weather.

## SEVERE WEATHER'S IMPACT ON MANUFACTURERS

Large weather disasters, or weather events causing more than \$1 billion in damages, are becoming more frequent. The country experienced 20 weather disasters in the 1980s, 47 in the 1990s, and 48 in the 2000s; but in the just the past four years, 36 weather disasters have occurred, more than double the pace of the previous two decades.

Over the past four years, American assembly plants and factories have been disrupted by typhoons in Thailand, hurricanes in the Gulf of Mexico, droughts in Texas, tornadoes in Kentucky, falling water levels across the Great Lakes, and flooding in the Northeast. The result? Cargo ships are carrying less cargo to avoid running aground. Ports are preparing for more hurricanes (and rising sea levels). Highways and bridges are subject to more frequent delays, and train cars' worth of parts detoured during last winter's storms still have not arrived at their destinations.

The total impact per plant, per year, is far greater than the 20 hours of unexpected downtime a plant has historically experienced.

## ELECTRICITY USAGE, POTENTIAL IMPACT OF EPA STANDARDS

**Manufacturers, all industries.** While manufacturers use a great deal of electricity, the cost of that electricity is a comparatively small portion of their total costs. The average across America's 19 largest industries is 0.9 percent.<sup>v</sup> Therefore, if the proposed standards were to increase electricity rates by 6.2 percent in 2020, the average industry's total costs would rise 0.056 percent. In other words, if it costs a company \$100 to make one of its products, that cost would increase less than six cents.

**Automakers and suppliers.** Electricity represents less than 1 percent of an assembly plant's total expenses. For auto suppliers, electricity costs represent 0.75 percent of their total costs, on average. The total cost of electricity used from rolled steel through final assembly is about \$105 per car or truck.<sup>iv</sup> A 6.2 percent increase on that cost would increase that automaker's per car assembly costs by less than \$7 per car or truck (in 2020). The average car sells for about \$30,000.

## COMPARISON OF ELECTRICITY COST INCREASE TO A FINAL ASSEMBLY PLANT VS. COST OF ASSEMBLY LINE DISRUPTION

About \$60 of the \$105 parts suppliers and automakers spend on electricity (per car) is consumed at the final assembly plant. If 1.) per car electricity costs for an assembly plant (\$60) increase by \$3.72 (6.2 percent); 2.) a plant assembles 300,000 vehicles

each year; and, 3.) it has a typical downtime costs (\$1,250,000 per hour), the increase in the plant's electricity-related costs (\$1,116,000) is less than the cost of losing an hour of production time.

This past winter, several assembly plants lost days of production to severe weather.

## **TRENDS AGGRAVATING SUPPLY CHAIN RISK**

First, many of our most important parts suppliers operate in regions or countries that are highly vulnerable to rising sea levels, severe storms, and extreme temperatures. Second, as supply chains grow (and become global), they become less transparent: manufacturers cannot manage risks they cannot measure. Third, small businesses, which dominate the lower levels of the auto supply chain, are less likely to survive catastrophic events. Fourth, our infrastructure is aging, while congestion is growing. Finally, automakers have eliminated excess plants, so more of their plants operate double and triple shifts. Disruptions cost more at plants operating near full capacity.

# SCALE AND INTERDEPENDENCE OF 21ST CENTURY SUPPLY CHAINS

## SUPPLY CHAIN COSTS, ACROSS INDUSTRIES

Intermediate costs—the cost of buying, moving parts and materials and converting them into services or goods for sale—represent 60 percent of manufacturers’ costs, on average. Costs vary by industry. For example, supply chain-related expenses for the farming, plastics, and food and beverage industries are 58, 68, and 74 percent of total costs, respectively.

## AUTO SUPPLY CHAIN

Over the past 50 years, the auto industry has transformed from one in which the major automakers purchased raw materials and made all of their own parts to an industry that has outsourced nearly all production, except for the final stage of assembling a motor vehicle.

As a result, the bulk of an assembly plant’s expenses (75 percent) come from its supply chain. Cars and trucks sold in the U.S. contain between 8,000 and 12,000 different components, made from as many as 15,000 different parts.<sup>vii</sup> A mid-size sedan contains 3,000 pounds of steel, aluminum, glass, rubber, copper wiring, and electronics.

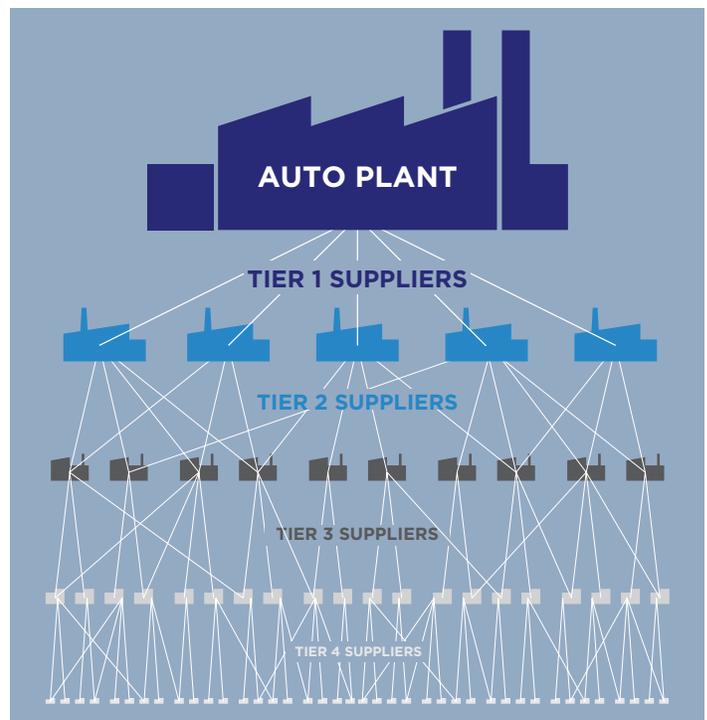
Auto supply chains are highly specialized and vertically integrated. More than 5,600 companies produce auto parts in the U.S. “Tier 1” suppliers produce finished seats, wheels, tires, interior components, air bags, entertainment systems, brakes, exhaust systems, and other large components. To produce these parts, the Tier 1 suppliers rely on Tier 2 suppliers for stamped parts, rubber products, plastics components, and electronic components. Tier 2 suppliers rely, in turn, on Tier 3 suppliers, who manufacture basic items such as ball bearings, screws, lubricants, joining compounds, and various rubber and plastic parts. Beyond the Tier 3 suppliers are Tier 4 suppliers who produce rolled steel, plastic polymers, leather, fabrics, and other basic materials.

A typical assembly plant purchases \$3 billion worth of parts each year. Parts typically arrive by truck, and

those trucks arrive every three to five minutes, nearly 24 hours each day.

Today’s auto supply chain is global. About half of the parts that go into making a car or truck sold in the U.S. are imported from other countries. Approximately 20 percent of those parts come from other continents, with the bulk of those coming from Asia.<sup>viii</sup>

Because each supplier serves more than one other supplier or plant, and because components can move back and forth from factory to factory as they are produced, these three tiers of suppliers operate less as a “chain” and more as a “network.” For example, an automaker with plants in Michigan and Ontario, Canada, estimates that some of its parts will cross the U.S.-Canada border seven times before they are installed in a finished car or truck.<sup>ix</sup> The result? Every day, that automaker’s U.S. plants rely on the timely arrival of 600 trucks crossing the Windsor-Detroit border.



**“JUST IN TIME” TRUCKS ARRIVE  
AT AN ASSEMBLY PLANT**

**EVERY 3 TO 5  
MINUTES,  
NEARLY 24 HOURS  
EACH DAY.**



With 44 assembly plants, 61 engine, transmission and stamping plants, and thousands of supplier manufacturing facilities nationwide, automakers and suppliers also rely heavily on America’s ports. Parts for plants in Missouri, Kentucky, Tennessee, Virginia, Michigan, Ohio, Pennsylvania, Indiana, and Illinois generally arrive at ports in Los Angeles, California, or Norfolk, Virginia. Plants in Texas, Mississippi, Georgia, Alabama, and South Carolina rely more on ports in the Gulf of Mexico, such as Mobile, Alabama.

Finally, automakers’ 44 assembly plants delivered each of the more than 10.5 million vehicles they assembled last year to one of the 17,000 dealerships across the U.S.

#### **TRADEOFF BETWEEN EFFICIENCY AND INTERDEPENDENCE**

Specialization is meant to maximize each individual plant’s efficiency. Sourcing globally is meant to reach low-cost providers. “Just in time” is meant to reduce overhead. But each of these characteristics also makes the auto supply chain vulnerable to disruption, including disruptions caused by droughts, storms, and extreme heat and cold.

Because assembly plants are so large, so are these risks.



**SUPPLIERS, FACING**

**\$10,000  
PENALTIES FOR  
EVERY MINUTE  
THEIR SHIPMENTS  
ARE LATE,**

**OFTEN HIRE HELICOPTERS TO  
DELIVER SUBSTITUTE SHIPMENTS.**

A dark blue silhouette of a person sitting on the roof of a stylized factory building. The factory has several chimneys and windows. The background is a light blue gradient.

**EACH HOUR OF DOWN TIME  
COSTS AN ASSEMBLY PLANT  
\$1.25 MILLION.**

**COST OF AN HOUR OF EXTRA INVENTORY VS.  
COST OF HOUR OF DOWN TIME**

Today's supply chains also move at increasingly fast speeds, due to the auto industry's increasing reliance on "just in time" inventory. "Just in time" attempts to balance a plant's cost of maintaining excess inventory against the risk of running out of parts.

In practice, "just in time" manufacturing means that a plant maintains only two to four hours worth of materials at the assembly plant at one time. In other words, an efficient plant should have only enough parts and materials on its shelves to operate for two to four hours before shutting down. The reason? Having one extra hour's worth of production parts onsite to prevent a shutdown costs as much as \$950,000.<sup>x</sup>

If all goes according to schedule, this practice is highly profitable, but if supplies are disrupted, that same plant shuts down. Each hour of down time costs the automaker \$1,250,000 or more.

To encourage suppliers to arrive on time, automakers penalize suppliers as much as \$10,000 for every minute their shipments are late. Faced with these penalties, a supplier whose trucks are delayed will often hire a helicopter to deliver a substitute shipment.

# COSTS OF SEVERE WEATHER

## HISTORIC DISRUPTION RATE

According to a survey of manufacturers (all industries), the average factory incurs four unexpected disruptions each year, causing 20 hours of assembly line downtime, on average.<sup>xi</sup> Causes include mechanical failure, power outages, and supply disruptions.

## CURRENT DISRUPTION, RECENT EVENTS

**Events abroad.** Many of the auto industry's most important parts suppliers operate in regions or countries that are highly vulnerable to rising sea levels, severe storms, and extreme temperatures. In a May 2014 report, S&P ranked nations according to their vulnerability to climate change. The bulk of nations scoring worst were deemed vulnerable because their populations, cities, and factories are concentrated at low elevations, close to shore. Of 116 nations measured, several key auto parts supplying countries scored in the bottom quartile, including Thailand, Malaysia, Philippines, Vietnam, and Bangladesh. China, one of our biggest parts suppliers, ranked 83<sup>rd</sup> out of 116 in terms of climate change resilience.

When storms in Asia flooded more than 1,000 factories across Thailand, auto parts shipments from that country ceased. Nineteen days later, U.S. assembly

IT TOOK ONLY

**19 DAYS**

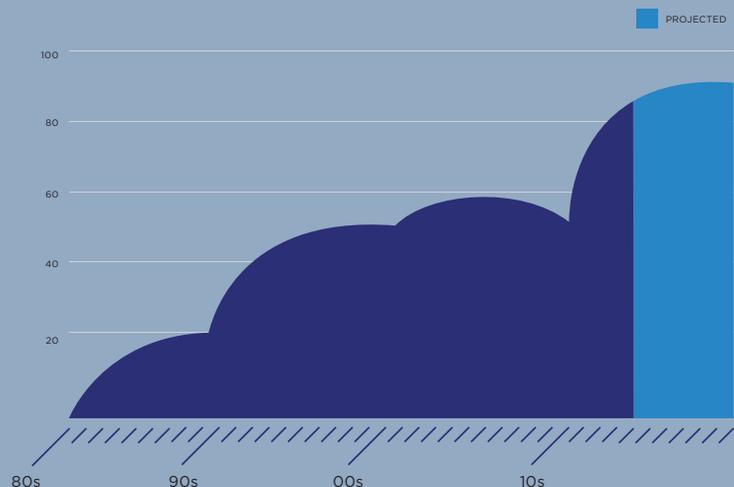
FOR FLOODS IN THAILAND TO SHUT DOWN AUTO PLANTS IN THE MIDWEST.

plants across the U.S. began slowing down or shutting down. Some did not return to normal production for a full month.

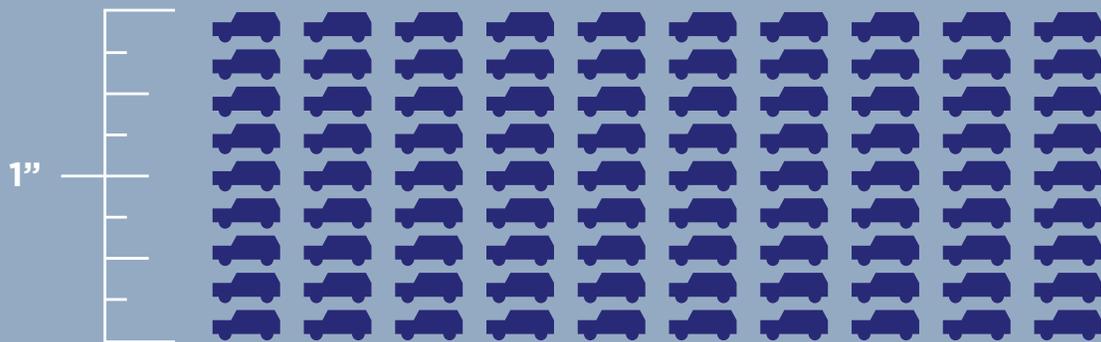
**Events in the U.S.** Temperatures from 2001 to 2012 were warmer than any previous decade in every region of the United States. For the contiguous 48 states, 12 of the 15 warmest years on record have occurred in the past 15 years.

Large weather disasters, or weather events causing more than \$1 billion in damages, are becoming more frequent. The country experienced 20 weather disasters in the 1980s, 47 in the 1990s, and 48 in the 2000s; but in the just the past four years, 36 weather

**DAMAGES FROM EXTREME WEATHER EVENTS COST THE U.S. MORE THAN \$200 BILLION.**



Projection based on 2010-2013 events.



To gain one inch of draft, large cargo ships have to leave 270 tons of cargo on the dock. That's the equivalent of 90 mid-size sedans.

disasters have occurred, more than double the pace of the previous two decades.

**Shipping.** American auto plants rely on shipments of materials and parts shipped across the Great Lakes. Recent droughts have reduced Lake Michigan and Huron water levels to all-time lows, forcing shippers to leave cargo behind. (This allows the ship to float higher in the water, reducing its draft.) To gain a single inch of waterline, a large cargo ship must dump 270 tons of cargo. If that ship were carrying mid-size sedans, that inch would require the captain to leave about 90 cars on the dock.

Last summer, Lakes Huron and Michigan were 23 inches below their normal levels. Ships crossing those lakes carried 6,000 fewer tons per trip than they carried in 1997 (from 71,000 tons to 65,000 tons). That 8 percent drop in cargo is lost revenue to the shippers and higher prices for the businesses that rely upon them. Snow-melt from this past winter's severe weather should raise levels substantially this summer, but they will remain four to 10 inches below normal.

**Highways and bridges.** The bulk of parts produced in the U.S. are shipped by truck. Imported parts arrive by ship and typically move by train but are shipped by truck from rail line to plant.

The volume is enormous—and so are the costs of severe weather disruptions. One automaker with plants in Michigan and Ontario reports that it ships

approximately \$4 billion worth of parts between the U.S. and Canada each year. More than 600 of its suppliers' trucks cross the Ambassador Bridge (which connects Detroit, Michigan, and Windsor, Ontario) every day. When a winter storm in 2010 closed Highway 402 near Port Huron, Michigan, officials diverted traffic south to the Ambassador Bridge, causing day-long delays for shippers. Plans in both Michigan and Ontario experienced parts shortages and shut down production lines.<sup>xii</sup>

Severe storms this past winter slowed or stopped production at factories across the country. One plant in Indiana, which previously had experienced little snow-related downtime, lost five days of production to heavy snow this winter.

**Ports.** Automakers rely heavily on parts shipped to ports in Norfolk, Virginia; Mobile, Alabama; and Los Angeles, California. Because of their location and elevation, the Mobile and Norfolk ports have been judged to be two of the country's most vulnerable to hurricanes and other severe weather.

**Rail.** Severe heat and drought has compromised Union Pacific railroad lines across Texas (home to two assembly plants and more than 100 auto suppliers).

Rail shipments have also been disrupted by recent storms. As of mid-May 2014, auto suppliers and assembly plants report that some of the parts delayed by this past year's winter storms still have not reached their destination.

# BUSINESS TRENDS INCREASING SEVERE WEATHER RISKS

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Four industry trends threaten to increase supply chain risk substantially:

**As supply chains grow (and become global), they become less transparent.** A plant or supplier may not know where all of its parts are sourced. For example, in a study of the industrial impact of the 2010 Thailand floods and 2011 Japan tsunami, nearly half of the production disruptions affecting automakers and electronics manufacturers were caused by lower tier suppliers *that the manufacturers did not know*.<sup>xiii</sup>

**Small businesses, which dominate the lower levels of the auto supply chain, are less likely to survive catastrophic events.** Tiers 2 and 3 of the supply chain are comprised largely of small businesses (typically, fewer than 250 employees per location).<sup>xiv</sup> Disasters have a disproportionate impact on small and medium-sized enterprises. According to the U.S. Department of Homeland Security, one-quarter of small and medium sized enterprises do not re-open after a catastrophic event. Because they have smaller cash reserves, tend to operate out of a single location, and are less likely to have backup systems, they have a harder time relocating.

**America's infrastructure is aging, while congestion is growing.** A study by the Texas Transportation Institute found that peak traffic periods ("rush hours") have expanded to six hours per day, while off-peak hours have grown more congested. Across America's 498 urban areas, only one in nine trips were disrupted by traffic congestion in 1982. By 2011, one in four trips were disrupted. During this same period, the number of delays for commuters more than doubled.

**Disruptions cost more at plants operating near full capacity.** Automotive manufacturing is a highly capital-intensive business, so automakers' profits depend largely on how well they manage the number of plants they build and use. Building a new plant costs more than \$1 billion;<sup>xv</sup> having a plant that is underutilized or offline can cost hundreds of millions of dollars each year. For that reason, an automaker cannot compete unless its plants operate near full capacity. While a plant operating at 50 percent capacity can make up for a lost shift over time, a plant operating at full capacity loses that production entirely.

# ELECTRICITY COSTS FOR MANUFACTURERS

## CURRENT ELECTRICITY USAGE

While manufacturers use a great deal of electricity, the cost of that electricity is a comparatively small part of their total costs. For 60 percent of America’s largest manufacturing sectors, electricity costs represent 1 percent or less of their total expenses. The average across all industries is 0.9 percent. Only paper, non-metallic materials, and primary metals have electricity costs of 2 percent or more.

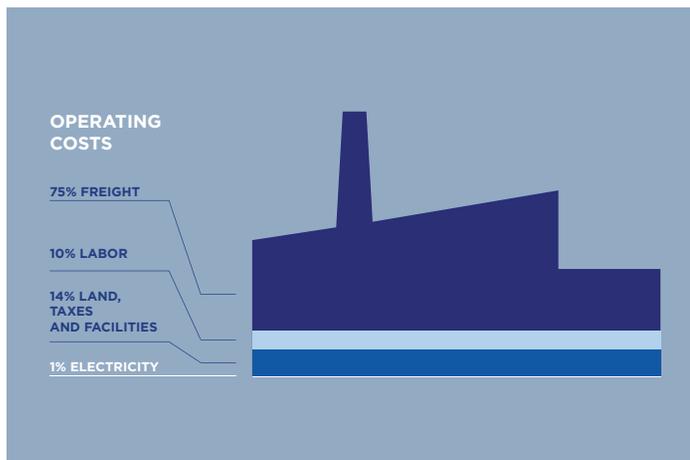
## IMPACT OF 6.2 PERCENT INCREASE, ACROSS INDUSTRIES

Because electricity represents a comparatively small portion of each industry’s total expenses, a 6.2 percent increase in electricity costs in 2020 would cause the average industry’s total costs to rise less than 0.056 percent, or less than six basis points. In other words, if it costs a company \$100 to make one of its products, that cost would increase less than six cents.



## AUTO ASSEMBLY PLANTS AND SUPPLIER PLANTS

Assembly plants use a great deal of electricity, but it represents less than 0.9 percent of their total expenses. Labor costs, supply chain costs, and facilities (including taxes and land) represent 10, 75, and 14 percent, respectively. Because suppliers produce a wide range of parts and materials, their cost of electricity varies. On average, their electricity costs represent 0.75 percent of their total costs.



Automakers and suppliers are investing heavily in energy efficiency, which has caused their use of electricity to drop. A leading automaker recently announced that it had reduced the energy use at its plants by 22 percent over the past 8 years. It expects to reduce its usage by another 25 percent in the next three years. Other industries have taken similar steps. This is one reason why electricity usage by industry declined by 10 percent from 2000 to 2013. Industry's consumption of fossil fuels dropped by 8 percent during that same period.

Automakers and suppliers, together, spend between \$105 on electricity assembling each car (depending on regional electric rates, production processes, vehicle size and plant capacity utilization). Painting a vehicle is an assembly plant's most electricity-intensive process, so the kind of paint used also has an impact.

## IMPACT OF 6.2 PERCENT INCREASE ON AUTOMAKERS AND PARTS SUPPLIERS

Because electricity represents such a small part of an assembly plant's total costs, an increase in that cost has a comparatively small impact.

From steel and glass through final assembly, the cost of electricity is about \$105. If electricity rates were to rise 6.2 percent in 2020, because of the EPA's proposed greenhouse gas standards, it would increase a car's costs by .056 percent, or less than six basis points. In other words, a 6.2 percent increase on 0.9 percent of costs would increase that automaker's per car assembly costs by less than \$7 per car.

The average car or truck purchased in the U.S. sells for about \$30,000.

# CONCLUSION

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## COMPARISON OF ELECTRICITY COST INCREASE TO FINAL ASSEMBLY PLANT VS. COST OF ASSEMBLY LINE DISRUPTION

About \$60 of the \$100 parts suppliers and automakers spend on electricity (per car) is consumed at the final assembly plant. If those costs rise 6.2 percent in 2020, as result of the EPA's new standards, the assembly line's cost (per car) rises \$3.72. The cost of electricity for an entire shift (8 hours) rises about \$1,860. By comparison, if a plant has the typical downtime cost (\$1,250,000 per hour), the cost of losing an entire shift is \$10,000,000.

If a plant assembles 300,000 vehicles each year, the increase in the plant's annual electricity-related costs (\$1,116,000) is less than the cost of losing less than an hour of production time.

This past winter, several assembly plants lost days of production to severe weather.

ONE YEAR OF ELECTRICITY  
RATE INCREASES

= LESS THAN  
ONE HOUR

OF ASSEMBLY LINE  
DOWNTIME

## CONTRIBUTORS

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## ENDNOTES

- i EPA projects an increase in the national average (contiguous U.S.) retail electricity price between 5.9 and 6.5% in 2020. Regulatory Impact Analysis (June 2, 2014), page 3-38.
- ii U.S. Census Bureau (2014); U.S. BEA (2014)
- iii U.S. BEA (2014)
- iv HILL, FRANK
- v U.S. Census Bureau (2014); U.S. BEA (2014)
- vi Data from the U.S. Census Bureau’s “Annual Survey of Manufactures” (ASM) and the U.S. Department of Commerce, Bureau of Economic Analysis “Input-Output Accounts Data” (IO Tables) were used to calculate the cost of electricity used to produce a vehicle. Additional supporting data, publicly available and specific to individual OEMs, was used. For assembly operations, the range of electric costs at the plant to produce a vehicle is \$25 to \$60. To calculate the cost of electricity to parts suppliers to the OEMs, data from both ASM and the IO Tables were used. These data were adjusted to exclude parts produced for aftermarket consumption as well as company shipments to other industries. The range of electric use to produce OEM parts is \$40 to \$95. Summing up electric use per vehicle by both OEMs and parts producers yields a range of \$65 to \$140 per vehicle - with an average of about \$105.
- vii KLIER (2008)
- viii NHTSA (2014)
- ix CME (2005)
- x McALINDEN (2011)
- xi HILL, FRANK
- xii WALSH (2010)
- xiii CONRAD (2012)
- xiv HILL (2013)
- xv ACP (2014)

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