Research Report: Reusing auto parts reduces the carbon footprint of vehicle repairs.

A comprehensive study of the materials and processes used to manufacture 30 specific automotive parts, from headlights to tailgates, documents the significant greenhouse gas emissions saved when reclaimed parts are used to repair vehicles instead of newly manufactured parts.

Given the magnitude of auto repairs across the United States, indeed across the world, the use of reclaimed auto parts can help consumers, companies and communities reduce their carbon footprint and make progress toward carbon neutrality goals.

The details of the research are reported in the study "Quantifying the greenhouse gas emissions (carbon) impact of reusing automotive parts for vehicle repairs", conducted at Worcester Polytechnic Institute (WPI) by Hyunsoo Jin, PhD, a Post-Doctoral Fellow in the Mechanical & Materials Engineering Department and Professor Brajendra Mishra, PhD, the Kenneth G. Merriam Distinguished Professor of Mechanical & Materials Engineering and Director of the Metal Processing Institute at WPI.

Public purpose

When a vehicle needs repair, the owner often faces an important decision; whether to use brand new parts or used original equipment parts reclaimed from end-of-life vehicles that are suitable for the repair.

Historically, choosing between a new part and the same part reclaimed from a used vehicle has been viewed as an economic decision. It is also, however, a major environmental decision with significant potential impact on greenhouse gas emissions.

The financial metrics of the choice are clear to the consumer. Both the new and used automotive parts are priced at the point of transaction. The environmental metrics of that decision, however, are vague at best, and typically unknown to the consumer.

The principal aim of this study is to document the savings in greenhouse gas (carbon) emissions when a specific automotive part is reclaimed and reused for vehicle repair, compared to using a newly manufactured part for the same purpose. Having the environmental data available at the point of transaction, in addition to the prices, will help consumers make more informed decisions.

Scope of study

This project focused on 10 of the most common automotive parts that are now reclaimed by auto recyclers and made available to automotive repair shops and consumers.

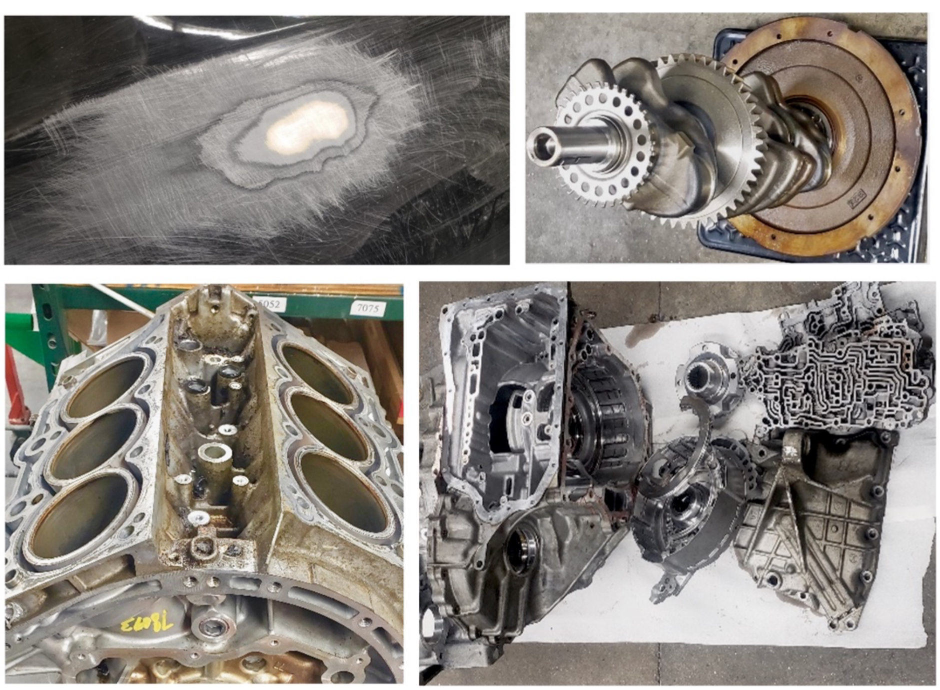
The study covered 10 parts from three classes of vehicles: a sedan, an SUV, and a pick-up truck. More specifically the subject vehicles were 2015 models of:

- Toyota Camry with a 4-cylinder gasoline engine
- Jeep Grand Cherokee with a 6-cylinder gasoline engine
- Ford F-150 with an 8-cylinder gasoline engine

The following parts, from each subject vehicle, were analyzed:

- Engine
- Transmission
- Front bumper
- Headlight
- Front door
- Wheel
- Fender
- Tailgate
- Hood
- Door mirror

These parts were shipped to WPI's metal processing laboratory in Worcester, Massachusetts for analysis. Each part was dismantled and processed to determine the amount and type of materials (i.e. metals, plastics, rubber, etc.) used to manufacture that part.



Photos: sample of parts in varying states of dismantling and analysis at WPI

Most auto parts are made from composite materials and different grades of alloys which are not typically public knowledge due to industrial competition. So, it was important for WPI to break down each part into its constituent components for precise analysis whenever possible. The research team used several technologies to perform the materials analysis. These methods included:

- **Inductively coupled plasma optical emission spectrometry (ICP-OES).** Acid digestible samples were analyzed by ICP-OES. To check for homogeneity of materials, results from multiple spots on a specific sample were compared.

- **Optical emission spectroscopy (Spark-OES).** Bulk and flat samples were analyzed by Spark-OES. This method uses arc spark discharge to vaporize the sample and collect the radiation emitted from atoms and ions to identify the constituent materials.

- **X-ray fluorescence (XRF).** Handheld XRF was used for items with variable shapes and did not need any pretreatment. In addition, XRF is a non-destructive method, so the samples can be kept or reused.

Photos: sample of parts in varying states of dismantling and analysis at WPI

Energy analysis

Using the detailed composition of the specific parts, researchers then quantified the energy required to manufacturing those parts. This analysis included calculating the energy used to:

- Mine raw materials
- Manufacture steel, aluminum, copper, and other inputs from raw materials
- Manufacture specific auto parts (engine, transmission, etc.) from those materials

All of these manufacturing activities use a variety of fuels and energy sources, including electricity, natural gas, residual oil, diesel, coal, LPG, and gasoline. For the purpose of consistency in carbon footprint analysis across sectors, the best practice is to convert all the energy inputs into kilowatt hours of electricity.

Results: The table below lists the energy needed to make the specific parts studied in terms of kilowatt hours (kWh) of electricity.

	Camry	Grand Cherokee	F-150
Engine	1,615.49	1,722.34	2,276.56
Transmission	872.50	873.04	855.23
Front bumper	102.37	81.29	124.34
Headlight	21.45	17.17	25.05
Front door	161.74	201.37	307.17
Wheel	179.20	227.49	228.09
Fender	14.52	22.88	41.80
Tailgate	76.08	208.17	401.63
Hood	124.22	179.05	228.04
Door mirror	9.155	11.41	13.63

Carbon footprint assessment

With the amount of energy needed to make each specific part known, the next step in the study was to calculate the greenhouse gas emissions (carbon footprint) associated with generating the energy used to manufacture specific new parts.

This assessment is based on the Argonne National Laboratory's GREET2 (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) model and EPA (U.S. Environmental Protection Agency) guidelines.

The study also used data from the U.S. Energy Information Administration (EIA) which quantifies electrical generation in the United States and the resulting CO2 emissions based on the fuel used to power the plant.

The carbon footprint for each auto part studied is presented in the following two tables. The first table shows emissions is based on natural gas generation, the second on electricity generated by oil/petroleum burning power plants.

Carbon dioxide emissions for each part in kilograms. (Fuel source natural gas.)

	Camry	Grand Cherokee	F-150
Engine	710.82	757.83	1,001.68
Transmission	383.90	384.14	376.30
Front bumper	45.04	35.77	54.71
Headlight	9.44	7.56	11.02
Front door	71.17	88.60	135.16
Wheel	78.85	100.10	100.36
Fender	6.39	10.07	18.39
Tailgate	33.47	91.60	176.72
Hood	54.66	78.78	100.34
Door mirror	4.03	5.02	6.00

Carbon dioxide emissions for each part in kilograms. (Fuel source petroleum).

	Camry	Grand Cherokee	F-150
Engine	1,760.89	1,877.35	2,481.45
Transmission	951.02	951.61	932.21
Front bumper	111.59	88.61	135.53
Headlight	23.38	18.72	27.30
Front door	176.30	219.49	334.82
Wheel	195.33	247.97	248.62
Fender	15.83	24.93	45.57
Tailgate	82.92	226.91	437.77
Hood	135.40	195.17	248.56
Door mirror	9.98	12.44	14.86

Conclusion

It is common sense that a reclaimed auto part, by definition, doesn't have to be manufactured, so its use avoids the greenhouse gas emissions generated by using a newly manufactured part. The data presented here, however, add facts to the discussion and show the significant and specific greenhouse gas emissions saved when using a reclaimed part instead of a new part, manufactured from virgin materials.

Furthermore, there a several factors that make these results conservative.

Given the scope of the project, the final metals data presented here is based on the quantification of steel, aluminum and copper, which account for the majority of materials (by mass) of the parts. Numerous other metals were detected in smaller quantiles. If those materials were included in the energy/carbon analysis, the greenhouse gas emissions savings would be even higher.

In addition, because original equipment auto parts are manufactured across North America and then transported to end users in varying locations the emissions from these transportation steps were difficult to estimate so they have not been included.

It is clear, however, from site-visit evaluations of auto recycling companies, that the energy attributed to transportation of newly manufactured parts and the labor inputs of making those new parts are significantly higher than the energy used to dismantle automobiles and reclaim parts.

So, we estimate the carbon savings from using reclaimed parts are likely to be greater, perhaps 15 to 20 percent more than the conservative results presented here.

Although this report is conservative, the data presented still shows significant environmental benefits. For example, according to the EPA Greenhouse Gas Equivalencies Calculator, reusing one Camry engine saves 710.82kg of carbon dioxide (natural gas) which is equivalent to the carbon sequestered by11 tree seedings grown for 10 years; or the equivalent of the electricity used to charge 44,449 smartphones.

Consumers can see many other carbon saving equivalences by entering the specific parts data into the EPA calculator here: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator),

Study sponsor and disclosures

The research question was proposed to WPI by the Automotive Recyclers Association (ARA), a non-profit organization that represents the interests of over 4,500 professional automotive recyclers across the United States and in 17 countries internationally. ARA is dedicated to the efficient removal and reutilization of genuine original equipment manufacturer (OEM) automotive parts.

ARA provided financial support to WPI for the study and ARA members provided the 30 auto parts analyzed by the WPI team at no cost.

ARA played no role in the conduct of the research, ensuring the independence of the analysis and conclusions of the research team.