WARDSAUTO™

THE BIG STORY / MARCH 2019

BATTERIES & PISTONS

The Powertrain World Needs Both

History is fluid, and its purpose is to help identify inflection points when everything changed, when cultural events have shaped the narrative so dramatically that they become indelibly etched in a timeline. Earlier generations tell the stories.

There was life before World War II and then life after. There was life before the Model T and then life after. Life before and after the Internet. No one knew in 1964 whether the Beatles would fizzle quickly after a couple good tunes and teenage hysteria, or if the four lads from Liverpool ultimately would change the course of popular music in an unbelievably short time.

For the Wards editorial team, we view 2019 as a watershed moment in the world of powertrain development.

For the past 25 years, we have been identifying the 10 Best Engines available in mainstream

OPTIMIZING THE COMBUSTION ENGINE — **ENABLING E-MOBILITY**

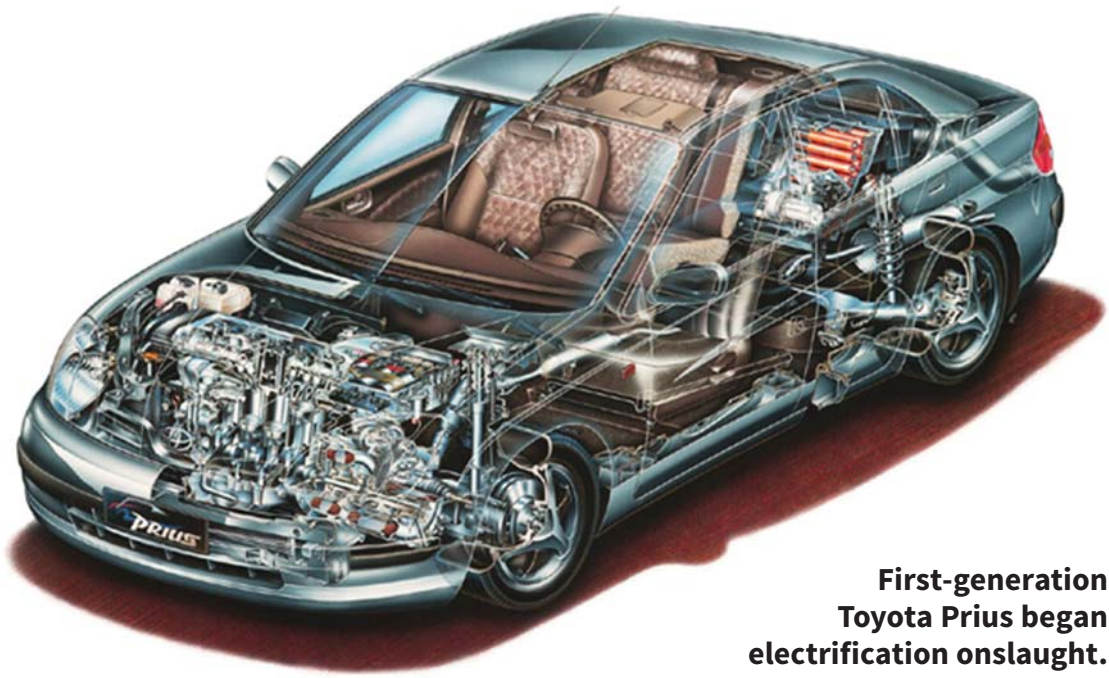
MAHLE is a leading international development partner and supplier to the automotive industry as well as a pioneer and technology driver for the mobility of the future. The MAHLE Group is committed to making transportation more efficient, more environmentally friendly, and more comfortable by continuously optimizing the combustion engine, driving forward the use of alternative fuels, and laying the foundation for the widespread acceptance and worldwide introduction of e-mobility.

MAHLE products are fitted in at least every second vehicle worldwide. For decades, MAHLE components and systems have been used on the world's racetracks as well as off the road—in stationary applications, for mobile machinery and rail transport, as well as marine applications.

www.us.mahle.com

MAHLE

Driven by performance



First-generation Toyota Prius began electrification onslaught.

production vehicles sold in the U.S., and the waters grew murky soon after we started this competition when electrified hybrids began creeping into the market.

Admittedly, there were heated conversations in those early days in the 1990s about whether the Honda Insight or Toyota Prius hybrids should even be in contention because the concept was so foreign to a world that had known nothing but internal combustion.

Remove the gasoline engine altogether when battery electrics and hydrogen-powered fuel cells came along and the debates became even more intense.

It has taken the better part of two decades to realize there is no singular powertrain technology in production or in development that will dominate the landscape and propel vehicles into the future of mobility.

OUR RENAMED COMPETITION, WARDS 10 BEST ENGINES & PROPULSION SYSTEMS,

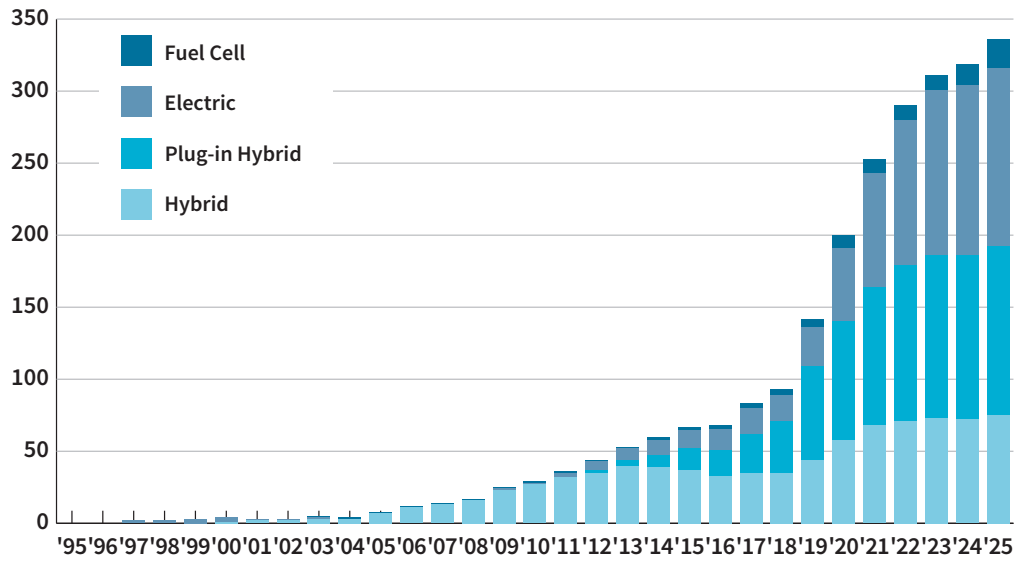
will recognize the best technologies that get us down the road, literally and figuratively.

Nemak

Powering the Future with Lightweighting Solutions

Powertrain | Body-in-White | Chassis | E-mobility

Number of Alternative-Powertrain Models Available in U.S.



Source: Wards Intelligence

It's the Wild West out there, and gunslinging engineers are fighting for the survival of engines fueled with gasoline, diesel and compressed natural gas, along with hybrids and plug-in hybrids that rely on internal combustion.

And in the face of tightening regulations to drastically reduce tailpipe emissions in much of the world, automakers are hard-pressed to develop viable business cases for fully electric powertrains with high-capacity batteries. Partnerships to offset development costs are in the works.

NO IDEA SEEMS TOO CRAZY

Powertrains are evolving so quickly these days that no idea seems too crazy. College students are pushing boundaries with solar cars that can top 50 mph (80 km/h) with the rays of the sun and store enough renewable electricity to keep driving a few hundred miles at night.

Where we go from here is anyone's guess. But we're marking

AUTOMOTIVE COMPOSITES CONFERENCE & EXHIBITION

Novi, Michigan • September 4-6, 2019

Presented by SPE Automotive Division and SPE Composites Division

COMPOSITES: Forming the Future of Transportation Worldwide

SEPT 4–6, 2019

CALL FOR PAPERS

ATTEND THE WORLD'S LEADING AUTOMOTIVE COMPOSITES FORUM You're invited to attend the 19th Annual SPE Automotive Composites Conference and Exhibition (ACCE), September 4-6, 2019 at the Suburban Collection Showplace in Novi, MI. The show features technical sessions, panel discussions, keynotes, receptions, and exhibits highlighting advances in materials, processes, and equipment for both thermoset and thermoplastic composites in a wide variety of transportation applications.

PRESENT BEFORE A GLOBAL AUDIENCE The SPE ACCE draws over 900 attendees from 15 countries on 5 continents who are interested in learning about the latest composites technologies. Few conferences of any size offer such an engaged, global audience vitally interested in hearing the latest composites advances. Interested in presenting your latest research? Abstracts are due ***April 30, 2019*** and papers on ***June15, 2019*** to allow time for peer review. Submit abstracts via www.SubmitACCEPapers.com.

EXHIBIT / SPONSORSHIP OPPORTUNITIES A variety of sponsorship packages are available. Companies interested in showcasing their products and / or services should contact Teri Chouinard of Intuit Group at teri@intuitgroup.com.

FOR MORE INFORMATION SPEautomotive.com/acce-conference +1.248.701.8003

2018 SPONSORS

Premier Plus Sponsors & Exhibitors

Ashland · Continental Structural Plastics (A Teijin Group Company) · Teijin · DSM · HEXION* · MITSUBISHI CHEMICAL* · Mitsubishi Chemical Carbon Fiber and Composites, Inc. · comusa · Quadrant Plastic Composites · Nippon Electric Glass

* Reception Sponsors

Scholarships Sponsor

planetM · Michigan Economic Development Corporation

Lunch Sponsors

ARKEMA · DSM · sampe North America

Breakfast/Coffee Break Sponsors

ASAHI KASEI PLASTICS · covestro · DUPONT · faurecia · MAGNA · MICHELMAN

Student Poster Sponsor

Ford

Premier Sponsors & Exhibitors

3D SYSTEMS · AOC · BYK Additives & Instruments · ADDCOMP · BASF · ENGEL · Gurit · HUNTSMAN · LANXESS · LOTTE ADVANCED MATERIALS · 光威新材 · MX-NYLON · MITSUBISHI GAS CHEMICAL · MP Molding Products · OWENS CORNING · SOLVAY · TORAY Innovation by Chemistry · WELLMAN · PRET

Associate Sponsors & Exhibitors

3M · ABP Technology · ABARIS · agy · RENOLIT · AUTOMATED DYNAMICS · carbon conversions · CANNON USA · CNAM · EPIC · Canada · Moldex3D · DIEFFENBACHER · EVONIK · EXPANSE · Cstream · FAGOR · FAGOR ARRASATE · Fraunhofer · Highland Composites · HUBER · IACMI · Composites International · Johns Manville · JUSHI · KRÜSS · LAYSTITCH · MAFIC · MICHELMAN · Mitsui Chemicals · NORPLEX MICARTA · PIERCAN · plasmatreat · PolyOne · POLYSCOPE · PROPEL · Rotaloc · Schmidt & Heinzmann · SCHRÖDINGER MATERIALS · SUMITOMO CHEMICAL · stratasys · WILLIAMS WHITE & COMPANY · ZOLTEK

Advertising Sponsor

DSC CONSUMABLES INCORPORATED

this point in time by changing the name from 10 Best Engines for the recently completed 2019 competition to 10 Best Engines & Propulsion Systems for 2020. Understood, it's a mouthful and our engraver getting paid by the letter is quite excited.

The name change merely confirms what we've been doing since the original Prius hybrid first made our list in 2001. We've been recognizing all manner of propulsion systems, and now we have a proper moniker to reflect the massive change washing over the industry.

So as we move forward into an uncertain future, let's reflect on 25 years of powertrain trends that have led us here.

On the combustion side, you

WARDSAUTO™

Interiors Conference™

May 9, 2019 | Suburban Collection Showplace | Novi, MI

A full day laser-focused on the automotive interior

- Hear from leading design keynotes
- Attend informative panel discussions
- Watch key executives take the stage to accept their award
- Experience the award-winning vehicles on display
- View exhibits from top suppliers
- Network with colleagues and make new connections

Meet winning OEM designers on hand for the Wards 10 Best Interiors awards ceremony, and see the honored vehicles in our Winners Showplace.

Join us to explore these topics and more!

- Rethinking Materials for Autonomous Materials
- Creating the Ultimate User Experience
- Advanced Design and Manufacturing
- The Future of Vehicle Displays and Controls
- Innovative Materials
- How Vehicle Sharing, Commercial Ride-Hailing Fleets will Change Interiors
- Designing Specifically for Fully Autonomous Vehicles
- New Concepts and Tech for Enhancing Interiors

Register Today! **AutoInteriors.com**

FCA's Mack Avenue engine plant in Detroit.

know them all: downsizing, forced induction, high-pressure direct fuel injection, cooled exhaust-gas recirculation, lightweight engine blocks and heads, continuously variable transmissions, urea-dosing SCR systems for diesel engines, the Atkinson combustion cycle, variable valve timing and cylinder deactivation.

For electrified propulsion systems, we've seen the rise of lithium-ion batteries, high-capacity charging, stop/start systems, 48V electrical architectures and motors placed just about everywhere – on the engine, the front axle, the rear axle, in the transmission and at each wheel.

Direct injection first appeared on the Wards 10 Best Engines list in 1997, courtesy of the 1.9L Diesel 4-cyl. in the Volkswagen Passat TDI.

It would take several more years before gasoline engines would

WARDSAUTO™

Stay Up-To-Date on Industry Focused Topics with our **FREE** Newsletters

WardsAuto Daily Edition

FREQUENCY - DAILY

Daily highlights of top stories from the comprehensive WardsAuto.com website focused on news, analysis and commentary on matters impacting automakers and automotive suppliers.

The Big Story: OEM Issue

FREQUENCY - 4X PER YEAR

Go in-depth on an important topic with WardsAuto and see beyond the headlines on issues that matter to your business.

WardsAuto Sales Report

FREQUENCY - MONTHLY

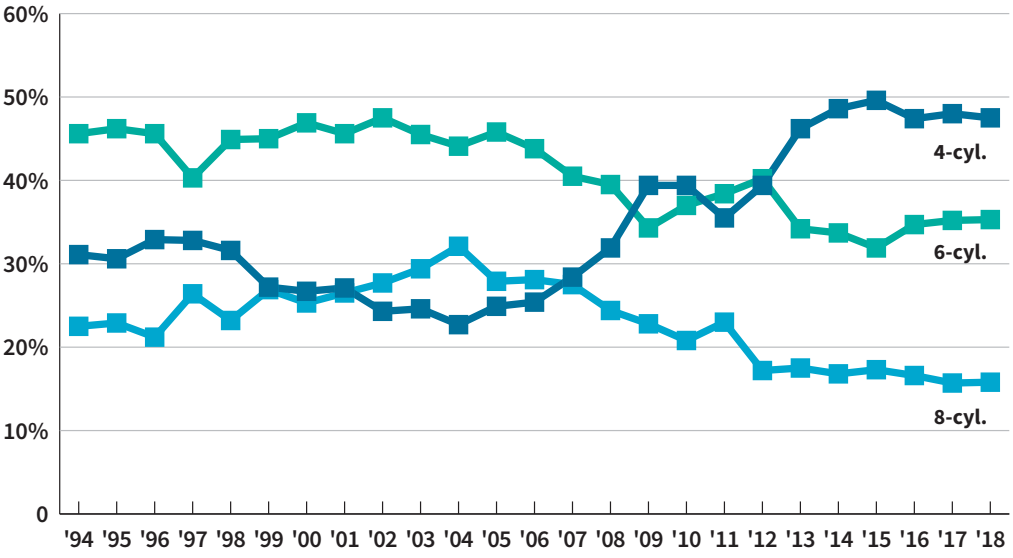
Monthly summary of the sales reports from the world's major automakers, with data pulled from Wards Intelligence supplemented with analysis from our trusted data crunchers.

Engine, Propulsion & Tech Update

FREQUENCY - BI-WEEKLY

Delivered every other Monday, this provides an overview of WardsAuto articles and analysis on engines, powertrains and other technologies, some of which require subscriber-level access to Wards Intelligence.

Subscribe at **WardsAuto.com/Newsletters**



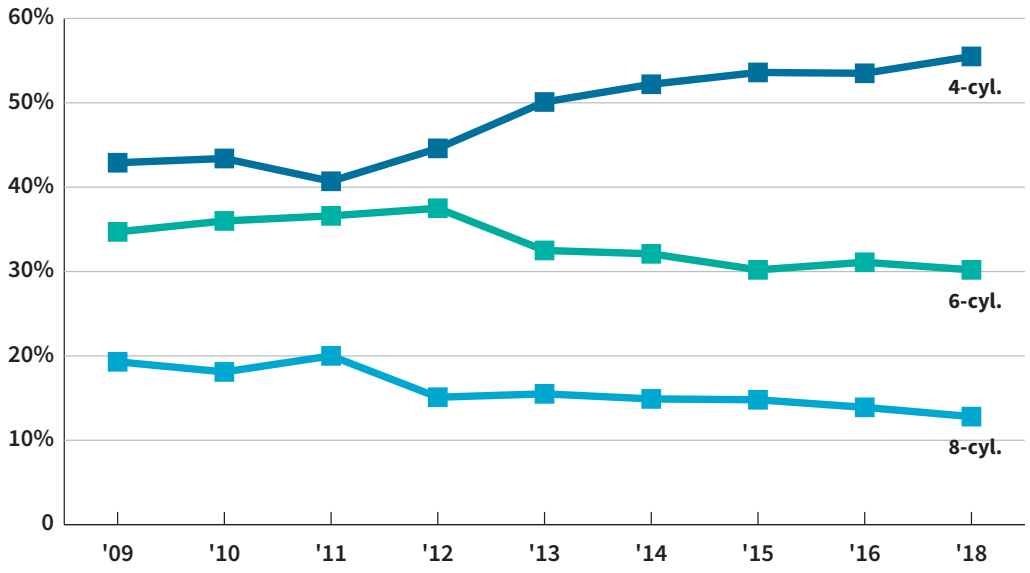
appear on the list with high-pressure direct injection, boosting output and fuel economy, while also adding cost.

ENGINES GOT SMALLER

It wouldn't take long before GDI and turbocharging were paired in a host of 3-, 4- and 6-cyl. engines as the downsizing trend would span the entire industry as it strived to meet increasingly stringent fuel-economy standards worldwide.

From the early 2000s going forward, downsizing triggered a massive shift in the makeup of the Wards 10 Best Engines list. Spend some time with the two-page 10 Best Engines history at the end of this story, and an overarching trend leaps out: Automakers have been winning with smaller engines, not bigger ones.

In 1999, four V-8s earned trophies and the average displacement of the 10 powerplants equaled 3.8 liters. In 2005, three V-8s were honored in a year with average displacement of 3.59 liters.



Source: Wards Intelligence

That was the last time three V-8s made the cut in a single year.

In 2010, 2012, 2013, 2014 and 2016, only one V-8 was chosen, while hybrids, plug-in hybrids, battery-electrics and FCVs were honored, pushing average displacement to new lows.

In 2017, for the first time, the Wards 10 Best Engines list had not a single V-8, while three hybrids reached the winners' circle.

In the recently completed 2019 competition, average displacement fell to 2.68 liters, which is remarkable considering it was the first year when three fullsize pickup-truck engines made the list.

For the record, two of those trucks – from Ford and Ram – relied on V-6 power. But all of this year's winning trucks, including the 6.2L V-8 in the Chevy Silverado, earned their honors for advanced technologies designed to make these hulking vehicles more fuel efficient.

Improvements in modern powertrains have been achieved

WARDSAUTO™

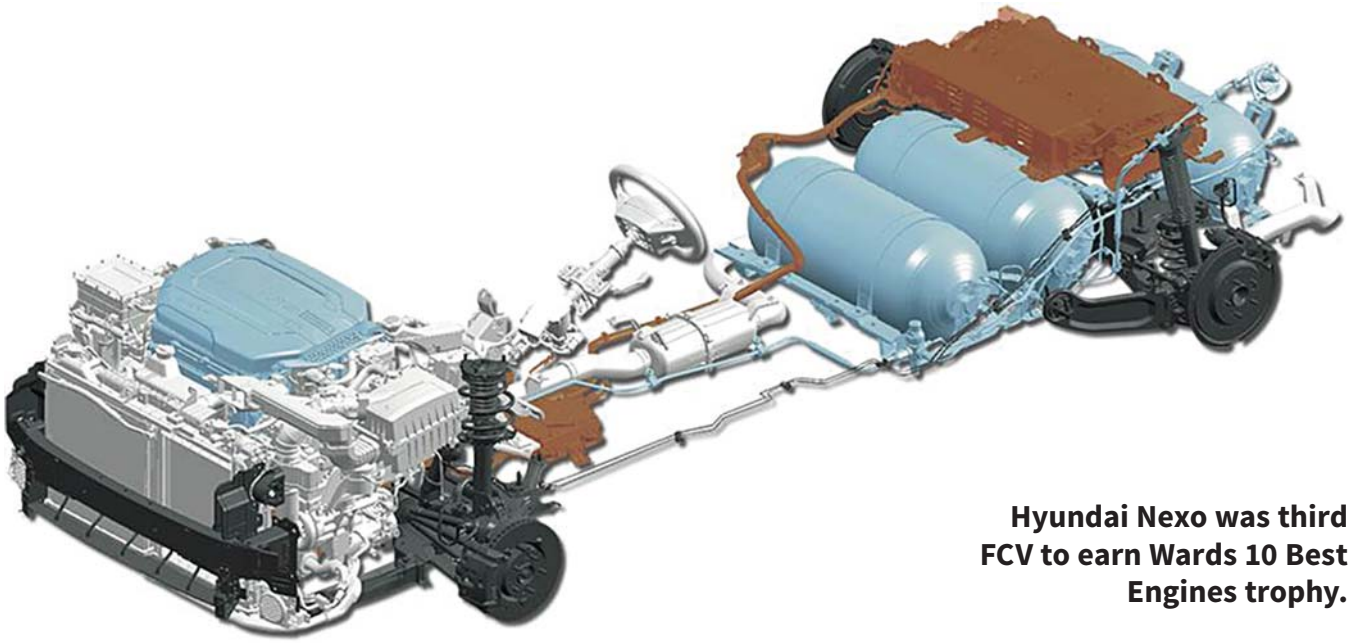
MAHLE

2019
Light vehicle engines

North American Availability & Specifications

COMING LATE MARCH!

Get Engine Data in
FREE Poster or Digital File!



Hyundai Nexo was third FCV to earn Wards 10 Best Engines trophy.

across the spectrum, from fire-breathing V-8s topping 700 hp and high-output 4-cyl. engines using both supercharging and turbocharging to conventional hybrids topping 50 mpg (4.7 L/100 km) and BEVs cruising more than 200 miles (322 km) without burning a drop of gasoline.

In 2018 and 2019, four electrified powertrains were honored in a single year.

Since 2001, we've honored a total of 12 hybrids, six plug-in hybrids, five BEVs and three FVCs.

It's hard to imagine the trend skewing heavily back in favor of internal combustion in the coming years. But anything could happen, including further technological advances nudging both forms of propulsion ahead. **WA**

This story was written by Managing Editor Tom Murphy, who has worked at Wards for 22 years, covering technology and leading selection each year of Wards 10 Best Engines, 10 Best Interiors and 10 Best User Experiences.

WARDS 10 BEST ENGINES • WINNERS 1995-2019

ENGINE / PROPULSION SYSTEM	LATEST MODEL TESTED	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	TROPHY TOTAL
AUDI																											18
1.8L DOHC Turbocharged I-4	A4 1.8T			•				•																			2
2.0L TFSI Turbocharged DOHC I-4	A4												•	•	•	•	•										5
2.7L Twin-Turbo DOHC V-6	A6 2.7T						•	•																			2
3.0L TFSI Supercharged DOHC V-6	S5																•	•	•	•	•						5
3.2L FSI DOHC V-6	A6											•															1
4.2L DOHC V-8	S4 Avant										•	•	•														3
BMW																											34
127-kW Electric Motor	i3 EV/EREV																					•					1
2.0L N20 Turbocharged DOHC I-4	328i																		•	•							2
2.5L DOHC I-6	323is				•																						1
2.8L M52B28 I-6	328i					•																					1
3.0L DOHC I-6	Z4							•	•	•			•	•													5
3.0L Turbocharged DOHC I-6	X5													•	•	•		•	•	•			•	•		•	9
3.0L Turbodiesel DOHC I-6	535d															•	•				•						3
3.2L S50USB32 (30) I-6	M3	•	•	•	•	•	•		•	•	•																9
4.0L M60B40 V-8	540i	•	•																								2
4.4L DOHC 90-degree V-8	540i			•																							1
DAIMLER																											9
2.0L Turbocharged DOHC I-4	Mercedes C300																							•			1
3.0L Turbodiesel DOHC V-6	Mercedes E320 Bluetec													•	•												2
3.2L Turbodiesel DOHC I-6	Mercedes E320 CDI											•															1
3.2L SOHC V-6	Mercedes E320				•	•	•	•																			4
5.0L SOHC V-8	Mercedes ML500								•																		1
FIAT CHRYSLER																											19
83-kW Electric Motor	Fiat 500e																				•						1
3.0L EcoDiesel DOHC V-6	Ram 1500																				•	•	•				3
3.6L Atkinson DOHC V-6/Dual Motor PHEV	Chrysler Pacifica Hybrid																							•	•		2
3.6L DOHC Pentastar 60-degree V-6	Ram 1500																	•	•	•							3
3.6L Pentastar eTorque V-6	Ram 1500																									•	1
4.7L SOHC V-8	Jeep Grand Cherokee					•																					1
5.7L OHV Hemi V-8	Challenger R/T / Dodge Ram									•	•	•	•	•		•											6
5.9L Cummins 600 Turbodiesel OHV I-6	Ram HD										•																1
6.2L Supercharged OHV Hemi V-8	Dodge Challenger SRT Hellcat																					•					1
FORD																											34
1.0L EcoBoost DOHC DI I-3	Fiesta SE																				•	•					2
2.0L EcoBoost DOHC I-4	Focus ST / Taurus																		•	•							2
2.3L EcoBoost Turbocharged DOHC I-4	Focus RS																							•			1
2.5L DOHC I-4 HEV	Fusion Hybrid															•	•										2
2.5L DOHC V-6 (Duratec)	Contour, Mystique	•																									1
2.5L SVT High Output DOHC V-6	Contour SVT				•	•																					2
2.7L EcoBoost Twin-Turbo DOHC V-6	F-150																								•		1
3.0L DOHC Turbodiesel V-6	F-150																									•	1
3.5L Duratec 35 DOHC V-6	Lincoln MKX													•													1
3.5L EcoBoost Twin-Turbo DOHC V-6	Taurus SHO																•										1
3.9L DOHC V-8	Lincoln LS						•																				1
4.6L DOHC 90-degree V-8	Mustang Cobra		•	•																							2
4.6L SOHC V-8	Mustang GT / Shelby GT											•	•	•	•												4
5.0L DOHC 90-degree V-8	Mustang GT / Bullitt																	•	•						•	•	4
5.2L DOHC 90-degree V-8	Shelby GT350 Mustang																						•				1
5.4L Triton SOHC V-8 / 5.4L Supercharged	F-Series SVT Lightning			•	•	•	•	•	•																		6
5.8L Supercharged DOHC V-8	Shelby GT500																			•							1
6.0L Power Stroke OHV Turbodiesel V-8	F-Series Super Duty									•																	1
GM																											33
150-kW Electric Propulsion System	Chevrolet Bolt																								•		1
1.4L/1.5L DOHC I-4/Dual Motor EREV	Chevrolet Volt																	•					•	•			3
2.0L LUZ Turbodiesel DOHC I-4	Chevrolet Cruze																				•						1
2.0L Turbocharged DOHC I-4	Cadillac ATS																		•	•							2
2.0L LSJ Supercharged DOHC I-4	Chevrolet Cobalt SS												•														1
2.4L LAF Ecotec DOHC I-4	Chevrolet Equinox																•										1
2.8L LP9 Turbocharged DOHC V-6	Saab 9-3 Aero												•														1
3.5L LX5 Twin Cam V-6	Olds Intrigue / Aurora					•	•																				2
3.6L DOHC V-6	Cadillac ATS, Chevrolet Camaro														•	•							•				3
3.8L L67 Supercharged 90-degree OHV V-6	Buick Park Avenue Ultra	•	•	•																							3
4.2L LL8 Vortec DOHC I-6	Chevrolet TrailBlazer								•	•	•	•															4
4.6L L37 DOHC 90-degree V-8 (Northstar)	Cadillac STS	•	•	•																							3
5.7L LS1 V-8	Chevrolet Corvette				•	•																					2
6.0L LFA OHV V-8 HEV	GMC Yukon Hybrid														•												1
6.2L LT1 OHV DI V-8	Chevrolet Corvette Stingray																				•	•					2
6.2L OHV V-8 with Dynamic Fuel Management	Chevrolet Silverado																									•	1
6.6L LB7 Turbodiesel DOHC V-8	Silverado / Sierra HD							•	•																		2

WARDS 10 BEST ENGINES • WINNERS 1995-2019

ENGINE / PROPULSION SYSTEM	LATEST MODEL TESTED	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	
HONDA																											19
130-kW Fuel Cell/Electric Propulsion Sys.	Honda Clarity																								•		1
2.0L DOHC I-4	Acura RSX Type S						•	•	•	•																	4
2.0L Atkinson i-VTEC DOHC 4-Cyl./HEV	Honda Accord Hybrid																							•		•	2
2.0L DOHC VTEC Turbocharged 4-Cyl.	Honda Civic Type R																								•		1
2.2L H22A1 VTEC I-4	Honda Prelude VTEC	•	•																								2
2.4L DOHC I-4	Honda Accord Sport																			•							1
3.0L / 3.5L SOHC V-6	Honda Accord EX/Coupe									•	•	•			•	•				•	•						7
3.0L SOHC V-6 IMA HEV	Honda Accord Hybrid											•															1
HYUNDAI																											10
Fuel Cell Powertrain / Electric Motor	Hyundai Nexo																					•				•	2
Single Motor Electric Propulsion System	Hyundai Kona																									•	1
1.4L Turbocharged DOHC I-4	Hyundai Elantra Eco																							•			1
1.6L DOHC I-4	Hyundai Accent																		•								1
2.0L DOHC I-4/50-kW Drive Motor	Hyundai Sonata PHEV																						•				1
3.3L Twin-Turbo DOHC V-6	Kia Stinger																								•		1
4.6L Tau DOHC 90-degree V-8	Hyundai Genesis															•	•										2
5.0L Tau DOHC DI 90-degree V-8	Hyundai Genesis																	•									1
JAGUAR																											1
2.0L Turbocharged DOHC 4-Cyl.	Jaguar XF																								•		1
MAZDA																											11
1.3L Renesis Rotary	RX-8										•	•															2
2.0L SKYACTIV DOHC I-4	Mazda3																		•								1
2.3L DISI Turbocharged DOHC I-4	MazdaSpeed3												•	•	•												3
2.3L Miller-cycle DOHC V-6	Millenia S	•	•	•	•																						4
2.5L Turbocharged DOHC I-4	CX-9																							•			1
MINI (BMW)																											3
1.5L Turbocharged DOHC DI I-3	Mini Cooper Hardtop																					•					1
1.6L Turbocharged DOHC DI I-4	Mini Cooper S																	•									1
1.6L Supercharged SOHC I-4	Mini Cooper S									•																	1
NISSAN																											20
80kW AC Synchronous Electric Motor	Leaf EV																	•									1
2.0L DOHC VC-Turbo 4-Cyl.	Infiniti QX50																									•	1
3.0L Twin-Turbo DOHC V-6	Infiniti Q50 / Q60																							•	•		2
3.5L DOHC V-6 HEV	Infiniti M35h																		•								1
VQ 3.0L / 3.5L / 3.7L DOHC V-6	Nissan Maxima	•	•	•	•	•	•	•	•	•	•	•	•	•	•								•				15
PORSCHE																											4
2.7L DOHC DI 6-cyl. Boxer	Cayman							•	•												•						3
3.2L DOHC 6-cyl. Boxer	Boxster S						•																				1
SAAB																											2
2.3L LPT I-4	9000 CS	•	•																								2
SUBARU																											5
2.0L FA DOHC H-4 Boxer	Subaru BRZ																			•							1
2.0L Turbocharged DOHC DI H-4 Boxer	Subaru WRX																					•	•				2
2.5L Turbocharged DOHC H-4 Boxer	Subaru Legacy GT										•						•										2
TOYOTA																											14
1.5L / 1.8L DOHC I-4 HEV	Prius							•			•						•						•				4
2.0L Atkinson DOHC 4-Cyl./HEV	Lexus UX 250h																									•	1
2.5L Atkinson DOHC 4-Cyl./HEV	Toyota Camry Hybrid																								•		1
3.0L 1MZ-FE V-6	Avalon		•																								1
3.5L DOHC V-6	Lexus IS 350												•	•	•	•											4
4.0L DOHC V-8	Lexus GS 400				•	•	•																				3
VOLVO																											4
2.0L Turbocharged T5 DOHC DI I-4	S60																					•					1
2.0L Turbo/Supercharged DOHC DI I-4	V60 Polestar																						•	•			2
3.0L Turbocharged DOHC I-6	S60																	•									1
VW																											7
1.8L TSI Turbocharged DOHC I-4	Golf TSI				•				•	•											•	•					5
1.9L Turbodiesel DI I-4	Passat TDI			•																							1
2.0L Turbodiesel DOHC I-4	Jetta TDI															x	x	x									x
2.8L VR6 15-degree SOHC V-6	Passat	•																									1

x – Trophies withdrawn