

## Motorhead Messiah

Johnathan Goodwin can get 100 mpg out of a Lincoln Continental, cut emissions by 80%, and double the horsepower. Does the car business have the guts to follow him?

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"Check it out. It's actually a jet engine," says Johnathan Goodwin, with a low whistle. "This thing is gonna be even cooler than I thought." We're hunched on the floor of Goodwin's gleaming workshop in Wichita, Kansas, surrounded by the shards of a wooden packing crate. Inside the wreckage sits his latest toy--a 1985-issue turbine engine originally designed for the military. It can spin at a blistering 60,000 rpm and burn almost any fuel. And Goodwin has some startling plans for this esoteric piece of hardware: He's going to use it to create the most fuel-efficient Hummer in history.

Goodwin, a 37-year-old who looks like Kevin Costner with better hair, is a professional car hacker. The spic-and-span shop is filled with eight monstrous trucks and cars--Hummers, Yukon XLs, Jeeps--in various states of undress. His four tattooed, twentysomething grease monkeys crawl all over them with wrenches and welding torches.

Goodwin leads me over to a red 2005 H3 Hummer that's up on jacks, its mechanicals removed. He aims to use the turbine to turn the Hummer into a tricked-out electric hybrid. Like most hybrids, it'll have two engines, including an electric motor. But in this case, the second will be the turbine, Goodwin's secret ingredient. Whenever the truck's juice runs low, the turbine will roar into action for a few seconds, powering a generator with such gusto that it'll recharge a set of "supercapacitor" batteries in seconds. This means the H3's electric motor will be able to perform awesome feats of acceleration and power over and over again, like a Prius on steroids. What's more, the turbine will burn biodiesel, a renewable fuel with much lower emissions than normal diesel; a hydrogen-injection system will then cut those low emissions in half. And when it's time to fill the tank, he'll be able to just pull up to the back of a diner and dump in its excess french-fry grease--as he does with his many other Hummers. Oh, yeah, he adds, the horsepower will double--from 300 to 600.

"Conservatively," Goodwin muses, scratching his chin, "it'll get 60 miles to the gallon. With 2,000 foot-pounds of torque. You'll be able to smoke the tires. And it's going to be superefficient."

He laughs. "Think about it: a 5,000-pound vehicle that gets 60 miles to the gallon and does zero to 60 in five seconds!"

This is the sort of work that's making Goodwin famous in the world of underground car modders. He is a virtuoso of fuel economy. He takes the hugest American cars on the road and rejiggers them to get up to quadruple their normal mileage and burn low-emission renewable fuels grown on U.S. soil--all while doubling their horsepower. The result thrills eco-evangelists and red-meat Americans alike: a vehicle that's simultaneously green and mean. And word's getting out. In the corner of his office sits Arnold Schwarzenegger's 1987 Jeep Wagoneer, which Goodwin is converting to biodiesel; soon, Neil Young will be shipping him a 1960 Lincoln Continental to transform into a biodiesel--electric hybrid.

His target for Young's car? One hundred miles per gallon.

This is more than a mere *American Chopper*--style makeover. Goodwin's experiments point to a radically cleaner and cheaper future for the American car. The numbers are simple: With a \$5,000 bolt-on kit he co-engineered--the poor man's version of a Goodwin conversion--he can immediately transform any diesel vehicle to burn 50% less fuel and produce 80% fewer emissions. On a full-size gas-guzzler, he figures the kit earns its money back in about a year--or, on a regular car, two--while hitting an emissions target from the outset that's more stringent than any regulation we're likely to see in our lifetime. "Johnathan's in a league of his own," says Martin Tobias, CEO of Imperium Renewables, the nation's largest producer of biodiesel. "Nobody out there is doing experiments like he is."

Nobody--particularly not Detroit. Indeed, Goodwin is doing precisely what the big American automakers have always insisted is impossible. They have long argued that fuel-efficient and alternative-fuel cars are a hard sell because they're too cramped and meek for our market. They've lobbied aggressively against raising fuel-efficiency and emissions standards, insisting that either would doom the domestic industry. Yet the truth is that Detroit is now getting squeezed from all sides. This fall, labor unrest is brewing, and after decades of inertia on fuel-economy standards, Congress is jockeying to boost the target for cars to 35 mpg, a 10 mpg jump (which is either ridiculously large or ridiculously small, depending on whom you ask). More than a dozen states are enacting laws requiring steep reductions in greenhouse-gas emissions. Meanwhile, gas prices have hovered around \$3 per gallon for more than a year. And European and Japanese carmakers are flooding the market with diesel and hybrid machines that get up to 40% better mileage than the best American cars; some, such as Mercedes's new BlueTec diesel sedans, deliver that kind of efficiency and more horsepower.

General Motors, Ford, and Chrysler, in short, have a choice: Cede still more ground--or mount a technological counterattack.

Goodwin's work proves that a counterattack is possible, and maybe easier than many of us imagined. If the dream is a big, badass ride that's also clean, well, he's there already.

As he points out, his conversions consist almost entirely of taking stock GM parts and snapping them together in clever new ways. "They could do all this stuff if they wanted to," he tells me, slapping on a visor and hunching over an arc welder. "The technology has been there forever. They make 90% of the components I use." He doesn't have an engineering degree; he didn't even go to high school: "I've just been messing around and seeing what I can do."

All of which raises an interesting possibility. Has this guy in a far-off Kansas garage figured out the way to save Detroit?

America's most revolutionary innovations, it has long been said, sprang from the ramshackle dens of amateurs. Thomas Edison was a home-schooled dropout who got his start tinkering with battery parts; Chester Carlson invented the photocopier in his cramped Long Island kitchen. NASA, desperate for breakthroughs to help it return to the moon, has set up million-dollar prizes to encourage private citizens to come forward with any idea, no matter how crazy. As the theory goes, only those outside big industries can truly reinvent them.

Goodwin is certainly an outsider. He grew up in a dirt-poor Kansas family with six siblings and by age 13 began taking on piecework in local auto shops to help his mother pay the bills. He particularly enjoyed jamming oversized engines into places no one believed they'd fit. He put truck engines inside Camaros, Grand Nationals, and Super Bees; he even put a methanol-fueled turbocharger on a tiny Yamaha Banshee four-wheeler. "We took that thing from 35 horsepower to 208," he recalls. "It was crazy. We couldn't put enough fins on the back to keep it on the ground." After dropping out of school in the seventh grade, he made a living by buying up totaled cars and making them as good as new. "That," he says, "was my school."

Along the way, Goodwin also adopted two views common among Americans, but typically thought to be in conflict: a love of big cars and a concern about the environment. He is an avid, if somewhat nonideological, environmentalist. He believes global warming is a serious problem, that reliance on foreign oil is a mistake, and that butt-kicking fuel economy is just good for business. But Goodwin is also guiltlessly addicted to enormous, brawling rides, precisely the sort known to suck down Saudi gasoline. (I spied one lonely small sports car in the corner of his garage, but he confessed he has no plans to work on it right now.) When he picked me up from my hotel, he drove a four-door 2008 Cadillac Escalade XL that should have had its own tugboat. He parallel parked it in one try.

If Goodwin is an artist, though, his canvas has been the Hummer. His first impression of the thing was inauspicious. In 1990, he bought an H1 in Denver and began driving it back to Kansas. Within 50 miles, the bolts in the transmission shook loose, forcing him to stop to fix it. "By the time I made it home, after three roadside repairs, I pretty much knew that the Hummer was not all it should be," he told me. He didn't think much of the 200 horsepower engine, either, which did "zero to 60 in two days. It was a piece of junk."

So Goodwin decided to prove that environmentalism and power could go together--by making his new lemon into exhibit A. First, he pulled the gas engine so he could drop in a Duramax V8, GM's core diesel for large trucks. Diesel technology is crucial to all of Goodwin's innovations because it offers several advantages over traditional gasoline engines. Pound for pound, diesel offers more power and torque; it's also inherently more efficient, offering up to 40% better mileage and 20% lower emissions in engines of comparable size. What's more, many diesel engines can easily accept a wide range of biodiesel--from the high-quality stuff produced at refineries to the melted chicken grease siphoned off from the local KFC.

"Think about it," Goodwin laughs. "A 5,000-pound vehicle that gets 60 miles to the gallon and will do zero to 60 in five seconds!"

Putting a diesel engine in the Hummer, however, required Goodwin to crack GM's antitheft system, which makes it a pain to swap out the engine. In that system, the engine communicates electronically with the body, fuel supply, and ignition; if you don't have all the original components, the car won't start. Goodwin jerry-rigged a set of cables to trick the engine into believing the starter system had broken, sending it into "fail-safe mode"--a backdoor mechanism installed at the factory. (At one point in his story, Goodwin wanders over to a battered cardboard box in the corner of the garage and hauls out an octopuslike tangle of wires--"the MacGyver," his hacking device. "I could have sold this for a lot of money on eBay," he chuckles.)

Once he'd picked the car's lock, Goodwin installed the Duramax and a five-speed Allison--the required transmission for a Duramax, which also helps give it race-car-like control and a rapid take off. After five days' worth of work, the Hummer was getting about 18 mpg--double the factory 9 mpg--and twice the original horsepower. He drove it over to a local restaurant and mooched some discarded oil from its deep fryer, strained the oil through a pair of jeans, and poured it into the engine. It ran perfectly.

But Goodwin wanted more. While researching alternative fuels, he learned about the work of Uli Kruger, a German who has spent decades in Australia exploring techniques for blending fuels that normally don't mix. One of Kruger's systems induces hydrogen into the air intake of a diesel engine, producing a cascade of emissions-reducing and mileage-boosting effects. The hydrogen, ignited by the diesel combustion, burns extremely clean, producing only water as a by-product. It also displaces up to 50% of the diesel needed to fuel the car, effectively doubling the diesel's mileage and cutting emissions by at least half. Better yet, the water produced from the hydrogen combustion cools down the engine, so the diesel combustion generates fewer particulates--and thus fewer nitrogen-oxide emissions.

"You can feed it hydrogen, diesel, biodiesel, corn oil--pretty much anything but water."

"It's really a fantastic chain reaction, all these good things happening at once," Kruger tells me. He has also successfully introduced natural gas--a ubiquitous and generally cheap fuel--into a diesel-burning engine, which likewise doubles the mileage while

slashing emissions. In another system, he uses heat from the diesel engine to vaporize ethanol to the point where it can be injected into the diesel combustion chambers as a booster, with similar emissions-cutting effects.

Goodwin began building on Kruger's model. In 2005, he set to work adapting his own H1 Hummer to burn a combination of hydrogen and biodiesel. He installed a Duramax in the Hummer and plopped a carbon-fiber tank of supercompressed hydrogen into the bed. The results were impressive: A single tank of hydrogen lasted for 700 miles and cut the diesel consumption in half. It also doubled the horsepower. "It reduces your carbon footprint by a huge, huge amount, but you still get all the power of the Duramax," he says, slapping the H1 on the quarter panel. "And you can feed it hydrogen, diesel, biodiesel, corn oil--pretty much anything but water."

Two years ago, Goodwin got a rare chance to show off his tricks to some of the car industry's most prominent engineers. He tells me the story: He was driving a converted H2 to the SEMA show, the nation's biggest annual specialty automotive confab, and stopped en route at a Denver hotel. When he woke up in the morning, there were 20 people standing around his Hummer. *Did I run over somebody?* he wondered. As it turned out, they were engineers for GM, the Hummer's manufacturer. They noticed that Goodwin's H2 looked modified. "Does it have a diesel engine in it?"

"Yeah," he said.

"No way," they replied.

He opened the hood, "and they're just all in and out and around the valves and checking it out," he says. They asked to hear it run, sending a stab of fear through Goodwin. He'd filled it up with grease from a Chinese restaurant the day before and was worried that the cold morning might have solidified the fuel. But it started up on the first try and ran so quietly that at first they didn't believe it was really on. "When you start a diesel engine up on vegetable oil," Goodwin says, "you turn the key, and you hear nothing. Because of the lubricating power of the oil, it's just so smooth. Whisper quiet. And they're like, 'Is it running? Yeah, you can hear the fan going.'"

One engineer turned and said, "GM said this wouldn't work."

"Well," Goodwin replied, "here it is."

Goodwin's feats of engineering have become gradually more visible over the past year. Last summer, Imperium Renewables contacted MTV's show *Pimp My Ride* about creating an Earth Day special in which Goodwin would convert a muscle car to run on biodiesel. The show chose a '65 Chevy Impala, and when the conversion was done, he'd doubled its mileage to 25 mpg and increased its pull from 250 to 800 horsepower. As a stunt, MTV drag-raced the Impala against a Lamborghini on California's Pomona Raceway. "The Impala blew the Lamborghini away," says Kevin Kluemper, the lead calibration engineer for GM's Allison transmission unit, who'd flown down to help with

the conversion. Schwarzenegger, who was on the set that day, asked Goodwin on the spot to convert his Wagoneer to biodiesel.

Observers of Goodwin's work say his skill lies in an uncanny ability to visualize a mechanical system in precise detail, long before he picks up a wrench. (Goodwin says he does much of his mental work during long drives.) "He has talent unknown to any mortal," says Mad Mike, *Pimp My Ride*'s host. "He has this ability to see things so exactly, and I still don't know how he does it."

For his part, Goodwin argues he's merely "a problem solver. Most people try to make things more complicated than they are." He speaks of the major carmakers with a sort of mild disdain: If he can piece together cleaner vehicles out of existing GM parts and a bit of hot-rod elbow grease, why can't they bake that kind of ingenuity into their production lines? Prod him enough on the subject and his mellowness peels away, revealing a guy fired by an almost manic frustration. "Everybody should be driving a plug-in vehicle right now," he complains, in one of his laconic engineering lectures, as we wander through the blistering Kansas heat to a nearby Mexican restaurant. "I can go next door to Ace Hardware and buy a DC electric motor, go out to my four-wheel-drive truck, remove the transmission and engine, bolt the electric motor onto the back of the transfer case, put a series of lead-acid batteries up to 240 volts in the back of the bed, and we're good to go. I guarantee you I could drive all around town and do whatever I need, go home at night, and hook up a couple of battery chargers, plug one into an outlet, and be good to go the next day.

"Detroit could do all this stuff overnight if it wanted to," he adds.

In reality, Goodwin's work has begun to influence some of Detroit's top auto designers, but through curious and circuitous routes. In 2005, Tom Holm, the founder of EcoTrek, a nonprofit that promotes the use of alternative fuels, heard about Goodwin through the Hummer-junkie grapevine and hired him. When Holm showed GM the vehicles Goodwin converted, the company was duly impressed. Internally, Hummer executives had long been looking for a way to blunt criticism of the H2's gas-guzzling tendencies and saw Goodwin's vehicles as an object lesson in what was possible. So GM decided to flip the switch: It announced the same year that, beginning in 2008, it would convert its gasoline Hummers to run on ethanol; by 2010, it said, Hummers would be biodiesel-compatible.

"It *was* an influence," concedes Hummer general manager Martin Walsh, of the EcoTrek vehicles. "We wanted to be environmentally responsible by having engines in Hummers that run on renewable fuels." But until I contacted Hummer for this story, GM didn't know that the man behind those machines was none other than Goodwin.

GM's commitment is a start, however halting. Overall, though, Detroit still seems to be all but paralyzed by the challenges of fuel economy, emissions, and alternative fuels. And it's not just about greed or laziness: Talk to car-industry experts, and they'll point out a number of serious barriers to introducing radically new alternative-fuel vehicles on a scale that will make a difference. One of the highest is that low-emission fuels--biodiesel,

ethanol, electricity, hydrogen, all of which account for less than 3% of the nation's fuel supply--just aren't widely available on American highways. This creates a chicken-and-egg problem. People won't buy alternative-fuel cars until it's easy to fill them up, but alternative fuel makers won't ramp up production until there's a viable market.

Goodwin admits all these things are true but believes the country could be weaned off gasoline in a three-step process. The first would be for Detroit to aggressively roll out diesel engines, much as Europe has already begun to do (some 50% of all European cars run diesel). In a single stroke, that would improve the nation's mileage by as much as 40%, and, because diesel fuel is already widely available, drivers could take that step with a minimum of disruption. What's more, given that many diesel engines can also run homegrown biodiesel, a mass conversion to diesel would help kick-start that market. (This could have geopolitical implications as well as environmental and economic ones: The Department of Transportation estimated in 2004 that if we converted merely one-third of America's passenger cars and light trucks to diesel, we'd reduce our oil consumption by up to 1.4 million barrels of oil per day--precisely the amount we import from Saudi Arabia.)

The second step in Goodwin's scheme would be to produce diesel-electric hybrid cars. This would double the mileage on even the biggest *diesel* vehicles. The third phase would be to produce electric hybrids that run in "dual fuel" mode, burning biodiesel along with hydrogen, ethanol, natural gas, or propane. This is the concept Goodwin is proving out in his turbine-enhanced H3 Hummer and in Neil Young's Lincoln: "At that point, your mileage just goes really, really high, and your emissions are incredibly low," he says. Since those vehicles can run on regular diesel or biodiesel--and without any alternative fuel at all, if need be--drivers wouldn't have to worry about getting stranded on the interstate. At the same time, as more and more dual-fuel cars hit the road, they would goose demand for genuinely national ethanol, hydrogen, and biodiesel grids.

For Goodwin, navigating this process is all about imagination and adaptability. "The point is to design cars that are flexible," he says. "You'll see a change in how vehicles are fueled in the future. Which fuel source will be the exclusive one or the one that'll take over the petroleum base is, you know, anybody's guess, so it's like the wild, wild West of fuel technology right now. I think it'll be a combination between a few different fuels. I know hydrogen will definitely come around."

Imagination and vision, of course, are often rewarded. As global pressure increases on the United States to reduce our carbon emissions, those rewards are likely to get juicier. Under some versions of legislation being considered in Congress, for example, companies voluntarily deploying superefficient vehicles in large fleets could be awarded substantial offsets. Take DHL, the FedEx rival: Goodwin says his company, SAE Energy, is negotiating with the shipper to convert 800 of its vehicles to dual fuel. "We could get them an offset of something like 70 cents a gallon," Goodwin says, "and reduce their cost of fuel by 50%."

Industry insiders and observers agree with many of Goodwin's prescriptions, particularly his concept of fuel flexibility. "We have to have alternatives," says Beau Boeckmann, vice president of California's Galpin Motors, the largest Ford dealership in the country, who recently partnered with Goodwin to convert a 2008 F450 truck to hydrogen and biodiesel. "Only with a combination of things can we get alternative fuels off the ground." Boeckmann believes hydrogen is the true "silver bullet" for ending greenhouse gases but thinks it'll take more than a decade to figure out how to create and distribute it cheaply. Mary Beth Stanek, GM's director of environment, energy, and safety policy, also agrees with the multifuel approach--and points out that this is precisely how Brazil weaned itself from regular gasoline. "They pull up to the pump, and they've got a whole bunch of different choices," she notes. She, too, predicts diesel will make a comeback because of its inherent fuel efficiency: "You will see more vehicles going back to diesel over a lot of different lines."

Yet in reality, American carmakers seem conspicuously slow on the uptake. Stanek is about as ardent a fan of alternative fuels as you're likely to find inside GM, but even she admits no one there is seriously thinking of abandoning the gasoline engine anytime soon. The 300-million-gallon U.S. biodiesel business is a fraction of the 12-billion-gallon ethanol one. And Detroit is extremely cautious about what the market can bear.

A Detroit carmaker does, of course, have to worry about selling millions of cars at reasonable prices. But we've been hearing this refrain for a long, long time. And with European and Japanese carmakers driving ever harder into our market--and with Chrysler having become just another meal for Cerberus Capital--this hardly seems like the time to be overly cautious. (Those ultralow-emission Mercedes BlueTec diesels, for example, include a four-wheel-drive sedan that gets 37 mpg and goes from zero to 60 in 6.6 seconds.) Moreover, after decades of consumer apathy, improving fuel economy and reducing carbon output are becoming urgent national priorities. The green groundswell has arrived, and, given the stakes, anyone who ignores it does so at his peril. If Detroit can't sell diesel now--especially a clean, high-performance, money-saving diesel--it never will.

With U.S. carmakers being stripped for parts, now is hardly the time for them to play it safe.

Goodwin, perhaps, can afford to be a visionary. He has the luxury of converting cars for fancy clients who'll pay handsomely to drive on higher moral ground. (He charges \$28,000 for a "basic H2 conversion to diesel--custom concept cars cost far more.") The future of the American car will likely be won by an automaker that can split the difference--one that may innovate more slowly than Goodwin would like, but a hell of a lot faster than the Big Three.

Goodwin himself seems more oracle than implementer, slightly unsure of how his ideas could be brought to the masses. He's working on patenting aspects of his and Kruger's dual-fuel work and would love to license it to the big carmakers. But the truth is, he's a mechanic's mechanic--happiest when he's solving some technical puzzle. He loves getting



his hands dirty, "throwing wrenches around" in his shop, pioneering some weird new way to fuel a car. Today, he's thinking about taking his wife's Infiniti, outfitting it with a tank of ether, and powering the engine via blasts of compressed air in the cylinders. "Zero emissions!" he crows. It's the visionary inventor's curse: constantly distracted by shiny objects.

Goodwin eyes the turbine, which he has dragged out to the center of the floor. Just for kicks, he says, he's thinking of mounting it on a wheelie board and firing it up. "I'd love to see how fast that goes," he says. "I'm just not sure how I'm going to steer it."

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