

Volkswagen Emissions Scandal

We are going to continue our ethics discussion with Volkswagen, which is highly germane to software engineers.

Context

There is some political will to reduce CO₂ emissions in response to climate change. Diesel produces maybe 10–20% fewer CO₂ emissions than gasoline per distance travelled, and more torque, but also more nitrous oxides (NO_x) and more fine particulate matter (also known as PM2.5, or soot).

Historically, diesel has been popular in Europe (around 50% of the car market) but not in North America (around 3% of the car market, was growing until the scandal broke). Yet people had been observing higher soot emissions in cities, and the Paris mayor, Anne Hidalgo, had called for diesel bans or buybacks, even prior to the scandal.

The Issue

Volkswagen's CEO had a stated objective of leading VW to be the biggest car manufacturer in the world. However, to sell cars in the US, they had to meet new, stricter NO_x limits. (NO_x aggravates asthma, among other ill effects). Since 2008, they have been advertising “clean diesels” which allegedly meet the new limits.

Catalytic converters reduce NO_x levels in gas engines, but don't work for diesel engines. Instead, the usual solution is to use “selective catalytic reduction”, which injects urea into the combustion mixture. But the car then needs a urea tank and refills.

Or, in an illustration of a classic engineering tradeoff, the manufacturer can sacrifice either power or fuel efficiency for cleaner emissions. Since it's 2016, the tradeoff is controlled by software running in the engine control unit.

The Discovery

Before the scandal broke, experts had been quietly suspicious about the lack of an urea tank¹; and customers had noticed soot on their cars.

¹Afterwards, Prof. Dudenhoffer, director of the Center for Automotive Research at the University of Duisburg-Essen, said “They must have known that it's impossible, or else it's not possible they have degrees as engineers.”

In any case, it was odd that the US cars satisfied stronger standards than those in Europe. The International Council on Clean Transportation (ICCT), an engineering-heavy thinktank, wanted to know why. It commissioned engineers at West Virginia University to investigate.

VWU engineers Marc Besch and Arvind Thiruvengadam performed in-lab and on-road testing of both VWs and BMWs. The in-lab tests, under controlled conditions, achieved the advertised emissions targets. But once they brought the VW cars on the road, they found NO_x emissions that were 5× to 35× over targets. Not so for the BMWs. They presented their work at the *Real-World Emissions Workshop*, an academic conference, in May 2014.

Regulators and Consequences

The US Environmental Protection Agency started quietly investigating soon afterwards. Presumably after some period of discussions with Volkswagen, they published a Notice of Violation in September 2015, at which point the scandal made the news (see below). Although Volkswagen owned up to the cheating (at some level) fairly early, it continues to face massive consequences, including a steep decline in sales, a change in CEO, a drop in stock value, and even raids of their offices.

Engineering Analysis

How did this work?

- it's all software-controlled;
- when the software detects test conditions (no steering/fixed speeds/etc), it switches into so-called “dyno calibration” mode.
- fewer emissions but also less torque and less efficiency.
- must have been put in by software engineers working with the engine designers.

How did this happen?

- regulators set an objective testing scheme that was possible to hack (is being improved);
- fundamentally, there is an engineering tradeoff: urea tank vs targets for torque and fuel efficiency.
- Upper management set specifications which were not achievable; they attempted to blame rogue engineers; VW is an engineering-focussed organization, not credible.

References

I've only provided a superficial summary of the situation. There is a lot of good long-form journalism on this topic. Good to read over Christmas. All links retrieved 21 November 2016.

These are good general articles about the Volkswagen scandal.

- Russell Hotten, BBC. "VW: The scandal explained." 10 December 2015. <http://www.bbc.com/news/business-34324772>
- Damien McGuinness, BBC. "VW emissions scandal hits 11m vehicles." 22 September 2015. <http://www.bbc.com/news/business-34325005>
- Clifford Atiyeh, Car and Driver blog. "Everything you need to know about the VW Diesel Emissions Scandal." Updated 15 November 2016. <http://blog.caranddriver.com/everything-you-need-to-know-about-the-vw-diesel-emissions-scandal/>
- Ezra Dyer, Popular Mechanics. "This VW Diesel Scandal is Much Worse Than a Recall." 21 September 2015. <http://www.popularmechanics.com/cars/a17430/ezra-dyer-volkswagen-diesel-controversy/> (includes editorializing)
- Daniel Beaulieu, autotrader.ca. "Dieselgate from the Driver's Seat, Part 1." 22 June 2016. <http://www.autotrader.ca/newsfeatures/20160622/dieselgate-from-the-drivers-seat-part-1/#mJcbvZyFcUR6rimd.97> (Canadian first-person viewpoint)

About diesel in general:

- Richard Anderson, BBC. "Diesel cars: What's all the fuss about?" 16 September 2015. <http://www.bbc.com/news/business-34257424>
- Damian Carrington, Gwyn Topham and Peter Walker, The Guardian. "Revealed: nearly all new diesel cars exceed official pollution limits". 23 April 2016. <https://www.theguardian.com/business/2016/apr/23/diesel-cars-pollution-limits-nox-emissions>
- Taras Grescoe, NY Times. "The Dirty Truth about 'Clean Diesel'." 2 January 2016. <http://www.nytimes.com/2016/01/03/opinion/sunday/the-dirty-truth-about-clean-diesel.html> (opinion piece about diesel)

Earlier hints of defeat devices and diesel drawbacks:

- Arthur Neslen, The Guardian. "European commission warned of car emissions test cheating, five years before VW scandal." 20 June 2016. <https://www.theguardian.com/environment/2016/jun/20/european-commission-warned-car-maker-suspected-cheating-five-years-vw-scandal>
- John Voelcker, Green Car Reports. "Are 'Clean Diesels' Actually Not Nearly As Clean As Claimed?" 9 April 2015. http://www.greencarreports.com/news/1097698_are-clean-diesels-actually-not-nearly-as-clean-as-claimed (coverage before the headlines)

- Brian Turner, driving.ca. “To diesel or not to diesel? Pros and cons of diesel vs. gas.” 23 March 2015. <http://driving.ca/volkswagen/golf/auto-news/news/to-diesel-or-not-to-diesel-that-is-the-question> (pre-scandal opinions re: diesel)
- David Booth, driving.ca. “Motor Mouth: Is diesel a sticky, ticking time bomb?” 13 February 2015. <http://driving.ca/auto-news/entertainment/motor-mouth-stinky-time-bomb-why-diesel-is-at-a-crossroads> (notes Paris mayor is anti-diesel due to soot, pre-scandal)

Long-form investigative reporting:

- William Boston, The Wall Street Journal. “Volkswagen Emissions Investigation Zeros in on Two Engineers.” 5 October 2015. <http://www.wsj.com/articles/vw-emissions-probe-zeroes-in-on-two-engineers-1444011602> (paywall)
- Dune Lawrence, Bloomberg. “How Could Volkswagen’s Top Engineers Not Have Known?” 21 October 2015. <http://www.bloomberg.com/news/articles/2015-10-21/how-could-volkswagen-s-top-engineers-not-have-known-> (contains an engineering analysis)
- Geoffrey Smith and Roger Parloff. “Hoaxwagen: How the massive diesel fraud incinerated VW’s reputation—and will hobble the company for years to come.” 7 March 2016. <http://fortune.com/inside-volkswagen-emissions-scandal/> Super detailed investigative reporting.

Primary sources:

- Rachel Muncrief, The International Council on Clean Transportation. “Defeat device testing in the EU: So far, not so good.” 28 April 2016. <http://www.theicct.org/blogs/staff/defeat-device-testing-eu-so-far-not-so-good>
- John German, The International Council on Clean Transportation. “The emissions test defeat device problem in Europe is not about VW.” 12 May 2016. <http://www.theicct.org/blogs/staff/emissions-test-defeat-device-problem-europe-not-about-vw>