

Problem 1

"Toyota sold 1.52 million electrified vehicles in 2017, three years ahead of 2020 target; cumulative sales >11.47M"

<http://www.greencarcongress.com/2018/02/20180202-tmc.html>

"Toyota aims for sales of more than 5.5M electrified vehicles including 1M ZEVS per year by 2030; no models developed without electrified version" -

<http://www.greencarcongress.com/2017/12/20171218-toyota.html>

These articles discussed Toyota's annual sales and compared them with previously set targets, as well as discussing future targets for sales and how they might be met. In 2017, Toyota sold 1.52 million electrified vehicles (i.e. hybrid vehicles and battery electric vehicles). Toyota had originally set a target for selling 1.5 million electric vehicles in 2020, but they were able to reach their target 3 years ahead of schedule. Toyota has sold 11.47 million electrified vehicles cumulatively, which is quite an accomplishment. However, they intend to sell 5.5 million electrified vehicles per year by 2030, with 1 million of them being BEVs or fuel cell vehicles. To reach this target, Toyota intends to sell 10 different BEV models globally. Perhaps the most aggressive step noted in the article is the target of having every vehicle in the fleet available either with an electrified option or only as an electrified vehicle. Toyota also hopes to develop a prismatic battery system with Panasonic and to develop a social infrastructure that promotes electrified vehicle adoption by partnering with governments and other companies to encourage battery recycling and the installation of charging and hydrogen fueling stations.

These articles struck me as important because they helped highlight both how far the industry has come in a short time and also how far it still has to go. Clearly, electrified vehicle technology has progressed at a pace that has far exceeded the expectations of both customers and manufacturers, which is encouraging and inspiring. These vehicles have been widely adopted and are increasing in popularity, and as the powertrain technology improves, their popularity will surely increase at a more favorable rate. However, there is still a long way to go between 1.5 million sales and 5.5 million sales. The ICE vehicle is somewhat entrenched in our society and significant infrastructure installments are necessary in order to support an electrified vehicle fleet that large. While auto manufacturers have clear and direct incentives to adopt new technologies and provide consumers with what they want, they are also dependent on large and slow institutions like utilities and governments to help develop the required infrastructure, and if these institutions do not get on board and start to move quickly, things may get complicated. However, my biggest takeaway from these articles was that the writing is on the wall - electric vehicles are here to stay and consumers are seeing the benefits of these vehicles more and more.

"Ford ups its electrified vehicle ante to \$11B; 86% trucks and SUVs in the product mix by 2020"
<http://www.greencarcongress.com/2018/03/20180316-ford.html>

In this article, the author details the multitude of ways in which Ford intends to modernize its vehicle fleet over the next few years. Overall, they intend to spend \$11 billion through 2020 on electrified vehicles, which is a significant increase from \$4.5 billion that was proposed in 2017. Hybrids will play a more significant role in Ford's future vehicle fleet – more efficient and cheaper hybrid drivetrains will lower ownership costs for customers and hybrid drives will be added to popular models like the F-150 and the Mustang. In order to produce and sell more BEVs, Ford is considering ways of making BEV ownership "effortless" and is redesigning the manufacturing process, cutting the required factory floor space and the required capital investment both by 50%. Ford also intends to design "flexible vehicle architectures" so that all models are based on the same 5 core designs, which is estimated to save \$4 billion and cut development time by 20%.

I felt this article was important because it highlighted where the auto industry needs to go in order to meet customer's expectations. When I think about electric cars today, I mostly think about cars that are in production like the Tesla Model S, BMW i3, Nissan Leaf, and the Chevy Bolt. However, this article mentioned that Ford estimates that 50% of sales will be SUVs in 2020 and Ford's revenues from the F-Series trucks alone exceeds the revenues of companies like Facebook, Coca-Cola, and Nike. Building small, lightweight electric vehicles is one thing, but meeting consumer demand for larger cars like SUVs and pick-up trucks is another. This article has encouraged me to think more into the future about how to combine electric vehicle technology with the qualities consumers seek in these large vehicles and how to address the technical challenges presented by this task.

"New Argonne-developed tool helps car buyers compare electric-drive and traditional vehicles"
<http://www.greencarcongress.com/2018/02/20180215-evolution.html>

This article described a new online tool developed by Argonne National Laboratory to help consumers in the Midwest make an informed vehicle purchase. The tool, called EVolution, considers consumer inputs like purchase price and compares the financial and environmental benefits of conventional vehicles and their electrified counterparts. The tool uses the individual's commute time and ZIP code so that climate data, fuel and electricity prices, and vehicle incentives can be used to help determine the financial and environmental benefits of each option. The tool also uses maps of charging stations, which are provided to the consumer, to help determine what options are available for charging.

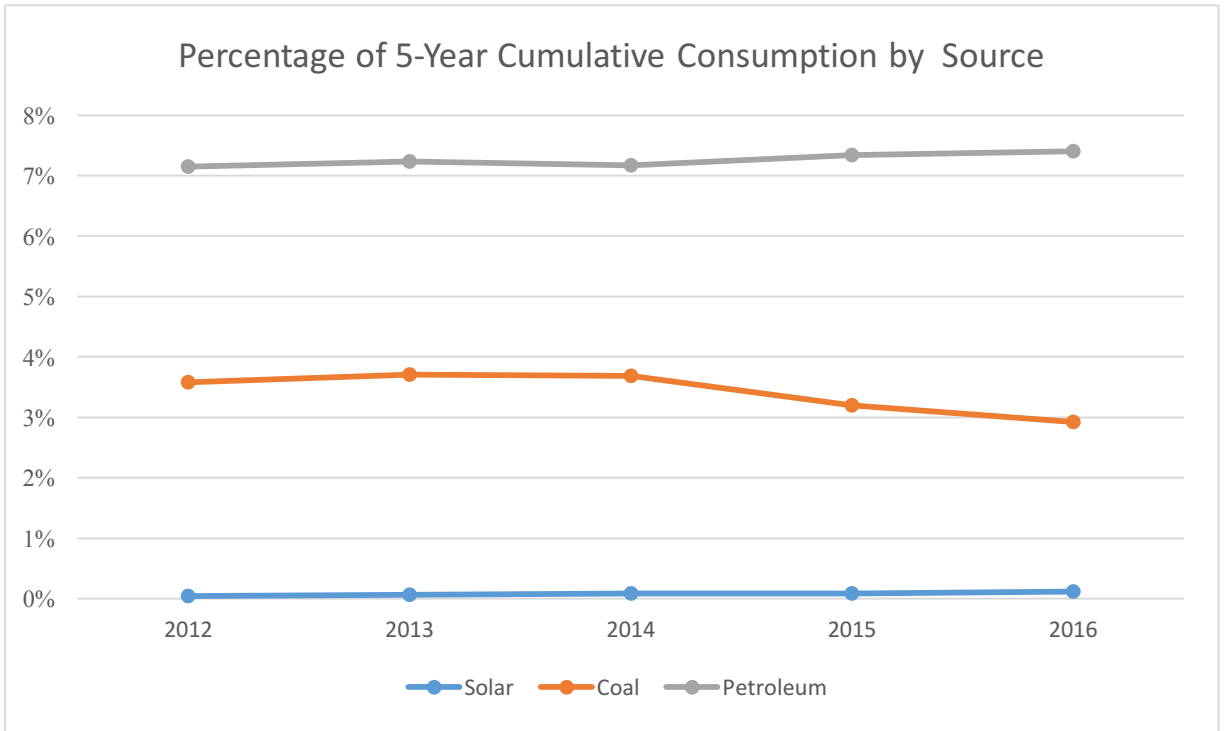
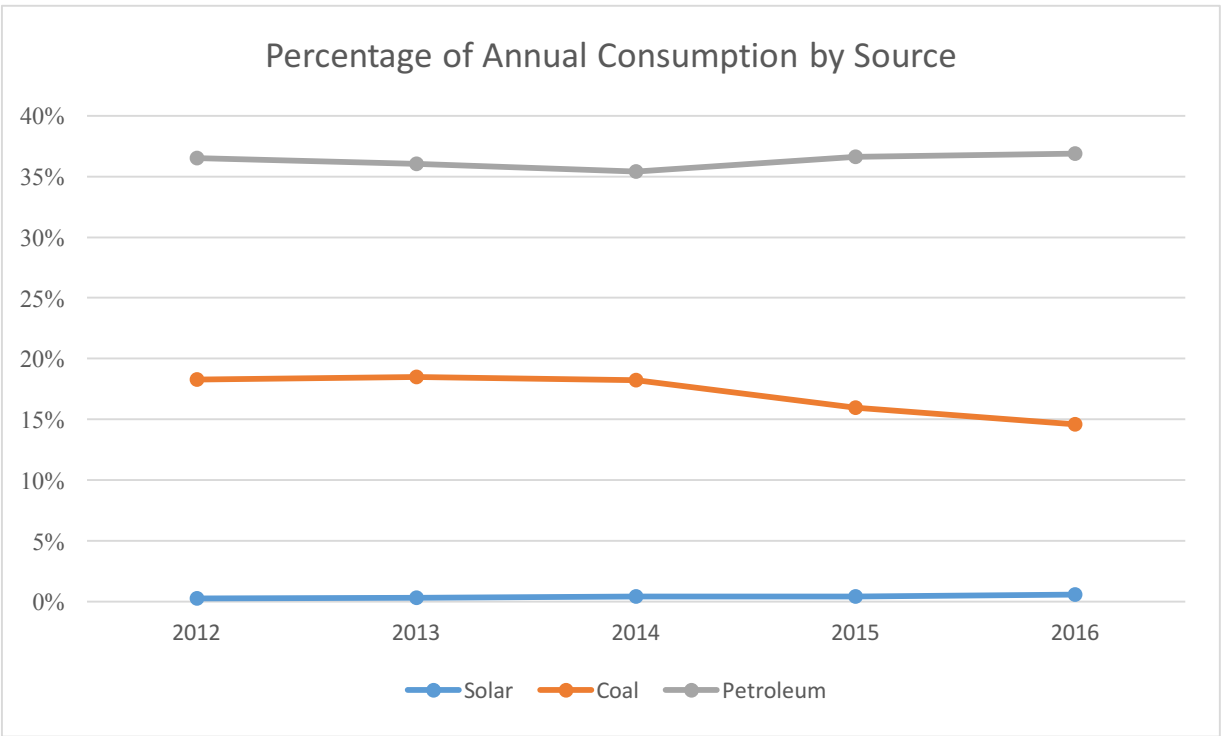
Two things in particular struck me about this article. Firstly, the tool makes use of information that all seems to be publicly available on sites like the Alternative Fuels Data Center, FuelEconomy.gov, and the US EIA. While a particularly determined consumer might have been able to go out and find and interpret all this information on his or her own, simple tools like these can vastly simplify the process and allow significantly more consumers to make a better choice without creating a need for more or enhanced data collection. Secondly, this tool was created with support from a partnership that included the American Lung Association and Clean Cities coalitions in the Midwest. It is always striking to me to hear about domestic air quality concerns, since I have generally been fortunate to live in places with good air quality. The benefits of electrified vehicles are broad, and this is not emphasized often enough. Hopefully tools like this can be built for other areas of the country.

Problem 2

Energy Use by Source (Quads)				
	Solar	Coal	Petroleum	Total
2012	0.235	17.4	34.7	95.1
2013	0.32	18	35.1	97.4
2014	0.427	17.9	34.8	98.3
2015	0.426	15.5	35.6	97.2
2016	0.587	14.2	35.9	97.3

Percentage of Annual Energy Use by Source			
	Solar	Coal	Petroleum
2012	0.25%	18.30%	36.49%
2013	0.33%	18.48%	36.04%
2014	0.43%	18.21%	35.40%
2015	0.44%	15.95%	36.63%
2016	0.60%	14.59%	36.90%

Percentage of 5-Year Cumulative Energy Use by Source			
	Solar	Coal	Petroleum
2012	0.05%	3.59%	7.15%
2013	0.07%	3.71%	7.23%
2014	0.09%	3.69%	7.17%
2015	0.09%	3.19%	7.34%
2016	0.12%	2.93%	7.40%



Problem 3

1. How can test-induced degradation mechanisms be minimized?

In general, observing the procedures outlined in the Battery Test Manual will help to minimize test-induced degradation. Observing voltage limits is important in minimizing degradation, including the max/min operating voltage, the max/min pulse voltage limits, and low-temperature voltage limits. Tests should be performed at 30°C and manufacturer-specified charging procedures should be observed.

2. What is the recommended resting time after each charge (or discharge) prior to further testing?

The recommended resting time is 60 minutes. The manufacturer will also likely specify a rest time that should be observed. However, if performing charge depletion life cycle testing, it may be acceptable to wait only 15 minutes between charges or discharges.

3. Define the Battery Size Factor (BSF).

The BSF is a ratio that defines the minimum number of cells, modules, or sub-batteries needed for a device to meet the specified energy and power targets.

4. What are the only two tests that are defined in terms of requested current as opposed to requested power?

The Static Capacity Test and the High Rate Charge Test are the only two tests that are defined in terms of requested current.