Kerrisdale Capital

January 2021

Plug Power, Inc. (PLUG)

Pulling the PLUG on this Fool-Cell Maker

We are short shares of Plug Power, a $40 billion provider of hydrogen fuel-cell solutions that's set to generate a paltry $300 million in revenue in 2020 and trades at 40x its own aggressive revenue projection for 2024. The company's stock has almost doubled in just the last few weeks, and has risen by 15x in the last year, on the naïve excitement of uninformed investors over the prospects of the "hydrogen economy," or the idea that hydrogen and the fuel-cells (FCs) it can power will be a critical part of the transition from fossil fuels to "green" energy. But it's all just a pipe dream, because "green" hydrogen is too expensive and too inefficient to produce, store, transport, and burn. That's not because of manufacturing inefficiencies or an imaginary technology S-curve that has yet to be scaled. It's because of the laws of physics, which we don't expect Plug can successfully defeat.

For the time being, Plug Power has found precisely one use-case for its FCs: forklifts. That's almost comical for a company with a market value greater than any of the oligopolists dominating the diesel truck engine market. But the material handling market, as the company calls forklifts in its presentations, is much less than meets the eye. For one thing, the FCs sold to large warehouse customers Amazon and Walmart have been linked to warrant issuance that leaves them owning close to 15% of Plug in return for virtually nothing. Hundreds of millions of dollars' worth of fuel cell "revenue" from Amazon and Walmart over the last few years has been exchanged for ownership stakes now worth billions of dollars. The revenues from selling these forklift fuel-cell systems have also been attached to service and refueling agreements that consistently result in negative gross profits, which begs the question: if Plug can't even provide "black" environmentally-unfriendly hydrogen at a profit, how does green hydrogen stand a chance?

More importantly, despite the $30 billion total addressable market (TAM) and 1.5 million annual forklift purchase volume that Plug claims it can penetrate in the material handling market, the real problem is the same one with which the "hydrogen economy" will never be able to contend: lithium ion (Li) batteries have already demonstrated their value proposition for forklifts and are quickly coming to dominate the market. Hydrogen-powered forklifts are a small and cheap niche bet on the part of large corporations, either directly on Plug's stock price, as in the case of Amazon and Walmart, or on the ESG bragging rights that come along with the false perception of "being green." But aside from the reality that Li-powered forklifts, in contrast to those powered by hydrogen, *can* actually turn environmentally friendly over time, batteries will also *almost always* be more economical than fuel-cells – in any application – because electricity is much more efficiently produced and stored than hydrogen. And that's without considering the plant-altering capital expenditures required to use fuel-cells.

Recent weeks have seen investor enthusiasm about hydrogen reach astonishing levels, aided by two strategic partnerships Plug has entered. Both partnerships, though, should be seen as signs of *weakness* rather than strength. The first, with SK Group, is just an opportunistic capital-raise on the part of Plug from South Korea's utility monopoly, which is struggling to find its place in a decarbonized future given the region's lack of solar and wind resources. The other, with Renault, is a desperate attempt to stay relevant on the part of one of Europe's weakest auto manufacturers by entering a costless JV with Plug. Renault will supposedly be making FCEV light vehicles that are already miles behind their BEV competition. Both deals contemplate finalizing actual details at a later date, but by the time that's supposed to happen, we expect Plug's stock price will have collapsed, along with the once-a-decade recurring myth about a "hydrogen economy." SK and Renault might be able to afford the trifling write-off, but Plug investors are in for a shock.

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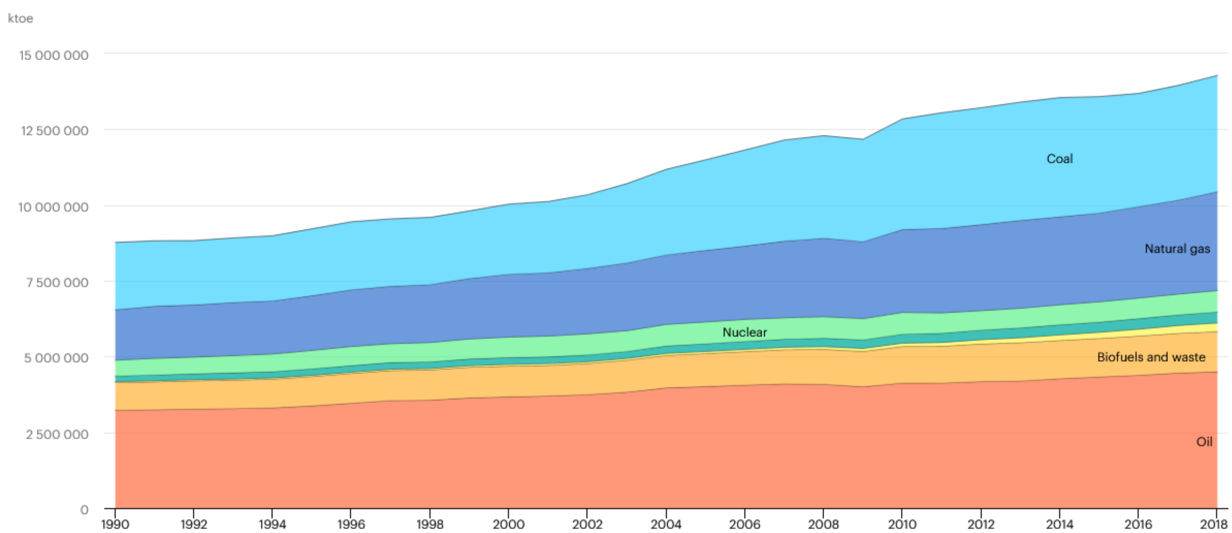
I. The "Hydrogen Economy" is a Fantasy

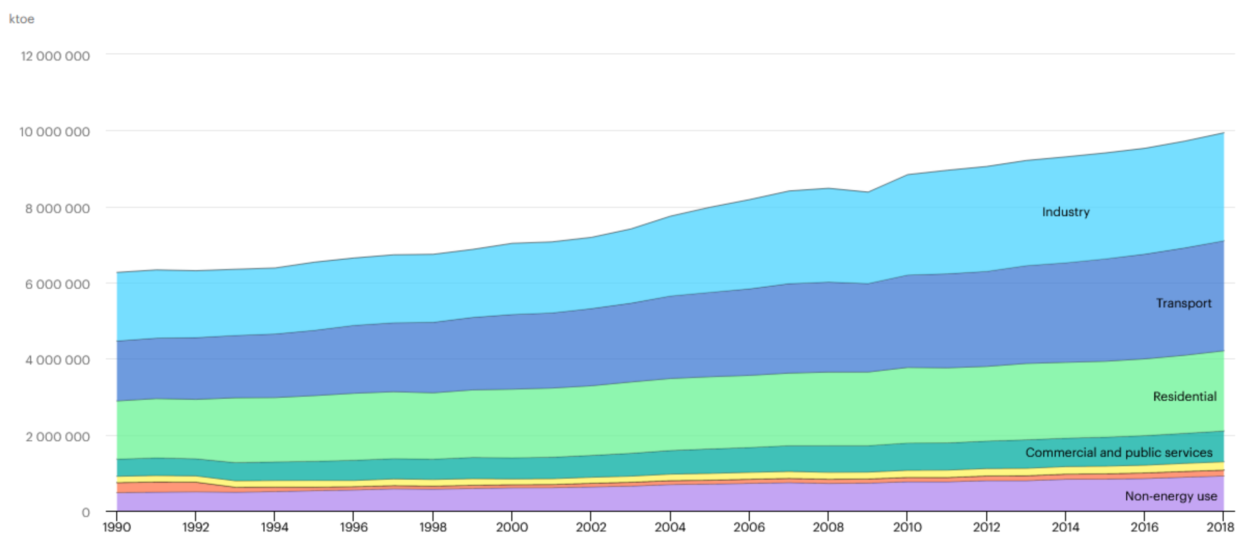
The myth underlying Plug Power's 120x revenue multiple is that, as the world begins to earnestly address climate change by reducing its reliance on carbon-emitting fossil fuels, hydrogen power will play a key role as a clean source of energy. When that happens, the companies that specialize in developing and supplying the equipment necessary to extract energy out of hydrogen – including, among others, Plug Power – will be able to capitalize on the spending boom.

World Energy Consumption by Source and Sector, 1990-2018

Total energy supply by source:



Total energy consumption by sector:



Source: International Energy Agency

But the "hydrogen economy" will never happen. Electrolyzers will never be sold at scale to power vehicles or industrial processes. And hydrogen fuel cells (FCs) will never be used beyond the niche applications we consider below. To understand why, it's worth delineating exactly what fossil fuel energy is primarily used for, and whether hydrogen-powered energy production can plausibly substitute fossil fuels in these applications. As the top graph on the previous page shows, according to the International Energy Agency (IEA), world energy consumption is dominated by oil, natural gas, and coal. The data also indicates that the end uses of this energy are almost entirely comprised of electricity production, transportation, heating, manufacturing, and construction.

Can hydrogen be used as the primary energy source for any of these applications? Answering that question requires a basic understanding of how energy is extracted from hydrogen and how it can subsequently be transported and consumed by the end user. To produce pure hydrogen, electrolysis – the process of passing an electric current through, in this case, water – is used to separate water into hydrogen and oxygen. Electrolysis presupposes an external power source to produce the electric current which, in the green future, will ostensibly be wind- and solar-powered electricity. Given the low density of pure hydrogen gas, the hydrogen produced is then compressed, and either stored or transported via pipeline to the end user as is now done with natural gas. The end user can't just burn the hydrogen, though, and so a fuel-cell is required, the purpose of which is to convert the energy of the hydrogen into electricity through a pair of redox reactions.

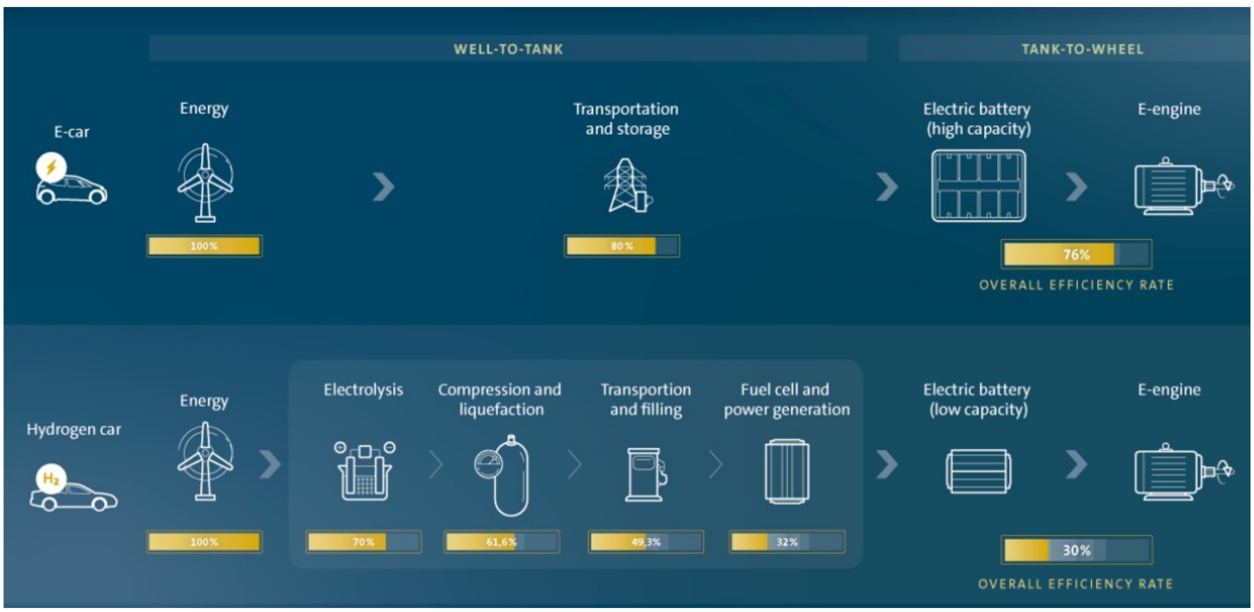
The entire chain starts with electricity and ends with electricity, which begs the question: why not just store the initial renewable-generated electricity in a battery, especially given the rapid improvements in lithium ion (Li) battery technology in recent years? Other considerations include:

- Inefficiency – Every step of the hydrogen energy process results in efficiency losses and energy leakage. A kilogram of hydrogen theoretically contains 39 kWh of energy, but the electrolysis process is only 70% efficient, at best, due to heat leakage. Compressing the hydrogen requires some of the energy stored in that hydrogen, which results in further inefficiencies (anywhere on the order of 1-30% losses, depending on how long the hydrogen needs to be compressed and at what pressures). Finally, the FC reactions converting the hydrogen back into electricity and water are also only approximately 50% efficient due to the heat leakage. The result is that, even without any energy leakage in the course of hydrogen transportation, each initial kWh of electricity results in only about 0.3 kWh to the end user. By contrast, the "well-to-wheel" efficiency of storing electricity in an Li battery is about 75% (a comparison between the battery and fuel-cell supply chain efficiency dynamics is shown in the diagram on the next page, courtesy of Volkswagen, which has had extensive experience trying – and quitting – to fit FCEVs into their long term plans).

- Infrastructure – the logistics required to generate energy from renewables, convert it to electricity, and subsequently store it in batteries already exists. For many applications – heating and most electricity generation, for example – the storage element isn't even necessary. The ability to generate and transmit electricity at mass scale already exists. Using hydrogen at mass scale, on the other hand, would require trillions of dollars of investment in electrolyzers, fuel cells, and completely redesigned and rebuilt pipeline networks, and even then we'd be wasting a huge proportion of the electricity produced at the electrolyzer power plant due to the aforementioned inefficiencies.

- Safety – Hydrogen flames are invisible to the naked eye and spread quickly (its flame velocity is 8x that of methane). Hydrogen also has no natural odor and odorizing it like we do with natural gas would contaminate the FCs that are supposed to harness the hydrogen energy. None of these safety issues are insurmountable, but they would likely lead to even more expense and inefficiency and would result in a less safe energy source being at scale.

Well-to-Wheel Efficiency: Hydrogen FC vs Li Batteries



Source: "Hydrogen or battery? A clear case, until further notice," Volkswagen AG

We've seen and heard hydrogen evangelists talk about the inefficiencies of the hydrogen power chain and the relative expense of hydrogen-power equipment as resulting from the lack of R&D or the lack of scale in manufacturing hydrogen-power equipment. Given time and scale, the argument goes, the hydrogen-power supply chain will get both more efficient and cheaper. The problem is that electrolyzers and fuel cells are actually relatively mature technologies, with over 100 years' worth of R&D embedded in them. Scale might bring down the cost a bit, but it won't be by the orders of magnitude necessary to make infrastructure investment remotely worthwhile. Meanwhile, the energy leakage at each stage of hydrogen production and transport has nothing to do with the inefficiency of the equipment, and everything to do with the basic laws of physics: heat leakage into water vapor is not reclaimable, and gas compression requires energy.

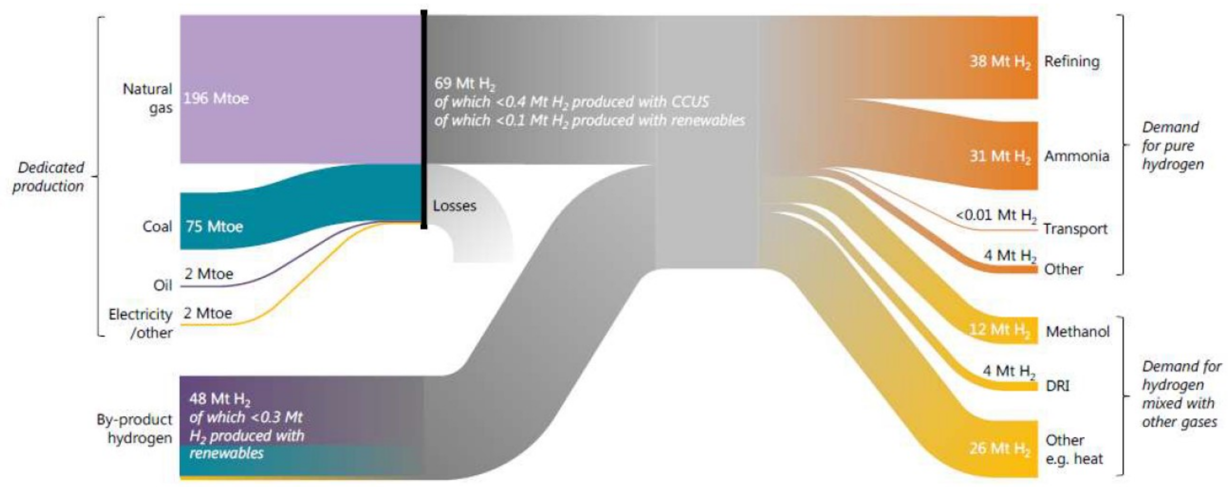
The downside of direct electrification is that, with respect to storage, Li batteries are heavy. For large stationary energy use cases – heating, cooking, household and commercial electrification, for example – this isn't really an issue. Electricity is delivered directly from the power plant to the end-user with little energy leakage. For electricity produced via solar or wind, which might be variable, batteries are already being used to help with peaking capacity, while base-load generation has much simpler and cheaper solutions than hydrogen electrolysis, including pumped hydro storage or the rapidly advancing redox flow batteries. At the same time, the vast majority of mobile applications – including light vehicles, short-range delivery, materials handling, urban-distance aircraft, and the vast majority of freight transport – are either unconstrained by the limits of Li batteries, or will require some level of recharging infrastructure to build out, which will be exponentially more economical than building out the "hydrogen economy."

So, what's left? If an enormous multi-trillion-dollar world hydrogen infrastructure will not be built (and it won't), hydrogen energy will have only very niche use cases where range is critical and refueling impossible, or where the hydrogen produced from electrolysis can be used on-site. The only applications that fit into the former category are long-distance overseas-shipping and long-haul flight. In the case of shipping, it's still likely that the incremental weight of batteries will not hinder their use on large intercontinental vessels, while in the case of long-haul flight, a simple calculation suggests that a single transatlantic flight requires as much energy as its passengers will consume in their automobile over the course of a year, and given the low energy density of hydrogen, that problem has yet to find a realistic solution.[1]

There are *current* uses of hydrogen power though, where the hydrogen is produced through steam reformation of natural gas or coal gasification and used on-site in the production of ammonia and methanol, oil refining, or as a heat source for a variety of industrial processes where hydrogen is a byproduct of the early parts of the process (see the diagram on the next page). Generally, producing hydrogen this way is extremely carbon-intensive, and renewables-driven electrolysis would be a welcome alternative if it would make economic sense, though a "decarbonized" future would ostensibly lack methanol production or oil refining at the scale they currently exist. Either way, there's not much in these use-cases for Plug Power or its FC-manufacturing peers. That's partly because the hydrogen for these industrial uses would be more economical if produced with a Chinese-made alkaline electrolyzer that's a lot cheaper than the more high-tech Polymer Electrolyte Membrane (PEM) electrolyzers sold by Plug Power, and also capable of larger single-site industrial deployments. These industrial processes would also have no use for the fuel cells needed to convert hydrogen back to electricity, because the hydrogen used in these processes is consumed directly rather than converted to electricity.

[1] For calculations of energy usage in flight, see Chapter 5 of David MacKay's *Without Hot Air*, available on the web at https://www.withouthotair.com/c5/page_35.shtml. We're aware of one startup that has actually run a hydrogen-powered flight, but the use cases being addressed by ZeroAvia are already probably being addressed more cheaply and simply by Li batteries.

Supply and Demand for Hydrogen Globally: 2018



Source: International Energy Agency report, 2019

In sum, Plug Power's incredible share-price performance recently is entirely predicated on a future in which hydrogen energy is ubiquitous, replacing fossil fuels across the range of humanity's energy needs. In this hypothetical future, electrolyzers made by hydrogen-energy-equipment manufacturers harness wind and solar energy to produce hydrogen from water, and that hydrogen is converted back to electricity by hydrogen fuel-cells (HFCs), which are also conveniently sold by these same manufacturers. For the reasons elaborated above, this hypothetical future is a fantasy that will undoubtedly remain hypothetical, in a repeat of the "hydrogen economy" delusions propagated in the 1970s in the wake of the oil crisis, in the 1990s in the early stages of the global warming debate, and in the early 2000s as emissions requirements were stepped up due to fears of peak oil. This time though, Li batteries and renewables-generated electricity mean that hydrogen power has a real green alternative that is more economical and actually works without any grand trillion-dollar cooperation among the world's major energy consumers. Widespread hydrogen energy, and the electrolyzers and FCs Plug Power would sell to harness it, are as far from reality as they've ever been.

II. Plug Power's Revenue is Almost All from Selling Hydrogen-Powered Forklift Systems, a Niche Product Destined for Obsolescence

The delusional nature of the "hydrogen economy" is reflected in the fact that at the current time (see the diagram above), a negligible amount of hydrogen is produced using electrolysis, and an even more negligible proportion of its final usage is in the kind of large scale applications that the "hydrogen economy" contemplates. And that's with relatively cheap and continuous electricity from the grid using alkaline electrolyzers rather than the intermittent renewables-based electricity that will require much more expensive and higher-capacity electrolyzers in the "future."

Plug Power's historical revenues are consistent with these trends. Over the past *decade*, the company has generated just over a billion dollars in *total* revenues, with about two thirds of that coming in just the last 3 years, and almost entirely from selling hydrogen-powered forklift systems. If hydrogen power really had so much potential, Plug Power might have found a larger market to attack than the niche business of forklift batteries.

But even the forklift business, as niche as it is, is a dead end for hydrogen. Traditionally, warehouse operators have powered their forklifts using lead-acid batteries, which take a long time to charge (8-10 hours), resulting in non-optimal fleet availability. Forklifts powered by lead-acid batteries also generally require more than one battery, experience declining performance as the battery's charge runs down, and require a battery swap every time the battery's charge goes out. The warehouse itself also has to dedicate valuable space for a battery room, and lead-acid batteries carry a non-trivial risk of dangerous acid spills. Back in 2013, Plug Power began to market a solution to lead-acid's shortcomings: the GenDrive hydrogen fuel-cell (HFC).

Since then, GenDrive has evolved into GenKey, which is a full-service turn-key warehouse hydrogen-power system. With GenKey, Plug Power builds an on-site refueling infrastructure, supplies the HFCs for the forklifts, delivers the compressed hydrogen to the warehouse, and takes responsibility for maintenance of both the HFCs and the refueling infrastructure. The forklift HFCs take only about one or two minutes to refuel, which on its own essentially solves almost all the problems with lead acid batteries: fleet availability is constant, battery performance is consistent, and no battery swaps or warehouse battery rooms are needed. The downside is that hydrogen fuel has some safety risk in its flammable/combustible nature, and the system would still require a large upfront investment. As a result of the latter problem, Plug offers its customers GenKey systems under a service contract paid monthly.[2]

As with the "hydrogen economy" as a whole, the major disincentive for companies to make large plant-altering hydrogen investments in their warehouses is that Li batteries can solve most of the problems presented by lead-acid batteries, but for a fraction of the cost of building hydrogen infrastructure. Li batteries require no swapping out, provide consistent performance over the course of the battery's charge, obviate the need for a battery room, and are safer than both lead-acid batteries *and* HFCs. One Li battery can replace 3 lead-acid batteries, and while Li batteries can take 15-30 minutes to charge (compared to 1-2 minutes for HFC-forklifts), there's virtually no maintenance downtime and operator breaks leave more than enough time for recharging without putting the forklift out of commission for an entire shift (as is the case for lead-acid).

How many warehouses globally are so busy and so perfectly efficient that it's worth it for their owners to install a hydrogen fueling infrastructure and buy large numbers of fuel-cells that are incompatible with any equipment in their other warehouses? We've spoken to several

[2] With these monthly-payment contracts, Plug simultaneously enters a sale-leaseback transaction with a financial institution that allows the company to benefit from a large cash inflow, while offsetting future lease payments with the customer's monthly payment.

warehouse operators and we estimate that the number is close enough to zero that the real TAM for Plug Power's material handling business is a small fraction of the $30 billion claimed by Plug Power. In that context, it's worth understanding how Plug Power has been successful in selling even the small number of HFC-powered systems that it's sold.

First of all, it's worth noting that Plug has a grand total of *nine* customers that have deployed HFC-powered forklifts in more than one warehouse. Plug's historical presentations suggest that at least 2 customers – Sysco and Volkswagen – used to be multi-site customers and are no longer powering *any* warehouse forklifts with hydrogen power, while another 17 customers, including well-known logistics-intensive companies like Nike, Coca-Cola Bottling, FedEx, and Kimberly-Clark – all deployed Plug hydrogen solutions at one of their warehouses and then pulled the plug on the project.

Perhaps even more concerning is that about two thirds of the material handling systems deployed by Plug over the last 3 years have gone to just 2 customers: Amazon and Walmart, both of which signed sweetheart warrant deals with Plug in early 2017 with the following terms:

- Each deal contemplated $600 million in future GenKey purchases.
- Upon deal-close, each company received 5.82 million warrants struck at $1.19/share for Amazon and $2.12/share for Walmart (strike prices were a function of where Plug's stock price had been trading prior to each deal being consummated).
- Each company also received a second tranche of 29 million warrants, struck at the same price as the original warrants, which would vest in 4 equal installments each time the company would make $50 million in payments for goods or services. So for every incremental $50 million in purchased goods and services, Amazon and Walmart would receive about 7.25 million warrants struck at $1.19 and $2.12, respectively.
- Finally, a third tranche of about 20 million warrants would vest in 8 equal installments each time Amazon or Walmart would make another $50 million in payments, but the exercise price of these warrants would be equivalent to 90% of the 30-day VWAP as of the final vesting date of ***the second tranche of warrants***.

At the time these deals were signed, Plug's stock price was hovering at between $1-2/share, so while there was an extraordinarily large amount of optionality built into each agreement, the warrants on their own wouldn't necessarily be enough of an incentive to buy GenKey systems. It's highly probable that Amazon and Walmart both had a large enough warehouse footprint that it would be wise to experiment with hydrogen power even if the overwhelming likelihood was that it wouldn't make economic sense. Consider also that, in early 2017, when these agreements were signed, the next 4 years of dramatic improvement in Li-batteries was obviously not yet envisaged.

Interestingly, Amazon's first two installments of the second tranche vested in 2017 and 2018, respectively. That implies a total of $100 million in payments to Plug over those two years, even though total revenue attributable to Amazon during those years was only about $40 million (as disclosed in Plug's 2018 10-K). Plug's 2018 balance sheet contains at least some hints that Amazon made some prepayments in order to have its warrants vest *prior* to the revenue being booked, probably in connection with a sale-leaseback transaction covering GenKey systems. Fortuitously, that would mean that the vesting-date value of the options (in 2017-2018), which would be charged against future revenues, would be smaller than if the warrants would vest at the time the revenue would be booked (i.e., 2019), at which point the stock price – and implicit subsidy to Amazon – would be higher on the order of 25-100%.

Fast forward to 2020. With Plug's stock price consistently above $4 in the first half of the year, Amazon and Walmart both had the ability to make purchases in which their payments would be discounted 30-50% by dint of the warrant strike prices on the second tranche of warrants. Both companies exploited the opportunity, with Walmart having its first installment of tranche-2 warrants vest by the end of the third quarter, and Amazon having its final two installments of warrants vest by November 2nd. Additionally, Amazon's complete vesting of its second tranche of warrants on 11/2 allowed it to secure a strike price of $13.81 for the next 20 million warrants that are vestable upon $400 million in payments. Those warrants are now in the money to the tune of $1.1 billion, which is a pretty good incentive for Amazon to spend the next $400 million on Plug equipment even if it's NPV-negative. As for Walmart, it's still in the early phase of its second tranche of warrant-vesting, and considering the next 22 million warrants vest at a strike price of $2.12, the company is very much incentivized to purchase the next $150 million of Plug products considering the $1.4 billion payoff it stands to earn from those purchases. *All this is to say that we believe a substantial portion of Plug's 2020 and 2021 revenue is actually a pull-forward by Amazon and Walmart in order to vest their warrants at attractive terms*.

Amazon and Walmart Warrant Transaction Agreements: Summary

Amazon Warrants

Tranche	Shares (mm)	Strike	Vest Date	Terms
1	5.82	$1.19	4/4/2017	Granted upon Deal Signing
2	7.27	1.19	2017 Q4	Vested upon 1st $50M payment
2	7.27	1.19	2018 Q4	Vested upon 2nd $50M payment
2	7.27	1.19	2020 Q2	Vested upon 3rd $50M payment
2	7.27	1.19	2020 Q4	Vested upon 4th $50M payment
3	20.37	13.81	TBD	Will vest in 8 installments upon $50M individual payments

Walmart Warrants

Tranche	Shares (mm)	Strike	Vest Date	Terms
1	5.82	$2.12	7/20/2017	Granted upon Deal Signing
2	7.27	2.12	2020 Q3	Vested upon 1st $50M payment
2	7.27	2.12	TBD	Will vest upon 2nd $50M payment
2	7.27	2.12	TBD	Will vest upon 3rd $50M payment
2	7.27	2.12	TBD	Will vest upon 4th $50M payment
3	20.37	TBD	Not vested	Will vest in 8 installments upon $50M individual payments

Source: PLUG company filings, Kerrisdale Analysis

We summarized the warrant activity in the above table. In short, for the prospect of $1.2 billion in revenues over the course of a decade, Plug was comfortable diluting its shareholder base by about *a third* at the time these deals were signed, or what is now about $5.5 billion.

One of the great ironies of Plug Power's material handling business is that, while its customers can claim "green" zero-emissions warehouse operations, the actual hydrogen that Plug is delivering to these customers is as "black" as can be, produced by suppliers like Linde and Air Liquide primarily by steam reformation of natural gas or grid-supplied electricity. Given the efficiency losses across the hydrogen supply chain, *current warehouse usage of HFC forklifts results in 2-3x the carbon emissions as the same warehouse running on Li battery forklifts*.

To summarize: Plug has been unsuccessful in materially commercializing any of its array of hydrogen-power products, with the sole exception of HFCs and refueling infrastructure for forklifts. Those products, though, operate at an inherent cost disadvantage to warehouse equipment powered by Li batteries, the latter of which are rapidly gaining share. It's hard to look at almost any trade journal in the space and not get the sense that Li batteries have already conquered warehouse operators' hearts and minds, and it's only a matter of time before they also conquer the warehouses. Just since 2017, the global share of Li-powered forklifts has gone from about 5% to about 20% in 2020, even as HFCs mostly languish as a niche product with less than 2% market share.[3] Even one of Plug's primary hydrogen suppliers – Linde – is now aggressively marketing Li-powered forklifts. Finally, even the forklift products that Plug has successfully commercialized have capitalized on primarily two customers, both of whom have been strongly incentivized to make purchases in order to snag an equity interest in Plug on the cheap. If this is what commercial success looks like in the "hydrogen economy," we'd hate to see what failure looks like.

III. Plug Power's Recent Partnerships are Signs of Weakness Rather than Strength

Just in the last two weeks, the hype surrounding Plug Power, which itself was a beneficiary of the hype surrounding the "hydrogen economy," got an added boost from two separate deals into which Plug entered. But the deals are actually no different than any of the array of "transformational" deals in the hydrogen space over the last decade, all of which have faded into obscurity.

The first deal, announced on January 6, provided that SK Group, the third largest Chaebol in South Korea, acquire a 9.9% interest in Plug for $1.5 billion. The partnership is meant to "accelerate hydrogen as an alternative energy source in Asian markets," and both companies announced "a plan to form a joint venture…to provide hydrogen fuel cell systems, hydrogen fueling stations, and electrolyzers to the Korean and broader Asian markets." South Korea is no stranger to splashy proclamations regarding hydrogen's integral place in its future energy needs, but the reality has never matched the rhetoric. Under its "Hydrogen Roadmap," which it

[3] Market share estimates are from consulting firm Interact Analysis

released in 2018, the country planned on having commercialized hydrogen-powered shipping, delivery vans, buses, and delivery drones. Unsurprisingly, none of that has even begun, unless the 27 FC-powered buses across the country count. The country has also aimed to have 80 thousand FCEVs on the road by 2022, and with just under a year left to accomplish that, the number stands at 10 thousand (and those are FCEVs produced over *years*). The country is similarly short of its goals regarding FC refueling stations.

One almost sympathizes with the government's quandary given that South Korea imports almost all its energy, and has little in the way of solar or wind resources it could use to decarbonize its electricity grid. SK Group's ill-advised investment in Plug Power is another South Korean hydrogen endeavor borne of desperation, not a vote of confidence in Plug's business model or its ability to effectively decarbonize the country through electrolyzers and fuel cells. After all, even hydrogen enthusiasts proclaim that the goal is "green hydrogen" made by electrolyzers powered by wind- and solar-energy. If South Korea doesn't have those, powering the country with hydrogen simply replaces its reliance on one set of fossil fuels with another energy source that can only be produced with fossil fuels. SK's investment in Plug is far from the first time South Korea has chased the hydrogen illusion, and we don't expect it to be the last. But we do think it ends like the other ones – with a quiet write-off, and an unceremonious termination of the JV, if it even gets off the ground by the 2022 target date.

A week after transacting with SK, Plug announced a second agreement, with Renault. This was much shorter on details than the deal with SK, which at least saw Plug opportunistically raise capital after a 2-month doubling of its stock price. The "memorandum of understanding" between Plug and Renault contemplates a JV formed by the middle of this year that "will serve the fast-growing market of fuel cell light commercial vehicles, taxis, and commercial people transportation… The JV will start commercializing fuel cell LCV's [light commercial vehicles] in Europe starting in 2021 with pilot fleet deployments." The JV may or may not happen, but we confidently expect it will amount to nothing either way. The last place in which HFCs will have any applicability is in light vehicles, where the market for EVs has already begun to boom. Renault is already one of the weakest automobile manufacturers in Europe, and a no-cost MOU allows it to signal its "green" bona fides without actually making EVs that will sell. Like the SK deal, the agreement with Renault says much more about the weakness at Renault, which was so desperate to start a European hydrogen JV that it selected a partner whose only major product goes into a forklift.

These "major" deals should be seen in the context of all the past "major" deals that never panned out. In late 2016, Plug signed an MOU with Furui and "one of the big three Chinese automakers to develop new fuel cell applications and fueling solutions to be utilized in the large and expanding industrial electric vehicle market in China." It's never been talked about since. Also in late 2016, Plug announced a "culmination of a year of product evaluation and engineering collaboration" with Mitsubishi, but the latter, despite being one of the larger forklift manufacturers globally, never began to make any FC-powered products. In mid-2018, Plug announced that, in combination with Workhorse Group, it was delivering an FCEV delivery van to FedEx in what was "the beginning of a hydrogen transformation in the delivery van industry."

But it was not the beginning of any such transition. We don't expect Renault-Plug to dominate the non-existent market in FCEVs any time soon either. Nor do we expect the deal with SK to be the first one that actually results in substantive South Korean hydrogen infrastructure.

IV. Conclusion

Plug Power: Capitalization and Financial Results

Capitalization	
Share price ($)	$ 66.47
Fully diluted shares (mm):	
Basic Shares Outstanding	406.1
Dilutive impact of warrants	82.2
Dilutive impact of RSUs	6.0
Dilutive impact of stock options	9.8
Shares issued in offerings	95.1
Total	599.2
Fully diluted market cap (mm)	$ 39,831
Less: net cash	2,227
Enterprise value	$ 37,604
EV/TTM revenue	122.3x

Financial Results	2018	2019	TTM
Consolidated Revenue	$ 175	$ 230	$ 308
Adjusted EBITDA	(54)	(1)	(45)
Cash from Operations	(58)	(52)	(157)
Free cash flow	(76)	(64)	(186)

Source: PLUG company filings, Kerrisdale Analysis

Adjusting for the outstanding warrants that are virtually certain to vest, and therefore dilute current shareholders, Plug Power is valued at an astronomical $38 billion, even as the company currently doesn't actually make or sell much more than about $300 million in HCV-powered warehouse equipment. As we explained in this report, though, there's even less to those forklifts than meets the eye considering that 70% of them are sold to just two companies that, upon further reflection, are actually being *compensated* for buying them through deeply discounted equity stakes in Plug. None of this is particularly surprising considering that Plug has sold orders of magnitude more stock in the last decade than it has sold actual products.

From a wider perspective, Plug's enterprise value assumes with near certainty the successful propagation of a future "hydrogen economy" in which green hydrogen power fuels our cars, trucks, homes, and factories. Sadly, the laws of physics virtually guarantee that a large-scale hydrogen economy will *never exist*. It will always be more efficient, cost-effective, and safer to just use electricity directly. Since the company's founding in 1997, it has not generated so much as a single dollar of free cash flow. In fact, it's never even had a single year in which it generated cash from operations. Given the absurdity of the large-scale use of its products, we don't expect that to ever change. Twenty years ago, around the time of the last hydrogen mania, the market quickly realized that the dreams embedded in Plug's valuation are mostly just hot air, and the stock price collapsed by over 95%. The past, we believe, is prologue.

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