Connected Strategies for the Hydrogen Value Chain

Leveraging the power of connectivity to deliver 'zero-carbon' energy solutions

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September 2022

Acknowledgements

We share our sincere thanks to the following people for their insights and contributions to this paper

Rajiv Murali, Managing Director & Partner, BCG

Chris DiGiovanni, Manager, Gas Strategy & Policy, Pacific Gas and Electric Company

Sudharson S., Connected and Autonomous Vehicles Business Development, Nvidia

David Snoswell, Technical Principal, Schlumberger New Energy

Kapil Kedia, Assistant Chief Engineer, General Motors

Aaron Melson, IOT Research, Ford Motor Company

James Kast, Hydrogen Infrastructure Manager, Toyota

Andrew Mingst, General Manager, Hydrogen, Chevron

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Michael Ruddock, Hydrogen Business Development Manager, Chevron

Keith Shaw, Global OEM Heavy Duty Truck & Non-Road Sectors, Chevron

Darin Rice, General Manager, Hydrogen Strategy & Market Insights, Chevron

Abhishek Banerjee, Hydrogen Commercial Manager, Shell

Jarred Guthrie, Global Head of Hydrogen Projects, Shell

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Contents

Introduction 4
Executive Summary 6
How is this white paper organized? 8
Part 1 | Hydrogen as a transport fuel for heavy trucks 9
Heavy duty trucking business customer needs 9
Customer willingness to pay 14
Heavy duty trucking business model 16
Connected strategies in hydrogen heavy duty trucking 18
Vehicle-to-vehicle (V2V) communication 18
Vehicle-to-infrastructure (V2I) communication 20
Remote Diagnostics 21
Autonomous Operation 21
Emerging business models and monetization structures 24
Implications 25
Part 2 | Hydrogen as a zero-carbon power sector i.e., Energy & Utility (E&U) 27
Power sector challenges and role of connected technologies and hydrogen in alleviating these challenges 27
Consumer Willingness to pay 30
Current Value Chain and Business Model 33
Connected strategies in hydrogen power sector 34
Internet of Things (IoT) 35
Artificial Intelligence (AI) managed smart grids 37
Robotic Process Automation (RPA) 38
Cloud computing to manage energy production and distribution 39
Developing Power Sector Business & Monetization Model 41
Prosumers 41
Aggregator 42
Peer-to-Peer (P2P) Electricity Trading 43
Energy-as-a-Service 44
Community Ownership Model 45
Implications 46
Part 3 | How can energy & utility (E&U) companies participate in the emerging hydrogen value chain? 47

Existing E&U companies still have a role to play however the landscape of players is changing 48
Deep partnerships will be important but place in the network will be more important 50
E&U companies will have to learn to fail fast 51
Is Amazon becoming the energy company of the future? 52
The E&U industry will have to focus on creating entirely new skills sets 53
Responding to employees' environmental concerns will be fundamental while connecting them to the sustainability purpose will be critical 55
Organizational Design will be critical for success 56
References 58

Introduction

Climate change is one of the most pressing issues of modern times. The use of fossil energy is one of the main man-made activities that is responsible for this change. The intergovernmental panel on climate change (IPCC) has concluded that in as little as 10 to 20 years the global average temperature is forecast to increase by at least 1.5 degrees Celsius. This creates immense urgency to decarbonize energy systems and shift to lower carbon sources to satisfy global demand. This is being referred to as the *energy transition*.

Currently, the power sector, consisting of electricity and heat generation contributes ~26 percent of CO_2 emissions. Studies predict that demand for electricity will grow more than for any other energy source. The growth rate for electricity already exceeds that for oil, gas, and coal. By 2050, it is expected to be seven times higher than the average for other fuels. Mobility, on the other hand consisting of road, aviation, rail, maritime, and other forms of transportation contribute to about ~16 percent of CO_2 emissions. Additionally, energy use in industry accounts for ~30% of global greenhouse gas emissions. Hence, based on current accounting methodologies, energy use across sectors makes up as much as ~72 percent of carbon dioxide emissions[1]. Thus, climate challenge is largely an energy transition challenge, and the energy system transition must be at the heart of any climate solution.

Energy is the foundational element of all economic activity. Secure, reliable energy and affordable supply is essential for most industrial processes and the provision of public services such as lighting, heating, cooking, information and communications technology, and mobility. Additionally, decarbonizing entire economies means tackling sectors where emissions are especially difficult to reduce, such as shipping, heavy duty trucks, aviation, heavy industries like steel, cement and chemicals, and agriculture. This is not easy work.

Hydrogen is being explored as a zero-carbon energy alternative in large, heavy and “hard to abate” sectors of the economy such as aviation, shipping, and other heavy industry. While hydrogen has several features that make it attractive for this end goal, there are several challenges that persist. Widespread hydrogen use is today limited by availability of renewable electricity (for green hydrogen), regional cost and efficiency of carbon capture (in the case of blue hydrogen) and several safety and handling limitations.

Synchronously, a digital revolution is sweeping the global energy sector with the potential to facilitate and accelerate the energy transition by transforming the way energy is produced, transported, and consumed. There are several digital technologies such as cloud computing, AI and blockchain technology that could have far-reaching impacts to decarbonizing the power sector.

The electricity grid today is not as smart as it could be. Digitalization can help with the use of distributed sensors, generators, and appliances to shore up the health and reliability of the centralized grid. A smarter power grid could make it possible to deploy much more intermittent wind and solar power. Power utilities and grid operators can gather critical grid performance data through low-cost devices that communicate and integrate throughout the transmission and distribution networks. The result is real-time grid operational information, both technical and economic. Armed with this information, utilities could deploy hydrogen and other zero carbon energy storage resources to meet customer needs during times of high instantaneous demand.

Today's end consumers expect convenience and want greater influence over everything they buy. While this trend is evident in retail, it is reaching other sectors such as transport and energy. Customers are moving from being passive consumers to playing a more active role in managing their energy consumption and procurement, whilst still being somewhat price sensitive. Energy and utility companies are now offering plans that make clear linkages to how the power was generated from renewable sources. There is also a growing trend in decentralization of power and growth of micro-grids. This presents the opportunity for energy companies to use connected strategies and technologies to set up distribution markets which will allow customers to deploy their distributed energy resources to help balance supply and demand at all points in the power network.

Vehicle connectivity is also becoming an increasingly important topic for the future, especially for commercial fleets. Logistics experts are looking for solutions that will make the best use of new technologies for them. Transport and fleet companies already have experience with relevant software solutions, and they appreciate the gain in efficiency which almost always correlates with improvement in carbon performance. For example, big rig manufacturer PACCAR has taken a step in its digital transformation by launching a global connected truck platform that will be fitted into the Kenworth, Peterbilt and DAF brands. The PACCAR Connect system consists of proprietary hardware and software that will simplify customers' fleet management operations. The *Connect Fleet* system gives fleet

customers real-time information on truck and driver performance including fuel consumption, fleet utilization, idle time, and route optimization. This information enables drivers to improve fleet efficiency and reduce fuel consumption and CO2 emissions.

The use of green hydrogen will be central to any decarbonization solution. The hydrogen value chain is still evolving and could be the avenue where these disruptive new entrants bring together digital and connected technologies to create new business models that help enhance the customer experience.

This study looks through a "system"[1] lens at the emerging B2B hydrogen value chain as applied to 1) power generation by utilities and 2) heavy duty truck transport to explores the ways in which connected strategies can enable hydrogen adoption.

In addition, the study analyses emerging business models and relationships to evaluate how energy companies will have to transform to stay competitive in this new emerging hydrogen value chain.

Executive Summary

The energy transition combined with digitalization, decarbonization and decentralization are having a significant impact on the energy industry. The sector is moving from transactional, commodity-based business models to improving the customer experience through innovation. Connected strategies will be critical to capitalize on these shifts which will drive efficiencies throughout the entirety of the value chain. As innovation takes place, new entrant and business models are emerging which have the potential to replace the dominant forces of today in the energy and utility sector.

Smart freight made possible via digitalization and connected strategies such as driverless operation will soon self-identify and self-monitor. When paired with a hydrogen powertrain they pose a formidable solution for safe and zero-carbon logistics. The autonomous technology companies are the new entrants that are starting to dominate the central hub position in a hub and spoke partnership model. These new entrants are acting as an aggregator, bringing attributes of power train, truck chassis and fueling infrastructure under their proprietary autonomous architecture. Monetization models are emerging wherein autonomous technology companies are providing autonomous mobility as a service on a pay per

[1] Systems approach looks at the efficiencies at the value chain level. It views the efficiencies of activities not individually but as contributing factors for the overall value chain

mile basis to logistics providers. Vehicle connectivity combined with data analytics are driving an improvement in fleet efficiency, reducing fuel consumption and CO2 emissions for improved carbon performance. This pay per-mile fee is part of a subscription program for fleets where a "turnkey virtual driver" works across an autonomous freight network. "The connected truck-as-a-service" market will continue to grow and is anticipated to surpass $99.2 billion. Over time growing partnerships and unique interface architecture has the potential to bring several of these skills to be locked in a *platform-based business model*. Such platforms will facilitate purposeful collaboration and generate additional value for participants in the trucking ecosystem. The ability for companies to quickly engage in platforms is a benefit as such platforms will create integrated environments that support and enable ecosystems to operate. As we look toward the future, we see that fleet platforms will continue to grow, and data and asset platforms will become more relevant to create customized experiences with customers. Autonomous technology companies will support logistics providers to take advantage of the huge amounts of data accessible to them to tailor such customer experiences.

Hydrogen produced from renewable electricity through electrolysis can be used as a medium for low carbon energy storage. It can be distributed to users in re-purposed natural gas grids and in the case of autonomous trucks reacted in fuel cells to generate electricity. Hydrogen can also be stored as energy on a large scale and for the long term (i.e., seasonal storage), reduce the curtailment of variable renewable energy (VRE), decarbonize the industry sectors through sector coupling strategies, replace "grey" hydrogen made from natural gas in certain industrial processes. Connected digital technologies such as IOTs, AI, robotic process automation and cloud computing are de-risking adoption and enabling faster and better scale-up and optimization of the hydrogen in the power sector. These technologies are facilitating new models, such as virtual power plants (VPPs), based on bilateral power exchange and increased roles for consumers and third parties to provide energy, capacity and flexibility services that were once the exclusive domain of utilities. While these trends are changing paradigms, unlocking system flexibility for a high share of VRE penetration, they are also changing the roles and responsibilities of actors and opening doors to new entrants in the power sector. Consumers are transitioning from being passive, captive actors into active players in the energy transition. Consumers can now generate, trade and store electricity and provide services to the grid, thereby converting to prosumers.

For the existing and new energy and utility companies (E&U), the disruption caused by this transition across the value chain is shifting the paradigms for investments, requiring new skills, and ways of thinking:

away from physical asset (wires pipes and wells) to data exploration, away from persistent focus on traditional, large competitors to non-traditional small disrupters and a fundamental shift from a commodity to a product company mindset with untiring focus on customer experience. Building a continuous relationship with one's customer and taking a value chain approach will be critical for survival.

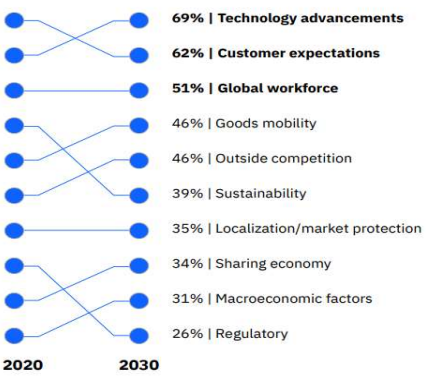
While the future workforce will require many of the skills that the current workforce has built over time, it will also need to evolve and develop new competencies to realize its full potential. Companies will need to be ready to adapt, renew and evolve to execute their strategies with a workforce that is agile and equipped to support their business. As Energy and Utility companies adopt a more connected strategy, there will be a bigger demand for digital skills with a huge shift in the need for data management and analysis. With a huge increase in data being generated through the IoT sensors, analysis to drive system improvements will require an increase in the workforce with skills that can drive systematic changes. Although digital skills exist within the current workforce today, they are in short supply to meet the future demand, and this will require a significant retraining of its existing workforce.

How is this white paper organized?

The white paper is organized into three key sections. In Section 1 we explore use cases that show how connected strategies enable the adoption of hydrogen in the transport sector. Section 2 explores the application of connected strategies to enable the adoption of hydrogen into the power generation mix. Section 3 explores the key organizational strengths and shifts that incumbent energy and utility companies should consider to be a valued participant in the emerging hydrogen value chain.

Part 1 | Hydrogen as a transport fuel for heavy trucks

Sustainability requirements are driving the need for zero carbon powertrains in heavy duty trucks. For the next 10 years, technology advancements (zero carbon fuels and powertrains) and customer expectations (through connected technology and strategies) are the top truck industry influencers (see insert on right). In this section we explore critical needs of the logistics companies (business consumers) and how synergistic application of connected technologies and hydrogen help meet those needs while creating a superior customer experience.



Note: lines indicate change in priority
Q: What are the most important external influences that will impact the industry today and in 2030?

Heavy duty trucking business customer needs

Trucking is the dominant mode of US inland freight transport, accounting for 67.7% of the sector (amounting to 11.8 billion tons of carried freight in 2019[2]), and it is forecasted to remain dominant for the next decade. In 2019 the trucking industry accounted for $791.7 billion in revenue in the US, and in the next 30 years is expected to grow by 40%.[3]

Why these matters: Nearly every good consumed in the U.S. is put on a truck at some point.

Commercial trucking is a canary in the coal mine for the larger economy. Everything from manufacturing to consumer spending is encapsulated in freight metrics. High freight rates limited by the low utilization and high costs of the heavy-duty trucking industry not only increase the price of consumer goods but also limit the growth in the ecommerce business.

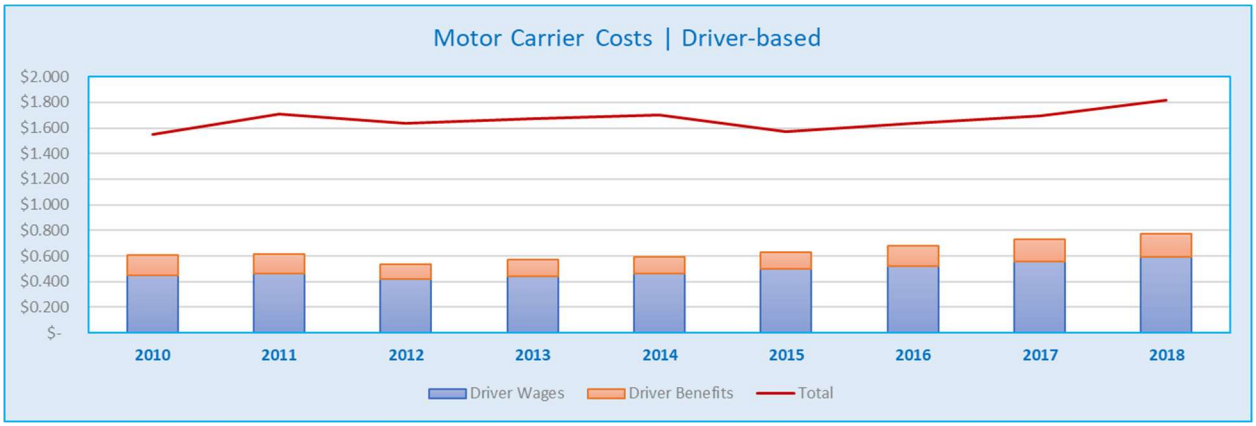
HYDROGEN FOR TRUCKS ACT

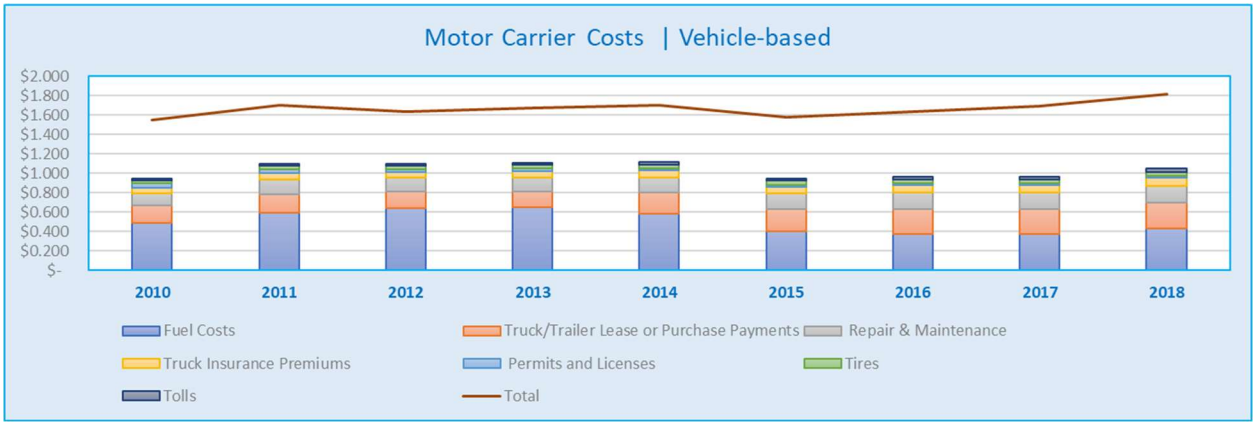
The transport industry is a major consumer of energy and burns most of the world's petroleum. The reliance on fossil fuels, especially in the trucking sector makes transport a major contributor of greenhouse gases into the environment. An estimated 15% of trucking miles in the US are currently driven with no load. The industry is seeking solutions to increase the utilization of trucks to reduce "empty miles"

and “deadheading” (driving with an empty trailer). Connected technologies paired with a zero-carbon fuel like hydrogen enable both operational and environmental benefits for the trucking industry. The heavy-duty greenhouse gas emissions and fuel efficiency standard is a key federal regulation that is driving climate conscious behaviors. A new bill introduced in the U.S. House of Representatives called the *Hydrogen for Trucks Act* attempts to expedite the adoption of hydrogen fuel cell trucks. Additionally voluntary shipment zero targets set by freight customers like Amazon, FedEx, UPS are driving business led consciousness towards environmental performance of trucks.

HEAVY DUTY TRUCKING STAKEHOLDER PAIN POINTS

There are four key trends in the long-haul trucking industry that are causing majority of the stakeholder pain points. There is a labor shortage and costs are up with marginal transport costs increasing by 18% since 2010 (see Fig 1).[4] Fig 2 shows the components of the cost, it can be seen that apart from fuel costs, driver wages are the main component. Since the 1980s, the trucking industry has experienced labor shortages. Much of it attributed to low wages and an aging workforce. Devoid of significant changes to the industry’s business model and talent pool, it may be difficult to see how carriers will attract the 890,000 new drivers that the American Trucking Associations (ATA) estimates will be needed through 2025 to meet rising demand (see Fig 3) [5]. Finally, the consequences of accidents are particularly severe, and the industry has seen an increase in crashes leading to fatalities. These types of accidents usually occur from fatigue, sleep deprivation, and distracted driving behaviors with trucking companies seeing an increase in insurance premiums. The case for autonomous driving (connected strategy) is strong with all three elements of digitalization, hydrogen as a fuel decarbonization and infrastructure changes decentralizing. Figure 4 shares key trucking liability and driver safety metrics. Driverless technology is positioned to solve several of the safety inciodents ailing the trucking industry.





Motor Carrier Costs	2010	2011	2012	2013	2014	2015	2016	2017	2018
Vehicle-based									
Fuel Costs	$ 0.486	$ 0.590	$ 0.641	$ 0.645	$ 0.583	$ 0.403	$ 0.368	$ 0.368	$ 0.433
Truck/Trailer Lease or Purchase Payments	$ 0.184	$ 0.189	$ 0.174	$ 0.163	$ 0.215	$ 0.230	$ 0.264	$ 0.264	$ 0.265
Repair & Maintenance	$ 0.124	$ 0.152	$ 0.138	$ 0.148	$ 0.158	$ 0.156	$ 0.167	$ 0.167	$ 0.171
Truck Insurance Premiums	$ 0.059	$ 0.067	$ 0.063	$ 0.064	$ 0.071	$ 0.074	$ 0.075	$ 0.075	$ 0.084
Permits and Licenses	$ 0.040	$ 0.038	$ 0.022	$ 0.026	$ 0.019	$ 0.019	$ 0.023	$ 0.023	$ 0.024
Tires	$ 0.035	$ 0.042	$ 0.044	$ 0.041	$ 0.044	$ 0.043	$ 0.038	$ 0.038	$ 0.038
Tolls	$ 0.012	$ 0.017	$ 0.019	$ 0.019	$ 0.023	$ 0.020	$ 0.027	$ 0.027	$ 0.030
Driver-based									
Driver Wages	$ 0.446	$ 0.460	$ 0.417	$ 0.440	$ 0.462	$ 0.499	$ 0.523	$ 0.557	$ 0.596
Driver Benefits	$ 0.162	$ 0.151	$ 0.116	$ 0.129	$ 0.129	$ 0.131	$ 0.155	$ 0.172	$ 0.180
Total	**$ 1.548**	**$ 1.706**	**$ 1.634**	**$ 1.675**	**$ 1.704**	**$ 1.575**	**$ 1.640**	**$ 1.691**	**$ 1.821**

Figure 1 | Average marginal costs per mile, 2010–2018, Source ATRI

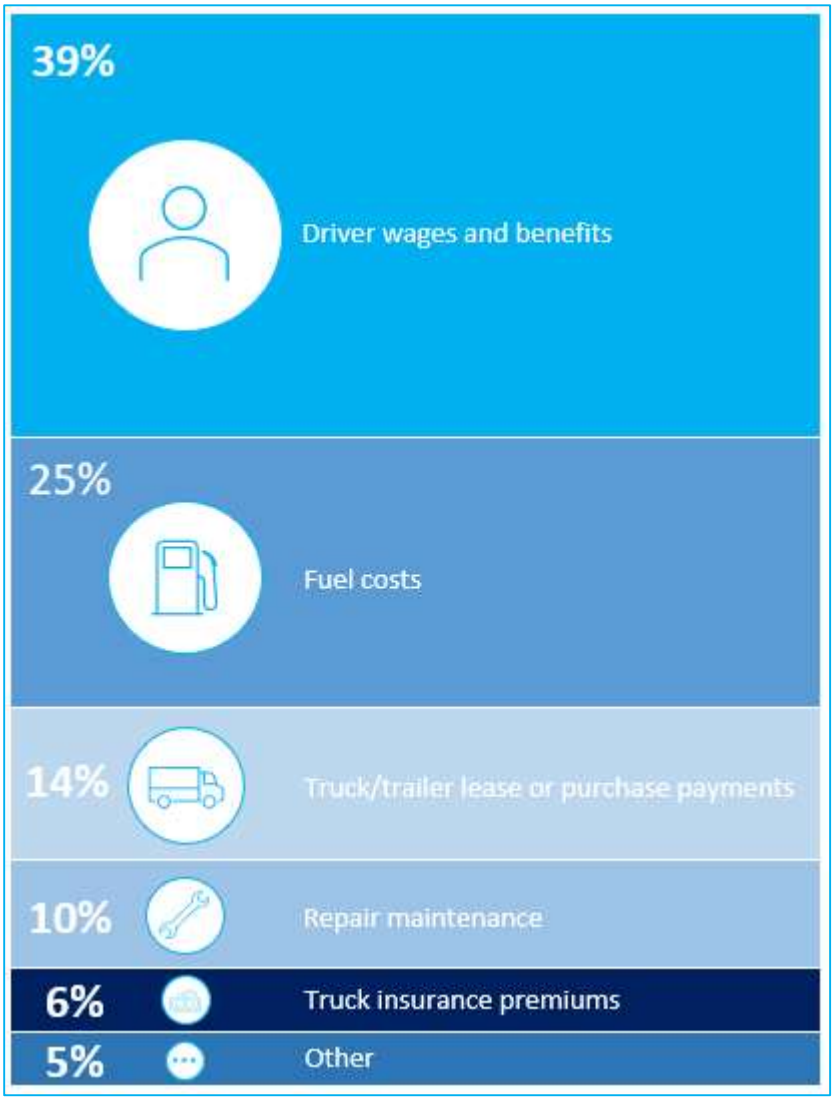


Figure 2 | Share of marginal cost, Source: American Transportation Research

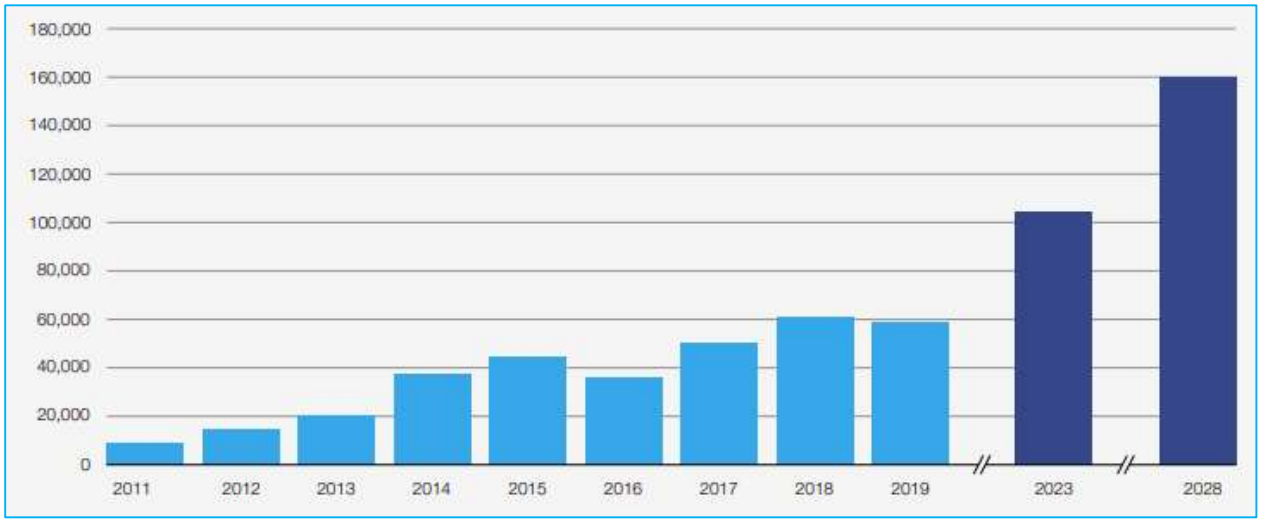


Figure 3 | Historical and Predicted Driver Shortages, Source: Trucking.org

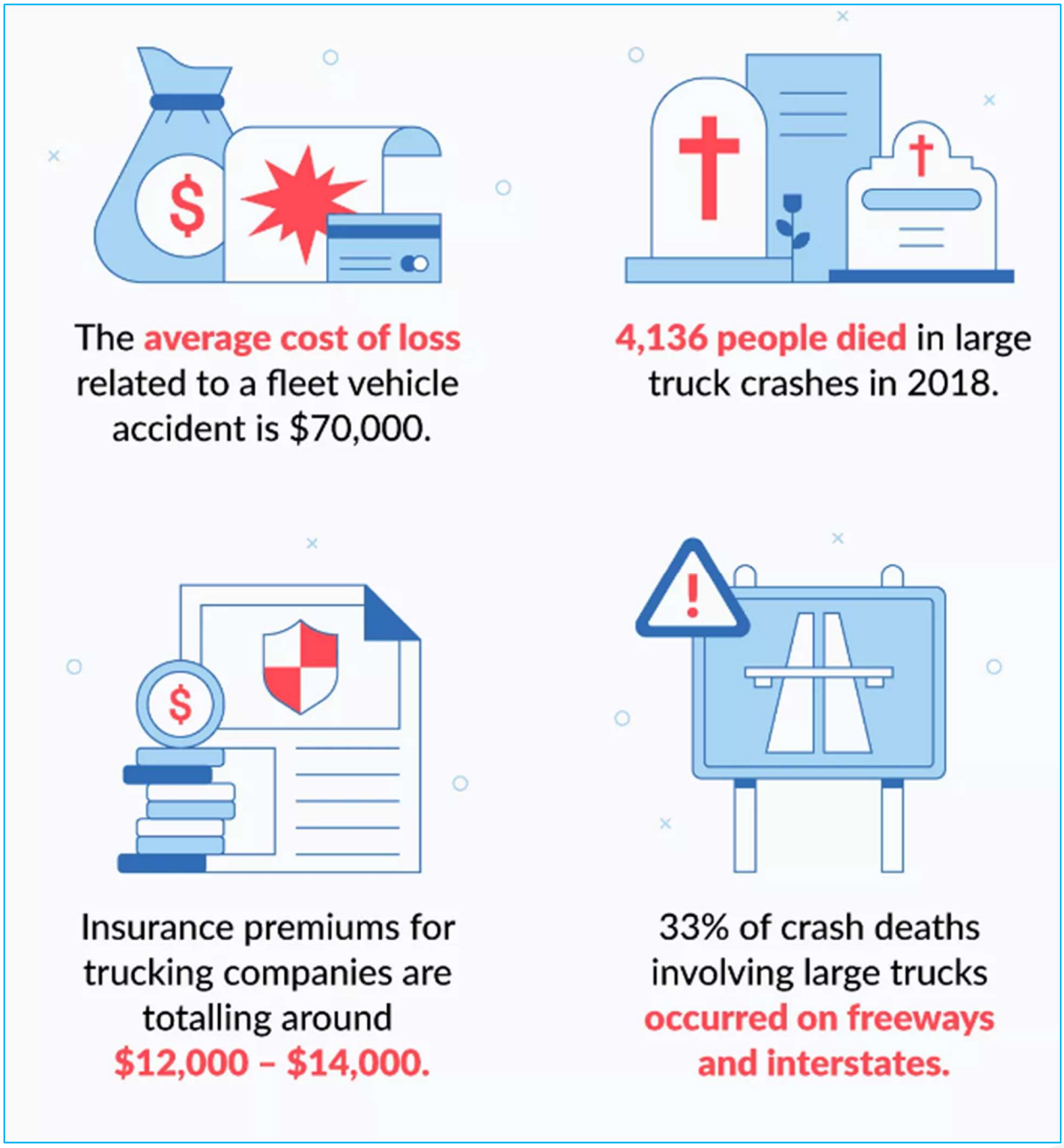


Figure 4 | Liabilities, Accidents and Fleet Driver Safety Statistics

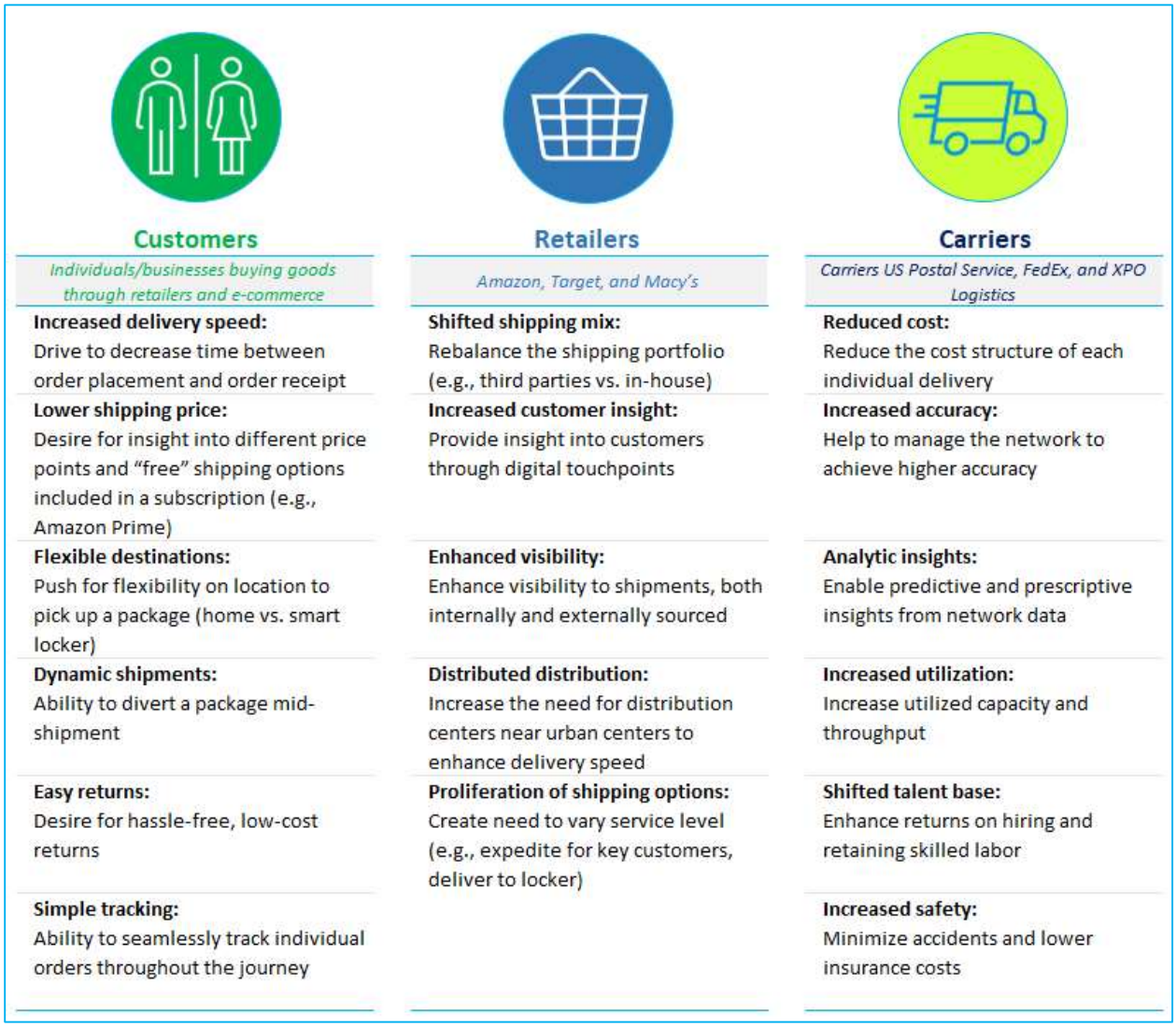
Customer willingness to pay

PwC and the Manufacturing Institute recently surveyed 128 large and midsize U.S. manufacturers and transportation companies to further explore willingness to pay considerations. The survey showed that

logistics companies could save nearly 30% of their total transportation costs through 2040 if connected/autonomous technologies were aggressively adopted in long-haul trucking. Additionally, 90% of U.S. logistics companies said that fully autonomous trucks, if widely adopted, could save up to 25% of their trucking costs showing high willingness to adopt. However, the survey found that just 10% of truck OEMs had adopted some form of semi-autonomous or autonomous mobility within their operations. An additional 11% said they will adopt the technology in the next three years. Cost is still the deciding factor for these firms when considering autonomous technology. Nearly 90% of manufacturers said they would adopt autonomous mobility if it provided a cost/mile advantage.

The survey further raised the question of whether such a shift to self-driving trucks would be embraced by workforces knowing that it has the potential to eliminate their jobs. It predicts that autonomous trucks will "usher in a new generation of logistics technicians" to oversee the software and algorithms that may be in driver's seats of the future.

In a separate survey conducted by clean technology consultant Gladstein, Neandross & Associates (a well-known heavy-duty truck consulting firm) on 250 US based fleets that use clean fuels including propane, compressed natural gas, battery-electric vehicles, or fuel-cell-electric, nearly 85% report that their use of clean vehicle technologies will grow over the next five years. Hydrogen trucks are on the horizon with 150 hydrogen heavy-duty truck orders in 2021[6]. Figure 5 compiles the key willingness to pay considerations across the stakeholders of the trucking value chain.



Customers	Retailers	Carriers
Individuals/businesses buying goods through retailers and e-commerce	*Amazon, Target, and Macy's*	*Carriers US Postal Service, FedEx, and XPO Logistics*
Increased delivery speed: Drive to decrease time between order placement and order receipt	**Shifted shipping mix:** Rebalance the shipping portfolio (e.g., third parties vs. in-house)	**Reduced cost:** Reduce the cost structure of each individual delivery
Lower shipping price: Desire for insight into different price points and "free" shipping options included in a subscription (e.g., Amazon Prime)	**Increased customer insight:** Provide insight into customers through digital touchpoints	**Increased accuracy:** Help to manage the network to achieve higher accuracy
Flexible destinations: Push for flexibility on location to pick up a package (home vs. smart locker)	**Enhanced visibility:** Enhance visibility to shipments, both internally and externally sourced	**Analytic insights:** Enable predictive and prescriptive insights from network data
Dynamic shipments: Ability to divert a package mid-shipment	**Distributed distribution:** Increase the need for distribution centers near urban centers to enhance delivery speed	**Increased utilization:** Increase utilized capacity and throughput
Easy returns: Desire for hassle-free, low-cost returns	**Proliferation of shipping options:** Create need to vary service level (e.g., expedite for key customers, deliver to locker)	**Shifted talent base:** Enhance returns on hiring and retaining skilled labor
Simple tracking: Ability to seamlessly track individual orders throughout the journey		**Increased safety:** Minimize accidents and lower insurance costs

Figure 5 | Stakeholder needs across the trucking value chain

Heavy duty trucking business model

Connected technologies paired with hydrogen is positioned to disrupt the heavy truck value chain from a linear to a hub and spoke type business model with new entrants dominating the hub. Figure 6 shows the key players in the heavy-duty trucking business model.

The current logistics chain is dependent on several different, clearly distinct market players such as the tier suppliers, the truck OEMs, the logistics providers, or carriers that own the truck fleet and organize the shipping of goods, to the retailers and finally to the end consumers. Each entity largely owns its own inventory and adds value by creating finished product/service down that are passed down the value chain.

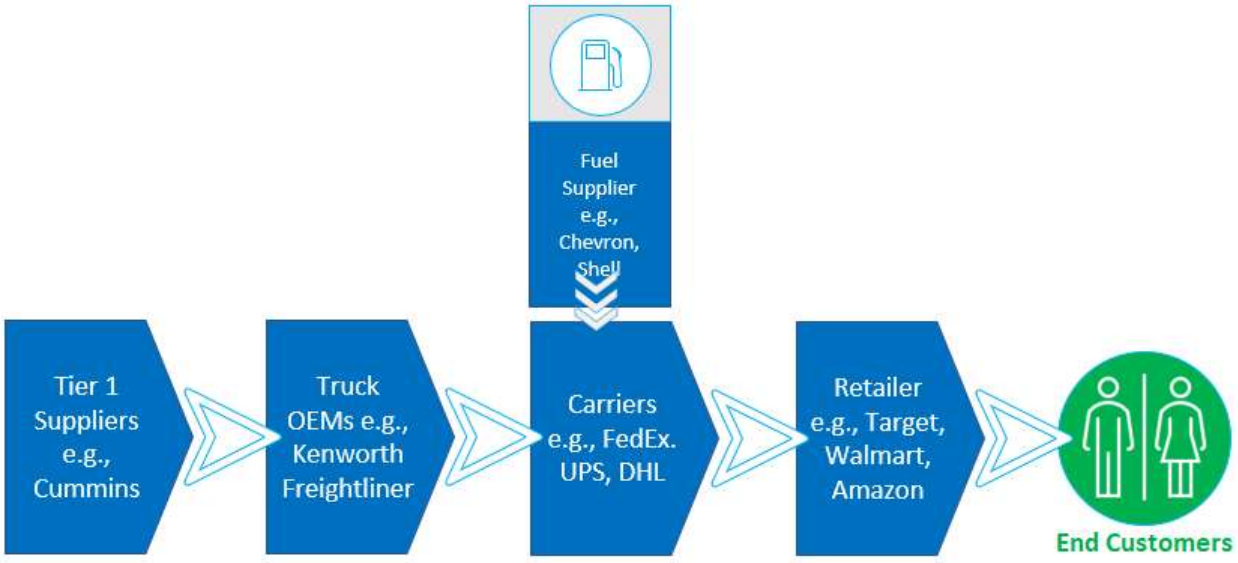


Figure 6 | Linear Logistics Business Model

In this model, the carrier is agnostic to fuel supplier and typically avails to fuel through long term supply contracts to the carrier's fleet or through retail truck stops and travel centers. Manuel fueling with mature industry standards is at the core of this model as it does not necessitate the need for partnerships to design specific fueling interfaces.

Additionally, the current trucking routes still largely follow point to point delivery point-to-point distribution model, packages typically move between points A to B, C, D, or E based on delivery requirements and inventory availability at that time. There is no centralized warehouse or distribution center, which leads to inefficient distributions and higher logistical costs. This is beginning to change with some large carriers moving to the hub- spoke model. Figure 6 shows the two distribution models.

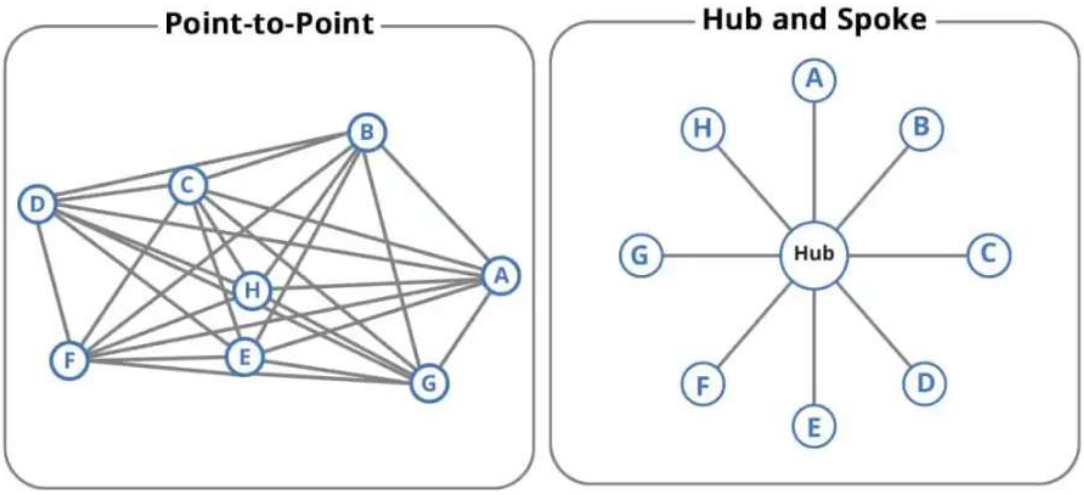


Figure 7 | Point to point and hub and spoke distribution models, source: Locus logistics Operation

Connected strategies in hydrogen heavy duty trucking

Hydrogen fuel-cell powertrain offers an ideal platform to implement connected and autonomous driving technologies, which require a massive amount of power to support the data communication as well as the operation of hardware (sensors). Autonomous trucking is best suited for long-haul applications, along pre-mapped routes (hub to hub), mostly highways. That is where studies see the strongest ROI for fuel cell hydrogen applications.

Hydrogen is clean burning. It also allows the long-term storage and transportation of large volumes of energy, such as from excess renewable energy generation, thus providing grid flexibility. While building a charging infrastructure for battery trucks is currently cheaper than hydrogen refueling stations, studies project that required investments will be lower for the latter once the number of trucks on the road are higher[7]. The refueling infrastructure also requires less space than battery recharging if deployed at scale. The refueling time is comparable to that of diesel trucks (8-10 mins).

The upcoming sections discuss the key connected technologies that are starting to be being paired with hydrogen trucking use cases.

VEHICLE-TO-VEHICLE (V2V) COMMUNICATION

This class of technologies comprises of intelligent telematic systems integrated with advanced driving technology such as adaptive cruise control, collision avoidance systems, and radar, that enable trucks to connect with other trucks when to save fuel through platooning. In the new smart truck platooning model, logistics companies can securely share relevant scheduling and truck information with centralized hubs via mobile networks, guaranteeing the optimum platoon configuration and navigation. Research indicates that smart truck platooning can deliver a 16% reduction in CO2 emissions.

Since the main goal of platooning is energy efficiency and CO2 reductions, hydrogen propulsion system pair well with platooning especially as they provide the long range required to test hub to hub transport without need for refueling. Figure 8 shows the possible pairings of powertrains with connected truck systems

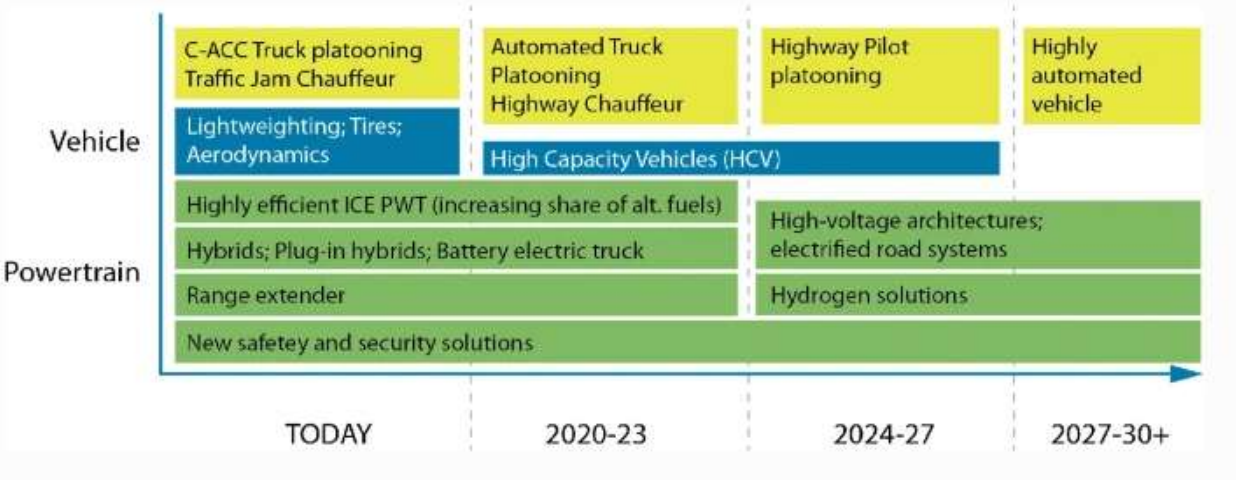


Figure 8 | Roadmap of possible technologies for highway domain source: Energy-Efficient and Semi-automated Truck Platooning

Daimler has begun testing the technique of platooning. According to Roger Nielsen, CEO of Daimler Trucks North America, "[platooning] stands for more carbon efficiency and safety." Separately, Daimler is testing its Mercedes-Benz GenH2 Truck fuel-cell prototype has been undergoing intensive testing.

VW owned Scania is testing 5G mobile technology in V2V communications in partnership with Ericsson Research. Separately, Scania is participating in Europe's Hy Truck project in collaboration with Cummins. This is a fundamental shift for Scania that has always been bullish about the adoption of battery technology even in heavy duty trucks. While Scania has not directly tested the applicability of connected

technology to hydrogen trucks it is not a stretch to say that it will be looking to do so when it has commercially ready trucks in 2024.

VEHICLE-TO-INFRASTRUCTURE (V2I) COMMUNICATION

This technology makes it possible for trucks to remain in constant communication with their surroundings through GPS tracking and digital links between the truck and the road or other infrastructure installations such as fueling outlets. Safety information, re-fueling or charging level, payment information, and other information may all be transmitted through such connected architecture. The north American startup Nikola Motors has secured a $2M department of energy grant to use this technology to develop autonomous fueling infrastructure for its own class 8 hydrogen trucks.

First generation of such technology would sense a truck pulling up for refueling and deploy a robotic arm (being developed by the company Robofuel) to insert the nozzle into the truck tank. Hydrogen refueling can be quite specialized and fraught with safety hazards. The use of such an unmanned refueling system would help minimize training and operational risks while integrating the automation, safety and explosion protection needs into a single processing system. Nikola has partnered with OPAL fuels to develop hydrogen hubs (large scale hydrogen production facilities in key geographies and routes) across America. In essence, this is very similar to the Tesla model that is looking to create an integrated ecosystem with the approach of optimizing regionally available green energy to produce hydrogen fuel in a cost competitive manner (zero to no logistics cost).

International company Rotec has also developed a Robotic Fueling System (RFS) of a similar scale. Its system connects in 75 seconds, has a 300 gallons per minute fuel rate, and can disconnect in an impressive 30 seconds, and is made up of a horizontally placed delta robot with three driving mechanisms mounted on a sub frame that moves six arms.

Plug power is innovating in the space of hydrogen robotics and automation, specifically with a first-of-its-kind robotic hydrogen fueling technology for motive power applications. The immediate goal of the robotic fueling station is to increase the ease and efficiency of fueling hydrogen-powered vehicles in warehouse settings.

REMOTE DIAGNOSTICS

Constant remote monitoring can help hydrogen trucks to stay connected to a control center that monitors onboard safety of fuel, fuel levels and other vitals of the truck to also provide driving, maintenance and refueling guidance. For e.g., Toyota is using its fuel cell technology developed for the LDV Mirai in Kenworth T680 chassis to introduce a truck which comes standard with remote diagnostics, collision mitigation, and smart lane-assist features.

AUTONOMOUS OPERATION

All these technologies, combined with short- and long-distance radar, laser detection, cameras, sensors, and 3D mapping is called autonomous or self-driving technology. There are several levels of automation that are shown in Figure 8. Autonomous trucks will lower the cost per mile by traveling during off-peak hours, eliminating breaks, avoiding issues like driver fatigue.

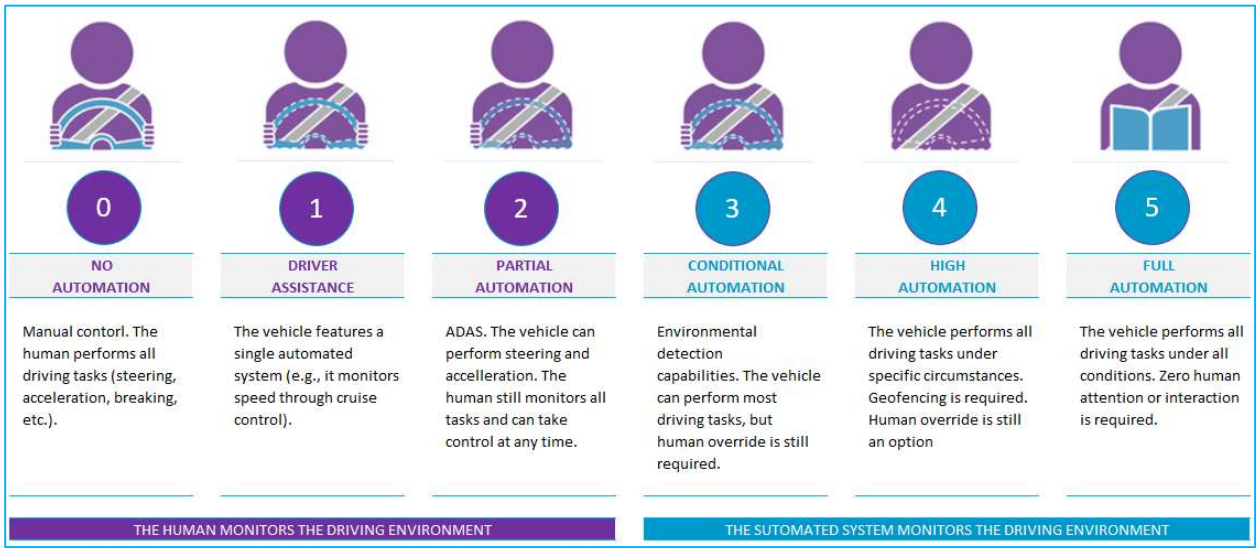


Figure 9 | The six levels of vehicle autonomy, source: synopsis.com

There are partnerships developing between the autonomous provider, trucking OEM, logistics company and fuel providers that will present interesting implications.

For e.g., California-based Gemini Motor is a cleantech company building autonomous, zero-emission semi-trucks powered by hydrogen fuel cells. The RoboTruck, Gemini's first product in line, will have a range of

up to 1,400 miles and can be refueled in less than 20 minutes. Since no drivers are involved, the fleet of Robot Trucks can operate 24 hours a day and seven days a week, quadrupling the operational efficiency of each unit over the conventional human-driven trucks. In addition, no driver cabin is required, which results in a significant drop in capital costs at volume production, mitigating the additional cost of AV sensors and compute equipment.

Using a software-centric approach that incorporates self-learning and sensor fusion, the Gemini AI runs vehicles autonomously, performs predictive maintenance, and maximizes fuel efficiency while meeting the highest safety standards. Gemini Motor is currently working with AV partners to develop its AV stack, which will be ready for early testing later this summer. According to Gemini's co-founder Maik Ziegler, the former head of Advanced Engineering at Daimler Truck North America and the former head of Commercial Vehicles at Hyundai Motor Europe, "Only fuel cell electric propulsion will give us the driving range and fast refueling needed to harvest the 24/7 operation benefits of an autonomous truck."

Gemini is partnering with Mzigo the logistics partner and with Trillium the Fuel infrastructure development company.

Similarly, Tu Simple is an autonomous trucking company that has completed its first autonomous truck run on open public roads without a human in the vehicle. TuSimple's Autonomous Driving System (ADS) navigated 100% of the 80-mile run along surface streets and highways between a rail yard in Tucson, Arizona, and a distribution center in Phoenix. This was a technical pilot run rather than commercial run however starting in 2023, the company is looking for full scale commercial deployment (driver out operations). Tu Simple is attempting to pair autonomous operations with hydrogen propulsion. The co-founder of Tu Simple, Mo Chen has also founded a hydrogen fuel cell propelled autonomous truck company called Hyzon. The first generation of Hydron trucks is predicted to enter mass production in the third quarter of 2024. The goal is to reach L4 autonomous driving, meaning the trucks will drive themselves under most but not all circumstances, without a human in the vehicle. To attain L4 autonomy, trucks will have to ship with a complete set of sensors, computing units, and redundant actuators. Hydron plans to develop, manufacture, and sell the hydrogen fuel cell vehicles as well as construct refueling infrastructure. Hydron also plans to collaborate with partners to build a manufacturing facility in North

"The first generation of Hydron trucks is predicted to enter mass production in the third quarter of 2024."

America to better meet U.S. supply chain challenges. The company will focus on the North American, European, and Middle Eastern markets.

This trend is pervasive across the sector as autonomous technology companies are partnering with truck original equipment manufacturers and logistics partners to create value chain solutions. In doing so they are developing cross-skills in more what started as their core competencies.

The table below compiles the developing partnerships in this space:

Autonomous Technology Company	Hydrogen Truck OEM Partner	Logistics Partner	Fueling Infrastructure Partner
Anonymous partners	Gemini Motors	Mzigo	Trillium
Tu Simple	Navistar, Hyzon hydrogen trucks (shares founder with Tu simple) Volkswagen Trucks (Traton group)	UPS, U.S. Xpress, McLane Co, Ryder	Woodside, Total Energies
Aurora	PACCAR (Kenworth)+ Toyota (FCEV technology)	FedEx	Air Liquide (OEM partner)
Waymo Via (Alphabet)	PACCAR (Peterbilt) Daimler	Uber Freight, UPS	
Torc Robotics (Now a Daimler subsidiary) **Luminar Technologies (Lidar technologies)** **Apex AI**	Daimler (Mercedes Benz) + Volvo group Daimler + Cummins	Penske Trucking	Shell (in Europe), BP (in UK), Total (in France) Linde (focus on a new process for handling liquid hydrogen)
Embark Trucks	Freightliner, Navistar International, PACCAR, and Volvo	Ryder, US Express, Amazon	Air Liquide (OEM partner)
Kodiak Robotics (Asia Focus)	Supports retrofits with all trucks	US Express, Ceva Logistics, SK group (Korean)	Plug Power
Enride (autonomous pods)	Scania Trucks, Hyzon Motors	Maersk trucks, Oatley NA truck segment	_
Plus, AI (Chinese)+ Velociti	Supports retrofits, IVECO, FAW Jiefang	-	-

Emerging business models and monetization structures

The cross-value chain partnerships especially with the autonomous technology company at the center is shifting the existing business model from linear to a hub and spoke type model. The autonomous technology company dominating the central hub position acting as an aggregator bringing attributes power train, truck chassis and fueling infrastructure into their proprietary autonomous architecture.

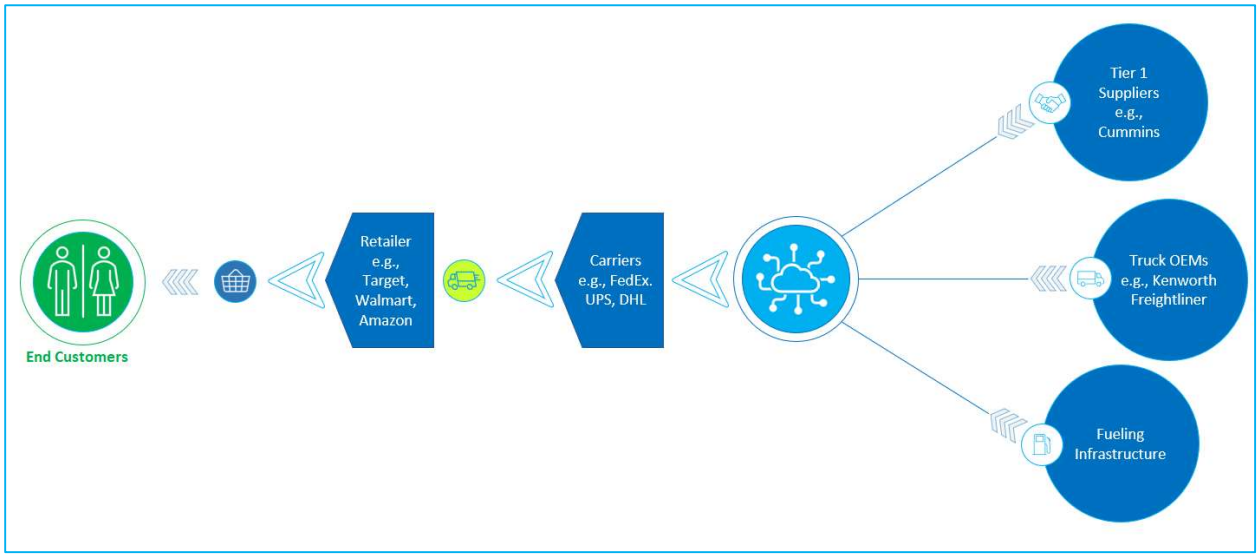


Figure 10 | Emerging autonomous business model

There is a new "autonomous mobility as a service" model developing where the autonomous technology provider is providing autonomous mobility as a service on a pay per mile basis to logistics providers e.g. once they have purchased a Kenworth truck with the TuSimple technology. This pay per-mile fee is part of a subscription program for fleets called TuSimple Path, which the company describes as a "turnkey virtual driver" that works across TuSimple's autonomous freight network. So, the fleet owns the vehicle while TuSimple operates it autonomously, is liable for its safety, essentially acts as a dispatcher with more control. Over time with growing partnerships (Navistar, Volkswagen Trucks, Woodside, Total Energies, UPS, U.S. Xpress, McLane Co, Ryder) and unique autonomous architecture TuSimple has the potential to bring several of these skills in-house to develop into a platform-based monetization structure that gains efficiencies and learnings from the growing participants on the platform. TuSimple already has an affiliate company Hyzon building commercially ready hydrogen trucks. Another example if of an incumbent truck OEM like Daimler that acquired Torc Robotics 's autonomous technology to offer an integrated fully

autonomous truck. This will likely be paired with a subscription based autonomous driving service which is still being developed.

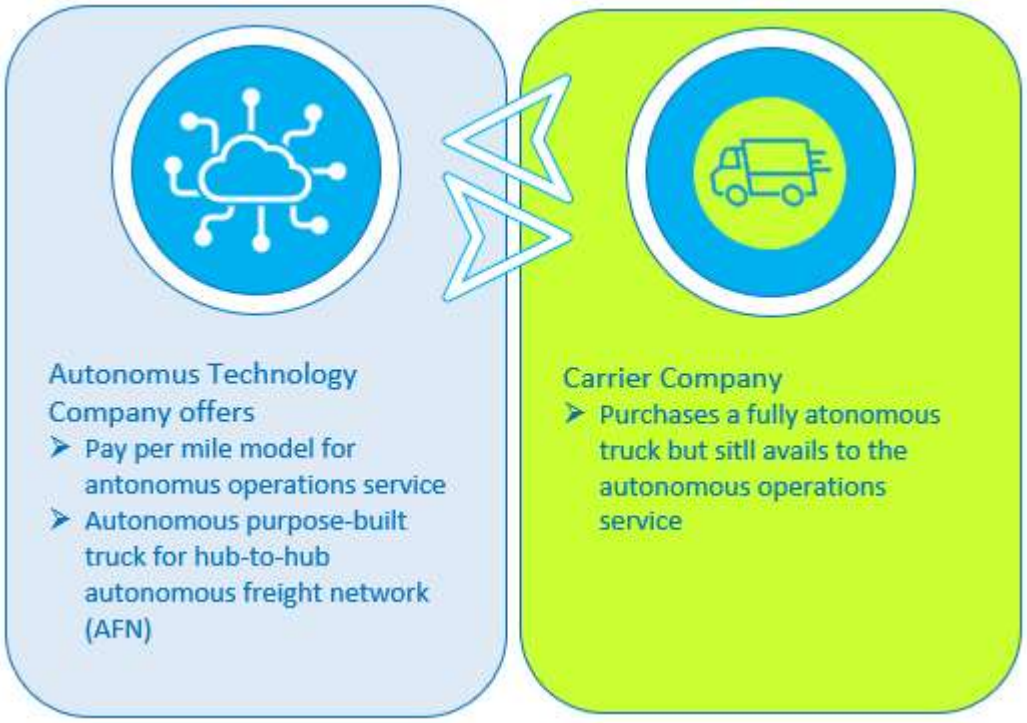


Figure 11 | Emerging autonomous monetization model

Implications

Smart freight made possible via digitalization and connected strategies such as driverless operation will soon self-identify and self-monitor. When paired with a hydrogen powertrain they pose a formidable solution for safe and zero carbon logistics. The autonomous technology companies are the new entrants that are starting to dominate the central hub position in a hub and spoke partnership model. These new entrants act as an aggregator, bringing attributes of power train, truck chassis and fueling infrastructure under their proprietary autonomous architecture. Monetization models are emerging wherein autonomous technology companies are providing autonomous mobility as a service on a pay per mile basis to logistics providers.

This pay per-mile fee is part of a subscription program for fleets where a “turnkey virtual driver” works across an autonomous freight network. “The connected truck-as-a-service” market will continue to grow and is anticipated to surpass $99.2 billion[8]. Over time growing partnerships and unique interface

architecture has the potential to bring several of these skills to be locked in a platform-based business model. Such platforms will facilitate purposeful collaboration and generate additional value for participants in the trucking ecosystem. The ability for companies to quickly engage in platforms is a benefit as such platforms will create integrated environments that support and enable ecosystems to operate. As we look toward the future, we see that fleet platforms will continue to grow, and data and asset platforms will become more relevant to create customized experiences with customers. Autonomous technology companies will support logistics providers to take advantage of the huge amounts of data accessible to them to tailor such customer experiences.

Close partnerships will inevitably lead to skill transfer across the value chain. There is already a blurring of distinct core competencies across the value chain for e.g., powertrain OEMs like Nikola are looking to build autonomous hydrogen trucks and automated fueling infrastructure. This may inevitably lead to obsolescence of certain value chain players.

Part 2 | Hydrogen as a zero-carbon power sector i.e., Energy & Utility (E&U)

Today's power-generation sector is facing disruption on an unprecedented scale. Renewables are becoming more competitive and a bigger part of the grid. The cost of energy storage is falling, electric vehicles are proliferating, distributed power generation is gaining traction, smart grids are spreading, regulators are pushing for decarbonization, and customer preferences are evolving. In this new world the digital assets of the utility sector connect and interact with the customer (business)'s digital assets shifting the utility's relationship with the customer. While traditional customer focus was on performance-based satisfaction, the future focus will be on enhanced engagement and personalized solutions. Additionally, the future management and sustainability of the grid will require a partnership between customers and the E&U providers requiring a strong interface, either directly or through intermediaries.

Decarbonization and storage needs position hydrogen as an attractive solution. Hydrogen pairs well with renewable energy as a peak-shaving resource, providing significant value to energy systems by avoiding the need for large amounts of backup.

In this section we explore critical needs of the E&U power segment and customers (business consumers) and how synergistic application of digital connected technologies and hydrogen can help meet those needs while creating a superior customer experience.

Power sector challenges and role of connected technologies and hydrogen in alleviating these challenges

It is expected that by 2050, 62% of generated energy will be covered by renewables. In contrast the amount of green energy generated in 2019 represented 27 % of the worldwide production and only 13 % of the entire production capacity in Slovakia. However, connecting renewable energy sources (RES) with the grid is not simple as it may seem, and its effectiveness is entirely dependent on weather conditions. From this point of view, RES are considered an unstable energy source and their operation, without an advanced management system, can cause a serious grid imbalance.

Hydrogen as an energy storage system that can store unused energy and save it for later need. Artificial intelligence and smart grids can improve prediction systems and thus allow for more accurate weather or energy consumption forecasts. With this approach, utility companies can improve the planning of their

clients' electricity needs and smart energy management solutions can turn green energy into hydrogen as a reliable and clean alternative to fossil fuels.

Electricity distribution over long distances increases the temperature within power lines and thus causes significant energy losses in the form of heat. In the end, these losses are paid for by everyday electricity consumers. In 2019, fees related to electricity transmission losses accounted for 4 % of business owners in Slovakia. Even though the amount of energy that is lost is relatively low in US and Europe i.e., around 4-5 %, losses are around 19% in India and an astounding 50 % in Haiti.

Utility customers, especially business owners, want reliability of supply. Serious cases of power outages threaten millions of people and have already caused billion-dollar damages across Australia and the United States. Besides paralyzing life within the affected areas, a huge blackout can result in device damage and important data loss for enterprises. While the operating lifetime of power lines is not eternal and the renovation or building of new power lines is costly, there is a constant need to increase its capacity.

Digitalization of the energy sector has also its side effects as well. There have already been cases detected when a group of hackers infiltrated systems of energy companies and exposed thousands of households to a controlled blackout.

Energy decentralization with local energy production and consumption lowers the amount of electricity distributed through the power grid thereby lowering transmission losses. With decentralization of generation, the responsibility for the grid operation is not in the hands of a single supplier, distributed generation means that a cyber-attack at on one single point in the grid, e.g., one power plant, cannot interfere with the operation of the entire system.

Hydrogen's unique properties make it a powerful enabler for the energy storage and deployment of distributed energy sources (Figure 12).

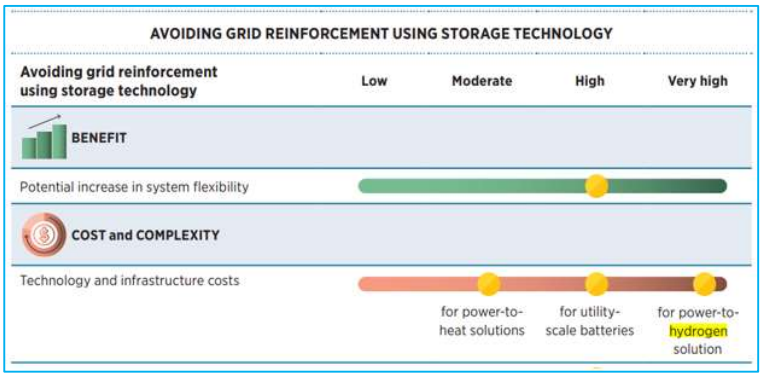


Figure 12 | Avoiding grid reinforcement using storage technology

Hydrogen is a zero-carbon source that avoids CO_2 and particulate emissions, can be deployed at large scale, and be made available everywhere via distributed energy resources (DERs). Using DERs for power-to-hydrogen solutions has the added benefit of avoiding grid modifications (Figure 13).

Hydrogen is hence the "missing link" in the energy transition: renewable electricity can be used to produce hydrogen, which can in turn provide energy to sectors otherwise difficult to decarbonize through electrification. Hydrogen can add supply-side flexibility and offer seasonal storage of solar and wind power.

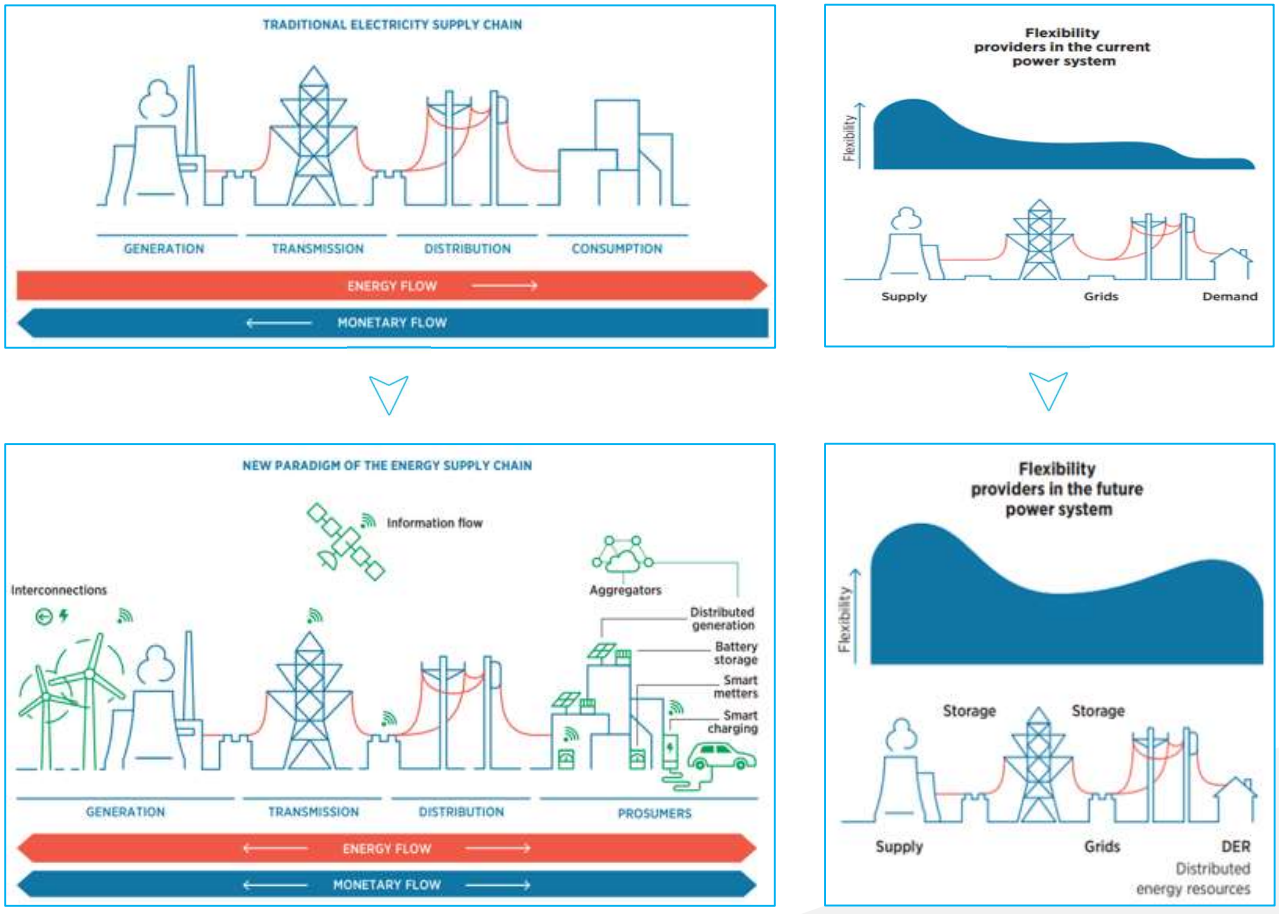


Figure 13 | Flexibility in the Energy Supply Chain[9]

Electric vehicles (EV) are still rare, but the fast advances in technology are increasing their popularity. EV charging can take a significant amount of time, for instance, a 2020 Chevy Bolt has an acceptance rate of 7.2kW and a 32 Amp HCS-40 will add about 24 miles of range per hour of charging. It is hard to justify spending half a day at charging station and faster superchargers consumes an immense amount of energy. To compare, one full charge using a supercharger equals the launch of 70 air-conditioning units at once. Such an instant change in power demand is a huge problem for the grid.

Smart grids can enable online connection of various sources such as solar panels, batteries, EV chargers or other equipment. Through the analysis of collected "Big data" in real-time, it is possible to speed up the reaction time to the changes in the power grid and thus ensure high quality and stable energy supply. Or in other words, devices can dispose of unused energy to benefit other equipment that need it.

Consumer Willingness to pay

EY conducted a US Fuels of the Future survey in April 2019 in which it polled 1,500 more than 100 corporate executives with responsibility for managing their company's energy usage (Figure 14) The survey found corporate customers were even more in favor of price competition. Among the 57% of energy decision makers (EDMs) without a choice of providers, 90% said having a choice in their utility would make a difference to their company.

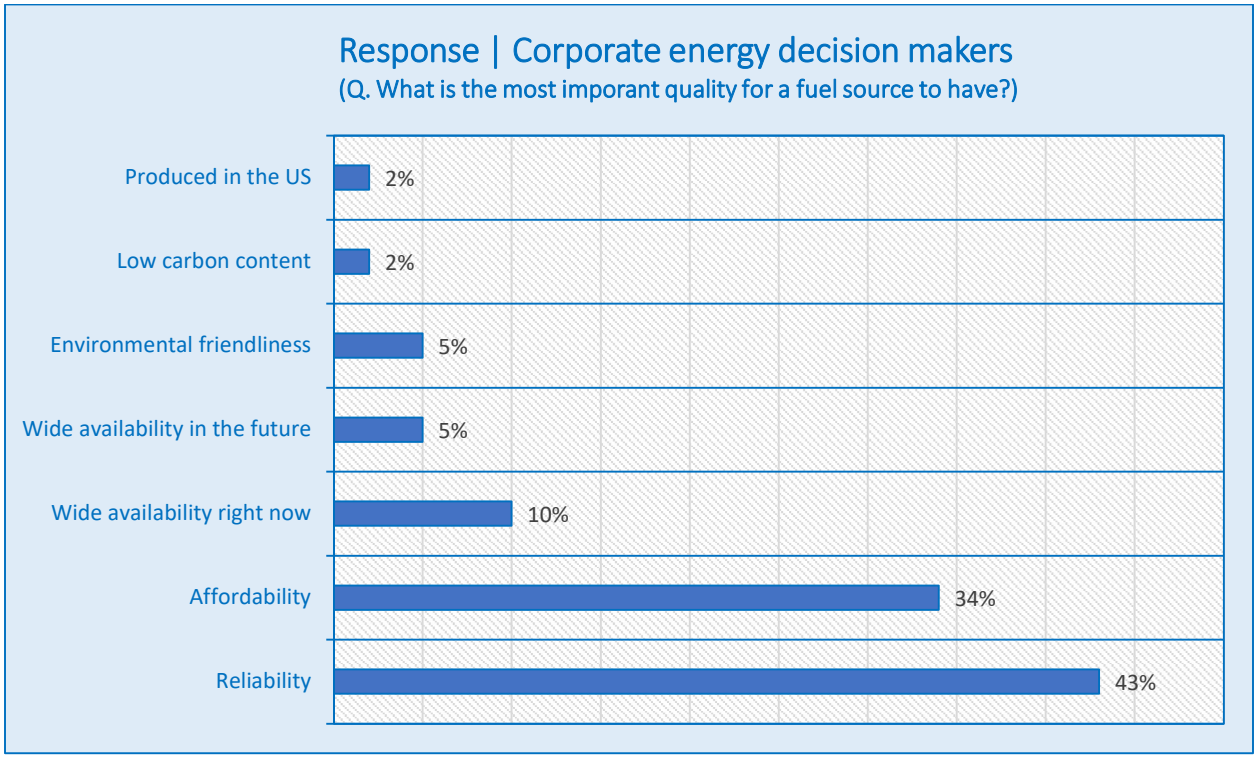


Figure 14 | 2019 US Survey fuels of the future | Q. What is the most important quality for a fuel source to have?[10]

87% of EDMs said choice of utilities would benefit their company, citing the opportunity to negotiate lower electricity prices, 85% said competition would keep prices low. Meanwhile, 45% said the ability to reduce their company's carbon footprint would be the biggest benefit of competition. EDMs also believe increased choice would enhance their access to the most sophisticated energy technology, with 60% citing that factor as a benefit.

Corporates were less emotive about the opportunity to move into renewables as price and reliability have a big impact on lost productivity and profits. EDMs with a choice in their utility said they choose based on price (86%), reliability (60%) and then the use of renewable energy (16%). When asked what would cause them to switch from their current provider, 92% of EDMs point to the opportunity for a lower price, and 37% say they would switch to use more renewable fuels in their operations.

It's not that corporations aren't interested in renewables. In fact, EDMs are willing to pay for more environmentally friendly fuel. Respondents, on average, said they would pay 2.22% for electricity generated with 10% less carbon and 7.61% more for electricity generated with 50% less carbon.

However, businesses have alternative pathways to greener energy, such as power purchase agreements (PPAs) with renewable providers, green tags from exchanges or even independent power generation (IPG).In fact, the US is leading the way for corporate PPAs and several large technology sector players are pursuing 100% renewable energy targets. When asked about IPG, 78% of EDMs agreed their company is interested in IPG for all its facilities, and 85% said it is interested in IPG for some.

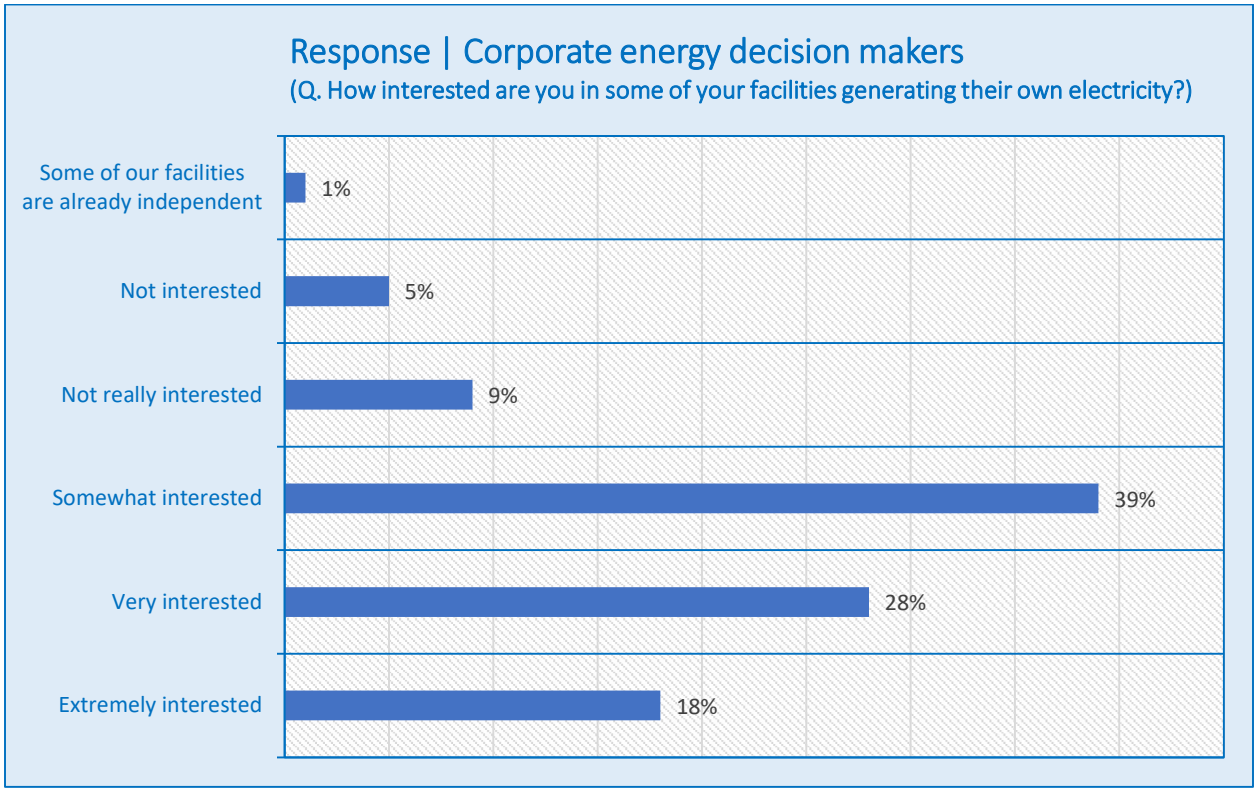


Figure 15 | 2019 US Survey fuels of the future | Q. How interested are you in some of your facilities generating their own electricity?)

These findings show corporate customers recognize the value of electricity competition and that price and reliability continue to be the key drivers when provider decisions are made. However, the survey also illuminates increasing environmental concerns and the desire to use more renewable energy. Utilities have the opportunity to implement business models that match customers desires; embed flexibility and agility to consistently meet changing expectations; and create deeper relationships and customer loyalty through innovative service and product offerings that speak to customers current and future wants.

Current Value Chain and Business Model

An energy utility is a generator and supplier of energy (electricity, gas, and heat) to households, communities, businesses, and other organizations that recovers its costs through the charging of rates. These rates reflect the areas of the energy 'value chain' (Figure 16) across which the energy utility operates (shaded).

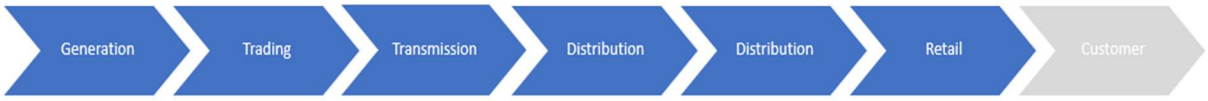


Figure 16 | Areas of the energy value chain

Utilities have traditionally recovered the cost for generating, transmitting, distributing, and selling electricity, gas, and heat to end-consumers. Given the liberalization of modern energy markets, most energy utilities' operations are now focused on the generation, trading, and retail of energy. The value proposition at the center of this business model is the bulk generation of electricity, typical scale is of 100s-1000s of megawatts (MW), using traditional sources such as coal or gas. Figure 17 shows the business model.

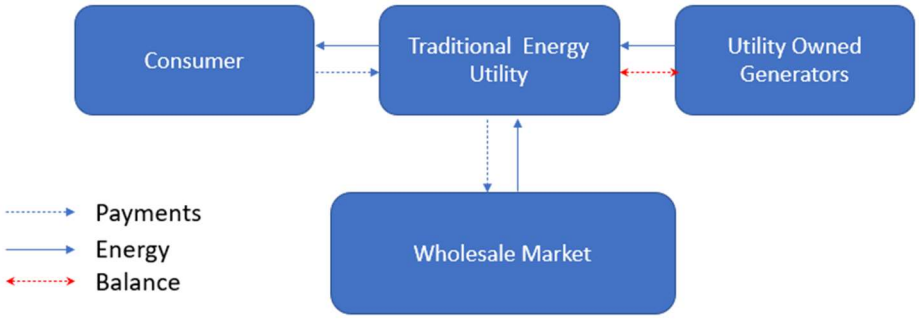


Figure 17 | Current Energy and Utility business model

Connected strategies in hydrogen power sector

In a recent Capgemini research report, it estimated that the E&U sector can save between $237 billion to $813 billion from Robotic Process Automation (RPA) and intelligent automation at scale. For example, the automation front-runners such as Gazprom, the Russian gas giant, used RPA to automate verification of meter readings. In the first two weeks after the implementation of the automation, an employee was able to validate about 130 invalid meter reads, saving 10 hours of the week per employee.[11]

The growing importance of digitalization in the power sector is partially a consequence of increasing decentralization (e.g., increased deployment of power generators at the distribution level) and electrification (e.g., the emergence of EVs, heat pumps and electric boilers). Recent analysis from International Renewable Energy Agency (IRENA) shows how all these new small and distributed assets on the supply and demand sides are adding complexity to the system and making monitoring, management, and control crucial for the success of the energy transition.

There are four critical enablers to enable a connected strategy. These four areas are already changing how the grid is managed and as technology evolves will provide greater insights to optimize, manage, produce, and distribute power through a smarter grid

- Internet of things - the bi-directional flow of data
- Artificial intelligence - to manage a smarter grid
- Robotic Process Automation - remove humans from the system to reduce error
- Cloud computing - to manage energy production and distribution

INTERNET OF THINGS (IOT)

The Internet of Things (IoT) is one of the digital technologies that can support the energy transition. By connecting energy suppliers, consumers, and grid infrastructure, IoT technology facilitates the bi-directional flow of data, the operation of increasingly complex power systems and the establishment of new business models by enabling clients to further monetize the value created by their assets through demand-side management.

IoT technologies are underpinning the transformation leading to cleaner, more distributed, and increasingly "smart" grids. Access to more, higher-quality data across the whole value chain enables better decision-support tools (i.e., AI) and enables remote control and automated execution of decisions (e.g., energy trading algorithm).

IoT smart meter boosts hydrogen energy sector

In the U.K. and other countries, pilot schemes with hydrogen blending are underway to meet carbon-emission targets. One challenge is that no domestic hydrogen gas meters are currently available to measure and charge for gas usage. Conventional meters measure gas flow using a mechanical system based on a diaphragm. Because of the small hydrogen molecular size, hydrogen diaphragm meters would need to be about three times the conventional meter size – an impractical and costly limitation.

One option is to replace mechanical diaphragm meters with ultrasonic devices. These rely on accurate 'Time of Flight' (ToF) measurement of the speed of sound to determine the gas's flow rate. But because the speed of sound in hydrogen is around three times faster than that in natural gas, significantly better timing precision is needed.

In response to this challenge, U.K.-based MeterTech has launched a smart meter that uses a more advanced technique for the "recovery" of the ultrasonic signals and has timing circuits capable of measuring ToF in hydrogen. Furthermore, the meter has been designed to meet the highest safety requirements in Europe and elsewhere in the world.

Source | https://blog.nordicsemi.com/getconnected/cellular-iot-smart-meter-boosts-hydrogen-energy-sector

The IoT enables real-time communication through the Internet, among devices in demand and across the grid, facilitating information gathering and exchange. The IoT, together with optimization algorithms, can:

- Increase system flexibility by enabling remotely managed and/or rapid automatic changes in distributed resources and demand

- Improved renewable energy forecasting and trading, decreasing uncertainty
- Enable energy storage and analytics tools that analyze market data to help reduce the imbalance in the supply and demand of renewable energy and hydrogen
- Enable real-time grid monitoring to help utilities to meet demand more effectively as well as identify leaks or underperforming assets. However, both energy and water grids are spread over large areas and have thousands of distributed assets. Traditional analytical models are unable to effectively handle modern grids. Therefore, startups are utilizing RPA-enabled solutions to improve the efficiency of grid monitoring.[12]

Guarantee of origin (GoO) is a prerequisite for monetizing green hydrogen by certifying the renewable nature of all consumed electricity. AIoT-monitored installations can leverage near real-time data to automate input to GoO issuers – this avoids manual processing, offers more confidence and reliability, and increases futureproofing as more and more certifications evolves towards real-time and automation. AIoT can also ensure end-to-end traceability along the entire life cycle of the green hydrogen, from cradle to grave.

The Clean Hydrogen Partnership (CHP) is unique public private partnership in EU supporting research and innovation (R&I) activities in hydrogen technologies in Europe. CHP funded project CertifHy has issued more than 75 000 Green and Low Carbon Hydrogen Guarantees of Origin (GO) that are now available on the market. Hydrogen consumers from industry and transport can use renewable energy in their processes and reduce the greenhouse gas footprint by purchasing CertifHy Green or Low Carbon Hydrogen Guarantee of Origins now. CertifHy GOs allow end-users to consume Green and Low Carbon Hydrogen across the EU, regardless of their location.

ARTIFICIAL INTELLIGENCE (AI) MANAGED SMART GRIDS

The combination of big data with AI has emerged as one of the most important developments in several fields. Although many AI technologies existed for several decades, only now are they able to take advantage of sufficiently sized datasets, providing meaningful learning and results for energy market applications. This combination could help integrate variable renewable energy (VRE) in the power system by:

- Increasing the accuracy of renewable energy generation forecasts
- Improving system operation and management of distributed power sources
- Improving asset management through remote monitoring, analysis, and maintenance optimization

High VRE penetration in the system would require a new approach to grid operation, one that uses data and communication tools to manage the variability and uncertainty associated with VRE. Smart grid technologies can help to effectively integrate high VRE shares by incorporating information and communications technology into every aspect of electricity generation, transmission, and consumption. This enhances the flexible operation of the grid, reduces operational costs, and improves efficiency.[13]

UK hydrogen storage provider H2GO Power is leading trialing of the use of artificial intelligence (AI) software coupled with hydrogen technology. The aim of the Hydrogen Artificial Intelligence (HyAI) project is to demonstrate the use of AI software integrated with hydrogen hardware in making data driven asset management decisions in real time and optimizing renewable energy integration into the electricity grid.

Trial results have indicated that the AI-enabled approach can produce hydrogen in a more cost-effective way, while also helping to alleviate stresses on the national grid. This has the potential to increase power reliability and allow for higher penetrations of renewable energy.

"HyAI brings us a step closer to delivering clean and sustainable energy with high degree of control, automation, intelligence and increased profitability for commercial hydrogen projects," says Dr Enass Abo-Hamed, founder and CEO of H2GO Power.

ROBOTIC PROCESS AUTOMATION (RPA)

With implementing RPA, E&U providers who automate their business process recognize a significant decrease in errors, usually over 60%. Fewer errors – more satisfied customers, implies that RPA improves customer service and customer management which is crucial for E&U companies to have a competitive advantage on the market.

United Utilities, a United Kingdom-based water company, has been a pioneer in using RPA in automating its back-office processes. Since 2017, they automated more than 20 processes, with another 12 in development. The company´s Head of robots, Wallace Dean says,

Compared to traditional IT solutions, RPA can help the E&U industry to drive digital transformation and achieve results quickly with minimal effort. Plus, implementing RPA doesn't affect or request changes in existing IT systems. As such, employees can use and accept RPA without having IT knowledge.

The E&U industry has a wide spectrum of processes that can be automated. Today more than 50% of automation use-cases are found in the E&U industry and most of them are core processes.

Even though there is still skeptic opinion about digitalization and automation in the E&U industry, automation front-runners and leading companies see benefits of implementing RPA just in few months, sometimes in a few weeks. Here are some of the real-world use-cases of implementing RPA in core and support functions[14]:

- **Energy Trading** | British Petroleum (BP) is using automation in its trading function. Ayman Assaf, CIO for compliance, regulatory, risk and finance at BP Supply & Trading says,

> *"Automation is allowing us to consolidate data on the trading floor, using RPA to mimic repeated processes. This shifts the role of our analysts, increasingly freeing up their time to focus on higher-value tasks. So rather than collecting data sets, they can spend time interpreting and interrogating the meaning of that data."*

- **Energy Automation Platform** | Accuracy and safety are critical for energy utility providers. With the advancements in smart grids, companies seek to offer features like grid balancing and transactional energy solutions. Therefore, utility startups are advancing energy automation with

RPA. With compliant automated processes, RPA-based solutions improve both productivity and energy savings.

Before committing capital, investors want to know if the hydrogen system configuration will optimize their return. From electrolyzer capacity to buffers (such as energy and hydrogen storage), multiple variables must be considered. Robotic automation makes possible digital twins can model multiple designs and scenarios, including variables such as weather, off-takers demand volatility and local infrastructure (current and future), optimizing each design to maximize return on investment and minimize risk. Estimates indicate that digital twin analysis can optimize capital expenditure (CAPEX) by 10-15% whilst reducing risk by 30-50%, along with a marginal change in operating expenditure (OPEX).

The UN led green Hydrogen Catapult Initiative is partnering with Emerson to use digital twins to model scale up of hydrogen production 50-fold to reduce the cost of green hydrogen production to $2/Kg.

CLOUD COMPUTING TO MANAGE ENERGY PRODUCTION AND DISTRIBUTION

Cloud computing is a service that makes computer system resources available on-demand. This makes the entire operation much more cost-effective and easier to collaborate between departments.

There are various reasons why Distributed Energy Resources (DERs) can benefit from the integration with cloud-based operations. Cloud-based solutions offer higher and less complex scalability due to the elasticity of the system. The system can automatically provision and de-provision resources according to the changes in workload. Cloud-based systems allow better network analysis, forecasting, and peer-to-peer (P2P) trading. With the right P2P platform, the E&U sector will have a better chance of getting the right price for renewable energy.

Power providers depend on IT for consistent deployment, smooth integration, and precise implementation, as well as access to data, data analysis and real-time data processing. The only cost-effective way to reach these objectives is through digital transformation. To make this happen, the way data is accessed and managed requires constant changes. This is where application program interface (API) technology makes all the difference.

The most significant benefit of digital transformation is the absolute agility of API connectivity. This agility means changes can be applied to the core systems of records, without interfering with the ability to replicate these actions for end-user systems, like internet and mobile apps. You get a cost-efficient system that will increase your profits and open new revenue-earning opportunities.

Companies in the E&U sector have an interconnected network of complex components. This makes it vital for them to stay structured, maintain order and clear communication. APIs are designed to create this network with three separate parts that improve agility, speed, and flexibility.

When you are dealing with intermittency in renewable energy, AI (artificial intelligence) and ML (machine learning) can help by enabling smart grid platforms at fair prices. These technologies let you decode the algorithms, making the performance of the distributed energy resources predictable.

By being able to predict the accuracy of weather forecasts and the efficacy of solar panels and wind farms, you can create smarter grids. Cloud computing helps in this by providing a bunch of real-time insights and services like AI and ML.

A virtual power plant (VPP) is a cloud-based distributed power plant that aggregates the capacities of heterogeneous distributed energy resources (DER) for the purposes of enhancing power generation, storage (hydrogen) as well as trading or selling power on the electricity market.

With DEMS Compact, the Siemens Smart Grid Division is providing municipal utilities in Germany with a cloud-based Web service for virtual power plants. This service enables the utilities to interconnect their customers' small distributed-energy resources together and offer the bundled power to operators of a large virtual power plant for marketing.

"With the cloud version of our distributed energy management system DEMS, municipal utilities can generate attractive revenues with their own individual consumption and generation capacities and at the same time play a role in developing the energy system of the future," said Jan Mrosik, CEO of the Siemens Smart Grid Division

Even though cloud-based services ensure higher security measures, the control is limited when integrating peer-to-peer (P2P) platforms. As such, users may find it difficult to trust such platforms as the control over the data storage is shared. This creates uncertainty, and one must rely entirely on the cloud provider's assurance of maintaining security standards. The benefit of data for E&U companies it that they can

personalize services based on data received. For example, having unique information such as quantity consumed, units of power used, and exact location of consumption enables E&U companies to adapt services to better meet the needs of the customer.

Nordic Projects Support Digital – Supported Green Hydrogen

Stockholm-headquartered IT solutions group Hexagon has partnered with the Hydrogen Utility (H2U), one of Australia's largest hydrogen infrastructure developers, to digitize its green hydrogen construction plants.

H2U's strategic partnership with Hexagon combines the Swedish digital reality solutions company's expertise in integrating industrial facility digital ecosystems with the Australian group's green hydrogen and green ammonia plant designs. Digital twin technology being delivered by Hexagon comprises computer programs that use real-world data to create simulations that can predict how a product or process will perform in industrial production conditions. Significantly, cost efficiencies can also be measured within the digital twin framework process that supports the development of rapid deployment scenarios required for green hydrogen to deliver deep decarbonization in the industrial and energy sectors.

Developing Power Sector Business & Monetization Model

There are several business models are emerging that enable the integration of the above-mentioned connected technologies and features such as renewable power to hydrogen

PROSUMERS

With the rising share of distributed generation, consumers are increasingly becoming prosumers. Not only do they withdraw energy, but they also produce, store and supply energy to the network. Distributed energy resources (DERs), together with emerging connected technology applications (i.e., IoT, AI, RPA, cloud computing) in the E&U sector, place consumers at the center. This centralized and informed viewpoint enables them to make active assessments concerning their energy supply and consumption.

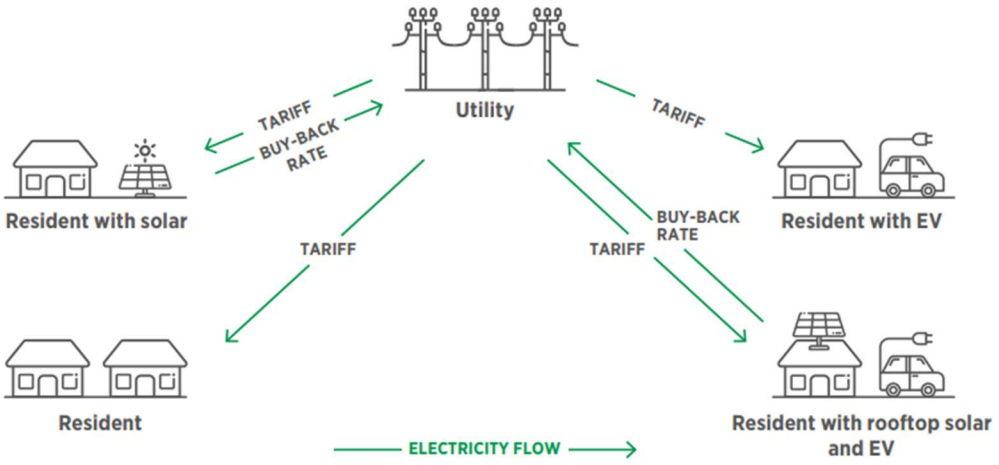


Figure 18 | Prosumer model

STEM is a California-based start-up with artificial intelligence technology that focuses on behind-the-meter energy storage systems and virtual power plants. It uses energy storage systems to reduce the cost of electricity for commercial consumers. The batteries are charged when the cost of electricity is low and discharged when the cost of electricity is high (typically during peak demand period). While traditional battery storage is used now, hydrogen will likely be adopted in the future. Stem can use its software to reduce the net demand of its customers, thereby reducing the demand of the whole area when the existing supply system cannot supply in the local area (Stem, 2019).

AGGREGATOR

An aggregator can operate many renewable DERs together, creating a sizeable capacity like that of a conventional generator (i.e., virtual power plant). As such, aggregators can then sell electricity or ancillary services in the wholesale market, or in the system operator's ancillary services procurement. An aggregator enables smoother integration of DERs into the power system, by allowing them to provide energy to the wholesale market and ancillary services to the grid operator. Thus, aggregator contributes to the system's flexibility.

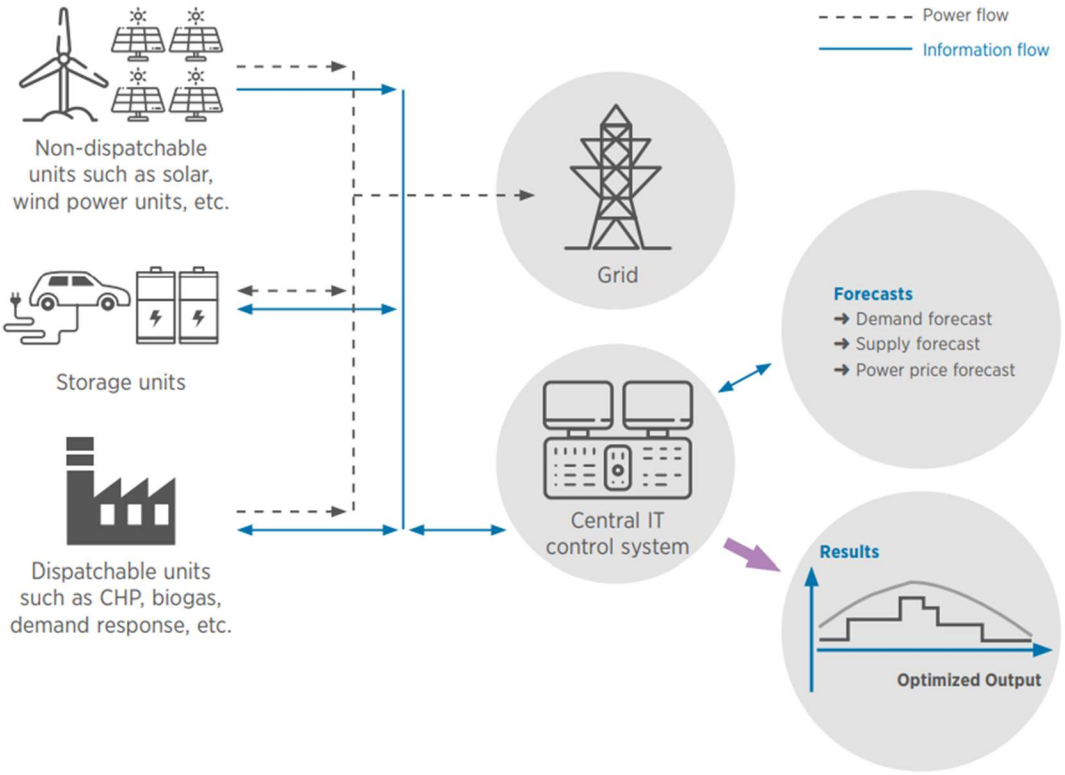


Figure 19 | Aggregator Business Model

PEER-TO-PEER (P2P) ELECTRICITY TRADING

Platform business models create an online marketplace for energy where consumers and distributed energy suppliers make peer-to-peer transactions. This energy can be bought by any consumer with whom there is a direct connection. The primary objective of a P2P market is to provide a trustworthy mechanism for prosumers to balance their preferences and requirements. An emerging innovation that facilitates P2P transactions is blockchain. P2P trading encourages more renewable energy distributed generation installations and increased local use of energy resources.

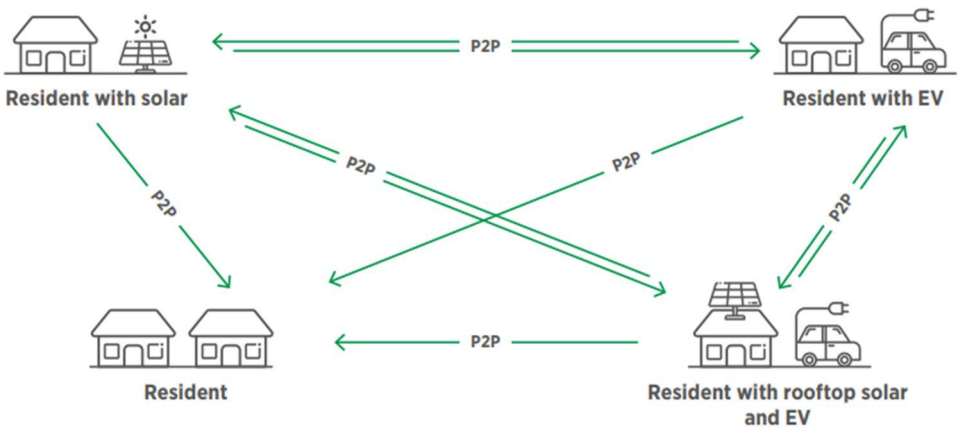


Figure 20 | P2P Electricity Trading

Brooklyn Microgrid is a community energy market within a microgrid. Under the platform, members can buy and sell energy from each other with smart contracts based on blockchain

ENERGY-AS-A-SERVICE

Energy-as-a-service (EaaS) refers to the shift from selling kWh to selling services to customers, given the increased potential of '"behind-the-meter" services, such as demand management, support for customers with decentralized generation and energy storage, and the exchange of electricity via local networks, advice on energy savings, comfort and security-enhancing measures, and other different services (e.g., E.ON Cloud, smart home solutions from EDP, ENECO, ENECO, etc.) EaaS enables the deployment of distributed generation and supports demand-side management, unlocking demand-side flexibility. Smart meters and ICT technologies are becoming key enablers for the EaaS business model.

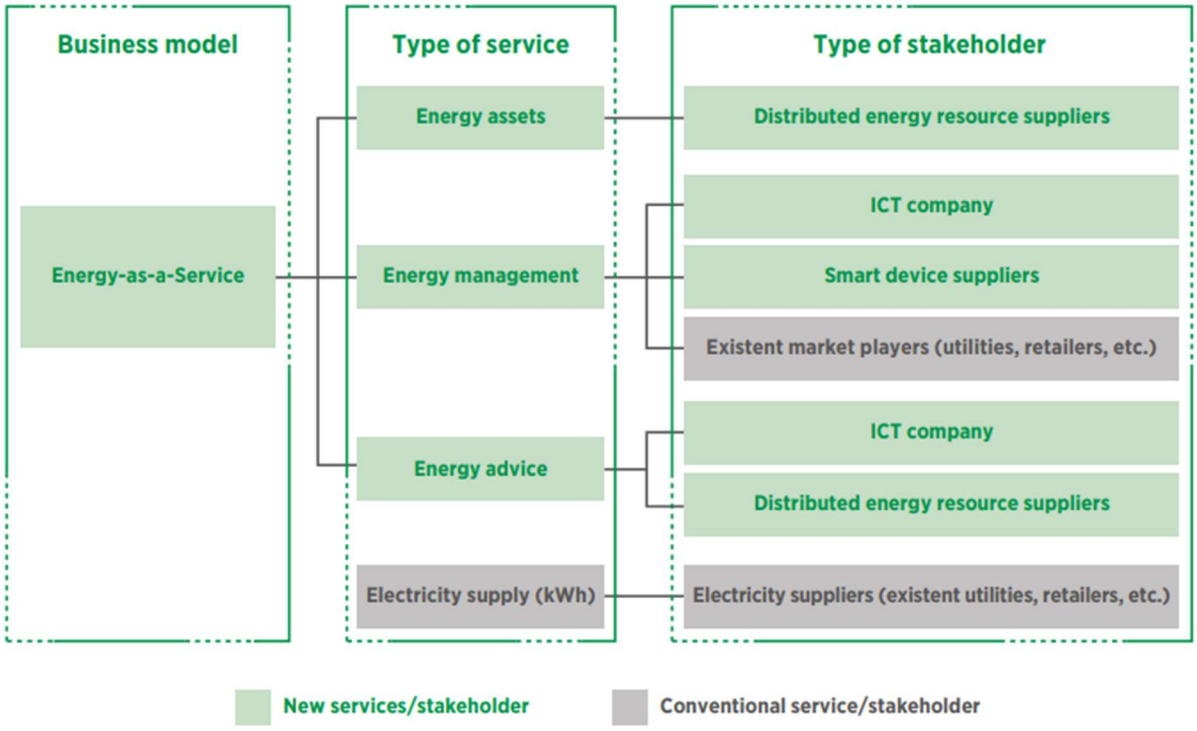


Figure 21 | Energy as service business model

COMMUNITY OWNERSHIP MODEL

Community ownership (CO) models are innovative business models that enable the sharing of ownership and management of energy related assets (i.e., energy generation systems, energy storage systems, energy efficiency systems, and district cooling and heating systems). CO models allow members of a community to share the costs and benefits of a renewable power plant. These models encourage distributed generation deployment and energy usage from sustainable, local renewable energy sources. This encourages people to unite and act on energy and other socio-economic challenges that are specific to their local areas and communities.

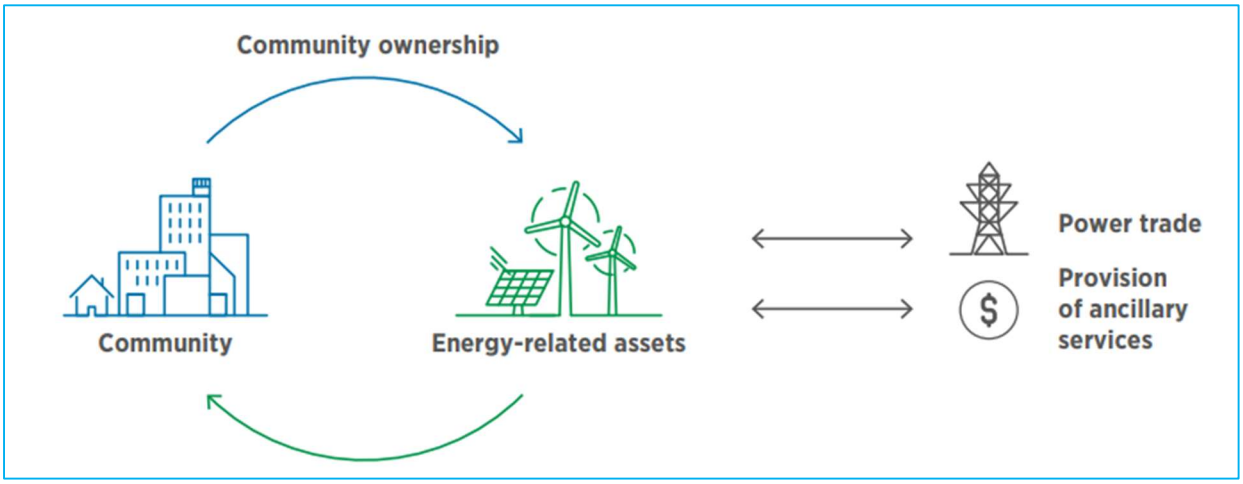


Figure 22 | Community ownership model

Implications

Hydrogen produced from renewable electricity through electrolysis can be used as a medium for low carbon energy storage. It can be distributed to users in re-purposed natural gas grids. It can be reacted in fuel cells to generate electricity, burned to drive a generator, used as a transport or heating fuel, and added to gas distribution networks or as a feedstock in other industries. This hydrogen could store energy on a large scale and for the long term (i.e., seasonal storage), reduce the curtailment of VRE (i.e., back-up generation capacity), decarbonize the industry sectors through sector coupling strategies, replace "grey" hydrogen made from natural gas in certain industrial processes.

Connected digital technologies such as IOTs, AI, robotic process automation and cloud computing are de-risking adoption and enabling faster and better scale-up and optimization of the hydrogen in the power sector. These technologies are facilitating new business models, such as virtual power plants (VPPs), based on bilateral power exchange and increased roles for consumers and third parties to provide energy, capacity and flexibility services that were once the exclusive domain of utilities. While these trends are changing paradigms, unlocking system flexibility for a high share of VRE penetration, they are also changing the roles and responsibilities of actors and opening doors to new entrants in the sector. Consumers are transitioning from being passive, captive actors into active players in the energy transition. They can now generate, trade and store electricity and provide services to the grid, thereby converting to prosumers.

A key element of innovation and change for U&E providers will be to ensure that they can build viable partnerships to use new providers of system services and flexibility (demand-side management, other distributed resources, etc.) rather than relying just focusing on their traditional role of thermal generation/distribution.

Part 3 | How can energy & utility (E&U) companies participate in the emerging hydrogen value chain?

Hydrogen adoption via connected strategies is bound to take off, however what role will energy and utility industry play in this transition? The disruption caused by this transition across the value chain is shifting the paradigms for investments, requiring new skills, and ways of thinking: away from physical asset (wires pipes and wells) to data exploration, away from persistent focus on traditional, large competitors to non-traditional small disrupters and a fundamental shift from a commodity to a product company mindset with untiring focus on customer experience. Building a continuous relationship with one's customer and taking a value chain approach will be critical for survival. While the future workforce will require many of the skills that the current workforce has built over time, it will also need to evolve and develop new competencies to realize its full potential. Companies will need to be ready to adapt, renew and evolve to execute their strategies with a workforce that is agile and equipped to support their business.

Existing E&U companies still have a role to play however the landscape of players is changing

For the oil and gas companies, it makes sense to prolong the lifespan of their existing assets in their own oil refining operations with infrastructure investments and reskilling of the workforce. They can service existing demand in various industries and start making the transition. It is noteworthy that the largest green hydrogen projects[15] recently announced are by existing oil and gas majors (Figure 23). What's changing rapidly is sole monopoly over the value chain.

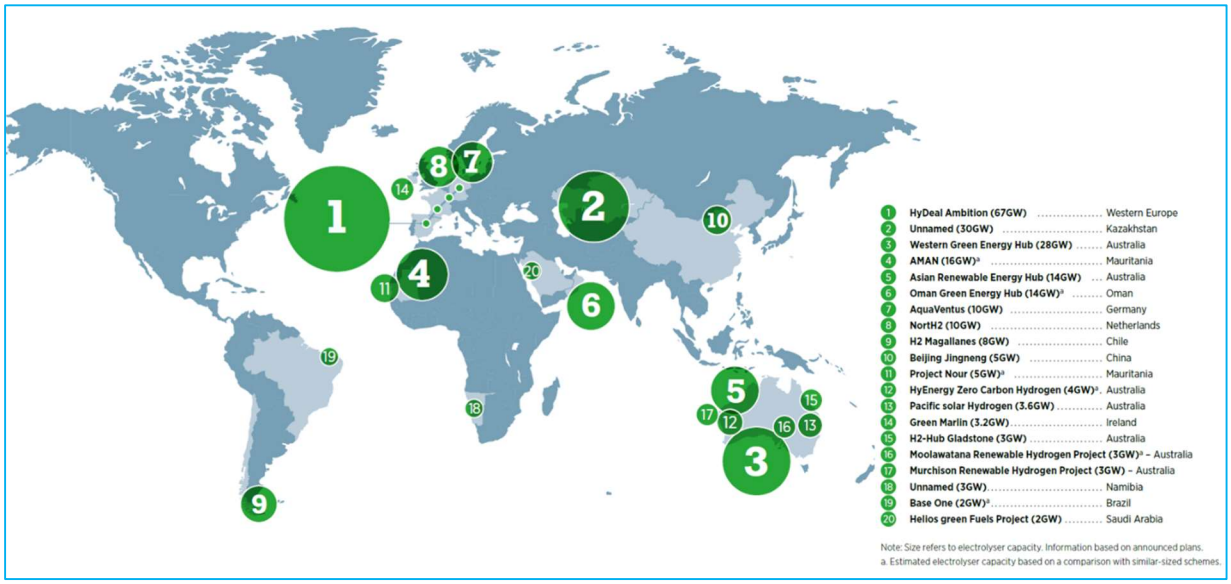


Figure 23 | Many of the new hydrogen projects are from existing Energy companies such as BP's Light source in Australia (1 GW),

Having access to large accounts and supply logistics will not be sufficient, and demonstrated through examples throughout the paper, it will be necessary to form technical and commercial partnerships to build the entire ecosystem with an eye on customer experience.

Meanwhile, U.S. utilities with power generation segments should advance investments to produce green hydrogen from excess renewable electricity generation to power turbines at gas-fired power plants. While gas utilities envision a future in which local distribution companies will decarbonize heating by delivering a blend of renewable hydrogen and natural gas to utility customers there has been lack of regulatory support towards that. In the meantime, gas utilities should focus on not being marginalized with renewable hydrogen in the meantime displacing hydrogen. A few U.S. utilities like NextEra Energy are advancing plans to produce green hydrogen from excess renewable electricity generation to power turbines at gas-fired power plants. NextEra is partnering with a community-based, not-for-profit organization Salt River Project to make this happen. In general, power generators are the wild card here, they might not wait for the gas grid to get good and be ready to blend hydrogen, they could bypass the gas industry altogether by buying electrolyzers and blending green hydrogen directly to run their gas plants.

Deep partnerships will be important but place in the network will be more important

Consider the network as simply drawn in Figure 24. On the left is a model where a hydrogen provider (red dot) is connected to customers and is sharing information with no sustainable competitive advantage. This provider can be easily replaced and bypassed. On the right you have a company in the center of a network that not only produces electrical power from hydrogen, but it also distributes it through its network and uses data and insights from its partnership to evolve and grow, data flows through the center to its network making it indispensable.

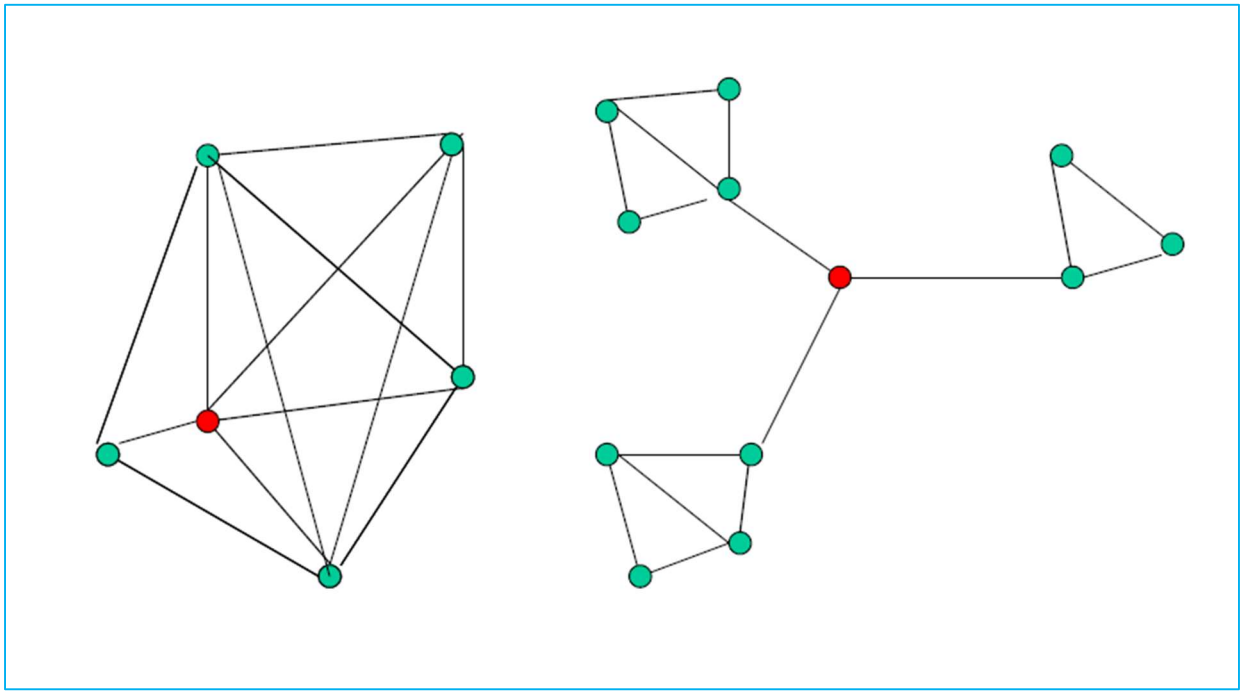


Figure 24 | Maintaining a competitive advantage through positioning in the network and being an aggregator of data.

OneH2 is a vertically integrated hydrogen fuel company that is looking to scale its hydrogen production and distribution system in South Carolina by following the model depicted on the right. OneH2 envisages a future where modular hydrogen production units combined with fuel production hubs can form an efficient and` highly scalable hydrogen fuel network for industrial trucks and the heavy vehicle market. Consider OneH2's future hydrogen network and partnership it is developing in South Carolina. OneH2 is creating a new hydrogen truck ecosystem that will allow Navistar's vehicles, powered by GM's hydrogen fuel cell to be refueled by its modular, mobile, and scalable hydrogen production and fueling capabilities. Data sharing to optimize system performance will be required between GM (Battery suppliers), Navistar

(truck manufacturers), OneH2 (Hydrogen production and distribution network) and JB Hunt (transport services) to understand fuel demand. This places OneH2 at the center of a network which can be expanded and modified based on insights gained. It is partnering across the value chain to make GM, Navistar, and JB Hunt more efficient. What is notable is that they have moved beyond commodity provision to creating an ecosystem where they are central to their partner's success.

Fuel cell designers, hydrogen systems specialists, plant managers and logistics specialist will all work for different companies and yet each require something from each other to design an integrated system that works. Should OneH2 be successful in placing itself at the center of a network it could be beneficial to its long-term well-being. As an arranger of partnerships and broker of information OneH2 will be sought out for contacts that move beyond being a commodity. It also has a first entry advantage, establishing itself as the partner of choice and making the barriers to entry higher. When combined with its ability to broker information within the ecosystem it should help OneH2 maintain the health and wellbeing of the company for the future... Overall, 73% of energy and utility industry executives expect new-energy models to be their mainstream business within the next five years.

"71% of energy and utility industry executives say that energy and utility companies that do not implement new-energy models will be wiped out given the massive shift to decarbonization, digitization and decentralization."

E&U companies will have to learn to fail fast

Utility companies in Europe and North America are increasingly becoming large actors in the global energy stage. Iberdrola, Spanish multi-national utility recently announced its intention to build a 20-Megawatt electrolyzer project for an ammonia factory in Spain[16]. As Iberdrola builds out its project it will start to partner with those who benefit and create an ecosystem with Iberdrola at the center. This is a strategy that is repeating itself with other companies across the globe. What is interesting is that the project will not make any money. The work Iberdrola is doing is learning and failing fast to enter a new space where they see a long-term future allowing for intelligent learning and acquisition as more is understand from the business model. Iberdrola are demonstrating a

"Our project is not designed to generate profit, this is an innovation project, to test technology, help to drive down costs for the future and increase Iberdrola's knowledge and experience."

willingness to enter a new market and through partnership learn about the business for future application. It is through these partnerships that they become "partners or choice" and with insights more critical to the ecosystem. This is a competitive advantage over the companies that are currently on the sidelines watching or who see themselves not as an aggregator but commodity supplier. Commodity suppliers can be easily replaced. Replacing companies that not only provide the commodity but who connect others to the ecosystems for the benefits of all will have a sustainable competitive advantage.

Is Amazon becoming the energy company of the future?

To revisit the earlier statement that new entrants are filling the void and the production of Hydrogen is no longer the sole domain of existing energy companies. Consider the work that Amazon is doing through their $2 billion Climate Pledge Fund (CPF), their venture investment program to support the development of sustainable technologies and services to meet their net-zero carbon goal. Recently their CPF made investments in two companies, Electric Hydrogen and Sunfire, in their view two of the most promising US and European based developers of electrolyzers to make green hydrogen using water and renewable electricity.

> *"Amazon's Climate Pledge Fund is a model for corporate investment in pragmatic climate solutions. We are thrilled to have Amazon as a partner in decarbonizing industries like long-haul freight transport and aviation,"*
>
> *Raffi Garabedian, CEO of Electric Hydrogen*

Electric Hydrogen is a decarbonization company pioneering new technology for low-cost, high-efficiency, renewable hydrogen systems which includes freight transport. Amazon will partner with CPF to develop a hydrogen solution that supports their vision to decarbonize their operations. As Amazon decarbonizes its fleet through green Hydrogen (through many partnerships) they will intelligently learn and possibly acquire the company.

As they build out their capability, they will also reach a point where they have the capacity of to supply at a volume greater than its internal demand. At some point it transitions to being a consumer to consumer of Hydrogen and provider of solutions to others. When this is combined with its existing partnerships and insights from its own ecosystem, companies such as Amazon will pose a significant threat to the Energy and utility companies that exist today.

The E&U industry will have to focus on creating entirely new skills sets

The number of graduates joining the O&G upstream sector has fallen by 61 percent in the last four years[17]. In addition, many Petro technical professionals have retired, while those who wish to rejoin the industry lack the skills required by the latest technical enhancements. These combined trends threaten to lead to another generation-related skills gap, like that faced by O&G operators in the early 2000s because of a lack of hiring in the 1990s.

Digital innovation, coupled with new asset portfolios and the technology required to achieve decarbonization goals, will create new technical professional roles and redefine existing ones. The traditional roles of geologists, geophysicists and reservoir engineers will diminish with a greater demand for data analytics, digital and process automation. As technology rapidly changes, this will be an ongoing process, and as such, the workforce of the future will need continuous reskilling along a technology-oriented trajectory. The World Economic forum[18] estimates that by 2025, 50% of workers will need reskilling because of automation. While 85 million jobs will be replaced, 97 million new roles will emerge which are expected to have a heavy emphasis on data analytics, digital experience, and process automation with a new division of labor between humans, machines, and algorithms.

In making the transition to the new business models it will be imperative that the Energy and Utility companies have a highly technical workforce who can innovate, connect, and help optimize the future energy and utility systems. In its recent report, the World Economic Forum identifies the following top five skills for the workforce of 2025:

- Analytical thinking and innovation
- Active learning and learning strategies
- Complex problem-solving
- Critical thinking and analysis
- Creativity, originality, and initiative

These are not skills that are exclusive to one industry or sector. Analysis by Deloitte suggests that the power sector workforce could triple by 2035 so the fight to attract and maintain the workforce will be fierce. The analysis takes full account of power sector growth considering both core and the broader sector. The core being defined as utility scale electric generation, transmission, and distribution in

alignment with the US bureaus of labor statistics. This estimate is conservative as many booming sectors such as wind and solar have previously been captured in manufacturing sectors. As Energy and Utility adopt a more connected strategy, there will be a bigger demand for digital skills. Figure 25[19] shows the share of job postings from 2010 to 2020 with a huge shift in the need for data management and analysis. With a huge increase in data being generated through the IoT sensors, analysis to drive system improvements will require an increase in the workforce with skills that can drive systematic changes.

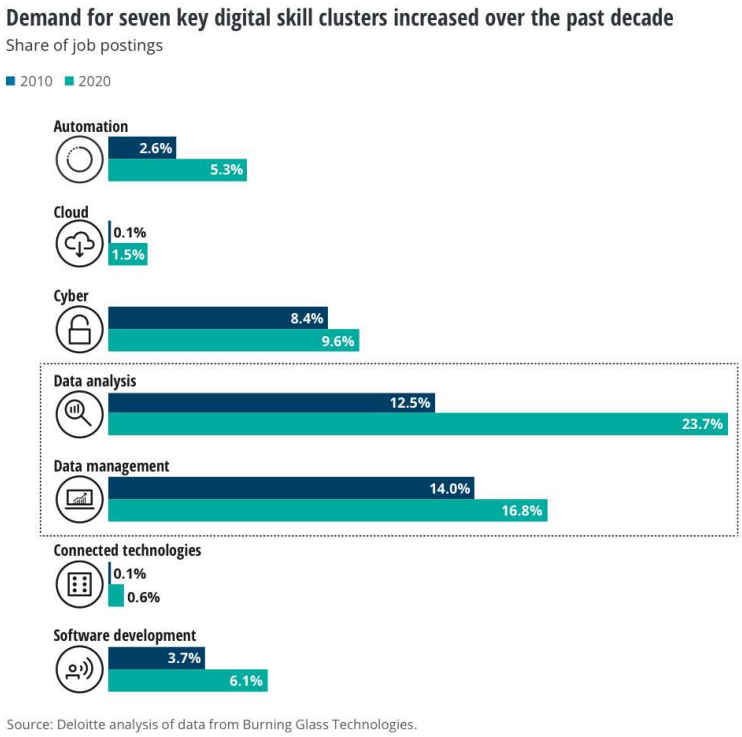


Figure 25 | Deloitte analysis of digital job postings from 2010 to 2020

Although the seven digital skills highlighted in Figure 25 exist within the current workforce today, they are in short supply to meet the future demand, and this will require a retraining of its existing workforce. Companies will need to attract the best talent from the workplace; however, they also will need to reskill their employees who are in traditional carbon jobs that heading to obsolescence. This has already started with many companies who are paying for their employees to take yearlong sabbaticals to learn the lates in data analytics, management and connected technologies. This however won't be enough.

Responding to employees' environmental concerns will be fundamental while connecting them to the sustainability purpose will be critical

Although there has been a decrease in graduates joining the Upstream sector of the business, the overall mix of is evolving as highlighted by research from the Center for Energy Workforce Development[20] The 2021 report has shown that there was an increase in the number of millennials up to 32% from 29 % the previous year, the workforce is getting younger. The turnover was also highest in this group with 60% of non-retirement attrition occurring in this demographic. Many quote leaving organizations as they are not aligned to their own values or purpose. In addition, employees have environmental concerns with many "looking for a job with environmental purpose." More than eight in 10 women and seven in 10 men say they want to play a role in tackling climate change. Connecting the company's vision and purpose to the employees will be a focus area that requires continuous effort.

New entrants are not held back having to satisfy existing customers whilst planning. OEMS in the transportation industry producing only electric or hydrogen powered vehicles do not have to concern themselves with moving at a pace that leaves behind and disenfranchise their employees and customers.

Andrew Roth (senior director of innovation and ventures for CLP Group, a Hong Kong–based regional energy supplier): "Sustainability is no longer just a thing to do on the side. It's becoming central to everything you do. I recently spoke with the CEO of White Peak, who operates residential real-estate complexes in China, and he believes that if you don't have a clear, transparent sustainability strategy, you won't be able to do business. That's how serious it's getting".

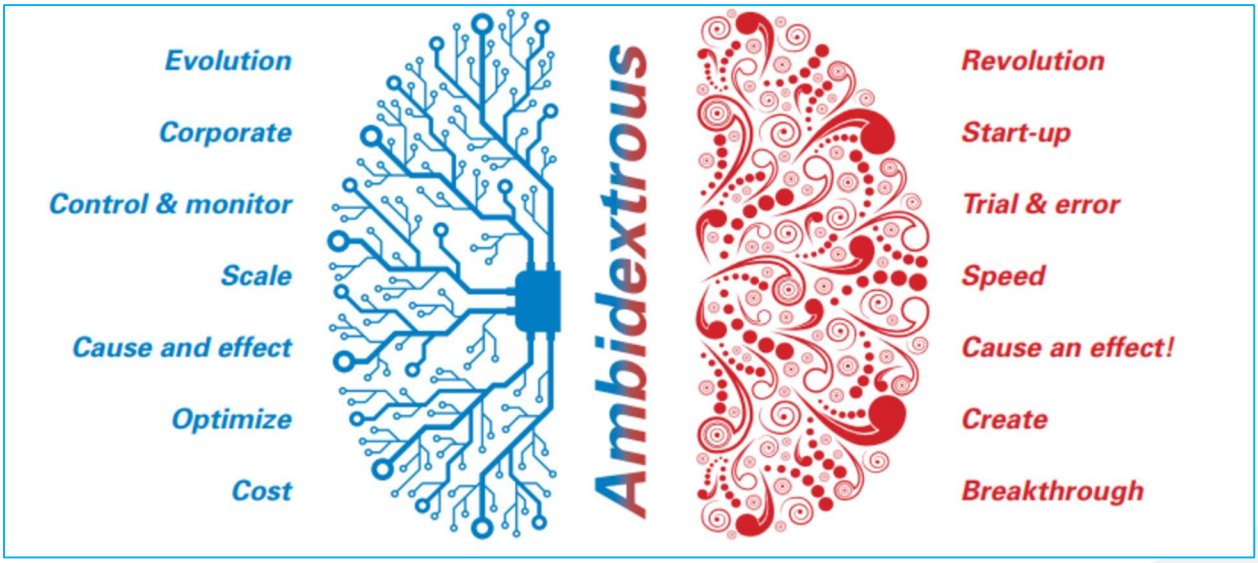
Companies will therefore need to re-connect their employees of today to their company's purpose, which will need to have a compelling story from a sustainability standpoint. To attract and then retain the best talent, companies will need to connect employees to work those matters. A workforce where they feel engaged and connected to purpose, empowered to act on and take decisions and energized around solving problems that matter. Employees need to see that the work they are doing is driving towards a bigger goal. What makes this hard is that for the established companies, they cannot leave behind or disenfranchise the employees who are working in the traditional business. Everyone must feel that they are part of this shared journey.

Organizational Design will be critical for success

For the Energy companies that are entering the new energy space, having an organizational construct that can take advantage of its existing tools and processes while exploring new opportunities will be very challenging. This mental balancing act can be one of the toughest of all managerial challenges as it requires executives to explore new opportunities even as they work diligently to exploit existing capabilities and it's no surprise that few companies do it well.

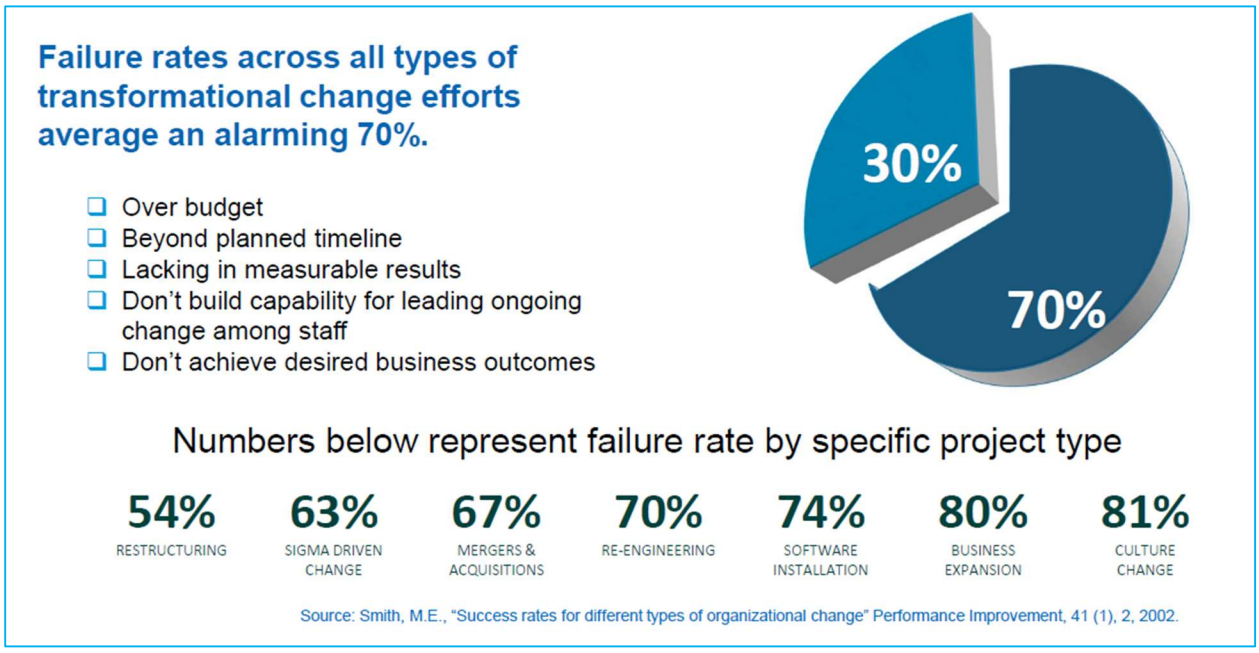
Ambidextrous organizational structure lends itself particularly well for this. With such a structure, even as sharing and synergy are promoted, the organizational integrity of the units is carefully maintained.

> *Because of its ambidextrous organization,* USA Today *has continued to compete aggressively in the mature business of daily print news while also developing a strong Internet franchise and providing Gannett television stations with coverage of breaking news. During the Internet collapse, when other papers' profits plunged,* USA Today *made $60 million, fueled in large part by the* company's ability to continue to attract national advertisers and by revenues from its profitable USAToday.com operation.



One should expect this to very difficult as most change efforts fail to meet their intended purpose[21]. Success rates for different types of organizational change show that if the change was simply a restructuring effort (e.g., a switch to an ambidextrous organization) 54% of the change efforts would fail

to meet the desired outcome. The failure rate increases to 81% when seen through the lens of culture (e.g., leveraging your current business while switching to a new innovative model).



For any enterprise change effort to take place the organizational leadership needs to break down existing silos and present a vision and path forward for the workforce that can be easily consumed and understood. What will be challenging is setting a vision for the entire organization that works for both the emerging and existing business. This paper does not address the challenges companies face in driving organizational change which is covered extensively by others however it wants to acknowledge that even with a compelling vision of the future, energizing the workforce to act on the vision will be incredibly hard.

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