HYGEN

Business Plan

Company Description: Hygen SIA is an ambitious and innovative Latvian SME dedicated to the development and commercialisation of refuelling technology for the natural gas vehicle (NGV) market. Our company has a host of awards to its name, including a 2018 EIT Innovators Award Nomination. Hygen employs 14 highly qualified staff and has a strong and ambitious leadership team consisting of Mario Parraglia (CEO) – executive positions at multiple gas and NGV related companies; Alex Safronov (Founder and CTO) – 20 year technical and entrepreneurial background in CNG industry; and Robert Strods (Co-Founder and COO) – specialist in finance, with successful track record in investment banking and project management. Julia Guzeyeva (Co-Founder), with support from key staff members, is leading the CEN European Standardisation Committee on gas vehicle fuelling appliances (VFAs). Alex Safronov, the inventor of the HYGEN core technology, founded the company in 2009 to develop and commercialise an innovative new approach to refuelling VFAs, at a time when others were spearheading solutions based on unreliable mechanical piston compression technology. Hygen has received a total of €3.5million, which it has helped to develop the HYGEN platform technology to TRL6. The technology has just been successfully independently tested by ENGIE Lab on behalf of GRDF, one of a number of large energy companies very interested in our HYGEN VFAs ("HYGEN-Plus" for business fleets and "HYGEN-Gasdroid" for homes).

Summary

Description of the innovation: HYGEN+ (HYGEN-Plus) is a solution for convenient and cost-efficient refuelling of NGVs that will transform the gas grid into a vehicle refuelling network. Our compact vehicle fuelling appliance (VFA) is simply installed at the user's home or business and connected to the gas grid (e.g. natural gas, biomethane, or synthetic e-gas). To refuel an NGV from the grid requires the gas (low pressure) to be compressed (high pressure) before injecting into the vehicle's fuel storage tank. Existing state-of-the-art (SoA) systems, based on mechanical compression technology, are too costly, require frequent servicing and are unreliable. As a result, these systems have yet to make any headway in this sizeable new market. Hygen's patented liquid piston compression technology, the only solution of this type in the world, allows us to both dramatically reduce the number of moving parts needed and to streamline the system. As a result, HYGEN+ goes well beyond the capabilities of the product offered by the current market leader COLTRI. Our solution is significantly cheaper (€17k vs €25.7k), has considerably lower maintenance costs during the service life (€5.7k vs €76.0k), and a faster refuel time (7mins vs 60mins @ 80L tank). COLTRI also lacks an integrated storage system and cannot be certified as a VFA (Vehicle Fuelling Appliance) when new CEN standards come into force late 2020/early 2021. We have 5 major players from the energy industry (GRDF, ENAGAS, GCA, FLUXYS, UNIPER) committed to piloting a certified HYGEN+ system (letters of support in Annex 3).

How HYGEN+ relates to the overall strategy of our company: To achieve market success, our company's strategy is to initially capitalise on the light commercial vehicles (LCVs or vans) segment of the market. HYGEN+ is specific to this segment. We have adopted this strategy for three main reasons. Firstly, the expansion of electric vehicles in the passenger car segment means our solution is more financially attractive in "business LCV" segment than the "home car" segment. Secondly, LCVs are not very well serviced by electric models, due to much lower range performance and significantly higher purchase costs. NGV LCVs are similarly priced to diesel LCVs and have a range of 500km. Thirdly, our potential customers and strategic partners (SEAT, ENAGAS, GRDF etc.) see a major gap in the LCV market for a compact VFA that can enable decentralised vehicle refuelling. Therefore, our strategy is primarily focused on certifying and piloting a HYGEN+ system for this segment of the market. With our HYGEN+ VFA pioneered for the LCV market, and HYGEN-Gasdroid (home VFA) for the passenger car market, we will generate annual sales of 927 units in 2024, breaking even in the same year. These sales will result in annual revenues of €8.9m and gross profits of €3.05m. By 2029, we intend to have rapidly scaled the business to become a large enterprise, with revenues in excess of €100m and employing over 250 staff in Latvia and across the rest of Europe.

1 EXELLENCE

1.1 Idea and Solution

1.1.1 Problem to be solved

Climate change, air quality and energy transition are among the greatest challenges in our society. Transportation sector accounts for 27% of all CO2 emissions in Europe with on-road vehicles accounting for 72.5% of CO2 emissions in transport. 94% of all energy used in the sector is still oil-based. Despite the continuous progress in improving vehicle efficiency, energy demand from the sector is growing. Consequently, CO2 emissions from the sector are still increasing representing and a reversal of this trend is currently not in sight. Therefore, the transport sector has to go through a deep transformation in the next decades. Gaseous fuels being biomethane, synthetic and natural gas represent a concrete answer to these challenges. As a vehicle fuel it emits up to 95% less PM and up to 70% less NOx compared with the very strict European emission standards for new heavy-duty vehicles (Euro VI) and light-duty vehicles (Euro 6) using petrol or diesel[1]. Exhaust gases from biomethane and natural gas engines are also free of other harmful and carcinogenic pollutants.

Furthermore, in addition to eradication of PM and NOx, CO_2 emissions can also be reduced by 95% (or even more according to some recent studies) through blending natural gas with biomethane or e-gas from renewable sources. Biomethane is a renewable energy source with very low carbon footprint; when applied as a fuel, it allows gas vehicles to run not only carbon neutral but also carbon negative if the biomethane is produced from waste. Biomethane is refined from biogas produced by the natural breakdown of organic material in waste from agriculture, municipal waste, plants, sewage or food waste. It has the same composition as natural gas (being the same methane), can be injected into the natural gas distribution grid and used directly by natural gas vehicles. Used in this manner, ***NGVs vehicles powered by biomethane produce the lowest amount of CO_2 emissions compared to all other transport modes*** (Figure 1.1[2]), even electric vehicles charged from renewable energy sources. In the ADAC 2019 EcoTest, the top two most environmentally friendly vehicles are CNG powered. Of the 6 vehicles to receive a 5-Star rating, half are NGVs[3].

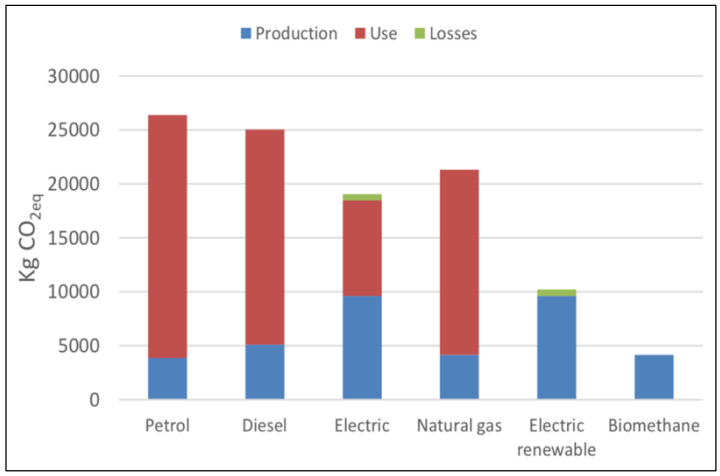

Figure 1.1: Full vehicle environmental impact for alternative fuels

Despite these benefits, NGVs are viewed as an unattractive proposition to the consumer due to the inconvenience and/or inability to refuel such vehicles. Apart from Italy, very few countries in Europe have an extensive network of gas refuelling stations. With ~58% of all electric vehicles sold in conjunction with a home charging, and another ~25% on the premise that there is a charger on a parking lot in the customers office, EV market rollout has proven that the availability of decentralised "fuelling" is essential to wider market adoption of alternative fuel vehicles. This is especially the case in the early phases of market development.

In spite of the successful market rollout as demonstrated by recent market research, battery technology is not capable of delivering for all segments of the market. In its last annual report, The European Automobile Manufacturers Association stated that nearly all of the commercial vehicles are run on diesel[4]. Users of commercial vehicles require greater range than that typically afforded by battery power drive trains 120-140km. The number of diesel light commercial vehicles (LCVs or vans) on Europe's roads increased by 2.3% and 2.7% respectively in the past 5 years, raising serious challenges to our zero-emissions targets and the upcoming diesel and petrol vehicles.

NGVs with their clean burning engines, mature technology and renewable gas flexibility combined with successful and proven concept of decentralised refuelling presents an interesting market

[1] www.ngva.eu/policy-priorities/renewable-gas/
[2] The Oxford Institute for Energy Studies, 2019; "A review of prospects for natural gas as a fuel in road transport"
[3] www.adac.de/rund-ums-fahrzeug/tests/ecotest/ecotest-ranking-sauberste-autos/
[4] https://trans.info, EC Data; "Nearly all commercial vehicles still run on diesel"

opportunity. In the same way as electricity, gas is being delivered to more than 260 million homes and offices worldwide[5]. With decentralised refuelling, these gas connection points have the potential to be turned into refuelling points. However, although many have tried, **no solution has managed to fully address the requirements for decentralised NGV refuelling; economical purchase price, simple to install and low maintenance**.

The most widely publicised company to have attempted a decentralised solution for NGV home-refuelling (2x vehicle capacity) is Fuel-Maker. Its solution was based on reciprocating piston technology. The company received significant private equity investment, reportedly in excess of €50million. Gas de France had even pre-ordered 2,000 of its home refuelling units. However, Fuel-Maker was unable to deliver upon its cost and reliability targets. Following this failure, the company was acquired by BRC and there remains no viable home refuelling solutions currently on the market. For business fuelling (+5x vehicles capacity) only Coltri, an Italian company, offers a refuelling solution through its CNG MCH 14 traditional piston compressor system. The market has reported widely on the unreliable nature of the system, while independent tests by ENGIE Lab on the CNG MCH 14 and HYGEN+ (HYGEN-Plus) proved the superiority of our system. GRDF, the gas utility that commissioned the tests, decided to continue to the next stages of its commercial and market negotiations with Hygen only, excluding Coltri from the process.

It is abundantly clear that **for decentralised CNG fuelling to be a success, a business model based on very low total cost of ownership is a critical**. Without one, the "chicken and egg" problem to NGV enablement will persist.

1.1.2 HYGEN+ – an innovative solution

Hygen SIA introduces HYGEN+, an on-site refuelling appliance for natural gas vehicles (Figure 1.2). On-site refuelling with HYGEN+ will "level playing field" for environ mentally friendly NGVs, in what is already common practice for households and businesses with electric vehicles. It will enable a future alternative fuel transport mode to flourish, where growth has been depressed due to a bottleneck in the number of public gas refuelling stations. Unlike large centralised public stations that require millions of euros to build, HYGEN+ is a cost-effective decentralised system, dedicated to the owner of the NGV. By offering convenient refuelling for the motorist, HYGEN+ removes the bottleneck of a limited centralised refuelling network of stations.

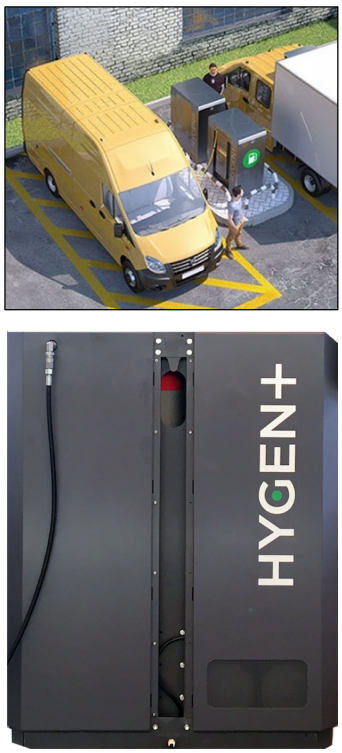

Figure 1.2: HYGEN+ (Top) how HYGEN+ will be used to refuel LCVs

We are the only company to base its refuelling system on liquid piston technology, a world's first for CNG refuelling. The innovative nature of HYGEN+, described in Section 1.2., gives our solution a significant edge over the competition and provides the following unrivalled user benefits to NGV owners:

- Faster refuelling (7 mins – standard 80L tank) than competition and more convenient/practical than visiting public CNG filling station.
- 35% fuel cost savings when using HYGEN+ CNG versus diesel, 25% better than nearest competitor (Figure 1.3).
- No upfront investment for end user (our business model allows gas companies to own, install and maintain HYGEN+), the user only pays for the fuel.
- Low electrical consumption (0.45kWh/GLE) and noise levels (65dB).
- Allows end-user companies to "Green" their fleet of vehicles, moving to g-Mobility without compromising on cost and vehicle range.

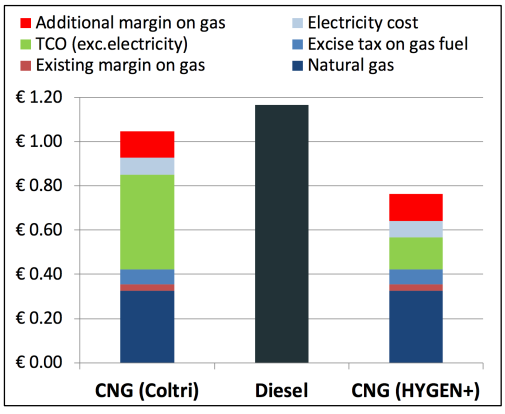

Figure 1.3: CNG price with Coltri vs HYGEN+ vs Diesel price (litre equivalent)

HYGEN+ also enables our customers, the gas companies, to offer their customers' CNG at a competitive price compared to diesel/petrol and the unique customer

[5] KPMG market research done for Hygen in 2014

experience of fast at the office/home refuelling. Our range of unique customer benefits are summarised overleaf.

- Viable means to increase biomethane and syngas sales and decarbonise the grid.
- Year around volume increase (not seasonal i.e. space heating in winter period).
- Increase utilisation of existing assets for Transmission and Distribution Service Operators (T/DSOs).
- Known and predictable customer acquisition costs.
- Leading the transition from diesel to g-Mobility.
- Support decarbonisation of the gas grid and reduction in carbon footprint
- Significantly lower total cost of ownership (TCO) versus market leader Coltri. No moving parts dramatically reduces maintenance and TCO costs. The hydraulic pump is the only "friction" part. In the unlikely event it fails, replacement costs less than €100.
- Low TCO is a critical enabler for the model of decentralised refuelling.
- **As a user of HYGEN+** for their own >50,000 fleet of vehicles, T/DSOs benefit from cheap gas and even lower running costs than the rest of the market.

We have been engaging with a cross spectrum of end-users including major OEMs and gas operators (see Figure 1.4 and Section 2.3). For example, VW Group are currently testing our technology. GRDF, the main French gas company which we met at world gas conference in 2018, paid for a HYGEN+ prototype and for it to be independently tested against market leader Coltri. Gas Connect Austria, the gas transmission service operator (TSO), piloted the HYGEN-Gasdroid home-fuelling technology and expressed a keen interest a larger business fuelling solution for business and have committed to piloting HYGEN+ (see letter of support). These are just some of the very large potential customers showing a very high degree of interest in our breakthrough solution.

Figure 1.4: Selection of companies and OEMs that are closely engaged with Hygen

1.1.3 Objectives

The overall objective of this project is to pilot and demonstrate our product with key strategic partners, optimise the design for market scale-up, and complete the final stages of certification and standards implementation. Table 1.1 contains the project's specific measurable objectives.

Table 1.1: The major objectives for the HYGEN+ project

No.	Objective	Measure of Success	
1	To optimise the design of the HYGEN+	The design conforms to explosion protection and electrical safety certification requirements. Software bugs in the current system are removed and working algorithm updated. The design meets serviceability and manufacturability requirements. Optimised flow rates and heat transfer. Off-the-shelf (OTS) components used where possible.	
2	To build 5x TRL8 HYGEN+ systems for piloting with owners of LCV (Light Commercial Vehicle) Fleet owners	• Compression flow rate: 4.8**GLE***/h (4.4 m3/h) • Maximum gas outlet pressure: 200 bar • System storage capacity: 98**GLE** @ 200bar (90 m^3) • Fuelling time: 7 min (27GLE) • Electric consumption: 0.45kWh/GLE (0.5kWh/m^3) • Gas inlet pressure: 17 mbar to 6 bar	**** GLE = Gas Litre Equivalent** is a metric used to compare the amount of gas to an equivalent litre of gasoline fuel.*

3	To undertake 5x pilots with strategic industry partners and potential customers in initial target markets: GER, BEL, AUT, SPA, FRA.	**(1) SEAT HQ** (OEM) and **ENAGAS** (TSO) - pilot carried out in SPAIN, 1x HYGEN+ at SEAT HQ. **(2) Fluxys** (Belgian TSO) and **Gas.BE** (Belgian gas association) joint pilot carried out in BELGIUM. **(3) GRDF** (French DSO) Gaz Réseau Distribution France single pilot carried out in FRANCE. **(4) UNIPER** (largest German gas wholesales company) single pilot carried out in GERMANY. **(5) GasConnect** (Austrian TSO) – in AUSTRIA.
4	To gain approval for sale and operation in Europe	PED (Pressure Energy Directive) Certificate and CE mark obtained and HYGEN+ CE Declaration approved. New incoming EU harmonised standard for Vehicle Fuelling Appliances is published and implemented into national law in each of the key markets.

1.2 Innovativeness

1.2.1 Advantage over existing alternatives

Figure 1.5: Our COO and Co-Founder Robert Strods speaking at 5th EU Energy Summit

The reputation of Hygen's technology is growing every year. We were an invited guest at The 5th European Energy Summit, where we presented the case for decentralised CNG fuelling as a key enabler to sustainable g-Mobility (Figure 1.5). Our technology holds a number of major advantages over existing solutions, which are critical to decentralised CNG refuelling. Existing alternatives employ reciprocating compressor technology and are unreliable. These compressors use an electric motor to rotate a crankshaft, which is tied to several metal pistons that pump to compress gas. The technology requires pistons and piston rings, crankshaft and bearings, cylinders and valves. Since all these components generate friction and heat during operation, the compressor and related components require regular maintenance and a complete compressor overhaul at specified service intervals, which is costly. And, even with regular servicing, unexpected component failure is often experienced. In many cases, the combined maintenance costs end up being higher than the cost of the equipment itself. Since most of the components in reciprocating compressor solutions are specifically designed and manufactured, these tend to cost more and often have longer lead times for replacement parts. Traditional compressor systems tend to be inefficient and their complex components make them expensive to manufacture, difficult to maintain, and short-lived.

HYGEN+ overcomes reliability issues by eliminating the need for moving parts within the compressor, leaving no requirement for compressor service and overhaul. The HYGEN+ does require some minor regular service, such as gas filter replacement (like other systems require) however, the high service cost associated with compressor is no longer necessary, therefore substantially decreasing the TCO. **A very low total cost of ownership is a critical enabler for the whole business model of decentralised CNG fuelling solutions.** Due to lower cost of components in the compressor we can incorporate a storage system for fast fill capability and still remain competitive on price.

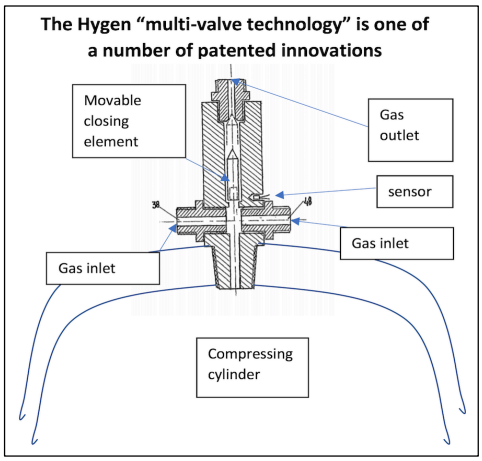

Figure 1.6: Multi valve HYGEN+ innovation

The basis for the HYGEN+ system is: two high pressure cylinders, hydraulic pump with motor, set of valves allowing direct and reverse flow of hydraulic liquid between two compressing cylinders. It is a "closed-loop" hydraulic system, unlike conventional mechanical compression fuelling appliances. There is no additional draining hydraulic reservoirs in the design of our system. Our solution consists of a number of key patented innovations, including a "multi-valve" that allows safe and reliable operation. The multi-value, shown in Figure 1.6, is placed in the upper neck of both compressing cylinders. The valve provides safe shut-off when the hydraulic fluid - acting as a liquid piston - reaches the very top of the cylinder and forces the compressed gas out. As such, it protects the outlet gas line from penetration of the working liquid, as well as allowing the entire release of the compressed gas from the compressing cylinder (also known as liquid/gas carryover). As such, HYGEN+ is able to provide considerably higher efficiency compared to other liquid piston technologies.

When first presented with the HYGEN+ system for independent testing, both ENGIE Labs and GTI (Gas Technology Institute) USA, voiced their reservations about how our technology would address the liquid/gas carryover issue prevalent in liquid piston systems. However, **as a result of our unique approach, ENGIE Labs and GTI discovered that the prevention of liquid/gas carry over by HYGEN+ was the best of any small-scale compressor systems tested**, equivalent to mechanical reciprocating compressors at public CNG stations.

Our patented system allows HYGEN+ to fill a vehicle's fuel tank in two quick-succession stages (Figure 1.7):

A. Free flow partial-fill: gas flows from the HYGEN+ storage into the vehicle's fuel tank (80-120 bar)
B. Boost flow full-fill: the remaining gas in the storage tank is supplied to the compressing cylinders for further compression (boosting to 200 bar) and transferred to the vehicle fuel tank for 100% fill.

By performing these two rapid-succession stages, HYGEN+ provides complete and rapid filling of the vehicle tank (200 bar). **There is no similar system in the World that can achieve this, which we manage by combining the hydraulic liquid piston technology for both gas compression and for storage system evacuation**. HYGEN+ is a unique fuelling appliance, in that both compressing and boosting modes are performed by the same components - compressing cylinders and elements of hydraulic drive. This allows us to make the fuelling appliance cost effective and convenient for the user. **The limitations of specific competing solutions in comparison to HYGEN+ are described**.

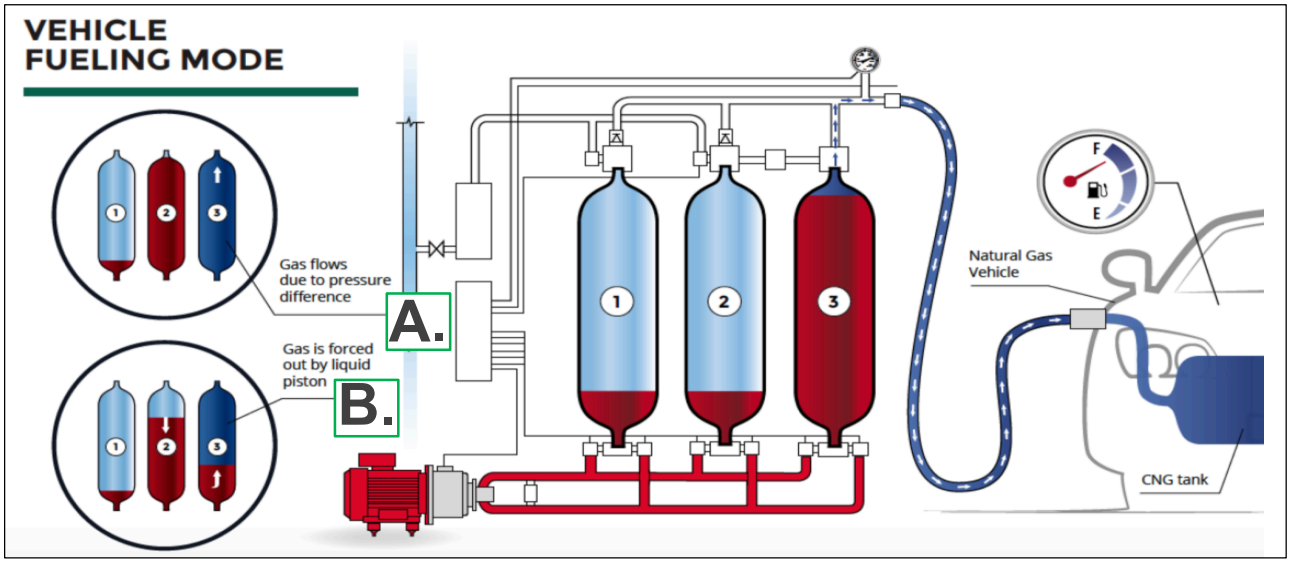

Figure 1.7: HYGEN+ multifunctional liquid piston compression (red – liquid; blue – gas)

- **GE Appliances, Whirlpool and Cheseapeak Energy** – Reciprocating Compression
  In 2013, Chesapeake Energy, the second-largest producer of natural gas in USA, teamed up with GE Appliances. and Whirlpool Corp. to develop a $500 home-refuelling unit. The collaboration did not produce any tangible results. At the time, both GE and Whirlpool made announcements at 2013 ACT Expo clarifying that their projects are in the very early research and development stages. Both companies provided no information on potential completion release year, distribution channels, nor on anticipated GGE per hour i.e. the time taken to fill the vehicle's CNG tank.

  BRC FuelMaker – Reciprocating Compression**:** FuelMaker was probably the leading company in the past decade to try to develop reliable and cost-effective small-scale refuelling stations. **Alex our CTO, was a European regional manager at FuelMaker during this period and could see for himself the flaws in the company's technology approach**. The company was sold to BRC (an Italian compressor company) in 2009, when it failed to deliver upon its development objectives. The €1,000 target price was never achieved and the product in the end the costs exceeded €5,000. The reliability should have been 7,000hrs to overhaul but ended up being 2,000hrs (replacement of the compressor). Despite its best efforts, FuelMaker failed due to reliability issues, delayed timelines,

and the high price of its solution, mainly as a result of the mechanical piston compression technology being employed.

- **Coltri CNG MCH 14** – Reciprocating Compression: As outlined in Section 1.1, Coltri CNG MCH 14 is the leading CNG refuelling solution for business fleets. As part of GRDF's interest in HYGEN+, it requested that our solution be evaluated and compared against the next best competitor CNG MCH 14, which is mechanical piston compressor technology. The study was carried out by ENGIE Lab CRIGEN, an evaluation and testing arm of ENGIE; a business based on responsible growth to take on the major challenges of energy's transition to a low-carbon economy. The technical characterisation of two compressors was performed using a test bench developed by ENGIE to monitor the thermodynamic parameters of different NGV cylinder configurations (up to 780L Cylinders). Additionally, the electrical consumption of the device as well as the gas quality after passing through the compressor were monitored.

  The test results showed that the COLTRI compressor refilled an 80L tank in 1hour, compared with 7minutes for HYGEN+. The total electrical consumption needed to fill of a 240L volume storage tank at 200bar was measured to be 17.11 kWh for Coltri CNG MCH 14, compared to 2.04 kWh for HYGEN+. The commercial advantages of HYGEN+ over Coltri are displayed in Table 2.2 in Section 2.1. During final testing at ENGIE Labs, the Coltri system experienced part failure and could therefore not complete the entire test regime. This again highlights the reliability issues for Coltri. The system has sold a few hundred units in Italy and the Czech Republic, but high TCO prevents wider uptake of the Coltri system.

- **Various** – Liquid Piston Compression (LPC): To the best of our knowledge there are no LPC solutions on the market. Some companies have patented LPC systems (the closest related being: US 4,805,674 Knowlton, US 6,652,243 B2 Krasnov, US 5,454,408 DiBella). All of these patents were opposed during the granting of our patent. Furthermore, there are a number of common limitations between the technologies presented in these patents. Firstly, they are not capable of addressing the problem of contamination i.e. where the liquid contaminates the gas under pressure, or vice-versa, where the gas contaminates the liquid under depressurisation.

1.2.2 Timeliness of innovation

HYGEN+ is on the cusp of market readiness, right at the moment when it is more critical than ever to reduce particulate matter and GHG emissions. **In 2021, regulations will impose a CO_2 emission limit on OEM fleets, set at 95 g CO2 eq/km (based on annual sales)**. Penalties will be incurred if the manufacturer breaches this ceiling. In this harsh regulatory context, a performance improvement in combustion engines alone will not be sufficient, strongly encouraging manufacturers to use other low-carbon technologies. In addition to this, Denmark, backed by 10 other European Union countries, has called for a European Union strategy on the phase out diesel and petrol cars, including allowing **the ban of sales at member state-level by 2030** to combat climate change. While the **banning of all diesel and petrol vehicles under 3.5T, which includes light commercial vehicles (LCVs)**, is for the good for society and the environment, it will result in significant challenges for both the transport and energy industries.

EVs that are fantastic alternative for passenger cars, but will face challenges in terms of scaling up production to meet demand: increases in battery production, drive trains etc. Ensuring that the electricity grid can provide sufficient energy for all the millions of new EV cars coming onto the market. Banning of petrol and diesel cars will also create other such as, requiring the poorest in our society to upgrade their existing vehicles for more expensive electric vehicles.

HYGEN+ is coming at **the right time to assist the drive towards a carbon neutral economy, as electric vehicles alone cannot solve all the issues outlined**. It is the perfect replacement solution for diesel LCVs, a very large segment within which EVs fall short. HYGEN+ will also help those in inequitable financial circumstances as outlined in the EC's Green Deal. Rather than having to trade up to EVs at a much greater cost, there is the option for them to upgrade their existing combustion engine vehicles can be easily and cheaply retrofitted for clean gas power. New NGVs are also similarly priced to diesel, unlike EVs.

Furthermore, the **incoming CEN standard in 2020/21 will open up the market for decentralised VFA solutions** (see Section 1.3.2). We are therefore well placed to ensure HYGEN+ can take maximum advantage of this important opportunity. NGVs, fuelled by near-zero PM emissions natural gas and/or near-zero CO_2 emissions biomethane, with the right fuelling infrastructure can thrive and provide a sustainable transport mode for now and into the future. HYGEN+ can deliver a convenient

fuelling solution without the need for massive governmental investment in refuelling infrastructure. Not only this, **HYGEN+ comes at a time when the biogas sector is maturing. Biomethane, supplied through the gas grid will be further economically enabled as it can compete even more competitively on price when sold as a transport fuel**.

1.3 Stage of Development

1.3.1 Achievements to date

The initial concept for the core proprietary liquid compression technology was developed in 2007. Hygen filed for its first patent in 2008, which proved to be an extremely robust application, with 6 claims granted, 2 on the method and 4 on the device itself. Hygen's IP is now patent protected in more than 50 countries globally, including Europe, USA, and Canada.

Hygen Awards and Recognitions

- 2020 - **Start Up Energy Transition (SET) Award**, the Top 100 Start-Ups of 2020 WEC
- 2019 – **European Start-up Prize for Mobility** - top 50
- 2019 - **Top 7 Global winner of the H2 Refuel Accelerator**, sponsored by Toyota
- 2018 - **EIT Innovators Award Nomination**
- 2018 - **Start Up Energy Transition (SET) Award**
- 2015 - **European Venture Contest Germany** Top 5

- **2009** – Company established in December 2009 by Alex Safronov and Julia Guzeyeva, and Robert Strods. **Hygen secured a long-term investment loan of €50,000 from the local business incubator centre** in Latvia, helping the company to successfully develop and build a laboratory concept system.
- **2011** - **Hygen was awarded €400,000 in funding** from the national Climate Change Mitigation Instrument program to develop its technology for refuelling CNG stations.
- **2014** - Hygen was approach by KPMG on behalf of InnoEnergy. KPMG was responsible for InnoEnergy's scouting activities. InnoEnergy saw a significant opportunity for the HYGEN technology in decentralised refuelling – "home refuelling" (home or business). InnoEnergy provided Hygen with €50k to carry out a feasibility study (due diligence) for 6 months.
- **2015** - InnoEnergy invest €2.9million in Hygen following the results of the feasibility study, allowing further development.
- **2016** – **TRL5 achieved** through project in collaboration with AGH University of Science and Technology, a technical university in Kraków Poland, and Bay Zoltan Research Centre, Budapest Hungary. The project was aimed at validating the technology in a relevant environment.
- **2018** - our engagement with VW Group commences. System redesigned to meet VW and wider market requirements. VW support Hygen throughout the design process. The redesign of the Gasdroid (home-refuelling; 2x vehicles) was successfully completed end of 2019 and the pilot with VW is to be relaunching May 2020.
- **2019** - GasConnect Austria (GCA) a gas transmission services operator (TSO), pilot Gasdroid. Success of pilot leads GasConnect to market the pilot on its website homepage (Figure 1.8 – source GasConnect.at). SEAT Austria (Porsche Holding, also a major shareholder of VW Group) picked up on the pilot and its results and invited Hygen to display Gasdroid on their booth at Vienna Autoshow (Figure 1.9).

Figure 1.8: GasConnect pilot

Figure 1.9: Hygen was a guest of SEAT Austria at the Vienna Autoshow

- **2019** – Hygen scale-up technology for LCV business refuelling (5x LCV vehicles). GRDF pilot technology and commission independent tests versus market leader. GRDF publishes successful results on its website[6] and chooses to proceed with HYGEN+.
- **2020** – multiple engagement with potential customers and end-user (see 2.3 external strategic partners)

1.3.2 Further steps to achieve commercialisation

Since we began our technology development journey, EVs have gained a lot of traction, especially in the last 5 years. Therefore, many OEMs and dealerships are focused on selling EVs passenger

[6] www.grdf.fr/documents/10184/6229674/CNG+-+Testing+Report+for+HYGEN.pdf/ (abbreviated – link embedded)

cars. Our potential customers and strategic partners (Enagas, GRDF, SEAT/VW amongst others) see a major gap in existing viable solutions and/or fuelling infrastructure in the light commercial vehicle market where EV performance falls well short. They have therefore asked us to focus our technology in this segment. The HYGEN+ prototype is a scaled-up version of Gasdroid. The work we have done in the past year has been to reconfigure the design and supply the prototype to GRDF and ENGIE Lab for testing. The success achieved in these tests, carried out by ENGIE Lab, means we are now in a position to proceed towards the final stages of market readiness. To achieve commercialisation, we therefore need to carry out a number of activities in order to remove exploitation bottlenecks: design for production, certification, accelerate the harmonisation of the new VFA standard, and industry piloting with key potential customers.

DESIGN FOR PRODUCTION: We will refine the design of HYGEN+ to make it market ready. Firstly, the HYGEN+ prototype is not certifiable for explosion protection and electrical safety. Secondly, currently used components in the system are overly expensive and interconnectedness of sub-systems sub-optimal. It should be rethought and some of the components exchanged. This will required the change in working algorithm which needs to be updated. Thirdly, the current prototype is not easily installable, serviceable and manufacturability is low. Flow rates and heat transfer will be optimised. We will also source off-the-shelf (OTS) components for the production prototype and reconfigure subsystems for easier assembly, installation, serviceability, performance with cost competitiveness and compliance with applicable codes and standards in mind. An assembly line plan will also be devised to deliver a quality assured production prototype. This will include sub-assembly workstations, workstation instructions, systematic manuals, inventory system, post-assembly testing procedures (performance and reliability testing), packaging procedures, and documentation requirements for the assembly plant.

PED
Certification

CE

CERTIFICATION: To carry out the certification process Hygen will need to produce a range of documentation (see footnote[7]). The documentation will be assessed by a notified body (e.g. TÜV, KIWA) to ensure conformity to all relevant standards. Following assessment, we will receive full feedback, possible requiring us to make corrections. In parallel, we will need to provide detailed explanations in relation the rational for each of the design elements and how they comply with applicable codes and standards.

The conformity assessment also includes inspection and testing of the HYGEN+ production prototype system by the notified body. The type of testing includes: tests verifying the results of risk analysis, pressure tests, gas leakage tests, electromagnetic testing; stress testing; fire testing and component performance testing etc. The production prototype built in Work Package 1 will be used to make all the necessary tests required by notified body.

The result of these activities will be a certificate form the notified body, along with a documentation package verifying the HYGEN+ appliance conforms to the CEN Directive and CE Marking. The documents will also verify that HYGEN+ complies to all other applicable directives, standards, local codes and regulations and can be legitimately deployed in any European Union country.

STANDARDISATION: Hygen is a participant in the EU standardisation Committee CEN/TC 326, in particular Working Group 6 (WG6), Natural Gas Vehicles – Vehicle Fuelling Appliances (VFAs). WG6 created a draft of the new standard - prEN17278, which will remove the requirement for residential and small business fuelling appliances to adhere to the procedures applicable for large station regulation. It is based on industry standards already in place in the USA (e.g. ANSI NGV 5.2-2017) for “small business fleet on-site” VFAs. This new European standard prEN17278 is to be published by December 2020. We will then need to work with the standardisation bodies in our target market countries to accelerate the adoption of prEN17278 into national law and regulations, which is mandatory under European Law. Since no distinction is currently made between VFAs for large public CNG stations and small scale-refuelling points, the permitting process for HYGEN+ is made considerably longer (up to 6 months) and much more expensive (€8,000) than it needs to be, thereby limiting the scalability potential of our product. With

[7] **The documentation that we will be required to produce will need to reflect the final design of the product and will include:** 3D drawings of the product, P&ID (piping and instrumentation diagrams), electric scheme, electronics diagram, software code, BOM (Bill of Materials), description of the working algorithm, flow diagram, results of risk analysis and testing done internally, Installation and Service manual, User Manual, etc.

the new standard in place, no permit will be needed, only the submission of a registration document and payment of a one-off €500-€1k registration fee. One of our five initial target markets is Germany. The relevant body here is DVGW. HYGEN is in touch with Mr. Tilo Scheibe, a leading expert on gas fuelling stations and their standards in Germany (see Section 2.2.2). When this activity is successfully completed, the new standards adopted in national laws and regulations will ensure costs effective, fast and simple (scalable) installation and commissioning in our target countries.

INDUSTRY PILOTING WITH INTERESTED CUSTOMERS: We will confirm and onboard the largest and most scalable direct customers and/or distributors in our target market countries with whom we have signed letters of intent (LOIs - Annex 3). The companies committed and signed up for our pilots are as follows:

1. **SEAT HQ** (OEM) and **ENAGAS** (TSO) - pilot carried out in SPAIN, ENAGAS will install HYGEN+ equipment at the SEAT site and the LCV NGVs (SEAT TGI) vehicles would be fuelled from HYGEN+.
2. **Fluxys** (Belgian TSO) and **Gas.BE** (Belgian gas association) - joint pilot carried out in BELGIUM, tested at the Fluxys site and the information distributed by Gas.BE.
3. **GRDF** (French DSO) Gaz Réseau Distribution France - single pilot carried out in FRANCE,
4. **UNIPER** (largest German gas wholesales company) - single pilot carried out in GERMANY,
5. **GasConnect** (Austrian TSO) – single pilot carried out in AUSTRIA.

As it's likely that the standardisation work will not be completed by the time pilots commence, we will therefore need to obtain a permit in order to commission and run the unit. We will need to engage with local authority having jurisdiction, present the product, its safety design and features, explain risk mitigation strategies we have applied in the design and how that complies to local codes, standards and regulations. A permit has been secured for our previous trials, so we are well versed in the requirements of this process.

As permits are received, we will begin to install and commission the HYGEN+ systems. The pilots will be carried out in an operational environment. The performance of the systems will be monitored and data gathered. The pilots will also include evaluation of the operational performance, costs, durability, reliability, usability, safety, noise level, and obtain qualitative data in the form of feedback from our pilot partner regarding subjective evaluation aspects. Over a 3-month, as the pilots are successfully concluded, HYGEN+ will reach TRL 8; system complete and qualified in our 5 initial target markets: Spain, France, Belgium, Germany and Austria.

1.4 Feasibility and Risks

1.4.1 Technological, practical and economic feasibility

Working with key OEM and Gas Operators across the sector, we have undertaken a full economic feasibility i.e. a cost-benefit analysis of the innovation project to assess whether it is possible to implement. Our assessment consisted of market analysis, economic analysis, technical and strategic analysis has demonstrated HYGEN+ as a highly feasible market innovation. HYGEN+ is similar to any gas appliance (for example gas heater) it will be very easy to integrate the technology with the existing processes and systems in gas industry.

Furthermore, an NGV is simply a vehicle with a conventional internal combustion engine that has been modified to run natural gas or biomethane. Numerous OEM models are available, but it is also common practice to modify existing vehicles to run on gas. There is no need to come up with a new system or a process. The fundamentals of CNG as an alternative fuel is established and in widespread use. Therefore, our approach only combines CNG as alternative fuel and our product as a gas appliance. As outlined, the product category has established industry standards in the USA (e.g. ANSI NGV 5.2-2017) with new incoming EU standards coming later this year. By introducing HYGEN+ in a well-known product category, we are significantly improving the cost efficiency and convenience of using the product and therefore enabling the

Figure 1.10: Testing HYGEN+ at

market of decentralized fuelling of g-Mobility. Our technology has already been tested in the field at GTI, Eesti Gaas, AGH Krakow university and VW Group.

The technical and practical feasibility of HYGEN+ has been further affirmed through independent testing carried out by ENGIE Labs on behalf of GRDF (Figure 1.10). In its report, ENGIE stated that the HYGEN+ system is a "***very interesting technology that could easily be deployed for private fleet"***. The report also confirmed that "***the behaviour of the system complies with the needs of NGV fleets"***. ENGIE recommended some small improvements to the system, which will be made during WP1 of this project. Firstly, simplify user operation through the introduction of one control button instead of two. Secondly, to make filling even faster by developing free flow protocol, which could reduce fill time by about 1 min by setting a pressure cut-off value instead of a time cut-off value. Finally, ENGIE suggested that the system could be even further improved by increasing the inner buffer storage. This would allow HYGEN+ system to be adapted to larger vehicles or a larger fleet size, as well as reducing the time for filling the tank up to 200 bars.

The greatest risk to rapid exploitation of our solution is the potential that there are delays to the implementation of standards being adopted and enshrined in national law. In spite of CE certification, you can install the system but cannot operate without the national permit. Therefore, for every system installed, we need to hire an engineer to complete the permit and this typically takes up to 6 months. We want to avoid a situation where a permit is needed every time, as this reduces the attractiveness of our solution. The customer doesn't want this type of inconvenience when considering the purchase of a new product for their business. Although such a scenario would not prevent an attractive exploitation situation, we will mitigate this risk through work we carry out in this project.

2 IMPACT

2.1 Markets and Customers

2.1.1 Potential market and customers

In total, there are 31.6million light commercial vehicles (LCVs) in use around Europe[8], all of which help to power the European economy. Global growth of 6-7% CAGR in this segment is predicted over the period 2020 and 2024 (Figure 2.1)[9]. We can expect even higher figures in Europe since e-commerce is forecast to more than double between 2017 and 2025[10], a prime driver for LCV growth. Out of all vehicles registered in Europe during the last year, 2.1 million (12%) were LCVs. Almost all were either diesel (94%) or gasoline-fuelled (4%). At 6.2million vehicles, France has by far the largest LCV fleet, followed by Spain (4.6m). Together with Germany, Belgium and Austria, these countries will form our initial target markets; representing 1.1 million LCV registrations in 2019, accounting for 53.1% of total EU market.

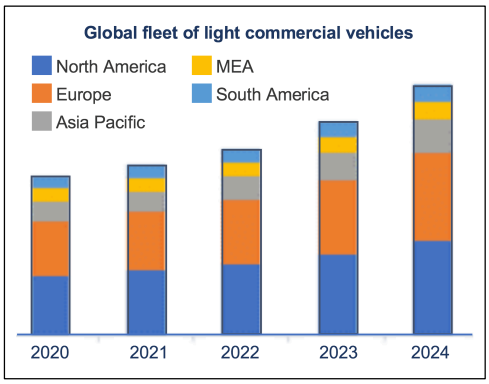

Figure 2.1: Future growth in LCV segment

Unlike passenger cars, the price sensitivity for LCVs is extremely high, with purchasing and operating costs being the number one deciding factor for fleet owners. Given limited range and long charging times, battery electric (BEV) LCVs are generally only used for city centre distribution or other relatively short distances[11]. Even in short distance applications, the higher acquisition cost of the vehicle and reduced payload (due to weight of the batteries under maximum weight regulations) as well as limited battery range makes BEVs a totally unviable option for businesses[12]. **Comparing the purchasing prices of electric LCVs to similarly equipped diesel vehicles reveals a significant 67% price gap in favour of the diesels** (sometimes that is even double the price of a diesel)[13]. Fast charging stations with a charging capacity of about 350kW can cost €250,000 and above with installation[14]. As a result of all these factors, diesel/petrol LCVs remain the "Number 1" choice.

With rising awareness for the use of clean energy and upcoming legislation, fleet owners are showing increased appetite for environment-friendly transit options. The much lower cost of NGV LCVs and longer range (400-500km) versus BEVs (100-150km), indicates the NGV market will witness good growth in coming years.

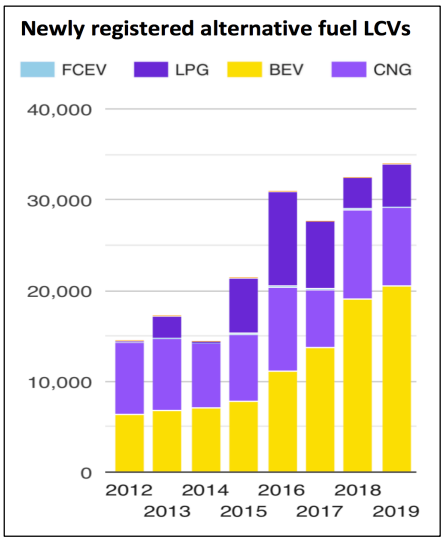

Figure 2.2: Alternative fuel share LCVs

As of 2019, CNG vehicles are operational in 86 countries with over 73 vehicle manufacturers investing in CNG/LNG vehicle production[15]. NGVA (Natural and Bio-Gas Vehicle Association) Europe recently released data on ***NGV registrations for 2019, showing that 69,900 passenger cars and 8,910 LCVs (Light Commercial Vehicles/Vans) were registered last year***[16]. As can be seen from Figure 2.2, CNG vehicles have increasingly lost share to BEVs (battery electric vehicles) in the alternative fuel category[17] due to a lack of fuelling infrastructure. Only 3.9% of public fuelling stations in Europe offer CNG (Figure 2.3). In spite of this, new registrations of LCV NGVs are expected to reach 40k in 2023 and 110k in 2028 (Figure 2.4). Countries such

[8] www.prnewswire.com "Fleet Management Industry in Europe, Outlook to 2023"
[9] www.techsciresearch.com/report/light-commercial-vehicle-market/3953.html
[10] ENEDred, Fleet &Mobility, Challanged and opportunities in the European Road Transport Sector
[11] European Automobile Manufacturers Association; Post-2021 CO2 regime for LCVs
[12] ENEDred, Fleet &Mobility, Challanged and opportunities in the European Road Transport Sector
[13] www.adlittle.com/en/german-market-battery-electric-light-commercial-vehicles
[14] Frost & Sullivan; Global market to be shaped by advances in electric and autonomous technology
[15] https://bekryl.com/industry-trends/cng-vehicles-market-share-analysis
[16] www.ngva.eu/medias/2019-in-numbers-gas-in-transport-to-satisfy-european-consumers/
[17] European Alternative Fuels Observatory, 2020; www.eafo.eu/vehicles-and-fleet/n1#

as France have specific targets for NGVs in LCV sector - 2.3% of new LCVs sold in 2023 being CNG and 3.7% in 2028[18].

In 2017 Volkswagen Group (ŠKODA, AUDI, SEAT, VW), the OEM group with the most NGV models in the market, announced and signed the statement of CNG mobility expansion. It is targeting a 10-fold increase in Germany and similar expansion into the rest of the EU with gas operator partners such as E.ON Gas Mobil GmbH, ONTRAS Gastransport GmbH, Pitpoint B.V and others. Market is being restrained due to high upfront investment costs (installation and storage tanks) and the limited number of refuelling stations[19]. With The upfront investment cost of an NGV LCV is now on average only €540 more than a diesel LCV [20]. The last unsolved problem for the industry is the availability of cost effective and convenient fuelling solution. While an overall trend stays optimistic with VW Group launching new NGV models soon (new Golf Mk 8 TGI, Caddy TGI, Audi A3 and Seat Leon), all industry stakeholders are required to mobilise efforts and accelerate the growth of the market to keep OEMs interested.

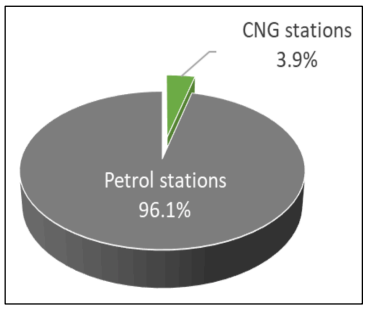

Figure 2.3: Low % CNG stations

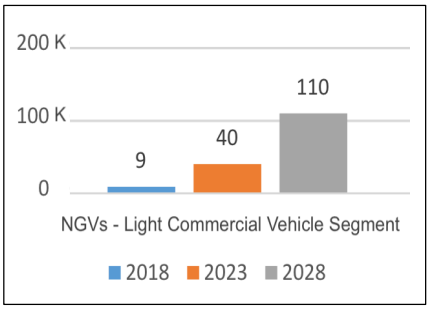

Figure 2.4: EU growth in NG-

Key **industry sectors for LCVs that represent promising target user markets**[21] include: urban distribution and transport companies; construction workers; city and municipality fleets; **energy and utility companies**; and other companies with technical service vehicles (e.g. household appliance manufacturers). In a survey of fleet managers for these kinds of companies, over 70% of those surveyed planned to acquire low emission vehicles in the near future, mostly driven by their ambition to reduce fleet emissions[22]. However, only a small share of them have actually acquired an electric LCV at this point. Fleet managers tend to be very rational buyers who prioritise practical "usability" of a vehicle and objective commercial considerations like TCO when making their purchase decisions. Our analysis shows that current generation EV LCVs have a hard time competing with diesel vehicles in these categories due to battery range limitations, charging requirements and a significantly higher price tag. However, the lower cost of NGVs and the longer range, put this category of user as a prime customer. The beachhead verticals of the market in terms of end users are:

1. **Gas company (TSO/DSO) vehicle fleets:** Using HYGEN+ in their own organisations, gas companies (in particular who maintain the gas infrastructure) will be able to conveniently fuel the vehicles they use for grid inspection, gas connection inspection and other technical services. **TSO/DSOs therefore represent a perfect "beachhead market"** (see footnote[23]) due to numerous strong value proposition points for NGVs use (see table 2.1), including access to very cheap gas. They also have the pressure to either innovate or/and to switch over to gaseous fuel, by converting their fleets over to NGV.
2. **Service vehicles of smaller companies** (e.g. plumbing companies, electrical companies, cable companies, etc.). In Germany for example, there are 50,600[24] companies with an average of 3-5 vehicles). The company staff are technically oriented, so the fact that they can get fuel from the grid acts as an emotional driver.

[18] French Strategy for Energy and Climate 2019
[19] www.alliedmarketresearch.com/compressed-natural-gas-market
[20] CREG Studie 28.03.2019. Study on the competitive position of CNG and LNG fuel for different vehicle types
[21] www.adlittle.com/en/german-market-battery-electric-light-commercial-vehicles
[22] www.adlittle.com/en/german-market-battery-electric-light-commercial-vehicles
[23] **Beachhead market**: defined as a small market with specific characteristics that make it an ideal target to sell a new product or service. This is based on the compatibility between the resources available, the product, and the market itself.
[24] de.statistica.com, 2019; "Number of companies in the sanitary, heating and air conditioning trades in Germany 2018"

3. **Delivery vehicles** (e.g. beverage, food delivery, parcel and postal service, furniture delivery).

In Europe, **over 27 million buildings (businesses and homes) are connected to gas grid in Europe.** Germany and UK have the largest markets in the EU, with 4.49million and 3.53million buildings connected to grid respectively. The breakdown per country is shown in Figure 2.5.

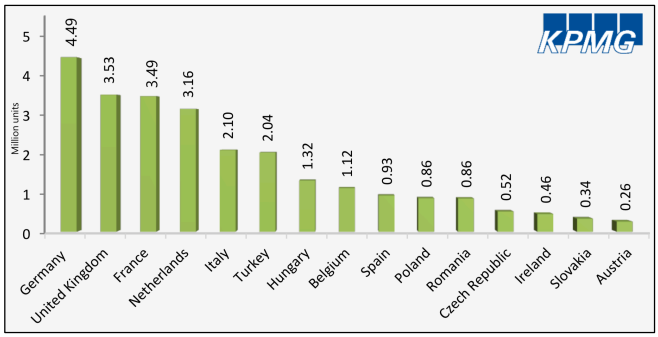

Figure 2.5: Number of building connected to gas grid [KPMG study 2015 for HYGEN]

Biomethane in Europe: The number of biogas plants in Europe has grown tremendously in the last decade. In the period between 2009 and 2016, the number of plants increased from 6,227 to 17,662. In line with biogas plants, biomethane production has increased significantly in recent years. From 2011 to 2016, production has grown exponentially, having experienced a growth of 752 GWh to 17,264 GWh, only in 2016 the increase was 4,971 GWh (+40%). The countries showing most were Germany, France and Sweden (900 GWh, 133 GWh and 78 GWh)[25].

By 2030, the production of renewable gas (biomethane) will increase dramatically. A conservative estimation demonstrates a production potential of close to 45 billion cubic metres (bcm), largely overcoming the entire demand for gas fuel of about 30 bcm, which corresponds to a 13-million-unit fleet (Figure 2.6). This would significantly contribute to the European decarbonisation path: 30% renewable gas will provide a GHG emissions reduction of more than 45% compared to conventional fuels on a well-to-wheel basis[26]. In many EU countries, biomethane is rapidly replacing natural gas as the primary transport fuel used in NGVs. In Germany, the proportion of biomethane in CNG fuel has doubled in recent years and as of February 2020 is currently 47%[27]. This is already better than electric vehicles where the renewable share in European electricity grid today is around 40%. In Sweden, biomethane reached 90% share in Swedish vehicle gas in 2018[28]. The industry's goal is to have 100% biomethane in vehicle grade gas by 2030. It is expected that biomethane production in France will be greatly exceed CNG consumption, allowing the country to offer 100% biomethane for mobility by 2030 without competing with other uses of gas (heat, industry etc.).

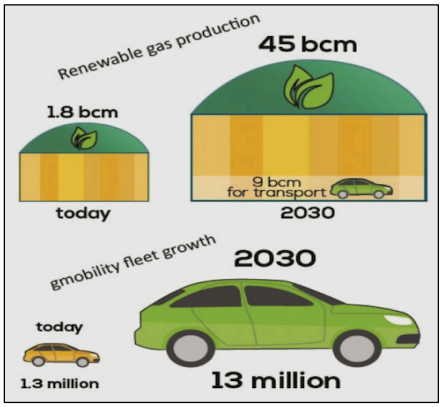

Figure 2.6: Biomethane capacity

Table 2.1: Benefits of NGV over EV in NGV category

Iveco LCV case study	EV LCV	NGV LCV
Economic		
Vehicle price	**€88.0k**	**€44.0k**
Energy cost (100km)	€4.04	€6.74
Total lifetime fuel cost	€12.7k	€21.2k
Total lifetime cost (fuel + purchase) 10.5years	**€100.7k**	**€65.2k**
Total savings delivered by NGV		**€35.5k**
Emissions Reduction		
PM emissions	100%	95%
CO_2 reduction (renew-bio)	95%	95%
Market		
Range km (average)	**144**	540
Charge/Refuel time	**4 hours**	7 min
Retrofit existing vehicles	No	Yes
Vehicles on the road (All)	5M	26M

Table 2.2: Commercial benefits of HYGEN+ vs SoA

Parameter	HYGEN+	Coltri
Compression technology used	Liquid piston	Mechanical reciprocate piston
Price (EUR)	**€17.0k**	**€22.7k**
Lifetime maintenance costs (EUR)	**€5.7k**	**€76.0k**
Permitting (EUR)	**€1.0k**	**€8.0k**
Fuelling time 1 LCV	**7min**	**60min**

[25] www.ngva.eu/medias/2019-in-numbers-gas-in-transport-to-satisfy-european-consumers/
[26] www.ngva.eu/wp-content/uploads/2020/03/NGVA-Europe_Report-of-Activities_2019.pdf
[27] Zukunft ERDGAS news on 12.03.2020
[28] https://bioenergyinternational.com/markets-finance/biomethane-reaches-90-share-in-swedish-vehicle-gas

COMPETITORS: The economic, convenience, environmental and market advantages offered by NGV LCVs in comparison to EV LCVs are dramatic and are listed in Table 2.1. The upfront costs for an EV LCV can be over twice as much as that of a diesel. For example, the **Iveco Daily Electric** (EV) has a 56kWh battery pack and a range of 144km, but retails for a significant €90,000 before (PiG – plug in grant). The **Iveco Daily Natural Power** (NGV) is 100kW power and a range of 440km, and retails for €44,000. While the EV could make savings on the price of fuel per 100km, it would take 54 years of driving (30,000km/yr) to recoup the difference. The same van in diesel retails for around €42,000. The **Renault Master ZE** runs a 33-kWh battery and has a meagre 118km range, and retails for €65,000 list price (before PiG). The Master in diesel retails for €35,000.

As outlined in Section 1, Coltri is the only competitor of compressed gas systems for homes and small businesses. Coltri is primarily a manufacturer of air compressors, and according to data from Coltri dealer in Czech Republic, has sold only a few hundred units of its gas vehicle fuelling appliance (VFA) in Italy and the Czech Republic. The commercial advantages of HYGEN+ are presented in Table 2.2, giving a total economic benefit of €83,000 over the 20-year lifetime of the appliance.

The only other manufacturers of gas compressors used for the purpose of compressing gas for NGVs are those supplying large public centralised fillings stations. The main players in this market are listed in Table 2.3.

Table 2.3: Potential future VFA competitor overview

Company	Ariel	SAFE/IMW	Cubogas/BRC	Bauer	Atlas Copco
Country of origin	USA	Italy/Canada	Italy	Germany/USA	EU, USA, India
Market reach	Worldwide	Worldwide	EU, Asia	EU/USA	Worldwide
Market Position depending on geographical area	1 in the USA, minor penetration in the EU	1 in Italy and Russia - 2/3 in rest of EU	2 in Italy - 3/4 in other parts of EU	2/3 in Germany, minor in rest of EU	Minor player, but resources to be a major player.
Market insight	Considered the one to beat. Brand has a superb reputation for reliability. Relies on packagers. Most expensive.	Good reliability and value for the money. Not as energy efficient as Ariel.	Cubogas is a well-known brand, but uses an old vertical design. Smaller footprint than others. susceptible to vibration.	Has a good reputation for producing a quality product. Company's has its roots in breathing air compressors.	Purchased greenfield brand and Intermech brands. Attempts to re-introduce these brand into the market being made.

When the market for VFA grows, these players can potentially become our competitors. However, all of them are utilising the traditional technology of reciprocating piston compressors. In essence, they are using a linear drive to move a mechanical piston back and forth and this motion compresses the gas by reducing the volume it occupies. This type of compressor requires pistons, seals, bearings, valves, and other moving components. These moving components require regular maintenance and may fail unexpectedly. Therefore, a high maintenance and consequentially high TCO will always be an issue for the products based on traditional reciprocating piston technology.

2.1.2 Unique selling points

HYGEN+ is able to position itself as the only home and small business vehicle fuelling appliance available at an economical cost and that can take advantage of the gas grid that feeds into millions of homes and businesses across Europe. In doing so, we are able to offer a number of USPs to all our stakeholder groups.

Table 2.4: USPs for each of the key stakeholders (distributor customers and end-users)

Distributor customer (DSO/Retailer)	**End-user customer** (Business fleet)
• Enabler for accelerated grid decarbonisation • Increase gas sales (Unlocks a large and previously hidden €30Bn market opportunity for gas as motor vehicle fuel (decentralised) • Increases margin at which gas can be sold • Known and predictable customer acquisition costs (compared to building public stations)	• 35% reduction in fuel costs (most EU states) compared to diesel vehicles (45% reduction when DSO/TSO are users) • Convenience (Fast 7 min fuelling at office) • Increased productivity (fuelling at place of business as opposed to filling station) • Productivity/time saving factor for employees utilising the service vehicles = to 15% reduction in fuel costs. • Emission reduction (free parking, tax reduction etc.) • Fulfilling environmental responsibilities

• Enabler for EV type of business models replicating electric retailers • Allows to win and lock in customer in the market where customer loyalty is low	• No upfront investment for end user. The gas company who owns and maintains HYGEN+

2.2 Commercialisation Strategy

2.2.1 Strategy for commercialisation

Hygen will apply a "cost-plus" pricing model to its customers (product "distributors") who will then distribute the product to the end user. Our preference is to commercialise our product via the gas companies, as we envisage this route will provide us with a much greater scaling opportunity. As well as distributing HYGEN+, gas companies can also install and use it for the purpose of fuelling their own fleet of vehicles. The reason we identified gas companies as our main target distributors is complimentary interest that allows us to plan without need for an additional margin for a distributor. In the same way as a gas company owns and operates centralised public CNG stations, which generate revenue for them; HYGEN+ offers these companies a similar opportunity, but in a decentralised model. Our product will allow them to sell more gas and at a potentially at higher margin. The HYGEN+ unit will have an initial selling price of €17,000, which will include a gross profit of €5,500, as outlined in Table 2.5, the business model table. As production volumes increase, the cost of manufacture will drop considerably according to the particular production volumes (see Figure 2.7).

The **gas utility company acting as a distributor** will likely use value-based pricing. In this case the utility company will offer the HYGEN+ to the end-user for free and charge for the natural gas used, which will include a mark-up on the gas price to cover the cost of the equipment. With 2,000 units in operation, the gas company can generate a gross margin of €5.4M per annum. The end-user fleet operator will realise annual savings of €727,000 based on a fleet size of 100 vehicles. Savings will be even higher for those gas companies that use HYGEN+ with their own fleet of vehicles.

Table 2.5: Business model table – gas company acting as distributer (final columns shows gas company acting as user)

HYGEN		Gas Company		End User (5 LCV Fleet)		End User (T/DSO 5 LCV Fleet)	
Sales price	€ 17,000	**Revenue** (from CNG sold)	€ 13,724	**Fuel cost savings** (per yr)	€ 7,276	**Fuel cost savings** (per yr)	€ 12,046
Cost manuf.	€ 11,500	**CAPEX** (HYGEN+/install)	€ 20,000	**Fuel cost savings** (lifetime)	€ 76,398	**Fuel cost savings** (lifetime)	€ 120,460
Gross Profit	€ 5,500	**Amortisation of HYGEN+**	€ 2,000	**Investment**	€ 0	**Investment** (HYGEN+/install)	€ 20,000
	-	Maintenance & Interest	€ 610	**Payback** (yrs)	€ 0	**Payback** (yrs)	1.7
	-	Cost of gas (incl. excise)	€ 7,064		-		-
	-	Cost of electricity	€ 1,350		-		-
	-	Gross Profit 1 unit	€ 2,700		-		-
100 units	**€ 550k**	**100 units (per yr)**	**€ 270k**	**100 units impact (per yr)**	**€ 727k**	**100 units impact (per yr)**	**€ 1.2M**
2,000 unit	**€ 11M**	**2,000 unit (per yr)**	**€ 5.4M**	**2,000 unit impact (per yr)**	**€ 14.5M**	**2,000 unit impact (per yr)**	**€ 24.09M**

The role of OEM vehicle manufacturer (or dealership) is to market the offering available from gas companies, together with vehicle in the same way as it is done in the electric vehicle segment; BEV LCVs are usually marketed together with charging solutions[29]. The same approach for HYGEN+ will facilitate the sales and usage of our product. Since our solution will allow the OEMs to overcome the "chicken and egg" barrier to the consumer, sales of NGV models will substantially increase. In partnership with the gas company, the OEM will be able to bundle the product (LCV) and service (refuelling) into one sale.

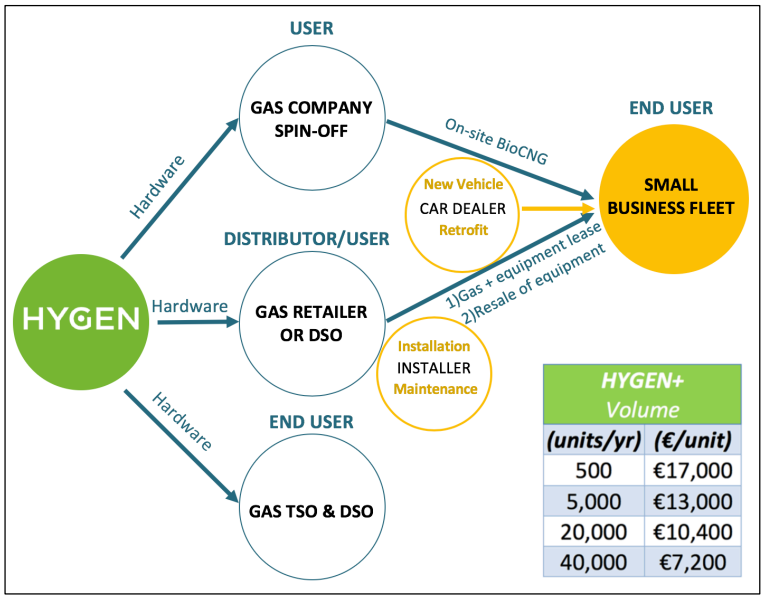

Figure 2.7: HYGEN+ business model – selling to gas companies

[29] www.adlittle.com/en/german-market-battery-electric-light-commercial-vehicles

The gas companies and OEMs (Car dealers) will have a complimentary relationship. The gas company includes all the costs on the gas bill (unit, maintenance, installation, etc.) and provides a package to the end user commercial customer. Car dealer facilitates the sale of the vehicle by having a fuelling solution with the gas company providing a full service for an end user including installation, operation, maintenance and financing.

The sales cycle will depend on geographical location, type of customer, pricing model used and political motivation. For example, the shortest sales cycle will be in a country that has experience with NGVs, it's a commercial customer requiring an alternative fuel vehicle to enter its working area, the gas utility is offering a value-add pricing model and the political environment is supporting VFAs. For these reasons, we have chosen Germany, Belgium, Austria, Spain and France as are initial target markets. We have excluded Italy as an initial target market due to its well-developed gas refuelling infrastructure, which is unique to Europe.

2.2.2 Regulatory approvals and compliance

We have been approved for CE Marking for the Gasdroid VFA, which comes off the back of complying with the PED (Pressure Equipment Directive). Due to the similarities between Gasdroid and HYGEN+, we expect a similarly smooth process to obtaining CE Marking. CE Marking allow us to install our vehicle fuelling appliance in any European country. As outlined in Section 1, for the user to operate the VFA they must obtain a permit from the local jurisdiction, which can cost up to €8,000 and takes up to 6 months. While this process would not preclude our system from the market, it does make the offering somewhat less attractive. We are therefore working towards a unified standard to be accepted across Europe as is the case in the USA. This would reduce the cost to just €500-€1,000 and the submission a form by an approved installer (e.g. plumber).

Hygen SIA is very active in the work of EU standardisation Committee CEN/TC 326 "Natural Gas Vehicles – Fuelling and Operation", especially in the activities of Working Group 6 (CEN/TC 326/WG6) "NGV Refuelling Appliances" (VFA). Our CTO, Alex Safronov is Convenor of WG6. Julia Guzeyeva is WG6 Secretary, while Jevgenijs Begens and Robert Strods are both members of WG6.

Our work has played a key role in shaping the new standard for Vehicle Fuelling Appliances, starting with the definition of the VFA as a complete device. The VFA will be certified according to the Pressure Equipment Directive (PED) and affords the use of storage capacity in line with our user's requirements (up to 90m^3 or 98 GLE gas @ 200 bar). This new standard will be recognised as **"CEN - PREN 17278 Natural gas vehicles - Vehicle fuelling appliances"**. The standard was submitted to CEN for public balloting. It appeared on the ballot at the end of March and remains there until June 2020. The previous ballot on PREN 17278 narrowly missed approval, but with amendments made. **Following a positive formal vote, at the beginning of 2021 the new standard will be published.** A published standard must be given the status of national standard in all member countries, who also have the obligation to withdraw any national standards that conflict with it. This guarantees that a manufacturer has easier access to the market of all the member countries.

Following publication, we will seek to accelerate the adoption of the standard at national level, especially in each of our initial target market countries, to bring these markets into line with the United States. To do this we will be working with the national standardisation bodies in each of these countries, as they are responsible for harmonising new standards at a national level. Due to our work in WG6, we have come into contact with many of the key players in these bureaus. For example, in Germany the relevant bureau is the DVGW or "National Standardisation Body". **We have a strong relationship with Mr Tilo Scheibe, the Chairman of the German standardisation committee "Natural gas fuelling stations and devices", responsible for the adoption in Germany of all new EU standards for natural gas vehicle fuelling and operation.** Our CTO, Alex Safronov has presented the HYGEN+ technology and draft of the EU standard for CNG vehicle fuelling appliances to Mr Scheibe. Our dealings with Tilo have included of meetings, discussions, exchange of e-mails. In our correspondence, Mr. Scheibe has expressed strong support and interest in the product and its potential and has indicated that he will support its integration into Germany. We will also use our relationships with gas companies such as ENAGAS and GRDF to push these committees to get this new standard into law.

2.2.3 Time to market

Hygen will be free to install and obtain permits for the operation of HYGEN+ units once CE Marking is obtained. This will be achieved by June 2021. Further to that, we expect CEN - PREN 17278 to be accepted into national law in all of our 5 initial target markets by January 2022, thereby addressing

the current permitting bottleneck process. We expect official product launch by Q2 of 2022. In doing so, we will be able to address the gap in the market and accelerate the transition towards sustainable mobility in Europe.

2.3 External Strategic Partners

Commercialisation requires utilising and leveraging the capabilities of gas companies and OEM dealers to reach the end user. There are 4 major player groups in gas market ecosystem: **TSOs** - Transmission system operators; **DSOs** - Distribution System Operators; Gas Suppliers/**Retailers**, and their **spin-off companies**. We are connected to all 4 groups in the gas market. On average , for example in Germany - 1 TSO covers 10 DSOs, which cover 100 retailers. Therefore, in terms of size, TSOs have the largest outreach (e.g. 16 TSOs in Germany). **The key strategic partners (operating within initial target markets) committed to helping Hygen finalise our product and commercialise it are outlined in Table 2.6.** These players are heavily incentivised to see HYGEN+ succeed for the following key reasons:

- Gas companies are **losing ground to electric companies in the decarbonisation** of the grids
- Gas companies are **losing market share in the mobility** market of the future
- Gas companies are **losing market share in the residential and small business energy** sector

Table 2.6: Key partners we are currently working with in order to commercialise the HYGEN+ innovation

ontras Gastransport GmbH	ONTRAS: **TSO network operator with 7,000km gas pipeline across eastern Germany** • **Pilot negotiations with Ontras spin-out Moviatec; builds operates CNG filling stations.** • **Ontras and Moviatec expressed desired to use HYGEN+ for its own fleet of vehicles** • **Ontras sees Moviatec as the natural distributor for HYGEN+ in eastern Germany** • **Currently validating business model concerning owning and operating HYGEN+ VFAs**
GAS CONNECT AUSTRIA	Gas Connect Austria **(GCA): large TSO in Austria, majority owned by OMV** • **Pilot completed for Gasdroid and showcased on the company website** • **GCA presented our Gasdroid solution at Vienna Autoshow and facilitated Hygen's attendance at the event as a guest of SEAT Austria (part of VW Group)** • **Committed to piloting HYGEN+ as part of thsi project (see letter of support)**
FLUXYS	Fluxys**: TSO gas infrastructure group in Belgium operating over 8100km of pipeline** • **Committed to piloting HYGEN+ as part of this project through the** Belgian gas company association Gas.be **(see letter of support)** • **Interested as a customer for its own vehicles, before setting up distributor spin-off**
enagas	Enagás: **Largest TSO in Spain and technical manager of the Spanish gas system.** • **Enagás has invested €200K in Hygen and has committed to piloting HYGEN+ at its site in Madrid. Also installing pilot for SEAT HQ Barcelona (see letter of support)** • **Its spin-out Scalegas (similar to Moviatec), installs and operates CNG stations and is interested in becoming the exclusive "distributor" for HYGEN+ in the Spanish market.**

Strategic Group	Partners roles, competences and commitment
    	**GRDF:** DSO is a main distributor of natural gas in France and Europe (200,000km pipelines). • ENGIE carried out successful testing of HYGEN+ on behalf of GRDF and shared results • GRDF has facilitated positive engagment with Hygen and GRT Gas, main TSO in France • GRDF has now set up an internal working group with Hygen to investigate the commercialisation plan for France, and identify next steps for French market release • Committed to piloting HYGEN+ VFA as part of this project (see **letter of support**) **Energie Südbayern:** ESB is a national energy service provider based in Germany and owner of DSO Energiesetze Bayern, largest gas distribution network operator in southern Bavaria. • Engaging with Hygen in the last 6 months to better understand the HYGEN+ offering • Committed to piloting 2x HYGEN+ systems with statement of intent post project **Uniper:** Global energy company and also leader within the gas industry, working in over 40 countries and with over 11,000 employees. Spin-out Liquis operating in Germany. • Currently negotiating with them to undertake a pilot of with 5x Gasdroid VFA • Through Spin-out Liquis, it wishes to expand its CNG capability through its small business customers in central and western Germany using HYGEN+(**letter of support**) **Naturgy:** Gas retailer in Spain and energy utilities company with >10M energy clients. • Interested in being partner in Spanish speaking countries as well as a customer • Negotiations are underway between both companies for potential of 8x pilots **E.ON:** One of the world's largest investor-owned electric and gas utility service providers. • E.ON Hungary and E.ON Sweden have expressed interest following series of meetings • Both divisions are now keen to investigate a future commercialisation plan with Hygen
OEMs 	**VW Group:** Most NGV models on market; includes Volkswagen, SEAT, Škoda, Porsche etc. • VW Group is currently piloting the Gasdroid VFA and supported early redesign work • Hygen attended Vienna Autoshow as a guest of SEAT Austria (part of VW Group) • Strong interest from SEAT HQ in Spain as well as SEAT Austria and SEAT Germany • SEAT is very committed to HYGEN+, will be piloting the solution as part of this project with ENAGAS/SCALEGAS installing and piloting it at the SEAT site. • Incentivised through increased sales of NGVs and are committed to working with us towards developing a partnership model between gas players and the auto industry
Key Opinion Leader	**Jens Anderson, former Executive at VW Group**. Over 20 years at VW, leading the group's efforts on NGVs. Former Board Member at NGVA Europe (main European association for g-Mobility). He retired from VW in 2018 and is now assisting Hygen with key gas companies and other industry stakeholders around Europe. Other activities and roles include VIP guest and speaker at CNG Mobility Days 2019 Berlin, member of the advisory board of Zukunft Erdgas (German Gas Association) and speaker at key conferences e.g. g-Mobility presenter at Frankfurt Motor Show etc. Often in the media, both TV and written press.
Associations	• **GASNAM:** Spain/Portugal represents SEAT, ŠKODA, FIAT, Iveco, VW **(letter of support)** • **GAS.Be:** Representing Belgian gas TSOs and DSOs, piloting HYGEN+ **(letter of support)**

2.4 Intellectual Property Right (IPR)

2.4.1 IPR Assets and ensuring Freedom to Operate

Hygen's intellectual property covers technologies for fuelling vehicles with gaseous fuels, including natural gas (also bio-methane) and hydrogen. Hygen owns the rights on the unique technology of hydraulic compression for vehicle fuelling, which is patented Worldwide: 29 patents covering 45 countries have been granted. No patent application was refused and all applications granted. The countries identified for patenting were chosen according to a highly developed natural gas grid, in addition to natural gas and bio-gas availability. Hygen's main Patent has a title: **"Method for compressing gaseous fuel for fuelling vehicle and device for implementation thereof"** (varies in some countries). The list of patents with their numbers, applications' numbers, as well as dates of submitting and granting is presented in the Annex 3.

Hygen's patents protect the main technology, as well as the device for its implementation. As a result, we are extremely confident that our IP can dominate over all other possible inventions in this field. The technology provides the possibility to create a wide spectre of vehicle fuelling appliances and systems as well as CNG, bio-CNG and hydrogen transporting systems, thus providing flexible solutions applicable for CNG and hydrogen vehicle fuelling, CNG, bio-CNG and hydrogen transportation.

We are confident that there is sufficient 'white-space' for us to exploit and further protect these technologies. Our full freedom to operate has been confirmed following an extensive IP review by our patent attorneys. As outlined in Section 1, the closest competing technologies were identified during our patent application process (US 4,805,674 Knowlton, US 6,652,243 B2 Krasnov, US 5,454,408 DiBella). All of these patents were opposed during the granting of our patent.

Figure 2.8: Hygen in the media & at recognised industry events

2.5 Scale-up Potential

2.5.1 Scale-up strategy

Our go to market strategy is to approach TSOs and the largest DSOs initially in order to pilot the product and build strong relationships. The rational for approaching the TSO, is that they will have multiple DSOs and then millions (sometimes tens of millions) of end users, allowing a scalable market rollout with minimum resources involved on our side. This process is of engaging with TSOs (and also some DSOs) is ongoing, as outlined in our section on External Strategic Partners. Many important partners are committed to pilots e.g. ENAGAS, GRDF, FLUXYS (via gas.be), GAS CONNECT etc. Using HYGEN+, these companies will be able to conveniently fuel the vehicles they use for grid inspection, gas connection inspection and other technical services. This represents a perfect beachhead market for HYGEN+ due to numerous strong value proposition points these companies have to use NGVs as their service vehicles (See table 2.6). USPs for each of the key stakeholders). Based on a detailed assessment of 34 gas companies in our target markets (mainly TSOs, some DSOs and retailers), they operate a combined fleet of 55,900 LCVs and passenger vehicles, out of which ~13 500 vehicles are LCVs performing service activities. e.g. GRDF has confirmed to us that it operates 1,600 NGVs, about 1/3 of GRDF's total vehicle fleet (total >4,500 vehicles). 12 companies out of our shortlist holding 90% of estimated service vehicle fleet with the rest companies holding around 1 150 vehicles. On average in Europe the vehicle fleet is renewed at a rate of 6.3% representing around 850 vehicles p.a. (e.g. ~200 HYGEN+ VFAs p.a. in total and 150 out of it in our target countries).

Following successful pilots with TSOs and large DSOs, we will approach smaller DSOs (e.g. 720 DSOs in Germany) by leveraging the relationships we have established with our TSOs in the pilots expanding our presence on the marketplace. DSOs (or Retailers) will set up a spin-out company to facilitate the sales of a gas as motor vehicle fuel (CNG) in the market. This is relatively common practice for gas companies e.g. ScaleGas spin-out from Enagas, LIQVIS spin-out from Uniper, Total's spin-out PitPoint, MoviaTech spin-out from ONTRAS, ENGIE's spin-out GNVert, E.ON.

Gasmobil and SNAM4Mobility among other used to fast track gas infrastructure for NGV deployment. This is very similar to the way Electric DSOs or retailers are setting up spinouts/companies, where the electricity is sold via chargers for EVs. A quick example is EWE's daughter company of WAYDO, which installs and operates EV chargers. Elenx[30] a manufacturer of EV chargers has managed to rapidly sell over 30,000 charging stations by working with energy companies, grid operators, renewable energy sites, retailers and technology partners to create a highly scalable model.

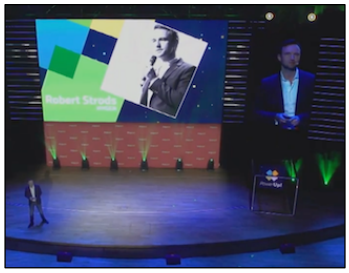

Figure 2.9: Presenting on-stage at Impact '19 Krakov

Together with them we will engage a broader market outside of the gas value chain. The beachhead market for gas companies will be small business fleets operating LCVs like plumbing companies, electrical companies, cable companies. From the LCV fleet in Germany (2.7million) around 200,000 LCVs are operated by 50,600 small companies making up around 8% from all LCV fleet. Considering 1.1 million new LCV registrations from our 5 target countries, this represents around 89 000 LCVs p.a. as our total addressable market in this specific market vertical. In a real life this will be narrowed down to total obtainable addressable market by factors like availability of the gas on the site, availability of our product and/or gas company offering in the specific city, other alternatives like electric vehicles, e.t.c. However, without product like hYGEN+ this particular market segment is extremely hard to be serviced by any clean vehicle offering.

Hygen's WOM (word of mouth) marketing, our ability to showcase our technology in the media and at recognised events, will allow us to gain the attention of key gas TSOs, DSOs, Retailers and auto OEMs. In the past, this has included front cover article in Forbes magazine Latvia and our speaking engagement at EcoSummit 2019 (Figure 2.8), and Impact 2019, Krakov (Figure 2.9). All Hygen's customer testimonials, editorials, reviews, success stories, ratings, and recommendations will be created together with industry players and related associations and shared via their channels and social media.

The capacity of our existing production facilities is sufficient for up to 300 units per year (multiple shift). Improved assembly adding HYGEN+ capabilities will be implemented in parallel with the existing assembly line running so there will be no downtime. Within WP5, we plan to expand the production capacity to 1,050 units p.a. with a maximum capacity of 2,100 p.a. in two shifts. We will plan to keep production in Latvia due to its many benefits as a manufacturing location: lower technical labour costs, low cost rent, shipping hub for Eastern Nordic EU, EC programs for manufacturing.

Figure 2.10: Hygen's existing assembly shop has capacity for production 500 units/year

2.5.2 Potential to develop new markets

Hydrogen (H2) is predicted to be the fuel of the future. A car can travel approximately 100 km on 1 kg of compressed hydrogen, whilst it drives a mere 1 km on the energy stored in 1 kg of batteries. The Hydrogen Council predicts that the cost of hydrogen will fall by 50% by 2030, enabling its use in a wide range of applications. HYGEN+ has the potential to develop the emerging H2 market in two ways; enabling gas grid decarbonisation through H2 blending and providing a new compression solution for H2 fuels.

- **HYGEN+ as a H2 compression solution:** Industry is in consensus regarding the inability of reciprocating piston compressor technology to deliver the required TCO, due to high maintenance costs, short service life and high susceptibility to failure when compressing to higher pressures (350/850 bar). The most promising solution for compressing H2 is liquid piston technology, for all the reasons outlined throughout this proposal. By leveraging our core technology and know-how, Hygen's fuelling solutions can be adapted to the requirements of H2. In doing so, Hygen's liquid piston technology can provide a cost effective and reliable means to compressing H2.

[30] https://evcharging.enelx.com/uk/about/partners

- **HYGEN+ as an enabler for H2 blending into gas grid:** International Energy Agency (IEA) stated that the gas grid can be decarbonised by blending hydrogen into the natural gas pipeline system. Blending limits of 20-30% are achievable. However, public CNG compressor stations, which are mechanical piston, are only capable of processing for a blend of 2-3%[31]. This means existing CNG stations would act as a bottleneck to decarbonisation of the grid through H2. By replacing mechanical compression at the public filling stations with HYGEN+ compression, high level H2 blending is enabled.

2.5.3 Growth impact of innovation on our company

As a result of our scale-up strategy, we expect Hygen to grow significantly. By break-even point in 2024 (3 years following market launch), we envisage employing a highly skilled workforce of 57 people. In that year we expect to sell 444 Gasdroid units and 483 HYGEN+ units. A further €154k revenue will come from our sales of our technology into the newly developing Hydrogen market. Total revenue generated from these sales will be €8.953M, with an associated gross profit of €3.053M (equivalent to 34% margin). As we continue to scale production volume and reap the associated efficiencies, we anticipate our gross margin to increase to 45% by 2029. A detailed breakdown of our growth figures between 2020 and 2029 is provided in Table 2.7. **Hygen's refuelling solutions will have a dramatic and positive impact on the NGV LCV market by 2029, delivering 40% more unit sales compared to the "business as usual" market predictions (see Figure 2.11)**. Our growth in sales with lead to a significant uplift in employment numbers for the company. By break-even point we will have created 35 new jobs and employ around 60 staff in total. By 2027, we will be a medium sized enterprise, with revenues close to €50M. A decade from now, Hygen will employ over 250 staff and have annual turnover in excess of €100M.

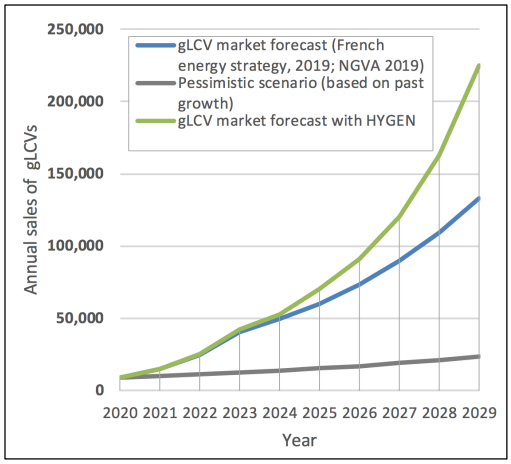

Figure 2.11: HYGEN+ will create a step

Table 2.7: Hygen sales penetration and abbreviated P&L accounts

Euro Figures in 000s	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
GasDroid units sold	17	56	145	254	444	777	1,360	2,380	4,165	6,247
Revenues from GasDroid	€153	€308	€725	€1,015	€1,554	€2,720	€4,760	€5,950	€10,412	€15,618
HYGEN+ units sold	0	7	76	276	483	845	1,479	2,589	4,530	7,928
Revenues from HYGEN+	€0	€119	€1,292	€4,692	€7,245	€12,679	€22,188	€38,829	€67,950	€103,058
Revenues from other products	€0	€0	€0	€77	€154	€363	€508	€777	€1,360	€2,380
Revenue	**€153**	**€427**	**€2,017**	**€5,784**	**€8,953**	**€15,761**	**€27,455**	**€45,556**	**€79,722**	**€121,056**
GasDorid cost of components	€99	€252	€609	€761	€888	€1,554	€2,720	€3,570	€6,247	€9,371
GasDroid cost of assembly	€51	€67	€87	€127	€178	€311	€544	€714	€1,041	€1,562
HYGEN+ cost of components	€0	€81	€874	€3,174	€4,347	€6,762	€11,834	€19,414	€33,975	€51,529
HYGEN+ cost of assembly	€0	€21	€114	€276	€386	€592	€888	€1,294	€2,265	€3,171
COGS of other products	€0	€0	€0	€56	€101	€210	€291	€414	€725	€1,263
Gross Profit	**€3**	**€6**	**€333**	**€1,389**	**€3,053**	**€6,332**	**€11,179**	**€20,149**	**€35,468**	**€54,160**
Gross Profit Margin	**2.2%**	**1.4%**	**16.5%**	**24.0%**	**34.1%**	**40.2%**	**40.7%**	**44.2%**	**44.5%**	**44.7%**
Selling, General & Administrative exp	-€153	-€375	-€857	-€1,326	-€1,591	-€2,185	-€3,035	-€4,261	-€6,042	-€8,643
R&D expenses	-€357	-€825	-€280	-€280	-€336	-€404	-€484	-€581	-€697	-€837
Other operational expenses	-€57	-€133	-€224	-€258	-€309	-€371	-€445	-€534	-€641	-€769
Other income (incl. grants)	€598	€731	€0	€0	€0	€0	€0	€0	€0	€0
Net Income	**€34**	**-€596**	**-€1,028**	**-€475**	**€817**	**€3,373**	**€7,215**	**€14,773**	**€28,088**	**€43,911**
CF from operating activities (excl. grar	**-€475**	**-€1,307**	**-€1,028**	**-€475**	**€817**	**€3,373**	**€7,215**	**€14,773**	**€28,088**	**€43,911**
CF from investing activities (net)	**€0**	**€0**	**-€172**	**-€344**	**€0**	**€0**	**€0**	**€0**	**€0**	**€0**
Proceeds from grants	€598	€731								
Proceeds from issuance of debt										
Repayment of debt	-€3	€0								
Proceeds from issuance of equity		€480	€1,400	€1,000						
Net increase/decrease in CF	**€120**	**-€96**	**€200**	**€181**	**€817**	**€3,373**	**€7,215**	**€14,773**	**€28,088**	**€43,911**
Total Jobs	16	19	26	40	49	68	95	130	189	264
Total Jobs Created (Cumulative)	**2**	**5**	**12**	**26**	**35**	**54**	**81**	**116**	**175**	**250**

[31] PG&E R&D and Innovation, 2018

2.6 Key Performance Indicators

Table 2.8: KPIs for the expected outcomes and the related success criteria for HYGEN+ (T-Tech; E-Economic; M-Market)

KPI	Current	Post project (2022)	Breakeven (2024)
Applications of technology (Tech)	Residential	Residential , small business	Residential, small business, CNG stations, H2 mobile delivery
Electricity consumption (Tech)	0.5 kwh/GLE	0.45 kwh/GLE	0.35 kwh/GLE
Compression capacity (Tech)	1.2GLE/h	4.8 GLE/h	20GLE/h - 40 GLE/h
Storage capacity (Tech)	24 GLE	98 GLE	800 GLE
Gases compressed (Tech)	Bio/CNG	Bio/CNG	Bio/CNG and Hydrogen (H2)
Price of HYGEN+ (Economic)	30,000 €	17,000 €	15,000 €
Permitting costs (Economic)	8,000 €	1,000 €	500 €
Installation costs (Economic)	5,000 €	2,000 €	1,000 €
Revenue (Economic)	130,000 €	2,017,000 €	10,134,469 €
Burn rate (Economic)	46,000 €	65,000 €	0 €
Assembly cost HYGEN+ (Economic)	5,000 €	1,500 €	800 €
Certified products in portfolio (Mrkt)	1	2	3
Markets addressed (Market)	Domestic CNG (D-CNG)	Small business CNG (SB-CNG)	D-CNG, SB-CNG, corporate fleets/public stations, Hydrogen
Permitting lead time (Market)	6 month	45 days	30 days
Gas company pilots/partnership (M)	6	10	20
Patents filed (Market)	3	5	8
New jobs created	1	12	64

2.7 Broader Impact

2.7.1 Societal and economic impacts

Transport in Europe is 94% dependent on oil, 84% of this imported, costing up to €1 billion per day[32]. The supply of oil often relies on unstable regions, with issues of supply security and price fluctuation. This project's outcome, a system allowing for convenient and cost-effective refuelling of NGVs, will **increase the use of NGVs rapidly**, replacing conventional fuels through new vehicles and converting older ones. A strategy for the transport sector to gradually replace oil with alternative fuels and build up the necessary infrastructure has been predicted to bring savings on the oil import bill of €9.3 billion per year in 2030, and another €1 billion per year from dampening of price hikes[32]. Additionally, research has indicated that 'greening' cars could generate about 700,000 additional jobs for the EU by 2025. The use of NGVs will boost European gas trades and also provide a robust market for biogas, which has seen growth slow in Europe with uncompetitive prices when supplied for household use.

The replacement of petrol/diesel vehicles with NGVs will see a great **impact on air pollution levels**, especially in urban areas where 77% of European city inhabitants are exposed to particulate matter pollution levels above WHO guidelines[33]. Particulate matter released by vehicle engines is a serious health hazard; linked to cancer, cardiovascular and respiratory diseases especially in vulnerable groups. Even with new car filters, particulate release is still well above safe limits[34]. Commercially available natural gas engines have demonstrated over 90% reduction in particulate matter when compared to diesel engines. Uptake could work immediately to reduce harmful pollution, **improving the health, lifespan and productivity of urban populations** greatly. The HYGEN+ system will not

[32] Communication from the EC to European parliament, the council, the economic and social committee, 2013
[33] www.transportenvironment.org/publications/new-diesels-new-problems
[34] https://epha.org/why-clean-diesel-cars-still-emit-health-harmful-particle-pollution/

only improve urban environments through pollution reduction, it will also support rural areas through increasing ease of infrastructure development.

2.7.2 Environmental and climate impacts

The expansion of NGV infrastructure and increase in NGV use over petrol and diesel will be critically beneficial towards the aims of the European Green Deal, supporting the movement by Europe towards sustainability and environmental security. The Green Deal outlines aims related to reducing climate change, pollution and environment destruction including cleaner, cheaper and healthier forms of transport. With NGVs running on biomethane producing over 90% **less particulate emissions** compared to diesel and 97% **less greenhouse gasses** in the lifecycle of the fuel[35], they are already a less polluting option. Additionally, most natural gas lifecycle emissions are produced in the extraction and transport of the fuel so the use of biomethane to power NGVs instead will substantially reduce the emissions of the vehicles; this is in contrast to the high emissions produced during the manufacture of electric vehicle engines. The European Automobile Association has described alternative refuelling infrastructure as one of the most important enabling conditions for achieving carbon neutrality and this will be substantially supported by the HYGEN+ innovation.

The HYGEN+ project's direct impacts by 2026 will stem from a projected sale of 6,339 HYGEN+ systems (5 vehicles per system) and 3053 GasDroid systems (2 vehicles), leading to a further 37,801 NGV's in use. These will likely replace diesel counterparts and will average 160,000km over their lifetime. This could directly lead to $3.3x10^{26}$ fewer particle emissions and 913,272 tonnes CO_2 equivalent less greenhouse gas emissions across the lifetimes of the replaced cars when run with 50% biomethane, as is possible across target markets. With an increase to 100% biomethane, it will be possible to reduce lifetime emissions by 913,272 tCO_2 equivalent based on 2026 sales figures, with this rising to 3,322,725 tCO_2 equivalent based on 2029 sales projections.

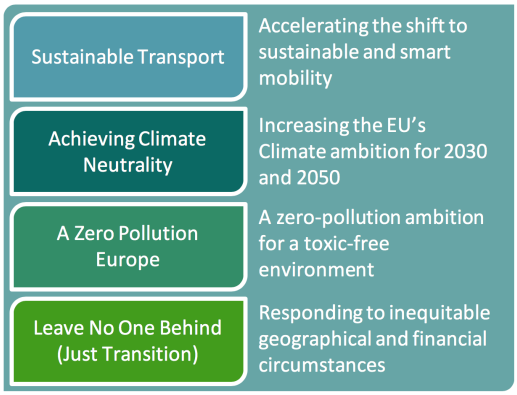

Figure 2.12: Key targets of the European Green Deal where HYGEN+ will deliver major impact

3. IMPLEMENTATION

3.1 Team and Capabilities

3.1.1 The Hygen Team

As presented in Table 3.1, Hygen has a highly experienced and committed team with the necessary expertise in all areas (technical, R&D, management, certification, business strategy, commercial, finance) required for the successful delivery of this project. It is a well-balanced mix of commercial and technical experience on all levels including governing level, executive level and operational level. Overall vision and direction for the project will be maintained by the Board of Directors and Steering Committee (BDSC), which consists of 3 members boasting considerable experience in supervising and managing companies, large scale development projects and teams. The BDSC will have a supervisory role to the Project Director (PD) and Project Manager (PM). The PM for the project will be Roberts Strods due to his extensive experience in managing private and publicly funded technology development projects with Mario Pirraglia acting as PD. In the event of any disagreement between the PM and the BDSC, the PD will make the final decision. If any decision has significant consequences for the forecasting of costs within a financial year, the timing of milestones, objectives for the project, the PM will consult EASME before any changes are initiated.

Work Package managers are Jevgenijs Begens, Davide Paganelli and Oleg Labetskiy. They will report directly to the PM on a weekly basis and will have project review meetings on a monthly basis, including progress reviews against the project time plan, risk reviews, decisions upon mitigating actions, identification of arising IPR, deliverable reviews, discussing and making milestone decisions when due. The PD, PM and Project Technical Director will report monthly to the BDSC giving an

[35] https://afdc.energy.gov/vehicles/natural_gas_emissions.html

overview status or the project identifying the main issues and organise a more comprehensive board meetings every quarter.

Table 3.1: The key team members, relevant information and project roles. Detailed CVs are available in Annex 2

Team Member	Position	Function/Key Competencies	Commitment
Mario Pirraglia *1.0% shareholding*	CEO	**Project Director:** Utilising his 25 years' experience in the field while being a Vice President at FuelMaker Corp and president at SAFE North America, he will manage the whole project from a strategic perspective and will provide support and actively engage in the most critical tasks for the project.	100%
Robert Strods *7.1% shareholding*	COO	**Project Manager and WP4 Leader:** With his corporate finance and EU funding project management background, he will manage the project in all its aspects. He will be responsible for overseeing the project, preparing and submitting the deliverable reports and acting as the main contact point for the project with everyone, including EC.	100%
Alex Safronov *46.3% shareholding*	Technical Director	**Technical Director:** Having well-rounded knowledge about technology, IP, technical design and engineering challenges of the technology as well as 18 years' experience in this industry he will be involved in all aspects of the project providing a technical lead for the project overall.	100%
Julia Guzejeva *10.6% shareholding*	IPR and Standard-isation Manager	Having experience in managing a CEN/TC326 committee and extensive experience in Hygen's patenting process, she will responsible for managing and executing IPR activities and standardisation activities as well as supporting the team in certification activities.	100%
Jevgenijs Begens	Technical Manager	**WP1 Leader:** Using his experience of developing, certifying and bringing to market a technically excellent product (Hygen's 1st product), he will be responsible for driving the final design.	100%
Davide Paganelli	Chief of Engineer-ing,	**WP2 Leader:** Employing a vast experience and knowledge gained through the development and bringing to market mechanical compressors in top tier companies in the world, he will be responsible for product certification activities.	100%
Oleg Labetskiy	Comm-ercial Manager	**WP3 Leader:** Utilising his marketing and commercial background in large German companies and vast experience in leading projects, he will be responsible for launching and managing pilot projects as well as performing tasks related to dissemination and commercialisation activities	100%
Dmitry Popov	Senior Engineer	Applying his work experience leading executive positions in large Latvian manufacturing companies, he will lead the mechanical engineering tasks in WP1 and WP2	100%
Jens Andersen	Member of BDSC	Being a former Head of Group Technology Strategy & Group Officer CNG Mobility at Volkswagen Group and having over 27 years in the automotive industry, he will provide necessary strategic advisory function and provide support in some of the key project tasks	12.5%
Matias Torellas	Member of BDSC	Having been on dozens of boards and utilising his vast experience in portfolio management for organizations funding companies, he will provide a necessary strategic advisory function.	5.0%
Inigo Echaniz	Member of BDSC	Using his experience in various financial analyst roles, portfolio companies' manager in corporate venture capitals as well as his gas industry experience, he will provide a necessary strategic advisory function.	5.0%

3.1.2 Main strengths and weaknesses

Strengths: Hygen has assembled a very strong and competent supervisory team having a vast experience in fields of car OEMs, conventional compressor manufacturing and sales, large scale portfolio management and capital markets, venture capital financing and M&A transactions. On the executive level, Hygen has a strong coverage of both operational management and technical management. Most of the operational team in Hygen has experience with designing, certifying and

piloting similar product to HYGEN+, ensuring that risks are kept to a minimum and the project plan is based on solid foundations.

Weaknesses: Hygen requires gas market competency on its advisory board. To make for the current gap, Hygen is working on involving a business unit/executive team member from ENAGAS to join Hygen's board. Since CFO function is covered by Roberts Strods, Project Manager (Chief Operating Officer), as soon as we are be able to afford it, we will bring in a professional CFO to enhance this competence in the company. On the technical side, we wish to bring in Davide Paganelli as a Chief of Engineering; enhancing the technical management function at the beginning of the project since the most challenging tasks in the project are technical tasks. On an operational level, some of the team members lack specific knowledge about the software solutions which will make the development work more effective and less time consuming. Therefore, we will ensure effective service providers to ensure training of staff is sufficient and, where there are small gaps, we are able to fill these externally.

3.2 Financing Needs

Table 3.2: Total finance required to develop HYGEN+ and reach the break-even point

Total project costs	Grant requested	Equity requested	Remaining financing
€4,299,312	€1,329,518	€2,400,000	€569,794

Table 3.3: Future financing plans

Equity (if blended finance requested)
Describe what the requested equity component will be used for and equity share to be given in return.
The requested equity funding will be used for the market rollout of the HYGEN+ product and getting the sales and assembly capacity to the point where Hygen as the company can break-even (detailed description in WP5 description, Section 3.5). Since we are planning to break-even in Q1 of 2024, the base for requested equity funding is our burn rate in years 2022 and 2023 considering the results of the "worst-case" scenario analysis with 30% decrease in gross profit margin compared to "expected" scenario. We are considering a pre-money valuation of €13.9M, therefore the equity share give in return would be 14.7%.
Describe/comment how the valuation of the company has developed over time (e.g. financing rounds) and the rationale behind it - relevant metrics/milestones achieved from start to present.
Seed round: Hygen's first institutional financing round was in Q2 of 2015 with EIT Innoenergy (KIC Innoenergy at that time). In this seed round Hygen raised €2.9M with EIT Innoenergy ending up owning 15% of the company, therefore the effective valuation of this financing round was €16.4M pre-money. However, since the financing provided by EIT Innoenergy is a hybrid financing (mixing EU funding and private equity from their Limited Partners) when speaking to other investors we have always discounted the valuation by 75% (since only 75% from funding is coming from public sources). Therefore, a private market valuation of the seed we typically present to our potential investors was €4.1M pre-money. This valuation also corresponds very well with average seed round valuations around Europe which is €3.8M (Pitchbook data, 3/31/2018 release). **Seed extension:** the round was closed in July 2019 with ENAGAS Empremde leading the round at a pre-money valuation of €9.4M. The valuation for seed extension round was set by two investors: the lead investor, being a Corporate venture capital arm for one of the leading gas companies in Europe and the other investor being exclusive Nordic dealer of high-pressure gas components. The valuation at this round also corresponds very well with average valuations that companies in Europe receive when they are in between Series Seed and Series A stages (Pitchbook, 3/31/2018 release, average Series A valuation €13.9M). The €10M post money also matches Discounted CF analysis did together with lead investor and due diligence partner (KPMG).
Explain company ownership and capital structure Table 4 of Annex 4. If there are different classes of shares.
78% of the company is still owned by the founders and management team including Mario Pirraglia (CEO), Robert Strods (COO), Alex Safronov (CTO), Julia Guzejeva (IPR & Standardization Manager) and Olga Jurina (Commercial Manager). 4.5% of the company is owned by early business angels who provided debt to the company in its early development. 17.5% of the company is owned by EIT Innoenergy, ENAGAS Empremde and Avellino, Series Seed and Series Seed Extension investors. All shareholders have the same class of shares. EIT Innoenergy and ENAGAS Empremde each has one board seat from a total of five seats. Therefore, the board level tactical decisions are still being made by founders with both investors having a say but not legal veto right to object. However, both investors have standard minority investors protective provisions, where

the approval of both investors is necessary to make important decisions like issue of new shares, dismissal or change of the board decomposition, etc.
What exit strategy do you expect, incl. timeline and expected return on investment? Explain assumptions
As we get to the point of break-even in 2024, Hygen will be the company which would have the products and be able to go after multiple markets (compressed biomethane and hydrogen) and qualify for Series B with ability to decide if we want to take on additional boost in financing or grow organically. Our aim would be to raise additional capital at that point to boost our activities in the hydrogen market and sell the company at 2026 – 2027 to either household appliance manufacturers (like BSH, Vaillant Group, VIESSMAN, GE, Electrolux or DAIKIN), Gas system producers (like Landirenzo group, Emerson, Hexagon, Worthington, Air Liquid, Chart Industries, Atlas Copco, Suzler) or energy companies (like TOTAL, ENGIE, SNAM, ONTRAS, Shell). According to our analysis of M&A market players outlined above, an average acquisition price is 2.1x of the revenues for hardware companies. Therefore, the expected sales price is around €60 – 100M. Therefore, investing at €16.3M post money, EC will make almost 5 times its original investment.

3.3 Risks

Table 3.4: Main risks associated with development and commercialisation and mitigation strategies

Risk Identified	Proposed risk-mitigation measures
MANAGEMENT: Inefficient implementation of product development activities or failure to meet WP objectives	T4.5 and T4.6 are dedicated to managing this risk , with Robert Strods (PM) leading WP4. He has 5 years of successful experience in managing EIT Innoenergy €2.9M funding which was governed under the H2020 framework with the same guidelines and rules applied. Hygen has also set up a supervisory Steering Committee consisting of savvy professionals who will support the PM in any issues and strategic as well as tactical decision making.
TECH: Manufactured parts cannot be delivered on time and/or to quality	In WP1 and during WP4, Hygen will carry out in-depth market research to find the most suitable suppliers and/ or component manufacturers. Hygen will discuss supply and quality condition with market-leading suppliers/ manufacturers.
TECH: Higher than expected cost of components or/and cost of production	A focus will be on cost as the priority when finalising the design of the product in WP1 and establishing and facilitating close relationships with our supply chain (which will be carefully selected for value and reliability). Utilising existing experience in product design and certification while working on the 1st Hygen's product.
TECH: Issues with and time required for certification	We have dedicated a whole WP for this (WP2) with a dedicated team. More than that, all of the Hygen's team on executive and operational levels have experience in certifying products according to Pressure Equipment Directive and related standards working with TÜV, KIWA and CSA Group while certifying Gasdroid prototype.
COMMERCIAL: Gas companies or their spin-offs will not want to take on the distribution or usage of the product	We will aim to validate the business model early in the process. Starting WP3 early enough and involving gas companies (direct customers, potential distributors/users) in the discussions and planning of the collaboration model and strategy in advance to the pilot project results in WP3. In parallel with exploring commercialisation models with large gas companies, we will approach smaller distributors to ensure a plan B is available for product commercialisation.
COMMERCIAL: Other CNG Fuelling appliances reach the market	A strong IPR strategy is to be implemented. We are not only relying on our background IPR but are also focussing on IPR activities in WP4 of our project. By implementing the right IPR strategy we will keep our position strong from other direct competitors using similar technologies. Since liquid piston technologies are superior compared to mechanical piston technology, we will monitor new compressors coming to the market using old and traditional mechanical piston technology but are not concerned about this technology being competitive.
COMMERCIAL: Our direct customers, and distributors have doubts about implementing technology from an SME	During WP3 we plan to complete pilots with the largest and most well-known gas companies and OEMs in Europe. One of the tasks in WP3 is focusing on monitoring, verifying and recording pilot results for establishment of technical track record of the product. In the framework of WP4 Pilot projects be well covered in media, social networks, and other communication channels. In our market rollout strategy, we are focussing on distribution channels like gas companies that are typically associated with fundamental brand credential.

COMMERCIAL: OEMs stop production of NGV vehicles	Even in the worst case there will still be a sizable market for the next 5 – 7 years from when the decision is made with companies rushing to purchase vehicles. We are working with closely with VW Group and via our Board Advisor Jens Andersen monitoring closely the market. In the worst case, there are other markets (MDVs, HDVs, gasoline LDVs which could be easily retrofitted), other geographies to work in.
COMMERCIAL: Not being able to raise future funding from private market.	The project (WP1-WP4) is structured to ensure Hygen as a fundable company for Series A investors. We already have early sales with the existing product and will boost sales figures right after project competition. In WP4 we will complete a commercialisation plan to be presented to Series A investors. Since it is hard for hardware company to raise funding on private market, we have also requested an equity funding from EIC to ensure rapid expansion in the market.
COMMERCIAL: EC CEN standard for Vehicle Fuelling Appliances is not approved	With leading members of the European Standardisation committee CEN/TC 326 "Gas supply for Natural Gas Vehicles" Working Group Nr.6 "Vehicle Fuelling Appliances" working with the company (Alex Safronov, Chairman and Julia Guzeyeva, Secretary), Hygen is ensuring that the new standard is published and approved as one of the tasks in WP4. By leading the process, Hygen makes sure that the standard includes all the necessary aspects for streamlining HYGEN+ commercialisation.
COMMERCIAL: VFA standard is not implemented into national law right away in each of the key markets.	The procedure of adopting new EU harmonised standard to national level is obligatory to each member state. However, there could be a time delays in the procedure which can slow down the market rollout of HYGEN+. By utilising our industry contacts gathered throughout years and years of being part of industry, within WP4 we have planned the task to monitor, support and push that the necessary activities are being carried out by national standardisation bodies to adopt new standard on a national level for the target countries as soon as possible. To mitigate the risk, in WP1 we are designing HYGEN+ to comply with local regulations and codes regardless, so that it can be installed according to existing legislation. This will ensure that in the worst case we are ready to bring the product to the market, although without the ease and low-cost of installation and permitting which would be afforded by the CEN standard for VFAs.

3.4 Approach

3.5.1 Overall structure of workplan

Brief presentation of the overall structure of the work plan: The work plan spans a duration of 18 months and its overall structure follows a logical flow to take the HYGEN+ technology from TRL6 to TRL8 – certification and field-demonstration having a completed and qualified product, the precursor to TRL9 and full market rollout. The project has been broken down into 5 manageable Work Packages (WP). Tasks (T), Deliverables (D), and Milestones to ensure the project can be easily monitored at every stage, ensuring that no important project outcome is overlooked or not achieved.

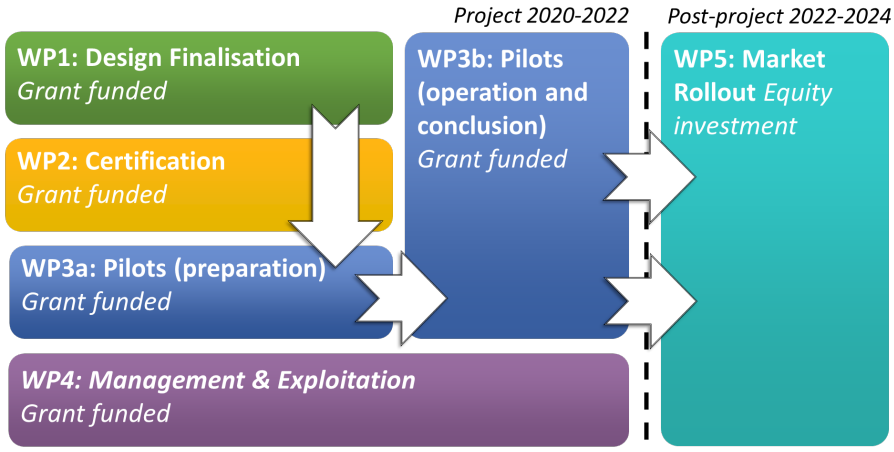

Figure 3.1: Project Pert chart outlining progression of work packages

We will begin the project by undertaking a complete finalisation of the design for HYGEN+ product. It will be done by updating the current TRL6 design so that it is more cost effective from point of view of production, installation and serviceability in the same time being capable to comply with European directives and standards as well as local legislation in target countries. As the pilots are concluded, HYGEN+ will reach TRL8 and will be ready to mass commercialisation via market rollout in first target markets

once the commercial pilots in target countries are conclude and TRL9 is achieved (WP5).

A WP dedicated to Management and Exploitation (WP4) will run throughout the course of the project. Discrete, manageable WPs enable us to effectively plan resource allocation and will allow effective management. For more information on the project flow and work plan, see Pert Chart, Gantt Chart and WP Description Tables.

Table 3.5: Summary Table for the HYGEN+ Project

Work Package Number/Title	Start /End	Deliverable	Milestone	PM	Indicative Budget	Fund Type
WP1 Design Finalisation	1-10	D.1.1 Technical documentation on the production prototype D.1.2 Technical documentation on the final product and its assembly line	HYGEN+ design completed and tested	**92**	€457.3k	Grant
WP2 Certification	1-12	D.2.1 PED Certificate for final product D.2.2 ISO 9001 certificate assembly line	**TRL7** HYGEN+ completed & certified	**53**	€327.1k	Grant
WP3 Pilots	1-18	D.3.1 Report on installed pilot sites D.3.2 Final report of 5x pilot projects	**TRL8** HYGEN+ industry demonstrated	**132**	€692.8k	Grant
WP4 Management & Exploitation	1-18	D4.1 Project mid-term, Periodic and Final Report D4.2 Mid/Final commercialisation plan	Commercialisation, IPR strategy is planned, verified and approved	**57**	€422.2k	Grant
WP5 Market Rollout	19 - 46	D5.1 Annual Financial report D5.2 Quarterly Financial report with positive Cash Flow from Operations	**TRL9** obtained, Company break-even achieved	**570**	€2.4M	Equity

Figure 3.2: Project Gantt chart outlining WP timings and task durations

Tables 3.6: Work Package description tables

Work package number:	**1**		
Work package title:	Design Finalisation		
Person months:	92	**Budget:**	€457 250
Grant or equity investment:	**Grant**		
Start month:	**1**	**End month:**	**10**

WP Description: Optimisation of HYGEN+ design from point of view of assembly, installation, serviceability, performance, cost and compliance with applicable codes and standards with cost and safety aspect being the priorities. The objective of this WP is to obtain the final design for certification and pilot projects.

Task 1.1: Development of improved originally manufactured (OM) components & subsystems: (Multivalve, ECU etc.). Development, construction, testing and optimisation of OM components like multifunctional valve, electronic control unit, frame, etc. based on the feedback from ENGIE Lab report and other gas companies.

Task 1.2: Source & test off-the shelf components for production prototype: We will define functional and technical characteristics of off-the-shelf components according to design requirements.

Task 1.3: Assembly, testing and optimising production prototype: Improving the design of our current TRL6 prototype to alpha TRL7 prototype by means of building it up and optimising it with off-the-shelf T1.2 and OM T1.1 components and iteration between both groups of components and subsystems. The components and subsystems will be modified, rearranged, tweaked and tested according to results of T2.2.

Task 1.4: Set up small scale pilot assembly line and supply chain: Using results of T1.3 will come up with an assembly line plan, including all the aspects of assembly line working stations, working station instructions, manuals, etc. By including results of T2.1 we will make sure that we can successfully conclude T2.4 Finally we will construct a small-scale assembly line and test it in industrial working environment.

Task 1.5: Assembly and testing final product: Using the assembly line designed, constructed and tweaked in T1.4, the final product will be assembled, disassembled and reassembled again and again. Results of certification task T2.3 may lead to top level system design reconfiguration and adjustment. TRL7 will be achieved ready for activities of WP3.

Deliverables	Type	Diss.level	Delivery
[D1.1] Technical documentation on the production prototype	R, OTHER	CO	M7
[D1.2] Technical documentation on the final product and its assembly	R, OTHER	CI	M11

Work package number:	**2**		
Work package title:	**Certification**		
Person months:	71	**Budget:**	€ 327 125
Grant or equity investment:	**Grant**		
Start month:	**1**	**End month:**	**12**

WP Description: This WP focusses on certification and compliances activities for the product and its assembly line, with the objective to obtain all the necessary documentation and verification for the product to be legitimately, easily and cost effectively deployed in EU countries.

Task 2.1: Confirming and categorising applicable codes and standards. Alongside certification against Pressure Equipment Directive (PED) we will also need to comply with EU industry standards as well as local codes used by local **A**uthorities **H**aving **J**urisdiction (AHJ). Therefore, we will need to review and update the design and testing codes and standards as well as list them out to server as the design requirements.

Task 2.2: Risk analysis and design review against applicable codes and standards. Risk analysis and compliance review of the design of the components and the whole system will be performed against all applicable codes and standards listed as the result of T2.1.

Task 2.3: Certification of HYGEN+ product. Notified Body (EU accredited certification body) will assess the compliance of HYGEN+ product against PED and relevant standards. Hygen will prepare a full technical documentation package, present it to Notified Body, receive and negotiate the feedback, carry out the compliance verification and testing procedure with the final production prototype resulted in T1.5.

Task 2.4: Certification of the HYGEN+ assembly line. The same procedures, tasks and activities undergone in T2.3 will be repeated in T2.4 right after T2.3 is finished only applying the activities to assembly line as opposed to product itself and proving the compliance of documentation and assembly line from T1.4 against requirements of ISO 9001 quality management system in assembly process.

Deliverables	Type	Diss. level	Delivery
[D2.1] PED Certificate for the final product	R	PU	M11

[D2.2] ISO 9001 certificate for the assembly line	R	PU	M13

Work package number:	**3**		
Work package title:	**Pilots**		
Person months:	145	**Budget:**	€692 750
Grant or equity investment:	**Grant**		
Start month:	**1**	**End month:**	**18**

WP Description: This work package focuses on setting up pilot projects with our partners, assembling units for pilots, installing them, obtaining permits, commissioning and finally running multiple pilot projects in parallel in first market rollout countries to prepare the product for market rollout phase.

Task 3.1: Confirm & set up pilots. Confirming and onboarding largest possible partners with whom we have signed LOIs with (Annex 3) in our target market countries. Those companies are: ENAGAS, Fluxys (via Gas.be), GRDF, UNIPER and GasConnect. Negotiating terms & conditions of the pilot contract as well as establishing side activities related to joint business plan development in parallel with pilot projects.
Task 3.2: Obtain local permits and prepare pilot sites. The process of obtaining permits typically have long lead and processing times (current situation until T.4.3 is finalised). In this task we will need to engage with AHJ, present the product, its safety design and features, explain risk mitigation strategies we have applied in the design and how that complies to local codes, standards and regulations.
Task 3.3: Assemble 5 HYGEN+ on assembly line. As soon as T2.3 and T1.4 are concluded, we will start to assemble HYGEN+ product units. We will need to order the off-the-shelf components, order manufacturing of OM components, check the quality assurance procedures are completed, physically assemble the products, make a burn test, package the units and ship them to the pilot sites.
Task 3.4: Install & commission 5 HYGEN+ units. We will complete a physical installation and commission the units. The commission will have to be done together with AHJ as they will visit the site and make the tests described in the operating permit.
Task 3.5: Run pilot projects & conclude the pilot results. We will start to run pilots in operational environments, monitor the performance and gather the data for the pilot report. Together with pilot partner we will evaluate operational performance, operational costs, durability, reliability, usability, safety, noise level, etc. By successfully concluding the pilots HYGEN+ technology obtains TRL 8 of actual system completed and qualified by proving it in the field in 5 target markets.

Deliverables	Type	Diss. level	Delivery
[D3.1] Report on units installed on the pilot sites	R, DEM	CO	M15
[D3.2] Final report of 5 pilot projects	R, DEM	CO	M18

Work package number:	**4**		
Work package title:	**Management and exploitation**		
Person months:	57	**Budget:**	€ 422 188
Grant or equity investment:	Grant		
Start month:	**1**	**End month:**	**18**

WP Description: The WP will ensure smooth progress on the project, ensuring all deliverables are completed on time and to budget. In parallel, IPR, dissemination and post-project exploitation will be addressed appropriately, including the standard being adopted in target countries to ensure scalability.

Task 4.1: Intellectual property protection. Confidentiality agreements detailing IPR topic will be prepared and signed by partners/collaborators. Existing IPR strategy will be updated and any new IP in the form of patents, copyrights, secret know from the project to be identified and patents filed where appropriate.
Task 4.2: Dissemination materials and activities. The dissemination plan will be produced and will be re-assessed and refined periodically. Dissemination of all publications, messages and projects outcomes will take place and will get maximum visibility at local, national and international levels. Methodologies include scientific and industry publications, conference posters, speeches and participation to industry events.
Task 4.3: Finalisation and adoption of the new standard at national level. We will be working with experts to resolve issues and submit the standard for formal vote again in Q4 of 2020 and then

making sure the standard is adopted in target markets (description of the standardisation topic in Section 2).
Task 4.4: Final commercialisation plan. A commercialisation plan will be finalised and will include all the relevant aspects of commercialisation including market strategies, competitive analysis, product roadmap, operations & management plan, financial plan and detailed description of the business model to be used with our direct customers, distributors and end users.
Task 4.5: Management and coordination. Includes project initiation, administration, organisation, technical and operational management. The project initiation will define the project conventions, documentation procedures, task management and communication tools, management decision and control procedures.
Task 4.6: KPI monitoring and risk management. Constant performance monitoring through key performance indicators and risks will be performed. We will track specific work packages and tasks, resource consumption, TRL advancement.

Deliverables	Type	Diss. level	Delivery
[D4.1] Project mid-term, Periodic and Final Report	R	CO	M6,13,18
[D4.2] Mid and Final commercialisation plan	R, DEC	CO, PU	M9,18

Work package number:	**5**		
Work package title:	**Market Rollout**		
Person months:	570	**Budget:**	€ 2.4million
Grant or equity investment:	**Equity investment**		
Start month:	**19**	**End month:**	**46**

WP Description: To deliver 5 key business activities to rapidly scale and breakeven by 2024

Task 5.1: Building distribution and strategic alliance partnership and making market rollout in target countries. Defining stakeholders and their engagement (car OEM dealerships, gas companies, installers/maintainers, authorities having jurisdiction, other local stakeholders) required for successful commercialisation of the product. Negotiating and signing necessary parties for HYGEN+ market rollout. As its done, we will engage in running commercial large-scale pilots to prove the business model before scaling it. As its completed, we will engage in commercial sales of the products in target countries with all the necessary parties contracted from T5.1.
Task 5.2: Increasing the production capacity to 1050 HYGEN+ units per year. Contracting production partners, supply chain and expanding existing assembly line with a max. capacity of 300 units/p.a. to 1050 p.a. a flexibility to expand it to 2100 units/p.a. when required.
Task 5.3: Ramp up sales and marketing resources. Come up with a sales playbook, defining sales procedures and KPIs, hire more sales reps and marketing people in order to hit the projected sales targets.
Task 5.4: Adapting product for higher pressures. With a feedback form Shell and Toyota accelerator (H2Refuel) we will adopt the design to higher pressures and H2 gas addressing key challenges of H2 market.
Task 5.5: Market rollout in other market (EU and emerging markets). Having an experience with rolling out HYGEN+ products in target countries, engage in necessary activities to do the same for 2nd tier countries.

Deliverables	Type	Diss. level	Delivery
[D5.1] Annual Financial report	R	CO	M32, M42
[D5.2] Quarterly Financial report with positive CF from Operations	R	CO	M45

3.6 Resources

3.6.1 Resources, equipment and facilities

To carry out the work described in the description of WPs, Hygen will utilise our own existing facilities where we have all the necessary equipment and space to successfully execute on the tasks required to reach the project objectives (see photos and short description in Annex 2). Other required consumables and services are presented and described in Table 3.6.

Table 3.7: Other direct costs justification table

Category	Cost (€)	Justification
Travel	**€32,900**	**€2,800** WP1: 2 trips total - visiting manufacturers while sourcing components (2 persons)
		€18,200 WP3: 5x trips visiting pilot partners (1 person). 6x trips visiting pilot sites and AHJ for the pilot site permitting (1person). 5x trips to commission 5 units in 5 sites and launch the pilots (2 persons). 3x trips to the pilot location planned as contingency (2 persons)
		€11,900 WP4: 5x trips to conferences, industry, venture capital/start-up events (1 person). 10x trips visiting pilot partners (1 person)
Other goods and services	**€323,000**	**€40 000** Consumables for WP1. All the components necessary to assemble HYGEN+ prototype (high pressure tubing, cylinders, valves, electronics, wire harness, actuators, motors, hydraulic pump, frame, etc.) and the components needed to adjust the design.
		€16 500 Consumables WP2. Subcomponents for OM components, additional components for tweaking the design of HYGEN+, etc..
		€115,000 Consumables WP3. Components necessary to assemble 5 pilot units, install them and have a replacement parts ready as a backup for pilots.
		€6,500 Utilities (gas, electricity, water, oil, etc..)
		€11,500 Shipment services of the pilot units
		€15 000 Development services in WP1 (CAD drawings, simulations, ANSYS simulations, Matlab calculations, etc.)
		€10,000 Component compliance testing services in WP1. (pressure bearing tests, electromagnetic compatibility etc.)
		€40,000 WP2: Certification of Electronics
		€30,000 WP2: Certification of the product and assembly line
		€18,000 WP4: Dissemination activities (conference, exhibitions, others)
		€5,500 WP3: Insurance for running pilots (for the first-time usage)
		€15,000 Lab rent (WP1,2,3)
Total	**€355 900**	