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# Prospects of Decarbonizing Industrial Areas in the Baltic States by Means of Alternative Fuels

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## ABSTRACT

All three Baltic States have reached good figures regarding the change in total greenhouse gas emissions from transport during 1990-2017. Particularly successful is Lithuania, showing a negative value of -2.7%. Latvia considerably lags behind Estonia (+15.1% vs. +1.5%). Amid the achievement of Latvian scientists, engineers and merchants, the authors point out the work of Lithuanian engineers who investigated how gaseous hydrogen affects the parameters of diesel internal combustion engine. Important to note that in the Baltic States, the activities of inland waterway vessels and the shunting locomotives are concentrated in only a few main cities. Regarding that, Baltic scientists and environment specialists nowadays are developing plans also for local air pollution decreasing, which can be carried out in particular cities or industrial areas, thereby allowing for improvements in air cleanliness and the ecological situation in concerned local area. A numerical estimation shows that applying the NYSMART technology, introduced in this paper, will make areas of active action of the high-volume diesels cleaner in the same amount as gained by photosynthesis of the urban green flora. In recent years, the developed technology of hydraulic piston compression allows producing numerous different vehicle fueling appliances for the CNG/bio-CNG fuel. The further development of this technology means the producing of various solutions, applicable at biogas/biomethane production sites, for CNG/bio-CNG compression, transportation and fast natural gas vehicles refueling in a cost effective and convenient way. The hydraulic piston compression and NYSMART have a potential in small and medium-scale technologies and therefore need to be developed further for applications with hydrogen. Production of biomethane and green hydrogen is delayed by the lack of state aid programmes in the Baltic States. Lithuania is on the way to change the situation in the coming years, with one of the first biomethane gas production plants due to be built near Panevėžys, in Šilagalys near the Via Baltica motorway. Summing up all aspects, the preconditions for the use of alternative fuels in the Baltic States are similar, allowing one to learn from other's experience and to consider joint projects.

**Keywords:** alternative fuels, biofuel, CNG, bio-CNG, HCNG, GHG emissions

## INTRODUCTION

The main point in using alternative fuels is to reduce the greenhouse gas (GHG) emissions, at the same time not increasing the fuel cost excessively and not reducing the performance of fueled engines. The term "alternative fuels" is not exactly defined – some explanations emphasize the renewable energy component, while others, including Directive of the European Parliament and of the Council on the deployment of alternative fuel infrastructure (DAFI), consider all fuel types and modifications that are more sustainable than traditional ones. In the range of alternatives, some definitions even include coal-derived liquid fuels.

In the European Union (EU), according to DAFI, "alternative fuels" are sources of fuel or energy which partially or completely replace fossil fuel oil sources in vehicle power supply, having the potential to contribute to decarbonization of transport sector and therefore of the environment. DAFI defines the following main alternative fuels (Directive (EU) 2018/2001):

- electricity,
- hydrogen,
- liquid biofuels (biodiesel, bioethanol and hydrogenated vegetable oil),
- biomethane,
- compressed natural gas,
- liquefied natural gas.

This paper deals with some technical solutions and predictions for developing an infrastructure for the use of gaseous alternative fuels in the Baltic States. Since the authors of the present paper are from Latvia, they give in details the achievements of Latvian scientists, engineers and merchants.

DAFI has defined the minimum requirements for building the infrastructure for alternative fuels, including refueling points. Generally, the entire infrastructure must be implemented by means of Member States' national policy frameworks. The set 2020 target for European countries was reaching 10% the share of energy from renewable sources in transport sector in terms of gross energy consumption. Only four countries were able to meet this goal. Nevertheless, from the National energy and climate plans (NECP) it is concluded that all EU countries are using similar templates, being a good precondition to work together to make efficiency gains across borders (National Energy and Climate Plans, 2018). The revised Renewable Energy Directive (RED II) has increased the target of the overall EU renewable energy consumption by 2030 from 27% to 32%, regarding 14% in the transport sector (EUR-Lex, 2018).

The use of alternative fuels in the transport sector, especially in small countries, strongly depends on the state aid programs. Leading countries of the EU have gone through different experimental attempts and come to electric power and hydrogen nowadays. For a pioneering example, a project on hydrogen engines for inland waterway vessels has been launched in the Netherlands and Belgium, starting from 2019 (H2SHIPS, 2019).

The long-term forecast for the fuel consumption in Latvia is summarized in Table 1.

The Baltic States have no sufficient support from the state aid programs to switch to electric power and hydrogen engines in particular important transport subsectors. Latvian experts consider that a combination of natural gas and biomethane could be brought forward as one of the most promising for short and mid-term transport decarbonization solutions in Latvia (Savickis, Zemite, Zeltins, Bode, & Jansons, 2020).

In this context, the Latvian-based company DiGas Ltd. is engaged in the conversion of high-volume locomotive diesel engines into dual fuel diesel-natural gas (http://digasgroup.com/about-company/). DiGas Ltd. project on the adaptation of diesel locomotives to dual fuel (EUROPA - Novel Dual-Fuel System, 2017) mentions very high figures: 30% reduction in fuel costs, 95% and 60% reduction in PM and NOx emissions, respectively. One of the DiGas projects has been implemented in Latvia by converting six Jurmala Mercedes Benz Citaro city buses Euro IV class to dual fuel. With NYSMART electronic fueling technology providing initial diesel power, the optimized fuel mix is 65% CNG, 35% diesel.

As stated by European Commission in 2020, in a distant perspective, hydrogen will become the fuel of the future (A Hydrogen Strategy for a Climate-Neutral Europe, 2020; Powering a Climate-Neutral Economy, 2020). This statement determines hydrogen not only as a pure fuel but also its role in power to gas conversion schemes, $H_2$ additive to gas network, and innovative HCNG fuel.

Among Baltic scientists, the Lithuanian-based company Dujas Ltd. may be taken as

**Table 1.** 2020–2050 forecast for the fuel consumption in Latvia (2014/94/ES Par Alternatīvo Degvielu Ieviešanu Scenārijiem, 2014: in Latvian)

| Type of fuel | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|
| Diesel | 65.2% | 67.2% | 64.0% | 52.4% | 34.4% | 27.9% | 23.1% |
| Gasoline | 25.2% | 20.4% | 12.1% | 11.7% | 12.8% | 11.9% | 10.6% |
| LPG | 5.0% | 7.1% | 13.9% | 15.0% | 7.0% | 6.1% | 6.4% |
| LNG | 0.5% | 0.5% | 0.7% | 1.7% | 2.0% | 1.9% | 2.1% |
| CNG | 0.8% | 2.5% | 4.5% | 10.7% | 19.9% | 27.5% | 30.2% |
| Bio-diesel | 1.6% | 0.2% | 0.2% | 0.2% | 10.4% | 11.0% | 12.9% |
| Electricity | 0.4% | 1.0% | 2.5% | 5.6% | 10.2% | 12.4% | 13.2% |

pioneers in applying the hydrogen addition to diesel fuel and modifying diesel engines to accept it. Dujas Ltd. investigated gaseous hydrogen addition of 10, 20 and 30 L/min to the air intake with Audi 80 (1992) 1Z type 4 stroke diesel internal combustion engine with the turbo binary compressor (Latakas et al., 2014). Following the conclusions of this work, with hydrogen additive it is necessary to adjust the diesel injection angle in order to optimize engine working cycles. As in DiGas Ltd. (diesel plus CNG) case, some important figures of Dujas Ltd. (diesel plus $H_2$) were high: the $CO_2$ concentration in the exhaust decreased in proportion to $H_2$ and was reduced by 18%, PM and NOx by 35%, smoke by half. In contrast, the HC concentration with increasing that of $H_2$ rose by 30%, from 8 ppm to 11 ppm. The overall verdict that the energy efficiency of the diesel engine is decreasing with the $H_2$ additive allowed concluding that gaseous $H_2$ additive to a standard diesel internal combustion engine is not profitable, at least, in the investigated scale.

A number of technical findings report on the positive effect of hydrogen additive on compressed natural gas (CNG) fuel. The product - hydrogen fuel additive to compressed natural gas (HCNG) is characterized by several advantages over CNG, the most important of which are:

- $H_2$ additive increases the fuel's H/C (hydrogen/carbon) ratio, which reduces the $CO_2$ emissions per mole of fuel, reducing the GHG effect,
- hydrogen flame propagation velocity is 8 times higher than that of natural gas, which ensures stable operation of cylinders even at lean burning well below stoichiometric conditions,
- faster combustion of the fuel blending due to the addition of hydrogen results in a higher adiabaticity in the combustion phase, resulting in a higher efficiency of the heat engine.

The fuel properties change gradually with an increase in hydrogen additive concentration in molar range of 0–30%, and it does not sufficiently alter the Wobbe index of the blended fuel. It is important to note that working regimes of the shunting locomotives and the port tugs include long idle hours that considerably increase the efficiency of using HCNG. The further development of the NYSMART technology from the CNG additive to HCNG is hindered by the issue of HCNG fuel blending and supply.

## NUMERICAL ESTIMATION OF THE "GREEN GAIN" GIVEN BY USE OF THE ALTERNATIVE FUELS

A numerical estimation was made for Latvian capital Riga, which is the largest industrial area by counting inland waterway vessels and shunting locomotives. The capital of Latvia, Riga, has an ambitious goal of becoming the first neutral city in the Baltic climate by 2050 (Cities - Race to Zero & Race to Resilience (unfccc.int)) (Riga Joins the Paris Climate Declaration, 2021). One of the sustainable development goals, defined in the sustainable development strategy of Riga up to 2030, is "A convenient, safe and citizen-friendly urban environment", which needs to be gradually released from pollution sources. As of 2005, the daily limit for $PM_{10}$ particles is exceeded in Riga and the overrun continues from 2011 up to nowadays.

Let us presume that by opening a state aid program, a hydrogen additive to the fuel stimulates modification of high-volume locomotive and vessel diesel engines. Using the data given by DiGas Ltd. and available in (Gaisa Kvalitāte, 2021: in Latvian), the modification of diesel engines with the NYSMART technology in Riga can contribute up to 30, 4 and 3 tons in year to the reduction of the $NO_2$, $PM_{10}$ and $PM_{2,5}$ emissions in the shunting locomotives sector, respectively, and 13, 20 and 18 tons in year in the river Daugava waterways vessels sector, mainly concentrated inside Riga borders. According to the data, given by Latvian State Forest Research institute "Silava", the trees in Riga remove an estimated 0.73 metric tons of air pollution. As the areas of active action of the shunting locomotives and the inner water vessels count ca. one eighth of Riga, 90 metric tons are obtained in the subjected areas. This value is very close to the sum of all three emission species, reduced with NYSMART technology and given above: 37 t/year from locomotives plus 51 t/year from vessels. Thus, it can be said that, applying the NYSMART technology makes areas of active action of the high-volume diesels twice greener than by the trees alone.

## MAIN CHALLENGES FOR USAGE OF ALTERNATIVE GASEOUS FUELS IN THE TRANSPORT REFUELING SECTOR

In the Baltic States, as in the whole EU, the deployment of CNG refueling points, accessible to the public, is defined. According to the DAFI requirements, the distance between CNG refueling stations in the TEN-T Core network should be 150 km maximum; in fact, this requirement has higher priority to determine the target number of CNG refueling stations (Savickis, Zemite, Zeltins, Bode, & Jansons, 2020).

The technical problems of widening the usage of all gaseous fuels are:
- efficient charging of the storage cylinders to high pressure,
- transportation of the gaseous fuel to destination points (injection point to the grid or to the refueling station),
- installation of efficient refueling appliances for on-farm applications,
- complete discharge of gas storage cylinders.

Firstly, let us focus on the complete discharge of a gas cylinder. It is a quite hard task because the fueling performed by a free flow of gas ends at the pressure balance between the donor cylinder and the target fuel tank. One of the incomplete solutions is the cascade fueling. It means fueling from multiply storage cylinders of increasing the initial pressure serially. It gives the advantage of ca. one fourth in terms of final pressure in the target tank.

Figure 1 displays numerical simulation of NG charging a 130 L target tank from the storage set of four cylinders, 22 L each, by both parallel and cascade fueling methods. Initial NG pressure in the target tank is at 5 bar whereas in the four donor cylinders at 200 bar. The result is reached 90 bar via the parallel fueling and 109 bar by using the cascade fueling method in the target tank. It is seen that achievement of the multiple cascades of reasonable number drops moderately behind the maximally possible pressure at 140 bar in a target tank, calculated by the amount of NG. Additionally, multiple cylinders in the cascade setup require complicated piping and valve triggering circuits that is a significant installation disadvantage. The technical solution, presented in this paper, shows how discharging the storage volume close to entirely is achieved by applying a pushing force by means of hydraulic boosting.

In 2008, a Latvian based company Hygen Ltd. has invented the technology of the hydraulic piston and though the years implemented it in various CNG vehicle refueling systems, intended for gas compression, storage and discharge (Hygen; Safronovs, 2009). Unlike conventional mechanical multistage compressors, the hydraulic

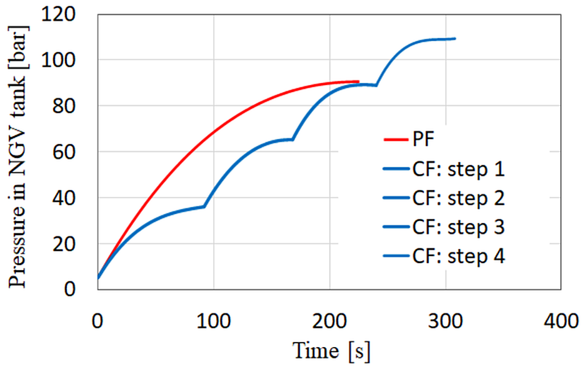


**Figure 1.** Numerical simulation of parallel fueling (PF) and complete cascade fueling (CF)

piston and boosting technologies use a method of gas compression and pushing by means of a working liquid, which is set in motion by a sufficiently powerful hydraulic pump, explained in details below.

## The hydraulic compressor: working principle and operating modes

### *Technology of the hydraulic piston compression*

Technology of the hydraulic piston compression and compressed gas accumulation in a cylinder is explained with a help of Figure 2. The cylinders (1) and (2) work serially as a compressor. The working liquid (red fill in Figure 2), the amount of which slightly exceeds the volume of each compression cylinder, is chosen to be chemically non-reactive with the gas, as well as having minimized gas diffusivity. A typical working liquid for this purpose is transmission oil. The working liquid is pumped from the first to the second compression cylinder and in reverse by employing the hydraulic pump and triggering the valves. Compression of the gas above the working liquid in a compressor cylinder occurs due to increasing the amount of liquid. At the same time, decreasing the amount of liquid in the second compression cylinder is the phase for inlet of a new portion of low-pressure gas. If the volume free of liquid is 22 L, and hydraulic pumping productivity is 7.5 L/min, each compression step takes 3 minutes. The inlet gas pressure can vary in a quite wide range, starting from residential low pressure of 17–25 mbar up to industrial high pressures. A pre-compressor up to 3 bar may be installed to avoid too low gas inlet pressure that reduces the overall efficiency of compressing.

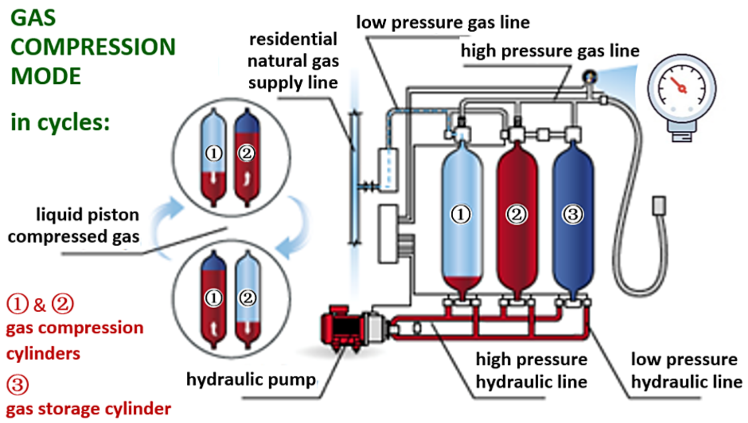


**Figure 2.** Principle of the hydraulic compression (Mezulis et al., 2020)

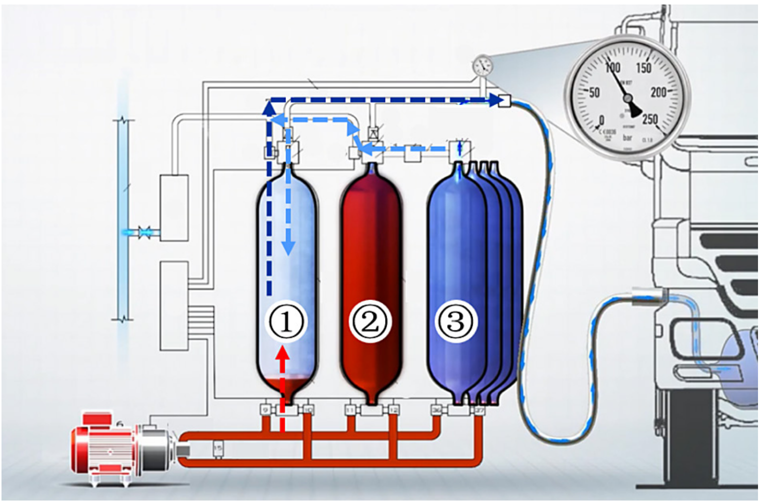

**Figure 3.** Principle of the hydraulic boosting (Mezulis et al., 2020)

Each compression cycle ends when gas pressure in the compression cylinder surpasses that in the accumulating cylinder, and a current compressed portion of gas is pushed through the check valve into the storage cylinder (3). As a result of multiply compression cycles, the storage cylinder is filled up with the gas at demanded pressure, with NG normally 200-250 bar. Driving all functions of the hydraulic compressor, including switching hydraulic and gas valves, nowadays usually is implemented by the electronic control unit.

### *Technology of the hydraulic piston boosting*

By charging a target tank, the first refueling stage is free flow stage. This stage ends when the pressure equilibrium between the storage tank and the target tank sets in. The boosting mode is employed with the aim to empty the storage cylinders (3) far behind the free flow level. The principle of boosting is displayed in Figure 3.

When the free flow stage is over, the remained gas at mid-pressure from the storage cylinder (3) is supplied to the compressing cylinder (1) (light blue arrow) for boosting. The hydraulic boosting is accomplished by activating the hydraulic piston and forcing the amount of gas directly into the vehicle's fuel tank (dark blue arrow). If necessary, the boosting cycles are repeated alternately in both compression cylinders (1) and (2) by switching the valves.

### *A typical diagram of the boosting mode*

For simple and fast boosting the volume of the target tank must be smaller than that of the storage capacity. For example, to fill a volume of 240 L up to 200 bar, the compressor operates in a boosting mode for about 13 minutes. As measured, the total electrical consumption of the device during this period is 1.12 kWh, which is quite a good figure. It is important to control the gas temperature to avoid overheating some types of cylinders and, due to acting the Joule-Thomson effect, to avoid frosting the valves and nozzles. With a manufactured setup at ambient temperature of 8 °C, the gas temperature in the tank first decreased down to -8 °C due to gas expansion and then increased up to 35 °C at the end of charging. These temperature values and duration are rather far from critical thresholds. Figure 4 displays charging the target tank of 240 L at initial 85 bar by hydraulic boosting from the storage capacity of 400 L. The whole boosting process takes five hydraulic cycles in 760 seconds.

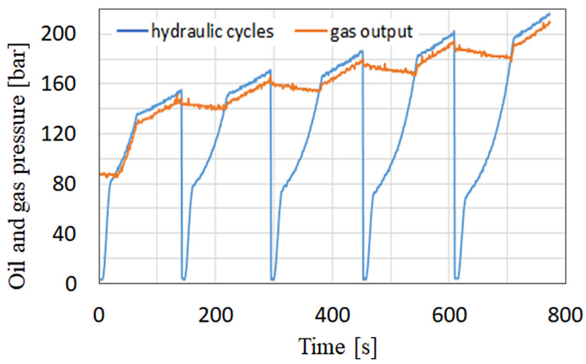


**Figure 4.** Hydraulic boosting pressure-time diagram

## CNG REFUELING APPLIANCES DEVELOPED IN LATVIA

By now, Hygen Ltd. has implemented the hydraulic piston technology for working with CNG and bio-CNG in some manufactured products. Let us focus on *GasDroid, HYGEN+* and *GasLiner*.

*GasDroid* (Fig.5) is a vehicle fueling appliance (VFA) for charging light duty vehicles with CNG/bio-CNG only by free flow principle. *GasDroid* has two compression cylinders 33 L each and four storage cylinders with a total volume of 88 L. Such setup supplies a light duty vehicle with an amount of fuel for 120–150 km run. The specifications of *GasDroid* are listed in Table 2.

*HYGEN+* (Fig. 6) is a vehicle fueling appliance for charging mid- and heavy duty vehicles with CNG/bio-CNG by free flow and boosting principles. *HYGEN+* setup is optimized for complete charging the vehicles with fuel tanks up to 300 liters. Larger tanks can also be charged, nevertheless, it takes more than 15–20 minutes. The specifications of *HYGEN+* are listed in Table 3.

For various off-grid supply needs Hygen Ltd. proposes a cost-effective solution, i.e., a mobile CNG/bio-CNG system named *GasLiner* (in detailed technical description *GasLiner/GasCharger*). The *GasLiner* technology represents the hydraulic compressor and storage cylinder modules in standard size load bearing frames that can be placed on a closed type car trailer. Each module accumulates gas volume of 3125 L, that equals to 935 Nm$^3$ of natural gas at 250 bar, and the long 13 m caravan carries 8 modules. The electricity consumed to fill the *GasCharger* storage cylinders up to 250 bar is 0.2 kWh/Nm$^3$ at 16 bar gas inlet pressure. The developed *GasLiner*

**Figure 5.** VFA *GasDroid*


**Figure 6.** VFA *HYGEN+*

**Table 2.** Specifications of *GasDroid*

| | |
|---|---|
| Compression flow rate | 1.2 m³/h |
| Gas outlet pressure | 200 bar |
| Storage capacity | 84 water litres |
| Fuelling time | 4 min |
| Electrical power | 0.5 kW (max 6 A) |
| Power supply line | 230 VAC |
| Gas inlet pressure | 17-25 mbar (or 3 bar) |
| Dimensions L×W×H | 90×50×176 cm |
| Weight (with working liquid) | 390 kg |

**Table 3.** Specifications of *HYGEN+*

| | |
|---|---|
| Compression flow rate | 4.4 m³/h |
| Gas outlet pressure | 200 bar |
| Storage capacity | 380 water litres |
| Fuelling time | up to 25 min for 60 m³ |
| Electrical power (2 pumps) | 4 kW (max 7.9 A) |
| Power supply line | 380 3-phase VAC |
| Gas inlet pressure | 17-25 mbar (or 3-16 bar) |
| Dimensions L×W×H | 120×100×170 cm |
| Weight (empty) | 1500 kg |

module with dimensions L×W×H ca. 160×240 ×270 cm as well as a standard 13 m long 6400 Nm³ *GasLiner/GasCharger* mobile refueler and an off-grid CNG/bio-CNG refueling station are shown in Figure 7.

Produced Alpha prototype of *GasLiner/GasCharger* is capable:

- to compress NG by onboard modules, i.e., without usage of a mother station;
- to accumulate CNG/bio-CNG, compressed to 250 bar, in the storage cylinders inside the modules;
- to deliver CNG/bio-CNG by roads to the selling/distribution points;
- to refuel a number of vehicles (simultaneously if the vehicles are connected to a branched pipeline) with CNG/bio-CNG in 1-2 hours without employing a daughter station.

The lack of the mother and daughter stations in the virtual pipeline system allows for *GasLiner/GasCharger* to significantly reduce the whole virtual pipeline exploitation costs. As measured, *GasLiner/GasCharger* off-grid refueling process reaches very high 96% efficiency at bio-CNG flow rate of 80 Nm³/min. The daily consumption of various public CNG refueling stations versus the number of demanded *GasLiner* mobile modules is shown in Figure 8.

The technology of the hydraulic piston is being developed further for employing with HCNG fuels. Theoretical estimations and experimental prototypes indicate no overwhelming technical barriers for hydraulic compression of natural gas with $H_2$ additive. Moreover, due to hydrogen behavior, some notable physical aspects, e.g., heating of compressor cylinders and Joule-Thomson effect are diminished.

## CHALLENGES FOR BIOMETHANE APPLICATION IN THE TRANSPORT REFUELING SECTOR

Biomethane stands for the methane produced by means of purification of raw biogas from biomass or from gases acquired from different types of organic waste. The chemical characteristics of biomethane are close or even equal to that of natural gas. The main point to fuel the vehicles with biomethane is to reduce their carbon footprint.

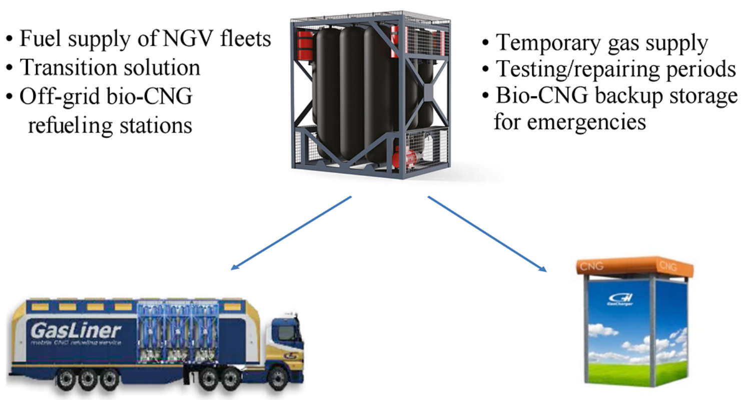


**Figure 7.** GasLiner CNG/bio-CNG module, mobile refueler and off-grid refueling station (Safronov et al., 2020)

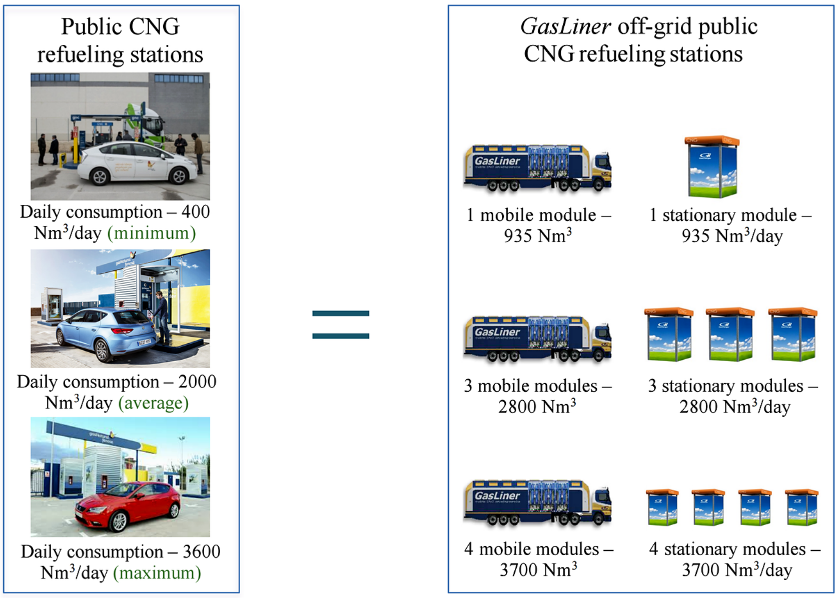


**Figure 8.** Scaling the public CNG refueling stations and the number of GasLiner modules

Usually, the CNG infrastructure and vehicles are compatible to work with renewable gaseous fuels without extra costs. The technical requirements and safety conditions for the use of biomethane-powered vehicles are identical to those for CNG vehicles, being in compliance with the regulations and standards, e.g., ISO 15403-1:2006. Likewise with other renewable fuels, the calculated amount of the $CO_2$ emissions from the biogas fueled transport is regarded to be zero. Though biogas combustion generates $CO_2$, there is no net increase in atmospheric carbon dioxide because the amount of $CO_2$, captured in the biodegradable feedstock, approximately equals to the amount released at biogas combustion.

The analysis of the collected data gives that the number of biomethane plants in Europe has increased in two years from 483 in 2018 to 729 in 2020 (The European Biomethane Map, 2020). Currently 18 countries are producing biomethane in Europe. The European Union is the world leader in biogas electricity production with growing gross electricity production from biogas of 62,500 GWh in 2020. Due to a large number of combined heat and power cogeneration plants, the second largest volume of produced from biogas energy is heat, reaching the gross value of 890 ktoe in 2020.

The Baltic States appear to be small against the background of large European countries in primary energy production from biogas, as displayed in Table 4. In Latvia there are 59 biogas plants in operation nowadays, and produced by them biomethane is mostly used for the production of electricity. In Lithuania, 38 biogas plants produce 35 MW of electrical and 10 MW of heating power. Estonia lags with 17 biogas plants, but has started to grow in production by attracting the German company EnviTec Biogas.

In the opinion of Latvian scientists, according to the present economical estimates, treatment of biogas into biomethane for use in transport sector should be regarded as more cost effective option in terms of economy than local combustion of biogas. The survey, conducted during January – March 2021

**Table 4.** Primary production from biogas (kilotons) in the European Union (Methanation Plant)

| Countries | 2018 | | | | 2019 | | | |
|---|---|---|---|---|---|---|---|---|
| | Landfill gas | Sewage sludge gas | Other anaerobic fermentation | Total | Landfill gas | Sewage sludge gas | Other anaerobic fermentation | Total |
| Latvia | 7.6 | 2.0 | 77.4 | 87.0 | 7.5 | 2.1 | 70.9 | 80.6 |
| Lithuania | 10.0 | 6.9 | 20.2 | 37.1 | 8.7 | 6.8 | 23.4 | 39.0 |
| Estonia | 1.4 | 7.5 | 4.8 | 13.6 | 1.4 | 7.6 | 4.8 | 13.9 |
| Total EU | 2398 | 1529 | 12425 | 16510 | 2260 | 1594 | 12612 | 16630 |

in Latvia, yielded that most of respondents consider contributing with their produced biogas not only for electricity and heat cogeneration but also for car refueling, whereas very few respondents consider producing biogas for injection into natural gas grid. Nearly all respondents keep upcoming technology upgrades in mind, many of them follow the research results and educational articles.

Thus far, there were no state aid programs in Baltic States for producing of bio-CNG fuel from biogas for the transport sector. However, the situation is set to change crucially in Lithuania in the coming years, with one of the first biomethane gas production plants due to be built near Panevėžys, in Šilagalys near the Via Baltica motorway, by 2023. The biomethane will be safely produced from biodegradable waste from the local agricultural company Šilagalis, i.e. – animal manure and agricultural and other organic waste. Regarding the set target of Lithuania's National Energy Independence Strategy that 15% of the energy consumed by the transport sector by 2030 will come from renewable energy sources, including biomethane, the expected gain of this project is of great interest for all three Baltic States.

## CONCLUSIONS

Nowadays a wide range of fuels and engines are developed concerning reducing the GHG emissions. The rapid growth of battery electric, fuel cell electric vehicles (BEV and FCEV) and hybrid engines demand a lot of investments and mainly regards to light-duty vehicles. The Baltic States are relatively small countries with a considerable number of inland waterway vessels and shunting locomotives with diesel engines, concentrated in only a few main cities. The point in reducing the fuel costs, PM and NOx emissions is not only to use biodiesel but also to modify large diesel engines for the fuels with gaseous additions. For the Baltic States, to contribute to the overall efforts to increase the use of alternative fuels amid other tasks is to create an efficient refueling infrastructure for CNG, bio-CNG and HCNG fuels. The hydraulic piston compression technology developed in Latvia and boosting up to the level of manufactured devices allows producing various vehicle refueling appliances for CNG/bio-CNG fuel. The further development of the hydraulic piston technology, by now accomplished as *GasLiner*/*GasCharger*, includes new ideas of mobile solutions for bio-CNG compression, transportation and fast discharging to natural gas vehicles (NGV) or injection into the gas grid in a cost effective way. Biogas/biomethane compressing and storage at the production sites are also of interest. In the cases of opened state aid programs, a part of Baltic biogas producers plans to start upgrading biogas to biomethane in a quality suitable for refueling CNG vehicles. Therefore, they will need the biomethane compression and transport equipment discussed in this article. The hydraulic piston compression and NYSMART have a potential in small and medium-scale technologies and therefore need to be developed further for applications with hydrogen. In general, the preconditions for the use of alternative fuels in the Baltic States are similar, allowing one to learn from other's experience and to consider joint projects.

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