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PITPOINT

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COST BENEFIT ANALYSIS - SUMMARY

PROJECT: LNG-MOTION - FUELLING TRUCKS WITH LNG/CNG ALONG THE CORE NETWORK

Co-financed by the Connecting Europe Facility of the European Union

Cost Benefit Analysis- Summary

1. Introduction

As part of the Connecting Europe Facility Transport (CEF-T) program supported study project titled: *LNG motion: Fuelling trucks with LNG/CNG along the core network (hereafter LNG Motion pilot deployment)* a social economic cost benefit analysis (CBA) has been prepared. This EU CBA combines the CBA analysis input received from the operational LCNG and LNG stations included in the scope of the LNG motion pilot deployment. This report is also prepared in line with the preliminary business case for the global project, which aims to assess the rollout and scaling up of LNG fuelling stations and LNG trucks throughout Europe in a next phase.

The investment decision analysed in this CBA concerns a stand-alone socio-economic and technical initial phase of this project. The investment decision entails the construction of fuelling stations supplying Compressed Natural Gas (CNG) and fuelling stations for Liquefied Natural Gas (LNG) from both Bio-Methane and Natural Gas for heavy duty transport, logistics and public transport along the TEN-T network.

The projections in this analysis cover the period 2019-2034 and relate to the geographic area of the European Member States France, Belgium, Germany and the Netherlands. The projections are based on a combination of past data with assumptions about future developments. The main elements that have been analysed are the expected impact of EU, national and regional legislation and policy measures on the transport sector and on fuel consumption. The projections are placed within the framework of general macroeconomic developments, population growth development, and general socioeconomic trends.

2. Methodology

As per the TEN-T directive (1315/2013), projects should be economically feasible based on a socio- economic assessment of the costs and benefits (article 7.2.c), in accordance with the EU CBA guidelines.[1] A CBA is based on a set of predetermined project objectives, giving a monetary value to all the positive (benefits) and negative (costs) welfare effects of the intervention. These values are discounted[2] and then totalled in order to calculate a net total benefit. The project overall performance is measured by means of indicators, i.e. the Economic Net Present Value (ENPV), expressed in monetary values, and the Economic Rate of Return (ERR), allowing comparability and ranking for competing projects.

The CBA is an ongoing, multi-disciplinary, exercise performed throughout the project preparation in parallel with other technical and environmental considerations. Prerequisites for the CBA of the proposed project solution are, howe ver, the finalisation of a detailed demand analysis and the availability of investment and operational and management (O&M) cost estimates, including costs for environmental mitigation and adaptation measures.

A positive economic return shows the society is better off with the project, i.e. the expected benefits on society justify the opportunity cost of the investment. The rationale of CBA lies in the observation that investment decisions taken based on profit motivations and price mechanisms lead, in some circumstances (e.g. market failures such as asymmetry of information, externalities, public goods, etc.), to socially undesirable outcomes. On the contrary, if input, output (including intangible ones) and external effects of an investment project are valued at their social opportunity costs, the return calculated is a proper measure of the project's contribution to social welfare.

[1] *Guide to Cost-Benefit Analysis, Economic Appraisal Tool for Cohesion Policy 2014-2020*, December 2014, EUROPEAN COMMISSION, Directorate-General for Regional and Urban policy.
[2] Art. 61 of (EU) Regulation 1303/2013 and Article 15 (Method for calculating discounted net revenue) of Commission Delegated Regulation (EU).

3. The source of the CNG and LNG is bio-methane from waste

With regard to bio-methane based CNG and LNG, research agency Ricardo concludes that the switch from diesel to second generation compressed and liquefied bio-methane (CBM and LBG), from second generation sources such as waste and manure reduces the emission of CO_2eq by approximately 90% when measured as tank-to-wheel (TTW) (actual emissions in highly urbanised areas).

With regards to compressed biomethane (CBM) and liquid biomethane (LBM), tailpipe emissions of CO_2 are reported as zero.[3] This is because for biomethane produced from waste biological materials such as landfill gas and anaerobic digestion of organic wastes, the tailpipe CO_2 emissions released on combustion are treated as biogenic and not considered to contribute to climate change.

For the calculation of the well-to-wheel (WTW) effect of bio-methane based CNG and LNG the Ricardo study offers a CO_2eq reduction (depending on the type of vehicle used) between 37% (for a heavy truck) and 72% (for a commercial light vehicle) when measured as WTW.[4]

Some studies even argue for the environmental impact to become negative when considering bio-methane pathways.[5] In June 2019, for example, a study has been published by CE Delft on the CO_2 balance of the bio-methane chain.[6] This study shows that when bio-methane is used to produce LNG and the captured CO_2eq. (by-product from the liquefaction procedure/ production of LNG) is being used as a raw material (such as biogenic CO_2 for greenhouse horticulture), or is being stored (Carbon Capture and Storage, CCS), the CO_2eq reductions are between 93% - 273%. This has to do with the CO_2eq emissions which are avoided by for example using kitchen waste or manure to produce CNG or LNG, which would have otherwise been released straight into the atmosphere.

For the calculation of the effects included in this CBA, the more moderate Ricardo research based WTW effect (37% WTW CO_2eq reduction for heavy duty trucks) has been taken into account for bio-methane based CBG and LBG.

4. The source of the CNG and LNG is Natural Gas (Fossil)

This major opportunity does not refer to the analysis on a TTW basis for these natural gas vehicles (regular CNG and LNG produced from natural gas). Based on a TTW analysis for the local and urban impact on the CO_2 and the air quality the benefits of regular CNG and LNG vehicles compared to the best Diesel vehicles available on the market, remain limited[7][8].

A WTW study by Ricardo[9] (2018) on GHG emissions in the transport sector shows that the switch from diesel to regular Natural Gas produced CNG and LNG does not reduce overall CO_2 equivalent (incl. CO_2, CH_4, N_2O) WTW emissions. The shift from diesel to Natural Gas even causes a slight increase in CO_2equivalent (CO_2eq). This is an effect of the higher fuel consumption and higher emissions of CH_4 and N_2O of Natural Gas when compared to diesel.

Based on a more recent (2019) WTW analysis for the overall climate impact including the transport and logistics of the fuel, manufacturing of the vehicles and the fuelling infrastructure etc, this picture shifts.[10]

[3] Ricardo Natural Gas, *The role of natural gas and biomethane in the transport* sector. p.18
[4] Ricardo Natural Gas, The role of natural gas and biomethane in the transport sector.table 2-30 p.25
[5] EBA, NGVA, RENEWABLE GAS in TRANSPORT Opportunity to fast accelerate decarbonisation with a clean and sustainable solution. Published: March 2018.
[6] CE Delft, CO2 balansen groengasketens Vergisting en vergassing. p. 8-10 Available at : https://platformduurzamebiobrandstoffen.nl/wp-content/uploads/2019/06/2019_CE-Delft_CO2-balansen-groengasketens-vergisting-en-vergassing.pdf

[7] NRC, Rijden op LNG is niet echt beter. September 2019. Available at: https://www.nrc.nl/nieuws/2019/09/18/rijden-op-lng-is-niet-echt-beter-a3973877
[8] https://repository.tudelft.nl/view/tno/uuid:1a455afb-ac09-477e-a851-112904eb3384
[9] Ricardo, *The role of natural gas and biomethane in the transport sector*. ED 61479 | Issue Number 1 | Date 16/02/2016.
[10] Irena, *Renewable energy Prospects for the European Union*. 2018. Available at: http://irena.org/publications/2018/Feb/Renewable-energy-prospects-for-the-EU

When compared from a WTW perspective, the research institute Irina has identified that the natural gas vehicle already generates a GHG emission reduction of up to 23% compared to a diesel vehicle. This WTW analysis for the natural gas vehicle offers a better result than Electric (environmental impact of the battery is relatively high) and Hydrogen technology (energy losses in the fuel production, etc) vehicles.
In order to remain on the save side, in the calculations for the Cost Benefit Analysis (CBA) for natural gas based CNG and LNG, the Ricardo WTW results have been used and an increase in CO_2 emissions has been applied to natural gas CNG and LNG. As such, an additional societal cost has been included in the CBA for the natural gas CNG and LNG in the scope of the project (related to phasing out of the natural gas and gradually replacing this with bio-methane based CNG and LNG within the project scope).

5. More details on environmental performance from recent independent studies

The Austrian research agency Joanneum Research[11] has executed a study (in request of the German ADAC) comparing the environmental impact of different fuels. This study concluded that the current CNG vehicle (15% bio-methane) offers the most sustainable alternative.[12] According to the researchers that executed the study, the EV vehicles would have had the smallest environmental impact if they would have been fuelled from 100% renewable energy sources. The question remained, however, how the equation would look like comparing 100% second generation bio-methane based CNG with 100% renewable energy EV on a life cycle analysis basis.

A very recent French study (September 2019), published by IFP Energies Nouvelles, has compared Diesel, 100% renewable energy EV, and 100% second-generation bio-methane based CNG.[13] Besides offering a life cycle analysis for light vehicles, this study has also analysed busses and 12 ton trucks. The study shows that for light vehicles, commercial vehicles and even heavy goods vehicles up to 12 tons, the use of a bio-CNG-powered engine gives better results in terms of reduced GHG emissions than Electric and hydrogen vehicles. This is largely due to the large amount of CO_2 emitted during battery manufacturing, resulting from the extraction and refining of the metals used (lithium, cobalt, nickel, etc.), and by the energy-consuming processes used to manufacture and assemble fuel cells. The main expected environmental impact (target group) of the stations included in this Project are heavy duty vehicles. As such the study results for the 12 ton truck category (372 000 km per year, operational life-time of 12 years) are presented below expressed as CO_2 equivalent per tonne kilometre (tkm).

Based on the current state of technology 2019, the study offers a result of approx. 350 grams of CO_2eq/tkm for a diesel vehicle, approx. 330 grams of CO_2eq/tkm for a regular fossil fuelled CNG vehicle, 100 grams CO_2eq/tkm for an EV vehicle and approx. 60 grams CO_2eq/tkm for a Bio-CNG vehicle.[14] This analysis includes the environmental impact of the vehicle lifecycle, the battery lifecycle, the Diesel, electricity or CNG used during the technical lifespan and the environmental impact of the tires.

Importantly, the bio-methane which we need to produce bio-CNG and bio-LNG is already being generated in our current societies (house-hold waste, landfill, feedstock manure, drinking water plants, sewage plants, etc).[15]

[11] https://www.joanneum.at
[12] https://www.adac.de/verkehr/tanken-kraftstoff-antrieb/alternative-antriebe/co2-treibhausgasbilanz-studie/?redirectId=quer.klimabilanz
[13] https://www.afgaz.fr/sites/default/files/u200/rapport_afg_versionfinale.pdf

[14] IFP Energies Nouvelles, Etude ACV de v'ehicules roulant au GNV at bioGNV. Available at : https://www.afgaz.fr/sites/default/files/u200/rapport_afg_versionfinale.pdf p.20
[15] EBA, Biogas Basics, https://www.europeanbiogas.eu/wp-content/uploads/2019/08/Biogas-Basics-v6.pdf

6. Preliminary results

In this CBA the comparison was made between three alternatives: The Business as Usual (BAU) scenario (diesel fuelled), the natural gas fuelled scenario and the bio-methane and bio-methane with natural gas blend fuelled scenario. The BAU scenario serves as the reference case, in which projections are made of cash flows related to the operations of the next best alternative for each year during the project lifetime. These cash flows projections are based on the analysis of the last three years of the cash-flows of a comparable infrastructure of regular diesel (traditional fossil oil-based fuel) fuelling stations and equipment.

For each of the three alternatives, Business as Usual (diesel fuelled), Alternative 2 (standard natural gas fuelled), and Alternative 3 (bio-methane and bio-methane with Natural Gas blend), the scope of the users has been prepared in the CBA calculation. The results are positive both for alternative 2 (natural gas) as well as for alternative 3 (bio-methane) compared to the BAU. The results show a slightly better societal impact for alternative 3 (bio-methane) caused by the CO_2 reduction from this shift from carbon to renewable fuel source. When analysing the CBA results against the background of the aim the decrease the impact of transport and mobility on the climate, alternative 3 offers the most attractive project alternative.

The direct internal and external benefits of the project significantly exceed the costs. The CBA offers a cost-benefit ratio on the complete project of 5.5 for the selected alternative 3 (bio-methane stimulation alternative). This ratio above 1, indicates that the benefits of the project for society are higher than the costs of the project. The net present value (the balance between costs and benefits) is positive with a total sum of EUR 1,7 billion. Based on these results the conclusion can be drawn that the implementation of this project is desirable from a socio-economic perspective.

Sensitivity analyses have been executed for the selected Project-alternative to assess the risk of:

- An increase of the investment costs (project cost overrun) by 25%;
- an increase of the Maintenance and Operational costs during the lifespan of the Project by 25%;
- a delay of the number of years necessary for the construction of the infrastructure (6 months, 12 months, 24 months);
- monetary value of environmental effects.

The sensitivity analysis offers positive benefit/ cost ratios for each of the different scenarios. With a 25% increase of the investment costs, the ENPV remains positive with EUR 1,4 billion and a Cost/Benefit Ratio of 5.3. With a 25% increase of the M&O costs, the ENPV remains positive with EUR 1,3 billion and a Cost/Benefit Ratio of 4.5.

Furthermore, a delayed realisation by 6 months, 12 months or 24 months provides a positive result with an ENPV of 0,6 billion with a 24 months delayed realisation, an ENPV of EUR 0,7 billion with a 12 months delayed realisation, and an ENPV of EUR 0,9 billion at 6 months delayed implementation.

It is noted that these net results of the CBA do not take account non-monetised impacts. These impacts have been assessed qualitatively. These qualitative impacts are positive with regard to all assessed categories. This includes reduced damage to buildings from (road-) GHG emission and particles pollution and positive climate change mitigation effects. As these effects are positive, they would, if valuing in monetary terms were possible, most likely positively affect the CBA outcome and thus result in higher societal benefits.

The overall assessment for the project risk is determined to be low as the project activities are executed by highly experienced consortium partners and contractors, and the activities implemented consist mainly of standard engineering and are executed in a well-know and highly accessible geographic area.

Emissions of Greenhouse Gasses (GHG), such as CO_2, contribute to the continuing increase of the average temperature in the Earth's climate system, a phenomenon commonly referred to as climate change. The transport sector, including road transport, is an important source of GHG emissions worldwide.
The implementation of readily available CNG and LNG technology in the road transport sector provides a major opportunity to lower transport emissions.