

NGV DOCUMENT RESOURCE LIBRARY FOR BRAZIL STAKEHOLDERS
COMPANION TO
The Brazil Roadmap for Natural Gas & Biomethane Heavy Duty Trucks and Buses

EXPLANATION OF SUPPORTING DOCUMENT FILES

- This Document Resource Library, separate from Part 1 and Part 2 of the main Roadmap, is intended to list and, in some cases, link various sources and documents that could be useful to Brazil policy makers and stakeholders in moving forward with heavy duty natural gas trucks and busses.
- Original documents are provided in separate files comprising the companion ‘library’ of relevant information
- The ‘contents’ of the library are listed below, grouped in specific categories of subjects that correspond to separate pdf document files provided. Because website links frequently change, making documents unavailable, copies of most documents are provided directly in order to create an actual resource library rather than one only linked to the internet. In some cases where links are provided they are as existed in July 2021.

ANALYTIC MODELS

1. **NGV INFRASTRUCTURE CALCULATION TOOL (NICA). CNG Fuel Station Economic/Sizing Tool:** A task within the project, *Legal & Regulatory Environment for the Construction & Operation of CNG Filling Stations in European Countries*, European Business Congress, April 2012. Model developed by Gijs van Schoonhoven (Ingenieurbüro van Schoonhoven [IvS]) with Clean Fuels Consulting.
Purpose
The purpose of this tool is to assist potential investors and fuelling station planners in understanding the cost and economics of installing a network of CNG compressor stations (also suitable for biogas). This could relate to a single fuel station or could be extrapolated to cover a more complete network of stations for both private fleet operators as well as public fuelling stations.
2. **NICA User Manual** is provided in a separate pdf file accompanying the calculation tool; which also included within the first Excel sheet preceding the other sheets in the calculation tool.
3. **The GREET model Framework** (Greenhouse gases, Regulated Emissions, and Energy use in Transportation), (Argonne National Laboratory). The GREET model is a one-of-a-kind analytic tool that simulates the energy use and emissions output of various vehicle and fuel combinations. GREET sustainability metrics include energy use, criteria pollutants, greenhouse gases and water consumption. Argonne has been developing the GREET **life-cycle analysis (LCA)** model since 1995 with annual updates and expansions. It is available at greet.es.anl.gov.
4. **AFLEET**, developed at Argonne Laboratory, includes a suite of useful ‘tools’ including: 1) AFLEET Spreadsheet that details energy, emissions, and cost data for light-and-heavy

duty alternative fuel vehicles (U.S. costs only); afleet-web.es.anl.gov; 2) AFLEET Online, a user-friendly interface that analyzes petroleum, emissions and simple payback afleet-web.es.anl.gov/afleet/; and 3) Heavy Duty Vehicle Emissions Calculator comparing NOx, Particulate Matter, GHGs and cost-effectiveness afleet-web.es.anl.gov/hdv-emissions-calculator/.

BIOMETHANE DECISION MAKERS GUIDES

1. ***The Biomethane Decision Makers' Guide: How to Implement a Biomethane Project*** was a result of the European Commission-funded project 'Biogas as a vehicle fuel- Market Expansion to 2020 Air Quality (BIOGASMAX). The Biomethane Decision Guide explains all aspects of the biomethane decision – from the biomethane pathway to biomethane business – with the aid of practical examples. As such, it intends to help other municipalities and regions in determining whether or not they are candidates for biomethane implementation and, in the case of a positive decision, what steps to take next.
2. ***Biomethane Guide for Decision Makers: Policy Guide on Biogas Injection into the Natural Gas Grid***, the Biomethane Guide for Decision Makers has been created within the European Commission-funded project, GreenGasGrids, 2013.

CNG CYLINDER SAFETY AND INSPECTIONS

These documents represent a variety of important, expert contributions to ensuring CNG cylinder safety through inspections, practical use considerations and decommissioning at the end-of-useful-life.

1. ***In-Service Inspection of High Pressure Installation Using CNG***, CETIM (Technical Centre for Mechanical Industries (France), CID Inspection, February 2006.
2. ***Natural Gas Vehicle Cylinder Safety, Training and Inspection Project***, Clean Vehicle Education Foundation funded by the National Energy Technology Laboratory, U.S. Department of Energy, 2009.
3. ***Best Practices for Defueling, Decommissioning, and Disposal of Compressed Natural Gas Vehicle Fuel Containers and Liquefied Natural Gas Vehicle Fuel Tanks***, SPE2.1 series, Canadian Standards Association (CSA), 2018.
4. ***Inspection and Requalification of CNG Cylinders and Fuel Systems***, Livio Gambone, CSA Group, 2015.
5. ***Development of Performance Based Standards for CNG Cylinders/Fuel System Components & History of CNG Vehicle In-Service Failures***, Livio Gambone, CSA Group, 2015.

CO₂ POLICY DOCUMENTS-EUROPE

Both these studies advocate a balanced emissions policy approach that recognizes the holistic contributions of natural gas vehicles and, in particular, renewable biomethane. Though the advocacy is targeted to European policy makers, there are suggestions and recommendations that could benefit policy makers in other world regions.

1. ***CO₂ Emission Abatement Costs of Gas Mobility and Other Road Transport***, Frontier Economics for NGVA Europe, April 2021.

2. ***Smart CO2 Standards for Negative Emissions Mobility***, European Biogas Association, 2020.

FUEL STATION STRATEGIES AND BEST PRACTICES

This is the overview report covering strategic approaches to create an NGV fueling station network, developed for the European Business Congress. The project included profiles of 21 European countries, an examination of the legal and regulatory frameworks, as well as the NICA CNG station calculation tool (see above Analytic Models).

1. ***Legal and Regulatory Environment for the Construction and Operation of CNG Filling Stations in European Countries***, European Business Congress, May 2012.

GAS COMPOSITION, QUALITY & REFERENCE FUELS

These documents provide background to the critical importance of standards and regulations related to natural gas composition and quality as well as its impact on vehicle emissions.

1. ***Effects of Natural Gas Composition Variations on the Operation, Performance and Exhaust Emissions of Natural Gas - Powered Vehicles***, Hien Ly, CFS International Pty Ltd, 2002.
2. ***Natural Gas/Methane Fuels: European Automotive Fuel Quality and Standardization Requirements***, Ulrich Kramer (Ford Werke GmbH), et.al. 2015.
3. ***Towards Well-Founded Standards for Siloxanes in Bio-CNG***, DNV-GL for AFNOR Normalization (France), 2016.
4. ***Evaluation of the Performance and Air Pollutant Emissions of Vehicles Operating on Various Natural Gas Blends-Heavy-Duty Vehicle Testing (Phase I)***, Thomas D. Durban, University of California, for the California Air Resources Board (CARB) and California Environmental Protection Agency, 2014.
5. ***Evaluation of the Performance and Air Pollutant Emissions of Vehicles Operating on Various Natural Gas Blends,(Phase 2)***, Thomas D. Durban, University of California, for the California Air Resources Board (CARB) and California Environmental Protection Agency, 2015.
6. ***Issues Associated with Gas Composition & Quality***, J.Seisler, NGV Global Technical Forum, Long Beach California, 2014.
7. ***Impacts of Natural Gas Composition on Air Quality-An Assessment Using TEMPLES Model, Phase I***, Andrew Martinez, et.al., University of California, for the California Air Resources Board, 2014.
8. ***Impacts of Natural Gas Composition on Air Quality-An Assessment Using TEMPLES Model, Phase 2***, Marc Carreras-Sospedra, et.al., University of California, for the California Air Resources Board, 2016.

MEASUREMENT UNITS FOR PUBLIC DISPLAY OF METHANE PRICES – GASOLINE & DIESEL GALLONS/LITERS EQUIVALENCIES

1. **Program and Committee Reports for the 79th National Conference on Weights and Measures**, U.S. National Institute of Standards, July 1994, standard for Gasoline Gallon/Liter Equivalent.
2. **Background and Justification for Handbooks 44 and 130 Definition of “Diesel Gallon Equivalent (DGE)” of Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) as a Vehicular Fuel**, Douglas Horne, Clean Fuel Education Foundation, 2013.
3. **Natural Gas Conversion Guide**, International Gas Union, 2012. (These guidelines relate to all forms of gas conversion nomenclature, as a general reference document.
4. **Report of the Laws & Regulations Committee**, National Conference on Weights and Measures (NCWM), 2016. (Final rule adopted re: DGE/DLE). Also with references to GGE/GLE and other fuels as well.

MAINTENANCE FACILITY SAFETY

1. **Guideline for Determining the Modifications Required for Natural Gas Vehicle Maintenance Facilities**, Dan Bowerson based on D.Horne Clean Vehicle Education Foundation, NGVAmerica, 2017.
2. **Risk-Informed LNG/CNG Maintenance Facility Codes and Standards**, C.LaFleur, Sandia National Laboratories, presentation Clean Cities Transportation, Israel, September 2015.

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE (UNECE) REGULATIONS FOR NGVS

NAVIGATING UNECE REGULATIONS AND STANDARDS

- To view and download UNECE regulations by number: <https://unece.org/un-regulations-addenda-1958-agreement>.
- UNECE Regulations of importance to NGVs are: 1) R.110 within the Working Party on General Safety (GRSG) <https://unece.org/transportvehicle-regulations/working-party-general-safety-provisions-introduction> ; and 2) within the Working Party on Pollution and Emissions (GRPE) (<https://unece.org/transportvehicle-regulations/working-party-pollution-and-energy-introduction>) R.49 (Emissions of C.I. and P.I. (LPG and CNG) engines containing the technical provisions for the pollutant emissions standards up to EURO VI for trucks and busses); R.83 (technical provisions for the pollutant emissions standards up to Euro 6 for cars); ADR (Dangerous Goods) that has provisions allowing the use of CNG and LNG to fuel trucks registered and certified as Dangerous Goods Vehicles.
- ISO. ISO standards are ‘freely available’ but are not ‘available for free’. ISO maintains strict copyrights on their standards. They are referenced (and sometimes copied) within UNECE regulations but for full access, ISO standards must be purchased.

Regulation 110

Regulation 110, Uniform provisions concerning the approval of: ***I. Specific components of motor vehicles using compressed natural gas (CNG) and/or liquefied natural gas (LNG) in their propulsion system; and II. Vehicles with regard to the installation of specific components of an***

approved type for the use of compressed natural gas (CNG) and/or liquefied natural gas (LNG) in their propulsion system is in a state of almost constant amendment as new issues and corrections are made by the Contracting Parties (signatories to the applicable 1958 UN treaty) and non-governmental organizations participating in the Working Party on General Safety. The last complete revision (Series 3) was published in 2014. Since then, however, numerous revisions and amendments have been made, through to the Series 6, however, the amendments have not yet been incorporated into one single document (“pending”). As such, when viewing the regulation it is important also to take into consideration the various amendments available at the UNECE site to ensure the most current components in the regulation.

1. **UN Regulation 110, Series 3 document complete as of June 2014.**
2. **UN Regulation 110, Addendum 109, Periodic Technical Inspections and Requalification of Cylinders, 2020.**

Dual Fuel R.49

1. **Uniform provisions concerning the measures to be taken against the emission of gaseous and particulate pollutants from compression ignition engines for use in vehicles, and the emission of gaseous pollutants from positive-ignition engines fuelled with natural gas or liquefied petroleum gas for use in vehicles, Addendum 48, Revision 7, applicable for OEM vehicles.**
2. **Proposal for a new Regulation on uniform provisions concerning the approval of Heavy Duty Dual-Fuel Engine Retrofit Systems (HDDF-ERS) to be installed on heavy duty diesel engines and vehicles, 2016.**

Road Signage for Fuel Stations



The Working Party 1, Road Traffic Safety within the UNECE Inland Transport Committee deals explicitly with issues from the 1949 Convention on Road Traffic, the 1968 Convention on Road Traffic, and the 1968 Convention on Road Signs and Signals. These Conventions are subject to continual amendment by WP1 members and interested parties such as non-governmental organizations that bring various issues to the attention of WP1. CNG and LPG road signage were adopted in 2005; LNG & H2 in 2010. Road signage for alternative fuels adopted in a Consolidated Resolution by the UNECE now has recognized international ‘legal status’. It is not (yet) a finalized amendment adopted in the 1968 Convention on Road Signs and Signals can be used as legal, international signage.

1. **Background to United Nations Road Signage for Alternative Fuels**, Jeffrey M. Seisler Clean Fuels Consulting, 2014.
2. **Consolidated Resolution on Road Signs and Signals (R.E.2)**, ECE/TRANS/WP.1/119/Rev.2 (See text sections plus pictogram specifications in Annex VI, p.31

UNECE Dangerous Goods Vehicle Regulations (CNG & LNG)

NGV Global, in conjunction with KIWA (national testing institution, the Netherlands) lobbied from 2012 to 2017 to add CNG and LNG as propulsion fuels for vehicles certified as Dangerous Goods Vehicles. These were included in the 2019 editions of the UNECE ADR regulations. New ADR documents (for Road Vehicles ADR; for Marine Vehicles ADN) are published every two years on the odd number years. The latest (2021) ADR documents are available at <https://unece.org/transportdangerous-goods/adr-2021-files> . (They are included in document collection provided with the Roadmap.)

1. ***Agreement Concerning the International Carriage of Dangerous Goods by Road, Volume 1***, Applicable as from 1 January 2021.
2. ***Agreement Concerning the International Carriage of Dangerous Goods by Road, Volume 2***, Applicable as from 1 January 2021.

EXISTING EUROPEAN/ISO STANDARDS FOR FUEL STATIONS

Copyrights prohibit distribution of these document, which are for sale on-line at ISO (and identified by putting the specific standard title and number into the browser).

EN/ISO 16923 CNG stations

- The European standard EN ISO 16923 ‘*Natural gas fueling stations – CNG stations for fueling vehicles*’, covers the design, construction, operation, inspection and maintenance of stations fueling CNG vehicles, including equipment, safety and control devices. This European standard also applies to portions of a refueling station where natural gas is in a gaseous state and dispensing CNG derived from liquefied natural gas (L-CNG) according to EN ISO 16924. It also applies to biomethane, upgraded coal-bed methane (CBM) and gas supplies coming from LNG vaporization (on-site or off-site). The elements of the standard EN ISO 16923 ensuring the interoperability of the CNG refueling stations and the vehicles should apply to CNG refueling points. This supplements point 3.4 of Annex II to Directive 2014/94/EU.
- <https://standards.iteh.ai/catalog/standards/cen/0544f853-6f5e-49c7-a52b-a97cb6e5bf08/en-iso-16923-2018>

European Commission **DELEGATED REGULATION (EU) 2019/1745 of 13 August 2019**

EN/ISO 16924 LNG Fuel stations

- The European standard EN ISO 16924 ‘*Natural gas fueling stations – LNG stations for fueling vehicles*’, in its current version, covers the design, construction, operation, maintenance and inspection of stations for fueling liquefied natural gas (LNG) to vehicles, including equipment, safety and control devices. This European standard also specifies the design, construction, operation, maintenance and inspection of fueling stations for using LNG as an onsite source for fueling CNG vehicles (L-CNG fueling stations), including safety and control devices of the station and specific L-CNG fueling station equipment. The European standard covers fueling stations having the following characteristics: private access; public access (self-service or assisted); metered

dispensing and non-metered dispensing; fueling stations with fixed LNG storage; fueling stations with mobile LNG. The European standard EN ISO 12617 '*Road vehicles – Liquefied natural gas (LNG) refueling connector –3,1 MPa connector*' in its current version, specifies liquefied natural gas (LNG) refueling nozzles and receptacles constructed entirely of new and unused parts and materials for road vehicles powered by LNG. An LNG refueling connector consists of, as applicable, the receptacle and its protective cap (mounted on the vehicle) and the nozzle. This European standard is applicable only to such devices designed for a maximum working pressure of 3,4 MPa (34 bar) to those using LNG as vehicle fuel and having standardized mating components. The elements of the standard EN ISO 16924 ensuring the interoperability of the LNG refueling stations and the standard EN ISO 12617 defining the specifications for connectors should apply to LNG refueling points. This supplements point 3.2 of Annex II to Directive 2014/94/EU. European Commission **DELEGATED REGULATION (EU) 2019/1745 of 13 August 2019**

EN/ISO 20519 Fueling stations Inland Shipping

- The European standard EN-ISO 20519 '*Ships and marine technology – Specification for bunkering of liquefied natural gas fueled vessels*' is differentiated for refueling points for seagoing ships and inland navigation vessels. For seagoing ships, which are not covered by the International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), the refueling points for LNG should comply with standard EN ISO 20519. For inland navigation vessels, however, the refueling points for LNG should comply with standard EN- ISO 20519 (parts 5.3 to 5.7) for interoperability purposes only. The European standard EN ISO 20519 should apply for refueling points for seagoing ships and the same European standard (parts 5.3 to 5.7) should apply for refueling points for inland waterway vessels. This supplements point 3.1 of Annex II to Directive 2014/94/EU. European Commission **DELEGATED REGULATION (EU) 2019/1745 of 13 August 2019.**