Plan Overview

A Data Management Plan created using DMPTool-Stage

Title: Revisiting the Efficacy of LNG/CNG Fueled Transportation in Transition to Zero-Emission Mobility

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Funder: United States Department of Transportation (DOT) (transportation.gov)

Funding opportunity number: FY 2021-2022

Template: National Center for Sustainable Transportation - Project Data Management Plan

Project abstract:

Natural gas (NG) has long been referred to as a transition fuel and a bridge to the clean energy future. Nevertheless, there has not been a consensus among the scientists for assuming such a role for this fossil fuel. NG leaks from the entire petroleum and natural gas infrastructure, from production to distribution and delivery to consumers. The major component of natural gas is methane, a potent greenhouse gas (GHG), with a global warming potential of 85 and 30 times of CO_2 over a 20-year and a 100-year time horizon, respectively. Over the last decade, direct measurements of methane leaks by climate scientists have shown that the rate of methane emission from the natural gas systems has been several times higher than the official inventories by local and federal governments. Production of NG by hydraulic fracturing (fracking) has been associated with contamination of drinking water and inducing earthquakes. This process is also known to be a source of release of fugitive methane to the atmosphere. It has been suggested that such underestimated methane emissions can negate the short-term benefit of switching from coal to methane. The climate impact or benefit of use of NG depends on the amount of methane that escapes from the NG infrastructure uncombusted. The notion of natural gas as a clean fuel has helped the expansion of the transport of natural gas in liquid form, known as Liquified Natural Gas (LNG). LNG density is more than 600 times of natural gas and can be transported by ships and trucks. In 2018, the U.S LNG export increased 53% compared with the previous year. In 2019, U.S. exported LNG to 35 countries and is projected to be soon in third place globally, after Australia and Qatar.16 Canada has been investing in expanding its LNG production facilities and exporting to the Asian markets. LNG is advertised as a promising clean fossil fuel to displace coal in China. LNG is stored at atmospheric pressure and -162°C. It is traditionally exported by specially designed ocean tankers, which either combust the boil-off gases in their steam engines or use diesel engines and are equipped with a refrigeration system that re-liquifies the boil-off gases (BOG). BOG is mostly methane that evaporates and should not be released into the atmosphere because of the environmental impact and the economic losses. The GHG life cycle assessments of LNG in the literature

consider these two designs of the LNG carriers. However, an emerging cheap method of exporting LNG is ISO containers, which do not have a BOG re-liquifying system. This container has a holding time; if passed, they release methane to the atmosphere to avoid overpressure caused by accumulating the evaporated LNG. These containers have a daily evaporative loss, reportedly between 0.2 to 1.0 % of LNG content/day. Use of ISO containers, instead of the LNG carriers equipped with BOG re-liquification systems, has been growing significantly to export LNG from Canada to China. The amount of methane released into the atmosphere by this transportation mode in practice remains unknown. The LNG storage tanks installed in LNG/CNG (Compressed Natural Gas) fueling stations have a similar design to ISO tanks. NASA has developed AVIRIS (Airborne Visible Infrared Imaging Spectrometer) to identify and quantify methane super-emitters (above 2 kg methane/h). Between 2016 and 2018, NASA aircraft using AVIRIS identified 5 LNG/CNG fueling stations near Los Angeles, emitted methane repeatedly at an average rate between 140 to 970 kg methane/h. We estimate that these storage tanks' maximum evaporative losses are between 6 to 22 kg methane/h. This estimate is based on a maximum evaporative loss of 1% of the LNG content per day, as specified by the tank manufacturers. Two scenarios that can explain the significant differences between AVIRIS measurements and the estimated evaporative losses are: either the tanks holding time are passed repeatedly, and methane released through the pressure relief/safety valves, or the daily evaporative losses are much more than 1% of the LNG content/day in contrast with the technical specifications provided by the manufacturers. While NASA AVIRIS flights paths and schedule were not planned to merely identify the methane leaks from LNG/CNG fueling stations and their frequency, the data are nevertheless indicative of such fueling stations being sources of methane super-emitters. Reasonably, it is expected that more LNG/CNG fueling stations emit methane at a higher than estimated rates and more frequently than expected, and thus, similarly constructed ISO containers in transportation of LNG. Current NG and LNG/CNG GHG emission factors should be reviewed to include such methane emissions. In this study, we revisit the efficacy of LNG/CNG as a transition fuel by reassessment of the life cycle GHG emission factors of NG and LNG/CNG, considering: • The reported underestimated methane leaks from the natural gas infrastructure • Fugitive methane from petroleum and natural gas produced by hydraulic fracturing based on the literature • Methane emissions from transportation and distribution of LNG and Liquified Natural Gas (modeling and direct measurement) The focus of this study will be on modeling of the ISO tanks evaporative losses, holding times, and the amount of methane released from the tanks pressure relief/safety valves when the holding time is passed. NASA AVIRIS data and the collected data on methane emission rates from LNG tanks by ground measurements will be used to verify this model. Ultimately, we update the GHG emission factors that indicate the efficacy of LNG/CNG fuels and reassess these fuels role as transition fuels in a 20-year time horizon compared with electrical transportation and other renewable fuel options. Overestimating natural gas as a clean fuel and long-term promotion of it by the local governments and the natural gas distribution companies to power passenger cars, trucks, and ships can hinder the real progress toward zero-emission transportation.

Start date: 03-31-2021

End date: 10-30-2021

Last modified: 03-31-2021

Copyright information:

relationship to, your project or proposal

Revisiting the Efficacy of LNG/CNG Fueled Transportation in Transition to Zero-Emission Mobility

1.Name the data, data collection project, or data producing program, if applicable.

- We collect and compile data from research and technical papers addressing the underestimation of the GHG emission factors and the recommended corrected emission factors
- We collect information about the Riverside transit buses powered by compressed natural gas (CNG), e.g., the engine types, fuel efficiency, miles driven per day, to calculate the emissions

2. Describe the data your project will generate in terms of nature and scale (e.g., numerical data, image data, text sequences, video, audio, database, modeling data, source code, etc.).

Modeling data (Life cycle assessment), potentials for GHG reduction, revising emission factors if applicable

3. Describe methods for creating the data (e.g., simulated; observed; experimental; software; physical collections; sensors; satellite; enforcement activities; research-generated databases, tables, and/or spreadsheets; instrument-generated digital data output, such as images and video; etc.).

Lifecycle assessment modeling, energy system modeling

4.Discuss the period of time data will be collected and the frequency of any updates, if applicable.

April 1st, 2021 to October 31st, 2021

5.If the project uses existing data, describe the relationship between the data you are collecting and the previously collected data.

We will collect the data from the publically accessible literature and the Riverside transit buses operator if accessible. If the transit bus technical data does not become accessible, we will use publically available data from the California Air Resources Board or other related government agencies.

6.List potential users of the data.

The PIs and a graduate student for doing research. The results will be published for the public.

7.Discuss the potential value that the data will have over the long-term for the NCST and the public.

We investigate the likelihood that investment in fossil-based CNG/LNG fueled transportation is not consistent with the California plan for decarbonizing the economy by 2045 (California Executive order B-55-18, SB 32, and SB 100) and can hinder the move toward zero-emission electric cars.

Government, public, clean energy technology entrepreneurs, and energy sector investors can benefit from our research.

8.If you request permission not to make data publicly accessible, explain the rationale for lack of public access. Provide sufficient detail so that reviewers will understand any disclosure risks that may apply.

We do not use any data or technical information collected under a non-disclosure agreement.

9.Indicated who will be responsible for managing the data at the project level.

Dr. Kourosh Vafi, Co-PI and technical lead

1.List in what type of format(s) the data will be collected, and indicate if they are open or proprietary.

MS Excel: This platform has been frequently used by California Air Resources Board and other California agencies. If needed we submit the data in CSV format which is cross-platform.

2.If you are using proprietary data formats, discuss your rationale for using those standards and formats.

Not applicable

3.Describe how versions of the data will be signified and/or controlled.

We do not work with very large sets of data. We can properly manage quality assurance and quality control of the data using MS Excel and by assigning version numbers to updated data files.

4.If the file format(s) you are using is(are) not standard to transportation, describe how you will document the alternative you are using.

Not applicable

5.List what documentation you will be creating in order to make the data understandable by other researchers.

This is a standard academic research, the output is a paper, a supplemental information document (which explains the details of the calculations and describes the data), and excel files which include the raw data, the processed data, the results, and the model. All will be open-source.

6.Indicate the type of metadata schema you are using to describe the data. If the metadata schema is not one that is standard for your field, discuss your rationale for using that schema.

We collect technical data, e.g., the engine types, fuel efficiency, miles driven per day, to calculate the emissions or emission factors from the literature. These data types are standard for our field of research and the California Air Resources Board (e.g., CA-GREET model).

7.Describe how the metadata will be managed and stored during the collection process.

In MS-Excel files. We can submit the data in CVS format if requested.

8.Indicate what tools or software are required to read or view the data.

MS Excel

9.Describe the quality control measures you will implement in your project to ensure its accuracy, etc.

- Strong data profiling and control of incoming data
- Precise data pipelining to prevent duplicate data
- Accuracy in data collection
- Enforcing data integrity
- Traceability of the source of data in any stage of the project
- Automated multivariable regression testing
- Commitment of the research team members in data quality control and quality assurance

Not applicable:

Our research team will work with publically available data. The results will be available to the public through publishing in international journals and via workshops and seminars open to the public.

1.Name who has the right to manage the data.

Francesca Hopkins (PI), Kourosh Vafi (Co-PI)

2.Indicate who holds the intellectual property rights to the data.

Francesca Hopkins (PI), Kourosh Vafi (Co-PI), the graduate student who collect the data for their research, and the University of California, Riverside

NCST and University of California, Davis, based on the term and conditions of the research grant.

3.List copyrights to the data, if any. If there are copyrights, indicate who owns them.

We will cite all the literature and or entities where the data are collected from appropriately following the governing academic traditions and the Univerisity of California regulations.

4.Discuss any rights to be transferred to a data archive.

Not applicable: The collected data and our research results are open to the public.

5.Describe how your data will be licensed for re-use, redistribution, and derivative products.

Not applicable: The collected data and our research results are open to the public.

1.The data must be archived before the research project's DRAFT FINAL REPORT is delivered to the NCST Program Manager. Discuss how you intend to archive your data and where if not on Dryad (include URL).

We record the data in Excel files or CSV if required and upload in Dryad.

2.Indicate the approximate time period between data collection and submission to the archive.

Five months

3.The PI of each NCST-funded project should ensure that the data to be archived temporarily at their home institution is stored securely on a designated device (computer, external hard drive, etc.). Identify where data will be stored prior to being deposited to an archive.

The data are publically accessible; they will be stored on PI, co-PI, and the graduate student's laptop before uploading to Dryad.

4.The PI of each NCST-funded project should ensure that the data collected will be backed up prior to being archived. Describe how back-up, disaster recovery, off-site data storage, and other redundant storage strategies will be used to ensure the data's security and integrity.

The data will be backed up in cloud storage (dropbox and google drive) in addition to hard drives.

5.Describe how data will be protected from accidental or malicious modification or deletion prior to receipt by the archive.

We will back up the data in several hard drives and cloud storage. We will consider more than two backups in different physical and cloud storage.

6.If you will not be using Dryad ...

Not applicable: We use Dryad

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Graduate student Michael Rodriguez
