Gas in road transport: (still) a dead-end

A short rebuttal of NGVA's criticisms of T&E's study on gas in transport

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1. Why this response

Earlier this year the European Commission published a communication on the security of the EU natural gas supply. The Commission is also preparing a decarbonisation of transport communication and action plan. In this context, T&E commissioned Ricardo Energy & Environment to perform a study that analyses the climate and economic impacts of a switch from oil-based fuels (for example petrol, diesel, HFO) to natural and bio-gas-based products (LNG, CNG, bio-methane). The purpose of the study was to assess, in a scientific and objective manner, what role natural gas and bio-methane can play in decarbonising the transport sector. Upon completion of the study, T&E published the study and accompanied it with a briefing.

In response, the Natural Gas Vehicle Association (NGVA) circulated a "*statement on the T&E study on the role of natural gas and biomethane in the transport sector*" to selected stakeholders and policymakers. In this statement, NGVA questions the validity of the Ricardo study (note: it is not a T&E study) and its key findings. This note responds to the main concerns raised by the NGVA.

2. "T&E claims high natural gas leakage rates would diminish the GHG advantage of natural gas" but "there has been only one main study on this subject"

The NGVA claims that there is no solid scientific data on methane leakages in natural gas production/transportation/distribution, suggesting GHG effects of the leaked methane should not be accounted for when analysing the climate impacts of a switch from oil to natural gas.

We disagree. There is a growing body of scientific literature highlighting the extent of methane leakage problems across the production and supply chain as well as at vehicle level. In Annex I and II you will find a non-exhaustive list of peer-reviewed academic and non-peer-reviewed studies on this issue.

Most of this research is relatively recent. We recommend that the Commission should review this new evidence and, if need be, complete it before committing to promoting gas as a fuel for cars and trucks.

The NGVA also argues that methane losses can be *"controlled and overcome through the application of technology".* This is an extremely important issue that raises a number of problems:

1. A voluntary attempt by the industry to reign in the losses would require additional investment. The resulting savings of the previously flared methane volumes may not offset the investment costs. This is exactly why the US Environment Protection Agency is moving to regulate methane emissions in the oil and natural gas industry. The EU is not currently planning similar regulatory initiatives.

2. While the US can to a large extent control the methane leakage of the American gas industry, this is less straightforward for the EU. Indeed, the EU import dependency on natural gas is likely to further increase from the current 61% to 86% in 2035. It is not clear how the EU would control methane leakage across multiple (non-EU) national jurisdictions with broad differences in regulatory oversight. A form of fuel quality legislation would be required to account for the

different origins and GHG impacts of different sources of natural gas. The history of the Fuel Quality Directive suggests this is complex and politically challenging.

Finally, it is important to note that our analysis looked at methane leakage and GHG impacts in a 100-year perspective. If it would have done so with a 20-year perspective (and there are good reasons to do this) gas in transport would look much worse.

In conclusion, the available scientific evidence suggests there is a significant risk that increasing gas usage in the transport sector would lead to the EU '*exporting*' rather than *reducing* its GHG emissions in the transport sector. Due to this risk – and the huge investment uncertainty it entails (for trucking companies, for example) – we recommend that the Commission reviews the issue before committing to the promotion of gas in transport. As part of this review, the Commission should also assess other solutions to reduce transport GHG emissions.

3. "Natural gas is one of the key contributors to fight climate change"

The NGVA claims that natural and biogas are the most cost-efficient routes to decarbonising the transport sector. Even if we would ignore the issue of methane leakage – and that is not a good idea – the potential for natural gas remains limited. In fact, the study that NGVA quotes to substantiate its cost-effectiveness claims states that:

"The very marginal share of natural gas vehicles in current passenger cars fleet (ca. 0,1%) makes them only relevant as an option to save CO_2 in the passenger car sector at an unrealistic degree of (market) diffusion. The share of NGVs would have to reach 23% in order to achieve 10% emissions reductions from the transport sector's current GHG footprint."

A common mistake is that often the societal cost-effectiveness of different technologies is analysed from a post-tax perspective – giving low-tax alternatives like natural gas an artificial cost advantage. For this reason the Ricardo study looks into cost-effectiveness from a pre-tax perspective and concludes that the cost of deploying natural gas in surface transport far outweighs environmental benefits – if any "analysis of net costs and benefits to society indicates that societal costs would be higher with natural gas".

What is clear is that neither gas, or a combination of gas and biogas, would be allow us to reduce transport GHG emissions by 60% by 2050 compared to 1990, let alone the deeper cuts that are likely required if the Paris agreement is implemented. This means there is a risk of technological lock-in as well as diversion of investments that slows down the uptake of the technological solutions that can decarbonise the transport sector. Indeed, hybrid, plug-in-hybrid and battery-electric technology are developing very rapidly. Our recommendation would be to focus on policies and fiscal instruments that accelerate the uptake of ultralow carbon technologies.

4. "The study does not consider latest technology developments"

For heavy-duty vehicles, the study focuses on commercially available technology. Dual-fuel technology does exist on the market, although not for new vehicles. Ricardo's study points out "there are significant opportunities for improving the fuel efficiency of methane-powered HDVs, which may mean that it is possible for reductions in the fuel efficiency gap with diesel HDVs in future years". For example, we are aware that "high pressure direct injection" technology would enable significant efficiency improvements compared to current engines types. However, as far as the authors of the study were aware, this technology is not currently commercially available in Europe.

Moreover, conventional diesel engine efficiency can also be improved. Compared to current engines baseline, improvements of 5 to 15% are still be possible.[1] The ICCT estimates gas HDVs will remain less energy efficient than equivalent diesel vehicles in the future.

5. "T&E has completely ignored the capability of natural gas engines to run on blends of natural gas with biomethane"

Sustainable bio-methane can offer verifiable GHG savings vis-a-vis liquid fossil fuels (petrol and diesel). In fact, the Ricardo study indicates that the use of sustainable bio-methane could deliver significant GHG savings for all vehicle categories. Sustainable bio-methane is bio-methane produced from waste and residues, and possibly manure as well, as opposed to crops. Such types of bio-methane can offer only limited contribution to GHG abatement in the transport sector due to the limited availability of waste, residue and manure as feedstock for bio-methane production. The point can be made that a sustainable society produces very little of any in the first place. The study says that if the maximum sustainably produced biogas potential would be achieved and it would only be used in the road transport sector – currently it is mostly used for electricity production and heating – bio-methane could cover a maximum 15% of transport demand. In 2020, less than half that amount is projected to be available – only part of it being sustainable.

The use of non-sustainable or crop based bio-methane would increase GHG emissions, as it is the case with crop-based biofuels. Policy-driven demand for crop-based bio-biofuels and bio-methane leads to the displacement of existing agricultural production to previously uncultivated, high-carbon stock lands, which in turn release CO_2 into the atmosphere, thus causing *indirect* GHG emissions. Currently, in places like Germany, more than three quarters of all biogas is produced from energy crops especially maize.

The key issue with bio-methane is therefore its scalability. The evidence suggests sustainable bio-methane is not very scalable. Hence, our observation that sustainable bio-methane use will remain limited to niche applications at local or regional level. This is why T&E recommends against an EU strategy to promote natural gas and bio-methane blending.

6. "Natural gas is consistent with the Energy's Union strategy for sustainable mobility"

The NGVA[2] suggests increasing gas usage in the transport sector would be in line with the Energy Union's objectives. One of the EnU's key objectives is reinforcing European energy security.

The European Union's gas demand is largely and increasingly met through external supplies. The International Energy Agency forecasts that the EU domestic gas production will decline from 185 bcm/a in 2011 to 135 bcm/a in 2020 and further to 104 bcm/a in 2035.[3] EU import dependency in natural gas is expected to further increase from the current 61% to 86% in 2035. This means additional demand, for example, from the transport sector, would have to be met by increasing imports. It is not unlikely that these additional imports would come from the Russian Federation since there exists fully amortised and fixed transportation infrastructure towards the EU. In conclusion, it is hard to see how using more gas in the transport sector would do anything to strengthen the EU's energy security or make it less dependent on its powerful neighbour.

Further information

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[1] *Cummins response to the EPA on fuel efficiency standards, pp. 14*
[2] Several importers of natural gas, either by pipeline from Russia (Gazprom) or by LNG (Shell) sit on NGVA's board.
[3] World Energy Outlook, 2013, pp. 108–109.

ANNEX I

Chronological non-exhaustive list of recent peer-reviewed scientific study on the link between gas, methane leakages and climate change:

- **"*Improved Attribution of Climate Forcing to Emissions*" (Shindell et al, Oct 2009)**: Reassessment of methane's Global Warming Potential (GWP) potential: GWP over 100-year = 33, GWP over 20-year = 105
- **"*Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study*" (Pétron et al, Feb 2012)**: Natural-gas producers in an area known as the Denver-Julesburg Basin are losing about 4% of their gas to the atmosphere — not including additional losses in the pipeline and distribution system: releases of that magnitude could effectively offset the environmental edge that natural gas is said to enjoy over other fossil fuels.
- **"*Greater focus needed on methane leakage from natural gas infrastructure*" (Alvarez et al, Feb 2012)**: shifting from coal-fired to natural gas-fired electricity generation is only beneficial for climate if the cumulative leakage rate of natural gas – including leakage during the production, processing, and transmission (but not distribution) stages -- is less than 3.2%.
- **"*Mapping urban pipeline leaks: Methane leaks across Boston*" (Phillips et al, Feb 2013)**: The City of Boston is riddled with 3,356 natural gas leaks from its aging natural-gas pipeline system: In six locations in Boston, gas concentrations exceeded the threshold above which explosions can occur.
- **"*Methane emissions estimate from airborne measurements over a western United States natural gas field*" (Karion et al, Aug 2013)**: The measurements show that in the Uintah Basin, the natural gas field leaked 6 to 12% of the methane produced, on average, on February days.
- **"*Measurements of methane emissions at natural gas production sites in the United States*" (Allen et al, Sept 2013)**: On some fracking rigs, valves allow methane to escape at levels 30 percent higher than those set by E.P.A. Valves and compressors located at well pads, for example, all leaked more methane than the EPA estimated. Emissions from chemical injection pumps, which are used at wellheads to keep pipelines flowing or to neutralize corrosive substances, were found to be twice as high as the EPA's estimate.
- **"Anthropogenic emissions of methane in the United States" (Miller et al, Nov 2013)**: Emissions of methane from fossil fuel extraction and refining activities in the South Central U.S. are nearly 5 times higher than previous estimates. "Most strikingly, our results are higher by a factor of 2.7 over the south-central United States, which we know is a key region for fossil-fuel extraction and refining". US emissions of methane are probably 50% higher than current estimates by the US Government. Full life cycle emissions from conventional natural gas must be ≥ 3.6% on average of the total lifetime production of methane.
- **"Natural Gas Pipeline Leaks Across Washington, DC" (Jackson et al, Jan 2014)**: 5,900 natural gas leaks discovered under Washington, D.C. 19 of the leaks had high concentrations of methane, 12 could have caused explosions because of their levels — up to 10 times the threshold at which explosions can occur. 51 of the leaks in D.C. contained more methane than Boston's biggest leak
- **"Methane Leaks from North American Natural Gas Systems" (Brandt et al, Feb 2014)**: First comprehensive look at North American methane emissions: "Atmospheric tests covering the entire country indicate emissions around 50% more than EPA estimates. And that's a moderate estimate." Emissions from the natural gas industry, including both conventional gas and shale gas, could best be characterized as averaging 5.4% of methane emissions for the full lifecycle from well to consumer. Methane leaks negate the climate change benefits of using natural gas as a transportation fuel: Methane not only leaks during production but elsewhere in the natural gas

supply, production and transportation chain: methane could be leaking from facilities where natural gas is stored, compressed or transported.

- **"Toward a better understanding and quantification of methane emissions from shale gas development" (Caulton et al, Apr 2014)**: Survey of hydraulic fracturing sites in Pennsylvania which revealed drilling operations releasing plumes of methane 100 to 1,000 times the rate the EPA expects from that stage of drilling.
- **"*Four corners: The largest US methane anomaly viewed from space*" (Kort et al, Oct 2014)**: Analysis of a 2,500-square-mile cloud of methane floating over the Four Corners region (Arizona, Colorado, New Mexico, and Utah intersection). --> "the source is likely from established gas, coal, and coalbed methane mining and processing.": the hot spot happens to be above New Mexico's San Juan Basin, the most productive coalbed methane basin in North America.
- **"*Remote sensing of fugitive methane emissions from oil and gas production in North American tight geologic formations*" (Schneising et al, Oct 2014)**: On the basis of a mass-balance approach, we estimate that methane emissions for two of the fastest growing production regions in the US, the Bakken and Eagle Ford formations, have increased by 990±650 ktCH4 yr−1 and 530±330 ktCH4 yr−1 between the periods 2006–2008 and 2009–2011. Relative to the respective increases in oil and gas production, these emission estimates correspond to leakages of 10.1% and 9.1% in terms of energy content, calling immediate climate benefit into question and indicating that current inventories likely underestimate the fugitive emissions from Bakken and Eagle Ford.
- **"Key factors for assessing climate benefits of natural gas versus coal electricity generation" (Zhang et al, Nov 2014)**: The report identifies power plant efficiencies and methane leakage rates as the factors that explain most of the variance in greenhouse gas emissions by natural gas and coal power plants.

  --> During the period of plant operation, if there is substantial methane leakage, natural gas plants can produce greater near-term warming than coal plants with the same power output. Without CCS, natural gas power plants cannot achieve the deep reductions that would be required to avoid substantial contribution to additional global warming. Meeting upcoming greenhouse gas emission targets will require deeper emissions cuts than just building natural gas plants with low methane leakage.

  --> If methane leakage would be greater than 2%, there would be less warming in the near term if the natural gas plant were shut down instead of the coal plant.
- **"*Direct measurements of methane emissions from abandoned oil and gas wells in Pennsylvania*" (Kang et al, Dec 2014)**: Study based on methane emission measurements from abandoned oil and gas wells: It found substantial emissions, particularly from high-emitting abandoned wells, emissions which are not currently considered in any emissions inventory. We scaled methane emissions from our direct measurements of abandoned wells in Pennsylvania and calculate that they represent 4–7% of current total anthropogenic methane emissions in Pennsylvania.
- **"Methane emissions from natural gas infrastructure and use in the urban region of Boston, Massachusetts" (McKain et al, Jan 2015)**: Study quantifying emissions of methane from natural gas installations in urban areas (including pipelines, storage terminals and power plants). Methane is leaking from natural gas infrastructure in Boston and the surrounding region at rates 2 to 3 times higher than EPA estimates. The Boston study found an overall leak rate of 2.1% to 3.3% in the region, compared with the 1.1% estimated by Massachusetts' official state greenhouse gas inventory. The amount of methane lost over a year in the study area is worth $90 million.
- **"Sensor transition failure in the high flow sampler: Implications for methane emission inventories of natural gas infrastructure" (Howard et al, Mar 2015)**: The research paper raises serious questions about the validity of existing methane data used by the US EPA on methane leaks, because of the instrument used to measure methane leaks from oil and gas operations and which could severely underestimate emissions under certain conditions

- **"Constructing a Spatially Resolved Methane Emission Inventory for the Barnett Shale Region" (Lyon et al, July 2015)**: Eleven teams of researchers looked at fracking operations over an area that included 30,000 oil and gas wells, 275 compressor stations and 40 processing plants, in the Barnett Shale (Texas), and discovered that at least 50% more methane was escaping from drilling operations there than the EPA has suspected.
- **"Methane Emissions from United States Natural Gas Gathering and Processing" (Marchese et al, Aug 2015)**: The study looked at 16 processing plants and 114 gathering facilities, across 13 states. 20% of gathering facilities had leaking storage tanks. On average, these facilities leak .47% of the gas they process, and at least one was leaking 9% of its gas.
  --> Natural gas gathering and processing plants leak much more methane than producers have reported, and EPA has estimated:
    - The industry reported that 500 metric tons were lost at gathering facilities. The study estimates that 1,875,000 were lost.
    - U.S. gathering and processing facilities (where natural gas is consolidated for distribution through pipelines) leak 2.4 million tonnes of methane each year, nearly 87% higher than the EPA's most recent estimate, and "could be responsible for something like 30% of emissions for all natural gas production"
- **"*Natural Gas Pipeline Replacement Programs Reduce Methane Leaks and Improve Consumer Safety*" (Gallagher et al, Sept 2015)**: Methane is spewing from more than 1,000 natural gas leaks under Manhattan, giving it 10 times the number of leaks per mile in its aging natural gas pipelines as cities with more up-to-date infrastructure. Pipes under Manhattan averaged 4.3 leaks for each mile of pipe, compared to 0.2 leaks per mile in Durham and 0.5 in Cincinnati which had their aging pipelines recently replaced. Roughly half of the industry's emissions occur far from wells, in "downstream" locations such as the leaks under city streets.
- **"Potential of hydraulically induced fractures to communicate with existing wellbores" (Montague et al, Oct 2015)**: Fractures in surrounding rock produced by the hydraulic fracturing process are able to connect to preexisting, abandoned oil and gas wells, common in fracking areas, which can provide a pathway to the surface for methane.
- **"Reconciling divergent estimates of oil and gas methane emissions" (Zavala-Araiza et al, Dec 2015)**: Methane emissions from the Barnett Shale in North Texas are at least 90% higher than US EPA estimates and 5.5 times higher than numbers used by the EC JRC. 2% of the oil and gas facilities in the Barnett released 50 percent of the methane.
- **"A large increase in US methane emissions over the past decade inferred from satellite data and surface observations" (Turner et al, Feb 2016)**: Use of satellite retrievals and surface observations of atmospheric methane to suggest that US methane emissions have increased by more than 30% over the 2002-2014 period, with emissions ranging from about 39 million tons to about 52 million tons… This large increase in US methane emissions could account for 30-60% of the global growth of atmospheric methane seen in the past decade.
- **"Differences between carbon budget estimates unravelled" (Rogelj et al, Feb 2016)**: Previous estimates of the carbon budget have been far too generous, and that the actual carbon budget is only about half the size previously estimated: Instead of a maximum amount of permissible carbon emissions placed at 2,390 billion tons from 2015, the new study concludes that the very most humans will be able to emit is 1,240 billion tons.
  → Reason: (1) Uncertainty about future human behavior and (2) Effect of other GHG such as methane and the oxides of nitrogen (released in smaller quantities than CO2 and more transient)
- **"*The '2°C capital stock' for electricity generation: Committed cumulative carbon emissions from the electricity generation sector and the transition to a green economy*" (Pfeiffer et al, Mar 2016)**: Using IPCC carbon budgets and the IPCC's AR5 scenario database, and assuming future emissions from other sectors are compatible with a 2°C pathway, we calculate that the 2°C capital stock for electricity will be reached by 2017 based on current trends. In other words, even under the very optimistic assumption that other sectors reduce emissions in line with a 2°C target,

no new emitting electricity infrastructure can be built after 2017 for this target to be met, unless other electricity infrastructure is retired early or retrofitted with carbon capture technologies.

ANNEX II

Other non-peer-reviewed documents:

- **Scottish Widows Investment Partnership – "*Shale gas: the fugitive methane problem*" (May 2012)**: According to the SWIP, a major financial investor in fossil fuels, no benefit from switching from coal to gas because of the leaks that pour methane into the atmosphere
- **Robert Howarth (Cornell University)** – **"*A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas*" (April 2014)**: Review of recent studies on methane emissions from shale gas, published since Howarth's 2011 study: On a 20-year time period, the conclusion stands that both shale gas and conventional natural gas have a larger GHG than do coal or oil. Even if society eliminated CO2 emissions tomorrow but ignored methane, Howarth argues the planet would still warm to the dangerous 1.5 to 2 degree Celsius threshold within 15 to 35 years.
- **Mary Kang (Princeton University) – "*CO2, Methane, and Brine Leakage Through Subsurface Pathways: Exploring Modeling, Measurement, and Policy Options*" (June 2014)**: Between 200,000 and 970,000 abandoned wells in the state of Pennsylvania likely account for four to seven per cent of estimated man-made methane emissions in that jurisdiction. Methane leaks from plugged wells, which were properly sealed with cement at the time of their abandonment, were just as high as rates from unplugged wells --> cement seals in active and abandoned wells crack, shrink and fracture over time, allowing methane to leak and find the path of least resistance, such as natural fractures
- **Environmental Defense Fund – "*Untapped Potential - Reducing Global Methane Emissions from Oil and Natural Gas Systems*" (Apr 2015)**: The 20-year climate impact of methane escaping from oil and gas operations worldwide has the same near-term climate impact as emissions of 40 percent of total global coal combustion --> Without action, these emissions will increase globally more than 20 percent by 2030
- **US Environmental Protection Agency – "*U.S. Greenhouse Gas Inventory Report: 1990-2013*" (Apr 2015)**: U.S. emissions increased by 2% from 2012 to 2013. Methane Leaks from O&G wells now top polluters: The O&G sector contributed 29% of the United States' overall methane emissions (cattle industry: 26%)
- **Environmental Defense Fund – "Onshore Petroleum and Natural Gas Operations on Tribal and Federal Lands in the United States" (June 2015)**: Fugitive and vented losses from oil and natural operations in federal and tribal lands amounted to over 65 billion cubic feet (Bcf) in 2013, worth more than $360 million at current prices --> Equivalent to the GHG pollution from 5.6 million cars
- **International Council for Clean Transportation** – "***Assessment of Heavy-Duty Natural Gas Vehicle Emissions: Implications and Policy Recommendations*" (July 2015):** minimizing overall well-to-wheels leakage is the key determinant in whether trucks using natural gas will offer long-term benefits as part of an overall shift to a more efficient and lower-carbon heavy-duty vehicle fleet. Keeping well-to-wheel natural gas leaks at or below 1 percent throughout the supply chain is critical to ensuring a climate benefit. Finally, the decision as to which global warming potential (i.e., 100-year or 20-year) to use is approximately as important as an additional 1 percent of methane leakage, indicating the importance of considering both GHG time accounting metrics.
- **Robert Howarth (Cornell University) – "*Methane emissions and climatic warming risk from hydraulic fracturing and shale gas development: implications for policy*" (Nov 2015)**: Shale gas development during the 2009–2011 period, on a full life cycle basis including storage and delivery to consumers, may have on average emitted 12% of the methane produced.