Ferry Services in Scotland

Submission from Euan Haig

December 2024

LNG and Boil-Off Gas (BOG)

CalMac's LNG Carbon Emissions Report (Ref 1) states that the Global Warming Potential (GWP) of methane is 86 times higher than CO2.

This unsolicited submission is by Euan Haig C Eng, FRINA, RCNC (Rtd). Its primary aim is to advise NZETC that Transport Scotland, CalMac, and CMAL have omitted Boil-Off Gas from every statement made on emissions. The writer has no objection to LNG but merely wishes the full implications of its use are undisguised. Similarly LNG had implications for ship design, systems complexity, shore facilities, difficulty of vessel construction, and costs of constructing vessels and shore infrastructure. These were not fully explored in the formative states of the Project.

Physics

Natural gas consists mostly of methane (~85%). At atmospheric pressure It becomes liquid at about -160^{o} C and is transported and stored for use at about -162^{o} C and 0 - 0.15 bar. LNG auto-refrigerates at low pressure by allowing evaporation This evaporation is termed 'Boil-Off Gas' Bulk boiling or simmering does not occur; BOG merely consists of surface evaporation. Ref 2 describes the basics.

Auto-refrigeration is possible only because of Boil-off. Transport and storage of BOG is possible primarily because of auto-refrigeration.

History

BOG has been known since natural gas was first liquefied decades ago. The writer toured an LNG tanker under construction in 1968. The first LNG tankers vented BOG to atmosphere. Later ships collected BOG and compressed it for propulsion machinery. Wärtsilä has been aware of BOG for decades and manufactures 'LNG Oxidisers' to convert BOG into less-damaging CO^2. (Ref 3)

The writer finds it inconceivable that anyone involved in procuring a vessel propelled by LNG would be unaware of BOG

On large ships BOG is sometimes collected, cooled, and re-compressed for return to storage. The equipment is large, high-tech, and costly. It is not an economic proposition for small ships. This paper does not consider BOG during extraction from the well or transport to UK, for which see Ref 2. For small ships such as ferries and road tankers BOG is normally vented to atmosphere.

Transport Scotland (TS) procured a Business Case (Ref 4) to justify ordering 801/2. It has an Appendix of 25 pages devoted to estimates of consumption, costs, and benefits of LNG/MGO dual fuel compared with MGO only. It does not mention BOG, methane slip, or any emission 'overhead', generated in use or transport of LNG..

BOG is not mentioned in any document produced by the Scottish Government, Transport Scotland, CalMac, or CMAL.

Various references encountered in writing this submission pre-date the inception of the Super Eco 1000 Ro Pax project (around 2012). Wärtsilä's website (Ref 3) mentions BOG only in relation to the systems it provides to re-liquify BOG evolved from LNG carriers. It does not mention BOG evolved and released to atmosphere from small vessels.

The issue is whether LNG/MGO dual fuel <u>actually</u> reduces emissions. If emissions are real they should not be ignored because another authority does not quantify them.

<u>Energy Density, Road Transport, and Shore Storage.</u>

MGO has an Energy Density of about 38.75 MegaJoules/m^3 (MJ/m^3) and LNG about 21 MJ/m^3. (Ref 15). Road tankers are built to UK's legal maximum of weight and dimensions, and the volumetric capacity of LNG tankers is about the same as MGO tankers. A tanker of MGO carries about 80% more energy than a tanker of LNG.

The writer understands that CalMac's shore storage LNG tanks will have capacity of 180 m^3. 801/2's LNG tanks have a nominal capacity of 149 m^3. The reader may infer the usage, replenishment cycle and periodicity of refuelling from the shore 'buffer' tanks whilst the buffer tank is replenished by road tanker about every second day. 801/2 will also require occasional replenishment with MGO since they will use some MGO on every sailing. The writer believes the cycle of LNG replenishment will take about 10 days and perhaps less.

The ferry to Arran operates from Troon at present. CalMac states (Ref 7):-

*"The typical transfer rate (of LNG - w*riter's clarification*) from a road tanker to receiving vessel is too slow - typically between 2 and 2.5 hours to decant 20 tonnes of liquid, by comparison, a full tanker of MGO is approximately 28 tonnes and can be transferred to the ship in about 45 minutes.'*

With no LNG terminal at Troon, GLEN SANNOX must go to Ardrossan to refuel LNG. This will incur additional crew time and cost, and there might be additional port fees at Ardrossan. None of these costs are known to have been estimated nor the impact of inconvenience..

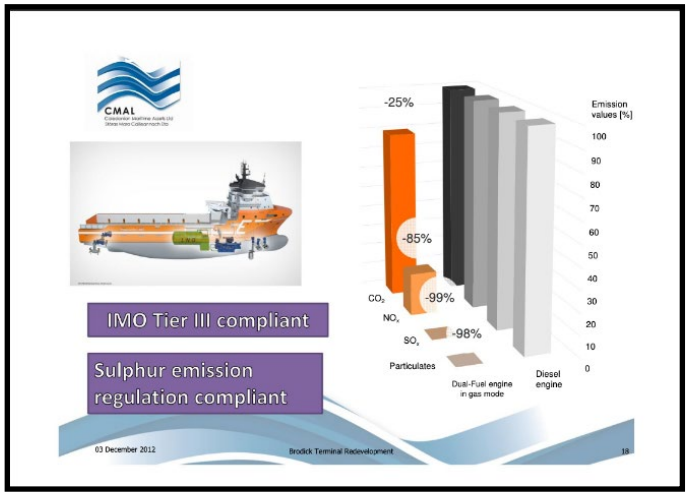
<u>BOG en route to LNG Terminals in Scotland.</u>

BOG makes it possible to transport LNG from the wellhead to the ferry in Scotland. Bringing LNG to Scotland for 801/2 releases BOG during supply from the Storage Terminal on the Isle of Grain (IoG) to storage in CalMac's LNG terminals ashore when complete, or directly to the ships' tanks until then. Transport Scotland states (Ref 5) that CalMac's LNG shore terminals will be at Ardrossan (467 miles by road from IoG) and Uig on Skye (697 miles). CalMac estimates (Ref 5) that:-

'The expected demand for the new ships with the current assumed timetable is approximately 105 cubic metres of LNG per vessel per week.'

CalMac estimates supplying 801 with LNG will require 2.4 LNG deliveries per week, or about 125 pa with better arithmetic since 'rounding down' to the nearest tanker is absurd. Assuming trouble-free tanker operation, each delivery will take one day or more to supply and the same to return, with discharging time between. Supplying LNG to each ship will put a tanker on the road, coming or going, 250 days of the year or more. LNG in the road tankers will evolve BOG at the higher rates in the range 0.02% to 0.1% because of the heating effect of sloshing in the tank. It is for CalMac/CMAL to provide data with the authority that comes from completeness and accuracy.

CalMac states the road tankers used by Molgas are fuelled by diesel (Ref 1). Transporting LNG from IoG to Ardrossan will involve about 116,750 road tanker miles pa, and to Ulg at least 174250 miles pa. That mileage merits consideration of emissions from vehicle fuel and particulate generation from several complete HGV sets of tyres. Road tankers returning empty may retain ~0.1 tonnes of LNG whose Boil-Off will refrigerate the tank in readiness for the next delivery. BOG will be vented to atmosphere during the return journey.



BOG in Scotland

It is for CalMac to furnish data with the authority that comes from completeness and accuracy. BOG should be added to other forms of 'methane slip.' The significant figure for operating 801/2 is the annual total of BOG released. The storage terminals will evolve BOG from the LNG Storage tanks.

Extracting the Truth

TS, CalMac, and CMAL have a long history of omitting or understating emissions. CMAL showed this slide in its presentation (Ref 8) to Arran ferry users on 3rd December 2012. It omitted mention of 'methane slip', BOG, and emissions from transport. Incompleteness renders it invalid.

The Business Case (Ref 4) briefly mentions SO_2 (p 12) and NO_x (p 21 and elsewhere), with particular mention in Sub Appendix III. Once again it does NOT mention 'methane slip', BOG,or emissions from transport.
Incompleteness renders it invalid.

Early in March 2016 CalMac commissioned Herbert Engineering Corporation (HEC) to report on incompleteness and incompatibility between the Statement of Technical and Operational Requirements and associated General Arrangement as then developed. HEC reported on 8 April 2016 (Ref 9). HEC raised the omission of 'methane slip' but not BOG.

More importantly, HEC warned that the balance and viability of the whole project was threatened by the inclusion of LNG:-

*'From a greenhouse gas perspective, the benefit of using LNG does not seem significant, even though we have used a low greenhouse gas factor (*writer's note - only 25 rather than 86*) for methane. If we increase the greenhouse gas factor, add*

methane release during bunkering and the CO_2 cost of transporting the LNG from afar, the CO_2 emission benefit virtually disappears.

The other advantages of LNG over MGO do remain (SOx, NOx and particulates) however they need to be further evaluated in light of other abatement technologies that exist which may lead to a reduction in lightweight and cost. The corollary of this is that there is a weight penalty associated with the use of emission reduction technology (such as LNG) which leads to a requirement for increased displacement and consequently increased engine power for a given deadweight and speed target.'

In February 2023 CMAL provided NZETC with a 'Briefing' (Ref 10). It ignored 'methane slip', BOG, and emissions from transport. It also ignored the considerable emissions from building 801/2, and the additional emissions arising from enlarging the ships in displacement terms at least, to accommodate the LNG tank and associated systems. It made the arithmetically absurd claim that despite their emissions 801/2's introduction to service would reduce the emissions of the whole CalMac fleet by 25%. Incompleteness renders the Briefing invalid.

Fractured Reasoning and Non-Sequiturs

On 6th October 2024 the writer emailed CMAL to ask for a copy of any submission CMAL might have made to correct the arithmetic error (Ref 11). CMAL kindly provided the corrected brief as then drafted. (Ref 12). The arithmetical error was corrected but the brief drafted by CMAL still omitted 'methane slip'. The writer emailed CMAL pointing out the omission (Ref 13). CMAL replied (Ref 14):-

'CMAL have not calculated the emissions associated with '*methane slip*'*, or the CO2* '*overhead*' *in liquefying LNG and shipping it to LNG terminals, and the construction of LNG terminals. We do not have this information to share, and therefore, in accordance with section 17 of the Freedom of Information (Scotland) Act 2002 (FOISA), this information is not held. The inquiry that this submission relates to is complete and the report published. The Committee Clerk advised us that they cannot replace the original submission with an updated version but advised us to simply correct the submission and explain the error in the original.'*

The writer regards the above as the most unsatisfactory of excuses for neglect to do all of the work required before an informed and rational decision could be made.

The Consequences of Imprecise Estimation of Emissions

Inaccurate estimation of emissions made it impossible to make a reasoned decision on machinery supplier or LNG/MGO dual fuel. Those making the decision presumed that Wärtsilä's machinery was especially beneficial to emissions because it was fuelled by LNG/MGO dual fuel, but lacked the data.

CMAL procured the General Arrangement and the Tender Technical Specification fir Invitation to Tender from Wärtsilä. Wärtsilä's machinery and associated systems proved a very tight fit in the spaces allowed by Wärtsilä in the ship design that CMAL accepted from Wärtsilä. The ship's LNG tank and associated systems and controls added greatly to the complexity, congestion, and cost of the ship. All that stems from specifying Wärtsilä machinery and LNG/MGO on the bases of the estimates of emissions that CMAL made visible.

The Scottish Government's approval of machinery and LNG/MGO fuel (Ref 4) was justified by incomplete expectations of reductions on emissions. LNG causes emissions, direct and indirectly but CMAL has never quantified or presented all of them. CMAL's procurement process did not include a costed 'concept study' of a version of the Super Eco 1000 Ro Pax ferry without the LNG tank and additional systems, controls and emissions peculiar to LNG. The total emissions from a simpler and cheaper ship with a more efficient hull shape could have been less than those from 801/2, but that was not examined.

The Need for Accuracy

Ref 1 is Calmac's LNG Carbon Emissions Report of 11 January 2024. CalMac does not wish the document exposed to analysis or criticism. Every page is marked:-

' Confidential – Do not distribute without express permission of CalMac Ferries Ltd.'

It is biased to justify the supposed reductions of emissions by using LNG and does not quantify all of them.

1. CalMac's Report makes no mention of BOG. The effect of BOG and its GWP reduces statements such as 8.3 to qualitative opinion only.

2. Underestimate - Para 3.8 - 'The expected demand for the new ships with the current assumed timetable is approximately 105 cubic metres of LNG per vessel per week.'

Density of LNG = ~0.46, therefore 105 m^3 = 48.3 tonnes.

CalMac's fuel supplier (Molgas) uses LNG road tankers with 20 tonne/`40m^3 capacity.

For two ships, this means 5 deliveries/week to either Ardrossan or UIG, or 10 tanker-days somewhere on the road every week.

Table 1 discloses that each ship will require 1/2 tankers of MGO per week, = 1.0 tankers/week.

3. Underplay the problem - Para 4.6 - 'full visibility' and 'monitoring' does not eliminate the emissions from road transport.

4. Section 8 seeks to excuse CalMac's exclusion of emissions in producing LNG and shipping to UK. These emissions are real. Ignoring them does not remove them.

5. CalMac seeks to 'talk down' valid and factual criticism. Para 9.4 mentions the need for:-

'….optimising engine load to maintain proper combustion and reduce methane….'
It is impossible to guarantee ideal operating conditions all the time. Estimates should be as 'real world' as possible. And why should 'environmental bodies ' not highlight it if it is true?

6. Para 9.23 is mistaken - '20-year GWP is <u>not</u> always used in the negative way alleged. Readers should note there statement quoted by CalMac:-

"Using LNG does not deliver the emissions reductions required by the IMO's initial GHG strategy, and that using it could actually worsen shipping's climate impacts"

7. Paras 3.10 and 11.1 imply that 801/2 are penalised by their large size. The writer is not surprised by this, and has always believed that the vessels are over-sized because defective process was used to produce their 'requirements'.

8. Para 10.4 is internally contradictory - Nitrogen purging does not 'eliminate' venting excess fuel to atmosphere - it is the means by which excess fuel is vented to atmosphere.

9. The statement in Para 11.2 is peculiar. Surely GLEN SANNOX must operate the hours to provide the scheduled service, regardless of actual usage of LNG (or MGO)

10. Paras 11.5 and 11.7 require clarification and quantification. !!.7 infers that emissions will be worse than the writer of the paper believes.

11. Table 4 is especially curious. **How can actual GWP *decrease by leaving the same CO_2 in the atmosphere another 80 years?***

References

1. CalMac - LNG Carbon Emissions Report. 11 January 2024

2 Transactions of Maritime Science Trans. marit. sci. 2013; 02: 91 - 100
Problem of Boil-off in LNG Supply Chain by Đorđe Dobrota, Branko Lalić, Ivan Komar

3 Wärtsilä website - www.wartsila.com, then Search 'Boil-off Gas'.

4. VRS - New Vessels 1 & 2 - Business Case 6 August 2014.

5. Transport Scotland - Troon Harbour Project - Link - https://www.transport.gov.scot/public-transport/ferries/infrastructure-projects/qa-troon- harbour-project/

6. The Safety Assessment of LNG Marine Bunkering - Halford, Robinson, and Haynes, 2019

7. CalMac - LNG FAQ's - Link - https://www.calmac.co.uk/en-gb/lng-faqs/#/

8. CMAL - Presentation of 03/12/2012 - Arran Terminal and Vessel Upgrades. (available from CMAL)

9. Ropax Design Assessment - Herbert Engineering Corporation - 8 April 2016 (Available from CalMac)

10. CMAL - 'Briefing' on 'Decarbonising Scotlands ferries on the route to net zero'

11. E Haig email to CMAL of 6th October 2024 timed 1419

12. CMAL email of 1st November 2024 timed 1637

13. E Haig email of 04 November 2024 timed 1520

14. CMAL email of 21 November 2024 timed 1016.

15. ‘Volumetric Energy Density of Alternative Marine Fuels’ - Marine Service Noord