Life Cycle Analysis (LCA) Report

John Lawrie Tubulars – The Environmental Benefits from Repurposing Tubular Steel from North Sea Oil and Gas Fields

Confidential Report by Giraffe Innovation Ltd

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Technical Brief

The purpose of this report is to present the environmental impacts and benefits of the repurposing and onward delivery of John Lawrie Tubulars products and to compare the benefits of repurposed tubulars to those made from prime steel[1] throughout their lifecycle. This includes the direct environmental benefits on a like for like basis and inbound supply scenarios of prime steel products supplied from the European Union (EU) (Czech Republic) as well as John Lawrie Tubulars distribution scenarios (outbound) within the UK and internationally to the USA and EU. A comparison between tubulars sourced from Japan, Brazil and Mexico is also calculated.

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[1] World Steel Association (WSA) global average data

John Lawrie Tubulars is a leading, award winning[2] specialist in the supply and purchase of new and repurposed tubulars, casing and drill pipe, and operates around the world, with activities throughout the UK, Europe, Scandinavia, North America, China and the Middle East.

Since being founded in the 1930s, delivering significant circular economy environmental and financial benefits through repurpose and recycling is central to the company's business model.

Giraffe Innovation Ltd was founded in 1998 and is an award-winning environmental management and technical consultancy[3]. Giraffe was described by The Guardian newspaper business pages as *'one of the UK's top green businesses'* due to its extensive experience in delivering a wide range of sustainability driven projects to UK and global organisations. The Manufacturer Magazine described Giraffe as *'Britain's leading eco-design consultancy'.*

[2] Circular economy award - VIBES -Scottish Business Environment Awards 2017
[3] DBA Design Effectiveness Award (Gold) with Virgin Atlantic Airways (VAA). Green Apple (Gold) awarded at House of Commons.

Glossary

Life Cycle
A view of a product system as "consecutive and interlinked stages … from raw material acquisition or generation from natural resources to final disposal" (ISO 14040:2006, section 3.1). This includes all material and energy inputs as well as emissions to air, land and water.

Life Cycle Assessment (LCA)
"Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO 14040:2006, section 3.2).

Life Cycle Inventory (LCI)
"Phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle" (ISO 14040:2006, section 3.3).

Life Cycle Impact Assessment (LCIA)
"Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product" (ISO 14040:2006, section 3.4).

Life Cycle Interpretation
"Phase of life cycle assessment in which the findings of either the inventory analysis or the impact assessment, or both, are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations" (ISO 14040:2006, section 3.5).

Functional Unit
"Quantified performance of a product system for use as a reference unit" (ISO 14040:2006, section 3.20).

Allocation
"Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems" (ISO 14040:2006, section 3.17).

Critical Review
"Process intended to ensure consistency between a life cycle assessment and the principles and requirements of the International Standards on life cycle assessment" (ISO 14044:2006, section 3.45).

Executive Summary

John Lawrie Tubulars is one of the largest suppliers of steel tubular products to the construction sector in the UK and USA, purchasing and supplying new and used tubing, casing, OCTG, drill pipe, drill collars and related products[4]. The company repurposes redundant steel tubulars from the North Sea oil and gas industry as a high-quality alternative for traditional concrete piles.

Extending the utility of materials through reuse, repurpose and recycling to minimise waste, pollution, water and the consumption of finite resources, reduce environmental impacts and cut Greenhouse Gas (GHG) emissions (CO_2e) are key tenants of the Circular Economy. The purpose of this report is to present the environmental impacts and benefits of repurposing and onward delivery of John Lawrie Tubulars products and to compare the benefits of repurposed products made from prime steel[5] throughout their lifecycle. This includes the direct environmental benefits (material only) on a like for like basis as well as the distribution of outbound finished goods within the UK and internationally to the USA and Europe. The comparison of repurposed steel tubulars is also made to inbound distribution scenarios for prime steel products from the EU (Czech Republic) (Table 3) as well as imported prime steel from Japan, Brazil, Mexico (Table 9) (Appendix A).

The Life Cycle Analysis (LCA) for John Lawrie Tubulars products is undertaken to ISO 14040 and ISO 14044 and A1-A4 as per EN 15804:2012+A2:2019, Sustainability of construction works- Environmental product declarations - Core rules for the product category of construction products[6] [7]. The system boundary is cradle to gate with transportation from gate to site. The analysis compares John Lawrie repurposed products to prime steel using World Steel Association (WSA)[8] seamless steel tube[9] Life Cycle Inventory (LCI) per kg (cradle to gate) (2019))[10] using the same 5 CML indicators to EN 15804:2012+A2:2019 methodology.

Results
The results of the LCA for the refurbishment of redundant tubulars by John Lawrie show that 1 tonne of repurposed tubular steel has a carbon footprint of 62.05kgCO_2e (cradle to gate).

By comparison, the World Steel Association (WSA) seamless steel tube has a carbon footprint of 2,226kgCO_2e per tonne (cradle to gate). Therefore, **John Lawrie Tubulars save 2163.95kgCO_2e per tonne of steel product, which is 97.21% of the carbon emissions of a prime steel equivalent[11]. In other words, the material carbon footprint of repurposed tubulars has 2.79% of the impact of those made from prime steel.**

The World Steel Association (WSA) welded steel tube has a carbon footprint of 2,795kgCO_2e per tonne (cradle to gate). Therefore, **John Lawrie Tubulars save 2,732.95kgCO_2e per tonne of steel product, which is 97.78% of the carbon emissions of a prime steel equivalent[12]. In other words, the material carbon footprint of repurposed tubulars has 2.22% of the impact of those made from prime steel.**

The analysis includes multiple environmental indicators associated with the material processing, on-site operations and supply chain. The benefits of repurposed tubulars are consistently beneficial across all environmental indicators when compared to prime steel tubulars (Table 1).

[4] https://www.johnlawrie.com/tubulars/piling-and-tubular-products
[5] World Steel Association (WSA) global average data. Qualification note: WSA data has been updated to the current ecoinvent data set and CML methodology. The original WSA data is presented in table 51.
[6] https://www.cencenelec.eu/news/brief_news/Pages/TN-2019-047.aspx
[7] https://shop.bsigroup.com/ProductDetail/?pid=000000000030424272
[8] https://www.worldsteel.org/steel-by-topic/life-cycle-thinking.html
[9] EU average welded steel pipe (WSA) 2.69kgCO_2e, - updated for consistent report method is 2.79kgCO_2e per kg. Therefore, welded steel tubulars are 0.53kgCO_2e per kg higher than seamless tubulars. JLT saves 97.78% of the carbon emissions for welded steel pipe compared to prime steel welded tubulars.
[10] Please note the % is rounded to the nearest whole number
[11] Including reverse logistics and on-site operations – John Lawrie Tubulars Montrose facility
[12] Including reverse logistics and on-site operations – John Lawrie Tubulars Montrose facility

Environmental Indicators	Units	WSA Seamless Tube	WSA Long Welded Tube	John Lawrie seamless tube	Reduction in impact vs Seamless tube (%)	Reduction in impact vs long welded tube (%)
Climate change Total	kg CO_2 eq	2,226	2,795	62.05	97% (97.21%)	98% (97.78%)
Acidification	mol H+ eq	9.357	8.57	0.620	93%	93%
Eutrophication, freshwater	PO_4 eq	0.0809	0.975	0.0129	84%	99%
Ozone depletion	kg CFC11 eq	1.325E-05	9.91e-6	7.661E-06	42%	33%
Primary energy demand from ren. and non ren. resources (net cal. value)	MJ	26,408	22,261	770	97%	97%

Table 1: 1 tonne John Lawrie Tubulars Vs World Steel Association (Global average for seamless tubular steel)

The environmental impact of UK distribution was modelled using an average distance from John Lawrie's Montrose facility to Birmingham (UK). This is an indicative distance, although it is acknowledged the products could be distributed across all regions of the UK. The average delivery in the UK adds 56.53kgCO_2e to John Lawrie's tubular steel giving a cradle to delivery at the customers gate of 118.53kgCO_2e per tonne[13].

The results for the tubular steel and average UK distribution (Montrose-Birmingham) are also given per metre for 3 products of varying diameter:

- 1m - 5½" tubular steel:
  - John Lawrie: 3.56kgCO_2e
  - World Steel Average: 60.80kgCO_2e
- 1m – 7" tubular steel:
  - John Lawrie: 5.16kgCO_2e.
  - World Steel Average: 88.16kgCO_2e
- 1m - 9 5/8" tubular steel:
  - John Lawrie: 9.52kgCO_2e.
  - World Steel Average: 162.63kgCO_2e

In all three tubular steel sizes the reduction in carbon footprint including average UK distribution is 94%. The material and distribution carbon footprint of repurposed tubular products has 6% of the impact of those made from prime steel.

Further analysis showed the environmental impacts of 1 tonne of tubular steel for distribution within Scotland and to the EU and USA (Table 2). This similarly highlights that John Lawrie repurposed tubulars have a relatively low carbon impact in comparison to prime steel seamless tubulars. Shipping by oceanic freight to the USA is a relatively efficient mode of transport compared to a mix of road haulage (UK) and road haulage and sea ferry (EU).

Parameter	Unit	Total UK average	Total Scotland	Total EU	Total USA
Climate change Total	**kg CO_2 eq**	**118.58**	**76.54**	**208.30**	**118.65**
Climate change - Fossil	kg CO_2 eq	118.69	76.70	208.04	118.79
Climate change - Biogenic	kg CO_2 eq	1.25	1.23	1.55	1.20
Climate change - Land use and LU change	kg CO_2 eq	5.15E-02	3.84E-02	1.30E-01	0.07
Ozone depletion	kg CFC11 eq	2.10E-05	1.11E-05	3.64E-05	1.90E-05
Acidification	mol H+ eq	0.81	0.67	2.00	2.45
Eutrophication, freshwater	Kg PO_4 eq	0.14	0.12	0.34	0.27
Eutrophication, freshwater	kg P eq	1.77E-02	1.42E-02	4.04E-02	0.02
Eutrophication, marine	kg N eq	0.19	0.16	0.54	0.60
Eutrophication, terrestrial	mol N eq	2.10	1.76	5.88	6.65

[13] If the same average delivery impact is assigned to world steel average the totals for WSA would be 1.97+0.05653tCO_2e which is 2.02652tCO_2e. Therefore, the John Lawrie product including distribution would save ~94% of the carbon impact (0.11858/2.02652)*100 =5.85%).

Photochemical ozone formation	kg NMVOC eq	0.63	0.50	1.65	1.76
Resource use, minerals and metals	kg Sb eq	2.46E-03	1.73E-03	3.31E-03	1.90E-03
Resource use, fossils	MJ	1652.64	982.98	2945.10	1476.15
Water use	m^3 depriv.	9.99	7.56	17.93	7.78

Table 2: Comparison of core environmental indicators and logistics (UK, Scotland, EU, USA)

Further modelling included the impact of John Lawrie tubulars versus those of seamless prime steel imported from the EU (Czech Republic has been used as an example because it is home to the 4th largest steel manufacturer) (Table 3). Under this scenario the tubulars travel 1,246 km by road from Czech Republic to Rotterdam Port, Rotterdam Port to Felixstowe (224km) and then from Felixstowe Port to Birmingham (265km). This shows the results of shipping from these four countries to Birmingham UK via Felixstowe Docks (per tonne)[14]. The results show that John Lawrie seamless tubulars reduce the carbon footprint by ~95% and is beneficial in all other environmental indicators.

Environmental Indicators	Unit	John Lawrie	Czech Republic (Prime)
Climate change total	kg CO_2 eq	118.58	2439.13 (95%)
Acidification	mol H+ eq	0.81	10.77 (93%)
Eutrophication, freshwater	PO_4 eq	0.0177	0.09 (83%)
Ozone depletion	Kg CFC11 eq	2.10E-05	6.39E-05m (67%)
Primary energy demand from ren. and non ren. resources (net cal. value)	MJ	1736	30006 (94%)

Table 3: John Lawrie Vs World Steel Association Global average and importing from Czech Republic. Results and comparison with % reduction in impact of John Lawrie tubular steel

Results comparing John Lawrie to seamless prime steel imported from Brazil, Mexico and Japan are given in Appendix A.

Equivalence

This study clearly shows the demonstrable benefits of repurposed John Lawrie tubulars over that of both seamless and welded prime steel tubulars. This data can be used by John Lawrie to demonstrate the environmental impacts and benefits of their tubulars and supports the efficacy of environmental claims and contribution to circular economy.

In order to 'humanise' the LCA results, the environmental impact and carbon savings of John Lawrie Tubulars can be compared to the equivalent impact of everyday products and activities such as driving a car, beef, watching Netflix. Plus, a comparison saving is given to the average UK citizens annual emissions and also the number of trees and land required to sequester the associated carbon emissions. This helps to give a relatable understanding of the analysis which can be further used in communicating the benefits of John Lawrie Tubulars to a wider audience. A like-for-like materials comparison is given below (materials only):

Driving a car: John Lawrie repurposed tubulars save 2,163.95kgCO_2e per tonne which is the equivalent emissions of driving a Ford Focus[15] 15,280 miles (24,591km), about the distance from London to Nairobi and back.

Beef: the carbon footprint of 1 tonne of John Lawrie repurposed tubular steel is equivalent to the production of 1.3kg of beef, which is equivalent to 14 burgers sold in a high street restaurant[16]. By comparison 1 tonne of WSA seamless tubular is equivalent to 48.2kg of beef, which is enough for 535 burgers sold in a well-known high street restaurant.

[14] Please note the % is rounded to the nearest whole number.
[15] https://www.nextgreencar.com/view-car/54691/ford-focus-1.5-tdci-style-econetic-105ps-diesel-manual-6-speed/ (88gCO_2/Km)
[16] 1kg of beef is equivalent to 46.4kgCO_2e. Burger comparison presumes 2 beef patties used by a well-known restaurant chain.

Netflix: The carbon footprint of 1 tonne of John Lawrie repurposed tubular steel is equivalent to streaming Netflix[17] on a 55" OLED TV for 527 hours 38 minutes or 22 days, 24 hours a day in the UK. The carbon footprint of 1 tonne of prime seamless tubular steel is equivalent to streaming Netflix on a 55" OLED TV for 18,928 hours 34 minutes or 788 days (24 hours day).

John Lawrie Tubulars Case Study - P&J Live Arena[18]

An excellent example of John Lawrie Tubulars circular economy projects is the repurposing of oil and gas tubulars from North Sea oilfield wells for the foundations of the P&J Live Arena, Aberdeen's state-of-the-art conference, exhibition and entertainment complex[19] [20]. John Lawrie supplied ~1,925 tonnes/1,750 of tubulars to the project contractor, which then utilised the tubes for setting the foundations of the new arena. By way of example, the carbon footprint for the 1,925 tonnes of repurposed tubulars supplied by John Lawrie for the P&J Live Arena in Aberdeen is 119.35t CO_2e (0.062*1,925) in materials and 11.89tCO_2e for distribution (Montrose to Aberdeen) which totals 131.24tCO_2e. If the arena had used prime steel tubulars the environmental impact would have been 4,285.05tCO_2e (2.226*1,925) in materials plus distribution (Montrose-Aberdeen) of 11.89tCO_2e giving a total of 4296.94tCO_2e.

P&J Arena – Carbon footprint saving (materials):

For the P&J Live Arena using John Lawrie repurposed tubulars rather than prime steel (materials only) saves ~4,165.7tCO_2e. This is an equivalent saving to:

- 616 UK citizens annual carbon footprint[21];
- Driving a Ford Focus[22] 29,414,000 miles (47,337,500Km) which is the same as driving around the circumference of Planet Earth[23] 1181.2 times;
- 90,166kg of beef[24] which would produce enough patties for over 1 million (1,001,8441) burgers sold in a well-known high street restaurant[25];
- Streaming Netflix[22] on a 55" OLED TV continuously (24 hours a day) for 4,043 years in the UK;
- The CO_2 absorbed by 10.4 hectares of UK forestry per annum which is equivalent to 17 football pitches; and
- The amount of CO_2 absorbed by 4,165 trees in 100 years[26].

P&J Arena – Carbon footprint saving (EU Czech Republic):

The environmental benefits of specifying John Lawrie repurposed tubulars increase when the distribution of routes prime steel alternatives is considered - for instance, prime seamless steel tubulars from the EU (Czech Republic) (Table 4). Two indicative shipping routes are presented:

- Arriving in UK in a container ship at Felixstowe port and then by road to P&J Live Arena (554 miles) (891.5Km);
- Arriving in the UK by break bulk shipment at Aberdeen Port and then by road to P&J Live Arena (5.4 miles (8.7km)).

[17] Figures based on 55" OLED TV and Netflix. Netflix (89.46gCO2e per hour, 1.49gCO_2e per min). TV (Energy 110W – 1 Hour 0.11kWh (0.2556/1000*110) = 0.02816KgCO_2e. 1 minute (0.02816/60=0.0004686) = 0.4686gCO_2e. Total 1.96g$C0_2e$ per minute. Please note these are indicative figures and can vary depending on make and specification of TV. Energy figures based on UK data. Netflix data source: https://www.carbonbrief.org/factcheck-what-is-the-carbon-footprint-of-streaming-video-on-netflix. TV energy data based on brand specification.

[18] https://www.pandjlive.com/

[19] https://www.johnlawrie.com/tubulars/case-studies/teca-aberdeen

[20] Client: The Event Complex Aberdeen

[21] UK carbon footprint in 2018 confirmed at 449mt (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/790626/2018-provisional-emissions-statistics-report.pdf) and population of 66.4m in 2018 (6.76tCO_2e per person). (https://cy.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/overviewoftheukpopulation/august2019)

[22] https://www.nextgreencar.com/view-car/54691/ford-focus-1.5-tdci-style-econetic-105ps-diesel-manual-6-speed/ (88gCO_2/Km)

[23] Circumference 40,075

[24] 46.2kgCO_2e per kg of beef Quantis World Food LCA Database (WFLDB) 2019

[25] Assuming 45g of beef per patty

[26] https://www.woodlandcarboncode.org.uk/buy-carbon/why-buy-wcc-verified-carbon-units

Country	Prime steel (tCO_2e)	Sea freight (tCO_2e)	Road transport to P&J Live Arena (tCO_2e)	Total (tCO_2e)	Saving (tCO_2e)	UK citizens equivalent
Czech Republic to Felixstowe port	4285.05	47.44	505.00[27]	4837.49	4706.25	696
Czech Republic to Aberdeen port	4285.05	152.23	210.89	4648.17	4516.93	668

Table 4: World Steel Association Global average - Czech Republic to P&J Live Arena

Results comparing John Lawrie repurposed tubulars to seamless prime steel imported from Brazil, Mexico and Japan are given in Appendix A.

Specifying John Lawrie repurposed tubulars over prime steel for the P&J Arena sourced from Czech Republic and shipped into Felixstowe dock and then transported by road to Aberdeen would save 4,706.25tCO_2e. The equivalent of:

- 696 UK citizens annual carbon emissions;
- Driving a Ford Focus 33,293,137 miles (53,580,113Km) which is the same as driving around Planet Earth 1,339.2 times;
- 101,866 kg of beef which would produce enough patties for over 1.1 million (1,131,844) burgers sold in a well-known high street restaurant;
- Streaming Netflix[28] on a 55" OLED TV continuously (24 hours a day) for 4,568 years in the UK;
- The CO_2 absorbed by 11.76 hectares of UK forestry per annum[29] which is equivalent to 18 football pitches[30]; and
- The amount of CO_2 absorbed by 4,706 trees in 100 years.

[27] Includes road transport from Czech Republic to Rotterdam port

[28] Figures based on 55" OLED TV and Netflix. Netflix (89.46gCO2e per hour, 1.49gCO_2e per min). TV (Energy 110W – 1 Hour 0.11kWh (0.2556/1000*110) = 0.02816KgCO_2e. 1 minute (0.02816/60=0.0004686) = 0.4686gCO_2e. Total 1.96gCO_2e per minute. Please note these are indicative figures and can vary depending on make and specification of TV. Energy figures based on UK data. Netflix data source: https://www.carbonbrief.org/factcheck-what-is-the-carbon-footprint-of-streaming-video-on-netflix. TV energy data based on brand specification.

[29] https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/british-trees/how-trees-fight-climate-change/ quote 400t per hectare

[30] https://www.thecalculatorsite.com/articles/units/how-big-is-a-hectare.php