PIPA

COMPARATIVE ENVIRONMENTAL ASSESSMENT

PLASTIC AND DUCTILE IRON (DICL) PIPES IN INFRASTRUCTURE APPLICATIONS

JUNE 2025

COMPARATIVE ENVIRONMENTAL ASSESSMENT OF PLASTIC AND DUCTILE IRON (DICL) PIPES IN INFRASTRUCTURE APPLICATIONS

In an era where sustainable infrastructure is critical to addressing climate change, resource scarcity, and environmental resilience, it is essential to assess the life cycle impacts of the materials that underpin our built environment. Plastic pipes and ductile iron cement lined (DICL) pipes are both widely used in civil infrastructure, but their environmental footprints differ significantly depending on material composition, manufacturing practices, and supply chain energy sources.

To contribute robust, transparent data to this conversation, the Plastics Industry Pipe Association of Australia (PIPA) commissioned Edge Impact to conduct a comparative Life Cycle Assessment (LCA) of plastic pipes—specifically Polyethylene (PE), Modified PVC (PVC-M), and Bi-axially Oriented PVC (PVC-O)—against DICL pipes.

The study used Environmental Product Declarations (EPDs) as the primary data source to ensure standardised, third-party verified comparisons. EPDs were sourced from key industry manufacturers: Vinidex (Polyethylene Pipes, 2022), Iplex (PVC Pressure Pipes, 2022), and Saint-Gobain (Pipe System Natural DN100 and DN300, 2022).

By examining environmental performance across the entire product life cycle—from raw material extraction through to transport to site—this study provides valuable insights for asset owners, engineers, procurement officers, and policymakers aiming to select materials that align with Australia's sustainability priorities. The findings are intended to support more informed decision-making in the design, construction, and maintenance of resilient, future-ready infrastructure.

ENVIRONMENTAL BENEFITS OF PLASTIC PIPES

LOWER GLOBAL WARMING POTENTIAL (GWP)

Plastic pipes show consistently lower carbon emissions across Product Stage System A1-A3 compared to DICL pipes.

DN 100 PIPES:

- PE pipes emit **13 kg CO_2-eq** per metre.
- PVC-M pipes emit **10 kg CO_2-eq** per metre.
- PVC-O pipes emit **7 kg CO_2-eq** per metre.
- DICL pipes emit **37 kg CO_2-eq** per metre.

DN 300 PIPES:

- PE pipes emit **103 kg CO_2-eq** per metre.
- PVC-M pipes emit **81 kg CO_2-eq** per metre.
- PVC-O pipes emit **53 kg CO_2-eq** per metre.
- DICL pipes emit **126 kg CO_2-eq** per metre.

GWP-total breakdown

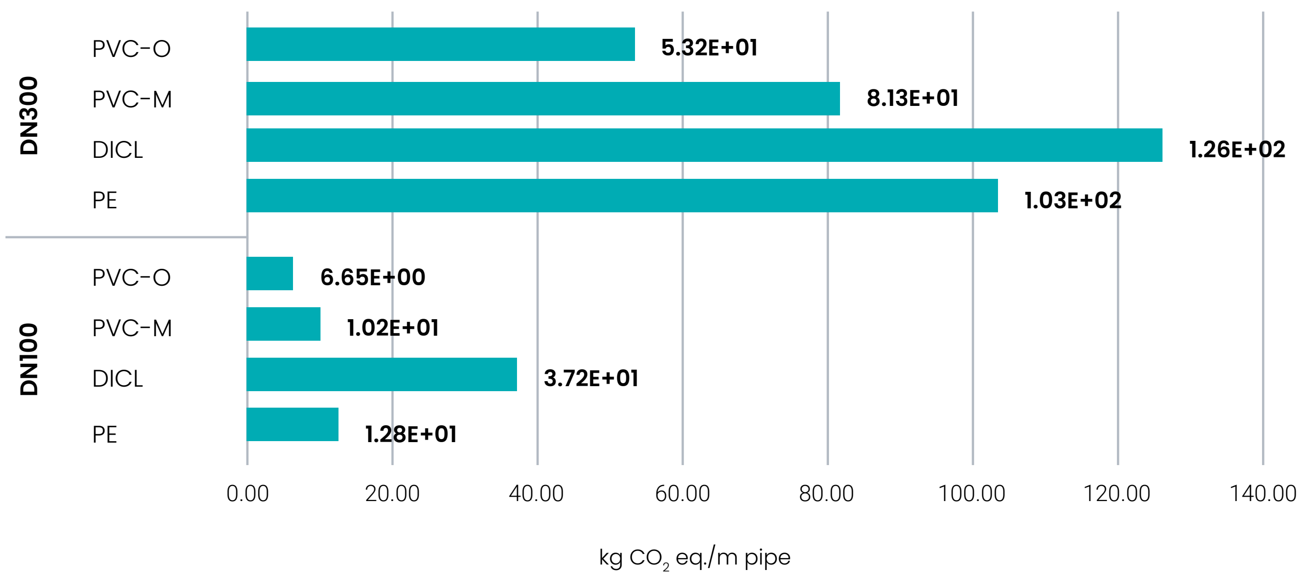

Figure 1: GWP-total comparison of plastic pipes with DICL pipes

17 National Transport Commission (2021) Light Vehicle emissions intensity in Australia, https://www.ntc.gov.au/sites/default/files/assets/files/Carbon%20Dioxide%20Emissions%20Intensity%20for%20New%20Australian%20Light%20Vehicles%202021.pdf

For context, a single 10 km round-trip by car emits approximately **1.47 kg CO_2-eq**. Producing 1 metre of DN 100 DICL pipe is equivalent to about **25 shopping trips**, while a DN 100 PE pipe is equivalent to roughly **9 trips**, and a PVC-O pipe only **4.5 trips**.

LOWER FRESHWATER USE

Plastic pipes require significantly less freshwater during their production than ductile iron cement-lined (DICL) pipes. This difference is particularly important in the Australian context, where water conservation is a critical component of sustainability planning. It is important to note, however, that some of the freshwater used in the production of raw materials—both for plastics and ductile iron—occurs outside of Australia. Both DN 100 and DN 300 plastic pipes demonstrate clear advantages over DICL in this category.

DN 100 PIPES:

- PE pipes 59.5 litres/metre
- PVC-M pipes 28.9 litres/metre
- PVC-O pipes 39.8 litres/metre
- DICL pipes 197 litres/metre

DN 300 PIPES:

- PE pipes 477 litres/metre
- PVC-M pipes 468 litres/metre
- PVC-O pipes 318 litres/metre
- DICL pipes 572 litres/metre

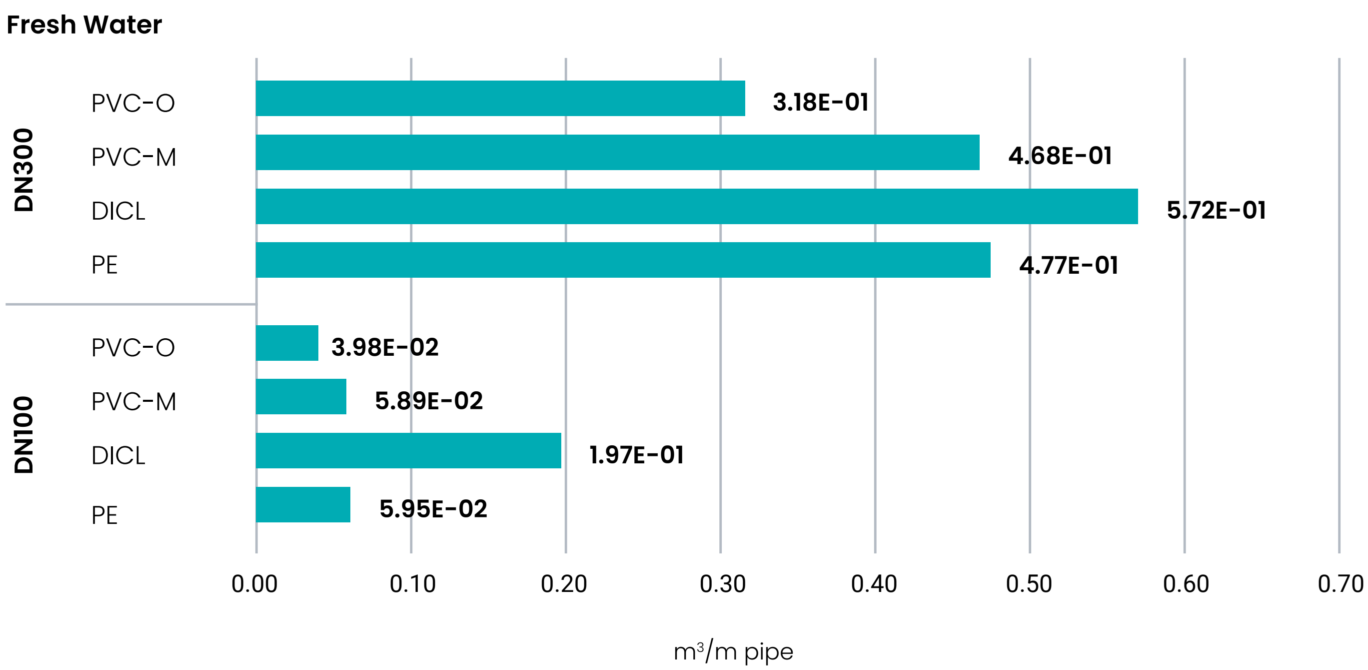

Figure 2: Use of net freshwater comparison of plastic pipes with DICL pipes

Plastic pipes use approximately 70-80% less freshwater compared to DICL at DN 100 and 17-44% less at DN 300.

LOWER RADIOACTIVE WASTE GENERATION

DICL pipes have significantly higher radioactive waste impacts compared to plastic pipes, primarily due to the use of nuclear energy in the production of ductile iron in regions like Europe, China, and India. This impact is less relevant in Australia, where nuclear energy is not used for electricity generation.

DN 100 PIPES:

- PE pipes 0.000195 kg/m
- PVC-M pipes 0.000184 kg/m
- PVC-O pipes 0.000128 kg/m
- DICL pipes 0.0178 kg/m

DN 300 PIPES:

- PE pipes 0.00156 kg/m
- PVC-M pipes 0.00146 kg/m
- PVC-O pipes 0.00102 kg/m
- DICL pipes 0.0603 kg/m

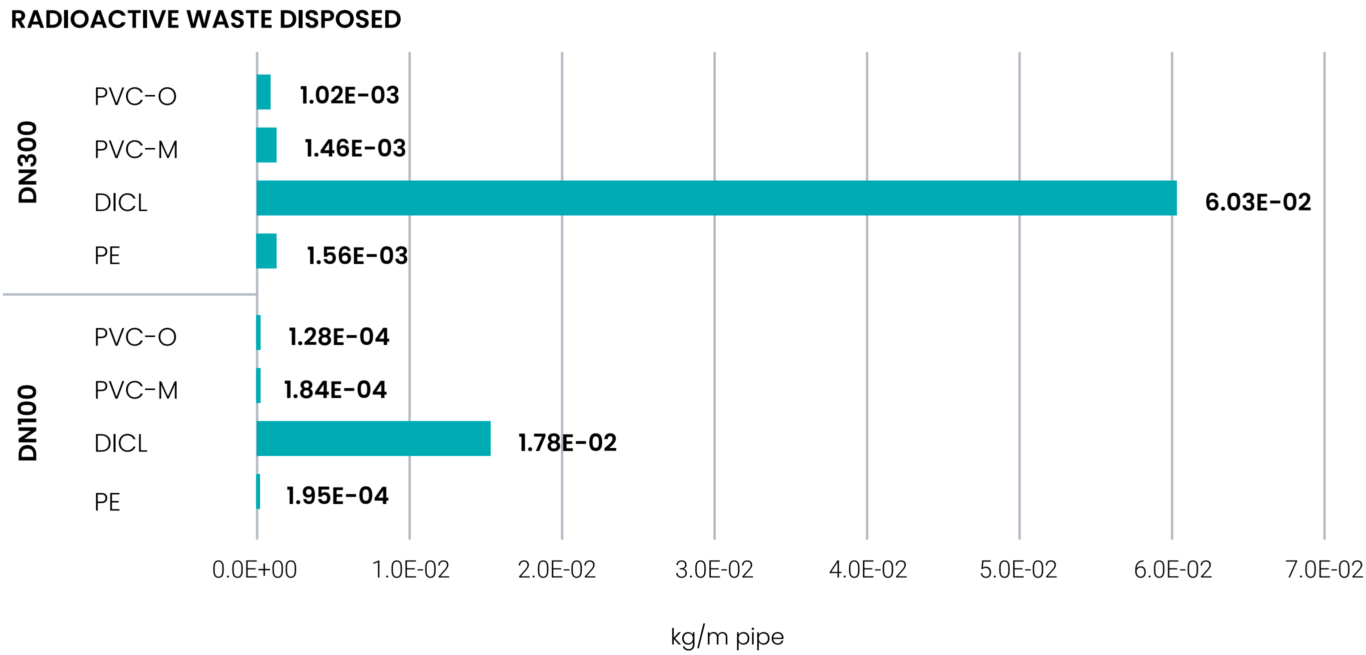

Figure 3: Radioactive waste disposed comparison of plastic pipes with DICL pipes

DICL pipes generate approximately 90 times more radioactive waste than plastic pipes at DN 100 and approximately 40 times more at DN 300.

TRANSPORTATION IMPACTS

Transportation impacts consider the environmental footprint of moving pipes from the manufacturing site to the construction site, which is influenced by weight, distance, and transport method.

Plastic pipes are significantly lighter than DICL pipes, which reduces emissions during transport.

DN 100 PIPES:

- PE: 4.18 kg/m
- PVC-M: 3.07 kg/m
- PVC-O: 2.04 kg/m

DN 300 PIPES:

- PE: 33.5 kg/m
- PVC-M: 24.4 kg/m
- PVC-O: 16.31 kg/m

DICL PIPES ARE SIGNIFICANTLY HEAVIER, INCREASING TRANSPORT-RELATED EMISSIONS.

- DN 100: 17.28 kg/m
- DN 300: 58.46 kg/m

This weight difference means DICL requires more fuel and results in higher emissions per kilometre.

Plastic pipes are typically produced locally in Australia, while DICL pipes are mostly imported from China and India. Although sea freight has lower emissions per tonne-kilometre than road transport, the long international shipping distance — combined with local road transport once in Australia — makes DICL's total transport impact much higher.

Measured greenhouse gas emissions for plastic pipes reflect this advantage.

PE DN 100 pipes generate just 0.164 kg CO_2-eq per metre for transport.

PE DN 300 generates 1.31 kg CO_2-eq per metre.

Although specific DICL transport emissions data for Australia is limited, the combination of their higher weight and longer shipping distances indicates a considerably larger carbon footprint.

While shipping is more efficient than road transport, the global transport chain for DICL pipes — international shipping plus Australian road delivery — creates higher overall emissions compared to the shorter, road-based delivery of local plastic pipes.

SUSTAINABILITY IN PRIORITY CATEGORIES

Plastic pipes outperform DICL pipes across the priority environmental impact categories assessed:

- DN 100, plastic pipes outperform DICL in 9 out of 13 categories, including acidification potential, freshwater and marine eutrophication, photochemical ozone creation, and waste disposal categories.
- DN 300, 5 environmental impact categories had similar outcomes for Plastic pipes and DICL. Plastic pipes however lead in 5 out of the remaining 8 environmental impact categories , showing particular strength in global warming potential, freshwater use, and photochemical ozone formation.

These results illustrate the strong alignment between plastic pipe systems and Australia's sustainability priorities.

UNDERSTANDING THE NUMBERS: INTERPRETING LIFE CYCLE ASSESSMENT RESULTS

When reviewing life cycle assessment (LCA) results, it's essential to understand the key assumptions and variables that shape the conclusions. Environmental comparisons between pipe materials — such as plastic pipes and ductile iron cement lined (DICL) pipes — depend on a consistent and transparent framework to ensure fair and meaningful insights for infrastructure decision-making.

FOUNDATIONAL ASSUMPTIONS

FUNCTIONAL EQUIVALENCY

The study ensures a fair comparison by normalising hydraulic performance across all pipe types. To achieve this, polyethylene (PE) pipes were evaluated using larger nominal diameters than DICL and PVC pipes, aligning the internal bore size and maintaining equivalent flow capacity. This adjustment ensures environmental comparisons reflect true performance parity rather than differences in physical dimensions.

DECLARED UNIT

All environmental impacts were calculated based on 1 metre of installed pipe with an assumed service life of 100 years — a figure aligned with typical infrastructure asset expectations. This standardised approach allows decision-makers to assess products without distortions caused by differing life expectancies or maintenance cycles.

MATERIAL COMPOSITION AND RECYCLED CONTENT

DICL pipes incorporate 40% recycled ductile iron, which lowers their environmental footprint compared to using virgin materials. Conversely, the plastic pipes assessed (PE, PVC-M, PVC-O) were manufactured from 100% virgin resin, as Australian standards for pressure pipe applications do not permit the use of recycled plastic. Despite this, plastic pipes generally outperformed DICL in key impact categories, highlighting the carbon and water efficiency advantages of polymer-based materials during production.

ENERGY SOURCE INFLUENCE

The geographic origin of production data also plays a significant role in LCA outcomes. For example, European Environmental Product Declarations (EPDs) for DICL reflect a higher reliance on nuclear-powered electricity, which impacts radioactive waste results. Plastic pipe resins also inherit some nuclear-related impacts via global electricity grids, but their lighter reliance on energy-intensive industrial processes typically results in a lower overall environmental burden.

IMPORTANT CONSIDERATIONS FOR COMPARING PIPE MATERIALS

When assessing environmental performance between different pipe products, it's important to account for several other factors that can influence LCA outcomes:

MATERIAL LONGEVITY AND RECYCLABILITY

Plastic pipes are engineered for long service lives, often exceeding 100 years. Due to this performance expectation and strict industry standards, recycled materials are generally not used in their production — a factor that can make pipes with higher recycled content, like DICL, appear more favourable in LCAs, even though plastic pipes often excel in other environmental impact categories.

SOURCE DATA VARIABILITY

LCA results can vary based on where and how the underlying data is sourced. For example, plastic resin data is frequently based on global averages, but the actual environmental footprint may differ significantly when sourced from specific local producers. A more accurate comparison arises when both products are evaluated using data from the actual manufacturing location.

PRODUCT SPECIFICATIONS

Direct comparisons between different materials and products can be challenging, as variations in composition, design, and manufacturing methods significantly affect outcomes. LCAs are highly sensitive to these specification differences, and it is essential to consider them when interpreting results.

ENERGY MIX AND REGIONAL VARIABILITY

The electricity mix used in resin production (e.g., fossil vs. nuclear vs. renewable sources) significantly affects LCA outcomes. As grid decarbonisation advances, especially in resin-manufacturing countries, the environmental performance of plastic pipes is likely to further improve.

VARYING STANDARDS AND METHODOLOGIES

Environmental assessments may follow different methodologies depending on regional or international standards. For example, European EN standards differ from the broader ISO framework, which can lead to inconsistent results when comparing products across geographies and manufacturers.

This structured and critical approach to LCA interpretation helps ensure that comparisons between pipe materials are not only transparent but also grounded in real-world relevance, providing confidence to decision-makers navigating infrastructure choices.

KEY CONSIDERATIONS WHEN COMPARING EPDS

1. DEFINE THE SCOPE AND BOUNDARIES CLEARLY

EPDs follow specific system boundaries. In this study, the assessment was limited to stages A1–A4: raw material extraction, manufacturing, and transport to site. Important life cycle phases such as installation, in-service use, maintenance, and end-of-life disposal were excluded, which may shift the overall environmental profile of a material when considered across its full lifecycle.

2. UNDERSTAND REGIONAL AND SUPPLY CHAIN DIFFERENCES

Geographic context significantly influences the environmental outcomes reported in an EPD. DICL EPDs used in this study were European, where nuclear energy is more common in the electricity grid, impacting categories like radioactive waste. Australian infrastructure projects also source products from Asia, where the energy mix differs again. Plastic pipes—while globally traded—also experience regional variations based on the energy sources and efficiency of resin production.

3. CONSIDER WEIGHTING AND RELEVANCE OF IMPACT CATEGORIES

Not all environmental categories are treated equally in certification schemes or regulatory frameworks. For example, Australia's Infrastructure Sustainability Council (ISC) assigns a significant **47.5% weighting to Global Warming Potential (GWP)** in their materials assessment process, while freshwater use and other categories may carry additional relevance depending on the project's geographic location and ecological context. Decision-making should prioritise categories most aligned with national and project-specific sustainability goals.

4. RECOGNISE DATA QUALITY AND UNCERTAINTY IN RESOURCE DEPLETION CATEGORIES

Impact categories like abiotic depletion of minerals and fossil resources have high uncertainty. The complexity of global supply chains and future resource extraction techniques makes these values harder to standardise or interpret in isolation. This underlines the need to weigh these categories thoughtfully against other, more predictable measures such as GWP and water use when making procurement choices.

CONCLUSION

While no single material is superior in every environmental category, plastic pipes present a strong case for sustainable infrastructure in Australia, particularly where reduced carbon emissions and water consumption are prioritised. This LCA study helps support informed choices in the transition toward environmentally responsible asset management and procurement.

For more information download the PIPA Infrastructure Pipe Comparison Report (2025).

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