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# New thinking is required for net-zero in the water industry

Marco van Winden, CPEng [1], Adriaan Window [2]

1: AECOM, Brisbane, QLD, Australia, marco.vanwinden@aecom.com

2: AECOM, Brisbane, QLD, Australia, adriaan.window@aecom.com

**ABSTRACT**

*The 2015 Paris Agreement aims to limit the rise in the global average surface temperature to 1.5°C to avoid the worst threats from climate change. The world had already warmed by 1°C by 2015. Exceeding 1.5°C risks feedback loops and tipping points in geophysical systems regulating the rate of climate change, making it even harder to adapt in time. It is critically important to humanity and the ecosystems upon which we depend that carbon emissions reductions are implemented rapidly. Many corporations and governments around the world have committed to net zero targets by 2050 or earlier. While corporations, governments and water utilities have a role, the infrastructure industry has a crucial role.*

*Water utilities carbon emissions can be characterised as follows:*

- *Operations: fleet vehicles, methane from sewage. Leading water utilities are already addressing these.*
- *Energy consumption: purchased electricity generated from fossil fuels. Many are already buying or generating renewable energy.*
- *Infrastructure works: purchased goods and materials, capital works, renewals.*

*Water utilities use concrete, steel and plastics in their capital works. But how many water utilities are specifying 'green' or 'low carbon' pipes? Besides the emissions resulting from energy used in manufacturing and transport of these materials; each tonne of steel releases 1.8 tonnes of carbon dioxide; and a tonne of cement releases a tonne of carbon dioxide direct to the atmosphere. While plastics in pipes release more carbon dioxide per tonne, their lower material densities mean plastic pipes have a smaller carbon footprint.*

*This paper challenges water utilities that are serious about net-zero commitments to consider emissions from infrastructure works, presents a case for using embodied carbon accounting as a basis for pipe material specifications whilst assuring design life and durability, and describes tools to support materials choices.*

## THE MOTIVATION FOR CHANGE

### Our Climate is Changing Rapidly

Our climate is already changing. If we don't change our practices – including in infrastructure – our planet will change rapidly from this point onwards. Climate Change is actually an emergency like no other. Global heating will cause drastic changes to our environment and ecosystems upon which humanity critically depends for its survival and economic activity.

The year 2020 was one of the three warmest years on record and the six years, 2015–2020, were the six warmest on record. (WMO, 2020). Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, according to the International Panel for Climate Change (IPCC, 2018). That report presents the science around the most ambitious goal of the Paris Agreement: to pursue efforts to limit the increase in global average surface temperature to below 1.5°C above pre-industrial levels. IPCC forecast that the global average surface temperature rise is likely to reach 1.5°C between 2030 and 2052 if carbon emissions are generated at the current rate. The 1°C threshold was reached in 2015. Without significant change, the 1.5°C threshold will be passed *early* in the 2030 to 2052 range, confirming accelerating warming.

The 2015 Paris Agreement's reference to 1.5°C is significant because it highlights the need to avoid the worst climate impacts and the reality that many countries will be severely affected by an increase in global temperatures (AIIF, 2016).

While most people equate global warming with sea level rise and increased frequency of fires and extreme weather, the consequences are actually far more significant:

- Drought will lead to desertification causing reduced crop yields and crop failures affecting billions of people. For every degree Celsius of global temperature rise, Zhao, et al (2017) projected a 10% loss of the United States' maize crop, 8% loss in China, and 5% in Brazil and India. With a growing population, the world can't sustain reducing food supplies. At least half a million people will die every year from malnutrition in a two-degree-warmer world because of climate change (Springman, et al., 2016).
- The increasing carbon dioxide concentration in the atmosphere will increase acidification of the oceans quicker than most ecosystems can evolve to acclimatise.
- Climate change is a stress multiplier – due to lack of food, water and forced migration there will be conflict in many parts of the world (UK MetOffice).

### Change will be Irreversible

Going past 1.5°C will risk feedback loops and a loss of control of the rate of climate change and make it even harder to adapt in time to save the planet. Feedback loops that have been observed or predicted include: Forest fires in North America deposit ash on Greenland ice darkening the ice and increasing melt rates; melting of Siberian tundra releases frozen methane; reduction in Arctic ice area means the darker ocean absorbs more of the Sun's energy; and warmer oceans increase the melt rate of Antarctic ice shelves – to name but a few.

Further, as a result of the relatively slow rate of melt of Greenland and Antarctic ice, sea level rise will occur relatively gradually but will be unstoppable if we allow the world to warm by 3°C. According to researchers, a sustained global warming of 3°C is enough to eliminate virtually the entire West Antarctic Ice Sheet, delivering five metres of sea level rise as a result. Their model results show that this scenario "causes almost complete collapse of the West Antarctic Ice Sheet within the next five hundred years' (Feldman, et al., 2015). This collapse happens within about 250 years in higher-emissions scenarios. The much larger East Antarctic Ice Sheet will also begin to decline, committing our descendants to continually rising oceans until at least the year 5000.

It is critically important to humanity and our descendants that carbon emissions reductions are implemented rapidly.

**Who can Help?**

Even though there is presently an absense of commitment to greenhouse gas reduction at a federal level in Australia, there is nevertheless a recognised responsibility on emitters of greenhouse gases to reduce emissions. Until recently, this was largely a moral obligation, undertaken by some so as not to contribute to the “tragedy of the commons”. Some governments and shareholders of corporations are making voluntary policy commitments to net-zero carbon. Recent legal cases are showing that there will be a legal and regulated requirement to reduce emissions. Examples include Sharma vs Minister for the Environment (May 2021), Shell ruling (May 2021), and Gloucester Resources Ltd decision (Feb 2019).

Creators of greenhouse gases include coal miners and users; and oil drillers and fuel users. In addition, some processes release greenhouse gasses directly, including the manufacturing of cement and steel. The making of cement and steel alone accounts for 10% of all global emissions (Gates, 2021). Both steel and concrete are key materials for infrastructure projects, including water conveyance infrastructure.

Steel is made using iron ore and carbon. To make steel, the oxygen needs to be separated from the iron in the iron ore, by adding a small quantity of carbon – from coal. This is accomplished by melting iron ore at 1,700°C in the presence of oxygen and coking coal. At those temperatures, the iron ore releases its oxygen, and the coke releases its carbon. Some of the carbon bonds with the iron, forming the steel, and the rest of the carbon binds with the oxygen, forming a lot of carbon dioxide. In fact, making 1 tonne of steel produces about 1.5 tonnes of carbon dioxide – much of it released during the coking process.

Cement is mixed with gravel, sand and water to make concrete. It is the cement that is a problem for the climate. Limestone contains calcium plus carbon and oxygen. Limestone is burnt in a furnace along with some other materials. After burning the limestone, the key outputs are calcium (for the cement) and carbon dioxide. There is no known way to avoid this key chemical reaction – limestone plus heat equals calcium oxide plus carbon dioxide. Further, it is one-to-one relationship – one tonne of cement causes the release of one tonne of carbon dioxide.

The manufacturing of a plastic, such as polyethylene, requires a significant energy input to melt, mix, de-gas and compress the raw resin to prepare it for extrusion into a useful form such as a pipe. The ‘melt’ is formed through a die into the desired shape and then cooled with refrigerated water sprays and through cooling tanks to finalise the pipe dimensions. Even though greenhouse gases are not released directly in any notable quantity, the energy used in the manufacturing process means that polyethylene pipes have a higher embodied carbon than steel, on a per-tonne basis.

Seventy-five percent of the infrastructure that will be in place in 2050 does not exist today (Egler, et al., 2016). Minimising the carbon emissions from such a scale of infrastructure development will impact whether or not the world locks into a high- or low-carbon growth path. All participants in the infrastructure sector have the opportunity to reduce global carbon emissions. As water utilities are a significant component of the infrastructure sector, they can make a contribution to the reduction in global carbon emissions with a considered selection of pipe materials. (‘Water utilities’ is used to represent water authorities, water corporations, local government water departments owners/operators of public water infrastructure.)

**What can water utilities do?**

As well as emitters of greenhouse gases, and policy makers, the market can also participate in reducing emissions. Green choices can initially be a little more expensive than the default choice. Generally, this is because coal, steel and oil industries are well-established, have been subsidised for decades and are not paying for the true environmental impacts they are causing. The higher cost one might need to pay for low-carbon materials is called a “Green Premium”. Not long ago, the cost of installing roof-top solar had a pay-back period such that only environmentally-motivated homes installed them – a Green Premium. However, in Australia, roof-top solar has a payback of 2-5 years and is projected to continue experiencing the fastest cost reductions of any source of energy technology (Graham, et al). The learning from this is that – in time – economies of scale supported by the right policy structures will reduce or zero-out Green Premiums.

When considering the water industry, the 'market' is comprised of the water utilities and their construction contractors. While the water sector is making reductions to carbon emissions from operations, it needs to also minimise the carbon emitted due to its capital works – especially given steel and cement amount to 10% of global emissions. Secondly, capital works materials choices that have a lower embodied carbon have an immediate benefit, while operational energy savings occur over many years. Both immediate and long-term gains are necessary. The way to achieve this is through materials choices.

Given the climate emergency, changes in the way pipe materials are selected need to be made as soon as possible. Now is the time to implement new approaches to pipe material selection.

## WHAT IS THE OPPORTUNITY?

### Water Utilities and Net Zero Goals

Water utilities use a lot of energy. In the state of Victoria, the water sector is the single largest contributor to the State Government's total carbon emissions, and Melbourne Water accounts for around half of the Victorian water sector's emissions (Melbourne Water – Our Path to Net Zero). But there is no published commitment to reduce the carbon footprint of their new or renewed capital assets.

How do other utilities compare? Several water utilities have a path to net zero carbon emissions. A review of the websites of several key water utilities is quite revealing, with only one – Watercare in Auckland, New Zealand – with a plan to reduce emissions resulting from infrastructure works (Watercare**Error! Reference source not found.**).

**Table 1. Water Utility Net-Zero Commitments**

| Water utility | Operational energy commitment | Infrastructure commitment |
|---|---|---|
| Sydney Water | Reduce carbon emissions to help meet NSW's aspirational objective of net-zero emissions by 2050 | Not defined explicitly |
| Melbourne Water | Halve emissions by 2025; reduce to net zero by 2030 | Not defined explicitly |
| Urban Utilities, SEQ | Not defined explicitly | Not defined explicitly |
| SA Water | Not defined explicitly | Not defined explicitly |
| Water Corporation, WA | Becoming a zero net greenhouse gas emission utility by 2050 | Not defined explicitly |
| TASWater | Not defined explicitly | Not defined explicitly |
| Watercare, NZ | Net zero by 2050 | 40% reduction in infrastructure emissions by 2025 |

(Source: Utility web sites

Legend: bold commitment moderate commitment no commitment defined )

South East Queensland's SEQ Code Design Criteria (SEQ Water Service Providers, 2020) requires that "all designs shall include estimation of the carbon footprint of each of the proposed options in a format agreed with by the relevant [water service provider]", but provides no further guidance, expectations or reduction targets. The WSAA Water Supply Code does not recommend or require consideration of carbon footprint for assets or materials.

**Examples of Annual Capital Works**

In Australia there is over 260,000 km of water and sewerage pipes – enough to go around the earth more than six times (WSAA CRC). And developers are continuously adding new pipes to the asset class, with no obligation to consider embodied carbon in their material choices. With a high proportion of water and sewer pipes in Australian cities and towns approaching the end of their life, many of these pipes will need to be renewed or replaced in the 29 year period over which utilities have committed to net-zero emissions by 2050.

Sydney Water has a connected population of 5,300,000 people (Sydney Water, 2021) and will renew 164 km of water mains and 46 km of sewer mains in the period 2021 to 2024 (IPART, 2020). Extrapolating these renewals plans across the major cities of Australia, in the order of 1,465 km of water and sewer pipe renewals in the 5 years to 2021 to 2024 can be expected, or 293 km per year. This excludes new assets – typically by developers - but includes lining and related renewals, which also warrant an embodied carbon approach to material selection.

**Table 2. Extrapolated Watermain and Sewer Renewals for Australia**

| Greater Capital City | 2020 Population* | Estimated water and sewer renewals (km) (2021 - 2024) |
|---|---|---|
| Sydney | 5,367,206 | 452 |
| Melbourne | 5,159,211 | 434 |
| Brisbane | 2,560,720 | 216 |
| Adelaide | 1,376,601 | 116 |
| Perth | 2,125,114 | 179 |
| Hobart | 238,834 | 20 |
| Darwin | 147,231 | 12 |
| Canberra | 431,380 | 36 |
| **Total capital cities** | **17,406,297** | **1,465** |

* Source: Australian Bureau of Statistics, Regional population 2019-20 financial year
** Pro-rated from Sydney Water's planned renewals

With 10,000 new houses per year being approved in Australia (ABS), one could assume 75% are in new developments and will be connected to new water and sewer services, adding about 150 km of new water and sewer pipes annually – all warranting a carbon-conscious materials choice.

The opportunity to reduce carbon with pipe materials choices therefore applies to almost 450 km of pipe per year.

**Works Opportunities**

Using responsive and responsible design approaches, infrastructrue can be implemented for greater liveability and the protection of our world.

The building industry has been computing the embodied carbon used in building materials for some years. Water sector capital works where there is a potential for reduction in embodied carbon include:

- Concrete works – reservoirs, tunnels, structures at treatment plants, access chambers, thrust blocks, gravity sewers
- Steel – pipes, reinforcing steel, buildings, screens, etc.
- Polyethylene – pressure pipes and gravity sewers
- PVC - pressure pipes and gravity sewers

This paper focuses on pipes - both pressure pipes and gravity sewers.

In particular, this paper focuses on the "cradle to gate" phase of pipe materials, which has the greatest opportunity for reduction in the embodied carbon per kilometre of installed pipeline. "Cradle to gate" includes raw material supply, transport and manufacturing of the pipe product, also referred to as A1, A2 and A3.

While end-of-life carbon emissions or reductions should be considered for specific projects, this assessment has not included end-of-life emissions because:

- There are multiple potential outcomes for a pipe once it is no longer serviceable, including renewal, repurposing, exhumation to waste, exhumation to reuse, exhumation to recycling, leave-in-place, and leave-in-place and grout-fill. These options have very different greenhouse gas outcomes, and generally can't be predicted at the design stage.
- Most water infrastructure is installed for a design life of 100 years. There is a reasonable expectation that everything that humans will do (in net terms) 100 years from now should be carbon neutral, including grout-filling of abandoned pipes, for example. Further, in 100 years' time the infrastrcuture sector should have efficient processes for recycling materials that no longer serve a function. If one was not certain of that outcome, one could apply a discount rate to carbon impacts in the future due to that uncertainty, which nevertheless weights the influence to the A1 - A3 phases as being the determinant considerations.

**Embodied Carbon in Materials**

Materials commonly used in sewer or pressure pipes include concrete, steel, ductile iron, glass-reinforced plastic (GRP), polyethylene, polypropylene (PP) and poly-vinyl chloride (PVC), each in various forms. Some are also in combination, such as mild-steel cement lined (MSCL) pipes which are lined with cement mortar and generally coated in fully bonded polyethylene (FBPE).

The life cycle of pipe materials – like any materials – are divided into three process modules according to the Australasian Environmental Product Declaration (EPD) Programme (EPD Australia) and four information modules according to ISO 21930 and EN 15804. The scope of EPD considered in this paper is "cradle to gate" as defined by EN 15804. "Cradle to gate" is the product stage of the pipe material, including the carbon emissions caused by raw material supply, transport to the factory and manufacturing ready for delivery. However, this paper also gives consideration to transport to the site and installation methods, where they differ for different materials choices.

The materials available for pipes vary in their density and strength properties. Figure 1 considers a nominal 600 mm pressure pipe rated to 16 bar (except that while a concrete pressure pipe is used here, it is not rated to 16 bar). For a given conveyance capacity and pressure class, wall thickness can also vary significantly for different materials, and therefore, the mass per metre of pipe can be even more variable. The embodied carbon in each of the materials in the chart ranges from 0.26 to 3.7 tonnes $CO_2$-equivalent per tonne ($tCO_2eq/t$) of material. Figure 1 shows that from an embodied carbon perspective, GRP, PVC and reinforced concrete pipes have the least impact on global warming – i.e. they have both low embodied carbon and have efficient materials strength and density properties – for this type of pipeline.

Figure 1 shows that even though the concrete pipe option has the greatest mass per metre, the relatively small cement and steel fraction in the reinforced concrete means that its embodied carbon per metre of pipe is one of the lowest. The very high material density of steel and ductile iron means that their carbon footprints for this solution are quite high. The high embodied carbon of the polyethylene pipe option is caused by the high reference carbon value and significant wall thickness, making it the least preferred from a greenhouse gas emissions perspective.

Other emissions associated with pipelines include:

- Transport from manufacturer to site – this is typically 1 to 20% of the total embodied carbon. The higher ranges occur for heavy steel or ductile iron pipe manufactures in China or India, for example.
- Thrust blocks - fully restrained solutions (PE and MSCL if fully welded) allow a reduction in the number of thrust blocks required, reducing the concrete used. This can make a ~5% difference in total embodied carbon.
- Embedment material and backfill – aggregate and sand typically have 0.0150 and 0.0057 $tCO_2eq/t$ respectively (AusLCI) and are usually transported over shorter distances than the pipe material, so any difference in embedment material types, dimensions or backfill is usually negligible.

By far the biggest contributor to greenhouse gas emissions in a sewer or pressure pipe project is the pipe material itself.

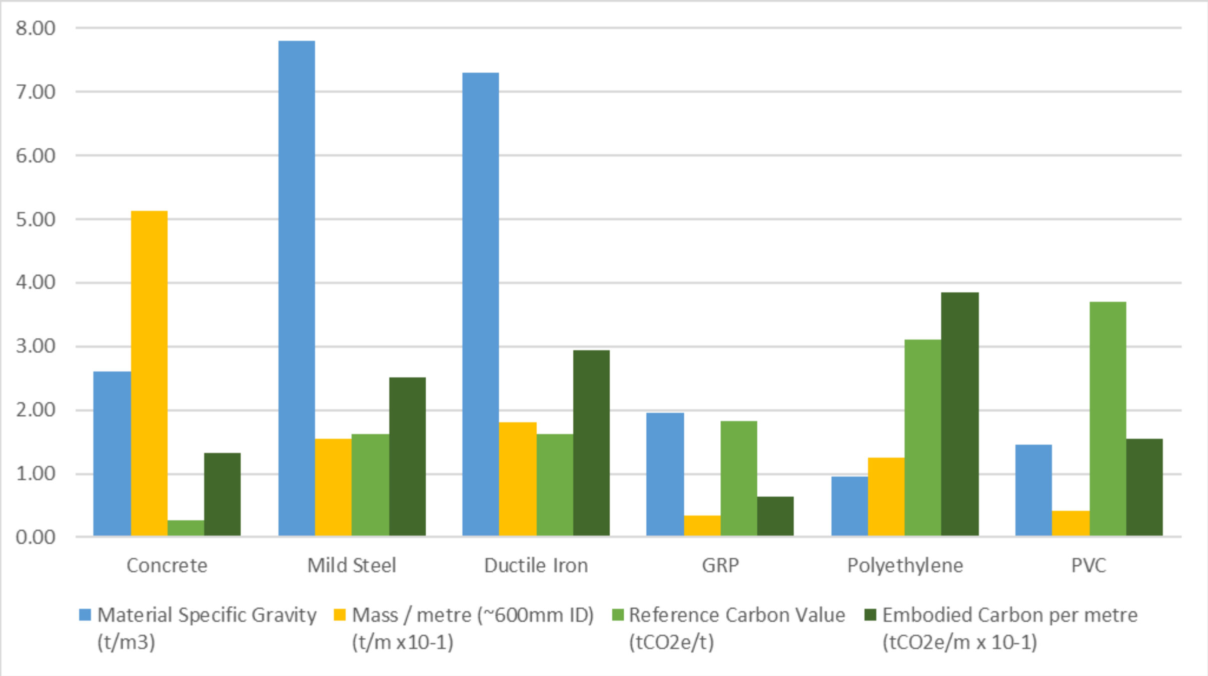


**Figure 1. Pipe Material Properties.**
(Concrete pipes would not have the same pressure rating as the other options shown here)

## PIPELINE MATERIAL SELECTION

### Current Practice in Material Selection

Traditionally, the selection of the pipe material for pressure pipelines considers (a) the required size (controlled by the design flow), (b) pressure criteria, (c) materials (for constructability, durability) and (d) cost. Similarly, the selection of the pipe material for gravity sewers considers (a) the required size (controlled by the design flow), (b) depth and external loads on the pipe, (c) materials (for durability) and (d) cost. The durability requirement is generally for a 100-year design life.

For operational reasons, including asset management, durability and maintenance consistency, most water utilities publish approved materials lists. Examples are South East Queensland's SEQ Code IPAMS list and Melbourne's MRWA Approved Products and Industry Standards.

Understandably, under the current process, for a given flow and pressure or load situation, materials are traditionally selected considering constuctability with an emphasis on cost.

### New Practice in Material Selection

This paper poses a further consideration. It does not propose new materials, as the water industry is necessarily conservative in its need for durable proven solutions. *This paper proposes that – for a given size and pressure/load situation - approved pipe materials with a lower embodied carbon should be given greater consideration than they otherwise would be*.

A Green Premium may need to be paid initially, but in time – as for roof-top solar systems and electric vehicles – this Green Premium will likely reduce, and the material may even become more cost-effective through economies of scale and purchasing power.

With the right signals to the market, there will be innovation in pipe materials sciences and in the energy profile of the pipe manufacturing plants. In time, new, greener products will come to the market, and be tested and approved. There are many examples of these new products, including zero cement concrete used for sewer pipes that surpasses minimum strength requirements and is more durable in aggressive acid environments than concrete pipes made with Portland cement (Roychand, et al., 2020). Ultimately, once approved by water utilities, these new products will succeed the present lower-carbon choices, providing yet more options.

For immediate carbon emissions reductions, an new pipe material decision-making process is required.

### Embodied Carbon Calculation Tool

AECOM has developed an embodied carbon calculation tool for pipe design. Once the 'duty' of the pipe has been determined (i.e. flow, pressure/load, durability constraints), the tool allows the user to consider multiple pipe materials, incremental size steps and multiple manufacturing locations so that two key parameters can be compared:

1. The embodied carbon of each pipe material choice, including:
    a. Raw materials extraction/production, transport and subsequent manufacturing
    b. Transport to the construction site
    c. Concrete in thrust restraints
2. The differences in energy consumed as a result of different internal diameters and friction factors (applicable to pressure pipes in pumped systems), considering:
    a. Pump system energy efficiency
    b. Proportion of green energy used in the local grid

The case studies presented in this paper show that some material choices can have a third of the carbon footprint of other equally acceptable materials. Further, by careful selection of pipe size (internal diameter), the low-carbon option can have either no increased operational energy or lower lifetime operational energy.

## CASE STUDIES

### Case Study 1 - Trunk Water Main

A recent project just north of Brisbane included the design of a 6 km long section of DN710 PE SDR11 PN16 pressure pipe (a high density PE pipe with outside diameter of 710mm and a pressure rating of 16 bar). Alternative materials choices are considered and findings in relation to the carbon footprint of the material choices are provided as follows.

***Materials Considered***

The materials considered in this case study include: polyethylene pipe manufactured in Brisbane; ductile iron cement-lined (DICL) pipe with polyethylene sleeve manufactured in China; mild-steel cement-lined (MSCL) pipe with fusion-bonded PE (FBPE) coating from Melbourne; and glass-reinforced plastic (GRP) from Adelaide. These materials are all commonly considered for a pressure pipeline of this size and pressure.

### *Findings*

This assessment found that transport of materials from the manufacturing facility has a relatively small impact of maximum 10%. Similarly, the additional thrust block concrete required for pipe material choices that cannot be welded and fully restrained is also relatively insignificant (Figure 2).

In these pressure ranges, the carbon footprint of a GRP material choice is more than three times *smaller* than that of the default or typical choice of PE (Figure 2). This is a saving of over 250 tonnes of $CO_2$eq per kilometre of trunk main. Further, because the assessed GRP has a larger internal diameter and lower roughness, Figure 3 shows that the annual operational carbon emissions is lowest for the GRP option. Figure 3 also confirms that the Green Premium for GRP is very small over the default material choice of PE.

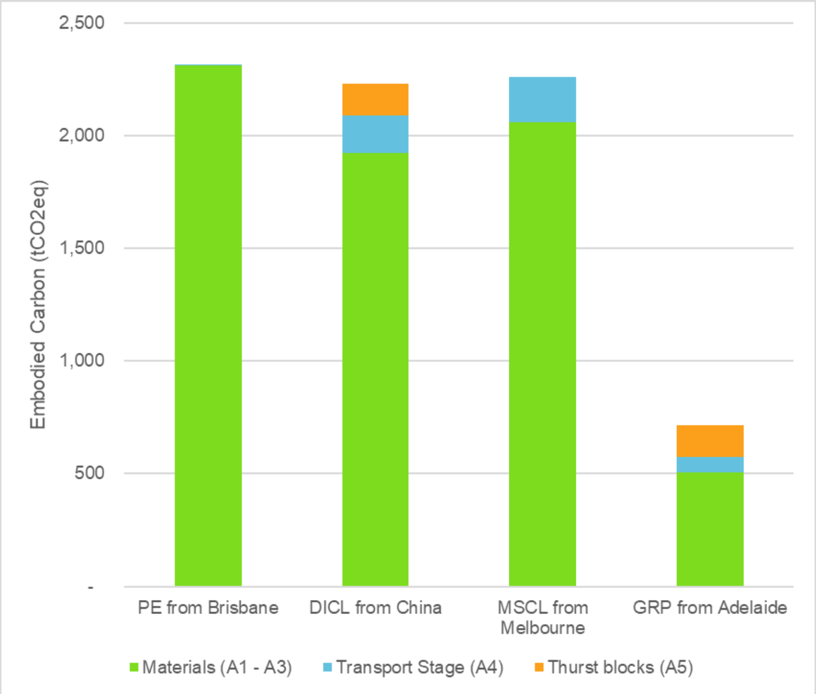


**Figure 2. Case Study 1 – Embodied Carbon.**

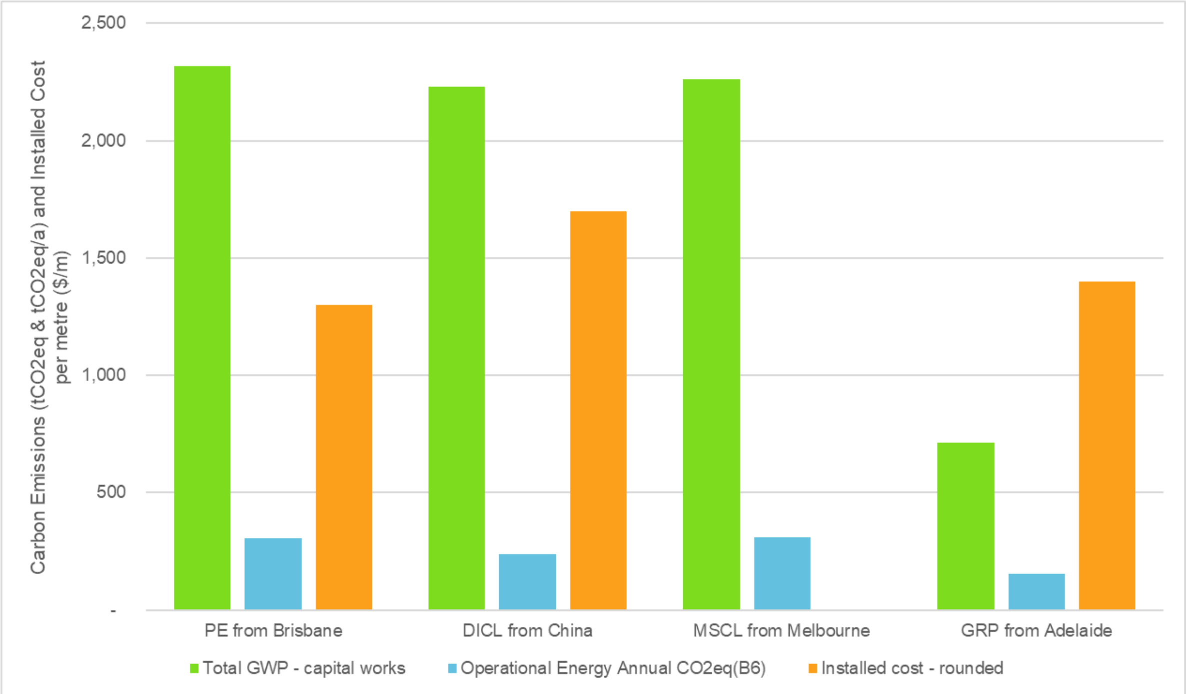


**Figure 3. Case Study 1 – Capital and Operational Embodied Carbon.**
(Installed cost is not available for MSCL)

*Embodied Carbon Decision-Making to save the Planet*

The tool demonstrates that the GRP choice will have the least impact on global warming for the installed works. The cost of installation is no more than 10% greater than the default material choice of PE. This is a small Green Premium to pay for protection of our planet.

**Case Study 2 - Sewer Main**

A 1 km long section of DN300 sewer to be constructed at the Gold Coast was assessed. Alternative material choices are considered and findings in relation to the carbon footprint of the material choices are provided as follows.

*Materials that can be Considered*

The materials considered in this case study include: PVC-U drain waste and vent pipe; Polypropylene (PP); PVC-U pressure pipe; ductile iron cement-lined (DICL) and coated pipe; reinforced concrete pipe (RCP) and polyethylene (PE). In this case, the DI pipe is manufactured in China. These materials are all commonly considered for a gravity sewer of this size.

*Findings*

This assessment shows that transport of relatively heavy materials options from as far as China does not have a significant impact overall (Figure 4).

For this service type, the carbon footprint of the RCP and PP material choices are almost half that of the next lowest material choice – PE – and less than half that of the typical material choices – PVC-U DWV or PVC-U pressure pipe (Figure 4). Therefore, RCP and PP materials offer a saving of over 30 tonnes of $CO_2$eq per kilometre of sewer.

*Embodied Carbon Decision-Making to save the Planet*

The tool demonstrates that for gravity sewers, PP and RCP are by far the best means of minimising global warming, as long as the durability requirements can be met for the application. Due to the corrosive environment of sewerage systems, RCP may not always be appropriate. In such circumstances, PP is the preferred material from an embodied carbon perspective.

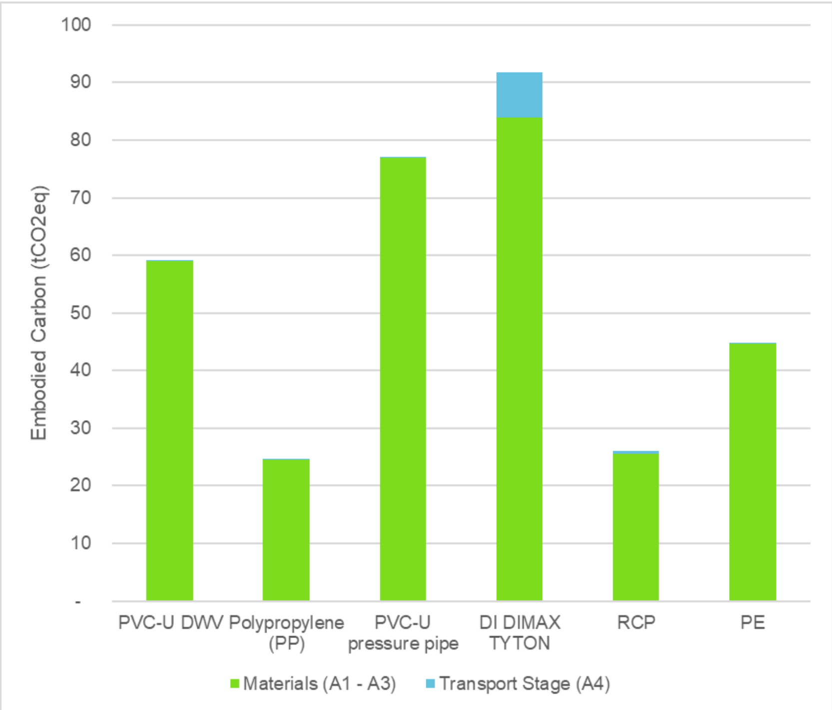


**Figure 4. Case Study 2 – Embodied Carbon.**
(DN300 gravity sewer)

## DISCUSSION

Like all indistries, the water infrastructure sector must do everything it can to reduce carbon emissions to the atmosphere. It follows that there is a responsibility to find opportunities to do so. Greenhouse gases are not only emitted with operations energy – they are also released in the manufacture and supply of materials for capital works.

With about 450 km of pipe being installed per year in municipal water and sewer works, if 10% of this is trunk or large-diameter pipe at a saving of 250 tonnes of $CO_2$eq per kilometre, this equates to a carbon reduction of 11,250 tonnes of $CO_2$eq per annum just for trunk mains. For the smaller pipes, a reduction of 30 tonnes of $CO_2$eq per kilometre would amount to an additional 12,150 tonnes of $CO_2$eq per annum.

The utilities that have made a commitment to reducing the emissions from their operational activities generally acknowledge that they can't avoid 100% of those emissions. Some intend to offset their remaining emissions by paying for carbon emissions reductions away from their asset base. This paper shows that it may be more cost-effective to make smart choices in pipe material specification and selection, while still maintaining serviceability and durability standards.

While this paper has focused on pipes, similar opportunities exist in consideration of materials used in facilities including dams, tanks, treatment plants, pump stations, etc.

## CONCLUSION

This paper has found that:

- Within the range of pipe materials that a water utility has already approved, the greenhouse warming potential resulting from material selection can be *up to three times less than* the default choice for a given pipe project.
- There are significant carbon emissions reductions that result from:
    a) Choosing a pipe material that has a lower embodied carbon; and
    b) Selecting a low-carbon material that also allows a greater hydraulic efficiency.
- When applied nationally, carbon-conscious pipe material selection alone could reduce the water sector's carbon footprint by over 23,400 tonnes per annum, without any significant increase in capital costs, and using already-approved materials.
- The reduction in emissions resulting from this approach will support the achievement of water utilities' net-zero carbon targets.

## RECOMMENDATIONS

It is recommended that water utilities:

- Include a requirement for their approved pipe manufacturers to undertake an Environmental Product Declaration (EPD) to report the greenhouse-gas warming potential of their pipe products. Many pipe suppliers have already done this including Iplex, Vinidex and Humes.
- Require that specifiers and designers of pipes consider the selection of the pipe material that has the lowest embodied carbon, while still meeting the water utility's operations and durability needs.

These changes should be implemented in the Codes to empower the water utilities to apply this approach. Initially, the WSAA Water and Sewer Codes could be updated to encourage a preference for low-carbon materials, and then regional codes such as the MWRA and SEQ Code Design Criteria should adopt the same approach. The sooner these measures are implemented, the sooner the water infrastructure sector can maximise its contribution to the reduction of carbon emissions.

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Marco is a talented Technical Director within the Civil and Infrastructure team at AECOM and has an extensive background leading significant engineering projects, critical planning studies and multi-disciplinary project teams. Marco leads planning and engineering design teams for public infrastructure projects, including water pipelines, treatment systems and transportation projects. His 28 years of professional experience has predominantly been in Australia and New Zealand, with projects in the Pacific Islands, Singapore, Papua New Guinea and China. Marco is also a Dad and a believer in the anthropogenic change that this planet has experienced since the advent of the industrial age.