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WHITEPAPER

Emission reduction in the construction industry: Benefits and opportunities

Assessing the challenges and opportunities presented to the construction industry by the transition to net zero and changing customer sentiment

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Introduction

In 2022, Australia committed to reducing emissions by 43% by 2040 (compared to emissions in 2005). The Climate Change Act 2022 also included a commitment to reach net zero emissions by 2050, and included a strong focus on investing in technology.

While the act does not impose any obligations on companies, it is expected to spark new policies and changes across all industries, including construction.

Australia's construction industry currently has work to do to reach net zero by 2050 and be in line with global trends for decarbonisation. To stay competitive in the global arena, answer the changing demands of customers, and keep up with Australian climate commitments, the industry must adapt its practices. It must also contribute to the reduction of greenhouse gas emissions, which can be a very costly and painful process.

On the other hand, proactively introducing more energy-efficient construction practices; introducing Environmental, Social, and Governance (ESG) commitments into business development; and prioritising emissions reduction in business operations could create a competitive advantage, improve bottom line, and deliver other long-term benefits.

In this whitepaper, we will assess the challenges and opportunities presented to the construction industry by the transition to net zero and changing customer sentiment.

We will also consider how the industry can adapt to reduce greenhouse gas emissions, embrace better and cleaner energy solutions, and make decisions that will benefit both business and the environment.

Background

The construction industry is facing a range of challenges, including skill shortages, disruption of supply chains, and rising costs. Some of the challenges are caused or exacerbated by the changing climate, for example, the rising price of timber (Nicholson M, 2021).

Climate change dictates where to build, with larger areas of land prone to floods, erosion, and fires. It also dictates how to build, since governments have responded to climate change with stricter building codes and regulations, which in turn affect construction costs.

The high energy consumption involved in many construction processes, coupled with growing energy and fuel prices, puts further pressure on builders. Finally, changing government regulations add a degree of uncertainty to business development.

Reducing emissions during the process of construction should be treated not as one of the challenges the industry is facing, but as an opportunity for growth and resilience. In fact, reducing emissions can even mitigate many other construction challenges. Doing so can bring economic, organisational, and environmental benefits, giving organisations a competitive edge and enhancing their reputation.

Emissions in the construction industry

Construction contributes considerably to global emissions throughout the building life cycle. This includes embodied carbon, which is comprised of carbon produced during the manufacturing of materials, the construction process and demolition, plus usage of the facilities once they have been constructed (i.e., building operations).

Australia is one of the greatest emitters of greenhouse gases per capita in the world, with the construction sector contributing up to 18.1% of the Australian carbon footprint. This includes both direct (owned and controlled by the reporting entity) and indirect emissions.

Electricity, gas and water, materials, and actual construction activities are the top contributors to construction's carbon footprint (Yu M. et al, 2017). Roughly 5.5% of these emissions originate from powering machinery and equipment during the construction process.

Construction's carbon emissions are projected to double by 2050 if the sector does not change the way it operates.

However, deploying projects focusing on sustainability and ratings could help the industry both reduce carbon emissions and reduce costs (Tabet T, 2021).

To mitigate construction industry emissions, it is proposed (Yu M. et al, 2017) that the sector should increase its usage of renewable energy, enhance equipment maintenance, optimise operations, and reduce the amount of carbon-intensive materials used.

A number of binding policies and recommendations have been introduced in Australia to reduce emissions in the construction industry. Thus, in 2022, the National Construction Code introduced changes related to residential properties' thermal performance and energy usage, setting the minimum level of thermal performance to 7 stars under NatHERS (the Nationwide House Energy Rating Scheme). Changes to commercial energy efficiency provisions now require certain buildings to have features which facilitate the future installation of on-site renewables and EV charging (National Construction Code, 2022).

While currently there are no nationwide carbon regulations in the construction industry, it is clear that decarbonisation is not possible without them. We can expect the Australian government to introduce changes that will support its long-term emissions reduction plan.

The Australian Sustainable Built Environment Council (ASBEC) states that **the building sector can reach zero carbon emissions by 2050 by using technologies available today, delivering substantial savings in energy** (Toumbourou S, 2019). Until further regulations are introduced, it is up to the industry to proactively use these technologies to reduce emissions.

Energy consumption in the construction industry

As well as contributing to greenhouse gas emissions, the construction sector consumes large amounts of energy. A recent study estimates that **"the buildings and construction sector accounts for about 36% of the global energy consumption. Accounting the energy spent for construction and demolition, the energy share is increasing up to 50% of the total energy consumption"** (Santamourisa, M, Vasilakopouloub, K, 2021).

Construction operations use a considerable amount of power for operating machinery and equipment, and also burn substantial amounts of fossil fuels. This is costly both for the bottom line and for the environment.

According to the Department of Climate Change, Energy, the Environment and Water, in Australia, "Energy used directly in the construction sector includes large volumes of diesel for machinery as well as electricity for powering buildings and tools, presenting many opportunities to save on energy" (Australian Government, n.d.).

It is worth mentioning that the share of renewables in electricity generation for construction has been on the rise in recent years and is expected to increase further as a result of current and planned renewable generation projects. On the other hand, unfortunately there is a very limited availability of electric construction equipment and machinery in Australia (Austin A, 2022), which means diesel engines will be around for a while.

In the short term we have been witnessing volatility of diesel prices due to macroeconomic factors, from the global pandemic to the war in Ukraine, which contributes to the costs of construction. But one of the questions for the longer term is: **"What is the future of diesel fuel?"** We need to be aware that fossil fuel usage will gradually be phased out, and we must be prepared for this shift.

Yet, even with diesel engines, alternative fuel options are still available, varying from renewable diesel to biodiesel and green hydrogen. In Australia there are currently no policies accelerating the adoption of renewable diesel, and availability of alternative fuels is low. The only option currently available is importing renewable diesel from overseas, but this situation is expected to change, as two renewable diesel refineries will be in production by 2025 (Austin A, 2022).

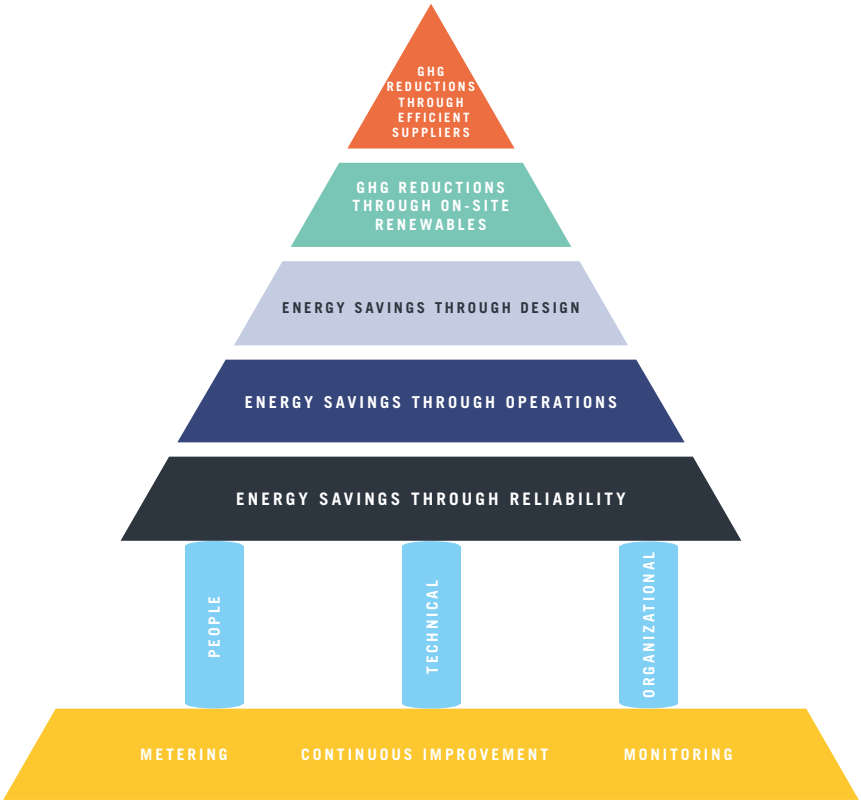
Green hydrogen may be a potential future energy resource, and the green hydrogen industry currently enjoys attention from the government in terms of legislation and investment in production facilities and research. Yet there are some barriers to the fast uptake of green hydrogen, including production costs, logistics, and safety considerations (Eljack F, Kazi M, 2021).

In the short term, while alternative fuels and electrified construction vehicles are not widely available in Australia, the industry should also be looking at other ways to reduce fuel usage. This could include increasing the efficiency of operations and using the most recent technologies.

Practical steps to reduce emissions through the construction life cycle

In this paper, we will concentrate on the actual construction process, highlighting ways to reduce emissions in the short and long term while keeping in mind that the construction process can influence not only emissions during actual construction, but also emissions during building usage and demolition.

We'll be using the energy pyramid (Connor M, 2018) to analyse practical approaches to reducing CO_2 emissions through energy savings across the whole construction process. Reducing energy consumption will in turn reduce construction costs, improving the bottom line.



As you can see, the base of the pyramid relies on continuous improvement as well as energy metering and monitoring to ensure the change is measured. Energy savings can be achieved on multiple levels, from operations and increasing reliability to incorporating on-site renewables and working with efficient suppliers.

A similar approach is proposed by KPMG (2021). Their strategic energy management approach enables organisations to adopt a culture of energy efficiency in order to reduce energy consumption and costs. This starts with the optimisation of current operations and existing assets, followed by installation of energy-efficient equipment, and finally, switching to renewables wherever possible.

They demonstrate that a strategic energy management approach can bring fast and considerable benefits in energy-intensive industries, even with no-cost or low-cost changes.

We will be looking at practical examples of this approach, starting with process improvements, which include taking measures to improve energy efficiency, modifying power equipment setup, switching to renewable energy sources, and embracing new technologies and innovations.

Energy efficiency

The starting point for improving energy efficiency is data monitoring, which provides construction companies with criteria for energy usage assessment and optimisation. Once this data has been collected, it is easier to identify the most readily achievable improvements in energy optimisation, such as equipment right-sizing or behavioural changes like reducing idling.

Let's look at all of the energy efficiency measures available to construction companies in detail.

1. Monitoring data on the fuel usage of construction equipment

Constant fuel usage monitoring, which can be performed on site or remotely, brings a range of benefits, leading to reduced fuel usage and emissions.

These benefits include:

- Energy optimisation: Remote monitoring can identify if equipment is being used inefficiently. For example, if a generator is running at a higher or lower load than is ideal, remote monitoring could guide the users to adjust the generator sizing or change the number of generators on site to improve equipment efficiency.
- Improved equipment maintenance for optimised performance, reduced inefficiencies, and reduced energy waste: Remote monitoring can help construction site managers to control the performance of equipment such as generators in real time.
- Environmental benefits: By reducing energy waste and optimising energy consumption, remote monitoring can assist in reducing greenhouse gas emissions and other pollutants associated with energy production.
- Cost savings: Improved maintenance can help reduce downtime and repair costs, while optimising energy consumption can help to reduce fuel costs.

2. Right-sizing equipment

Getting the right size of equipment for a project helps reduce inefficiencies. But, as there are many factors to consider, finding the perfect solution may not be a straightforward process. The best place to start is with high energy-consuming construction activities, such as using diesel fuel for tower cranes and concrete/mortar operations (Biswas W, 2014). Reducing fuel usage for these operations could bring substantial cost and CO_2 savings. This is possible with the right-sizing equipment approach.

Let's look at right-sizing generators. There could be several reasons that oversized generators are used in construction: for example, to accommodate motor starts, pump starts, and in general start-up currents; when the actual load or start-up is not known; or because a safety net or error tolerance has been added to cover for any unknowns.

As a result, the builder would face higher ownership, rental, and transport costs, as well as increased fuel usage and noise levels.

It is not uncommon for equipment to run at less than 30% load, meaning it is inefficient. Ideally the equipment should be running at 80% load regularly. This arrangement can offer significant savings in fuel, carbon, and local emissions. To achieve these results, we suggest implementing the following solutions:

- Load on demand – to deal with variable loads
- Flywheel technology – to help cope with start-up currents
- Battery hybrid technology – to minimise the runtime of the generator and to cope with start-up currents, or as a spinning reserve

Load on demand

Load-on-demand power solutions replace a large, constantly operating generator with a group of smaller generators that can power up or down automatically according to demand on site. For instance, if a site requires a total peak output of 1,500 kVA, it is possible to use three smaller 500 kVA generators together to achieve this output when the site is operating at full capacity. When the demand for power fluctuates and falls to less than 500 kVA, two of the generators can power down.

In this way, construction sites employing load-on-demand power systems can save money, since fuel is no longer wasted through having a large generator constantly operating at full capacity.

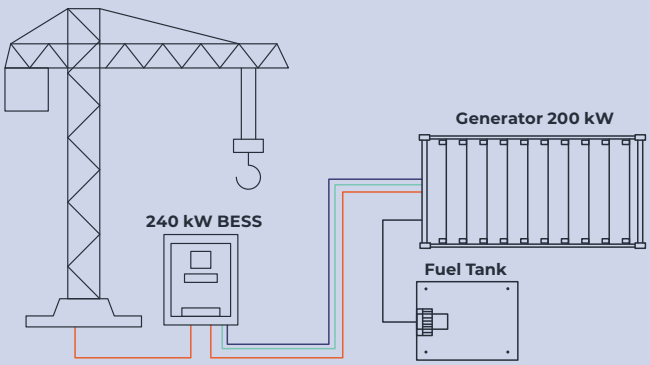
This option also provides redundancy, which can help to avoid downtime and ensure that the construction site remains operational. On top of this, reducing the number of generators in operation during quieter periods means a reduction in harmful emissions and noise pollution.

Flywheel technology

Generator sets are typically sized for peak loads, however, most of the time they run at low load factors. Connecting flywheel technology to a smaller generator set levels the peak loads that the generator has to deal with. The flywheel system delivers high-power energy during an increasing load step, and captures excess energy during a decreasing load step.

Smart battery hybrid system

This involves coupling battery storage with a smaller generator. Similar to flywheel technology, the battery output will combine with the generator output in order to cope with peak loads. The hybrid will then switch off, leaving the generator running at a more efficient load (around 80%). A smart battery hybrid solution can manage the system's power output entirely. Because it can run solely on the battery at very low loads, it allows users to switch the generator off completely, which provides additional fuel, carbon, and local emissions savings.



In addition to right-sizing equipment, there are a number of other steps that builders can take to promote energy efficiency on construction sites. Builders can optimise the layout of the site, for instance, by minimising the distance that cranes need to travel or reducing the need to lift materials over long distances. They can also use cranes with regenerative braking systems, which can help to capture and reuse energy that is generated during the lifting process.

3. Reducing idling

Idling machinery consumes fuel without any productive output. This can lead to significant fuel waste and increased operating costs.

By introducing a range of policies and small technological and process changes, it is possible to considerably reduce idling. For example, the following measures can be implemented:

- Behavioural changes, such as training operators to reduce idling, which could mean turning off the engine under certain conditions
- Adopting efficient loading policies for earthmoving equipment, such as double-sided loading (Mustaffa N, 2018)
- Using the equipment's automatic shutdown features

Incorporate renewable electricity sources and use microgrids

According to a recent report from the University of Queensland and Lendlease, based on today's technology and policy settings, 40% of construction machinery and equipment will be electrified by 2030, and 60% by 2040 (Austin A, 2022-2).

To quote from the report: "The Lendlease team determined that the clearest path to fossil fuel free construction is through plug-in electric and mobile electric machinery and equipment, supplemented by renewable diesel."

According to the Clean Energy Australia Report (2023), in 2022 renewable energy accounted for 36% of Australia's total electricity generation, and these numbers have been steadily on the rise – in 2017, the share of renewables was only 17%.

By transitioning to electrical equipment, builders ensure that their operations will travel towards net zero as the share of renewables grows in the grid.

When a construction site does not have access to the grid or cannot draw enough power from the grid to operate, microgrids could allow the site to still make use of electric machinery and equipment.

A microgrid is an independent energy system that services a site or local area such as a mine site, business complex, or neighbourhood. Microgrids contain one or more kinds of distributed energy (thermal generators, solar panels, wind turbines, combined heat & power) that produce their power. In addition, microgrids can contain battery energy storage systems (BESS) as well as a control platform (energy management software) and other supporting equipment. Microgrids can operate in a grid-connected mode and island mode (autonomously).

Smart energy management and incorporation of renewable generation into microgrids further reduces CO_2 emissions and brings energy savings, while waste heat utilisation for heating and cooling purposes further increases energy efficiency. 100% renewable microgrids, which use renewable fuels in their generators, are also achievable and can also be used on construction sites.

Using hybrid arrangements

If a construction site cannot avoid using diesel generators, huge savings can still be made by introducing hybrid arrangements that combine generators with battery storage and portable solar panels. Depending on the duration of the project, the size of the generators, and the power requirements, hybrid arrangements can allow construction companies to reduce fuel use by over 80%. Hybrid arrangements also bring the benefits of reduced GHG emissions and reduced noise.

Hybrid power systems can be easily scaled up or down to meet the power needs of different construction projects. They are also flexible enough to be used in remote locations, where access to grid power is limited. Their modular nature allows them to quickly ramp up or scale down power production, bringing further cost reduction for construction processes.

Using alternative fuels

Diesel engines have long been favoured for their efficiency, durability, and high torque output (absorb step loads), making them an integral part of the construction industry. However, the combustion of conventional diesel fuel releases greenhouse gases and harmful pollutants, contributing to climate change and air pollution.

To combat these issues, researchers and engineers have been actively exploring alternative fuel options that can provide a more environmentally friendly solution without compromising the performance and versatility of diesel engines.

Biodiesel

Biodiesel is derived from renewable sources such as vegetable oils, animal fats, or recycled cooking oil. It can be blended with conventional diesel fuel or used as a pure substitute, significantly reducing emissions of carbon monoxide, particulate matter, and hydrocarbons. Biodiesel is compatible with existing diesel infrastructure, requiring no significant modifications to engines or fuelling stations.

When replacing diesel with biodiesel, remember that diesel generator manufacturers' guidelines make recommendations for service intervals and maintenance requirements that are specific to their equipment. These guidelines may include details on maintenance tasks such as filter replacements, oil changes, and general inspections. It's important to adhere to these recommendations to ensure optimal performance and longevity of the generators in use.

Renewable diesel (HVO)

Another promising alternative fuel is renewable diesel, also known as HVO (hydrotreated vegetable oil) or “drop-in diesel”. Unlike biodiesel, renewable diesel is produced through a hydrotreating process that converts various vegetable oils and fats which contain triglycerides and fatty acids into a diesel-like fuel. It shares similarities with conventional diesel fuel in terms of chemical composition and performance, making it compatible with existing diesel engines without any modifications. This attribute makes renewable diesel an attractive option for fleet operators and heavy-duty vehicle manufacturers.

HVO is considered to be one of the cleanest, greenest fuels on the market. It can be distributed, handled, and stored in the same way as traditional fuel, making it a convenient alternative to diesel. It does not contain any esters or contaminants, like regular diesel, which means it can be stored for extended periods of time with no adverse effects on performance.

At present, there is limited availability of HVO in AUSPAC.

Synthetic diesel

Synthetic diesel, produced through gasification or pyrolysis of biomass or coal, is another alternative fuel gaining attention. Synthetic diesel can be tailored to meet specific engine requirements and possesses combustion characteristics that can lead to reduced emissions compared to conventional diesel fuel. Synthetic diesel availability in AUSPAC is also currently limited.

Hydrogen and ammonia

Advancements in technology have also brought attention to other alternative fuels such as hydrogen and ammonia. While these fuels have traditionally been associated with internal combustion engines, recent developments in fuel cell technology have made them viable options for fuel cell electric vehicles as well. Hydrogen and ammonia offer the potential for zero-emission operation, as they produce only water vapour and nitrogen when burned. However, challenges related to storage, distribution, and infrastructure development remain, creating barriers to widespread adoption.

Waste reduction

a. Fuel spillages

There are several ways to reduce waste and minimise fuel spillages at construction sites:

- Conduct regular training: Ensure that workers are trained on proper handling and storage of fuel and other hazardous materials. This includes how to use and maintain equipment and machinery safely.
- Use spill containment products: Use spill containment products such as double-walled fuel tanks to prevent fuel from spilling onto the ground or into waterways.
- Store fuel safely: Store fuel in approved containers and ensure that they are properly labelled and stored in designated areas away from potential ignition sources.
- Regularly maintain equipment: Regularly maintain equipment and machinery to ensure that they are in good working condition and do not leak fuel or other fluids.

By implementing these measures, builders can significantly reduce waste and minimise fuel spillages at construction sites. This will improve safety and environmental outcomes, and reduce costs associated with clean-up and remediation.

b. Lean construction

One way to minimise inefficiencies and reduce waste is through efficient management of the existing fleet of construction equipment. Implementing lean construction practices and reducing waste through innovation and collaboration will lead to increased productivity and profits.

If a company uses obsolete or ageing equipment, it is important to assess the risks associated with its low efficiency, unplanned downtime, and associated repair costs, as well as researching repairing and recycling options. Overall equipment effectiveness should be evaluated while considering the new technologies available.

Technology is evolving. New, more efficient equipment is becoming available.

Of course, if a business has already invested in machinery, it won't be economical to buy a new, more efficient model. As a result, inefficiency will be built into the business' operations. To avoid this, it is beneficial to rent newer equipment, such as power generation equipment. In these instances, construction companies should incorporate flexibility into rental agreements, following the principle **"only rent the equipment you need, when you need it"**. As rental companies are responsible for equipment maintenance, this course of action should further reduce builders' costs.

Design – choose low-carbon materials, built for energy-efficient usage

The manufacturing of materials such as steel, aluminium, and concrete produces high levels of CO_2, which means these materials have a substantial environmental impact. As a result, even minor changes in their usage can reduce the overall carbon footprint of an organisation.

For example, using low-carbon concrete can reduce emissions by up to 42% compared to traditional concrete (CEFC, 2021). Low-carbon concrete is an industrial cement combined with mineral compounds, such as calcined clays, fly ash, or blast-furnace slag, improving the durability of the material as well as offering environmental benefits. Low-carbon concrete is now broadly available in Australia through multiple concrete manufacturers.

At the governmental level, the NSW Government is working with the construction industry to encourage the voluntary use of low-emission building materials. These materials, apart from low-carbon concrete, include "green" steel and alternative products such as geopolymers (NSW Government, 2021).

The future is now

It is important for companies to stay up to date with the latest technologies and innovations, so that they can remain competitive in an ever-changing industry. New materials, design principles, and technologies can contribute to emissions reduction and improve the bottom line of your project.

For example, low-carbon steel reduces the overall carbon footprint of buildings, and cross-laminated timber also improves insulation properties, contributing to the comfort of the dwellers and reducing energy usage throughout the operational stage of the building. New design principles incorporating potential future reuse and reconstruction also influence total building life-cycle emissions.

New tools and technologies such as advances in 3D printing, availability of hybrid machinery, new fuels, hydrogen-powered equipment, EV and electric construction site machinery can all reduce the carbon footprint of the construction industry.

Incremental technology improvements also make a difference. Thus, newer and more efficient equipment could reduce fuel consumption during construction. For example, new models of power generators are more efficient, quieter, and reduce diesel usage, NOx and CO_2 emissions. So, wherever possible, consider using the most recent technology, which could be financially viable via rental agreements.

All in all, keep an eye on the trends across multiple industries and consider how new technologies used successfully everywhere else could be applied to construction; in this instance, innovation also means applying existing technologies in a new field.

The final word

Climate change and constantly changing legislation – related to Australia's commitment to reducing greenhouse gas emissions – are identified threats to the construction industry. High energy consumption and emissions, as well as lagging progress towards achieving net zero, are the weaknesses of the industry.

We have identified a range of opportunities and practical steps to reduce CO_2 emissions and create savings throughout the construction process. Some steps can and should be implemented immediately, while other options may become available in the coming years.

We recommend starting with energy usage monitoring, introducing energy efficiency measures, reducing waste, incorporating renewables into electricity production, utilising hybrid arrangements, and embracing prefabrication in design. Behavioural and project management changes could be a starting point for emissions reduction.

In the coming years, the construction industry should be ready to switch to using alternative fuels, shift to all-electric construction, and embrace the usage of new materials and technologies.

Finally, to keep up with ever-changing demands and technological advances, continuous innovation is key, and the flexibility offered by rental equipment could be the best possible approach to stay ahead of your competition.

We encourage the construction industry to contribute to emissions reduction, as these actions will improve a company's bottom line, strengthen its brand, and protect it against future risks and challenges. Continuous innovation and a commitment to sustainability are paramount in building a resilient and thriving construction industry in Australia.

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