Empowering Future Engineers: A Climate Safe Perspective

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ABSTRACT

CONTEXT

Engineers play a significant role in the development and operation of our built environment. Carbon emissions generated through engineering practices contribute to climate change, which in turn amplifies the effects of certain natural hazards related to extreme weather events. A regional university in Australia has taken on the challenge of equipping future engineers to play an active role in mitigating the impacts of climate change by reducing engineering-related emissions across all engineering activities, as well as adapting design approaches to manage residual climate-induced extreme weather events. This focus, which we call 'Climate Safe', will permeate all of our work, from research, to how we engage with communities and importantly how we educate the next generation of engineers.

PURPOSE OR GOAL

Throughout 2024 and 2025 we have redesigned our flagship Bachelor of Engineering (Honours) degree to infuse climate safe principles and context across all curricular elements. In this paper we seek to review our curriculum program as a whole against our twin pillars of zero emissions and natural hazard engineering and identify how effectively we have integrated this concept and identify areas for future work. The redesigned course will commence enrolments in 2026.

APPROACH OR METHODOLOGY/METHODS

To review the curriculum, we have defined scales to assess if units of study can be considered 'climate safe inclusive' or 'climate safe focussed' and any disciplinary differences in terms of density of coverage of our twin pillars zero emissions engineering and natural hazard engineering across our core units, and three key specialisations – civil, mechanical and electrical.

ACTUAL OR ANTICIPATED OUTCOMES

The core units had a higher density of 'climate safe focussed' units due to the climate safe core structure defined, where the specialisation units were mostly classified as 'climate safe inclusive'. Within the specialisations, mechanical and electrical had a greater focus on zero emissions while civil focussed primarily on natural hazard engineering. This reflects the fact that much of electrical and mechanical engineering typically tends to involve harnessing or using energy, while civil engineering tends more to consider the response of infrastructure to its environment.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

It was shown to be possible to meaningfully embed 'climate safe' concepts and contexts into the design of nearly every unit of study within the degree, while sufficiently covering the elements required to define each traditional discipline. This highlights the importance that the engineering profession plays in addressing all aspects of climate change, and reflects the direction the profession is heading. Such sentiments can be used to market the degree and increase the appeal to school children, as these values resonate with the majority of young people.

KEYWORDS

Curriculum design, sustainability, climate

Introduction

Engineers play a significant role in the development and operation of our built environment. Carbon emissions generated through engineering practices contribute to climate change, which in turn amplifies the effects of certain natural hazards related to extreme weather events. Across most developed economies, engineering-related industries are responsible for more than 80% of anthropogenic carbon emissions (Ritchie, 2020). By re-assessing and changing methodologies and designs, engineers can play a significant role in reducing emissions and mitigating the effects of climate change.

As an example, consider the electricity sector. Shifting from fossil fuels to renewable energy generation contributes significantly in avoiding severe climate impacts, with compounding benefits to be gained from electrification of transportation, heavy industries, and household heating and cooking. Engineers are at the centre of these transformations, but in the past have tended to follow the environmental trends, rather than step out and lead them with new and alternative designs and solutions.

Despite efforts to mitigate climate change, we are already experiencing heightened impacts due to increasing frequency and intensity of weather events. As these events become more severe in the future, before hopefully moderating later this century, engineers will be required to design infrastructure and systems to detect, monitor, and to ultimately resist severe impacts, in the interest of public safety. However, simply building bigger and stronger structures, for example, using more traditional materials (eg. concrete, steel, glass), is not the solution. Traditional engineering approaches will only further the demand for carbon-intensive materials. Future engineers will need to address the impacts of climate-induced natural hazards using methods that avoid further carbon emissions, which prompts new approaches involving nature-based solutions, alternative materials, and risk-based design methodologies.

We recognise both sides of the climate challenge. Firstly, we consider *mitigation*, which involves avoiding or displacing greenhouse gas emissions. Secondly, we consider *adaptation*, which involves designing solutions to ensure safe and reliable built environments under increased natural hazard impact. In addressing these two issues together, we defined the term ‘Climate Safe’ engineering. This climate safe engineering mission leads our research and teaching focus, and necessitated a redesign of our Bachelor of Engineering degree to facilitate genuine integration of the climate safe concept for delivery to students commencing in 2026. Often degree programs will take concepts like our climate safe focus, typically sustainability, and treat it as a tacked-on component rather than a central principle (Lozano and Lozano, 2014). For example, this may include placing in an existing module, creating a specific course that isolates the material from integration with other knowledge, skills or professional opportunities, or placing in a dedicated specialisation (Lozano and Lozano, 2014; Thürer et. al., 2018). Our curriculum design process has sought to avoid this common pitfall by ensuring a genuine and well-structured integration of the climate safe concept. A similar approach was taken by Worthy & Titu (2025) who focussed on social responsibility and climate justice in engineering through the integration of the Engineering for One Planet Framework. However, our approach is different in that we focus on understanding the risks created by a changing climate, leading to a need to mitigate future risk through the development of zero emissions technologies, and the design of engineering infrastructure to be tolerant against these risks and to not further contribute to the changing climate.

Our work in this area is aligned with broader contextual factors for the engineering industry including the Engineers Australia Code of Ethics (Engineers Australia, 2022) which states that engineers must aim to “deliver outcomes that do not compromise the ability of future life to enjoy the same or better environment, health, wellbeing and safety as currently enjoyed”. Additionally, the Engineering Futures 2035 report (ACED, 2021) identified the need for increasing focus on life cycle and sustainability considerations, environmental stewardship and professional engineering skills in problem identification, framing and solving. At a local level, our state is a leader in renewable energy, and our institution has a broader strategic focus on leading in sustainability and climate-conscious innovation and has been ranked in the Time Higher Education Impact Rankings as the number one university globally for Climate Action for the last four years, as at 2025 (THE, 2025).

This paper presents an audit of our curriculum design prior to the first delivery to assess the effectiveness of our climate safe concept integration. We seek to demonstrate how genuine integration of a concept like ‘climate safe’ engineering can be included in a course built from the ground up and also identify areas of improvement for our team to address before we deliver these units for the first time.

Curriculum Design Process

Our curriculum design process was aided by Generative AI (Lyden et. al, 2025), with a strong input from academics to shape the curriculum ensuring industry relevance, strong technical foundations and alignment to the EA stage 1 competencies (Engineers Australia, 2019). The climate safe concept was integrated into our Course Learning Outcomes (CLOs) which align with the domains of the EA stage 1 competency standard (Engineers Australia, 2019) framing what our graduates should be equipped to do upon completion of the course. Here we refer to a course as a 4-year program of study, made up of 32 units of study. In designing curriculum in the age of GenAI, where careful attention needs to be placed on assuring student learning, we adopted a holistic view of the course and specialisations to balance assessment opportunities and assure achievement of CLOs. Ensuring that units are not silos, creating links between units and assessments and ensuring secure assessments were important considerations of our curriculum design process, in addition to our focus on genuine integration of the climate safe engineering concept. Specialisation teams approached the design of their units in different ways, which may have led to differences in terms of the perceived amount of climate safe focus in different units investigated throughout this paper.

An innovative aspect of our curriculum design is our climate safe core structure which includes a series of six units across the first three years of the degree. The units in the Climate Safe core introduce students to climate sciences, and natural hazards, a range of professional engineering skills including project management, communication, finance, and ethics, along with technical topics like materials, design and resilient systems. These units also embed a vertically integrated project (VIP) where students will collaborate on a multi-year, multi-cohort project aligned with climate safe engineering. VIP projects are often used as extra-curricular activities, or non-compulsory for credit activities around the world and are known for providing authentic learning experiences (Bailey, 2020), peer learning (Clayton et. al., 2000) and helping students to develop the necessary technical and professional skills to be effective graduates (Sonnenberg-Klein et. al., 2023, Ramirez and Zoltowski, 2022). Our VIP is an opportunity for all students to develop these skills and through our climate safe core provides an opportunity for students to connect and practice their climate safe knowledge and skills on a real-world project.

Method

To review our innovative climate safe engineering degree, we have collected a range of data from the unit designs and performed assessments of the alignment of the units with our twin pillars of climate safe engineering – zero emissions and natural hazard engineering. Data consolidated from each unit design included:

1. Any intended learning outcomes (ILO) that included a climate safe element, either explicitly stated or clearly implied
2. Total count of ILOs in the unit
3. Assessment tasks whose main activities are aligned with the climate safe element of the unit
4. Content from the description which provides more detail on the climate safe context or content of the unit

Table 1 provides examples from our study that were and were not deemed to show alignment. Aligned examples connect with the climate safe concept, unaligned examples include core requirements of an engineering degree that may not have a direct alignment with climate safe engineering. We include these examples as a sample of our approach for identifying climate safe integration in the units.

Table 1 – Examples of alignment

	Aligned example	**Unaligned example**
ILO	Explain how human and engineering systems and practices can drive or mitigate climate change and its consequences for the natural world. (Climate Safe Core Y1)	Contribute to solving a multidisciplinary real-world engineering challenge using foundational knowledge (Climate Safe Core Y1)
AT description	This assessment focuses on identifying and evaluating components from the Environmental Impact Assessment assignment in terms of their sustainability and proposing more climate safe solutions, within the specific fields (electrical, mechanical and civil). Students will utilise their design and critical analysis skills to propose solutions/partial improvements of the proposed system. This assessment is directly linked with the work completed in the Environmental Impact Assessment assignment. Gen AI is permitted but must be acknowledged. (Climate Safe Core Y2)	Students will conduct a laboratory experiment and document their findings in a written report. This task prompts students to demonstrate various aspects of experimental work and writing techniques. Additionally, students develop their understanding of thermodynamics concepts. Week Distribution: 5, 6 Week Due: 7, 8 (Core Y1)
Unit description	The unit introduces the field of civil engineering. Students will learn methods for solving problems in civil engineering as applied to structural, geotechnical, transportation, and environmental engineering projects. The translation of theoretical concepts into designs will be demonstrated through examples involving buildings, tunnels, dams, roads, water supply, stormwater and wastewater systems, coastal protection, transportation systems, and traffic management. With the imperative to reduce carbon emission and adapt to increasing natural hazards, this unit will also introduce Climate Safe principles for design, including analysis of embedded carbon, circular use of materials, forecasting for future impacts, and use of natural materials. Through practical laboratory work, students will observe systems of forces in structural elements, fluid-structure interactions, and the response of engineered systems to extreme weather events. The skills developed in this unit establish the foundations for further studies in civil engineering. (Core Y1)	This unit provides students with the tools to develop the initial stages of a major research and/or industry-relevant project, which will be continued in the following semester as Honours Project B. Students will learn how to prepare a well-motivated, feasible, and complete research plan with clearly defined goals and progress monitoring methods. They will conduct a relevant literature search and review specific to their topic, and develop and test effective methods to achieve the specified goals. Under the guidance of an academic supervisor, students are expected to complete a research plan, comprehensive literature review, and methods chapters. Professional reporting and accountability are emphasised through an assessed reflective diary documenting meetings with their supervisor and other stakeholders. (Core Y4)

From this an assessment was made against the unit data to identify:

1. If the climate safe element is related to the 'content' of the unit (i.e. is taught) or is related to a 'context' within the unit (i.e. not specifically taught but included in how students apply a particular skill or knowledge)
2. Zero emissions engineering – if the unit can be considered to be 'climate safe focussed', 'climate safe inclusive', or 'not included' in relation to the zero emissions element of the climate safe concept.
3. Natural hazard engineering – if the unit can be considered to be 'climate safe focussed', 'climate safe inclusive', or 'not included' in relation to the natural hazard engineering element of the climate safe concept.
4. If the unit has 'not included' for both zero emissions and natural hazards engineering a secondary assessment is performed regarding if the unit has a sustainability focus or sustainability inclusion. While sustainability is broader than our climate safe concept, the skills and knowledge developed in focussing on sustainability can be useful for graduates in working towards a climate safe future.

These scales are defined as:

- 'Not included' – there is no or very minimal content or contexts in the unit aligned with the element
- 'Climate safe inclusive' – the content or contexts align with climate safe, but it is not the full focus
- 'Climate safe focussed' – the content or contexts strongly align with climate safe for the pillar
- 'Sustainability focussed' – while the content or context aligns with general sustainability principles, there is not specific alignment to either of our two key pillars of climate safe engineering
- 'Sustainability inclusive' – the content or context aligns with general sustainability principles, but it is not the full focus.

After the authors agreed on the parameters of the scale, we discussed several units together to ensure consistency of application of the scales. Then some of the authors took responsibility for performing the assessment on either core, civil, mechanical or electrical component to generate our dataset.

In performing our analysis units not delivered by or within the control of the School of Engineering (i.e. anything not with an 'ENGxxx' unit code) were deemed out of scope, including the four maths units offered in our program, and electives due to the range of options available to students. We have included geology and surveying units for civil engineers, even if this are not delivered or within the control of the School of Engineering to include equivalent number of units for each specialisation. Due to time constraints these units have not yet been modified to align to the climate safe principle directly, however work is underway to align this.

Results and Discussion

Table 2 shows our assessment of whether the climate safe elements in each unit are content, or context related. This clearly shows that in the core, and in the civil and mechanical specialisations, there is a strong focus on climate safe content being taught, however in the electrical specialisation there is an increased focus on climate safe contexts, like renewable energy, being used. The 16.6% of core units classified as neither climate safe content nor context were our final year honours project units, where students work individually with a supervisor on a project of their choice. Given the strategic alignment of the school towards climate safe engineering as a research focus in addition to teaching focus, while not explicitly indicated in the learning outcomes, assessment or unit descriptions there is a high likelihood that many students will undertake projects aligned with our climate safe mission. However, since project topic is selected (and may even be initiated) by the student, and/or often arises from industry contacts, it is inappropriate to dictate that the project should always be climate safe aligned.

Table 2. Climate Safe Content and Contexts as a percentage of units

	Content	Context	Neither
Core	66.7%	16.7%	16.6%
Civil	100%	0%	0%
Mechanical	66.7%	33.3%	0%
Electrical	33.3%	66.7%	0%

Figure 1 shows whether, according to our analysis, units are climate safe focussed, inclusive or related to sustainability. In the figure a heatmap has been used to indicate the strength of different units in contributing to either the zero emissions or natural hazards engineering pillars of climate safe Engineering. Additionally, if the unit contributes to neither pillar, it has been assessed against sustainability as a broader concept. The overall rating for each unit incorporates the climate safe pillars as well as the sustainability aspect where that has been assessed.

With the exception of the final year project units, all units were shown to have some alignment to climate safe engineering or a sustainability focus with this being strongest in our introductory climate safe engineering unit. Overall, by deliberate design, the core aligns most strongly to the climate safe engineering concept, largely due to our climate safe engineering core structure. Civil engineering units were next most strongly aligned followed by electrical and mechanical units. There was a significant difference between the results for electrical and mechanical compared to the core and civil in terms of the amount of alignment to climate safe engineering detected, with almost no green in the "overall" column. This may be an artefact of the different processes used by the specialisations to integrate the climate safe concept, but has also provided us with insight from this review on future improvements we can make before these units are taught for the first time to ensure a strong and cohesive integration of the climate safe concept. Civil units more strongly aligned with the natural hazards element of the climate safe concept, while mechanical was more balanced with a slight bias to zero emissions. Electrical was solely focussed on zero emissions engineering. This was not surprising since electrical and mechanical engineers are more directly involved in the processes of harnessing and using energy, while civil engineers more typically need to deal with how the build environment responds to the environment.

Figure 2 shows the weighted ILO climate safe impact of the units. This weighted ILO climate safe impact is calculated by considering the percentage of the ILOs in a particular unit that relate to the climate safe concept and multiplied this by our rating in terms of if the elements of the unit are climate safe inclusive or focussed. For example, for Y1U1, 3 of the 4 ILOs align with the climate safe concept (75%) and both domains are climate safe focussed, so the overall weighted score is 7.5 (one of the highest scores achieved for any unit). The average score is then calculated based on taking the average of the numerical scores for all units in the specialisation or core component. Note that in electrical the weighted component in a number of cases has dropped significantly as the climate safe concept is not clearly addressed in the relevant ILO, which aligns with earlier observations that a lot of the electrical units climate safe alignment was context based rather than content based. As expected, the core units, by design, have a high climate safe rating overall. The self-directed nature of the final year project and the opportunity for projects to come from industry here has not been aligned with the climate safe concept as this would restrict the available topics and contexts which students could study.

From inspection of Figure 2 it can be seen that a fairly consistent result is observed across the units in the civil and mechanical specialisations, while the electrical specialisation when weighting is considered has much greater variability, with some high scoring units and some that are zero. This is largely due to the number of aligned ILOs, in particular, some of the electrical units contextually had a strong focus on renewable energy which was integrated throughout most of the

ILOs leading to a higher weighted score here. A significant number of electrical units with a high climate safe weighted rating in spite of a lack of explicit focus in the ILOs reflects that climate safe is often a strong contextual element of the electrical engineering units. It is likely that these differences have been observed due to the differences in approach utilised by the specialisation teams in embedding the climate safe concept.

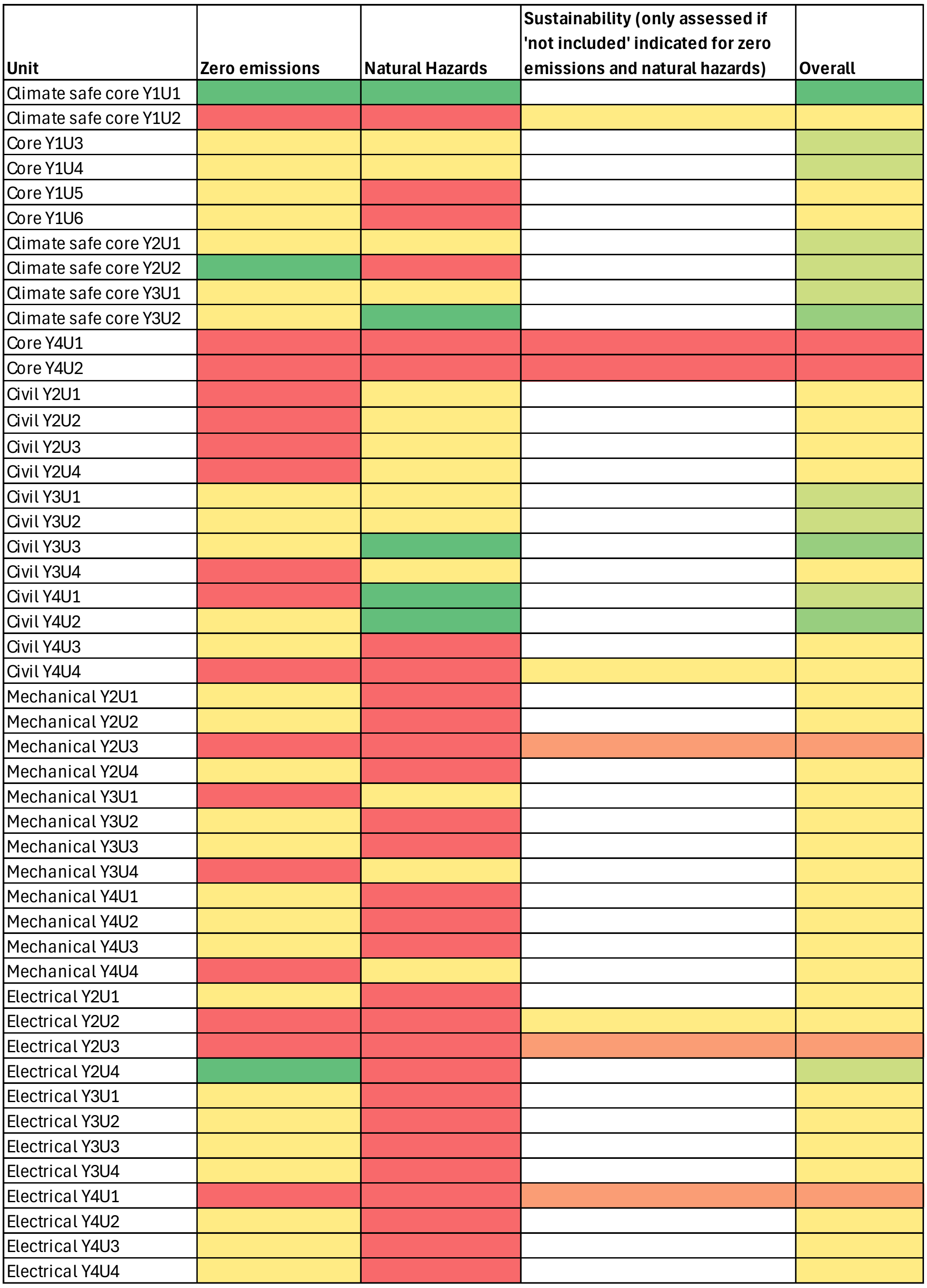

Figure 1. Results of our analysis represented as a heat map where Red = No explicit climate safe content, Orange = sustainability focussed, Yellow = climate safe inclusive and Green = climate safe focussed. The "overall" column incorporates both pillars and the sustainability element where appropriate.

Core	Weighted Climate safe component	Civil	Weighted Climate safe component	Mechanical	Weighted Climate safe component	Electrical	Weighted Climate safe component
Climate safe core Y1U1		Y2U1		Y2U1		Y2U1	
Climate safe core Y1U2		Y2U2		Y2U2		Y2U2	
Core Y1U3		Y2U3		Y2U3		Y2U3	
Core Y1U4		Y2U4		Y2U4		Y2U4	
Core Y1U5		Y3U1		Y3U1		Y3U1	
Core Y1U6		Y3U2		Y3U2		Y3U2	
Climate safe core Y2U1		Y3U3		Y3U3		Y3U3	
Climate safe core Y2U2		Y3U4		Y3U4		Y3U4	
Climate safe core Y3U1		Y4U1		Y4U1		Y4U1	
Climate safe core Y3U2		Y4U2		Y4U2		Y4U2	
Core Y4U1		Y4U3		Y4U3		Y4U3	
Core Y4U2		Y4U4		Y4U4		Y4U4	
Average score for each specialisation							

Figure 2. Weighted Climate Safe Content. The final line indicates an average score for each specialisation in an alternative heat map scale

Conclusions

In summary, our analysis has shown that it is possible to meaningfully embed an overarching concept like 'climate safe engineering' into an engineering degree program, while still ensuring that key professional, technical knowledge and skills are covered, and curriculum is aligned with achieving the EA Stage 1 Competency Standard.

Unsurprisingly given the overarching focus, the climate safe concepts were embedded most strongly in the core units studied by students from all disciplines. In the specialisation units, there were significant discipline trends. For example, climate safe content in electrical engineering was strongly in the area of zero emissions, focused more on context than content, and tended to vary between units, reflecting the importance of electrical engineering in transitioning to zero carbon energy. This was in contrast to civil engineering where it was more explicitly embedded in ILOs, less variable between units, and more directed towards natural hazards, reflecting civil engineering's roles in adapting infrastructure to climate change. The analysis also reveals potential opportunities for future course revision to strengthen the climate focus in specific units. The analysis will be used alongside student feedback and input from industry as we deliver and refine units.

Our future engineers will have a major role to play in addressing all aspects of climate change, which must, and demonstrably can be, directly addressed in curriculum design. In doing so, the 'climate safe engineering' concept may also be used to increase the appeal of engineering and related STEM professions to school children, as these values resonate with the majority of young people.

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