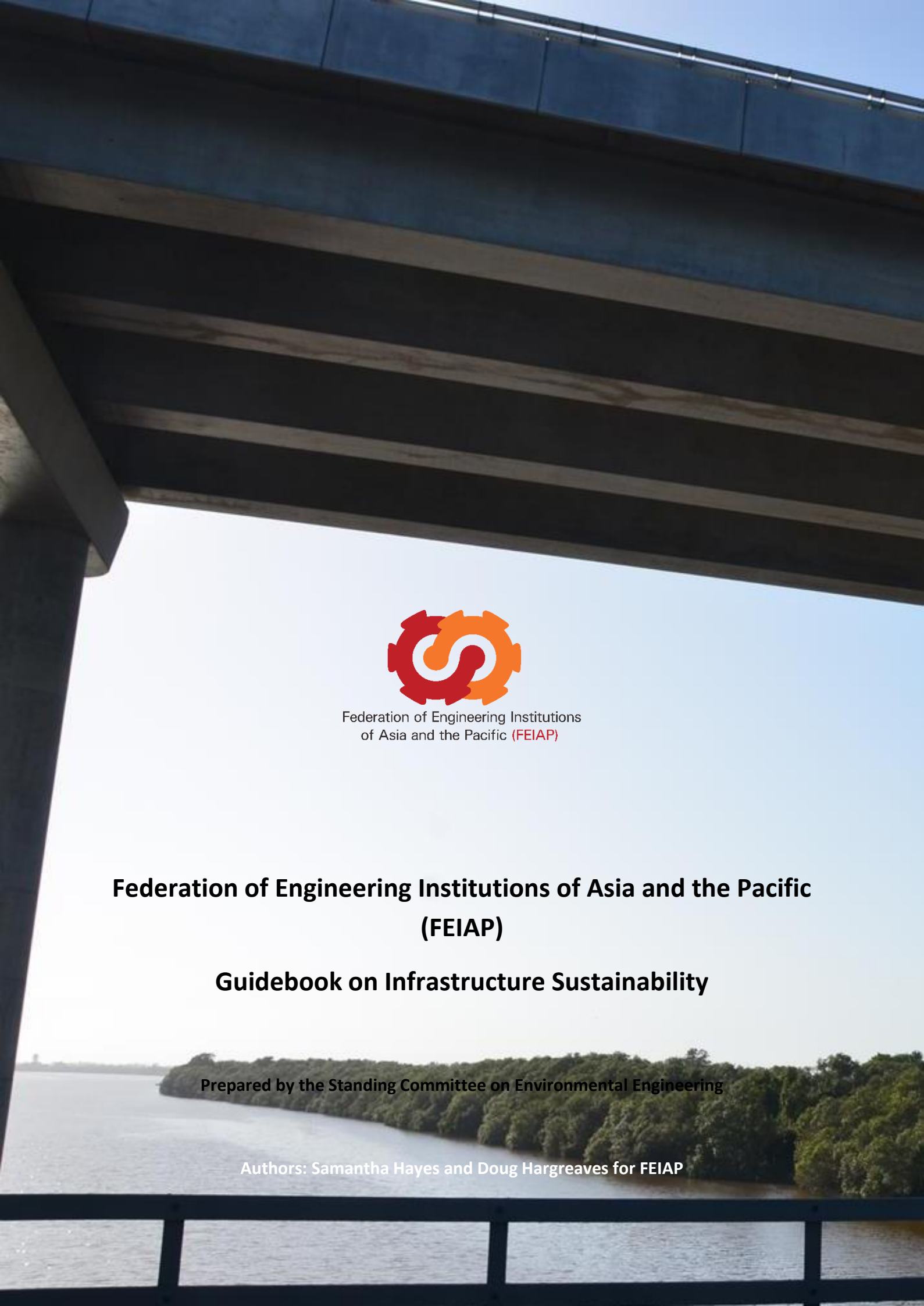

Federation of Engineering Institutions
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Federation of Engineering Institutions of Asia and the Pacific (FEIAP)

Guidebook on Infrastructure Sustainability

Prepared by the Standing Committee on Environmental Engineering

Authors: Samantha Hayes and Doug Hargreaves for FEIAP

Federation of Engineering Institutions of Asia and the Pacific (FEIAP)

Executive Summary

Infrastructure sustainability exists at the convergence of two important global trends – 1) urbanisation, population growth and the demand for infrastructure; and 2) efforts to mitigate damage and degradation of social and ecological systems through sustainable development.

Sustainability is emerging as an important priority area for both new and existing infrastructure, and as such a variety of rating schemes and frameworks have been developed. This guidebook offers a starting point for those looking to delve into infrastructure sustainability and better understand its relevance to their infrastructure asset, network or system.

It is important to recognise that this guidebook does not recommend a particular scheme or framework that should be adopted. Such decisions should be made on a case-by-case basis depending on the project priorities, objectives and context. It also does not promote the development of a new scheme for FEIAP economies. What it does provide, is an insight into what infrastructure sustainability means, key themes and categories relevant to infrastructure, and the kinds of ratings schemes that may be adopted to guide and measure success.

Foreword

The 'Guidebook on Infrastructure Sustainability' is the product of rigorous research and review of current global trends and benchmarking against the United Nations' Sustainable Development Goals (SDGs), in particular SDG 9 and SDG 11.

To recap briefly, SDG 9 aims to build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation; while SDG 11 focuses on making cities and human settlements inclusive, safe, resilient and sustainable. The scope and approaches under these two SDGs are vast, offering significant opportunities for engineers to contribute.

The FEIAP Standing Committee on Environmental Engineering has held many dialogues on environmental sustainability issues relating to infrastructure developments. These discussions sparked the idea of putting together a guidebook to serve as a reference for FEIAP members and to enhance their general understanding of sustainable and resilient infrastructures.

Engineering continues to be the backbone of infrastructure delivery and maintenance. Hence, engineering professionals carry the mandate of driving sustainability through planning, design and implementation. This Guidebook also provides a reference for the various infrastructure sustainability certification schemes that are presently available.

This Guidebook is a small but important step in FEIAP's journey to increase awareness and steer all stakeholders in the right direction in achieving the SDGs. We hope that it will allow us to further expand and crystalise understanding of the importance of sustainability covering environment, governance, social and economic factors as well as the role of infrastructure sustainability certification and rating.

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I would like to express our heartfelt gratitude to Doug Hargreaves and Samantha Hayes of Engineers Australia for their excellent authorship of this Guidebook as well as to our members from the FEIAP Environmental Engineering Standing Committee for their valuable contributions, support and feedback in making this publication possible.

Er. Chong Kee Sen
Chairman
Standing Committee on Environment Engineering
FEIAP

About the FEIAP

The Federation of Engineering Institutions of Asia and the Pacific (FEIAP) is an international non-profit professional organization founded on 6 July 1978. Its establishment following an exploratory meeting convened and organised by The Engineering Institute of Thailand under The King's Patronage with the support of the United Nations Educational Scientific and Cultural Organization (UNESCO) on 3 July 1978 in Chiang Mai.

Established as an independent umbrella organization for engineering institutions in the Southeast Asia and the Pacific region, its scope expanded to Asia and the Pacific in 2008. Its objectives are to encourage the application of technical progress to economic and social advancement throughout the world; to advance engineering as a profession in the interest of all people; and to foster peace throughout the world.

Cover Photo: Samantha Hayes.

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Introduction

In an age of climate change, pollution, biodiversity loss and resource scarcity, the sustainability of infrastructure is now more important than ever.

Across Asia and the Pacific, urbanisation is leading to increased demand for infrastructure. This involves both the construction of new assets and networks, and the repair and upgrade of existing infrastructure. The infrastructure market across Asia and the Pacific is projected to grow by around 8 per cent per year and reach US$5.36 trillion per annum by 2025 – approximately 60 per cent of the global total (Rathbone and Redrup, 2014). Growth markets require substantial infrastructure investment to support economic growth, including energy and water infrastructure to support industry and communities, and transportation networks to support mobility of people, materials and products (Rathbone and Redrup, 2014). Mature economies similarly require significant investment in infrastructure repair and retrofit, as well as social infrastructure including healthcare, education and housing.

The growing demand comes at a time where there is also a growing global appreciation of the need for more sustainable development, particularly in our cities. By 2030 it is expected that 60 per cent of the world population will be living in cities, with these cities contributing around 70 per cent of global carbon emissions and over 60 per cent of global resource use (UN, 2020). As the scale of climate change, biodiversity loss, resource scarcity, pollution and waste challenges become clearer, it is evident that the 'cities of tomorrow' must seek to actively address, and not further exacerbate, these issues.

In this context, there is an exciting opportunity for the design and construction of infrastructure in a way that better manages its environmental and social impacts, seeking to reduce damage and where possible generate positive outcomes for ecosystems and communities.

The term 'infrastructure' captures many of the essential physical systems that enable cities, communities and organisations to function. These systems include communication networks, transport systems, power infrastructure and sewer systems among others. These networks are responsible for enabling communication, mobility, and access to employment, health, and education services. Infrastructure systems are an integral and often long-lasting component of modern life.

The construction and operation of infrastructure has, however, resulted in an array of damaging environmental and social impacts, including pollution, biodiversity loss and substantial consumption of emissions intensive materials such as concrete and steel. Recognising the fundamental role of today's infrastructure in shaping tomorrow's cities and regions, it is important that our infrastructurereflects our changing priorities and objectives.

The opportunities are clear. Benefits of sustainable infrastructure can include cost savings through enhanced efficiencies, improved planning and effective governance; long term viability through enhanced resilience; reduced or avoided social and environmental impacts; and where applicable, the efficiency and credibility of independent rating frameworks (ISI, 2021a).

The United Nations acknowledge the important role of infrastructure in achieving the objectives of the 2030 Agenda for Sustainable Development (UNEP, 2020), noting that infrastructure are linked to all 17 of the Sustainable Development Goals, either directly or indirectly influencing 92% of the 169 individual SDG targets (SIP, 2020). The Asian Development Bank has recognised the importance of sustainable and resilient infrastructure across Asia and the Pacific, with a target of $80 billion in climate financing by 2030 (Lu, 2019); and Local, State and Federal Governments are including infrastructure sustainability in strategic sustainable development agendas (for example, the Singapore Green Plan 2030 (Joint segment on Sustainability, 2021).

Within this context, there is a clear need for capacity building across engineering disciplines. This Guidebook offers an overview of current approaches to infrastructure sustainability, to allow engineers to rapidly familiarise themselves with key concepts and resources in the area.

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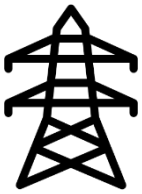
Types of Infrastructure

Infrastructure is the basic physical and organisational structures needed for the operation of a society. It includes the roads that we drive on, the electricity lines that bring us power, and the airports we fly from. Infrastructure includes but is not limited to:

Transport infrastructure

- Road, rail, tunnels and bridges
- Ports, airports, waterways and canals



Energy infrastructure

- Power stations, wind farms, hydro-electric plants
- Power grid, lines and connections

Communications infrastructure

- Telephone cables
- Phone towers

Water infrastructure

- Reservoirs and dams
- Pumping stations and levees

Social infrastructure

- Education, including schools, universities and other facilities
- Health, including medical centres, hospitals and emergency response
- Law and security, including policy and prison systems

Waste infrastructure

- Waste removal facilities and services

- Disposal and resource recovery facilities

What is infrastructure sustainability?

Infrastructure sustainability refers to infrastructure that has been planned, designed, constructed, operated and decommissioned in a way that ensures *"economic and financial, social, environmental (including climate resilience), and institutional sustainability over the entire infrastructure lifecycle."* (SIP, 2020). With this in mind, the goal of infrastructure sustainability efforts are *"to meet the needs of society whilst enhancing our environment and economy"* (ISCA, 2018).

These aspects are reflected in the four 'pillars' of sustainability highlighted in Figure 1, along with a selection of categories and considerations relevant to infrastructure.

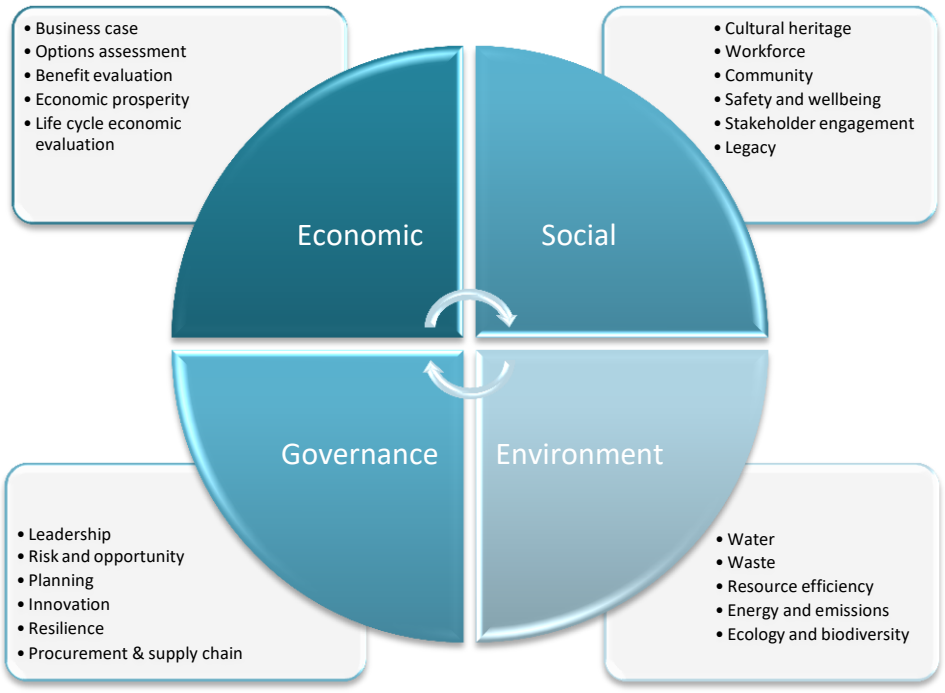


Figure 1. Four pillars of sustainability and a sample of considerations for infrastructure (Informed by ISCA (2018); CEEQUAL (2018), ISI Envision (2018).

Economic

The economic pillar of infrastructure sustainability includes, for example, consideration of life cycle economic performance, options evaluation and business case development. Importantly, these evaluations consider not only upfront costs and benefits, but those that are expected throughout the asset lifecycle, including operation and decommissioning / end of life. They consider not only the

financial performance of the project itself, but the economic implications of the infrastructure for the surrounding community.

Robust options analysis should occur prior to any decision to design or construct new infrastructure. This analysis explores all viable project options for addressing the challenge or problem at hand. Options may include a focus on behavioural change, or the utilisation or upgrade of existing assets, as well as new build options (ISCA, 2018). Options analysis should consider impacts and benefits from a financial, environmental and social perspective.

Business case development is another important economic consideration for infrastructure sustainability. This includes detailed analysis of the economic viability and affordability of the project itself, as well as key project initiatives (ISCA, 2018). Consideration of the costs and benefits of a project and project initiatives can help to ensure that key benefits are achieved across economic, social and environmental priority areas. As with options analysis, this should consider costs and impacts across the lifecycle, as design and procurement decisions made solely on upfront cost considerations may fail to account for longer term materials, repair, disposal and other lifecycle costs.

Table 1 captures a selection of issues and categories that are often considered under the 'Economic' pillar of sustainability:

Table 1. 'Economic' sustainability. Sources: ISI (2018), ISCA (2018), CEEQUAL (2018).

Life-cycle economic evaluation	Stimulate economic growth and prosperity	Options Analysis	Develop local capabilities	Business case development

Case Study: Economic potential through the construction of a submarine fibre optic cable system.

The Palau Submarine Cable Branch System Project is designed to create redundancy for Palau's internet capacity (AIFFP, 2021). This will create an incentive for private investment and a catalyst for development and economic growth in Palau. It will ensure secure, digital connectivity in Palau and open up opportunities for tourism, business and investment, as well as improved government services, health and education (AIFFP, 2021).

Social

There are many facets to the way infrastructure influences and is influenced by society and communities. Benefits of access, mobility, power, sanitation, health and education services are widely understood. Other issues to consider include the impact of the infrastructure on cultural heritage, whether it be through disturbance of culturally significant sites or items, disruption of community activities and livelihoods, or failure to recognise and retain important local history. This can involve sensitive preservation of important sites and practices, as well as consideration of how the asset or network may enhance people's connection to this heritage and history (ISCA, 2018). These considerations should be integrated and strategically considered throughout all stages of the

infrastructure lifecycle. Strategic stakeholder engagement is integral to sustainable infrastructure, with robust strategies for collaborative engagement with local communities.

Looking to the workforce, social considerations for project teams include the provision of effective training and support; the employment of diverse and inclusive workforces; and safety, health and wellbeing programs, among others. Strategic workforce planning includes an upfront skills analysis that explores workforce capacity and capability, before developing plans to address skills gaps through recruitment and training programs (ISCA, 2018).

Table 2 captures a selection of issues and categories that are often considered under the 'Social' pillar of sustainability:

Table 2. 'Social' sustainability. Sources: ISI (2018), ISCA (2018), CEEQUAL (2018).

Stakeholder Engagement	Workforce Sustainability	Public safety	Mobility & access	Workforce health & safety
Aesthetics	Community wellbeing	Legacy	Cultural Heritage	Social benefit

Case Study: Participation of local communities and women in road maintenance – Second Road Improvement Project.

The Second Road Improvement Project in the Solomon Islands improved the national road network, incorporated sustainability into road maintenance policies and practices, and focused on participation of local communities and women in road maintenance (Development Asia, 2019). It targeted at least 25 per cent of maintenance contracts with local communities, with at least 20 per cent of road maintenance contractors being women (ADB, 2016). Contractors were also encouraged to employ women in wage labour, and 40% of wage jobs were ultimately filled by women, with all maintenance contractors coming from local communities.

Environment

Environmental impacts of infrastructure construction, operation and decommissioning include energy use and carbon emissions; degradation of ecosystems and biodiversity; and consumption of significant quantities of materials, water and other natural resources. Further, pollution impacts to air, land and water can occur across the infrastructure lifespan.

Addressing these impacts requires a wide range of project controls and considerations. Energy and carbon management, for example, includes consideration of embodied energy in materials such as concrete and steel, as well as fuel and electricity consumed in project construction and operation. Similarly, consideration of waste management ranges from procurement and use of recycled content products and materials, and design for disassembly; to minimising waste during construction; and optimising reuse at disassembly/decommissioning at end of life.

Impacts on plants and animals can be widespread both in construction and operation of infrastructure, and as such sustainability efforts seek to minimise negative impacts through strategic assessment and planning approaches. Biodiversity conservation onsite, as well as through offsite

biodiversity projects that preserve important ecosystems and habitats. Through green infrastructure, there are also opportunities to incorporate nature into the infrastructure design itself.

Table 3 captures a selection of issues and categories that are often considered under the 'Environment' pillar of sustainability:

Table 3. 'Environmental' sustainability. Sources: ISI (2018), ISCA (2018), CEEQUAL (2018).

Materials & Resource Efficiency	Energy Use & Greenhouse Gas Emissions	Water Use	Waste and Recycling	Biodiversity
Vibration	Green Infrastructure	Land contamination and management	Habitat enhancement	Air Quality
Water Quality	Noise	Pest Management	Soil Quality	Light Pollution

Case Study: Sydney CBD and South East Light Rail (CSELR) Project

The CSELR project was the design, construction, manufacture, testing and commissioning of a 12km light rail system servicing Sydney's CBD and South East (ISCA, 2020b). The project adopted a Geothermal Air-conditioning system for the underground High Cross Park electrical substation, moving hot air out of the building using earth loops. This was an Australian first innovation and eliminated the need for cooling towers of condensing units, leading to significant energy, carbon and water savings (ISCA, 2020b).

Governance

Governance has more recently emerged as a key pillar of sustainability, with a central role in achieving tangible and material sustainability outcomes. In an infrastructure context, governance considerations relate to leadership and management approaches; planning; procurement and supply chain strategies; resilience and innovation efforts, among other factors. This pillar recognises that sustainability efforts are often introduced as ad-hoc and champion-based approaches, where siloed 'add-on' efforts struggle to gain traction among the broader project or network management approach. As such, governance for infrastructure sustainability requires that sustainability considerations are integrated into senior leadership and management approaches that identify material sustainability issues relevant to the project, asset or network, and develop comprehensive strategic responses to managing those issues. This includes mapping project responses against the UN Sustainable Development Goals setting tangible sustainability objectives and targets, and encouraging sharing of key findings and lessons learned both internally and externally.

Integrated and strategic sustainability management includes comprehensive risk and opportunity assessment that considers governance, social, environmental and economic risks and opportunities across the infrastructure lifecycle, with a diverse range of stakeholders (internal and external) involved in assessing and managing these.

Sustainable procurement and supply chain opportunities have often been hamstrung by a lack of integration and prioritisation, where sustainability initiatives are introduced late or applied only to minor or immaterial procurement categories. Strategic procurement approaches integrate sustainability considerations into the core procurement criteria and objectives. Similarly, the pursuit of innovation and resilience (including climate resilience) cannot afford to be ad-hoc considerations introduced late in the project lifecycle, rather they must be strategically integrated from project planning and inception.

Figure 2. Project life-cycle stages

Table 4 captures a selection of issues and categories that are often considered under the 'Governance' pillar of sustainability:

Table 4. Sustainability 'Governance'. Sources: ISI (2018), ISCA (2018), CEEQUAL (2018).

Leadership & Management	Risk & Opportunity Assessment	Planning	Procurement & Supply Chain	Resilience
Strategic Context	Collaboration & Teamwork	Knowledge Sharing and Education	Integration	Innovation

Case Study: Sustainable procurement on the Inland Rail Project

The Inland Rail project includes 13 projects spanning more than 1700km and designed to complete the freight network between Melbourne and Brisbane, Australia (Yardi and Gosse, 2020). The project developed a Sustainable Procurement Policy following widespread engagement. The sustainable procurement approach included a robust supplier sustainability assessment, which assessed suppliers on their sustainability performance during the tender process. It then scored each supplier, with scores returned to the supplier along with guidance on how to improve their score over time (ISCA, 2020c).

The role of infrastructure sustainability certification

> *"In order to achieve the SDGs and objectives of the Paris Climate Agreement, and safeguard our societies and economies against future crises, it is imperative that these infrastructure investments do not follow "business-as-usual" approaches, which have proven to be unable to deliver sustainable infrastructure at the scale required"* (SIP, 2020).

As highlighted in Figure 1, consideration of sustainability in infrastructure covers a wide range of disciplines, categories and areas of impact. Addressing these requires first exploring and understanding the breadth of categories, before selecting materially relevant focus areas, establishing appropriate benchmarks and targets, implementing initiatives, and measuring and reporting on success. Attempting to undertake each of these steps on each individual infrastructure project can be both inefficient and often ineffective, absorbing valuable time and resources.

The development of rating schemes and certification programs address this by offering frameworks that are:

- Consistent and standardised
- Relevant across the full infrastructure lifecycle
- Designed to build knowledge and capacity
- Representative of good or leading practice, and
- Designed to foster innovation.

Rating schemes provide a standardised interpretation of how sustainability applies to infrastructure, mitigating the need for each individual project or team to decipher this for each project, while allowing flexibility to suit the infrastructure scale and context. They offer practitioners a reliable insight into what constitutes 'good' and 'best' practice sustainability performance for infrastructure, including tangible approaches and performance targets.

They support whole of life analysis of risks and opportunities, including the identification and attainment of cost efficiencies through resource minimisation and waste reduction. Further, they offer a consistent approach that creates credibility and confidence in infrastructure sustainability efforts.

These tools are used for formal assessment and the attainment of accredited ratings, however they also influence industry in other ways. Research suggests that a large majority of users of rating tools used them for purposes other than formal certification, including as a guide or framework for infrastructure sustainability; for informal project assessment; to inform management systems, policies and strategies; for feasibility and planning; learning and awareness raising; and for incorporating sustainability into tenders (Griffiths et al., 2018). These are valuable ways for practitioners to leverage and learn from these schemes to inform their practice in a way that best suits their project or team.

How do rating schemes work?

A rating scheme with independent assurance or verification will typically include the following key steps (although variability will occur):

Figure 3. Illustrative representation of typical rating scheme process.

Rating schemes typically consist of a small number of core themes, which include within them several 'categories'. An example may be a 'Theme' of Governance, with a Categories of 'Procurement', 'Leadership' and 'Collaboration' within it. Each category then includes several 'Credits', which outline the details of the proposed approach. For example, a Procurement category may include one Credit that is focused on developing a sustainable procurement strategy, and a second Credit that sets quantitative performance benchmarks around procurement, for example the percentage of recycled materials procured.

These credits are the detailed components of the scheme that typically outline:

- The aim or intent of the credit
- Levels, scores or points that can be achieved
- Criteria for success - Key administrative or performance benchmarks
- Guidance on achieving the credit (Note – the level of guidance or direction can vary significantly across schemes)
- Examples of the types of evidence required to demonstrate success.

When a project achieves all of the requirements of a particular credit (or a level within a credit), they would apply for the points associated with that credit in their rating assessment/verification.

Typically, projects will not pursue all available credits but will identify those most relevant, material and/or achievable. Points will be added and lead to an overall category rating or ranking. Some schemes have mandatory credits, which all projects must be assessed against, however most schemes include at least some optional credits, allowing projects the opportunity to select appropriate credits for their project. Formal certification will then allow projects to publicise their achievements.

Existing infrastructure sustainability rating schemes

There are many infrastructure sustainability rating schemes and frameworks available internationally that can be utilised by infrastructure practitioners. Some apply to selected sectors (e.g. transportation infrastructure), while others are applicable to all infrastructure types. There is also variation in the lifecycle phases captured by each scheme. Some cover only design and construction, for example, while others span from project planning through to operation and decommissioning.

When selecting a rating scheme, it is important to consider a range of factors that may vary between schemes, and ensure that you adopt the most relevant and appropriate scheme for your project. Appendix A provides a brief case study of key questions and considerations for selecting an appropriate sustainability scheme (or multiple schemes).

To offer a preliminary insight into available schemes and frameworks and management practices, Table 5 highlights a small selection of infrastructure sustainability rating tools, however this list is far from exhaustive. An introduction to six of these schemes is provided in Appendix B, and a sample of non-infrastructure specific resource is also included for reference in Appendix C.

Guidance has also been developed by members of the FEIAP, including Engineers Australia's guide "Implementing Sustainability: Principles and Practice" (Engineers Australia, 2017), which discusses a range of options for qualitative and quantitative sustainability assessments. For further detail on a wide range of schemes, frameworks and guides refer to the Sustainable Infrastructure Tool Navigator: https://sustainable-infrastructure-tools.org/.

Table 5. A selection of infrastructure sustainability rating tools. Adapted from Sustainable Infrastructure Tool Navigator.

Scheme	*Country of origin*	*Launched*	*Infrastructure types*	*Infrastructure phases*	*Language*	*Open Source*
Infrastructure Sustainability (IS) Rating Scheme	Australia	2012	All sectors	Project planning, Concept design, Detailed Design, Construction, Operation and Maintenance	English	No
Envision	US & Canada	2012	All sectors	Project planning, Concept design, Detailed Design, Construction, Operation and Maintenance, Decommissioning / Repurposing	English, French	Yes
CEEQUAL	UK	2003	All sectors	Project planning, Concept design, Detailed Design, Construction, Operation and Maintenance, Decommissioning / Repurposing	English	Yes
Green Roads	US	2010	Transport	Project planning, Concept design, Detailed Design, Construction, Operation and Maintenance,	English	No
Green Mark	Singapore	2005	Urban Planning,	Project planning, Concept	English	No

			Energy, Transport, Food Systems, Health, ICT/Digital, Buildings	design, Detailed Design		
Green Star	Australia	2003	Buildings	Project planning, Concept design, Detailed Design, Construction, Operation and Maintenance	English	No
LEED	US	2000	Urban planning	Strategic planning, Project planning, Concept design, Detailed Design, Construction, Operation and Maintenance	English	Yes
The Sustainable SITES Initiative	USA	2015	Urban planning, Natural infrastructure	Strategic planning, Prioritisation, Concept design, Detailed Design, Construction, Operation and Maintenance	English	No
Living Community Challenge	USA	2017	Urban Planning	Strategic planning, Prioritisation, Concept design, Detailed Design, Construction, Operation and Maintenance	English	Yes

About the Infrastructure Tool Navigator:

The Infrastructure Tool Navigator is a web-based platform offering an overview of a range of infrastructure sustainability tools internationally. It captures over 90 sustainability tools, offering detailed explanations of each, as well as allowing users to filter search based on infrastructure lifecycle phases, sectors, types of tools (e.g. rating systems, modelling tools, benchmarks, guidelines) and languages, among other criteria. The Navigator has been developed by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH in collaboration with the United Nations Environment Program and Sustainable Infrastructure Partnership.

Concluding remarks

Infrastructure sustainability approaches have evolved rapidly in recent years to become mainstreamed and widely adopted in some markets and sectors, while still newly emerging in others.

While early efforts focused primarily on environmental aspects, infrastructure sustainability frameworks and guidance now recognise the importance of four key pillars: environment, governance, social and economic factors. Recognising the breadth of categories, approaches and performance measures across these areas, structured rating schemes have emerged as a way to achieve consistency and standardisation. These schemes reflect good and leading practice, encouraging innovation and knowledge sharing, and provide robustness and credibility to sustainability efforts, as opposed to ad-hoc and unverified sustainability initiatives.

There are now a plethora of schemes and standards to choose from, with some applicable to all infrastructure types, and others more targeted to specific assets such as commercial buildings, or road transportation infrastructure. Each scheme varies in its coverage, objectives and priorities, and as such it is necessary to explore multiple frameworks before selecting one (or several) that are most relevant to your project or network.

This Guidebook provides FEIAP members with an introductory insight into current approaches, available tools and resources, to support decision makers in determining why and how to pursue sustainability on infrastructure projects. The following pages highlight key references, resources and suggested further reading that will provide more comprehensive insights. The Infrastructure Tool Navigator, a free online resource, offers a directory of over 90 infrastructure sustainability schemes and is a logical next step for exploring these schemes in more detail. Similarly, engineering associations and sustainability networks in each country and online offer valuable forums for keeping abreast of emerging trends and best practice in infrastructure sustainability.

The FEIAP recognises the important role of sustainability in infrastructure planning, design, construction, operation, renewal and decommissioning into the future. Sustainability must become an integrated and strategic component of all infrastructure projects and networks, and as such it is critical that our industry practitioners and decision makers are well informed and capable of championing such change. Sustainability leadership and innovation are necessary across all projects in order to achieve the magnitude of change required in coming decades.

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UN Environment (2020) Sustainable Infrastructure Partnership (SIP) UNEP. Accessed online 12 October 2020 at: https://www.unep.org/explore-topics/green-economy/what-we-do/economic-and-trade-policy/sustainable-infrastructure

Zeitsman, J (2011) *A guidebook for sustainability performance measurement for transportation agencies* (Vol 708). Transportation Research Board.

Infrastructure Rating Scheme websites:

- Infrastructure Sustainability Council of Australia: https://www.isca.org.au/
- Greenroads: https://www.greenroads.org/
- Envision: https://sustainableinfrastructure.org/envision/
- CEEQUAL: http://www.ceequal.com/

Appendices

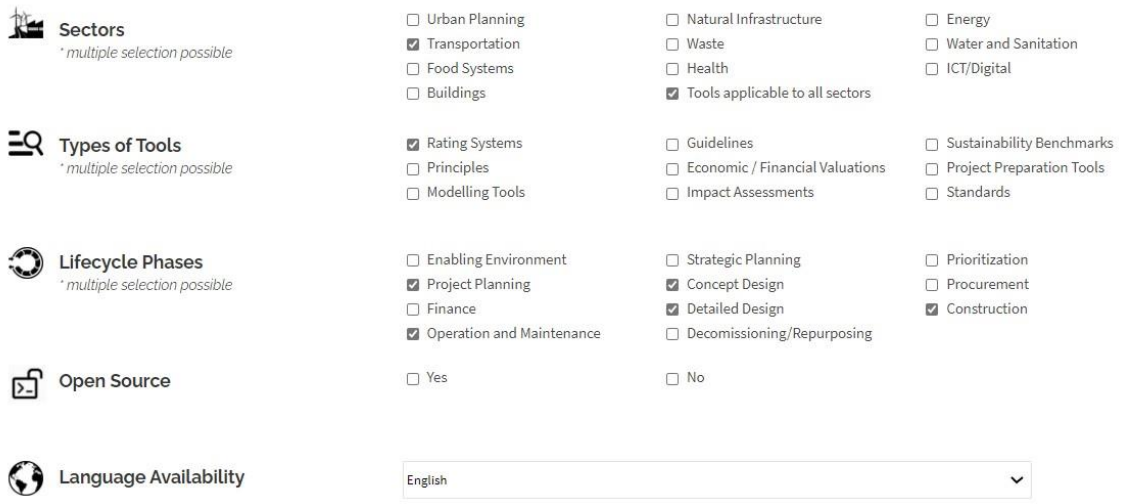
Appendix A: Selecting an infrastructure sustainability rating scheme

Hypothetical case study example: South-West Rail Link (New Zealand)

The South-West Rail Link Project in New Zealand involves the design, construction and operation of 15km of railway line, four new train stations and one multi-modal bus and train station.

The project proponent has mandated a strong focus on sustainability across the project, and a tender team is exploring which rating scheme(s) would be best suited to delivering on those requirements.

The Bid Director starts their search online, using the Sustainable Infrastructure Tool Navigator to explore options. It allows searches to be filtered by sector, type of tool, lifecycle phase, language, and whether the resources are open source.



Their search returns 9 tools that may be applicable to their project.

From the Navigator summaries they shortlist four that seem suitable, and after reviewing the web page for each scheme, they can see that the Infrastructure Sustainability Rating Scheme has had prior uptake in New Zealand and has in-country support, as well as resources that have been specifically adapted to suit New Zealand infrastructure projects. The tendering company also operates in Australia, and so the uptake of the IS scheme in Australia is appealing as they will likely be able to use the scheme again on future projects, allowing them to leverage the knowledge and capacity gained through this project.

The tender team then search again for 'building' rating tools to use for their station buildings, and decide to pursue a Green Star rating for similar reasons to the above. The find a resource by ISCA and GBCA called 'Guide for Projects Seeking Dual Certification', which reassures them that it is

possible to pursue both schemes on one project. Finally, they contact both the ISCA and GreenStar teams to begin discussing the potential for adoption on the South-West Rail Link Project.

In summary

Considerations for selecting an infrastructure sustainability scheme may include:

- What lifecycle phases does the scheme apply to? (e.g. planning, design, construction, operation)
- Does the scheme apply to all or only part of my project scope (e.g. buildings only, or entire communities)?
- Has the scheme been piloted/used in my country?
- How does it align with other rating schemes?
- Does the scheme support self-assessment, or only formal verification?
- What are the registration and verification costs?
- What languages are materials available in? Are verifications and in-person support available in my country?
- Are the scheme materials, guidance and resources freely available, or only available to paid members / registered users?
- Which credits (if any) in the scheme are mandatory, and which are optional?

Appendix B: Existing sustainability rating schemes (Sample)

Infrastructure Sustainability 'IS' Rating Scheme

The IS Rating Scheme is Australia and New Zealand's only comprehensive rating system for assessing sustainability across the full infrastructure lifecycle (ISCA, 2021a). It assesses quadruple bottom line sustainability performance, seeking to provide 'a common national language for sustainability in infrastructure' (ISCA, 2021a). It aims to provide a framework for consistent application and evaluation of sustainability in tendering; to support identification of whole of life sustainability risks and opportunities; to foster efficiencies, waste reduction and cost savings; foster innovation and continuous improvement; and to build organisations sustainability credentials and reputation (ISCA, 2021a).

Certification scores include bronze, silver, gold, platinum and diamond (Version 2.0), based on points allocated for achievements against specific credits across the themes of Governance, Economic, Environment and Social performance (ISCA, 2021a). The total score is calculated based on the points achieved in the different credits. Verification of the assessment result is undertaken by an independent third-party verifier. In addition to use as a formal certification scheme, the IS framework also promotes awareness of sustainability issues and opportunities for improving project and organisational sustainability performance. It seeks to support a common understanding of what sustainability means for infrastructure, across planning, design, construction and operation (ISCA, 2021b).

Key components and resources include (ISCA, 2021c):

- The IS Ratings Directory (listing all IS registered projects)
- Design & As Built ScorecardEA2017 - s (ISv2.0 & ISv1.2)
- IS Planning Scorecard (ISv2.0)
- IS Operations Scorecard (ISv1.2)
- AU ISv1.2 Materials Calculator and Guidelines
- NZ ISv1.2 Materials Calculator and Guidelines
- ISv1.2 Design Review Guide
- Innovations Challenge Guide

CEEQUAL

CEEQUAL was launched in the UK in 2003 and is an evidence based sustainability assessment, rating and awards scheme for civil engineering, infrastructure, landscaping and public realm projects (CEEQUAL, 2021). It aims to deliver improved project specification, design and construction of civil engineering works, and promotes and celebrates the achievement of high environmental and social performance.

CEEQUAL rewards project and contract teams in which clients, designers and contractors go beyond the legal and environmental and social minima to achieve distinctive environmental and social performance in their work. In addition to its use as a rating system to assess performance, it also provides significant influence to project or contract teams as they develop, design and construct their work, because it encourages them to consider the issues in the question set at the most appropriate time.

Envision

Envision provides a consistent framework for pursuing and evaluating sustainability and resilience in infrastructure (ISI, 2021b). Developed with a strong focus on research and education, it seeks to set a standard for sustainable infrastructure that incentivises best practice, creates a common language and recognises those making significant sustainability contributions (ISI, 2021b).

The Envision framework is a flexible system of criteria and performance objectives designed to support decision makers in identifying and implementing sustainable project choices, and help project teams identify sustainable approaches across the infrastructure lifecycle (ISI, 2021b). While formal certification is available, the Envision framework is designed with education as a primary objective, and is available for use in various ways, including informal assessment and as guidance resources.

Key components and resources include:

- Envision Guidance Manual: The written framework outlining the 64 sustainability and resilience credits across five categories.
- Envision Pre-Assessment Checklist: A checklist for early-phase high-level pre-assessment that can also support preparation of later assessments.
- Envision Online Scoresheet: The detailed online assessment tool and calculator.
- Envision Sustainability Professional Credential: Professional training in the use of the Envision framework.
- Envision Verification: The process of independent third-party review against the scheme.
- Envision awards: Recognition for qualifying verified projects. (ISI, 2021a)

Green Star

Launched in 2003 by the Green Building Council of Australia, Green Star is Australia's largest sustainability rating scheme for buildings, fit-outs and communities (GBCA, 2021a). It focuses on reducing the impacts of climate change; enhancing health and wellbeing; restoring biodiversity and ecosystems; driving resilient outcomes and contributing to market transformation and a sustainable economy (GBCA, 2021a). Green Star is focussed on formally certified ratings, with a robust, transparent and independent assessment process, noting that non-certified projects that claim to have met the Green Star requirements may be in breach of trademark rules (GBCA, 2021a).

Four Rating tools are available through the Green Star program:

- Green Star – Communities
- Green Star Buildings – Design &As-Built
- Green Star – Interiors
- Green Star - Performance

The Green Star rating system is based on 6 Stars, with '1 Star' reflecting Minimum Practice and '6 Star' reflecting World Leadership (GBCA, 2021a).

Leadership in Energy & Environmental Design (LEED)

The LEED Mission is to 'transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, health, and prosperous environment that improves the quality of life." (USGBC, 2021a). It was developed to measure and define 'green building', creating a roadmap for sustainability and establishing a baseline of universally agreed approaches tor educing impact (USGBC, 2021a).

Projects earn points for green building strategies across a variety of categories, and earn a rating level of Certified, Silver, Gold or Platinum depending on the points achieved (USGBC, 2021b).

LEED Rating Types (USGBC, 2021b):

- Cities and Communities: For cities and sub-sections of a city
- Building Design and Construction: For new construction or major renovations, including core and shell.
- Interior Design and Construction: For complete interior fit-out projects for commercial interiors, retail and hospitality.
- Building Operations and Maintenance: For existing buildings undergoing improvement work or little to no construction
- Neighbourhood Development: For new land development projects or redevelopment projects containing residential uses, non-residential or a mix.
- Homes: For single family homes, low-rise multi-family or mid-rise multi-family
- Recertification: applies to all occupied and in-use projects that have previously achieved certification under LEED, helping to maintain and improve the building.
- Zero: For LEED projects with net zero goals in carbon and/or resources.

Living Community Challenge

The Living Community Challenge is a framework for master planning, design and construction that seeks to create a symbiotic relationship between people and aspects of the built environment (ILFI, 2017). It builds upon the Living Building Challenge to extend the focus from individual projects sites to communities at large (ILFI, 2017). Rather than focusing solely on damage reduction, it pursues regenerative design and performance, where the built environment generates a net positive impact on communities and society. It supports users to create communities that are healthy, multifunctional, walkable and regenerative for both people and ecosystems, including net positive performance with respect to water and energy (ILFI, 2017).

The Living Community Challenge is comprised of seven themes or 'Petals', which are divided into 20 categories or 'imperatives'.

There are several ways to use the Living Community Challenge framework, including to pursue:

- Living Community Certification (attaining all 'imperatives' and achieving Living Building Certification for the majority of capital projects developed or renovated by the community);
- Petal Certification (achievement of at least 3 of the 7 'petals' of the framework)
- Zero Energy Community Certification (100% of the communities net annual energy needs supplied by onsite renewable energy).

Appendix C: Other sustainability rating schemes and management practices

A range of other sustainability rating schemes and practices are also available to assess sustainability in the built environment. These include schemes developed to assess, for example, environmental performance and efficiencies of buildings, equipment and products. The below list offers a sample of the types of schemes and practices that are available for use:

Green Mark (Singapore): Green Building benchmarking scheme (https://www.bca.gov.sg/greenmark/green_mark_buildings.html)

Energy management practices for new and existing industrial facilities

https://www.nea.gov.sg/our-services/climate-change-energy-efficiency/energy-efficiency/industrial-sector/mandatory-energy-management-practices-for-new-industrial-facilities

https://www.nea.gov.sg/our-services/climate-change-energy-efficiency/energy-efficiency/industrial-sector/mandatory-energy-management-practices-for-existing-industrial-facilities

https://www.nea.gov.sg/our-services/climate-change-energy-efficiency/energy-efficiency/industrial-sector

National Australian Built Environment Rating System (NABERS): Rating system to assess the actual environmental performance of buildings during operation (https://www.nabers.gov.au/)

Nationwide House Energy Rating Scheme (NatHERS): Rating of thermal performance of houses (https://www.nathers.gov.au/)

Calculating Cool: HVAC Online Rating Tool (www.calculatingcool.com.au/#/about)

Building Sustainability Index (BASIX): Minimum sustainability standards for new dwellings, alterations and additions (www.basix.nsw.gov.au/basixcms/)

Window Energy Rating Scheme (WERS): Ranking of window energy performance (www.wers.net/wers-home)

Energy Star: Rating the energy efficiency of products and appliances **(**www.energyrating.gov.au/about/other-programs/energy-star/)

Green Vehicle Guide: Testing and rating air pollution and greenhouse gas emissions of vehicles (www.greenvehicleguide.gov.au)