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Diagnostic Approach and Tool for Assessing and Increasing the Sustainability of Renewable Energy Projects

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Abstract: The imperative of achieving net zero carbon emissions is driving the transition to renewable energy sources. However, this often leads to carbon tunnel vision by narrowly focusing on carbon metrics and overlooking broader sustainability impacts. To enable these broader impacts to be considered, we have developed a generic approach and a freely available assessment tool on GitHub that not only facilitate the high-level sustainability assessment of renewable energy projects but also indicate whether project-level decisions have positive, negative, or neutral impacts on each of the sustainable development goals (SDGs). This information highlights potential problem areas and which actions can be taken to increase the sustainability of renewable energy projects. The tool is designed to be accessible and user-friendly by developing it in MS Excel and by only requiring yes/no answers to approximately 60 diagnostic questions. The utility of the approach and tool are illustrated via three desktop case studies performed by the authors. The three illustrative case studies are located in Australia and include a large-scale solar farm, biogas production from wastewater plants, and an offshore wind farm. Results show that the case study projects impact the SDGs in different and unique ways and that different project-level decisions are most influential, highlighting the value of the proposed approach and tool to provide insight into specific projects and their sustainability implications, as well as which actions can be taken to increase project sustainability.

Keywords: renewable energy; sustainable management; sustainable development goals (SDGs); sustainable management tool; ex-ante; biomass; hydropower; solar; geothermal; wind; ocean energy



Citation: Tian, J.; Culley, S.; Maier, H.R.; Zecchin, A.C.; Hopeward, J. Diagnostic Approach and Tool for Assessing and Increasing the Sustainability of Renewable Energy Projects. *Sustainability* **2024**, *16*, 10871. <https://doi.org/10.3390/su162410871>

Academic Editor: Andrea Nicolini

Received: 8 November 2024

Revised: 6 December 2024

Accepted: 9 December 2024

Published: 11 December 2024



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1. Introduction

There is an urgent need to reduce global carbon emissions in response to the increasing threat of climate change, which poses significant risks to ecosystems, economies, and public health worldwide. The transition to renewable energy is critical in this pursuit, with numerous sustainable alternatives to fossil fuels offering the potential to mitigate greenhouse gas emissions. However, the prioritisation of carbon emission reduction targets when implementing renewable energy projects has led to “carbon tunnel vision” [1]. This refers to an overly narrow focus on carbon metrics—such as carbon emissions and carbon footprints—when assessing the sustainability of renewables. Consequently, the impacts of the renewable energy transition on broader Sustainable Development Goals (SDGs) beyond Climate Action (SDG 13) and Affordable and Clean Energy (SDG 7) are generally overlooked.

To overcome carbon tunnel vision, several studies have investigated the links between energy production and the SDGs. Fuso Nerini et al. (2018) provided a high-level assessment exploring the synergies and trade-offs between SDG 7 (Clean Energy) and other SDG targets [2]. Their work underscored the critical role energy system decisions play in achieving the UN 2030 Agenda [3,4]. Bisaga et al. (2021) built on that study to conduct a more targeted analysis by focusing on a particular energy type, in this case, off-grid solar. They further highlighted the need to develop context-specific rapid assessments to

effectively evaluate the impact of a given renewable energy type on the SDGs [5]. Tian et al. (2024) further increased the resolution of the relationship between renewables and the SDGs by considering seven aspects of the renewable energy production process, including source selection, operational requirements, conversion processes, waste production, reuse, transmission and distribution, and storage. This was undertaken for six different renewable energy types, including biomass, hydropower, solar, geothermal, wind, and ocean energy (wave and tidal). This approach enables the assessment of the impact that a renewable energy project can have on the SDGs at a finer level of detail, helping to identify connections and dependencies that might be overlooked due to carbon tunnel vision [6].

To allow the links between renewable energy projects and the SDGs to be understood in a consistent, transparent, and user-friendly manner [7], various frameworks and tools have been developed and demonstrated, which have highlighted the value of the use of questionnaires in the sustainability assessment of renewable energy projects. Examples include:

- Multi-Criteria Decision Making (MCDM) tools to assist communities in ranking alternative local renewable energy sources (RESs) during the pre-feasibility stage by considering factors such as the ability of RESs to enhance energy security [8];
- A framework and Excel-based tool (the SDG-IAE framework) designed to help practitioners understand the interactions between energy projects and the SDGs and to inform conversations among stakeholders [9];
- The Energy Scenario Evaluation (ESE) framework for assessing the sustainability and public acceptability of energy transition scenarios, which includes a questionnaire consisting of five critical questions [10];
- The Data Envelopment Analysis (DEA) framework, which has been utilised in sustainability assessments to evaluate green growth among countries and has revealed that many nations face challenges in achieving high levels of sustainability [11];
- Energy-based sustainability evaluations, which have been developed to provide deeper insights into the complex interactions between human society and water supply systems for hydropower megaprojects [12]; and
- The Integrated Sustainability Assessment Framework (ISAF-GET), which has been applied to evaluate the socio-economic impacts of geothermal energy technologies in Mexico. This framework incorporates 36 sustainability indicators developed through stakeholder engagement, shedding light on key sustainability challenges faced by the geothermal industry [13].

However, the focus of previous studies has been solely on identifying links between RESs and the SDGs, not on determining which specific aspects of renewable energy projects contribute to these goals and/or the most effective ways of improving the sustainability of renewable energy projects. Even though these approaches raise awareness of potential problems, they do not help to diagnose any underlying causes that enable more sustainable renewable energy projects to be developed. Consequently, the overall aim of this study is to overcome this shortcoming by:

1. Developing an approach for identifying the *project-level decisions* made during the development of renewable energy projects that influence SDGs.
2. Developing an approach and tool for identifying the relationships between the *project-level decisions* identified in Objective 1 and the SDGs for specific renewable energy projects in a consistent, transparent, and user-friendly fashion.
3. Illustrating the application and benefits of the approach developed in Objective 1 and the tool developed in Objective 2 by applying them to three case studies that are based on proposed renewable energy projects in Australia, each with different attributes (e.g., type of renewable technology, location, local demand, and other contextual factors), as part of a desktop study conducted by the project team.

The structure of the remainder of this paper is as follows. Section 2 provides details of (i) the proposed approach for identifying the project-level decisions made during the development of renewable energy projects that have an influence on the SDGs and

(ii) the approach and tool for identifying the relationships between project-level decisions identified and the SDGs for specific renewable energy projects in a consistent, transparent, and user-friendly fashion. Then, Section 3 introduces the three case studies used to illustrate the relationships between project-level decisions and the SDGs as part of the desktop study conducted by the project team, with the results of the case study analyses given in Section 4. Finally, a summary of the overall utility of the proposed approach and tool and conclusions are given in Section 5.

2. Materials and Methods

Details of the approach for identifying the project-level decisions that influence the SDGs are given in Section 2.1. Then, Section 2.2 details the approach and tool for identifying the relationships between the project-level decisions developed in Section 2.1 and the SDGs for specific renewable energy projects.

2.1. Identification of Relevant Project-Level Decisions

A summary of the proposed approach for identifying the project-level decisions that influence the SDGs is given in Figure 1. The methodology comprises four key steps that sequentially establish connections between the SDGs and actionable outcomes:

- Step 1: Establish a linkage between the SDGs and the corresponding SDG targets.
- Step 2: Connect the SDG targets to their relevant SDG Indicators.
- Step 3: Develop a relationship between the SDG Indicators and a comprehensive set of Diagnostic Questions.
- Step 4: Utilise the Diagnostic Questions to guide Project-level Decisions during the development of renewable energy projects.

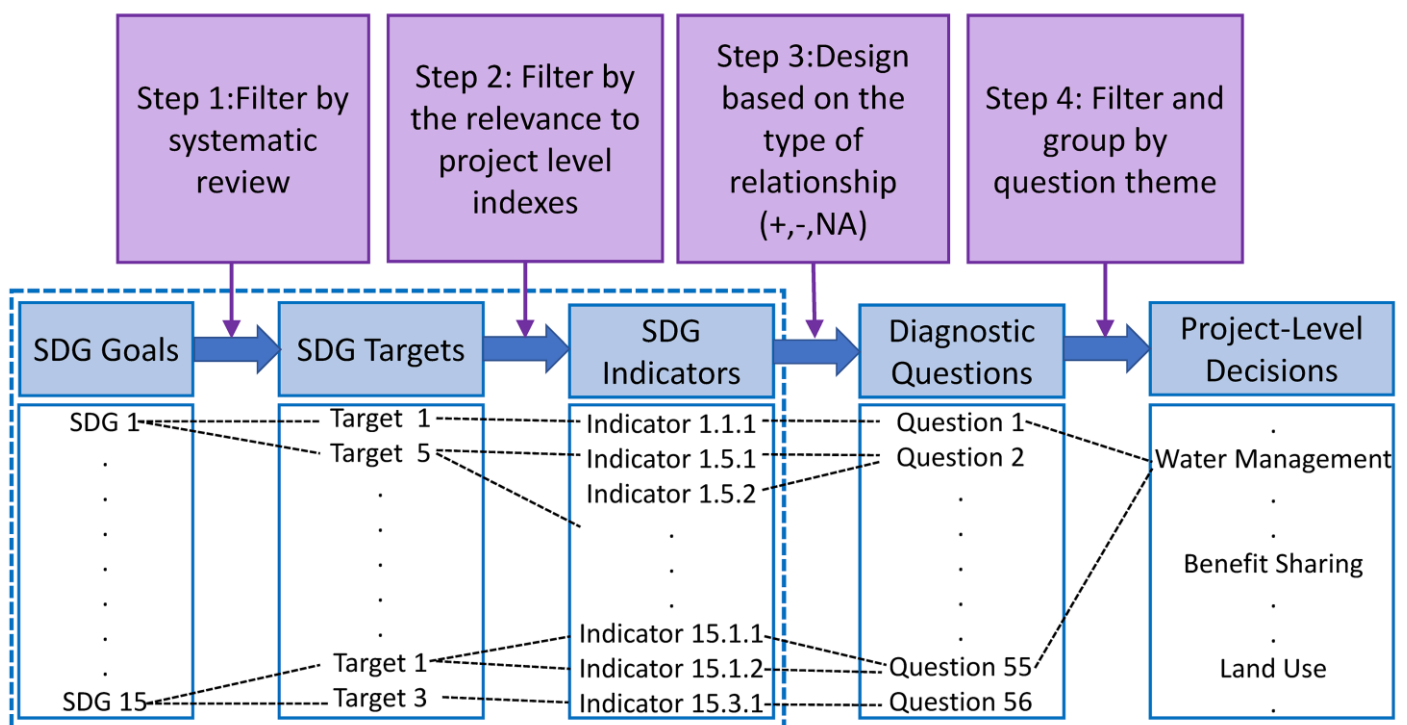


Figure 1. The proposed approach for identifying the project-level decisions that have to be made during the development of renewable energy projects that affect SDGs.

Details of each of these steps are given below.

As part of Step 1, the SDG targets related to each of the SDG Goals relevant to projects using different types of renewable energy were identified. By recognising the diverse impacts renewable energy projects can have on different SDG targets, we adopted

the framing from Tian et al. (2024) [6], which identifies how seven key aspects of these projects, including source selection, operational requirements, the conversion process, waste production, reuse, transmission and distribution, and storage, enable or inhibit specific SDG targets. This provides a high-level overview of potential linkages between the SDGs and major renewable energy types, leading to the identification of a subset of impacted SDG targets. Tian et al. noted that renewable energy projects do not have any direct impact on SDGs 4, 5, and 10, based on a systematic review of the literature. Further, there is no direct impact on SDGs 16 and 17, as these serve as fundamental interconnections to all other goals. These SDGs are therefore excluded from our study. The detailed table and reference list supporting this high-level overview are provided in Section S1, and the full list of SDG targets selected in this study is provided in Section S2.

As part of Step 2, the SDG Indicators related to each of the SDG targets determined in Step 1 were identified. A full set of indicators for all SDG targets is available from the SDG indicator framework [14]. Many SDG indicators operate at regional or national scales, limiting their direct applicability to individual local-scale projects. To address this shortcoming, we systematically identified keywords within the SDG indicators that relate to the preselected targets impacted by projects. Examples of such keywords include “sustainable agriculture”, “hazardous waste”, and “water-use efficiency”. We filtered out indicators applicable only at broader scales (e.g., national GDP). This filtering process refined broad associations into specific impacts relevant to individual projects, which assisted with establishing a direct link between project activities and the SDG targets they affect. The full list of SDG indicators identified through this process is summarised in Section S2.

In Step 3, a questionnaire was developed based on careful logic such that the answer to each question determines whether the associated project-level decision has a positive (enabling), negative (inhibiting), or neutral (neither enabling nor inhibiting but can be improved or managed) impact on each of the SDG indicators identified in Step 2. Questionnaires were used for this purpose as these instruments (i) have been used successfully in other approaches assessing the impact of renewable energy projects on sustainability, as discussed in the Introduction, and (ii) provide a means with which the SDG indicators that are relevant to a particular renewable energy project can be identified in a repeatable fashion.

The questions were formulated so that they only required binary “yes” or “no” responses and were aligned with established organisational reporting standards, such as the Global Reporting Initiative (GRI) [15,16] and the Environmental Impact Assessment (EIA) [17]. This was done to ensure the approach is robust, easy to use, and widely applicable. In addition, great care was taken to streamline the questionnaire and minimise the number of questions required to address all the relevant SDG indicators identified in Step 2. We achieved this by consolidating similar questions and eliminating redundancies. This resulted in a comprehensive set of 63 Diagnostic Questions, including some specifically tailored to reflect the unique characteristics of different types of renewable energy sources. This allowed for a systematic evaluation of how specific projects may influence SDG targets at the project level. These questions, along with the SDG indicators they address and the mapping of the relationship between the Diagnostic Questions and SDGs, are provided in Sections S2 and S3, which adapted method from Supplementary reference [18–21].

In Step 4, the 63 Diagnostic Questions developed in Step 3 were grouped into coherent themes to make it easier to understand the relationships between the different types of factors that have to be considered during the development of renewable energy projects and their impact on the SDGs. This assists with elucidating the types of decisions that are likely to result in the biggest increases in sustainability. These themes were adapted from common themes in ex-ante assessment frameworks [10,22,23], which organise questions into relevant impact categories to anticipate potential outcomes. Specifically, we incorporated information from existing assessment frameworks from Australia, such as the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) [24] and the Large-Scale Solar Energy Guidelines [25,26], to define the terminology for each Project-level Decision Theme, thereby

increasing understanding and consistency with established contexts and practices. This resulted in the identification of the following 14 Project-level Decision Themes, with details of which 63 questions belong to each of these themes given in Section S4:

1. Emissions Management;
2. Material Use and Efficiency;
3. Water Management;
4. Waste Management and Circular Design;
5. Climate and Disaster Management;
6. Benefit Sharing;
7. Biodiversity;
8. Land Use;
9. Heritage Protection (Natural and Historical);
10. Heritage Protection (Indigenous);
11. Community Engagement;
12. Energy Access and Local Use;
13. Hazard Mitigation and Health;
14. Storage Management.

Although the process for identifying the types of decisions that impact each of the SDGs is presented in the context of renewable energy projects in this paper, it is sufficiently generic to be applied to other decision contexts, such as sustainable tourism [27] and business strategy development [28]. Applying the methodology to other contexts would require the selection of context-specific SDG targets and indicators, as well as the development of context-specific assessment questions. This flexibility underscores the potential of our methodology to contribute to sustainable development initiatives in diverse fields.

2.2. Identification of Relationship Between SDGs and Project-Level Decision Themes

A summary of the relationship between the 14 Project-level Decision Themes identified in Section 2.1 and the SDGs is shown in Figure 2. These relationships are manifest via the 63 Diagnostic Questions (Section S4) and are colour-coded by SDG. The thematic grouping of the Diagnostic Questions facilitates easier analysis of the types of decisions that have a positive, negative, or neutral impact on each of the SDGs by allowing stakeholders to focus on specific areas of interest. It also enables the broader sustainability impacts of relevant project-level decisions to be systematically considered during the project development process.

The lines in Figure 2 represent all *potential* relationships between the 14 Project-level Decision Themes and the SDGs. Whether these relationships are positive (i.e., enabling), negative (i.e., inhibiting), or neutral (i.e., no effect) is project-specific and is determined by the yes/no responses to the 63 Diagnostic Questions for a particular renewable energy project. To illustrate this, consider the question: “Does the project provide more alternatives for energy access?” to SDG 7 (Affordable and Clean Energy). As renewable energy projects inherently enable progress at the target level, a “Yes” answer indicates a positive impact, enhancing progress towards the goal. In contrast, a “No” answer is considered neutral—while it does not directly inhibit progress, it also does not contribute to it. Similarly, for SDG 12 (Responsible Consumption and Production), consider the question: “Does the project have a waste management plan?” Since waste generation during the energy production process naturally inhibits this goal, a “Yes” answer provides neutral feedback by mitigating negative impacts, whereas a “No” answer results in negative feedback due to the unaddressed adverse effects.

The approach for performing such assessments is summarised in Figure 3, including how to implement the approach in an MS Excel tool that has been developed for this purpose. This tool is freely available on GitHub (<https://bit.ly/4fflZwo>, accessed on 1 November 2024), including a detailed user manual, and facilitates the practical application of the proposed approach in a transparent, consistent, and easy-to-use fashion (see Section S5 for further details on the MS Excel Tool (Version 2411 Build 16.0.18227.20082), which includes a detailed list of functions in the user interface design).

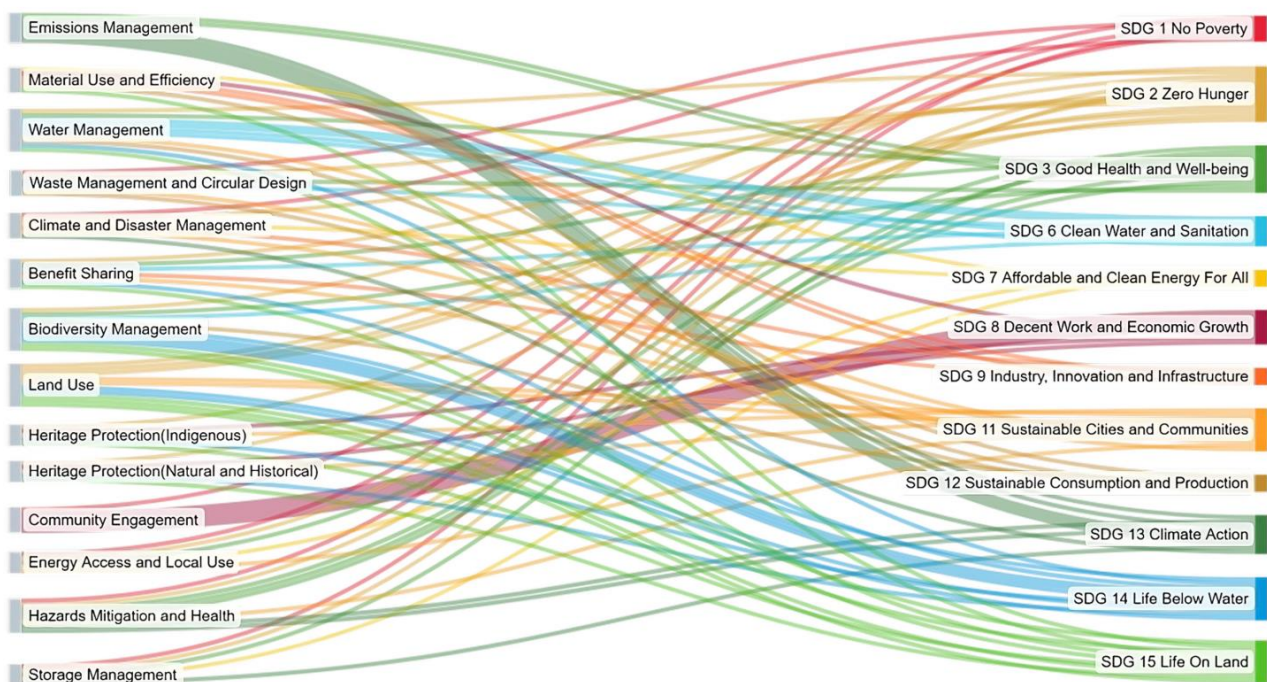


Figure 2. Developed relationships between Project-level Decision Themes and the SDGs. This consists of a Sankey diagram [29] showing which project-level decision themes impact different SDGs, colour-coded by SDG, enabling project-level decisions that require attention to be identified. Note that the widths of the lines indicate the number of questions in the developed questionnaire that either fall within the category of project-level decision themes or potentially cause an impact (positive or negative) on an SDG.

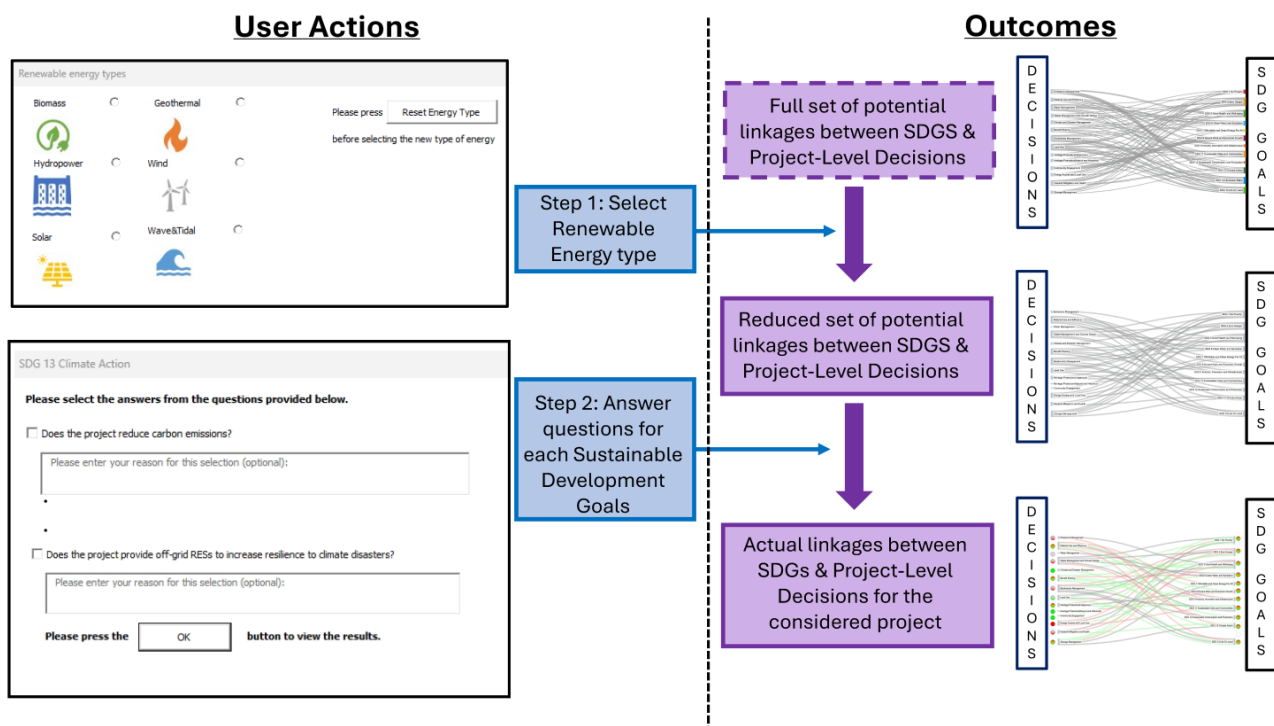


Figure 3. The proposed approach for identifying the relationships between Project-level Decision Themes and the SDGs for specific renewable energy projects, as well as screenshots of required user inputs via the MS Excel-based implementation tool.

The two steps required to implement the proposed approach in the MS Excel Tool are shown in the blue flowchart and the corresponding screenshots from the Tool on the left-hand side of Figure 3, labelled “User Action”. The “Outcomes” of each “User Action” are shown in the purple flowchart and corresponding illustrations on the right-hand side of Figure 3, labelled “Outcomes”.

Step 1 requires users to select the renewable energy type for the project under consideration by clicking on the appropriate radio button. The reason for this is that, as identified by Tian et al. (2024) [6], not all renewable energy types have the same impact on SDG targets. Consequently, the number of questions that need to be answered is tailored to the selected renewable energy source. For example, many onshore energy projects do not have an impact on SDG 14 (Life Below Water), which means that for this renewable energy type, the links associated with SDG 14 are removed. The corresponding reduction in the number of Diagnostic Questions also results in a reduction in the potential number of linkages between Project-level Decision Themes and the SDGs compared with those shown in Figure 2 (represented by the top Sankey diagram in Figure 3), as shown in the middle Sankey Diagram in Figure 3.

Step 2 requires users to provide yes/no answers to the Diagnostic Questions remaining after Step 1. As can be seen from the screenshot from the MS Excel Tool in Figure 3, this is achieved via tick boxes, with a tick indicating a “yes” response and the lack of a tick indicating a “no” response. Users also have the option to provide brief details on the responses provided, such as the rationale for the selected response or the type of action currently being undertaken. Based on this user input, the tool identifies which of the set of potential linkages between the Project-level Decision Themes and the relevant SDGs are positive, negative, or neutral, with the full mapping of project-level decision impacts on SDGs provided in Section S4. As can be seen by the bottom Sankey diagram in Figure 3, the sign of each connection is indicated by green (positive), red (negative), or grey (neutral) connections between Project-level Decision Themes and the SDGs.

- With the linkages identified as either positive, negative, or neutral, the MS Excel tool produces two summary output plots (Figure 4) that can be used for:



Figure 4. Illustrative result figures plotted by the MS Excel-based implementation tool. (a) presents the high-level sustainability assessments for the energy project under consideration. (b) presents the identification of project actions most suited to increasing sustainability.

- *High-level sustainability assessments (Figure 4a):* This consists of a plot indicating whether the renewable energy project under consideration has a positive (enabler—green), negative (inhibitor—yellow), or neutral (grey) impact on relevant SDGs for the seven aforementioned aspects of renewable energy production projects. This provides a high-level assessment of the sustainability impacts of the projects under consideration, which are likely to be unique for different projects due to differences in their specific contexts, such as type of renewable energy source and location. Information on

enabling impacts can be used to support the development of business cases and information on inhibiting impacts to identify areas that require attention.

- *Identification of project actions most suited to increasing sustainability (Figure 4b):* This consists of a Sankey diagram showing whether the project-level decisions have an enabling, inhibiting, or neutral impact on each of the SDGs, as shown by green, red, and grey connecting lines, respectively, in the sub-figure. This provides an indication of which project-level decision(s) can be targeted to increase the sustainability of the proposed project. The “traffic light” indicators on the right-hand side of the sub-figure summarise the impact on a particular SDG due to project-level decisions based on the questionnaire responses provided. A completely green traffic light indicates that all impacts on this SDG are enabling, a completely red traffic light indicates that all impacts on this SDG are inhibiting, a completely grey traffic light indicates that there is no impact on this SDG, and a traffic light with a mixture of colours indicates a proportionate combination of all of the above. The traffic light indicators on the left-hand side of the figure summarise the contribution of a particular Project-level Decision Theme to a particular SDG based on the questionnaire responses provided. The colouring of these traffic lights can be interpreted in a manner similar to the traffic lights on the right, as outlined above.
- The facilitation of stakeholder engagement, discussing both the sustainability impacts of proposed renewable energy projects and where the best opportunities for improving project sustainability lie.

3. Case Studies

To highlight the need for a consistent, transparent, and accessible approach to assessing the sustainability impacts of renewable energy projects, as well as the ability to link potential improvements in sustainability to project-level decisions, the proposed approach and tool are illustrated via three case studies implemented using a desktop study performed by the authors. The case studies are in different states in Australia, including New South Wales, South Australia, and Victoria, and consider different renewable energy sources, including biogas, solar, and offshore wind, as summarised in Figure 5. This significant diversity in the case studies was selected to illustrate how geographical information, project architecture, inherent technological characteristics, and natural environmental factors can affect project-level decisions related to the SDGs.

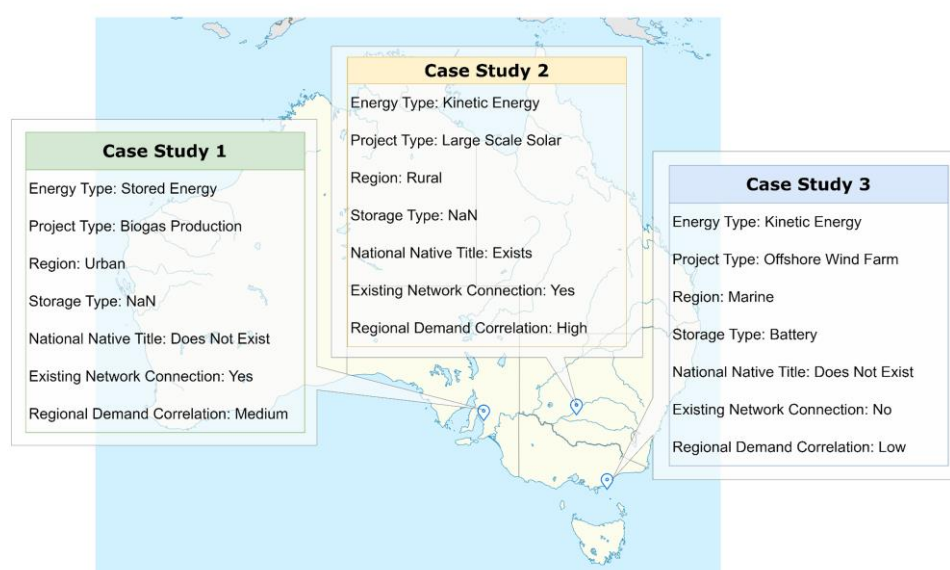


Figure 5. High-level summary of the key characteristics of the three illustrative case studies used to demonstrate the application and benefit of the proposed approach and MS Excel tool.

The first illustrative case study is based on a project in South Australia focused on biogas production from a wastewater treatment plant, where producing this type of renewable energy is highly feasible for integration into the existing energy supply chain. However, there are concerns regarding job displacement due to the new technology involved, unintentional emission leakage during conversion processes and from distribution pipelines [30], and chemical contamination of surrounding water bodies, which may have harmful impacts on protected marine areas [31,32].

The second illustrative case study is based on a large-scale solar project in New South Wales that has sparked controversy on social media [33,34]. The controversy stems from high construction costs, land disputes with the local community, construction delays, and multiple lawsuits involving stakeholders [35]. Moreover, it has been closely examined for its significant impact on biodiversity [36] and concerns regarding substantial ongoing water consumption [37]. Nonetheless, the low-carbon energy supplied by this project has amounted to 529 GWh of electricity supplied to 50,000 households [38], and therefore represents a particularly useful case study for exploring “carbon tunnel vision”.

The third illustrative case study is based on a proposed offshore wind farm in Victoria. Growth in offshore wind has recently emerged as a new trend in Australia’s green energy sector. However, potential concerns about this particular project have been raised in relation to significant job displacement in the fishing and shipping industries, as well as the need for large infrastructure to transmit and convert electricity [31]. Additionally, the potential impacts on marine and wildlife-protected areas are also uncertain and contentious [39].

As part of the demonstration of the application of the MS Excel tool to the three illustrative case studies, the relevant renewable energy sources were selected in Step 1 of the proposed process using the developed MS Excel Tool (see Figure 3). The resulting Diagnostic Questions were then answered by the authors in Step 2 using publicly available information for Case Studies 1 [40,41], 2 [42,43], and 3 [44]. Where insufficient information was available to answer the questions, reasonable assumptions were made. The full set of responses and assumptions for each case study is given in Sections S6–S8, respectively, with a summary of the main differences in the information used to answer the Diagnostic Questions given below:

- **Energy Type: *Stored energy versus kinetic energy.*** These energy types have different geographical impacts during source selection, distinct land impacts during the conversion processes, and varying requirements for overcoming intermittency in storage and distribution [45]. Case Study 1 uses stored energy (the storage of wastewater), while Case Studies 2 and 3 use kinetic energy (i.e., capturing readily available solar and wind energy).
- **Region: *Urban versus rural versus marine environments.*** The location of RESs plays a decisive role in local energy utilisation, influences the development status of existing infrastructure, and affects local populations differently [46]. Case Study 1 is located in an urban area, Case Study 2 in a rural area, and Case Study 3 in a marine area.
- **Storage Type: *Different storage methods, such as batteries.*** According to Environmental Impact Statement (EIS) assessments, when the capacity of battery storage exceeds certain thresholds, which vary by country, there are potential health and hazard impacts that need to be addressed [47]. For example, according to the Australian Standards [25], if a project includes battery energy storage with a capacity of more than 30 MW, the developer must undertake a preliminary hazard analysis. To investigate such potential impacts, it is assumed Case Studies 1 [48] and 2 [49] do not have storage onsite, whereas Case Study 3 has a battery energy storage system (BESS).
- **National Native Title: *Recognition of Indigenous land rights.*** Surveys conducted by the Australian Ministry of Energy (AMOE) indicate that many RESs in Australia are being built on traditional lands [50]. Recognising First Nations’ titles and protecting the land-use rights of Indigenous peoples should therefore be included in the development process of RESs. Also, engaging with local communities can boost the process of achieving public backing or certification, known as a “social license to operate”

(SLO) [51]. For Case Studies 1 and 3, the projects are not located on traditional land. For Case Study 2, the project is constructed on the land of First Nations' people, and there is a high possibility that the people living on this land may face relocation due to the construction of the project [52].

- Existing Network connection: *Infrastructure and material footprint*. Existing network connections are a critical factor influencing the material footprint during the construction of RESs. For example, offshore wind farms face substantial upfront costs and are criticised for lacking integration, necessitating additional supporting infrastructure to connect and transmit energy to the energy grid [53]. For Case Studies 1 and 2, both projects are connected to the existing grid. However, for Case Study 3, a new connection to the grid needs to be established.
- Regional demand correlation: *Local energy demand*. According to classifications adapted from [50], a higher degree of regional demand correlation indicates a greater need for local clean energy supply. As previously mentioned, the location of RES plants directly influences regional energy needs, affecting the share of green electricity supplied to the area. For Case Study 1, as the plant is located in an urban area within close proximity of the existing grid, the local demand for green electricity is considered medium. For Case Study 2, the plant is located in a rural area, and the correlation with demand for local energy is considered high. For Case Study 3, as the location is offshore and the main purpose of green energy generation is to support and supply the national grid, there is negligible correlation between local demand and the use of this type of renewable energy.

4. Results and Discussion

To demonstrate the differences in the high-level impact on the SDGs of the three illustrative case studies considered, Section 4.1 presents a sustainability impact assessment using the tool's output (see Figure 4a). Then, to show the benefits of linking SDG impacts to project-level decisions, Section 4.2 compares the impact of project-level decisions on the SDGs (see Figure 4b). It should be noted that the case study results do not represent sustainability assessments of the three actual renewable energy projects on which the case studies are based. They are simply intended to illustrate the usefulness of the sustainability assessment framework and tool introduced in this paper, rather than provide commentary on the proposed projects themselves.

4.1. Impact of Renewable Energy Projects on SDGs

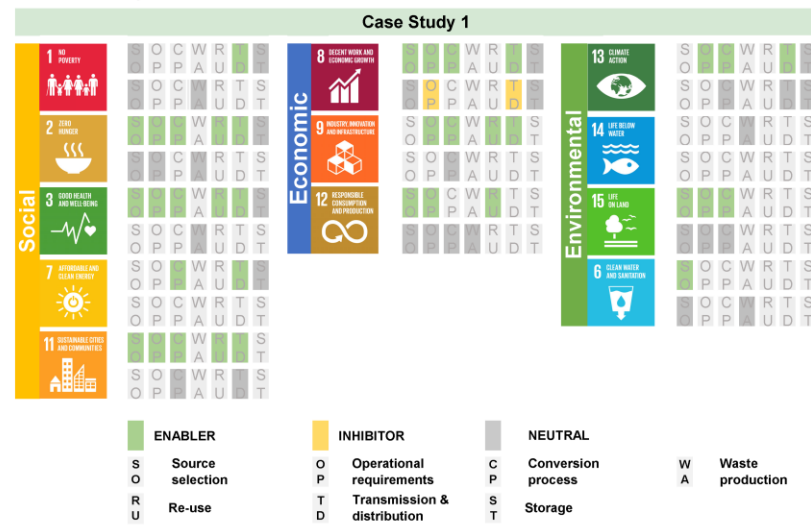
Figure 6 shows the impact of each of the three case studies on the SDG targets. As can be seen, there is a large difference in the impacts on the SDG targets across the three case studies. This is not only due to the differences in the types of energy systems but also the specific choices made for each project.

Among the case studies, Case Study 3 has the highest number of positive impacts on overall SDG targets, while Case Study 2 has the most negative impacts. Note that these findings do not comment directly on the magnitude of the impacts, just the number of connections identified based on the case study questionnaires.

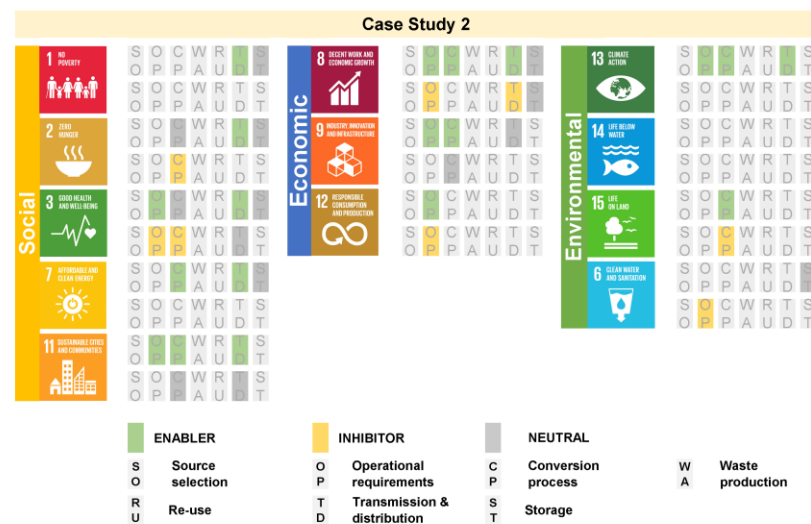
Considering social SDG targets, Case Study 1 has the highest number of positive impacts, as the project significantly contributes to the energy-food nexus and could further enhance sustainable agriculture. Conversely, both Case Studies 2 and 3 have negative impacts on food production; however, Case Study 2 further negatively affects native vegetation due to construction-related clearing, raising concerns about habitat disruption and wildlife protection.

Considering economic SDG targets, Case Study 3 has the highest number of positive impacts, as this project plays a critical role in boosting the local economy and providing more job opportunities. In contrast, Case Studies 1 and 2 negatively impact the job market, with Case Study 2 also demonstrating inefficiency in material use (see Sections S6 and S7).

(a) Case Study 1



(b) Case Study 2



(c) Case Study 3

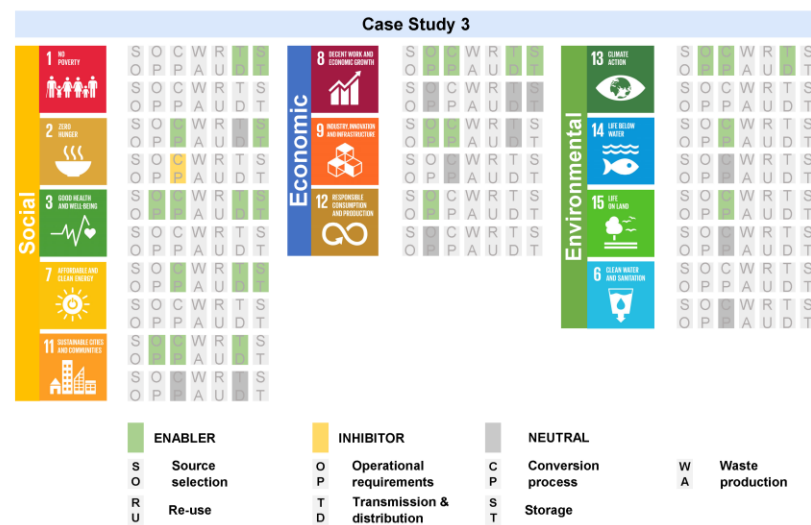


Figure 6. Summary of high-level SDG impacts for the three illustrative case studies.

Considering environmental SDG targets, Case Studies 1 and 3 both have a similar number of positive impacts, such as reducing carbon emissions and protecting biodiversity, although Case Study 1 could improve efforts in nearby marine wildlife protection areas. The downsides for Case Study 2 include interconnected social and environmental impacts from land occupation and substantial water usage across multiple stages of the renewable energy generation process.

While the above results are for three illustrative case studies, they demonstrate that the sustainability assessment of renewable energy projects is complex and can be affected by many different factors, highlighting the need to perform such assessments on a case-by-case basis. In addition, they demonstrate the value of the proposed approach and tool, as they enable detailed high-level sustainability assessment to be performed relatively easily by answering “yes” or “no” to 63 (or fewer) carefully designed Diagnostic Questions based on the best available information, as evidenced by the desktop study of publicly available documents conducted here.

However, although these results indicate which SDGs are affected and at which points in a project’s supply chain, they do not suggest how sustainability can be improved or altered, highlighting the need to also connect these types of assessments with project-level decisions.

4.2. Impact of Renewable Energy Project on SDGs

Figure 7 illustrates significant differences in the positive, negative, and neutral connections between Project-level Decision Themes and the SDGs across the three case studies considered, which is attributable to both the type of renewable energy and the specific project configurations, as reflected in the questionnaire responses (Sections S5–S7). In addition, the results of the three case studies demonstrate some of the potential key findings the proposed approach can provide for a renewable energy project assessment, as discussed below.

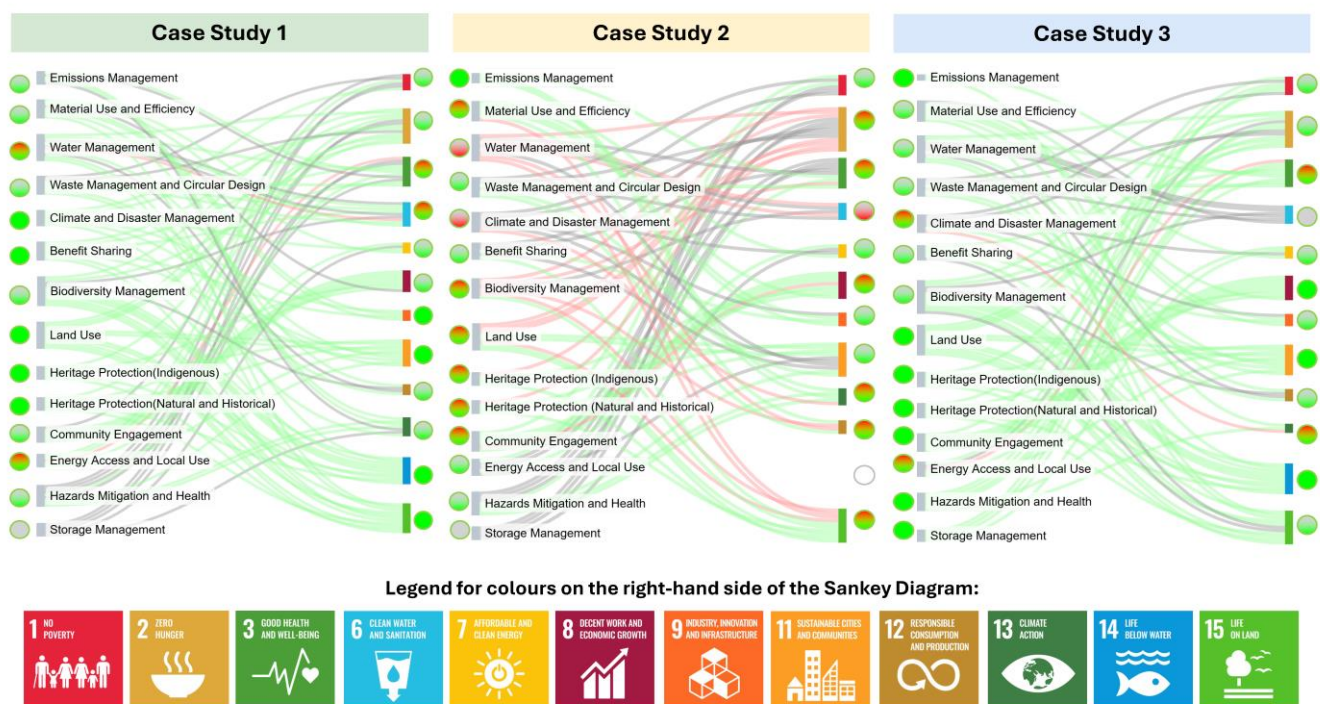


Figure 7. Impact of project-level decision themes on relevant SDGs for the three illustrative case studies considered. The “traffic light” indicators on the right-hand side of the figure summarise the impact on a particular SDG due to project-level decisions. The traffic light indicators on the left-hand side of the figure summarise the contribution of a particular project-level decision theme to the overall impact of a particular SDG.

In Case Study 1, the “Storage Management” project-level decision appears to be potentially underutilised because it has no positive impact on the SDGs, as indicated by its fully grey traffic light. The existence of multiple neutral connections highlights the potential role that pre-implementation storage plans could play in enhancing multiple SDGs. For example, if the project had included a large-scale battery on site, with a portion of demand dedicated to local use, it could provide a secure, reliable share of energy for nearby communities, enabling a direct positive impact on SDG 1 (No Poverty) and SDG 7 (Affordable and Clean Energy). Instead, the project is connected directly to the grid and does not directly contribute to local energy security. Therefore, implementing effective storage management can serve as a strong enabler of sustainable development when planned and executed properly for this particular case study.

Insight into which project-level decisions have already fulfilled sustainability objectives can also be gained by examining the traffic lights associated with the SDGs. For example, both SDG 14 (Life Below Water) and SDG 15 (Life on Land) received a fully green traffic light. This indicates that the combined effect of multiple project-level decisions—such as biodiversity management, benefit sharing, and heritage protection—was well-coordinated, highlighting areas of strong achievement.

In Case Study 2, multiple project-level decisions have resulted in several SDGs being marked as half green and half red on the right-hand side of Figure 7, indicating a mix of enabling and inhibiting impacts within the same categories. Poor performance in areas such as water management, waste management and circular design, climate and disaster management, and biodiversity management has led to these mixed outcomes. This demonstrates that when considering the project’s sustainability as a whole, it is crucial to make correct decisions across multiple domains rather than selectively focusing on certain goals. Additionally, the interconnection of these decisions highlights the necessity for different stakeholders to work collaboratively, ensuring that efforts in one area support progress in others. Notably, SDG 2 (Zero Hunger) is significantly impacted in Case Study 2, as indicated by the larger number of red connections from the project-level decisions to this SDG in Figure 7. This corresponds to the fact that land occupancy is one of the most controversial issues associated with this case study [33]. Multiple project-level decisions can aid in better handling this issue, including improvements in water management, land use planning, and heritage protection (both Indigenous and natural/historical). Additionally, SDG 14 (Life Below Water) does not apply to this case study, as there are no decisions or impacts related to marine protection or wildlife.

In Case Study 3, SDG 6 (Clean Water and Sanitation) is fully grey, with project-level decisions related to water management, waste management and circular design, and biodiversity management all having no impact on that goal. This highlights that additional actions in water and biodiversity management could result in a positive impact on SDG 6. Additionally, there are opportunities to increase the sustainability of the project by adopting improved climate and disaster management practices, which would have a positive impact on SDG 13 (Climate Action). This SDG could also be enhanced by connecting the project to off-grid infrastructure to aid surrounding communities, which is currently not the case as it is directly connected to the national grid.

The above results provide an indication of the complexity of the relationships between project-level decisions and the SDGs and how these can be significantly different depending on specific local project conditions and circumstances. This highlights the need for a project-specific approach and tool that can be applied easily and consistently to different projects, such as the one proposed in this paper. The results also highlight the value in linking project-level decisions with each of the SDGs, both in terms of the insights gained about which decisions contribute to different SDGs in a positive, negative, or neutral manner and, more importantly, the identification of actions that can be undertaken to improve the sustainability of renewable energy projects, thereby assisting with overcoming carbon tunnel vision.

5. Summary and Conclusions

This paper presents a novel high-level approach to evaluating the sustainability of renewable energy projects and to identifying which project-level decisions influence each SDG. It also provides a user-friendly MS Excel tool for implementing this approach in a consistent and easy-to-use fashion. A key attribute of the approach is that it is deliberately parsimonious, enabling the relationship between project-level decisions and relevant SDGs to be determined by answering fewer than 63 diagnostic yes/no questions. As a result, the approach is transparent and easy to implement in practice while providing a detailed, high-level sustainability assessment and identifying the linkages between project-level decisions and specific SDGs. This enables project developers and relevant stakeholders to better understand and mitigate their projects' positive, negative, and neutral impacts on the SDGs during the planning or feasibility study stages of a project. It also assists with identifying which actions can be taken to increase the broader sustainability of renewable energy projects beyond the goal of reducing carbon emissions, thereby overcoming carbon tunnel vision. Without overcoming carbon tunnel vision in renewable energy project development, we risk overshadowing biodiversity needs [54], ignoring social impacts [55], and missing out on synergies in planning decentralised energy security, such as improving resilience to natural disasters [56].

The application and value of the approach and tool were demonstrated in three illustrative case studies located in different geographical regions of Australia, each based on different types of renewable energy sources. While based on real projects, the case studies were constructed to provide varied contextual factors for the sake of demonstrating the proposed approach and tool, rather than providing sustainability assessments of the actual projects on which the case studies are based. This was achieved via a desktop study conducted by the authors by using publicly available information to answer the diagnostic yes/no questions. The results of the illustrative sustainability assessments show that the different case studies impact the SDGs differently and that different project-level decisions emerge as most influential depending on the specific project context. This highlights the need to perform such assessments on a project-by-project basis, as well as the value of the proposed approach and tool.

As the MS Excel tool for implementing the proposed approach is easy to use and produces outputs that relate a range of project-level decisions to all relevant SDGs, it facilitates dialogue among diverse stakeholder groups, enabling them to share their perspectives on specific projects. Providing a common platform helps stakeholders make more informed decisions to achieve a larger number of green “traffic lights” for the SDGs. The fact that the tool is developed in MS Excel, is freely available on GitHub and only requires answers to yes/no questions means that it is easily accessible and that practitioners can contribute feedback and submit suggestions for future updates and enhancements.

Future work includes the possibility of conducting more quantitative and statistical analyses by integrating the tool into detailed modelling approaches, such as System Dynamics models [57], reinforcement learning, and optimisation [58,59]. This will allow the framework developed in this paper, and the connections identified between project-level decisions and SDGs, to be used to identify the magnitude of sustainability impacts caused by renewable energy projects.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su162410871/s1>. GitHub, Tool S1: Diagnostic Tool for Assessing and Increasing the Sustainability of Renewable Energy Projects. Section S1. High-level overview of potential linkages between the SDGs and major renewable energy types with supporting literature. Section S2. The full list of SDG indicators and their corresponding questions. Section S3. The complete mapping of the relationship between Diagnostic Questions and SDGs. Section S4. The comprehensive relationships between the 14 Project-level Decision Themes and the 63 Diagnostic Questions. Section S5. Detailed functions of the MS Excel diagnostic tool. Section S6. Full set of responses to all Diagnostic Questions for Case Study 1. Section S7. Full set of responses to all

Diagnostic Questions for Case Study 2. Section S8. Full set of responses to all Diagnostic Questions for Case Study 3.

Author Contributions: Conceptualisation, J.T., S.C., H.R.M., A.C.Z. and J.H.; methodology, J.T., S.C., H.R.M., A.C.Z. and J.H.; software, J.T., S.C. and A.C.Z.; validation, S.C. and H.R.M.; writing—original draft preparation, J.T., S.C. and H.R.M.; writing—review and editing, S.C., H.R.M., A.C.Z. and J.H.; visualisation, J.T. and H.R.M.; supervision, H.R.M., S.C., A.C.Z. and J.H.; project administration, H.R.M. All authors have read and agreed to the published version of the manuscript.

Funding: The authors would like to thank the Future Fuels Cooperative Research Centre for funding this work through project RP1.2-04. The authors would also like to thank the three anonymous reviewers of this paper, whose comments have improved its quality significantly.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: Data are contained within the article and Supplementary Materials.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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