Resilient and Sustainable Energy Infrastructure: A Systematic Literature Review Protocol

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ABSTRACT

Background: Critical infrastructure resilience and sustainability are key components of both the 2015 Sendai Framework for Disaster Risk Reduction, as well as the 2015 Sustainable Development Goals (Panda & Ramos, 2020). The recent passing of the 2021 Security Legislation Amendment (Critical Infrastructure) Bill in Australia, coupled with the lack of a governing document at the state level in Tasmania, necessitates a review to uncover the governance settings, which will aide in increasing the resilience and sustainability of energy infrastructures in Tasmania.

Methods/Design: Following the 2015 PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols), the review will focus on scholarly sources that address the governance of energy infrastructures. An initial deductive data extraction template has been created to help structure data extraction from included studies. In addition to governance settings, secondary evidence will be sought regarding interruptions to energy infrastructures; policy problems and solutions; and resilience and sustainability definitions. Should other themes emerge, the data extraction template will be updated.

Discussion: Findings from this review will contribute to a more complete understanding of how the resilience and sustainability of energy infrastructures may be increased via deeper knowledge of their governance settings. Tasmanian policy-makers, practitioners, industry specialists, and researchers may use this research to inform and enhance their decision-making on this important topic.

Keywords: Systematic literature review, resiliency, sustainability, energy, infrastructure

1. Background

The purpose of this article is to register a systematic literature review (SLR). This process will be informed by the PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist (Moher et al., 2015). We identify energy infrastructure as the subject matter to be studied. This review seeks to explore a range of exposure to outcome pathways, always beginning with energy infrastructure, followed by identifying governance settings, the policy problem(s) identified, and the solution(s) provided. We will initially investigate key themes within three domains: governance settings, resilience

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and sustainability, and policy problems and solutions. We expect that other themes and domains will emerge inductively throughout the course of the review and will document these as they emerge. This review has the overarching goal of providing actionable research for policy-makers, practitioners, industry specialists, and researchers.

The United Nations Office for Disaster Risk Reduction (UNDRR) (2020) notes that there is no universally agreed definition for what characterizes critical infrastructure (CI) (Panda & Ramos, 2020). While the Sendai Framework has an emphasis on CI, it does not provide a definition, leaving it instead for national governments to determine the CI elements to include when reporting on progress (Panda & Ramos, 2020). The Australian Government, for example, identifies the following sectors as CI; Communications, Financial Services and Markets, Data Storage or Processing, Defence Industry, Higher Education and Research, Energy, Food and Grocery, Health Care and Medical, Space Technology, Transport (including aviation and maritime assets), and Water and Sewerage (Department of Home Affairs, 2021). Additionally, the United Nations, in their document 'Making Critical Infrastructure Resilient: Ensuring Continuity of Service - Policy and Regulations in Europe and Central Asia' state that CI resilience is a key component of the 2015 Sendai Framework for Disaster Risk Reduction and that the sustainability and resilience of CIs (in particular energy) is a key goal (9) of the 2015 Sustainable Development Goals (Panda & Ramos, 2020).In addition to this definitional ambiguity, increasing the resilience and sustainability of CIs, such as energy, is compounded further by the multitude of risks involved. These risks include cyber-attacks, such as the 2015 and 2017 attacks on the Ukrainian electrical grid (Øien et al., 2018) and those associated with climate change (Varianou Mikellidou et al., 2018). Energy infrastructures face a myriad of costly and wide-ranging ramifications from these and other emerging risks. The Sendai Framework Monitor reported that, in 2018 alone, 1,889 infrastructure assets in 20 countries in Europe and Central Asia were damaged or destroyed as a result of disasters, amounting to direct economic losses of over $3 billion (UNDRR, 2020). The interconnectedness across, and interdependencies between, CIs also impact their resilience and sustainability.

Newlove-Eriksson et al. (2018) liken CIs to the arteries and veins of humans, without them, it would be impossible for CIs to function. This is why infrastructures such as those identified by the Australian Government are labelled as critical. Indeed, some CIs have been labelled as more critical than others. These infrastructures have been defined as 'lifeline' infrastructure. According to the 2013 US National Infrastructure Protection Plan (NIPP), lifeline infrastructure comprises water, energy, transportation, and communications (Department of Homeland Security, 2013). Four of the twelve sectors identified by the Australian Government, water, electricity, transportation, and communications are identified as lifeline infrastructure because they are vital to all other sectors. As such, Lewis (2006) classifies them as 'Level 1' infrastructure, taken as infrastructure upon which all others depend. As the UN refrains from defining CI, national governments, in turn, have created their own definitions of what constitutes a CI. The Australian Government lists CIs as:

> 'those physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact the social or economic wellbeing of the nation or affect Australia's ability to conduct national defence and ensure national security' (Department of Home Affairs, 2015, p. 3).

Energy is a leading lifeline infrastructure. Molyneaux et al. (2012) note that as electricity is essential for other infrastructure systems to function, when power outages or fuel shortages occur, 'the entire industrialized economy comes to a standstill.' In addition to interdependencies between different CIs, energy infrastructures are also impacted by their interconnectedness across jurisdictional boundaries. Newlove-Eriksson et al. (2018) point out that although mostly developed and built at the national level, infrastructures share interdependencies, and interconnections, with other countries. Therefore, when they fail in one location, they are likely to have negative consequences for neighbouring jurisdictions as well. An example of this is the 2003 Italian power outage. On the 28th September, 2003, the European grid was hit with a series of outages, starting with line flashovers to trees and line trips on the Swiss electricity transmission grids, close to the Italian border, and culminating with the separation of the entire Italian system from the Union for the Co-ordination of the Transmission of Electricity grid (Sforna & Delfanti, 2018).The continuous function of energy infrastructure is becoming increasingly important as the energy transition from fossil fuels to renewable sources intensifies. Over the last decade there has been a significant increase in the proliferation of renewable energy generation sources including as solar photovoltaic and wind (Yan et al., 2018). As a result of their irregular and nonsynchronous condition, this change provides another layer of complexity for governing resilient and sustainable energy infrastructures.

The 2016 energy blackout in South Australia, Australia, serves as a contemporary example to the challenges in this transitional phase of energy generation. A severe storm impacted South Australia on September 28, 2016. It damaged several remote transmission towers and resulted in the loss of 52% of South Australia's wind generation within minutes (Yan et al., 2018). In 2016, South Australia generated roughly 2,900 MW peak load, with 1,600 MW coming from wind and 730 MW from solar generation. In the time leading up to the blackout, solar accounted for nearly 50% of total load demand in South Australia, leading to accusations of renewables being the culprit for the blackout (Yan et al., 2018). The island state of Tasmania, also in Australia, suffered its own energy crisis in 2016. A coupling of risk events, extremely low rainfall in 2014-2015 and an energy supply deficit due to a fault shutting down the Basslink cable connecting Tasmania to the Australian mainland, led to a six month energy crisis in the state (Wyrwoll & Grafton, 2021). With the cable out of service, and system-wide storage levels down to 12.5%, major energy consumers were required to scale back their energy consumption, and expensive diesel was imported to plug the energy gap (Wyrwoll & Grafton, 2021).

These challenges warrant a systematic literature review to collect, synthesise, and map exiting scholarly evidence about the effects of different governance settings on the resilience and sustainability of energy infrastructures. A systematic literature review will identify synergies for improvement as well as potential gaps where further research can be conducted. To achieve this goal, the review will concentrate on three major tasks. Firstly, it will search through databases for scholarly evidence to answer the research question. Secondly, it will determine the definitions offered for resilience and sustainability within the context of energy infrastructures with the aim of providing a workable definition for this study. Thirdly, the review will provide an evaluation of the quality of the included studies for the review. From this, a governance framework will be developed to enhance the governance of resilient and sustainable energy infrastructures in the state of Tasmania and more broadly.

2. Methods/Design

2.1 Protocol design

The methodological approach of this review is known as a systematic literature review. A systematic literature review allows for the identification of the current literature (Piper, 2013). Petticrew and Roberts (2008) assert that systematic reviews are a method of understanding and interoperating large knowledge bodies, which seeks to answer questions regarding what works, and what does not. They further point out that systematic reviews are helpful in mapping areas of uncertainty, of tracking down areas where little research has been conducted (Petticrew &

Roberts, 2008). Policy-relevant systematic reviews aim to clearly deliver findings in order to highlight policy issues and challenges, and/or to develop policy theories (Oliver et al., 2018). Policy decision-making, informed by evidence, requires policy-makers being able to use reviews, and researchers being able to publish them. The capacity to achieve this needs to be matched with the relevance and timeliness of evidence to inform policy problems (Oliver et al., 2018).

2.2 Research question

The research question that this review seeks to answer the following question
Q1: How can governance approaches enhance the resilience and sustainability of energy infrastructures?

2.3 Eligibility criteria

This review will include peer reviewed articles and reviews only. This is in line with the aim of reviewing the scholarly material to answer the research question. The protocol may be updated at a later date to include grey literature if required. All studies with English abstracts will be screened in the Title-Abstract screening stage. Full non-English studies, if they comply with the inclusion criteria, will be determined due to the financial cost of translation. There will be no time restrictions. Studies will have to refer to enhancing the resilience and sustainability of energy infrastructures to be included. These infrastructures can be across the domains of; electricity, generation, transmission and distribution, and retail.

2.4 Information sources

The Web of Science (WoS) and Scopus databases will be used for the search strategy. Daigneault et al. (2014) identifies that PhD candidates may struggle with the enormity of conducting a systematic literature review. It is with this is mind that we have limited the review to searching within two major databases only. As both Scopus and WoS are the largest and most comprehensive bibliographic databases (Pranckutė, 2021), we recognise that further databases may have to be added should this review be updated at a later date. Both Scopus and WoS provide the ability to conduct complex searches by using their advanced search option. These searches can be performed by exact phrases, truncated words, or by employing wildcards (Pranckutė, 2021), the use of which is similar across both databases.

2.5 Search strategy

The reporting of the search strategy is in line with the update to the PRISMA methodology (Page et al., 2021). This update requires that full strategies for every database searched within may be produced. Details of the strategy can be located in table 1 below.

Table 1. Full search strategy.

DATABASE	STAGE	AREA	SEARCH STRING
Web of science	1.	TI	(resilien* AND sustainab*)
	2.	TI	(centrali* OR decentrali* OR "top down" OR "bott om up" OR "command and control" OR hierarch* OR grassroot* OR polycentric OR monocentric OR govern OR governs OR governed OR governance OR governin g)
	3.	TI	(energ* OR hydro* OR nuclear OR coal OR gas OR therm* OR biomass OR wind OR oil OR solar OR steam OR renewable* OR smart OR tidal OR tide OR geothermal OR "fossil fuel" OR "fossil fuels" OR diesel OR petrol* OR electric* OR power OR grid* OR microgrid* OR battery or batteries)
	4.	AB	(resilien* AND sustainab*)
	5.	AB	(centrali* OR decentrali* OR "top down" OR "bott om up" OR "command and control" OR hierarch* OR grassroot* OR polycentric OR monocentric OR govern OR governs OR governed OR governance OR governin g)
	6.	AB	(energ* OR hydro* OR nuclear OR coal OR gas OR therm* OR biomass OR wind OR oil OR solar OR steam OR renewable* OR smart OR tidal OR tide OR geothermal OR "fossil fuel" OR "fossil fuels" OR diesel OR petrol* OR electric* OR power OR grid* OR microgrid* OR battery or batteries)
	7.	Combine #1 AND #2 AND #3 AND #4 AND #5 AND #6	
	8.	Refine by Articles and Reviews Only	

Scopus	1.	TITLE-ABS	(resilien* AND sustainab*)
	2.	TITLE-ABS	(centrali* OR decentrali* OR "top down" OR "bott om up" OR "command and control" OR hierarch* OR grassroot* OR polycentric OR monocentric OR govern OR governs OR governed OR governance OR governin g)
	3.	TITLE-ABS	(energ* OR hydro* OR nuclear OR coal OR gas OR therm* OR biomass OR wind OR oil OR solar OR steam OR renewable* OR smart OR tidal OR tide OR geothermal OR "fossil fuel" OR "fossil fuels" OR diesel OR petrol* OR electric* OR power OR grid* OR microgrid* OR battery or batteries)
	4.	Combine #1 AND #2 AND #3	
	5.	Refine by Articles and Review	

2.6 Data management and selection process

The data will be managed in the reference management software Endnote. Results will then be exported to the software Covidence for screening and data extraction. All data will be managed and stored according to University of Tasmania's 2019 Management of Research Data Procedure.

One researcher will conduct title and abstract screening in accordance with the eligibility criteria. However, two 5% pilot screening studies will be conducted between three researchers and inter-rater reliability will be determined using Fleiss' Kappa. Upon reaching 80% inter-rater reliability, the single researcher will begin screening. Kappa coefficients are interpreted using the guidelines outlined by Landis and Koch (1977), where strength of the kappa coefficients is interpreted in the following manner: 0.01-0.20 slight; 0.21-0.40 fair; 0.41-0.60 moderate; 0.61-0.80 substantial; 0.81-1.00 almost perfect. The two other researchers conducting the pilot study will have no less than three years' research experience.

A random article generator has been developed in Microsoft Excel to remove bias from the pilot screening process. Discrepancies in the screening process will be resolved between the three screeners for clarity, and to ensure consistency.

2.7 Data extraction

Data extraction will be conducted in Covidence according to a pre-designed data extraction template. The data template in Covidence can be amended during title/abstract screening, full readings, and any time during data extraction (Covidence, 2021). If new themes are identified, then the template can be updated to capture them. Studies that have already been extracted will go through extraction again, but only to search for the newly identified theme. This allows for new themes to emerge. The initial template is located in Table 2 below.

Table 2. Initial data extraction template.

Data item	Information sought	Options
1.	Country where study is located?	Australia; China; USA; UK; Germany; Other
2.	Methods used	Qualitative; Quantitative; Mixed
3.	Are study funding sources declared?	Yes; No
4.	Are conflicts of interest declared?	Yes; No
5.	Are infrastructures other than Energy/Water discussed?	Yes; No
6.	If so, which ones?	Water; Energy; Transport; Communication, Health, Food and Grocery; Space, Defence, Banking and Finance, Data and the Cloud; Other
7.	How is infrastructure referred?	interconnected; interdependent; coupled, linked, joined, interacting; Not referred to; other
8.	How is infrastructure disrupted?	Fire; Flood; Earthquake; Hurricane; Tsunami; War; Terrorism; Cyber; Drought; Other
9.	Is resilience defined?	Yes; No
10.	If so, how?	Author, year
11.	Is there more than one definition used?	Yes; No

12.	Who By?	Author, year
13.	Is sustainability defined?	Yes; No
14.	Who By?	Author, year
15.	Is there a policy problem identified?	Climate change; infrastructure age; urbanisation; globalisation; extreme events; Capitalism/neoliberalism; terrorism
16.	Other?	Yes; No
17.	What is it?	
18.	More than one?	Yes; No
19.	Which?	
20.	Is there a solution offered?	Yes; No
21.	What is it?	
22.	Is solution specifically tied to an international agreement?	Sendai Framework; Paris Agreement; Sustainable development Goals; Hyogo Framework Kyoto Protocol; Millennium Development Goals; Other
23.	Does solution emphasise collaborative or cooperative approaches?	Yes; No
24.	Are governance settings identified in solution?	Yes; No
25.	Which ones?	Centralised; decentralised; polycentric; monocentric; adaptive; transformative; collaborative; networked; hybrid; other
26.	Does the study refer to policy instruments	Yes; No

	to support solution?	
27.	If yes, which ones?	Financial; legal; regulatory; mixed; other

2.8 Outcomes and priorities

The primary outcome will be identifying how governance settings affect the resilience and sustainability of energy infrastructures. In addition to this, there are a number of secondary outcomes for which information will be sought. They are:

1. How resilience is defined;
2. How sustainability is defined;
3. The disruption to infrastructure;
4. The "connectedness" of infrastructures;
5. Policy problems and solutions;
6. Whether solutions align with international agreements, and;
7. The rate of collaborative or cooperative approaches offered in solutions.

2.9 Quality Assessment and Risk of Bias

Quality appraisal is a key component of evidence-based practice and decision-making (Rosella et al., 2016). The notion of quality is complex. It can be applied in a narrow-purpose/ situation specific judgements or in a genetic manner (Gough, 2007). Therefore, it may be assessed against generic quality criteria, or against tighter purpose-bound criteria (Gough, 2007). This project will not exclude individual studies owing to the quality judgements made on them; they have been included in the review due to them passing the screening stage. However, it will provide a quality assessment summary.

Risk of bias in individual studies will be assessed using the Public Health Ontario Meta-tool for quality appraisal (PHO MetaQAT). The appraisal tool comprises four spheres: relevancy, reliability, validity, and applicability (Rosella et al., 2016). The tool is designed with transparency at the forefront. Each sphere provides space for long-form written answers for justification. This allows for contextual factors to be considered when capturing the strengths and weaknesses of items (Rosella et al., 2016).

Publication bias has been reduced due to: (1) broad spectrum search strategy employed; (2) the protocol for utilising dual databases (Scopus and Web of Science); (3) two rounds of pilot screening processes conducted by three experienced researchers; and (4) no time limit set for studies within the search; (5) the inclusion of non-English studies if they are relevant; and (6) by contacting authors if access to studies is impeded.

Bias is impossible to avoid. We have listed the known biases as we understand them. An update of this research project could attend to the known biases we have listed. This would increase the rigor and value of the results. Additionally, twin screeners could be employed throughout the entire screening process. As with most research projects however, there is an expected timeframe and a finite budget to draw on. We believe we have adequately addressed the known biases evident in this research project.

2.10 Presenting the data

Due to the anticipated heterogeneity of the included studies, a statistical analysis of the data may not be appropriate. However, subgroup analysis will be conducted on sources of homogeneity arising from dichotomous questions in the data extraction template. For qualitative outcomes, a thematic summary will be employed to report on eligible studies. This approach involves the identification followed by extraction of common themes from qualitative narratives. It allows the review to classify studies into appropriate thematic groups for the reader (Snilstveit et al., 2012). The discoveries from each thematic group are then examined and synthesised separately with interpretive narrative syntheses (Snilstveit et al., 2012). This approach will provide a format to better understand not only the governance settings that lead to more sustainable and resilient energy infrastructures, but also capture the common and individual stressors and risks they face. The findings will then be summarised and reviewed for their consistency and to ensure they are appropriate regarding the investigation.

2.11 Confidence in cumulative evidence

We will use the Grading of Recommendations Assessment, Development and Evaluation - Confidence in Evidence from Reviews of Qualitative research (GRADE-CERQual) approach. GRADE-CERQual provides guidance on how to assess the amount of confidence that should be placed on systematic reviews of qualitative research (Lewin et al., 2018). It has been created in order to aid the use of outcomes from qualitative evidence syntheses in decision-making, together with guidance on policy development and formulation (Lewin et al., 2018).

3. Discussion

This protocol has set out the conditions in which a systematic literature review will be conducted. Globally, CIs are facing threats and stressors that their designers did not consider. Governments worldwide are formulating and implementing policies to increase the resilience and sustainability of their interdependent CI(s). Many of these policies are being formulated in tandem with policies aiming to reduce the effects of climate change. A systematic review will contribute to this knowledge by providing an evidence base for policies that increase the resilience and sustainability energy infrastructure(s). This will be beneficial to policy-makers, disaster resilience practitioners, and the owners and operators of CIs.

The limitations of this review include that it will suffer from selection bias as it is only including peer reviewed scholarly studies. Although a twin-pilot screening process will be used for inter-rater reliability and checked against Fleiss's Kappa, the study may be accused of further selection bias through the use of only one screener. In addition, there are other metrics with which to measure inter-rater reliability. By using only infrastructures identified by the Australian Government as critical, we introduce additional bias by not including infrastructures that other nations may identify as critical. Furthermore, and importantly, by limiting the databases used and omitting grey literature, we introduced research bias.

Following energy infrastructures, we will submit protocols and commence systematic literature reviews on the remaining identified 'lifeline' CIs: water, communication, and transport. The results from each 'lifeline' CI will then be combined so that synergies and common themes can be identified. With the recent passing of the amended Security of Critical Infrastructures (SOCI) act in the Australian Senate, and the State of Tasmania's absence of critical infrastructure protection legislation, this research will further inform the Tasmanian State Government as it develops its CI security agenda.

4. Conclusion

In this article, we have set out the conditions for the systematic literature review to be undertaken. Should there be any deviations from this protocol throughout the course of the research project, we will document and report them to ensure that the process remains as rigorous and transparent as possible.

Declarations

Competing/ conflict of interests: The Authors report none.

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Ethics approval and consent to participate: This is a systematic literature review protocol; therefore, ethical approval is not applicable.

Consent for publication: All authors have reviewed and consent to this publication.

Availability of data and material: There is currently no data available for this review.

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