DEVELOPING IMPLEMENTABLE POLICIES TARGETING SUSTAINABLE BUILDING CONSTRUCTION THROUGH INTERNATIONAL POLICY DIFFUSION

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ABSTRACT

The buildings and construction sector is one of the biggest sources of greenhouse gas emissions and contributes to vast list of negative impacts humans have on the environment through material production, natural resource usage, and waste. While many organizations like the United Nations (UN), OECD (Organization for Economic Co-operation and Development), and Architecture 2030 have been advocating for a shift to sustainability within the sector for decades, there is still a major disconnect between countries that have and haven't implemented sustainability into all practices. This research focuses on analyzing the content of national building codes for their level of sustainability and what aspects within those codes relate to sustainability. The top five, most sustainable countries ranked by the UN Sustainable Development Solutions Network (UNSDSN) are analyzed in addition to the United States (ranked at 32).

The purpose of this study is to identify policy recommendations for improving the U.S. building codes to lead a more sustainable buildings and construction sector. A sustainability policy analysis framework was adapted specifically for the buildings and construction sector. The framework was developed based on the practices of the Environmental Protection Agency (EPA) and extant literature. The framework contains four indices that include the three pillars of sustainability (environment, economic, and social), as well as feasibility due to its importance to policy success. Four volunteers of different backgrounds assisted in the analysis in addition to the author to reduce result biases. The results showed that of the six countries compared, Belgium was given the

highest building construction sustainability score (2.5/3) and the United States was given the lowest score (1.65/3). The scores were directly related to the number of sustainable indicators mentioned within the building codes as well as the level of detail provided in the codes. The policy recommendations for the U.S. include implementing all economic indicators into the code as there was no direct mention of the economic aspect at all. Another recommendation is to include the missing social indicators as well as provide further details on the ones currently existing. Finally, the U.S. was given the highest sustainability score for the environment index, so the only recommendation for this area is to make the requirements in this section more stringent. With these additions and adjustments, the U.S. building code will be more balanced in terms of sustainability and therefore should result in the assurance of implementation and feasibility.

Prior to researching the international context to identify policy recommendations to enhance the sustainability of the U.S. building and construction codes, preliminary research was conducted on local building codes to obtain insight on a smaller scale and provide our community (Ada County, Idaho) policy recommendations to improve their building and construction codes to be more sustainable. Ada County was analyzed in conjunction with Alameda County in California, one of the top sustainable counties in the U.S, ranked by the UNSDSN. Results show Ada County and Alameda County's building codes both root from the 2018 International Building Code (IBC) but differ in major ways when it comes to sustainability. Ada's building code contains less topics related to the three pillars of sustainability in comparison to Alameda's. Finally, it was found that Alameda County has a *Green Building Standards Code* that targets the implementation of sustainability into their practices and covers all three pillars. Ada

County has a *Green Building Resolution* that was established in 2003 which encourages new construction projects to become LEED certified; however, their resolution is not a code, and does not target the three pillars of sustainability. Ada County was given an overall sustainability score of 1.67 out of 3 while Alameda County was given a score of 2.67 out of 3.

This was due to the number of topics covered within their building codes that were related to the three pillars of sustainability. The policy recommendation for Ada County is to expand their *Green Building Resolution* to a dedicated code similar to the *Green Building Standards Code* to increase the number of sustainability-related topics and improve the sector's sustainability. It should be noted that this recommendation is not to simply take the code Alameda uses and apply that in Idaho, but to adapt a similar code that targets the three pillars of sustainability and fits the needs of Ada County.

Research limitations include a lack of reputable, comparable data to support analysis results as well as time constraints to expand research to more countries, or to include related programs and initiatives. The amount of policy analyzers could also be increased to obtain more perspectives and attempt to find a correlation between career backgrounds and analysis results.

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CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 Statement of Problem

Climate change outcomes are becoming more complex and damaging to the environment globally. This certainly is not an issue civil engineers can solve alone; however, it is crucial for Civil Engineers to do their part in reducing impacts on the environment. The building and construction industry accounts for 38% of global energy use and the related carbon emissions, hence it is important that sustainability is prioritized in this sector (*2020 Global Status Report for Buildings and Construction*, 2020). The current state of practice targeting sustainability within this sector in the United States is limited to sustainability policies of contracting firms which are not always implemented. Without federal policies or codes to ensure sustainable practice, nationwide implementation will continue to falter and not proceed at the rate the planet needs.

While the United States is striving to be more sustainable, other countries have had great success in the matter. The United Nations Sustainable Development Solutions Network (UNSDSN) ranks countries based on seventeen Sustainable Development Goals (SDGs) and ranks the United States at thirty-two while Finland, Sweden, Denmark, Germany, and Belgium are all ranked in the top five. As the world quickly approaches a point of no return with climate change, federal policies in the United States need to be made requiring sustainability within civil engineering and construction to reduce the industry's impacts and analyzing what other, more sustainable countries are currently doing to ensure this could lead to the solution.

1.2 Background

The buildings and construction sector generally has a negative impact on the environment. With the amount of the world's greenhouse gases the buildings and construction

sector contributes, surely the negative impact could be reduced with adopting and implementing sustainable practices. It is also notable that the United States' building construction code has very little mention of sustainable practices as of the 2021 version. This sector also uses many nonrenewable resources as well as produces large amounts of waste, much of which is harmful to the environment (Zabihi et al., 2012). Currently, the world collectively emits around 50 billion tons of greenhouse gases every year. *Our World in Data* breaks down all the different contributors to greenhouse gas emissions. All civil engineering and construction related areas include landfills, wastewater, cement, iron, steel, energy in buildings, transportation, and other industries which covers manufacturing and construction (*About Us*, n.d.-a).

In the United States, the Environmental Protection Agency (EPA) has various green building codes with only one that is mandatory (IgCC). It is important to also note that there is a difference between green buildings and sustainable buildings. Green mostly refers to being environmentally friendly while that is only one of the three aspects of sustainability. Sustainable buildings would include a balance between social, economic, and environmental aspects. Unfortunately, the EPA does not have any specific, mandatory, sustainable building codes.

The United States government has an infrastructure plan that President Joe Biden has as one of his key term objectives to achieve during his presidency. The plan is to "build a modern, sustainable infrastructure and an equitable clean energy future" (*The Biden Plan to Build a Modern, Sustainable Infrastructure and an Equitable Clean Energy Future*, n.d.). As there are many different ideas, propositions, and goals within the plan, the relevant sections pertaining to the building construction sector and different aspects of sustainability and resiliency for America's infrastructure will be highlighted solely. These goals include improving resilience to floods, fires, and other climate threats; supporting healthy and safe communities; upgrading four million buildings and weatherizing two million homes; improving school infrastructure; and addressing the affordable housing crisis with 1.5 million new homes. The most important goal to this research involves improving building codes in terms of building performance and new funding mechanisms for cities, states, and tribes to adopt those new codes. As of the time this thesis was published, no new codes had been introduced yet, nor had there been any public records of what these codes will specifically entail. This thesis supports improving the U.S. building codes through providing policy recommendations to do so.

The American Society of Civil Engineers was established in 1852 and is the oldest engineering society in the U.S. (*About ASCE*, n.d.). It is relevant to mention this society as they play an active role as an "authoritative source for codes and standards that protect the public" (*About ASCE*, n.d.). The policies ASCE has for the civil engineering industry serve to support, encourage, and recommend, not require. There are five of these policies related to infrastructure sustainability, which is a great start. In addition to these, ASCE offers a sustainability certification program for incorporation into business practice through six courses (*Sustainability*, n.d.). While advocating for important policies and issues, there is still much room for improvement to bridge the gap between ASCE's policies and federal requirements.

Over the last few decades, ASCE has been grading America's infrastructure in the 'Infrastructure Report Card' starting in 1988. The report card has seventeen categories that are graded including aviation, bridges, broadband, dams, drinking water, energy, hazardous waste, inland waterways, levees, public parks, ports, rail, roads, schools, solid waste, stormwater, transit, and wastewater. All categories are directly tied to the buildings and construction sector and through examination of the report cards' history, it is evident that the grades across the board have been staying mostly the same while the estimated cost to improve the infrastructure to at least a B rating increases (*Report Card History*, n.d.).

Most recently, the 2021 report card overall score was a C-, up from the D+ score in 2017. This was due to an improvement in the following categories: aviation, drinking water, energy, inland waterways, and ports; however, not all categories improved or stayed the same. The bridges category was the only one that decreased in quality. While this sounds like good news for the most part, the bigger picture must be considered, which is that out of the seventeen categories, eleven of those are still rated in the D range. Improvements still need to be made and ASCE suggested four actions that can take the U.S. where it needs to be through leadership and action, sustained investments, a focus on resiliency, and sustainability (*2021 Report Card for America's Infrastructure*, 2021).

1.2.1 Engineer's Role in Policymaking and Government

Laws and regulations are important in ensuring there are minimum requirements for institutions to follow. In the United States, policymakers are mostly within Congress and are either within the House of Representatives or the Senate. The majority of the people in congress have backgrounds in public service, politics, business, law, and education (Manning, 2021).

While Congress consists of 541 people in total, there are only nine engineers who are currently members with eight in the House and one in the Senate (Manning, 2021). While some representation is better than none at all, there needs to be more engineers involved with policy making for the field. That goes for any field that has little to no representation.

There are an infinite number of issues that always need to be solved and policies to be made. With the small number of representatives relative to the amount of issues to be dealt with and the lack of representation for engineering policies being made, technical information that should be required to make such decisions is significantly lacking (Wang, 2002). The book *Leadership for Lawyers* by Deborah L. Rhode also describes the importance of expert information for policy making: “Optimal decision is out of reach due to the complexity of issues, the limitations of information, and cost of obtaining it” (Rhode, 2020). If more engineers became involved in policymaking, their expertise would better portray what kinds of changes need to be happening in the sector.

ASCE encourages engineers to follow a career path that leads to a government position with *Policy Statement 386: Recruitment and Retention of Qualified Engineers for Government Service*. They also acknowledge that the lack of engineer government involvement and representation is negatively affecting the sector. ASCE states that the reason for this is due to a “lack of professional grade status and associated compensation for qualified engineers employed in many government agencies has been a disincentive for attracting and retaining engineering professionals in the public sector" (*Policy Statement 386 - Recruitment and retention of qualified engineers for government service*, n.d.). Though this may be true, it continues to be more crucial for engineer's involvement in policy making as technical and expert knowledge is needed to make the best decisions for the sector. With 2,467,400 engineers in the U.S, there are plenty of candidates to become involved in Congress and the policy making process (*Architecture and Engineering Occupations*, 2021). This thesis work combines public policy with engineering to bridge this current gap and provide an engineer's experience, knowledge, and background for building code policymaking.

1.31. Research Purpose, Objectives, and Tasks

The purpose of this research is to develop policy recommendations for the United States to adapt into their building code in order to improve the buildings and construction sector's sustainability. Two research objectives guided the study and included understanding where the United States stands with sustainability within the buildings and construction sector, and understanding where other, more sustainable countries stand with sustainability in the same sector. These objectives were completed through five supporting research tasks. The research work can be visualized below in the corresponding flowchart.

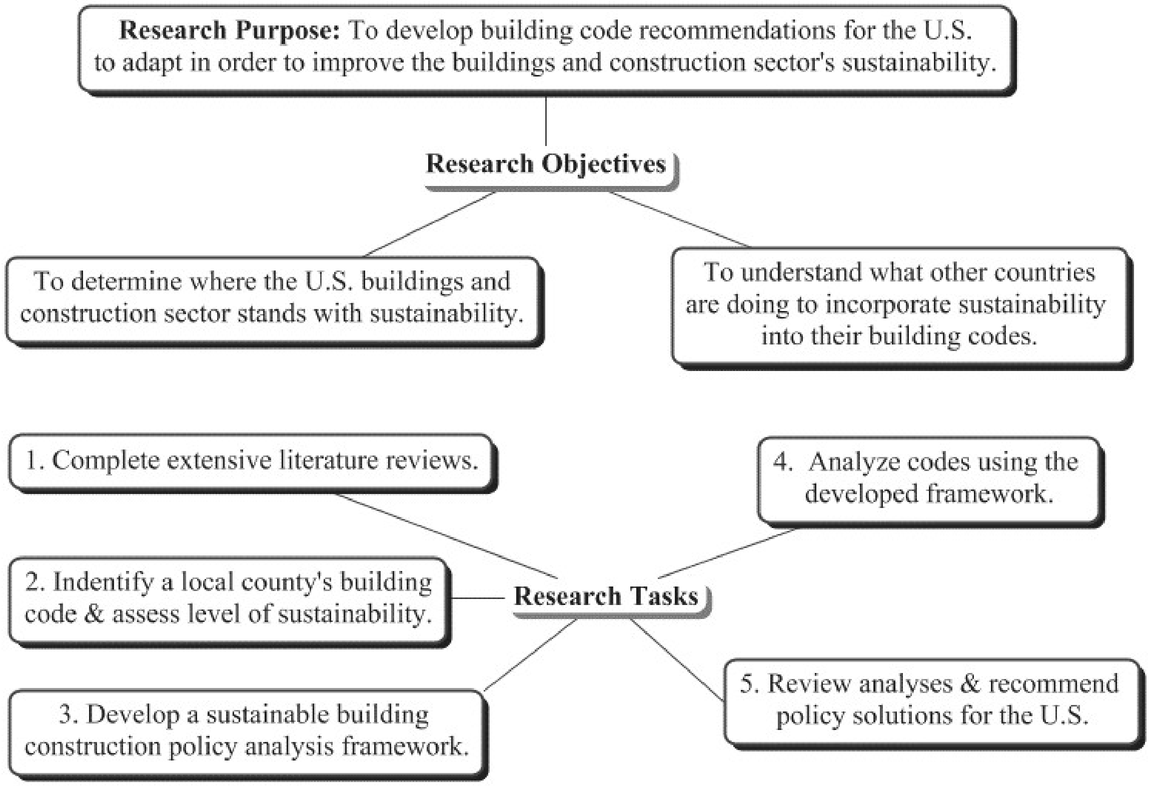

Figure 1.1 Research work flowchart

The research tasks that were carried out include:

1. Completing literature reviews on the buildings and construction sector, sustainability within construction, current environmental impacts from the sector, sustainable development on a global scale, public policy topics, and sustainable building construction policy.
2. Identifying a local county's building code and assessing its level of sustainability in conjunction with the most sustainable county in the U.S. (Ranked by the UNSDSN).
3. Developing a policy analysis framework to have a sustainability focus for building construction on the international level.
4. Analyzing the codes by using the developed framework.

5. Reviewing all analyses and recommending sustainable policy solutions for the U.S. to adapt to their building code to move towards higher levels of sustainability in the sector.

1.4.1 Organization of Thesis

This thesis dissertation begins with a literature review in Chapter 2. Key topics, definitions, related organizations, and a case study are identified in this section. Following the literature review is a preliminary analysis on local building codes for sustainability in Chapter 3. After the preliminary research, the larger scaled policy analysis on sustainable building codes internationally is in Chapter 4. Finally, the last chapter covers the summary, conclusions, and recommendations.

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CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

An extensive literature review was conducted to provide background on sustainability in general, sustainability in the buildings and construction sector, public policy and policy diffusion topics, and various other definitions applicable to the study.

2.2 Sustainability

Sustainability is a concept very important to ensuring our world persists through global warming, lack of resources, loss of biodiversity, and so on. Many different organizations define sustainability in their own way; however, they all have the same basis. Sustainability, as described by the United States Environmental Protection Agency (EPA), is creating and maintaining the conditions that humans and nature can coexist in a way that provides current and future generations with the same conditions (*Learn About Sustainability*, n.d.). There are three aspects, also referred to as pillars, of sustainability: environment, social, and economic (Basiago, 1998; Gibson, 2009; Pope et al., 2004). True sustainability is the balance of the three aspects and applies to any sector, company, or project.

To break down the three aspects, environment, social, and economic, a description of each can help in understanding what exactly is meant by achieving sustainability. The environmental aspect includes ecosystem services, green engineering & chemistry, air quality, water quality, stressors (e.g., emissions of pollutants), and resource integrity. The social aspect includes environmental justice, human health, participation (e.g., public access & understanding), education, resource security, and sustainable communities. The economic aspect includes jobs, incentives, supply and demand (e.g., life cycle cost analysis), natural resource accounting, costs, and prices (*Learn About Sustainability*, n.d.). There is a lot covered within each of these aspects, proving to be a challenging task to find a balance between the three; however, efforts can be made to achieve sustainability to the best of our abilities.

2.3 Important Definitions

Table 2.1 Key Definitions

Term	**Definition**
Building	*Noun* - Physical infrastructure that is permanent on land, or fully or partially underground (*Legislation Planning and Building Act (2010:900) Planning and Building Ordinance (2011:338)*, 2018). *Verb* - Action of constructing (*Build*, n.d.).
Green Building Strategies	Reinforces environmental benefits, societal benefits, and resiliency (*International Green Construction Code (IgCC)*, 2015).
Life Cycle Assessment (LCA)	Project evaluation considering lifetime, benefits, inputs, outputs, and environmental impacts (*2021 International Green Construction Code (IgCC)*, 2021).
Greenhouse Gases (GHG)	Emissions include carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, nitrogen trifluoride, and other gases (*Climate Change Act*, 2015).
Climate Change	Long-term changes to typical weather patterns (*Overview*, n.d.).
Mitigating Climate Change	Reducing the amount of GHG emissions into the atmosphere (*Responding to Climate Change*, n.d.).

Adaptation to Climate Change	Adjusting and preparing for the changing/future climate (*Responding to Climate Change*, n.d.).

2.4 Public Policy

While public policy is a topic outside of most engineer's realms, it is important to note key definitions for a better understanding of this study. Public policy covers a wide area, and many definitions exist for this reason. Encyclopedia Britannica defines public policy as "a set of actions - plans, laws, and behaviors - adopted by a government" (*Governance - Public Policy*, n.d.). James Anderson describes policy as a "purposive course of action or inaction undertaken by an actor or set of actors in dealing with a problem or matter of concern" in the textbook, Public Policymaking (Anderson, 2014).

Public policy has six stages that work as a cycle: 1. Problem Identification; 2. Agenda Setting; 3. Policymaking; 4. Budgeting; 5. Policy Implementation; and 6. Policy Evaluation (Anderson, 2014). Throughout this process, there are 'actors' who play the role of identifying problems and proposing solutions or policies to be adopted by the government (Gerston, 2014). Actors can vary between government authorities, investors, businesses, or the general public; however, non-governmental actors purely influence government officials to pursue said problems (Anderson, 2014).

<u>2.4.1 Policy Diffusion</u>

An important concept to understand for this research is policy diffusion. As described by Charles R. Shipan and Craig Volden, policy diffusion is "one government's policy choices being influenced by the choices of other governments" (Shipan & Volden, 2012). When mentioning government, this can include local, state, national, or international. Local levels of government are not likely to create climate protective initiatives due to a lack of funds and/or guidance from the federal level; therefore, widespread implementation will rely on requirements set on a national level. The local governments who are implementing climate protection initiatives are those with higher capital, education, and large numbers of environmental groups (Krause, 2011).

2.5 Relevant Global Organizations & Initiatives

There are countless advocates and organizations that work towards the implementation of sustainability into all aspects of life. The following described organizations and programs are globally recognized and good examples of how to incorporate sustainability into infrastructure development.

2.5.1 United Nations Sustainable Development Solutions Network

The United Nations Sustainable Development Solutions Network (UNSDSN) is a global organization that brings together scientists, industry experts, and researchers to compile solutions for sustainable development. This organization was established in 2012 and has created the Sustainable Development Goals (SDGs) for all countries to implement and are in the Paris Climate Agreement. The SDGs are also used to rank the 165 countries that are involved with the UN. The resulting documentation of country ranks began in 2015 and is an annual report called the Sustainable Development Report (SDR) (*About Us*, n.d.-b).

Though this report and its goals are not specific to civil engineering, building construction, or infrastructure, this report does come of use when deciding on which countries to use for a policy comparison because there is not a different, equally as reputable comparison ranking system of a country's infrastructure quality/sustainability.

From the 2021 SDR, the following are the top five countries: 1. Finland, 2. Sweden, 3. Denmark, 4. Germany, and 5. Belgium. The United States was ranked at 32 (Sachs et al., 2021). Of these six countries, the U.S. is the only one to not adopt the SDGs into government efforts including high-level statements, SDG strategies, and SDGs in the national budget. Belgium also has not implemented SDGs into their national budget; however, they have had high-level statements and implementation of SDG strategies (Sachs et al., 2021). It is these six countries that will be compared in the international policy analysis discussed in Chapter 4.

2.5.2 United Nations Environmental Program (UNEP) for Buildings & Construction

The United Nations Environment Program, also known as UNEP, creates global status reports for buildings and construction annually. UNEP's vision is a "zero-emission, efficient, and resilient building & construction sector" (*2020 Global Status Report for Buildings and Construction*, 2020). The organization's goals include being a global advocate for climate action in the sector, creating a 'common language' for decision-makers across the globe on the issue, creating objectives and minimum targets for sustainability, and making key measures to assist countries in achieving sustainable goals in the sector. Throughout the most recent report in 2020, it mentions sustainability for buildings and construction; however, the specific details only mention related policies for energy and nothing else (*2020 Global Status Report for Buildings and Construction*, 2020). Energy efficiency and decarbonizing the sector is important to sustainability; however, they are not the only aspects. There needs to be a shift in focus to overall sustainability instead of just the environmental aspects of it.

2.5.3 OECD - Sustainable Infrastructure Policy Initiative

The international organization OECD (Organization for Economic Co-operation and Development) works with policymakers, governments, and the general public to "establish evidence-based international standards and find solutions to a range of social, economic and environmental challenges" (*Who We Are*, n.d.). The Sustainable Infrastructure Policy Initiative was launched to improve the state of global infrastructure through collaboration, research, and analysis. This is done through five key steps: evidence-based research and data, standard-setting and guidance, capacity building, connecting dots through partners and convening global policymakers (Laboul, n.d.). The research conducted and discussed in this thesis manuscript coincides with the capacity-building step. This entails sustainable infrastructure policy reviews of select countries and is stated to be an important aspect of the initiative. 'Knowledge transfer' of existing policies ensures the identification of policy strategies, any gaps in implementation, development pathways, and individual country's circumstances (Laboul, n.d.). Researching policy is highly valuable and important in the improvement of sustainability in infrastructure.

2.5.4 Architecture 2030

Architecture 2030 is a non-profit, non-partisan, and independent organization established to advocate for sustainability in the building sector to reduce the impact of climate change. Their mission is to transform the built environment to be eco-friendlier and more sustainable. This organization is global and works towards its goal of a more environmentally friendly building sector through the four aspects on the screen, design &

planning, education, policy, and collaboration. It is these four things this thesis research targets to develop sustainable building construction policies and codes (*About Us*, n.d.-a).

2.6 Summary

The concept of sustainable development has been revisited by many organizations as it has potential to create positive impacts on the current state of the environment. With many governments, ranging from local to national levels, the adoption of Sustainable Development Goals (SDGs) has been gradually occurring. Reports show that the countries who are stricter on SDG incorporations have been reducing their greenhouse gas emissions (Sachs et al., 2021). By implementing sustainability into policies, positive change can be made on both small and large scales. New or updated policies can make impacts, but it is found that support from global organizations through programs and initiatives creates a security of the policies being followed. While analyzing a variety of policies along with related programs and initiatives would show this impact on a more detailed level, the time constraints of this research require a simplified and focused area. As the programs and initiatives seem to follow policies, it was decided to pursue research on various policies solely. Similarly, it was decided that incorporating resiliency into the policy analysis framework would also complicate and stray away from the main focus of sustainability.

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CHAPTER 3: MANUSCRIPT ONE – PRELIMINARY WORK ON LOCAL BUILDING CODES

Local Building Code Comparative Analysis to Identify Sustainability Improvements: Ada County, ID and Alameda County, CA

Abstract

The buildings and construction sector have considerable negative environmental impacts that involve more than just greenhouse gas emissions. In Idaho, Ada County is one of the bigger, booming counties that strives for sustainable innovation. The biggest city within this county and the state capital, Boise, has set the goal to become carbon neutral by 2050; however, their strategy for the buildings and construction sector solely focuses on improving energy efficiency. While this strategy will make an impact, more can be done to ensure sustainable development.

This research qualitatively analyzes the sustainability pillars targeted within building codes in Ada County in Idaho and Alameda County in California to identify solutions that can be implemented into Idaho building codes. The counties were ranked on a scale of 1 to 3 (low to high impacts) based on the number of topics within the codes that were related to the three pillars of sustainability. The results showed there is room for growth in Ada County's code with an overall score of 1.67 out of 3 while Alameda County had a score of 2.67 out of 3. Thus, policy recommendations were developed for Ada County: adapt their building codes to include a Green Building Standards Code. It should be noted that due to the difference in population, land mass, politics, and

community needs, Ada County cannot simply take the Green Building Standards Code that Alameda County and California use; however, adapting the code to better fit Ada County can be done. This study is not without limitations, a single individual analyzed the codes which may raise questions around the validity of the results. Avenues for future studies are identified.

Keywords: *local policy diffusion; sustainable infrastructure; buildings and construction industry; building code analysis*

3.1 Introduction

The changing climate continues to negatively affect weather patterns, human health, and the economy, a growing concern for many city and county leaders. The City of Boise, Idaho has a community goal of becoming carbon neutral by 2050. One of the seven focus areas of their climate action plan includes buildings and energy. As Boise has been rapidly growing in the last few decades, the sustainable infrastructure focus has been on energy efficiency and reducing emissions (*Climate Action*, n.d.). Currently, there is little mention of the building construction industry's impacts on Idaho or Ada County, which includes Boise. This is a significant issue as the building construction industry contributes around 38% of global greenhouse gases (*A Practical Guide to Climate-resilient Buildings & Communities,* 2021). Increasing the energy efficiency of buildings will have an impact on the sector's carbon footprint; however, more needs to be done to ensure sustainable development. Material production related greenhouse gas emissions have risen from 15% in 1995 to 23% in 2015 globally (Hertwich et al., 2020). These emissions are significant and cannot be reduced from energy efficiency alone, they need to be supplemented with sustainable production methods to have a visible impact on sustainability of the buildings and construction sector in general.

A heavier focus on all aspects of sustainability is necessary to reduce the negative environmental impacts this sector contributes while continuing to achieve this generation's needs as well as future generations. There are three pillars of sustainability that should be accounted for in any project evaluation and consideration: the *environment*, *economy,* and *society* (Basiago, 1998; Brown et al., 1987; Gibson, 2009; Pope et al., 2004). Not only can these pillars be used for construction project evaluation, but they can also be used in policy evaluation. UNEP's International Resource Panel (IRP) states that at the current increasing emissions rate, policy intervention is required to relieve the buildings and construction sector's impacts and maintain the targeted temperature increase of 1.5˚ C (Hertwich et al., 2020). Their suggested focus for this industry is to improve building codes to include all aspects of sustainability instead of just considering energy efficiency. Based on existing literature, sustainability indicators specific to the buildings and construction sector were identified (*Table 3.1)* and used to guide the policy analysis on the two building codes (Fiksel et al., 2012; Hertwich et al., 2020).

Table 3.1 Sustainable Building Construction Indicators

Indicator	**Description / Interpretation**
Environment Index	
a. Reduce Pollution	Recycling materials; using non-toxic materials only; reducing emissions, etc.
b. Resource & Waste Management	Managing and attempting to minimize any waste that would be deposited into a landfill otherwise; using eco-friendly materials; minimizing use of natural resources.
c. Energy Efficiency	Utilizing renewable energy sources, designing for natural temperature retention, etc.
Economic Index	
d. Material Efficiency	Minimizing number of materials used/needed; less material will result in a lower cost.
e. Life Cycle Cost Analysis (LCCA)	Determining the most economic & sustainable designs; including any aspects of a policy that considers costs and benefits to a design or project.
f. Cost Efficiency	Reducing maintenance costs, reducing operations costs, etc.
Social Index	
g. Public Health & Safety	Using proper signage; designing for accessibility; reducing noise pollution; including cultural preservation.
h. Air & Water Quality	Designing for acceptable ventilation, plumbing & sewage.

i. Quality of Life	Including aesthetics into designs; providing natural light; minimizing construction time delays.

When determining how best to implement sustainability into building codes, government leaders do not need to start from the ground up; instead, they can investigate what other governments are doing to ensure sustainability and adapt successful methods. This is an example of policy diffusion which is the spread of policies between governments and can include city to city, city to county, county to county, county to state, and so on (Gilardi and Füglister, 2008; Shipan and Volden, 2012). Policy diffusion can also be categorized by what type of governments the policies spread to. Top-down federalism is the spread of policies from the federal government down to states or cities. On the other hand, bottom-up federalism is the spreading of local or state policies to the federal level (Shipan and Volden, 2012). While larger scaled policies seem to have a more significant impact as they cover the entire country, it is worthwhile to consider local policies as they can be easier to change and adapt (Feiock and West, 1993). Both top-down and bottom-up approaches create impacts; therefore, choosing which level of government to target is something to be decided by policy analysis outcome goals (Fowler and Jones, 2019). Most green building policy innovation has been occurring on the city and municipal levels and these policies range from building codes to tax incentives and subsidies (Kontokosta, 2011).

This article analyzes local-level policies with the intention of encouraging bottom-up policy diffusion where the results of this analysis could eventually influence state and federal levels of government. Sustainability evaluations were made using a qualitative document analysis and indicators within the three pillars of sustainability (environment, economic, and social) for the building codes. This research could be repeated and used as a policy diffusion tool for other counties and local governments to follow as well. Recommendations for improving the level of sustainability for Ada County's building code are identified based on analysis results.

3.2 Methodology

This research is a qualitative, document analysis of sustainability within building codes using the framework shown in *Table 3.1*. The selected county's building codes are analyzed and compared to determine how Ada County's code can be modified towards sustainable development goals. Specific topics within the building codes that pertain to the three pillars are identified and categorized for comparison.

A scoring system was used to easily compare the county's level of sustainability within their building codes. Based on the number of topics covered that relate to the sustainable building construction indicators (*Table 3.*1), a score of 1, 2, or 3 was given for each category. 1

corresponds to a low sustainability score, 2 corresponds to a moderate sustainability score, and 3 corresponds to a high sustainability score. The scores for each pillar were averaged for an overall sustainability score on the same scoring system.

The United Nations Sustainable Development Solutions Network (UNSDSN) ranks all the cities within the United States, and this was used to determine which county to analyze with Ada County. It is well-known that the European Union (EU) and California are leaders in sustainability innovation and improvements to the environment; therefore, other governments can adapt their policies and movements (Bedsworth and Hanak, 2013; Erickson et al., 2018; Meckling et al., 2017). The top sustainable counties in California and the U.S. include Alameda County and San Francisco County, with Ada County ranked at 38 (*2019 US Cities Sustainable Development Report*, 2019). Alameda County was chosen to be analyzed with Ada County as San Francisco County is on a peninsula and has many unique features that separate it from Alameda and Ada Counties. Though Alameda County is much larger in both its population and land mass area as well as other significant factors like political party and community goals, it is still worthwhile to analyze for sustainability. This analysis is not to compare the two counties for how well or how poorly each have implemented sustainability into their building codes, but to identify key differences in the codes and apply new, innovative ideas into Ada County's current building code.

3.3 Results and Discussion

There are numerous codes each county has adopted that pertain to the buildings and construction sector. While both county's codes root from the 2018 edition of the International Building Code (IBC), there are notable differences in which sections were adopted and amended. In addition to the codes from the IBC, additional codes are followed as well. Most of Alameda County's codes are immediately adapted from the 2019 California Building Codes (CA BC). The 2019 CA BCs are adapted from the 2018 IBC. The table below demonstrates the similarities and differences between each county's codes followed and where they root from.

Table 3.2 Building-related codes for Ada and Alameda Counties

	Ada County	Alameda County
Codes Following		
Building Code (BC)	Yes (2018 IBC)	Yes (2019 CA BC)
Residential Code (RC)	Yes (2018 IRC)	Yes (2019 CA RC)
Existing Building Code (EBC)	Yes (2018 IEBC)	Yes (2019 CA EBC)
Green Building Code (GBC)	No (2003 Green Building Resolution)	Yes (2019 CA GBSC*)
Housing Code (HC)	No	Yes (1997 UHC*)
Mechanical Code (MC)	Yes (2018 IMC)	Yes (2019 CA MC)
Fuel Gas Code (FGC)	Yes (2018 IFGC)	No (mentioned in GBSC)
Electric/Energy Code (EC)	Yes (2018 IECC*)	Yes (2019 CA EC)

*GBSC = Green Building Standards Code
*UHC = Uniform Housing Code
*IECC = International Energy Conservation Code

Additional focus should be brought to the Green Building Codes. Currently, Alameda County follows the Green Building Standards Code (GBSC) from the 2019 California Code of Regulations. This code focuses on sustainability and encourages sustainable building construction practices through planning, design, energy efficiency, water efficiency, water conservation, material conservation, resource efficiency, and environment quality (*2019 California Green Building Standards Code*, 2019). Ada County has a Green Building Resolution established in 2003 that was created to encourage new construction to become LEED certified (*Green Building Resolution*, 2003). The resolution has not been updated since it was first established and there is room for improvement in this area as Ada County's building codes do not contain as many sections related to sustainability as Alameda County's. The areas pertaining to sustainability have been outlined in *Table 3.3* below. Based on the number of areas covered, a score for each pillar of sustainability was given on a scale of 1 to 3.

Table 3.3 Sustainability-related areas covered and corresponding scores

	Ada County	Score	Alameda County	Score
Environment	Energy efficiency (dedicated section)	2	Stormwater pollution prevention; Conservation of natural resources; Reduce waste; Energy efficiency; Solar energy; Reduce GHG emissions	3
Economic	Not mentioned	1	Lower energy usage; Reduce operation and maintenance costs	2
Social	Maintaining public safety and welfare; Use of noncombustible materials; Accessibility; Fire protection	2	Promote a healthy indoor environment; Protecting health and safety; pedestrian protection and safety during construction; Maintaining sanitary conditions; Accessibility; Fire protection	3
Overall Scores		**1.67**		**2.67**

It is shown in the table above that much more is covered within Alameda County's building codes than within Ada County's. Ada County only has energy efficiency mentioned in the environment category of the table because there were no other environmental-related areas/indicators covered within their building code. Their code has a designated section on energy conservation that is very detailed; therefore, it was given a score of 2 out of 3. Ada County's economic category was given a low sustainability score (1 out of 3) because the code does not specifically mention any economic indicators or ways to better manage the economics of building construction projects. The social category was given a score of 2 out of 3 for the number of related topics throughout the code; however, the level of detail and description was lacking and there were no specific sections on any of the topics except for fire protection.

Alameda County's codes covered more topics that related to the three pillars of sustainability and as a result, scored higher. Most of these topics shown in the table come directly from the Green Building Standards Code. A visual representation of each county's sustainability scores for each pillar and the overall scores is shown below in *Figure 3.1*.

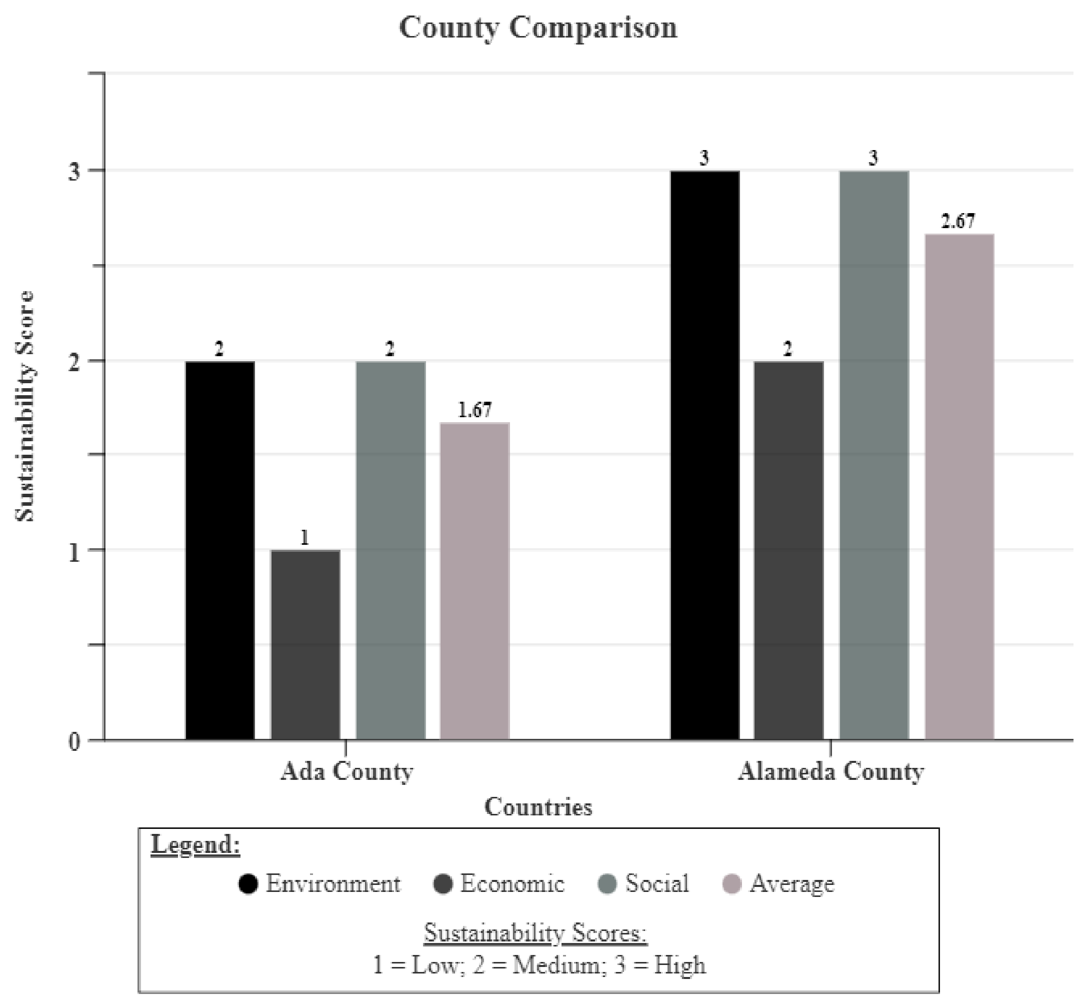

Figure 3.1 Sustainability scores for each county

Both Ada County and Alameda County have similar scoring patterns of the environment and social categories scoring the same and a lower score for the economic category. Alameda County did score higher than Ada County and this is due to the extended content that related to the three pillars of sustainability.

3.4 Summary

Ada County is a growing area in Idaho and the expected continuous growth will directly result in more building construction. While the buildings and construction sector has significant negative environmental impacts, change must occur everywhere to reduce those impacts. By utilizing the power of policy diffusion, Ada County can learn from other counties that have already implemented sustainability into the sector. This diffusion can spread to other counties as well as to state and federal governments. By analyzing both building codes, it was found that improvements can be made to account for all three pillars of sustainability on a more detailed level. Alameda County has taken great measures to implement sustainability into their building code through the adoption of California's Green Building Standards Code which led their sustainability scores to be higher than Ada County's. Currently, Ada County has a Green Building Resolution that was established in 2003 that encourages all new construction to become LEED certified. A more in-depth code that encompasses all pillars of sustainability is needed and something similar to the Green Building Standards Code could be the solution.

It should also be noted that the economic pillar is not mentioned directly in Ada County's building code, and it is assumed that cost savings is already pursued in the buildings and construction sector through the designs and practice. This may be true; however, there is still room for improvement in the creation of codes that target cost savings to provide guidelines that make it easier to implement practices that ensure cost savings in a project. A focus on conducting Life Cycle Cost Assessments (LCCA) for all projects should be implemented into the building codes. Consideration should also be given to providing a standard LCCA within the building code for reference that is required for all projects.

While Ada County is much smaller than Alameda, the cities within the counties do have similarities, especially with the creation of innovative ideas and implementations. It is important to note that Ada County cannot simply take Alameda's building codes and apply them; however, the concepts and codes that Alameda uses can be adapted to better fit the needs of Ada County.

4.3.1 Building Code Recommendations for Ada County

The recommendations to better implement sustainability into Ada County's current building code are as follows:

1. Update the 2003 Green Building Resolution to a designated code.
    a. Include all missing sustainable building construction indicators:
        i. For the environment pillar, indicators missing include reducing pollution and resource and waste management.
        ii. For the economic pillar, indicators missing include material efficiency, life cycle cost assessments (LCCA), and cost efficiency.
        iii. For the social pillar, indicators missing include air and water quality and quality of life.

*For further descriptions and guidance, refer to the most current International Green Building Code published by the International Code Council.

4.3.2 Research Limitations and Future Research

This study lacks inter-coder reliability testing and builds on a simplified policy analysis framework. More policy analyzers would result in a variety of scores as well as different perspectives and understanding of the two building codes, hence increasing the validity of the results. An addition of a couple more analyzers would reduce the likelihood of biases and should be considered for future related research. In addition, the policy analysis framework has potential to be more specific to sustainability within building construction; however, further research on policy analyses and sustainability within the buildings and construction sector is necessary. This would increase the analysis accuracy. Drawing from this article, future studies could include policy diffusion on a federal level to encourage a top-down diffusion. It is prevalent from the research conducted in this article that the counties build off of the International Building Codes; therefore, changes on a larger scale could have significant and positive impacts.

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CHAPTER 4: MANUSCRIPT TWO – GLOBAL BUILDING CODE COMPARATIVE ANALYSIS

Developing Implementable Policies Targeting Sustainable Building Construction through International Policy Diffusion

Abstract

The buildings and construction sector is one of the major contributors to global carbon emissions. Due to their use of large quantities of materials with negative ecological impacts, the buildings and construction sector has detrimental effects on the environment. Nations across the globe handle these issues by developing policies that compel the construction sector to be mindful of their environmental impacts. In this research, sustainability focused policies targeting the buildings and construction sector from different nations that rank high for sustainable development are compared with the United States (U.S.) to better understand these policies and suggest modifications to U.S. policies. For this purpose, building codes from Finland, Sweden, Denmark, Germany, Belgium, and the United States were analyzed. The analysis framework used in this research was adapted from existing literature and contains four categories targeting sustainability: environment, economic, social, and feasibility. Each of these categories contains specific indicators for building construction policies that guided the analyzers in determining the level of sustainability for the building codes in each country. Five analysts with backgrounds in Civil Engineering and Public Service conducted the analysis. Two of the analysts were students and the other three were professionals from

industry. Results show that the U.S. building code is the least sustainable with no mention of the economic index. Their policy is also scarce in the social aspect with a low likelihood of policy feasibility in terms of sustainability. The policy recommendations include addressing all sustainability indicators that are not currently being addressed to reduce the U.S. buildings and construction sector's impacts. Implementing the economic index into the policy should be the highest priority. Limitations on this research include a lack of comparable data to back up the qualitative analysis and its findings.

Keywords: *Sustainable building construction indicators, sustainability policy analysis framework, Civil Engineering public policy, international policy diffusion*

4.1 Introduction

Climate change continues to negatively impact the environment, human health, and living conditions and unfortunately there is not a single culprit or simple solution. Most sectors including energy, transportation, agriculture, waste, production, and many everyday actions (by the public) contribute to the growing issue of climate change. At the current rate, it is estimated that over a billion people will be living in extreme heat and around 800 million will be vulnerable to sea level rises by 2050 (*A Practical Guide to Climate-Resilient Buildings & Communities*, 2021). Currently, the buildings and construction sector emits 38% of energy related greenhouse gases globally (*2020 Global Status Report for Buildings and Construction*, 2020). These emissions come from a variety of areas throughout an infrastructure's life cycle which includes the construction, actual use, and "end-of-life" phases (Asdrubali et al., 2013).

There are infinite numbers of solutions to reduce GHG emissions proposed by global leaders, government officials, advocates, and activist groups. The question that arises from this is which solution will work the best and who has this answer? While there is not an answer to these questions, evaluating and emulating what other governments have tried through which 'solutions' have or have not succeeded can help determine a solution. In terms of governments and policy making, adapting existing policies to a separate government is referred to as policy diffusion (Shipan & Volden, 2006).

Some countries have had greater successes than others in this realm, so learning from what they have tried and discovered is beneficial to others like the United States. Exploring what other countries have tried to make their building codes include sustainability could assist the United States in improving their own policies. With the current level of negative impacts from the buildings and construction sector, it is crucial to learn, understand, and apply these concepts to create more sustainable practices.

With the global goal of preserving resources and meeting the needs of current and future generations, it is integral to incorporate sustainability into all aspects including development and construction. Instead of solely focusing on the environmental impacts from human actions, sustainability balances three aspects: environmental, societal, and economics (Basiago, 1998; Brown et al., 1987; Gibson, 2009; Pope et al., 2004). The balance of the three aspects seems to improve global impacts and numerous organizations recognize this including the United Nations Sustainable Development Solutions Network (UNSDSN), United Nations Environmental Programme (UNEP), Organization for Economic Co-operation and Development (OECD), and Architecture 2030 (*About Us*, n.d.-a; *Sustainable Buildings and Construction*, 2018; *Who We Are*, n.d.; Sachs et al., 2021). Though the concept of sustainable development was first introduced in 1987, the world seems to still be behind in its implementation (Brundtland, 1987).

There is a call for a transition to sustainable everyday actions and practices to reduce negative impacts on the environment, not only for us, but for future generations as well. While achieving a transition on such a large scale could seem impossible, breaking down the research and policies to individual sectors will make sustainable adjustments easier to achieve. This research focuses on sustainability within building codes and calls for implementing sustainable practice within the buildings and construction sector in the United States.

Little research has been conducted on Civil Engineering and/or Construction policy diffusion. There is however a plethora of research on sustainable building construction (Berardi, 2012; Sorrell, 2003; Spence & Mulligan, 1995; Zuo et al., 2012). In order to determine what is currently being done about sustainability within the buildings and construction sector, a policy analysis framework was developed that is specific to this sector's policies. This research analyzes sustainability within building codes for the top five, most sustainable countries (ranked by the UNSDSN) and the United States. The purpose of this research is to determine what the countries are doing to ensure sustainability within the buildings and construction sector through their building codes and what aspects of sustainability they are targeting to determine what is missing in the United States' codes. Drawing from other countries' experiences, policy recommendations will be described for the U.S. to adopt. In addition to the improvement of the buildings and construction sector, policy diffusion can occur and spread to other parts of the sector and to other sectors as well. Not only can this happen for the United States, but this study and process could serve as an example for other countries as well.

The structure of this article follows the following format: Section 4.2 provides background information on the current state of sustainability within the United States buildings and construction sector, sustainability on more general terms, policy diffusion, and the theoretical policy analysis framework. Following this, Section 4.3 explains the qualitative research methodology that was followed. This section also covers the analysis methods, information on the people who completed the analysis, how the countries were scored for sustainability, and the current building codes for each country. Section 4.4 contains the policy analysis results, discussion, and policy recommendations (for the United States). Section 4.5 concludes all information learned in this research and discusses research limitations and potential future research related to this topic. Finally, Section 4.6 is dedicated to acknowledgements for this research.

4.2 Background

4.2.1 America's Sustainability within the Buildings and Construction Sector

The current state of sustainability within the buildings and construction sector in the U.S. can be best explained through discussion on the leading civil engineering society, their policies, and the current United States' Infrastructure Plan.

4.2.1.1 ASCE Policies and Infrastructure Report

The American Society of Civil Engineers (ASCE) was established in 1852 and is the oldest engineering society in the U.S. (*About ASCE*, n.d.). This society plays an active role in the civil engineering industry as an "authoritative source for codes and standards that protect the public"; however, their policies solely serve as a form of support, encouragement, and recommendation, not requirement (*About ASCE*, n.d.). There are four of such policies related to sustainability including *Policy Statement 418: The Role of the Civil Engineer in Sustainable Development; Policy Statement 451: Life Cycle Cost Analysis; Policy Statement 517: United Nation's Sustainable Development Goals;* and *Policy Statement 556: Owner's Commitment to Sustainability* (*ASCE Sustainability Policies*, n.d.). In addition to these, ASCE offers a sustainability certification program for incorporation into business practice through six courses (*Continuing Education in Sustainability*, n.d.). While advocating for policies and issues has great value, there is still much room for improvement to bridge the gap between ASCE's policies and federal requirements.

Over the last few decades, ASCE has been grading America's infrastructure through the 'Infrastructure Report Card' beginning in 1988. The report card has seventeen categories that are graded which includes aviation, bridges, broadband, dams, drinking water, energy, hazardous waste, inland waterways, levees, public parks, ports, rail, roads, schools, solid waste, stormwater, transit, and wastewater. The grades are on an A through F scoring system: A means "exceptional, fit for the future"; B is "good, adequate for now"; C is "mediocre, requires attention"; D is "poor, at risk"; and finally, F is "failing/critical, unfit for purpose" (*Making the Grade*, 2016). Grades are given based on the following criteria: capacity, condition, funding, future need, operation and maintenance, public safety, resilience, and innovation. Through examination of the report cards' history, it is evident that the grades across the board have been staying mostly the same while the estimated cost to improve the infrastructure to at least a B rating increases (*Report Card History*, n.d.).

Most recently, the 2021 report card overall score was a C-, up from the D+ score in 2017. This was due to an improvement in the following categories: aviation, drinking water, energy, inland waterways, and ports; however, not all categories improved or stayed the same. The bridges category was the only one that decreased in quality. While this sounds like good news for the most part, the bigger picture must be considered, which is that out of the seventeen categories, eleven of those are still rated in the D range. Improvements still need to be made and ASCE suggested four actions that can take the U.S. where it needs to be with leadership and action, sustained investments, a focus on resilience, and sustainability (*2021 Report Card for America's Infrastructure*, 2021).

4.2.2.2 The United States' Infrastructure Plan

The current United States Infrastructure Plan was proposed as one of President Joe Biden's key term objectives to achieve during his presidency. The plan is to "build a modern, sustainable infrastructure and an equitable clean energy future" (*The Biden Plan to Build a Modern, Sustainable Infrastructure and an Equitable Clean Energy Future*, n.d.). There are quite a few sections pertaining to the building construction sector and different aspects of sustainability and resiliency for America's infrastructure within the plan. One proposed solution involves the "improvement of building codes in terms of building performance as well as new funding mechanisms for city, state and tribes to adopt those new codes" (*The Biden Plan to Build a Modern, Sustainable Infrastructure and an Equitable Clean Energy Future*, n.d.). At the time of this research, no new codes had been introduced yet, nor had there been any public records of what these new codes would specifically entail. Similar to ASCE's policies, a suggestion was made to improve building codes; however, no actual action has been taken to do so yet. This research conducted serves to assist the U.S. government in their building code improvements and provide policy recommendations to improve the buildings and construction sector to be more sustainable.

4.2.2 Sustainability

There are various definitions for sustainability; however, they all have common themes. Sustainability, as described by the United States Environmental Protection Agency (EPA), is “creating, and maintaining the conditions that humans and nature can coexist in a way that provides current and future generations with the same conditions” (*Learn About Sustainability*, n.d.). There are three aspects, sometimes referred to as pillars, of sustainability: environment, economic, and social (Basiago, 1998; Gibson, 2009; Pope et al., 2004). True sustainability is the balance of the three aspects and applies to any sector, company, or project.

To break down the three aspects (environment, economic, and social), a description of each can help in understanding what exactly is meant by achieving sustainability. The environmental aspect includes ecosystem services, green engineering & chemistry, air quality, water quality, stressors (e.g., emissions of pollutants), and resource integrity. The economic aspect includes jobs, incentives, supply & demand (e.g., life cycle cost analysis), natural resource accounting, costs, and prices. The social aspect includes environmental justice, human health, participation (e.g. public access & understanding), education, resource security, and sustainable communities. (*Learn About Sustainability*, n.d.). There is a lot covered in each section proving to be a challenging task to find balance between the three; however, efforts can be made to achieve sustainability to the best of our abilities.

4.2.3 Policy Diffusion

An important concept to understand for this research is policy diffusion. As described by Charles R. Shipan and Craig Volden, policy diffusion is “one government’s policy choices being influenced by the choices of other governments” (Shipan & Volden, 2012). When mentioning government, this can include local, state, national, and international. Most of the local levels of government are not likely to create climate protective initiatives due to a lack of funds and/or guidance from the federal level; therefore, widespread implementation will rely on requirements set on a national level. The local governments who are implementing climate protection initiatives are those with higher capital, education, and contain large numbers of environmental groups (Krause, 2011). With a focus on federal/national level government policy, international policy diffusion is relevant to this research. International governments and organizations have a major role in international policy diffusion (Arbolino et al., 2018). Government actions that prove to be successful can emulate to other countries and an example of this is with the eco- labelling policy first introduced in Germany which then spread to various countries as well (Tews et al., 2003).

4.2.3.1 Theoretical Policy Analysis Framework

Policy analysis is the use of analytical techniques, tools, and knowledge for and in policy making (Runhaar et al., 2006). There are countless variations of how to analyze policies. For the sake of simplicity, there are four basic key steps to be followed in policy analysis. First, the issue must be identified. In this research, the issue would be the lack of sustainability within building construction policies in the U.S. Second, an appropriate policy solution must be determined. This will be done with the help of other countries’ policies chosen to analyze. By analyzing their policies and techniques, policy solutions for the U.S. can be determined. Third, the policy solution options need to be identified and described in detail. The policies will need to be prioritized as well to help determine which will be most useful. Finally, a strategy must be developed in order for the selected policy solution to be adopted (*CDC's Policy Analytical Framework*, 2013).

When analyzing policies, indicators are used to determine the success or lack thereof in what the policy tackles. In terms of sustainability, indicators within the three pillars: social, economic, and environment; can inform analyzers of the level of sustainable coverage in a policy. Sustainable development assessments of policies will provide the state of sustainability; quantification of sustainability; feedback of policy implementation; and identification of best sustainability policy measures (Verma & Raghubanshi, 2018). The specific indicators for this research will be described in detail in *Table 4.1*.

The EPA uses a sustainable indicator database to evaluate and conduct research on their projects (Fiksel et al., 2012). Their evaluations then guide their decisions and policy making. This database is not specific to policy analysis nor building construction; however, the concepts of utilizing sustainable indicators as a project evaluation can be applied to a policy analysis framework. Another widely known organization, Centers for Disease Control and Prevention (CDC), conducts countless policy analyses and follows a simple analysis framework (*CDC's Policy Analytical Framework*, 2013). Their framework analyzes policies based on four categories: public health impacts, budgetary impacts, economic impacts, and policy feasibility. The CDC uses this framework to compare various policies by ranking each category with a low, medium, or high score. These scores depend on the effect size, reach size, and impact.

Currently, there are no specific building construction policy analysis frameworks; therefore, adapting different frameworks to meet the needs of this research is necessary. While the CDC is not related to building construction or building codes, their policy analysis framework can be adapted to fit this sector. By combining existing literature, the EPA's sustainable indicator theory, and the CDC's policy analysis framework, a suitable policy analysis framework can be used.

In conjunction with the EPA's sustainable indicators, a group of researchers from Islamic Azad University identified sustainable indicators specific to building construction (Zabihi et al., 2012). These were adapted to the theoretical policy analysis framework and the chosen indicators are demonstrated and described in *Table 4.1*.

Table 4.1 Sustainable Building Construction Index, Indicators, and Definitions

Indicator	Description / Interpretation
Environment Index	
a. Reduce Pollution	Could include any kind of greenhouse gas (GHG) emissions and is not constrained to only CO_2.
b. Reduce Waste	The management and attempt to minimize any waste that would be deposited into a landfill otherwise.
c. Manage Consumption	Minimizing waste and the number of materials needed. This could include mindfulness of the makeup of materials (eco-friendly), intentionally choosing materials or methods that are simplistic and requiring a minimum non-renewable and/or environmentally harmful materials.
d. Recycling	Managing the construction by-product through the reuse of existing infrastructure by recycling or repurposing anything that could be.
e. Compatibility	The way materials and structures would affect the environment and its inhabitants.
Economic Index	
f. Construction Speed	Work productivity; reducing the need for extensions on projects; quicker projects result in less money spent on pay and a faster completion date.

g. Reduce Waste	In terms of economy, this could include the cost savings attached to reusing building structures or materials instead of starting completely fresh. Could also include minimalism when it comes to design.
h. Profit (LCCA)	Include any aspects of a policy that considers costs and benefits to a design or project. Also known as a Life Cycle Cost Analysis (LCCA).
Social Index	
i. Public Participation	The level of involvement the people have on certain policies or codes. This could range from voting to involvement in the policymaking process.
j. Individualization	The uniqueness of a policy or code to the specific area, social class, average age group, population demographics, or accessibility, to name a few.
k. Health & Time Impacts	Includes maintaining human health, safety, and time. Examples include healthy air/water quality, comfortable living conditions, proper safety implications, reduced time infringements.
Feasibility Index	
l. Increase in Quality	An increase in quality for the public and/or environment.
m. Simplicity	A straightforward policy would be easy to understand and follow.
n. Optimized Design	Optimized designs should result in a design that is sustainable.
o. Flexibility	Specificity and details of the policy. If the policy is too flexible, they will be less likely to be followed.

4.2.3.2 Sustainability Indicator Alterations

The environmental indicators include reducing pollution, reducing waste, managing consumption, recycling, and compatibility. The economic aspects include construction speed, reduced waste, and profit. The social aspects of sustainability include public participation, individualism, and health and time impacts. The feasibility of the policies being implemented and carried out is not specifically an aspect of sustainability; however, consideration of this is important to the success of policies. While it is difficult to measure feasibility and the indicators are not necessarily listed within policies, the respective indicators mainly act to guide the policy analyzers to determine how feasible the policy may be. It should be noted that the feasibility of policies in this research analysis is constrained to a conceptual level. These indicators include an increase in quality, simplicity, optimized design, and flexibility.

The social, economic, and feasibility indicators were adjusted slightly to better fit a policy analysis. The environment indicators seemed well fit and did not need any alterations. 'Systematization' was originally placed in the social index; however, this indicator did not seem to have a significant impact on the level of sustainability of the policies (Zabihi et al., 2012). It was decided to eliminate this indicator from the analysis framework. The health and time impact indicator was added into the social index as these can be significantly impacted by building construction.

The only alteration to the economic index was the elimination of the 'programming' indicator (Zabihi et al., 2012). The was decided upon due to the lack of impact programming has on the economic index in terms of policy analysis.

In the referenced literature, the feasibility index was originally referred to as the 'technical' index (Zabihi et al., 2012). As the feasibility of policies is important to their success, it seemed necessary to include this into the framework to determine how likely it would be for the sustainable aspects of the building codes to be followed. In addition, the technical indicators all impact the feasibility, therefore, they are interchangeable in this context. The flexibility indicator was originally placed in the social index; however, it seemed to be better fit in the feasibility index. Flexibility was interpreted as the level of detail within a policy, which is directly related to how feasible it would be. 'Compatibility' was repeated in both the environment and feasibility indices (Zabihi et al., 2012). It was decided to eliminate this indicator from the feasibility index as it was not interpreted as an impact of a policy's level of feasibility.

4.3 Methodology

The research purpose is achieved by employing a qualitative research methodology. A document analysis of the most recent building codes for six countries was conducted using an adapted sustainability policy analysis framework. This framework was adapted from the existing literature and practices of the EPA and CDC. By evaluating their level of sustainability based on the three aspects, environment, social, and economic, the feasibility of the policies, and comparing the codes, a full analysis was completed using the selected framework.

4.3.1 Country Selection

The United Nations Sustainable Development Solutions Network (UNSDSN) is a global organization that brings together scientists, industry experts, and researchers to compile solutions for sustainable development. This organization was established in 2012 and has created the Sustainable Development Goals (SDGs) for all countries to implement and are in the Paris Climate Agreement. The SDGs are also used to rank the 165 countries that are involved with the UN. The resulting documentation of country ranks began in 2015 and is an annual report called the Sustainable Development Report (SDR) (*About Us*, n.d.-b).

Though this report and its goals are not specific to civil engineering, building construction, or infrastructure, this report does come of use when deciding on which countries to use for a policy comparison because there is not a different, equally as reputable comparison ranking system of a country's infrastructure quality/sustainability. From the 2021 SDR, the following were the top five countries: 1. Finland, 2. Sweden, 3. Denmark, 4. Germany, and 5. Belgium. The United States was ranked at 32 (Sachs et al., 2021). Of these six countries, the U.S. is the only one to not adopt the SDGs into government efforts including high-level statements, SDG strategies, and SDGs in the national budget. Belgium also has not implemented SDGs into their national budget; however, they have had high-level statements and implementation of SDG strategies. The other four countries have adopted the SDGs into their governments in all three ways (Sachs et al., 2021). It is these six countries that will be compared in the policy analysis.

4.3.2 Analysis

As mentioned previously, the policies are analyzed using an adapted framework for sustainable building construction indicators. Each country's building construction codes were identified and organized into each of the corresponding three sustainable aspects: environment, economic, and social. After compiling each of the categories for each policy, the corresponding indicators were identified. Each section then received a ranking of either low, medium, or high based on the number of indicators mentioned and the reach, effect size, and impact level. The final section considered, feasibility, was used on a conceptual level after analyzing the policies and three sustainable aspects. Based on the guiding feasibility questions created by the author of this research, the feasibility of each building code was considered and ranked as either low, medium, or high likelihood. *Appendix A* shows an example of one analyzer's rankings and analysis. The formatting used in *Appendix A* has many similarities to the formatting of the CDC's policy analysis tool and was used to shape the analysis layout for this research.

In addition to the author of this research completing the analysis, four other people also completed the analysis to reduce the likelihood of biases and provide a variety of perspectives. The author will be referred to as Analyst 1. Analyst 2 is a graduate student at Boise State University in the School of Public Service studying public administration with an emphasis in state and local public policy. Analyst 3 is a Senior Civil Engineer at Keller Associates Engineering Firm in the innovation and sustainability department. Analyst 4 is a Data and Climate Analyst for the City of Boise. Finally, Analyst 5 is a Policy Analyst for the Governor of Idaho's Office of Energy and Mineral Resources. All assisting analysts were not on the research committee for this project, nor did they have any relations to the author or other committee members. They were all selected based on their availability to assist on the project, knowledge on related topics, and for purposes of obtaining analyses from people in the industry with different backgrounds. All descriptions of the policy analyzers' backgrounds are current to the time of this thesis manuscript's publishing.

All analyses were completed in Microsoft Excel. The policies for each country were provided to analysts along with the list of indicators and their meanings. To make the analysis easier on the analyzers, the author identified all areas within each code that were related to the three pillars of sustainability for quick reference. For the sake of this chapter's length, all policy analyses in full detail are not provided, except for one analysis for reference purposes.

4.3.3 Sustainability Scoring Method

Numerical values were assigned to the level of sustainability rankings for comparison and analysis purposes. Low rankings were given a value of 1; medium was given a value of 2; and high was given a value of 3. To obtain average sustainability index scores for each country, all analyst's sustainability index scores were averaged. For the calculation of the country's overall sustainability score, their corresponding average sustainability index scores were also averaged to obtain values on a scale of 1 to 3 (low to high).

4.3.4 Current Building Codes

The policies chosen to analyze include each country's most recent building codes. As each code includes numerous sections, sub-sections, and details, only a summary of the sustainability-related sections will be described in *Table 4.2*. Of course, each country's building construction policies can be viewed for further detail on its respective website.

Table 4.2 Current Building Codes and Policies

Country	Policy Title	Sustainability-related Sections
1.Finland	National Building Code (*The National Building Code of Finland*, n.d.)	Strength & Stability of Structures, Fire Safety, Health, Accessibility, Noise Abatement & Conditions, Energy Efficiency
2.Sweden	Planning & Building Act (*Legislation Planning and Building Act (2010:900)*	Protection Against Disturbance, Shoreline Protection, Design of Construction Works, Technical Characteristics of Construction Works,
	Planning and Building Ordinance (2011:338), 2018)	Suitability of Construction Products
3.Denmark	Danish Building Regulations (*Danish Building Regulations*, 2021)	Construction Site & Execution of Construction Work, Building Law & Assessments, Energy Consumption, Pollution, Sound Conditions, Light & Visibility, Construction Classes, Fire Classes

4.Germany	Building Code General Regulations (*Building Code (BauGB)*, 2021)	Supplementary Regulations on Environmental Protection, Public Participation, Usage Restrictions on Future Public Needs, Traffic, Supply and Green Areas, Involvement of Authorities, Cash Benefits, Measures for Nature Conservation, Urban Redevelopment Measures, Social Plan & Hardship Compensation
5.Belgium	Manual for Standard Building Specifications (Office for Infrastructure and Logistics in Brussels, European Comission, 2019)	Functionality, Occupational Safety & Well-being, Environment, Fire Safety
32.United States	2021 International Green Construction Code (IgCC)	Site Sustainability, Water & Energy Efficiency, Indoor Environmental Quality, Materials &
	Standards (*2021 International Green Construction Code (IgCC)*, 2021)	Resources, Construction & Plans for Operation

The numbers next to the countries signify their 2021 SDR ranking. It is also important to note that the term ‘building’ can refer to either the noun building, meaning the physical structure, or the verb building, meaning the action of construction. In all the policies stated above, building refers to the action of construction.

4.4 Analysis

Conclusions were drawn on each country’s building code regarding sustainability and feasibility. The results are described below and grouped into the four sustainable building construction indices.

4.4.1. Environment

All policies compared mention reducing pollution (a), the management of consumption of materials (c) as well as environmental compatibility (e). Reducing waste (b) was mentioned in all policies except for Finland’s. Finally, recycling (d) was only mentioned in Denmark, Belgium, and the U.S.’s policies. Denmark, Belgium, and the U.S. are the only countries that mentioned all indicators within the environmental aspect of sustainability. Based on the number of indicators mentioned, their detail, and impact levels, each analyzer gave the countries a sustainability score of low, medium, or high. These scores are shown in the bar graph below in *Figure 4.1*. Overall, each country has relatively long and detailed environmental areas that are covered within their building codes.

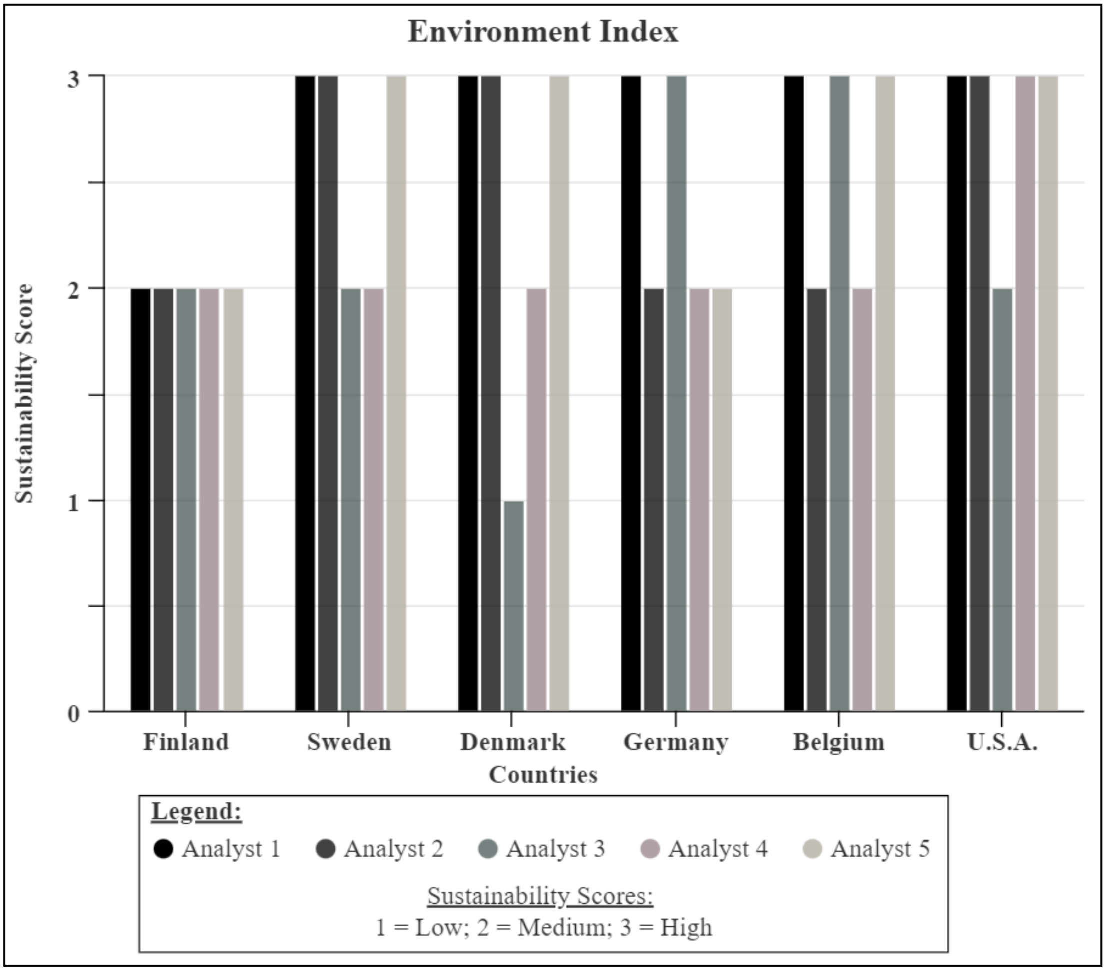

Figure 4.1 Countries' Environment Sustainability Scores

4.4.1 Economic

The economic aspect was a little scarce across the board. The most common indicators mentioned included construction speed (f) and profit (Life Cycle Cost Analysis) (h).

Construction speed (f) was mentioned in Finland, Denmark, and Germany's codes. Profit (h) was mentioned in Sweden, Germany, and Belgium's codes. Reducing waste (g) as a mode of economic value was mentioned a couple times in Sweden and Belgium's codes. Finland's policy did not mention any of the indicators but did mention that improvements in energy efficiency should be made if economically feasible. This statement is not pertinent to construction; however, it is noted that Finland has thought about the value of the economic aspect of sustainability. The United States' building code is the only one which does not contain any information or requirements that have to do with the economic aspect. This could be the reason for a lack of national policy implementation in the U.S. as the economics of projects is very important.

Based on the number of economic indicators, details, and impact level, all analyzers gave a corresponding sustainability score which is shown below in *Figure 4.2*.

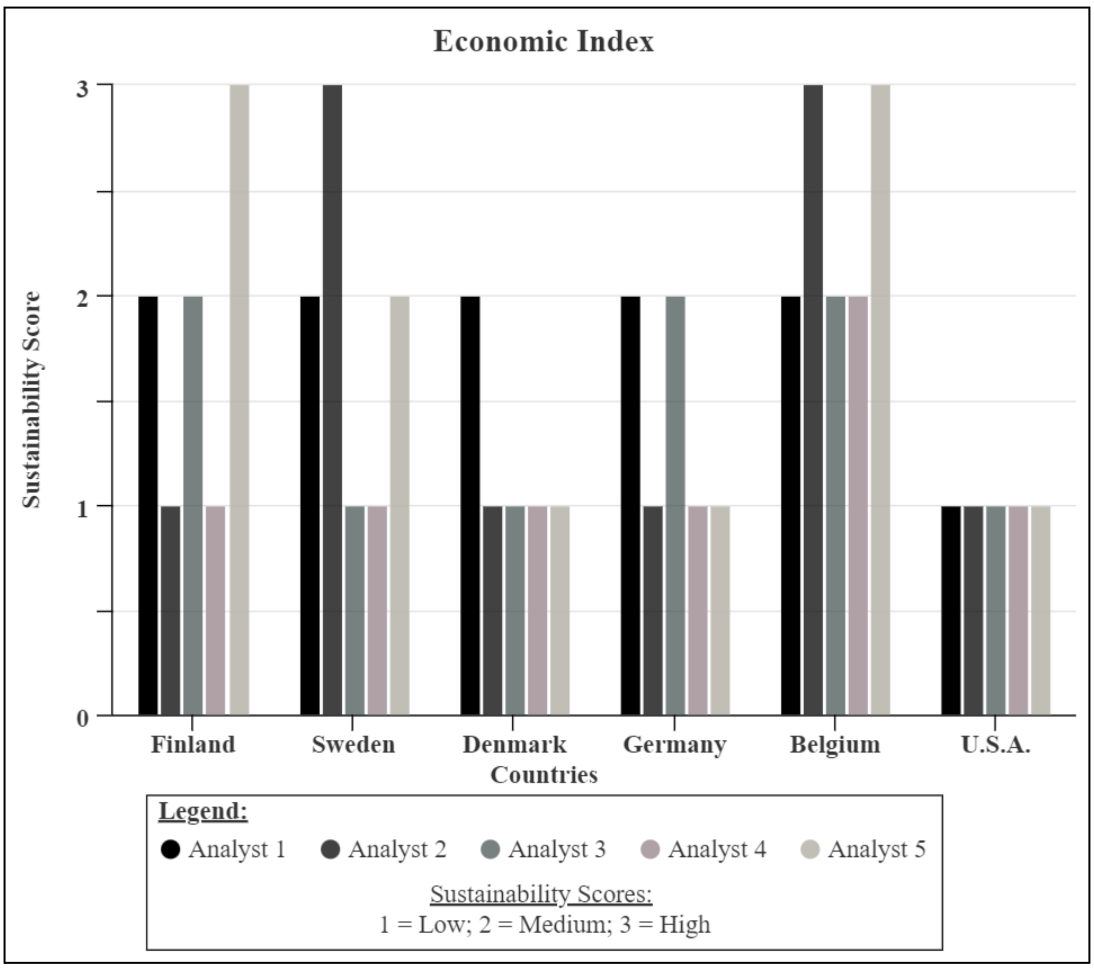

Figure 4.2 Countries' Economic Sustainability Scores

4.4.2 Social

Most of the policies had long and detailed social aspects covered. All policies mentioned the individualization (j) and health/time impact (k) indicators. Germany was the only country to mention all social indicators. Both Denmark and the U.S.'s social aspects were more general and minimal in comparison to the rest of the policies. All analyzer's social sustainability scores are shown below in *Figure 4.3*.

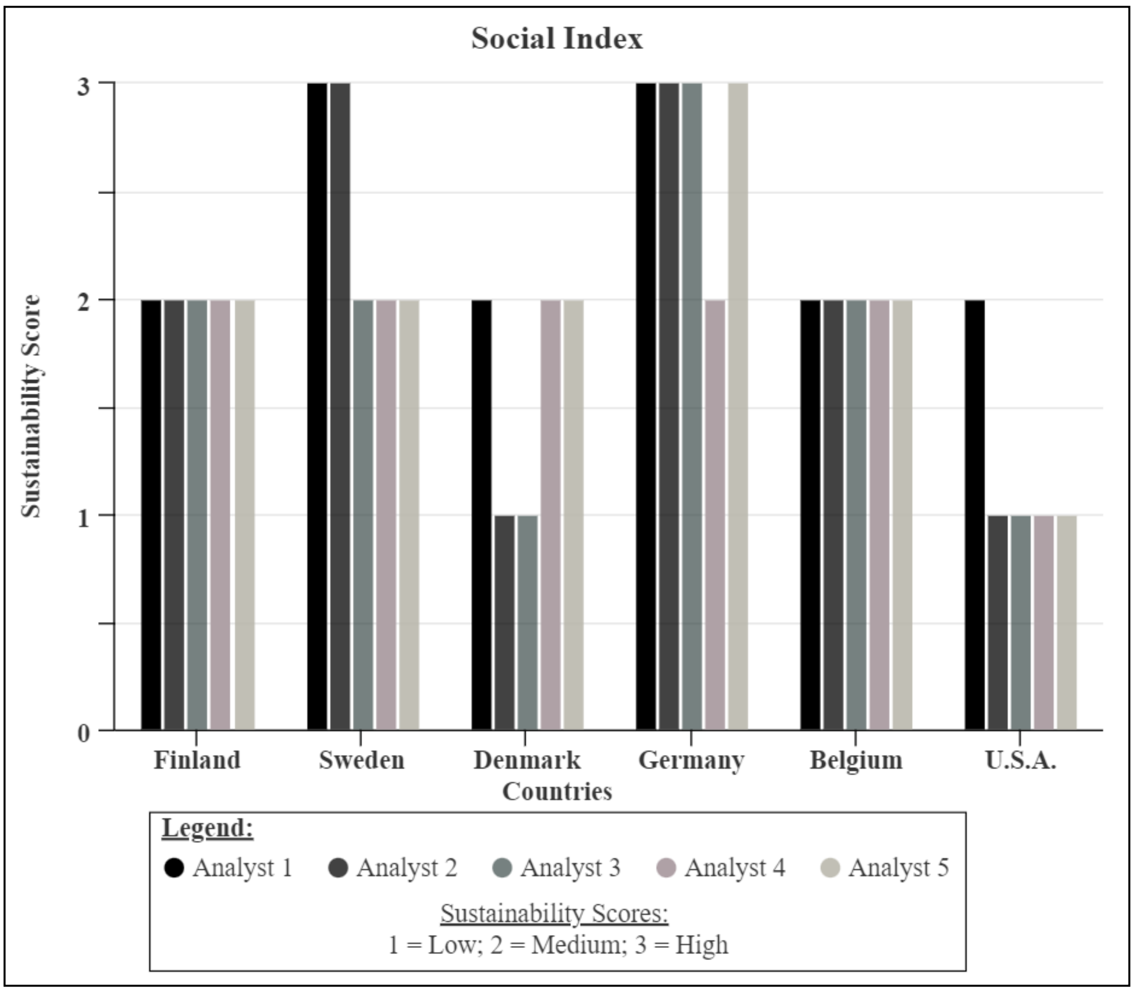

Figure 4.3 Countries' Social Sustainability Scores

4.4.4 Feasibility

Finland, Denmark, and Belgium were scored with an average of a high likelihood of feasibility between all analyzers. This was due to the level of detail, easy understanding, large effect size, and large impact. The United States had the lowest feasibility score with a moderate likelihood. This is resulting from the lack of details and indicators in the social index as well as the missing economic index. The environment index high sustainability score is what made the

U.S. 's feasibility score moderately likely over a least likely. Please refer to *Figure 4.4* for the feasibility sustainability scores.

While an actual and accurate measurement of each country's policy implementation and closely those policies are followed would be ideal, these measurements are difficult to attain.

For this analysis, the feasibility aspect is constrained to a conceptual-level measurement.

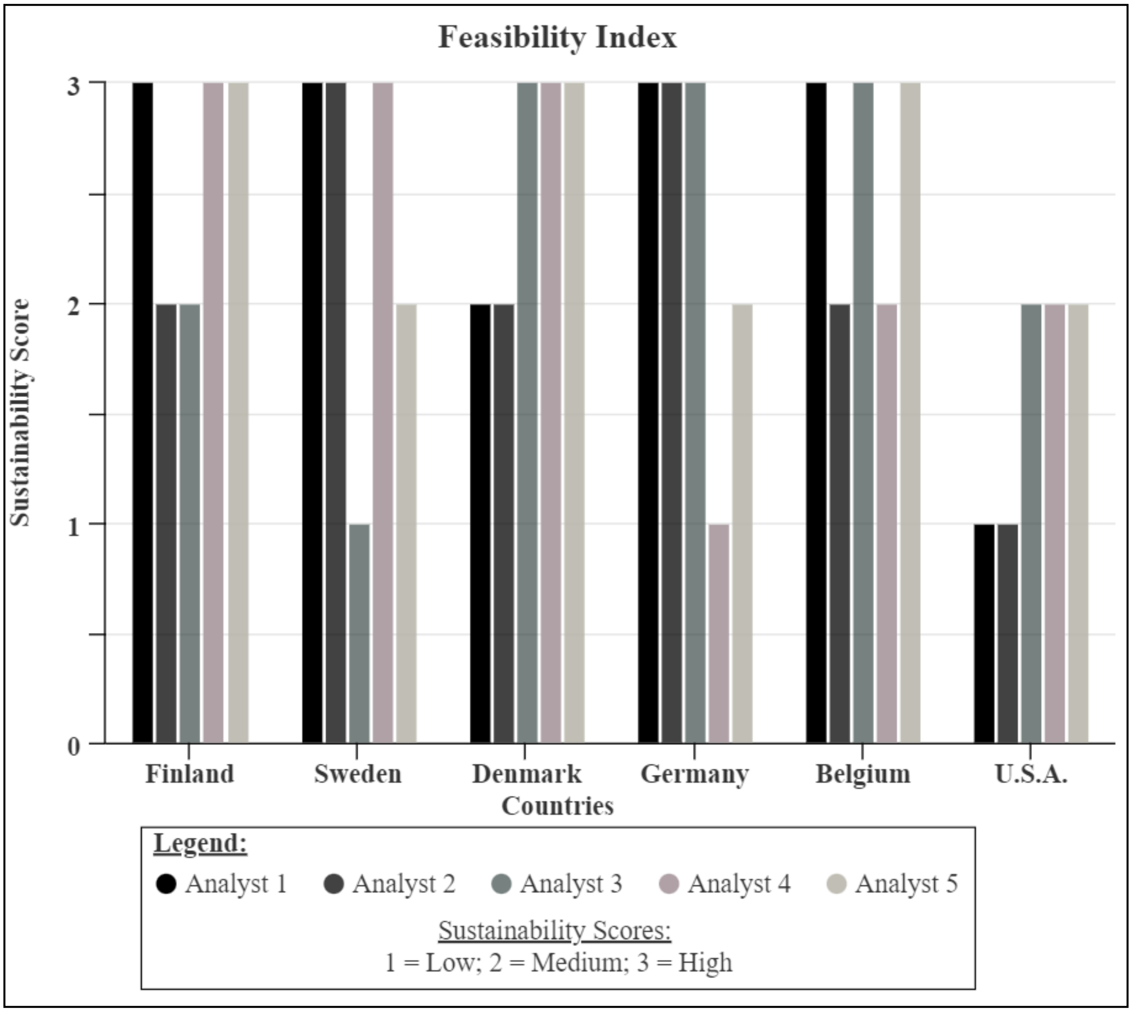

Figure 4.4 Countries Feasibility Sustainability Scores

4.4.5 Overall Sustainability Scores

Each country's sustainability scores for each index were averaged based on all analysts' scores. These are all shown below in *Figure 4.5*.

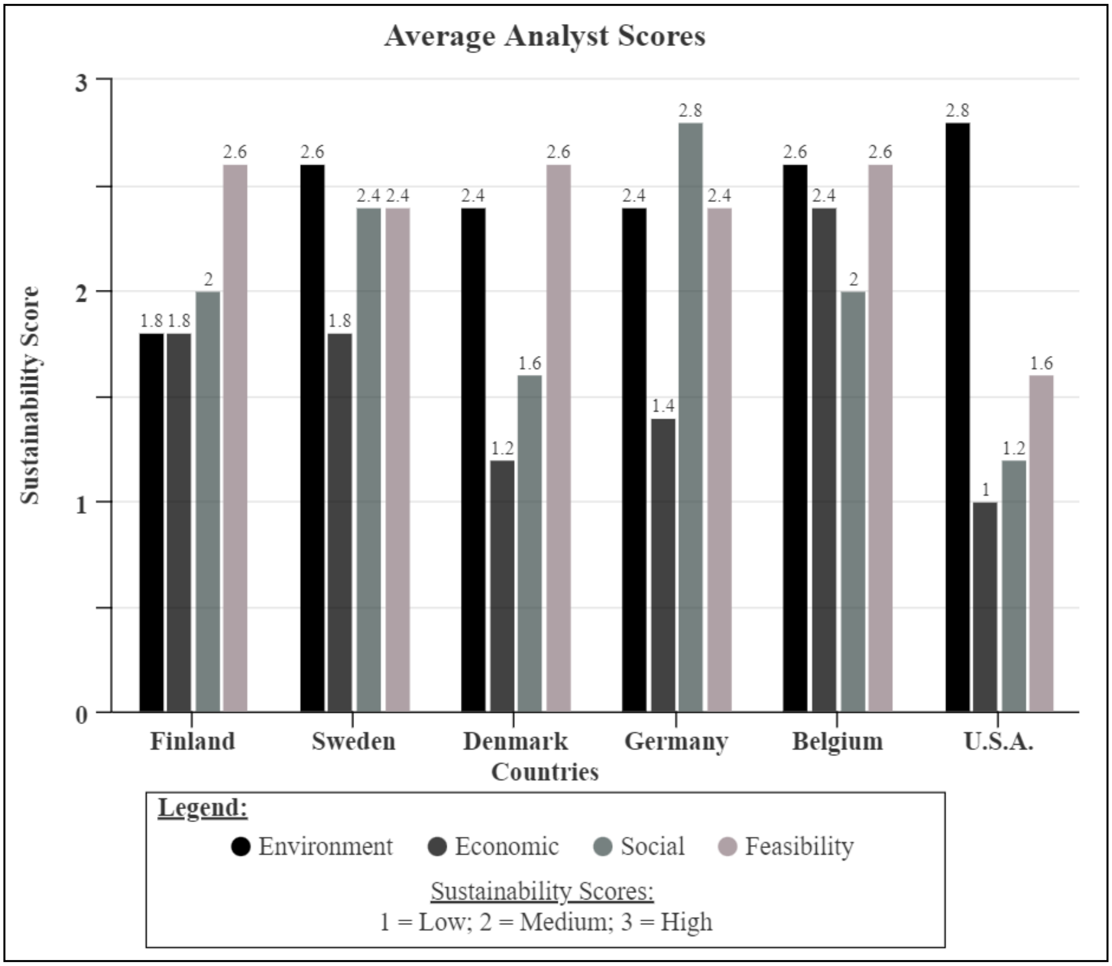

Figure 4.5 Average Analyst Scores for Each Sustainability Index

The overall sustainability scores for each country were calculated and are shown in the table below. The scores are consistent to the same scoring system of low (1), medium (2), or high (3). The numbers in front of the countries reference their respective 2021 SDR ranking.

Table 4.3 Final Sustainability Scores for Each Country

Country	Overall
1. Finland	2.10
2. Sweden	2.30
3. Denmark	1.95
4. Germany	2.25
5. Belgium	2.50
32. U.S.A.	1.65

The results show that Belgium has the highest level of sustainability for their most current building code. The United States scored the lowest with a 1.65. There were some categories that all analyzers came up with the same scores for; however, most of the categories had at least one analyst who disagreed with the majority. This could be due to each individual person's understanding of the policies themselves. As each person who assisted in this research analysis was unfamiliar with building codes and some analyzers having different previous knowledge on sustainability or even policy analysis, discrepancies between scores were expected. There were no identified patterns between analyzer backgrounds and scoring choices.

4.4.6.1 Policy Recommendations

To support the United States' IgCC policy towards sustainability and feasibility, this study recommends including all indicators that are currently missing. The results show that it was found that the countries which included more indicators than others had a higher impact and feasibility level. Some of the recommendations are taken and/or adapted from other country's policies as they are applicable to the U.S. These are identified with quotes and citations. Some policy recommendations include additions or updates from the existing U.S. policies and have been identified using bolded lettering. Finally, most of the recommendations have been created by the author based on the knowledge learned from the policy analyses, country sustainability scores, and literature reviews. An emphasis on implementing the economic aspect and its indicators should be the highest priority over all other recommendations as these are currently not considered at all and the lack thereof is directly correlated to the success of sustainable policy implementation. The following suggested policies are separated into each of the three sustainable indices: environment, economic, and social.

4.4.6.2 Environment

1. Change "**A minimum of 50%** of non-hazardous construction and demolition waste material generated prior to the issuance of the final certificate of occupancy shall be diverted from disposal in landfills and incinerators by reuse, recycling, repurposing, and/or composting." to "***All*** *non-hazardous construction…"* (a, b, d) (*2021 International Green Construction Code (IgCC)*, 2021)

2. Change "The sum of the recycled content and the salvaged material content shall constitute a minimum of 10%, based on cost, of the total materials in the building project." to "...***a minimum of 50%*** *based on..." (b, c, d)* (*2021 International Green Construction Code (IgCC)*, 2021)

4.4.6.3 Economic (Highest Priority)

3. Construction projects must be completed as quickly as possible in order to increase productivity and construction speed without compromising the quality of the infrastructure. (f)
4. Select projects, materials, and timelines that are economically feasible. (g)
5. Construction projects "must be selected in such a way as to minimize maintenance expenses and optimize costs during the building's life cycle (initial investment costs, operating costs, maintenance costs, replacement or removal costs)." (h) (Office for Infrastructure and Logistics in Brussels, European Commission, 2019)

4.4.6.4 Social

6. "The public is to be publicly informed as early as possible about the general objectives and purposes of planning, significantly different solutions that may be considered for the redesign or development of an area, and the likely effects of planning so they are to be given the opportunity to express themselves and to discuss it." (i) (*Building Code (BauGB)*, 2021)
7. Accessibility for elderly, disabled, and children must be included in designs as well as the social and cultural needs of the community. (j)

8. Update "Enhance building occupant health and comfort." to *"... health and comfort* ***by maintaining safe and healthy air quality, temperature, water supply, sewage, and lighting for all****."* (k) (*2021 International Green Construction Code (IgCC)*, 2021)

4.5 Summary, Findings, Recommendations and Limitations

The buildings and construction sector has significant negative impacts on the environment; however, there is room for improvement and ensuring sustainable development. Sustainable policy is more than just environmentally cognizant policies in that it also considers the social and economic side of things as well. True sustainability should be the goal of all projects and must be practiced to reduce negative impacts on the world. Through the incorporation of sustainability concepts into everyday practice, the negative environmental impacts should be significantly minimized without major costs attached. The goal of this research was to identify the issues the United States building construction policies have and to suggest new policies to improve the level of sustainability within this industry by completing a comparative analysis on different country's policies.

Through extensive research and literature reviews, it was found that there are many organizations out there both nationally and globally to advocate for sustainability within the construction sector (*About ASCE*, n.d.; *About Us*, n.d.-a; *About Us*, n.d.-b; *Learn About Sustainability*, n.d.; *Sustainable Buildings and Construction*, 2018; *Who We Are*, n.d.). Although there are many advocates and organizations that work hard to educate the public and construction sector on the importance of sustainability, it is not enough to make the drastic changes we need in the amount of time we must do so. It was also found that national-level policies usually act as a minimum requirement for states to follow, therefore targeting federal policies seems to be one possible solution to the minimal incorporation of sustainability into the buildings and construction sector. Unfortunately, the actual building construction policies in the U.S. currently, mostly consider the environmental side of sustainability and completely disregard the economic aspect.

Through analyzing the top five, most sustainable countries ranked by the United Nations' 2021 Sustainable Development Report in addition to the United States, many discoveries were made for the buildings and construction sector's policies. It was found that the U.S. was indeed less sustainable in the sector in comparison to the five countries. Belgium's building code was ranked with the highest sustainability at 2.5 out of 3. The U.S. trailed behind all five countries with a score of 1.65 out of 3. This was due to the lack of sustainable building construction indicators mentioned in the code, few details in the social index, and no mention of the economic index. In addition, it was found that the areas covered in the U.S.'s code were much more scarce and less descriptive in comparison to the other country's codes.

The final policy recommendations for the United States includes implementing all sustainable building construction indicators into the current building code. The highest priority for the U.S. should be implementing the economic indicators because the current code currently does not include any. The results demonstrated that a balance between the three pillars of sustainability had a direct impact on the success of the codes, therefore including the economic aspect is crucial. The second priority should include implementing the missing social indicators and extending the details of the currently included indicators. Finally, the environmental index was given a high score in the U.S. and was quite thorough; therefore, the only recommendations for this index would be to increase the minimum requirements for a higher level of environmental consideration in building construction projects.

4.5.1 Limitations and Future Studies

While conducting this research, it was prevalent that data to support the successes of the building codes would be helpful to the analysis. This kind of data could include interviews with construction companies in each country to see what protocols they use and how closely they follow their national code. Following interviews, information on the how the policies are ensured on being followed would be valuable to this research as well.

Data collected on the release of greenhouse gases over time for each country and for all sectors would also assist in determining the success policies may have on reducing emissions. Current data found at the time of publishing this manuscript is not specific enough to include in this research analysis. Data collected on all construction project's waste, recycling, and materials used would also be beneficial to the analysis of these policies. In addition, any data that could be collected on human health impacts over time could be beneficial to showing the impact of building construction projects to humans. The data would need to be area specific within the countries since an overall country assessment would not be conducive to impacts by building construction projects.

Other information that would be beneficial to this research would be analyzing any programs and/or initiatives that are highly used and followed. Due to time constraints and the extensive number of programs and initiatives, it was not feasible to include these in this specific project. Throughout this project, analysis on the quality of infrastructure for all countries was not found by the time of publishing. Though some information is out there about infrastructure quality, there is not currently an accurate and versatile grading system that all countries use.

4.6 Acknowledgments

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4.7 References

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CHAPTER 5: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary and Conclusions

The purpose of this thesis was to develop building code recommendations that target the three pillars of sustainability for the United States to improve their buildings and construction sector. Current reports and literature describe the negative environmental impacts the sector has globally and suggests the incorporation of sustainable practices as a solution. To determine what kinds of sustainable codes to recommend, research was conducted on both a local level as well as a national level. The preliminary research on building codes on a local level was conducted first to set the stage for the main research. Ada County, Idaho was chosen to analyze as it is in the author's community and due to the booming population, there is opportunity to expand the current building codes. Ada County was analyzed alongside one of the most sustainable counties in the United States, Alameda County in California. The purpose of this analysis was to identify sustainable practices Alameda County uses within their building code and adapt those concepts and codes to Ada County.

The major findings of the preliminary research include:

1. Ada County's code contains less topics related to the sustainability pillars than Alameda County's code.
2. Both building codes rooted from the 2018 International Building Code (IBC) but had big differences due to variations of added sections and amendments.

3. Ada County has a *Green Building Resolution* (established in 2003) which is not part of their building code and does not seem to hold much leverage over encouraging sustainability.
4. Alameda County has a *Green Building Standards Code* that provides guidelines to ensure sustainability that accounts for the three pillars.
5. Ada County was given a lower overall sustainability score of 1.67 out of 3 due to the minimal sustainability-related topic coverage.
6. Alameda County was given a higher score of 2.67 out of 3 as it had good coverage of sustainability-related topics.

The international-level research done for this thesis on building codes was a comparative analysis to determine the policy recommendations for the United States to apply to their building code to make their buildings and construction sector more sustainable. A policy analysis framework was adapted to target sustainable building construction based on the EPA's practices and existing literature. This framework incorporated various sustainability indicators targeted towards building construction that assisted in the analysis of various building codes. The top five, most sustainable countries' building codes were analyzed, in addition to the United States' building code, using the adapted framework. Four volunteers of different backgrounds completed the analysis, in addition to the author's analysis, to obtain non-biased results. The overall sustainability scores for all analyzed countries are shown in the table below.

Table 5.1 Overall sustainability scores for each country

Country	Overall
1. Finland	2.10
2. Sweden	2.30
3. Denmark	1.95
4. Germany	2.25
5. Belgium	2.50
32. U.S.A.	1.65

The following include the key findings from the analyses:

1. The U.S. building code is the only code that does not contain any information on the economic pillar of sustainability.
2. The U.S. building code contains a scarce amount of information related to the social aspect of sustainability, especially in comparison to the other countries.
3. Belgium has the most detailed information on the economic aspect of sustainability and scored the highest for overall sustainability.
4. Germany's building code is the only one to cover all social indicators.
5. The more indicators covered across the three pillars of sustainability within a building code, the more likely it is to be followed.

Overall, it was found that there are different levels of government all involved in the implementation of sustainability into building codes; however, it seems the national codes act as a minimum requirement for all levels of government to follow. State and local government action should not be disregarded because small impacts can also influence higher levels of government. It was the author's personal choice to place a main focus on the national building codes with hopes of influencing a minimum sustainability requirement for all levels of government to follow.

5.2 Policy Recommendations

The building code recommendations for Ada County includes the following:

1. Update the 2003 Green Building Resolution to a designated Green Building Code similar to California's Green Building Standards Code or the International Green Building Code (IGBC).
   a. Include all missing sustainable building construction indicators:
      i. For the environment pillar, indicators missing include reducing pollution and resource and waste management.
      ii. For the economic pillar, indicators missing include material efficiency, life cycle cost assessments (LCCA), and cost efficiency.
      iii. For the social pillar, indicators missing include air and water quality and quality of life.

The policy recommendations for the United States building code includes the following:

5.2.1 Environment

1. Change "**A minimum of 50%** of non-hazardous construction and demolition waste material generated prior to the issuance of the final certificate of occupancy shall be diverted from disposal in landfills and incinerators by reuse, recycling, repurposing, and/or composting." to "***All***

non-hazardous construction…" (*2021 International Green Construction Code (IgCC)*, 2021)

2. Change "The sum of the recycled content and the salvaged material content shall constitute a minimum of 10%, based on cost, of the total materials in the building project." to "...***a minimum of 50%*** *based on..."* (*2021 International Green Construction Code (IgCC)*, 2021)

5.2.2 Economic (Highest Priority)

3. Construction projects must be completed as quickly as possible in order to increase productivity and construction speed without compromising the quality of the infrastructure.
4. Select projects, materials, and timelines that are economically feasible.
5. Construction projects "must be selected in such a way as to minimize maintenance expenses and optimize costs during the building's life cycle (initial investment costs, operating costs, maintenance costs, replacement or removal costs)." (Office for Infrastructure and Logistics in Brussels, European Commission, 2019)

5.2.3 Social

6. "The public is to be publicly informed as early as possible about the general objectives and purposes of planning, significantly different solutions that may be considered for the redesign or development of an area, and the likely effects of planning so they are to be given the opportunity to express themselves and to discuss it." (*Building Code (BauGB)*, 2021)

7. Accessibility for elderly, disabled, and children must be included in designs as well as the social and cultural needs of the community.
8. Update "Enhance building occupant health and comfort." to *"... health and comfort* ***by maintaining safe and healthy air quality, temperature, water supply, sewage, and lighting for all****."* (*2021 International Green Construction Code (IgCC)*, 2021)

5.3 Recommendations for Future Research

Some research topics that could be considered for furthering the implementation of sustainability into the buildings and construction sector as well as improving the sector include the following:

1. Expanding the framework to include resiliency as it builds off of sustainability and could add value to this policy framework. Furter research on unifying resiliency and sustainability within building construction would be necessary for expansion.
2. Research on various construction companies from each country on how closely they follow the national building code or if they utilize a different variation of the code. Information collected on what protocols are used to ensure the codes are followed would also be beneficial to support the research findings in this thesis.
3. Certain data collections related to climate change from various countries over time would also support this thesis' research findings. The types of data that would be beneficial could include greenhouse gas emissions, air quality, water quality, human health impacts, infrastructure quality and construction project

waste and recycling. All data would only benefit the research findings if the data were area specific.

5.4 References

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APPENDIX

	Environmental		Economic		Social		Feasibility		Low/ Medium/ High	Sustainability Score for Each Category	Overall Policy Sustainability Scores	Average Country Sustainability Scores
	a. Reduce Pollution		f. Construction Speed		i. Public Participation		l. Increase in Quality		Low/Least =	1		1.00-1.67
	b. Reduce Waste		g. Reduce Waste		j. Individualization		m. Simplicity		Medium/Feas	2		1.67-2.33
	c. Manage Consumption		h. Profit (LCCA)		k. Health/Time		n. Optimized Design		High/Most =	3		2.33-3.00
	d. Recycling						o. Flexibility					
	e. Compatibility											
Criteria	**Environmental**		**Economic**		**Social**		**Feasibility**					
Scoring Definitions	**Low:** small reach, effect size & impact. **Medium:** small reach w/ large effect size & impact; or large reach w/ small effect size & impact. **High:** large reach, effect size & impact.		**Least:** costs are high vs benefits. **Favorable:** costs are moderate vs benefits. **Most:** costs are low vs benefits.		**Low:** small effect size impacted & benefited. **Medium:** moderate effect size impacted & benefited. **High:** large effect size impacted & benefited.		**Low:** no/small likelihood of enaction. **Medium:** moderate likelihood of enaction. **High:** prominent likelihood of enaction.					
1. Finland												
National Building	☐	low	☐	least	☐	low	☐	low	0	0		
	☑	medium	☑	favorable	☑	medium	☐	medium	3	1.5		
	☐	high	☐	most	☐	high	☑	high	1	0.75	2.25	**2.25**
2. Sweden Policy												
Planning & Building Act	☐	low	☐	least	☐	low	☐	low	0	0		
	☐	medium	☑	favorable	☐	medium	☐	medium	1	0.5		
	☑	high	☐	most	☑	high	☑	high	3	2.25	2.75	**2.75**

3. Denmark Policy												
Danish Building	☐	low	☐	least	☐	low	☐	low	0	0		
	☐	medium	☑	favorable	☑	medium	☑	medium	3	1.5		
	☑	high	☐	most	☐	high	☐	high	1	0.75	2.25	**2.25**
4. Germany Policy												
Building Code	☐	low	☐	least	☐	low	☐	low	0	0		
	☐	medium	☑	favorable	☐	medium	☐	medium	1	0.5		
	☑	high	☐	most	☑	high	☑	high	3	2.25	2.75	**2.75**
5. Belgium Policy												
Manual of Standard Building Specificatio	☐	low	☐	least	☐	low	☐	low	0	0		
	☐	medium	☑	favorable	☑	medium	☐	medium	2	1		
	☑	high	☐	most	☐	high	☑	high	2	1.5	2.5	**2.50**
32. U.S.A. Policy												
IgCC 2021 Standards	☐	low	☑	least	☐	low	☑	low	2	0.5		
	☐	medium	☐	favorable	☑	medium	☐	medium	1	0.5		
	☑	high	☐	most	☐	high	☐	high	1	0.75	1.75	**1.75**

Sustainability Index	Environmental	Economic	Social	Feasibility
1. Finland Policy				
National Building Code	"When the building and its systems are used as intended, the energy consumption and power demand remains low and the energy consumption can be monitored." "Buildings must be improved when carrying out any repairs and alterations or making changes to the intended use of a building if this is technically, functionally and economically feasible." "A building is designed and constructed in a way that it is fire safe, as required by its intended use." "Products used in construction work must be such that during their planned service life they do not cause emissions that cannot be considered acceptable into the indoor air, drinking water or the environment." "Environmental factors and natural conditions are taken into account in the location of residential buildings, arrangement of their spaces and other housing design." **Sustainable Indicator Letters policy covers, Impact Level:** c, e, a, High Impact	"Energy efficiency must be improved when carrying out any repairs and alterations or making changes to the intended use of a building if this is technically, functionally and economically feasible." **Sustainable Indicator Letters policy covers, Impact Level:** Favorable	"Safe with regard to indoor air, humidity, temperature and lighting conditions, and water supply and sewerage." "Buildings must not cause risk to health." "The building, its outdoor areas and pathways may not cause a risk of injury, accident or damage." "In the event of a fire, those inside it can escape or be rescued." "The safety of emergency service personnel must be taken into account in construction. The permit authority may require a safety report to be drawn up for a building that is particularly demanding in terms of emergency evacuation safety." "When undertaking a construction project it is to be ensured that the building and its yard and other premises are designed and constructed as required by the intended use, the number of users and the number of floors, especially in terms of accessibility and usability for children, the elderly and persons with disabilities." "The building, its yard, and other premises are designed and constructed in a way that noise exposure and noise conditions in the building, the yard, and other premises of the building site do not pose a risk to health, rest or working." "Spaces intended for residential use are designed and constructed in a way that are fit for their purpose, pleasant and comfortable." **Sustainable Indicator Letters policy covers, Impact Level:** k, j, High Impact	*Your description of how this policy will be conceived. Is it detailed and specific? Is it general and could be hard to understand? What kind of effect size is this policy covering? State, city, national-level? (All policies considered are mandatory national-level, so large effect size.) Based on your description, is the policy less likely, moderately likely, or most likely to be followed?* **Type your description here; Sustainable Indicator Letters policy covers, Impact Level:** Very detailed with no room for confusion on policy details. High Impacts and large effect size as this is a federal/national policy that all cities must follow as a minimum standard.

2. Sweden Policy				
Planning & Building Act	"Protection with regard to hygiene, health and the environment." "Energy management and heat retention; and economical management of water and waste." "The natural conditions are taken advantage of to the greatest possible extent." "Maintenance must be adapted to the character of the surroundings and the construction works' value from a historical, cultural-historical heritage, environmental and artistic point of view." **Sustainable Indicator Letters policy covers, Impact Level:** c, b, e, high	"Economical management of water and waste." "Normal maintenance, to continue to be fulfilled during an economically reasonable service life." **Sustainable Indicator Letters policy covers, Impact Level:** g, h, medium	"Accessible to and usable for individuals with limited mobility or orientation capacity." "In case of fire, protection with regard to hygiene, health and the environment, protection against noise; accessibility and usability for individuals with reduced mobility or sense of direction." "No significant negative impact arises for the surroundings or for traffic." "There must be a suitably located exit or other way out from the site, as well as facilities that allow for necessary transports and fulfil the requirement for accessibility by emergency vehicles." "Maintenance must be adapted to the character of the surroundings and the construction works' value from a historical, cultural-historical heritage, environmental and artistic point of view." **Sustainable Indicator Letters policy covers, Impact Level:** j, k, high	*Your description of how this policy will be conceived. Is it detailed and specific? Is it general and could be hard to understand? What kind of effect size is this policy covering? State, city, national-level? (All policies considered are mandatory national-level, so large effect size.) Based on your description, is the policy Less likely, Moderately likely, or Most likely to be followed?* **Type your description here; Sustainable Indicator Letters policy covers, Impact Level:** This planning and building act is very specific when it comes to the three pillars of sustainability. The economic pillar is lacking compared to the other two, but over all it is specific. It isn't hard to understand, and is most likely to be followed.

3. Denmark Policy				
Danish Building Act	"Unnecessary consumption of resources in buildings is prevented; unnecessary consumption of raw materials is prevented, including provisions on the use of certain materials or structures and on the recycling of materials." "Wastewater, rainwater, surface water and groundwater discharge complying with environmental protection legislation." "Drinking water supply complies with water supply and environmental protection legislation." "Follows requirements for installation of building heating based on renewable energy." **Sustainable Indicator Letters policy covers, Impact Level:** c, d, a, e, high	"Promote measures that can increase construction productivity." **Sustainable Indicator Letters policy covers, Impact Level:** f, favorable	"Buildings are constructed, laid out and used in a way that is satisfactory in terms of fire protection, safety and health." "The buildings cater to the needs of people with disabilities." **Sustainable Indicator Letters policy covers, Impact Level:** k, j, medium	*Your description of how this policy will be conceived. Is it detailed and specific? Is it general and could be hard to understand? What kind of effect size is this policy covering? State, city, national-level? (All policies considered are mandatory national-level, so large effect size.) Based on your description, is the policy less likely, moderately likely, or most likely to be followed?* **Type your description here; Sustainable Indicator Letters policy covers, Impact Level:** This building act is most descriptive in the environment area; however, mentions of profuctivity and social aspects are considered. Moderately descriptive overall and most likely to be followed in environmental area, but other areas, possibly not. Moderately likey.

4. Germany Policy				
Building Code General Regulations	"Protect and develop the natural foundations of life and to promote climate protection and adaptation, especially in urban development." "Preserve and increase the urban design and the local and landscape appearance." "Develop nature conservation and landscape management, in particular the effects on animals, plants, area, soil, water, air, climate and the interdependency between them as well as the landscape and biological diversity environmental effects on cultural and other material goods." "The avoidance of emissions and the proper handling of waste and wastewater." "The use of renewable energies as well as the economical and efficient use of energy." **Sustainable Indicator Letters policy covers, Impact Level:** e, a, c, high	"Must follow requirements for cost-saving construction." **Sustainable Indicator Letters policy covers, Impact Level:** f, h, favorable	"Help to ensure a humane environment, the housing needs of the population, in particular of families with several children, the social and cultural needs of the population, environmental impacts on people and their health as well as the population as a whole." "The public is to be publicly informed as early as possible about the general objectives and purposes of planning, significantly different solutions that may be considered for the redesign or development of an area, and the likely effects of planning so they are to be given the opportunity to express itself and to discuss it." **Sustainable Indicator Letters policy covers, Impact Level:** j, k, i, high	*Your description of how this policy will be conceived. Is it detailed and specific? Is it general and could be hard to understand? What kind of effect size is this policy covering? State, city, national-level? (All policies considered are mandatory national-level, so large effect size.) Based on your description, is the policy less likely, moderately likely, or most likely to be followed?* **Type your description here; Sustainable Indicator Letters policy covers, Impact Level:** Only the economic pillar is not as descriptive as the other two pillars. The environmental and social aspects are very descriptive and most likely to be followed. Most likely.

5. Belgium Policy				
Manual of Standard Building Specifications	"The various parts of the building, the area surrounding it and its façades must fit into the urban environment and help to improve it." "The design of the building must be such as to ensure that adequate standards of health, hygiene and safety are met for its occupants." "Adequate standards of health, hygiene and safety for the building's occupants must be guaranteed if opportunities to open exterior windows are limited." "An environmental assessment will be carried out for all of its newly constructed or substantially renovated buildings." "The building's entire life cycle (design, construction, maintenance, renovation, demolition) must be taken into account." "The minimum requirements of the applicable building energy performance regulations must be met." "The environmental impact throughout the building's life cycle, including the impact of the materials used, must be assessed on the basis of the nature of the works, the scale of the project and the complexity of the public procurement procedure including: a global life-cycle analysis (LCA) at building level; a life-cycle analysis at product level on the basis of environmental product declarations (EPD); construction products with an environmental label certified by an independent third party; construction products with a high percentage by weight of recycled products or reused products an option to recycle construction products (the availability of recycling facilities must be proven); and reduced CO2 emissions associated with the transport of heavy construction materials." "The generation of waste must be minimised as far as possible on the basis of a waste management plan." "A high percentage of the non-hazardous waste generated during renovation, demolition or renovation works must be reused or recycled." "In order to maximise biodiversity and ecosystem conservation opportunities, compliance with the applicable legislation must be guaranteed and priority must be given to areas which can be eco-managed (in-ground planting, areas of permeable soil, 'wetland' areas, green roofs or walls, edible crops, etc.) on the plot occupied by the building." **Sustainable Indicator Letters policy covers, Impact Level:** e, c, b, a, d, high	"Structural systems, technical installations and their components must be selected in such a way as to minimise maintenance expenses and optimise costs during the building's life cycle (initial investment costs, operating costs, maintenance costs, replacement or removal costs)." "Project contracts must be awarded in such a way as to guarantee the necessary level of building performance throughout the design, construction and operating stages." **Sustainable Indicator Letters policy covers, Impact Level:** g, h, medium	"In order to improve the working environment, promote collaboration, and make it easier for building occupants to find their way around, a high level of diversity (in terms of the spatial configurations and finishes of adjacent spaces) must be achieved in access areas, connecting zones, communal areas and working areas." "The quality of the architecture should both enhance the efficiency of work and create a pleasant and comfortable environment." "The colours in the working environment should be chosen to avoid monotony which might affect well-being at work, while complying with the requirements for visual comfort." "Accessible buildings benefit everyone, in particular the elderly, persons with a temporary disability and children." "The non-slip characteristics of floors must be appropriate to the intended purpose of the room." **Sustainable Indicator Letters policy covers, Impact Level:** j, k, medium	*Your description of how this policy will be conceived. Is it detailed and specific? Is it general and could be hard to understand? What kind of effect size is this policy covering? State, city, national-level? (All policies considered are mandatory national-level, so large effect size.) Based on your description, is the policy less likely, moderately likely, or most likely to be followed?* **Type your description here; Sustainable Indicator Letters policy covers, Impact Level:** This building code is very detailed and specific. Each category is specific in what is to be achieved. The economic aspect is lacking the mention of construction speed, efficiency, and the reduction of waste. It is most likely that this policy will be followed.

32. U.S.A. Policy				
IgCC 2021 Standards	"Reduce emissions from buildings and building systems." "Conserve water resources and protect local biodiversity and ecosystem services." "Promote sustainable and regenerative materials cycles." "Enhance resilience to natural, technological, and human-caused hazards." "A predesign inventory and assessment of the natural resources of the building project site shall be submitted with the site design and construction documents. This should include prohibited development areas, and identification of invasive plants, native plants, and site features." "Invasive plants must be removed from construction sites." "20% of native or adapted plants must be maintained on construction site at least." "At least 60% of vegetated area must include biodivese planting of native plants and/or adapted plants if site contains less thn 20% of existing native or adaped plants ." "A minimum of 50% of non-hazardous construction and demolition waste material generated prior to the issuance of the final certificate of occupancy shall be diverted from disposal in landfills and incinerators by reuse, recycling, repourposing, and/or composting." "The sum of the recycled content and the salvaged material content shall constitute a minimum of 10%, based on cost, of the total materials in the building project." **Sustainable Indicator Letters policy covers, Impact Level:** a, c, e, d, high	No mention of this section. **Sustainable Indicator Letters policy covers, Impact Level:** low	"Enhance building occupant health and comfort." "Support the goal of development that meets the needs of the present without compromising the ability of future generations to meet their own needs." "Each primary buildinng entrance shall be provided with a pedestrian walkway that extends to either a public way or transit stop." **Sustainable Indicator Letters policy covers, Impact Level:** l, k, medium	*Your description of how this policy will be conceived. Is it detailed and specific? Is it general and could be hard to understand? What kind of effect size is this policy covering? State, city, national-level? (All policies considered are mandatory national-level, so large effect size.) Based on your description, is the policy less likely, moderately likely, or most likely to be followed?* **Type your description here; Sustainable Indicator Letters policy covers, Impact Level:** While the environmental aspect is detailed in the areas it covers, there are many aspects left out. With no mention of economic aspects, this could result in little effectiveness of implementation alone. Some aspects of the social pillar are mentioned, but not all. It is less likely that these codes will be followed due to the lack of economic considerations.