



## Article

# Exploring the Relationship between Sustainable Projects and Institutional Isomorphisms: A Project Typology

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**Abstract:** With the increase in awareness about the wide range of issues and adverse effects associated with the use of conventional energy sources came an increase in project management research related to sustainability and sustainable development. Part of that research is devoted to the development of sustainable project typologies that classify projects based on a variety of external factors that can significantly impact these projects. This research focuses on developing a sustainable project typology that classifies sustainable projects based on the external institutional influences. The typology explores the influence of the coercive, normative, and mimetic institutional isomorphisms on the expected level of change, level of uncertainty, project team skills and experience levels, and the level of technology information exchange in sustainable projects. Two case studies are presented to demonstrate the use of the typology to classify sustainable projects based on the external institutional influences.

**Keywords:** sustainable projects; project typology; institutional isomorphisms; monte carlo

## 1. Introduction

This research focuses on developing a sustainable project typology that considers the impact of institutionalization on sustainable projects and how different institutional drivers can affect projects and project characteristics, as well as providing indicators that are used to measure the economic, social, and environmental impact of these projects. Developing such a typology would be extremely beneficial to engineering managers and decision makers in the early stages of the planning phase. The typology would essentially provide a guideline to engineering managers and decision makers in making objective judgements about a sustainable project based on what institutional driver is influencing the project and identify the different areas that require attention in the early planning phase.

A significant portion of the project management literature is devoted to the concept of sustainability and sustainable development, showing a significant increase over the past 10 years [1]. Part of that research is devoted to developing project typologies in which projects are classified into sets of ideal types where the degree to which a project fits any of these ideal types can provide an indication of the outcome of the project [2]. Given the fact that all projects could be affected by a wide variety of external forces [3], it is important to explore how these factors can impact different project characteristics.

One of the external factors that can potentially influence sustainable projects in a significant way is the concept of institutionalization. Institutional theory provides an insight into how institutional influences in a society can provide legitimacy to organizational practices based on culture, social values, and regulations in an institutional environment [4]. It suggests that groups and organizations

seek legitimacy by conforming to external institutional influences best known as institutional isomorphisms [5]. This indicates that business decisions are not always made based solely on the economic benefits, but instead may be based on what is viewed as favorable or acceptable in an institutional environment [6].

It is important to note that institutional theory mainly focuses on the organizational perspective as a whole in an institutional environment. However, the modern theory of project management describes projects as temporary organizations that are essentially vulnerable to the same external factors as regular organizations located under the same environment [1,7,8]. Following this theory of project management, it is then crucial to understand the effects of institutionalization on sustainable projects.

Developing a sustainable project typology based on external institutional isomorphisms can help answer the following two primary questions in this research:

- What is the relationship between institutionalization and sustainable projects?
- How can institutional isomorphisms be used to create a project typology?

Two case studies presenting sustainable projects are included in this research to demonstrate how the developed typology model can be used to classify projects based on the institutional isomorphic influences. Qualitative project data in these case studies is collected and analyzed to determine how the projects are classified. Quantitative data is also collected to determine the economic performance of these sustainable projects.

This article is organized into six sections. After the introduction, the second section provides a literature review of relevant literature and major literature gaps. The third section presents the sustainable project typology and explains the various aspects of the typology. The fourth section presents the two case studies used to demonstrate how the typology can be applied, as well as the data collection and analysis methodologies. In the fifth section, a discussion of the qualitative and quantitative case study data used to classify the case study projects is provided. The last section presents the conclusion and limitations of this article.

## 2. Literature Review

In an effort to acquire the necessary knowledge to develop a sustainable project typology that is based on the external influences of institutionalization, this research reviews literature related to project typologies, sustainability or sustainable development, and institutional isomorphisms in institutional theory. Exploring the literature in these three areas as well as literature with different combinations of these areas would provide the necessary basis in developing the typology.

Project management typologies are important tools found in the project management literature that are often used by project managers and decision makers in the decision-making process [9]. They provide important realistic predictions about several project characteristics early in the planning phase, allowing engineering managers and decision makers to be better prepared thus, increasing the project success rate. The project management literature is filled with project typologies each using a different combination of characteristics such as newness to market and newness to firm [10], system scope and technological uncertainty [11], novelty, technology, complexity, and pace [12], ability to generate other projects and the proximity to target [13], and ability to generate future projects, the proximity to the target customers, and quality of life [14].

Another set of the most commonly used characteristics found in the project typology literature include the level of change [11], project uncertainty, or more specifically technological uncertainty [11,12,15], the level of technological information transfer between the provider of the technology and the recipient of the technology [15], and the level of skill and experience required in different types of projects to ensure project success [11,15].

The concept of institutional isomorphisms was first introduced by DiMaggio and Powell [5] in an effort to identify the different types of external institutional influences that shape organizations. They identified three types of institutional isomorphisms: coercive, normative, and mimetic.

The coercive isomorphism represents the influences that are exerted from a position of power by putting pressures on organizations to follow a certain behavior [6]. The normative isomorphism represents the pressures that are exerted through professionalization and academic institutions to integrate new rules, regulations, or practices in an effort to seek legitimacy in a social environment [4]. Mimetic isomorphism represents pressures that organizations face when seeking legitimacy and competitiveness by mimicking other successful organizations within the same industry [6].

Institutional isomorphisms have proven to be an effective tool in identifying the impact of institutionalization on organizations and thus, have been used by many researchers in a wide variety of fields and industries. Kondra and Hurst [16] studied the impact of institutional isomorphisms on organizational culture. Shin, Lee [17] studied how institutional isomorphisms can be used to promote prosocial behavior in social networking services (SNS). Parga-Dans, Barreiro [18] used institutional isomorphisms as well to identify the impact of institutionalization on the Spanish contract archaeology industry, and how the industry evolved under these institutional pressures.

Researchers provided a wide range of definitions for sustainability in the literature, none more common than the one presented by UN World Commission on Environment and Development stating that sustainability is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [19,20]. The topic of sustainability is usually divided in the literature into three major parts: economic, social, and environmental. These three parts represent the bottom line of sustainability and are referred to as “the three pillars of sustainability” [9,21].

The project management literature has shown a greater focus on sustainability and sustainable development in recent years [1]. Labuschagne and Brent [22] presented a project management framework that effectively addresses the three pillars of sustainability in an effort to incorporate the principals of sustainable development into the project management life cycle. Qin, Grasman [23] developed a framework that summarizes the major effects associated with using different types of alternative energy. It is intended as an evaluation of different alternative energy strategies to help engineering managers and decision makers make better decisions in sustainable development. Rangarajan, long [14] developed an economic development typology that focuses on sustainable rural development by considering the economic, social, and environmental impacts at early stages of project planning.

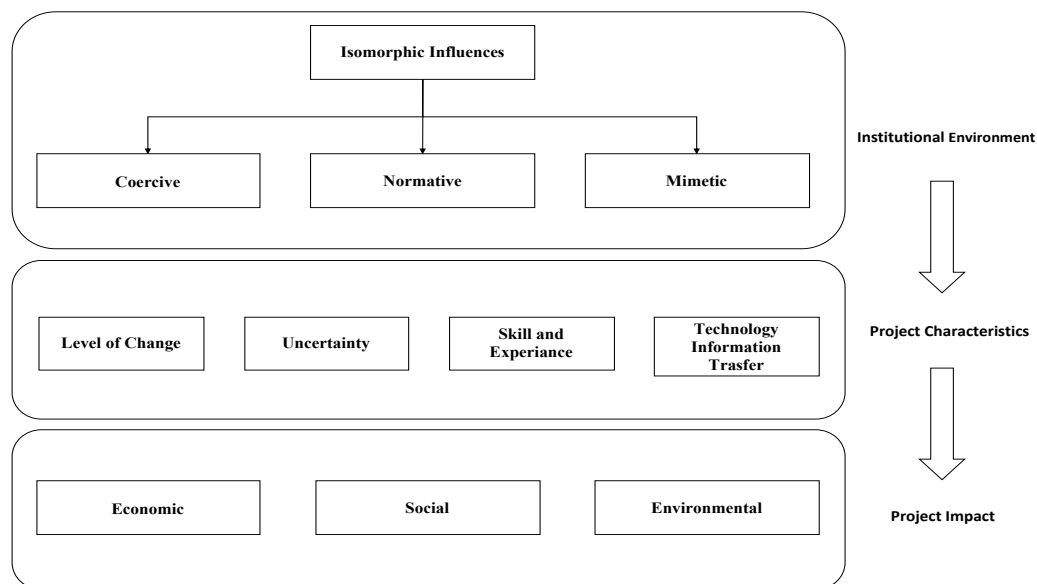
Another field that is also contributing to the concept of sustainability is institutional theory. Several institutional theory researches are exploring how institutional isomorphisms can affect the implementation of sustainability and sustainable practices in organizations and industries. Glover, Champion [4] implemented the concept of institutional isomorphisms to explore the influence of supermarkets on the development of sustainable practices in the dairy supply chain industry. Rivera [6] also used institutional isomorphisms to explore the impact of institutional forces on sustainable development in the Costa Rican hotel industry. Other additional examples exist on the effects of institutional influences on sustainability and sustainable practices [24,25].

When cross-examining literature from the three research fields, some patterns reveal gaps in the literature. Although the project management literature does in part focus on sustainability and sustainable development, there is little research that is dedicated to developing sustainable project typologies and their impact on the pillars of sustainability [9]. The institutional isomorphism literature mainly focuses on the effects of institutional forces on sustainable development and practices. However, there seems to be little research that is dedicated to the effects of institutional forces on sustainable projects [7]. Bresnen [26] explored the effects of institutionalization on the project management discipline and how it can shape the project management discipline. However, he did not go beyond that to explain the effects of institutional isomorphisms on projects.

### 3. Methodology

The typology model is divided into three different levels (Figure 1). The first level represents the coercive, normative, and mimetic institutional isomorphisms that can influence sustainable

projects. The second level represents the chosen sustainable project characteristics that can be affected by the external institutional influences. The third and final level represents the economic, social, and environmental factors that are commonly used to measure the impact of sustainable projects. By combining these three levels, a comprehensive evaluation can be performed to identify how the external institutional isomorphisms can influence the different sustainable project characteristics and measure the overall performance of these projects.



**Figure 1.** Isomorphic sustainable project typology model.

### 3.1. Typology Elements

Institutional theory is used by researchers to identify and examine influences on organizational practices towards survival and improved legitimacy in a social environment [4,5]. The theory suggests that external social norms, values, and beliefs create standards of legitimacy to organizations which in turn, influence their management decisions and practices [6]. Through the modern theory of project management that identifies projects a temporary organization, these coercive, normative, and mimetic pressures can also be explored from the perspective of projects in general or, more specifically, sustainable projects [9].

**Coercive:** in this typology, coercive pressures would represent the forced changes imposed on existing sustainable practices and technologies to comply with institutional norms and the regulatory environment. The most common example of such pressures would be a government-enforced change to existing regulations related to sustainability or sustainable development. These changes would force engineering managers and decision makers to adapt their projects to the new changes to avoid any legal repercussions. Coercive pressures are believed to be essential in promoting sustainability and sustainable practices [4].

**Normative:** in this typology, normative influences represent pressures that are exerted on sustainable projects through the norms of conduct in professional networks and academic institutions. These pressures involve integrating new processes, technologies, or sustainable practices in an effort to be viewed as being sustainable [4]. An example of such pressure would be an organization undertaking a project to integrate a completely novel sustainable technology in an effort to be seen as a leader in implementing sustainable practices.

**Mimetic:** mimetic pressures in this typology would represent projects that copy other completed projects that are seen as being successful in an effort to replicate the same success the copied project

accomplished, and gain the same legitimacy and competitiveness in the social environment [27]. It is also done to reduce uncertainty and help predict the project outcome [16].

### 3.2. *Typology Characteristics*

As mentioned previously, the typology classifies projects based on the effects of the coercive, normative, and mimetic institutional isomorphisms. It explores these effects on four common project characteristics used in project typologies [9]. These characteristics are level of change, uncertainty level, project team skills and experience, and level of technological information exchange. These characteristics, among others, are explored in many other typologies in different combinations based on the purpose of the typologies. It is important to note that, as with all typologies, the levels suggested in this research are chosen ideal levels and may not necessarily represent real projects.

**Level of change:** This characteristic describes the degree of change in a project from known standards and established practices, processes, and technologies, which can also be referred to as the novelty of the project. Under coercive pressure, the level of change is considered as moderate since only some changes to the established practices, processes, and technologies are needed while the basis still exists. Normative pressures however would provide entirely new practices, processes, or technologies and thus would create higher levels of change. Finally, mimetic pressures would provide lower levels of change because one project would be almost entirely copying other projects by using established practices, processes, and technologies with no or minimal change.

**Uncertainty:** uncertainty is defined in the literature as negative events in projects for which both the consequence and probability of occurrence are unknown [28–30]. In the typology presented in this research, uncertainty is another important factor in demonstrating the potential effects of institutional isomorphisms on sustainable projects. Under coercive pressures, the level of uncertainty is at a moderate range. It presents the uncertainties associated with the enforced changes on the established practices, processes, and technologies. Under normative pressures, the level of uncertainty is at the higher ranges. The higher level of uncertainty is associated with the higher level of change stemming from implementing entirely new practices, processes, or technologies [15]. On the other hand, the level of uncertainty is considered in the lower ranges under mimetic pressures since there are little to no changes to established practices, processes, and technologies used by the mimicked projects.

**Skills and Experience:** this characteristic describes the required level of skill and experience possessed by the project team to be able to carry out project tasks correctly and efficiently. It is concerned with matching the work force capabilities with the requirements of the projects. The higher the level of change and uncertainty in practices, processes, and technologies used, the higher the level of project team skill and experience required to successfully implement the project [15]. Based on that, under coercive pressures the level of skill and experience in a project team is considered in the moderate levels. Under normative pressures, the high levels of change associated with the high levels of uncertainty would require a highly skilled and experienced project team to be able to implement the entirely new practices, processes, or technologies successfully. Under mimetic pressures, the required level of project team skill and experience is in the lower levels.

**Technological Information Exchange:** this characteristic was presented by Stock and Tatikonda [15]. It describes the amount of interaction required between the supplier and the recipient to ensure the successful implementation of the supplied technology in the project. Ensuring that the right technology is correctly implemented in these projects is a major step in achieving the desired project goals. As the novelty and uncertainty of the used sustainable technology increases, the amount of interaction between the supplier of the technology and the recipient increases. Under coercive pressures, the level of interaction between the supplier and recipient of the technology is at moderate levels since the level of change and uncertainty are at medium levels. Under normative pressures, the level of interaction between the supplier and recipient is high since the level of change in the technology is high, which also results in higher uncertainties. Finally, under mimetic pressures, the interaction between the supplier and recipient of the sustainable technology is at lower levels and may sometimes

be described as routine since the level of change and uncertainty are low. In this case well-established technologies are copied from other successful projects and used with little to no change.

### 3.3. Project Impact

The selection process of sustainable projects requires a detailed analysis of several aspects of the different project options and identifying the project with the best possible outcome [14]. When evaluating sustainable projects, the evaluation does not only consider the economic return of the project but also includes social and environmental considerations. These three pillars of sustainability are an ideal way to determine the success of sustainable projects.

The environmental impact of sustainable projects can be categorized into air, land, and water as well as how the projects contribute to the conservation of existing natural resources in the surrounding environment. Indicators to measure such impacts include the reduction in Green House Gases (GHGs) caused by using renewable technologies instead of fossil fuels, the reduction of solid pollutants on land, and the reduction of both land and water waste. Sustainable projects can also have a positive social impact on employment either directly or indirectly, health, learning, and general welfare. Successful sustainable projects can also provide income-generating activities for project stakeholders. They can help support economic development by providing investment opportunities, providing new industrial activities, and reducing costs. Sustainable projects can also provide easy access to reliable energy sources with little to no negative effects on the environment.

Table 1 provides a more detailed explanation of some of the environmental, social, and economic benefits that can be attained through sustainable development projects. Table 1 is adapted and modified from Olsen and Fenhann [31].

**Table 1.** Sustainability development dimensions and indicators.

Dimension	Criteria	Indicators
Environmental	Air	Reduction in Green House Gases (GHGs), suspended particulate matter, non-methane volatile organic compounds, dust, fly ash and odor.
	Land	Reduction of solid pollutants on land, reduction of waste, and improvement of the soil through the production and use of e.g. compost, manure nutrient and other fertilizers.
	Water	Reduction in water waste production, wastewater management, water savings, safe and reliable water distribution, purification/sterilization and cleaning of water.
	Conservation	Conservation of natural resources such as natural minerals, landscape, and biodiversity.
Social	Employment	Creation of new jobs and employment opportunities either directly through the projects or through spinoffs of the original projects.
	Health	Reduction of diseases caused by pollutants, climate change, and depletion of resources. Improvement of health conditions through activities such as construction of a hospital, running a health care center, and preservation of food.
	Learning	Promote education and research regarding sustainable technologies and practices, construction of a school, running of educational programs, and site visits and tours.



Table 1. Cont.

Dimension	Criteria	Indicators
Economic	Welfare	Improving the local working and living conditions, poverty alleviation, and community upliftment, and income redistribution through e.g. increased municipal tax revenues.
	Growth	Income generating activities for project stakeholders, support economic development by providing investment opportunities, provide new industrial activities, cost reduction, enhancing productivity, setting an example for other industries, and creation of business.
	Energy	Improved access, availability and quality of electricity and heating services such as coverage and reliability.
	Balance of payments (BoP)	Reduction in the use of foreign exchange through a reduction of imported fossil fuels in order to increase national economic independence.

Source: adapted and modified from Olsen and Fenhann [31].

#### 4. Case Studies

In this section, two case studies are presented in an effort to demonstrate how the sustainable project typology can be used to classify sustainable projects based on the external institutional influences exerted on the project. The first case study is a solar photovoltaic (PV) energy project implemented on a private university campus in Riyadh, Saudi Arabia. The second case study is a solar village project on a public university campus in Missouri, USA. These projects are explored to determine the type of institutional pressures influencing the projects, and the impact of these pressures on the four project characteristics discussed above.

As it is extremely difficult to quantitatively measure the impact of the institutional environment, or more specifically the institutional isomorphisms, on sustainability and sustainable practices, a qualitative approach is traditionally used to gather data on the impact of these institutional pressures. In this research, a qualitative approach in the form of informal interviews was used to measure the impact of the coercive, normative, and memetic institutional isomorphisms on the two sustainable project case studies. The qualitative project data was collected through interviews with key people involved in the projects. For the first case study located in Saudi Arabia, the interview was conducted with the project manager directly overseeing the project. As for the second case study located in Missouri, the interview was conducted with the director of the solar villages and microgrids on campus who is also one of the people who the project team directly reported to and who was also directly involved in the project. These informal interviews followed a predetermined narrative in an effort to maximize the amount of relevant data gathered while reducing irrelevant data (Appendix A). The interview narrative focused on six different topics related to the projects. The interview included a description of the projects including their purpose and the type of technology used in these projects. The second topic of the interview covered the project background including the circumstances that led to the creation of these projects in an effort to determine the type of institutional pressures that influenced these projects. The remaining four topics of the interview cover how the projects compare to other similar projects (level of change), project uncertainties, the project teams, and the relationship between the project team and the sustainable technology suppliers.

The conversations with the interviewees were recorded and notes were also taken with permission from the interviewees. The recorded conversations and notes were then organized and analyzed in an effort to determine where each project fits in the isomorphic sustainable project typology. The member

checking methodology was used where the analysis and conclusions from the interviews were then presented back to the interviewees for respondent validation [32].

In this research, the social and environmental impacts of the projects can be measured against the sustainable development criteria and indicators discussed in Table 1. Some of these social and environmental measures are qualitative in nature and are difficult to quantify with high a level of certainty. Due to the lack of available data, the social and environmental impacts of the case study projects will not be included in this research. Nevertheless, measuring the social and environmental impact of sustainable projects is crucial in identifying the overall benefits of these projects.

The net present value (NPV) and internal rate of return (IRR) are the primary methods used to evaluate the economic impact of the projects [33]. They are used to identify the income gathering activities for stakeholders by determining the economic viability of the projects. A project is considered economically viable when the NPV is greater than zero, and when the IRR is greater than a minimum return [14]. The NPV is defined as the current value of a project by taking into consideration all future and present cash flows and discounting them to the present time. NPV is defined mathematically in Equation (1)

$$NPV = -I_0 + \sum_{t=0}^n \frac{CF_t}{(1+i)^t} \quad (1)$$

where  $I_0$  is the initial investment,  $n$  is the time horizon of the project,  $CF_t$  is the cash flow at time  $t$ , and  $i$  is the required interest rate of the project. The IRR is defined as the interest rate that makes the NPV equal to zero. IRR is defined mathematically as shown in Equation (2).

$$NPV = -I_0 + \sum_{t=0}^n \frac{CF_t}{(1+i)^t} = 0 \quad (2)$$

The results from Equations (1) and (2) should represent an accurate indication of the economic viability of the sustainable projects.

In an effort to determine the economic robustness of the sustainable projects in this research, the sensitivity of the different economic variables affecting the projects is considered. The Monte Carlo analysis is an effective and established technique to quantitatively measure the economic sensitivity of a project to changes in input variables that stem from uncertainty [34]. In a Monte Carlo simulation, a calculation is performed thousands of times where at each iteration, a different set of input variables is chosen randomly from a pre-defined distribution. In the case where the distribution for a specific input variable is not known, a triangular distribution is recommended [14]. A triangular distribution is comprised of three points: A minimum, maximum, and mode which represents the most likely value of the variable. In this research, the Monte Carlo technique is deployed to calculate the possible NPV and IRR values of the projects based on five thousand iterations. The results are presented in histogram charts showing the possible NPV and IRR outputs, the frequency of occurrence of these outputs, and the probability of getting a favorable output.

#### 4.1. Case Study 1: The Preparatory Year Program (PYP) Building Solar Project

The Preparatory Year Program building is a large structure located on a private university campus in Riyadh, Saudi Arabia. The building was constructed in 2017 to accommodate freshmen students as well faculty members and staff. It contains a large number of smart classrooms equipped with smart boards, computers, and a wide variety of technological equipment. It also holds a large number of offices, labs, two dining areas, and a large auditorium. The large number of technological equipment accompanied with the air conditioning and lighting systems in the building has led to high electricity costs for the PYP building compared to the other campus facilities, especially during the summertime.

Due to high electricity costs, the university decided to make use of the available solar resources to power the PYP building in an effort to reduce costs. Another reason for converting the PYP building to use solar energy is Saudi Arabia's Vision 2030, which promotes the use of renewable energy sources in



an effort to shy away from relying on oil and other fossil fuels for energy production. With the country wide focus on the use of clean sustainable energy, a growing number of organizations in Saudi Arabia decided to take advantage of the almost constant sunny weather in the country by using solar energy to generate power, especially with the expected increase in the price of electricity from \$0.05/kWh to around \$0.11/kWh in the next 10 years. Following in the footsteps of these organizations, the university also made the decision to build a solar PV project to supply the PYP building's average annual electricity demand of 3.4 GW by using commercially available solar PV technology in Saudi Arabia.

The uncertainties surrounding the project were considered from the social, technical, and environmental perspectives. When considering the social uncertainties associated with the project, social acceptance was determined as a major issue that needed to be discussed. By considering the positive feedback on similar sustainable projects done by other organizations and the increased awareness on the importance of environmental sustainability in the country, it is expected the PYP building solar project would be widely accepted by both the university and surrounding communities. When considering the technical uncertainties related to the PYP project, two issues were considered and discussed. One issue was related to the possibility that the solar PV technology would be obsolete within the next 10 years. It was decided by the project management team that the probability of occurrence is very low considering the continuous decrease in the production costs of solar panels which would make it extremely difficult to overcome such technology especially with the increasing electricity prices in Saudi Arabia. The other issue was related to the location where the solar panels would be placed and the uncertainty around whether or not future construction on the university campus would obstruct the currently chosen locations. To avoid this issue, the university construction master plan was shared with the project team to help them choose the optimal locations to install the solar panels and reduce the effects of any future construction. When considering the environmental uncertainties, the major concern was related to the loss of sunlight due to cloud coverage or dust. However, the weather in Riyadh is known for the lack of clouds and strong and direct sunlight almost every day of the year. Nevertheless, the solar panels should have sufficient sunlight exposure even during cloudy weather or dust winds due to the strong and direct sun exposure in Riyadh. Moreover, planned cleaning of the solar panels will be performed every month as well as any emergency cleaning if needed after dust storms. In addition, these conclusions are also supported by the similar solar projects in Riyadh where the local weather did not pose an issue for these projects.

As mentioned previously, the project will be built and maintained by a local contractor specializing in solar energy projects. The contractor as well as project members from the university were all involved from the beginning of the project. The project team mainly consists of members from the contracted company with a project manager assigned from the university to oversee the progress of the project. In other words, the project team will mostly consist of project technicians who will handle the on-the-ground installation and maintenance as well as project manager to oversee the overall progress. The team was given access to the PYP building design blueprints in addition to the university construction masterplan previously mentioned to assess the layout and determine the optimal location to place the solar panels. The university also shared the building's electricity demand and bills over a six-month period to determine the required solar system type and capacity.

In order to determine the economic viability of the PYP building solar project, several cash flows are considered to calculate the NPV and IRR of the project (Table 2). The PYP building solar project has an initial investment of \$3.31 million. The Operation and maintenance cost is \$24,000 with an annual increase of 1.5% per year. By considering the electricity price per kWh, the expected increase in electricity price per year, and the PYP building's annual electricity demand, the project's savings per year can be calculated as a positive income to the project. The NPV and IRR of the project are calculated using a 7% interest rate and a project time horizon of 30 years. Applying the inputs from Table 2 to Equations (1) and (2) yields an NPV of \$533,401 and an IRR of 8.27%.

**Table 2.** Financial analysis for the PYP building solar project.

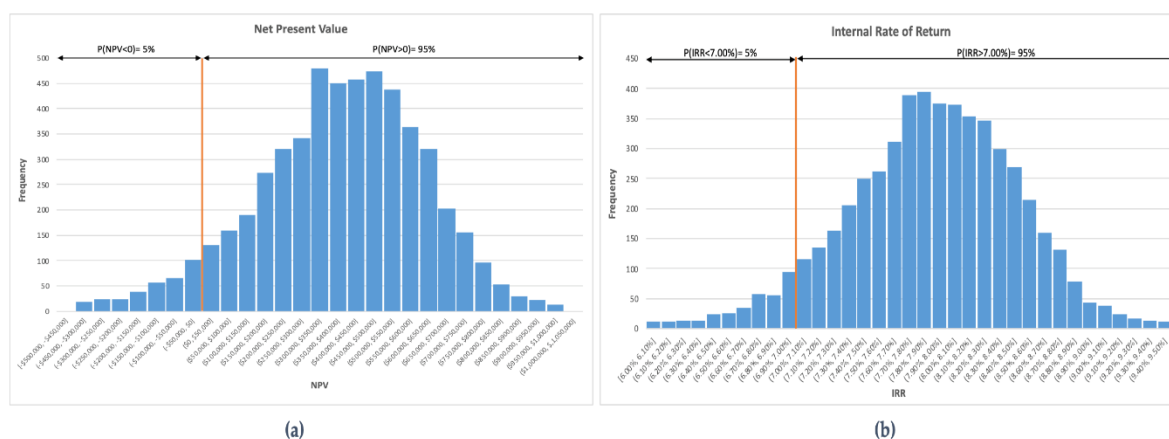
Input	Value
Initial Investment	\$3,318,165
Operation and Maintenance Cost in year 1	\$24,000
Increase in O&M Cost/Year	1.5%
Electricity price/kWh in year 1	\$0.05
Increase in Electricity price/Year	2%
Electricity Demand/Year	3,438,442 kWh
Project time horizon	30 years
Discount Rate	7%
NPV	\$533,401
IRR	8.27%

The Monte Carlo simulation was performed using the Microsoft Excel software to determine the economic sensitivity of the project based on the input and output variables. A triangular distribution was used for the input variables listed in Table 3 along with each variable's minimum value, most likely value, and maximum value. The lower and upper limits were assumed based on inputs from the project interviewee.

**Table 3.** Monte Carlo PYP Project input variables.

Input Variables	Lower Limit (%)	Most Likely	Upper Limit (%)
Initial Investment	90	\$3,318,165	120
Operation and Maintenance Cost in year 1	90	\$24,000	110
Increase in O&M Cost/Year	90	1.50%	120
Increase in Electricity price/Year	85	2%	125
Electricity Demand/Year	90	3,438,442 kWh	105

Figure 2a,b show the two histograms representing the NPV and IRR results from the Monte Carlo simulations.

**Figure 2.** PYP Project Monte Carlo result distribution. (a) NPV Monte Carlo result distribution; (b) IRR Monte Carlo result distribution.

#### 4.2. Case Study 2: The Solar House Project

The Solar House Project is a renewable energy project located in a public university campus in Missouri, USA. The project consists of two student-designed solar houses that run on their own solar power. These houses were used to compete in the 2013 and 2015 editions of the Department of Energy (DOE) Solar Decathlon Competition. After the completion of each competition, the participating houses

were then placed back on the university campus to serve as student housing facilities, and to facilitate different avenues of research in solar technology including energy production, sustainable living, and power sharing. The aim of the solar house project is to provide a window into what the neighborhoods of the future would look like with the use of sustainable solar technology.

The 2013 solar house is a 900 square foot box-shaped house. It is fitted with a 10.5 kW solar photovoltaic system that is designed for flat roofs by placing the solar panels at an inclined angle to optimize sunlight exposure. The power produced from the solar PV system is used to power all electrical systems in the house including heating, ventilation, lighting, and air conditioning. The 2015 solar house is a 1000 square foot house built using shipping containers as the main body with a tilted rooftop. The house is also fitted with a 10.5 kW solar photovoltaic system used to supply all electrical systems in the solar house. Each solar house is connected to its own Lead Acid battery system to store excess power for use during nighttime and during cloudy days. The Solar House Project can be compared to many existing solar projects including a solar project that was completed in 2009 on the same university campus. The Solar House Project was also built using commercially available solar PV technology supplied by local and national companies.

The technical, environmental, and social uncertainties surrounding the Solar House Project were studied in an effort to determine the impact of these uncertainties and develop appropriate mitigation plans. When considering the technical uncertainties surrounding the project, one major concern was related to the disposability and recyclability of the solar panels and batteries once they are out of service. To solve this issue, a recycling plan was set in an effort to find the best methods to recycle out of service equipment. The use of Lead Acid batteries is an integral part to this plan since lead acid batteries can already be easily recycled. Another major technical uncertainty is related to the effects of permanently placing the portable houses on campus after they were transferred back from the competition site. To solve this issue, data collected from the 2009 solar project was used to create a permanent placement plan in an effort to reduce any necessary design changes once the competition was over. When considering the environmental uncertainties, the major concern was related to supplying the houses with power during nighttime and frequent cloudy weather conditions in Missouri throughout the year. To avoid this issue, Lead Acid battery system were used to store enough power to run each house separately for several days. When considering social uncertainties surrounding the project, the major issue was related to social acceptance in addition to any project related ethical or privacy issues. As a result, several community outreach programs were launched reaching thousands of community members including students, businesses, local families, and industry professionals to explain what the project is and collect feedback. The feedback gathered showed an overwhelming sense of acceptance and support by the community for the project and the benefits of sustainable energy and sustainable development. In addition, positive feedback on previous solar projects can be a good indication that the demand for such projects is increasing within the local community.

The project was completely designed by students, with limited experience, under the supervision of expert faculty members on campus who also worked on the 2009 solar project. The faculty members only provided guidance into the basics of the project, leaving the students with the freedom to proceed with the project within the boundaries of the competition. The students also partially participated in the construction phase of the project working with the facilities department on campus. The solar panels and batteries used in the project were purchased from third-party contractors who also handled the installation under the supervision of the student design team. The project team provided the design and layout of the houses, the number of required solar panels, the required daily demand, and battery requirements and capacities. The contractors, in turn, provided and installed the appropriate solar systems and batteries to meet these requirements.

In order to determine the economic viability of the Solar House Project, several cash flows are considered to calculate the NPV and IRR of the project (Table 4). The project has a total initial investment of \$860,000. It also has an average operating and maintenance cost of \$1000 per year

and an annual utility costs and fees of \$674. Considering the project's average annual electricity generation of 17,754 kWh and local electricity costs, the savings in electricity is calculated to be \$1580 per year. The project's NPV and IRR are calculated using a 7% interest rate and a 20-year project time horizon. The project has a calculated NPV of −860,994. The IRR cannot be calculated since, under these conditions, there is no interest rate at which the NPV would be equal to zero.

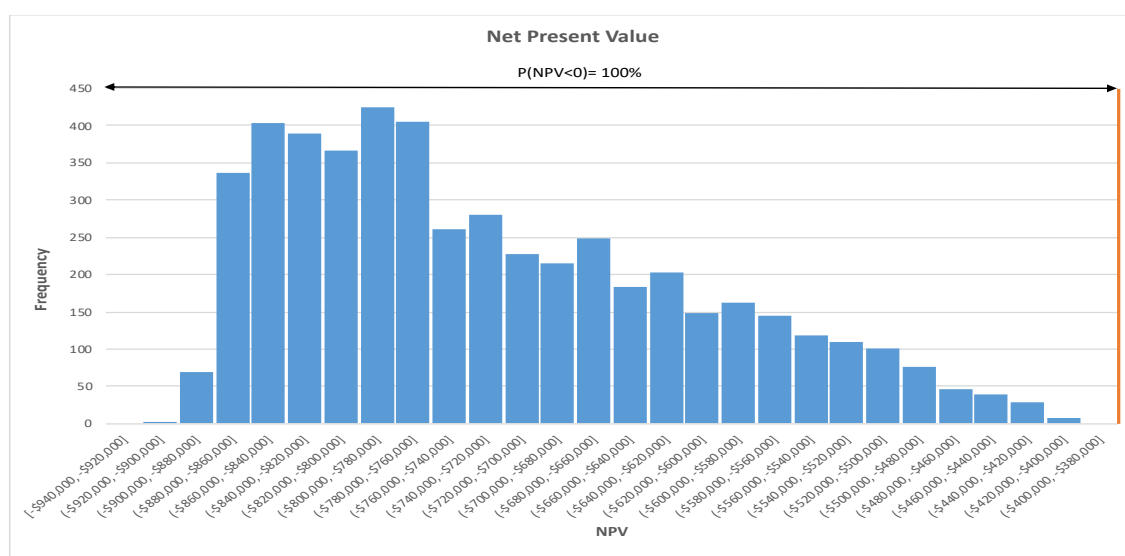
**Table 4.** Financial analysis for the Solar House Project.

Input	Value
Initial Investment	
Solar House	\$760,000
Microgrid (PV system, batteries...etc.)	\$100,000
O&M Cost/Year	\$1000
Utility Costs and Fees/Year	\$674
Electricity Cost/kWh	\$0.09
Electricity Demand/Year	17,754 KWh
Project time horizon	20
Discount Rate	7%

For further validation, the Monte Carlo method is used to determine the economic sensitivity of the project as well as the possible NPV and IRR output range. The input variables were defined using a triangular distribution (Table 5). Figure 3 shows the histogram representing the NPV results from the Monte Carlo simulation.

**Table 5.** Monte Carlo Solar House Project input variables.

Input	Lower Limit (%)	Most Likely	Upper Limit (%)
Initial Investment			
Solar House	40	\$760,000	105
Microgrid (PV system, batteries...etc.)	80	\$100,000	120
O&M Cost/Year	60	\$1000	140
Utility Costs and Fees/Year	80	\$674	120
Electricity Demand/Year	70	17,754 KWh	110



**Figure 3.** Solar House Project NPV Monte Carlo result distribution.

## 5. Discussion

### 5.1. The PYP Building Solar Project

The information collected in the PYP building Solar Project case study indicate that the project can be classified as mimetic. The growing number of solar projects in Riyadh, and the country in general, have been successful in implementing sustainable solar projects, which in turn exerted pressures on the university to mimic such success. By using the same standard and commercially available solar technology, the university can achieve its goal of reducing the high electricity costs associated with the PYP building. Furthermore, the positive feedback received by other solar projects in the area for following the country's Vision 2030 regarding the implementation of renewable practices created additional mimetic pressures on the university to replicate such practices. Mimicking such projects achieves the university's goal of reducing costs, as well as improves the legitimacy of the PYP Solar Project within local communities.

The technical, social, and environmental uncertainties surrounding the PYP building solar project can be categorized as relatively low. Considering the various similar projects in the area, these uncertainties can be mitigated or even eliminated by mimicking what has already been done in other solar projects. The project team's level of skill and experience varies with most of the team being certified technicians from the contractor's side with sufficient skill to install and maintain the equipment under the supervision of a project manager. The type and amount of information exchange between the university and the contractor is confined to the essential information required to build the project. This type of information exchange can be described as routine and does not include any required changes or modifications to a well-established and widely used solar technology.

Despite obtaining a favorable NPV and IRR results using the most likely input variables, the Monte Carlo simulation shows that such results are not guaranteed. Figure 2a shows that the project has a 95% probability of achieving an NPV greater than zero with a maximum and minimum NPVs of \$986,853 and -\$440,561 respectively. Similarly, Figure 2b shows that the project has a 95% probability of achieving an IRR greater than the minimum required rate of return of 7%, with a maximum and minimum IRRs of 9.48% and 6.02% respectively. Moreover, the results in the two figures are skewed towards the positive side which indicate that the project is relatively economically robust and would be economically attractive to invest in.

### 5.2. The Solar House Project

The information presented in the Solar House Project case study indicate that the project can be classified as mimetic. Participating in the Solar Decathlon Competition exerts pressure on the project team to successfully implement the project. By using the same standard and commercially available solar technology as many other projects participating in the DOE Solar Decathlon Competition, as well as mimicking the previous successful solar projects on campus, the project team can replicate such success in the competition. The project also aims to replicate the success of the 2009 solar project by serving as a solar energy research facility on campus. Considering the overwhelmingly positive feedback received by other solar projects in the area, mimicking such projects achieves the university's goal of successfully competing in the DOE solar competition as well as improves the legitimacy of the Solar House Project as a prominent solar energy research facility in the area.

The Solar House Project uncertainties regarding the disposal and recycling of solar panels, house designs, weather conditions, and social acceptance, can be considered as low. Solutions and mitigation plans were set to deal with such uncertainties. What also helps in further decreasing the level of uncertainty is mimicking what has already been done with similar projects in the area. The project team level of skill and experience can be considered low. The students managed the project by the limited skills gained through their academic studies and with the guidance of faculty members. Considering that the project did not require any changes to already established processes or technologies, the technological information exchanged between the project team and the contractors

supplying the technology is limited to the essential specifications required to select and install the appropriate technology. This type of technology information can be described as routine or standard with no changes to well established and widely used processes or technologies.

With an NPV of  $-\$860,994$  and a non-existing IRR, the project is economically not viable and should not be pursued from an economic standpoint. The Monte Carlo simulation confirmed the previous conclusion showing that the probability of the project yielding a positive NPV is equal to zero. The results from the simulation yielded a maximum NPV of  $-\$406,859$  and a mean of  $-\$725,563$ . The simulation was also unable to calculate a valid IRR further confirming the previous findings. These findings support the narrative that not all management decisions are made based on economic benefits, but instead on what is viewed as favorable or acceptable in an institutional environment in an effort to improve the legitimacy of the project [6]. In this case, the purpose of the Solar House Project is not financial gain, but to replicate the non-monetary benefits associated with sustainability and sustainable development from the previous solar project on campus.

## 6. Conclusions and Limitations of the Study

Although the project management literature does in part focus on sustainability and sustainable development, there is little research that is dedicated to developing sustainable project typologies. Moreover, there seems to be a lack of research that is dedicated to the effects of institutional environments on sustainable projects through the different institutional pressures known as institutional isomorphisms.

To help fill in these gaps, this research focuses on developing a sustainable project typology that explores the effects of the mimetic, coercive, and normative institutional isomorphisms on the project's level of change, uncertainty level, project team skills and experience, and level of technological information exchange. The typology model also describes some of the indicators commonly used to measure the economic, social, and environmental impacts of sustainable projects. Such a typology would be extremely beneficial as an objective decision-making tool for project managers and decision makers by providing them with a guideline to make better judgements about a sustainable project based on what institutional driver is influencing the project in the early stages of the planning phase.

In the typology model, coercive pressures represent forced changes imposed on existing sustainable practices to comply with institutional norms and the regulatory environment. These pressures would cause medium levels of change, uncertainty, skill and experience required, and technological information exchange since only some changes to the established practices, processes, and technologies are needed while the basis is still preserved. Normative isomorphism represents pressures that are exerted on sustainable projects through the norms of conduct in professional networks and academic institutions. These pressures would represent higher levels of change, uncertainty, skill and experience required, and technology information exchange since they would provide entirely new (novel) practices, processes, or technologies. Mimetic pressures in this typology represent projects that copy other completed projects that are seen as being successful in an effort to replicate that success, gain the same legitimacy, or reduce uncertainty. This type of pressure would represent low levels of change, uncertainty, skill and experience required, and technology information exchange since one project would be almost entirely copying other projects by using established practices, processes, and technologies with no or minimal changes.

The two case studies presented in this research demonstrate how the typology can be used to classify sustainable projects and provide an indication into the different project characteristics based on the type of institutional pressures exerted on the project early in the planning phase. The results indicate that both the PYP and Solar House projects are subject to mimetic pressures to replicate the success of other solar projects in their immediate institutional environment. These mimetic pressures led to a relatively low level of change, lower level of uncertainty, low levels of required project team skill and experience, and low-level technology information exchange. The case studies also included measuring the economic impact of the projects on immediate stakeholders by calculating the NPV and



IRR of each project. Further analysis was done using Monte Carlo method to determine the economic robustness of the projects by considering the sensitivity of the different economic variables affecting the projects.

Limitations in this research include the small project sample size used to implement the typology, which led to only one type of projects being explored. A larger sample size could provide an opportunity to further validate the typology model as well as explore the other project types presented in the typology. Another limitation would be the lack of data required to fully explore the economic impact and measure the social and environmental impacts of the case study projects. Future research should focus on further testing the isomorphic sustainable project typology on a larger sample of projects. Additional testing of the typology could also provide an opportunity to further develop the model and possibly include additional project characteristics which can uncover additional relationships within the typology model that were not included in this research.

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## Appendix A

### *Interview Protocol*

#### Project Areas of Interest and Questions

##### **Description of Project**

- Project Definition
- Project purpose
- Location
- Technology (Solar, wind, geothermal . . . etc.)

##### **Project Background**

- How the project came about?
- Inspiration behind the project (other similar projects? government regulations? new technology?)

##### **Level of Change**

- How this project compares to other similar projects? New or unique processes or technology?

##### **Uncertainty level**

- Technical? Social? Environmental?
- Any project specific uncertainties

##### **Project Team Skill and Experience**

- Who did the project team consist of? (Contractors?)
- Special experts hired or included in the project team
- Experience of project team members in dealing with similar projects.

##### **Technical Information Exchange**

- What type of information was shared with the renewable technology provider?
- Any special modification to the technology required? If so, what are the modifications?
- Relationship between project and technology provider (Purchasing only, purchase and install)

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