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Obtaining green warehouses from converting the potential energy of trucks into Piezoelectricity: A Conceptual Introduction

Sameer.B[1] , Hanafi.I[2] and Elbarky.S[3]

[1] Logistics & Supply Chain Management Department, College of International Transport & Logistics, (AASTMT), Alexandria, Egypt,
[2,3] College of International Transport & Logistics, (AASTMT), Alexandria,

E-Mails: Bassmasamir.nido@gmail.com, Islamhanafi@aast.edu, selbarky@aast.edu

1. ABSTRACT:

There is no doubt that the general trend in all countries of the world is the use of clean, renewable, and inexhaustible energy sources, no matter what happens, to preserve the environment by reducing emissions from fuels and at the same time preserving the existing stock of fuel for future generations. In addition, in the long run, the cost of renewable energy is more economical than the energy generated from fuels, and by extension, if clean energy is used in the fields of industry and transportation, it will have a very strong impact on the entire supply chain, whether service or production.

The research methodology is depending on reviewing the previous studies to get a theoretical framework linking between piezoelectric tiles and green warehouse so as to link piezoelectricity with obtaining green warehouses and to get a theoretical framework for the relationship among the dependent variable "Obtaining Green Warehouses" and the independent variable "piezoelectricity".

The research findings suggested a theoretical framework "The Research Model" to describe the research problem and define the research variables to show how they might relate to each other.

This research will be one of researches that links the idea of using kinetic energy through converting it into electrical energy with the concept of green warehouses.

Keywords: *Green Warehouse, Data, kinetic energy, Piezoelectricity and Green Energy.*

2. INTRODUCTION

There is no doubt that the general trend in all countries of the world is the use of clean, renewable, andinexhaustible energy sources, no matter what happens, to preserve the environment by reducingemissions from fuels and at the same time preserving the existing stock of fuel for future generations. In addition, in the long run, the cost of renewable energy is more economical than the energy generated from fuels, and by extension, if clean energy is used in the fields of industry and transportation, it will have a very strong impact on the entire supply chain, whether service or production. (Shahzad et al.,2015)

In this research, we highlight the technical potential and the economic feasibility of activating the conversion of kinetic energy, specifically the kinetic energy resulting from the movement of trucks and cranes. (Mike Hanlon, 2008).The possibility of converting it into electrical energy using piezoelectric techniques and the possibility of using this energy in factories, companies and warehouses and its effecton the supply chain in which clean energy will be included and transformed into a green supply chain

that the world strives to achieve, as well as discussing the economic feasibility of its application in the long run and seeing whether it is saving or not. (Al-Yafeai et al., 2020).

As for how to obtain electrical energy from piezoelectric tiles, this is done through the crystal materials from which piezoelectric tiles are made, which are characterized by their characteristics that they convert kinetic energy into electrical energy through the phenomenon of compressive energy. (Raghu Chandra Garimella et al., 2015). The conversion of kinetic energy into electrical energy takes place through piezoelectric crystals through the following physical equations "The formula to convert kinetic energy (1/2mv^2) to electrical energy (Energy = P*t) is, 1/2 mv2 = p*t, where **m** is the mass of the object, **v** is the speed of the object, **P** is the power and t is the time". (Megha BR,2019)

This will be done by integrating piezoelectric techniques with green logistics. It will explain how to obtain green warehouses from the movement of trucks moving inside warehouses and passing on a specific type of transformer that forms a direct electrical field from the movement resulting from the truck and generating Electrical energy that lights the warehouses for a period that allows goods to be transported to and from the stores. In addition, a detailed feasibility study will be discussed about the cost of electricity consumed by the stores and the cost of converting kinetic energy into green electrical energy and is it economically feasible in the long run or not. (Safaei et al., 2019)

1.1 GREEN WAREHOUSE

A green warehouse is defined as the performance in which the use of energy used is reduced and sustainable energy is utilized in its various forms, thus reducing the amount of waste and emissions. Progress towards a more environmentally friendly warehouse can be measured in a tangible way by seeking building certificates that evaluate performance across measures which are often associated withenvironmental, social and governance (ESG) standards. (Ranpak,2022).

Green logistics plays an important role in a larger mission: moving the world towards a green economy. A green economy is focused on low carbon emissions, efficient resources, and socially inclusive. Benefits of a green economy include reduced pollution, improved energy, and resource efficiency, slowing biodiversity loss, and maintaining ecosystem services, The green warehouse is considered one of the most important green logistics practices. (Agility,2021).

1.2 KINETIC ENERGY AND ITS ADVANTAGES

Kinetic energy is a form of energy that an object or particle possesses due to its motion. If work which transfers energy is done on an object by applying a net force, the object accelerates and thus gains kinetic energy. Kinetic energy is the property of a moving object or particle and depends not only on its motion but also on its mass. (Britannica,2022)

Kinetic energy is the energy possessed by a body in its motion. Kinetic energy is transferred between objects and can be converted into another form of energy. And the advantages of kinetic energy for a better understanding are: It is renewable, It is unpolluted as nothing burns, Reliable as there are 2 tidesper day, Cheap to run once built and Availability for being an abundant resource. (**MUNAALIISMAILX**,2014)

1.3 PIEZOELECTRICITY

Piezoelectricity literally translates as electricity because of pressure. word pesos Derived from the Greek word "piezin", which means to squeeze. Discovery Piezoelectricity was invented in 1880 by the sister duo of Pierre and Jacques Curie where they were He discovered that squeezing crystals, for example, generated electrical charges on the crystals The surface of these materials due to the direct effect of piezoelectricity. (A History of the Piezoelectric Effect,2019)

Piezoelectricity, the appearance of a positive electric charge on one side of certain non-conductive crystals and a negative charge on the opposite side when the crystals are subjected to mechanical stress. This effect is exploited in a variety of practical devices such as microphones, phonograph pickups, andwave filters in telephony systems. (Btitannica,2023)

3. METHODOLOGY

The research methodology is depending on reviewing the previous studies to get a theoretical framework linking between piezoelectric tiles and green warehouse to answer the following research questions:

a) What are the previous studies that link piezoelectricity with obtaining green warehouses?

b) Can we get a theoretical framework for the relationship between the dependent variable "Obtaining Green Warehouses" and the independent variable "piezoelectricity"?

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To achieve the research methodology's first aim to obtain the theoretical framework, the previous studies were divided into three sections to explain how to reach the required frame.

3.1 CONVERTING KINETIC ENERGY INTO ELECTRICAL ENERGY

As published by (Arfken et al., 1984) It explains kinetic energy that Galileo discovered in 1638, and the beginning of the law of motion, which explains how to deduce the law of motion, how to convert energyfrom kinetic to static, and all the laws of motion that have been discovered over the ages and show thatthe law of kinetic energy which is: K=1\2 m *v^2 (Equation1)

k= kinetic energy, m= mass of body, v= velocity

Published paper by (Iswanto et al., 2018) and it aims to clarify how to extract electrical energy from the movement of feet on piezoelectric tiles and clarify the amount of energies resulting from one step on the piezoelectric slab and clarify the great savings that will result from the use of these tiles.

(Urroz-Montoya et al., 2019) had a scientific paper explained the framework and proposals for piezoelectricity and clarification of the meaning of piezo energy and its uses and how to use it in extracting electrical energy from piezo energy by clarifying the idea of making piezoelectric tiles and different uses of piezoelectric tiles.

A study focused on the use of piezoelectric cells in high-density projects in the construction of self-powered projects, and people would start producing energy from walking around the facility. This paper highlighted the importance of replacing ceramic and granite tiles with sustainable piezoelectric tiles, which will create a self-sufficient project by redesigning an interior space for public facilities. The floortile design incorporating piezoelectric cells results in a useful amount of energy for the electrification of public facilities using the high visitor population density. The research began by analyzing projects that replaced regular tiles with piezoelectric tiles to understand the goals and limitations of using these sustainable building materials in Egyptian public utilities, this paper presented the types of piezoelectric tiles and their resulting floors as shown in table (1). (Madonna Makram Solban & Rania Rushdy Moussa, 2019)

Table (1) types of piezoelectric tiles

Company	Tiles Size	Energy Produced	Price in US $	Life span by years
Waynergy Floor	40 x 40 cm	10 W per step	451.5	20
Sustainable Energy floor (SEF)	75 x 75cm OR 50 x 50 cm tile	Up to 30 watt of continuous output. Typical power output for continuous stepping by a person lies between 1 and 10W (average 7W)	1,693	20
Pavegen tiles	50 x 50 cm	5 W continuous power from footsteps	395	20
(EAPs) Electro-Active Polymers	Sheets	1W	-----	20
Sound Power	50 x 50 cm	0.1W per 2 steps	270.9	20
PZT ceramic (Lead Zirconate Titanate)	Manufacturing in a small size	0.0084 W	36.1	20
Parquet PVDF layers	Layers	0.0021 W per pulse with loads of about 70 kg	-------	20
Drum Harvesters - Piezo buzzer Piezoelectric Ceramics	Vary	Around 0.002463 W	56.4	20

And the following figures show the different shape of tiles in market, figure (1) shows different type of SEF piezoelectric tiles which are explained in table (1), and figure (2) shows the inner materials of piezoelectric tiles.

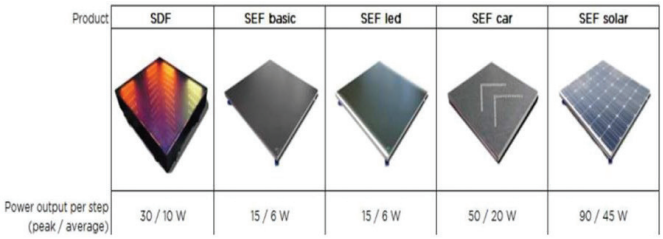

Figure (1) (SEF) tiles (www.rdso.indianrailways.gov)

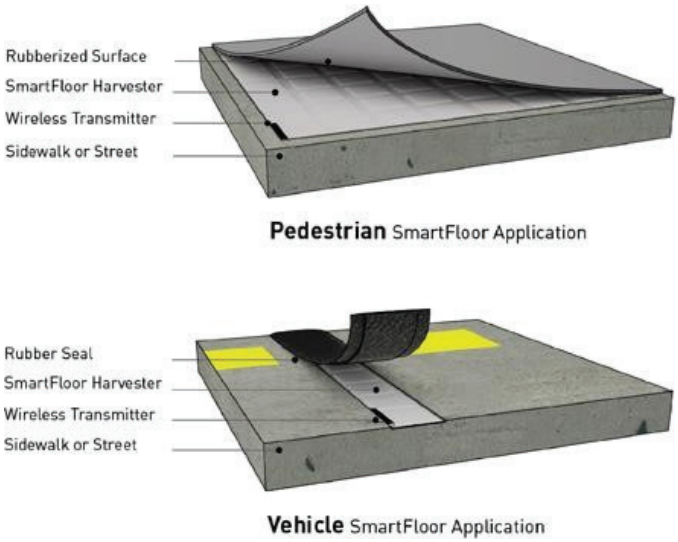

Figure (2) Pavagen piezoelectric company (www.wevolver.com)

VARIOUS LOGISTICAL ALLOCATIONS THAT USED PIEZOELECTRICITY

(Chuang, et al., 2016) published a paper explain the importance of remote sensors in logistics and various logistical operations that use tracking and other devices that monitor the movement of products and how to connect these devices to piezo energy to reduce the cost resulting from the use of sensors with non-renewable energy and clarify the extent of the savings.

A scientific paper written by (Zhao et al., 2019) and the research paper describes the energy that was harvested from the piezo energy by devices that extract electrical energy from the movement of trucks and are installed in the axles of the truck and with its movement, vibrations are collected through those devices to convert them into electrical energy that can be used instead of fuel in trucks and charging other devices to benefit The study also shows the savings achieved as a result of piezoelectric energy.

Article written by (Jettanasen et al., 2020) aims to obtain the use of piezoelectric tiles in several countries such as Switzerland, Ghana, and London to reduce the use of fuel energy and reduce carbon emissions to create smart cities that operate with sustainable energy and also shows the difference between carbonemissions before and after the use of the piezo energy resulting from human steps and electronic devicesvibrations.

3.2 THE ECONOMIC FEASIBILITY OF USING PIEZOELECTRIC TILES

(Taty-Etienne et al., 2018) published a paper explains the economic feasibility of installing piezoelectric crystals and ceramic tiles made of bio-electric in public roads on which cars run, and the extent of energy produced by them in the state of Pretoria, and the study showed that it was possible to provide sufficientenergy for lighting 6 of the lighting poles of pressure The high power of 250 watts, which explains the huge savings due to the piezoelectric tiles.

A research obtained from (Elhalwagy et al., 2016) presented about piezoelectric floors, their cost, types, the extent of their use, the amount of electricity generated from the use of floors made of piezoelectric tiles, and the work of a feasibility study for all types of tiles available at the present time, their prices, and an explanation of the areas in which these tiles are used and the amount of energy The result, but also its life span , From that study, the price of the tiles, the cost of their construction, as well as the energy produced from them and their life span, as well as in the first table, the percentage of electricity from the fuel energy that was saved as a result of using these tiles is clear.

Also to show the ratio in decreasing the cost, (Adnan Elhalwagy et al., 2017) explain if piezoelectric tiles applied on floor in building's interior spaces in different areas public area as shown in table (2), and private spaces as shown in table (3) and how much costs saved from applying these tiles and also explained the different companies that produced piezoelectric tiles.

Table (2) Output results of public area

option	Number of tiles	Company	Initial cost- EGP	saving percentage	total saved amount
1	1334	sound power	2668000	92.69%	33,833,333
2	14	pavagen	490000	98.72%	36,033,333
3	10	SEF	150000	99.48%	27,232,143
4	7	Waynergy	28000	99.93%	36,473,333

Table (3) Output results of private area

option	Number of tiles	Company	Initial cost- EGP	saving percentage	Total saved number
1	1600	sound power	3200000	-8667.12%	3,163,500 -
2	16	pavagen	560000	-1434.25%	523,500-
3	12	SEF	180000	-526.22%	144,054-
4	8	Waynergy	32000	12.33%	4,500

From the results of these papers, it's obtained that piezoelectric tiles are more cost-effective in large andpublic areas in all types of tiles in all company.

In a study on the extent of applying piezoelectric tiles there, the study showed that many families in India suffer due to the inefficiency of electricity. in some areas, there are frequent blackouts while power generation is lower in other countries. The solution to all this is the introduction and implementation of piezoelectric tiles. These tiles can also be used in places like slums where there are a lot of residents and lack of resources. Tiles can produce, store, and use electricity depending on the power comfort people, Although the cost of tiles is high for most of the population there, the study urges investment in India and believes that the return in the long run will be an economic aid because the tiles will provide electricity that will help, and in the long run the cost of electricity will also be negligible. (Deeya Wadhwa, 2021).

A study of two of the busiest stations in Japanese capitals after installing piezoelectric floor tiles in front of ticket gates showed that every time a passenger stepped on the mats, they released a small vibration that could be stored as energy. Multiplied many times over by the 400,000 people who use Tokyo Station on an average day, according to the East Japan Railway, and there is enough power to light electronic signboards. "We are just testing the system at the moment to examine its full potential," said Takuya Ikeba, a spokesperson for JR East, which indicates self-sufficiency in operating most of the signs and

lighting in those stations, which in turn means that regular electricity is not consumed and thus reduces electricity consumption costs. (Julian Ryall,2008)

To achieve the second objective the following questions are used for collecting data and then these data are analyzed.

In this study, the primary data is collected using a non-probability sampling method, in which respondents are selected from different departments especially those who have the basic ideas about the popular technologies in the market. Future ideas prevail in the current technological market, especially in the warehouse sector. This was required as many factors were felt necessary to draw a conclusion based on the outputs received by the samples. It depends not only on consumer behavior but also on themarket demands that were focused on during the sample analysis or study. To collect data, a questionnaire is prepared based on the variables and the SPSS program is used to analyze the data that will be collected from the selected sample, and the survey will be conducted using Google Sheets to collect qualitative data.

Data analysis

Data analysis is done as per objectives. To achieve the first objective the following questions are used for collecting data and then these data are analyzed.

Question 1: Will you choose to generate electricity through trucks?

Question 2. Are you interested in producing energy yourself?

Question 3: Have you heard of piezo electricity?

Question 4: How did you learn about this technology?

Question 5. Would you like to install new electronic floor tiles in your warehouse?

Question 6. How many times do the trucks go inside the warehouse per day?

Question 7. What is the truck load per day?

Question 8: How much do you prefer to invest in equipment that can generate electricity for the warehouse?

4. RESEARCH FINDING

The findings are the outcome of reviewing the previous studies, and the result of reviewing the literature is the suggested research theoretical framework "The Research Model". This theoretical framework describes the research problem and defines the research variables to show how they might relate to eachother.

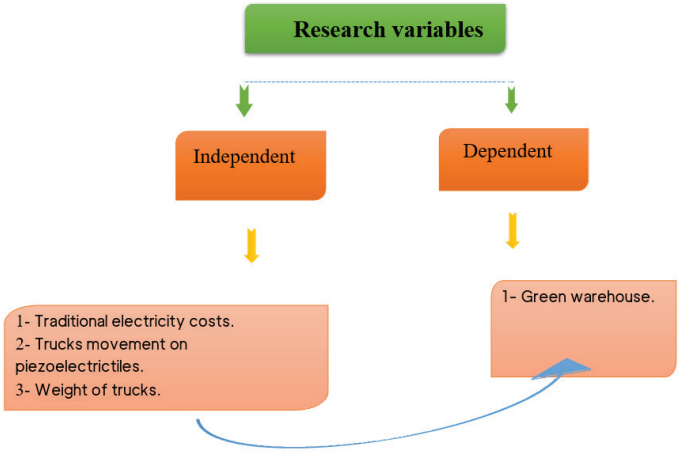

Figure 3: The Research Model

1- Weight of trucks.

2- earch Model

5. CONCLUSION

From the foregoing, it is clear that through previous studies, piezoelectric tiles have done practical and theoretical studies on many scales, whether in the practical field or even daily, and previous studies show the extent of savings, whether providing non-renewable energy or saving related costs, and therefore the presented model can be taken From this research paper, and as for the data that will be collected from the people interested in applying this model andanalyzing it, we can obtain the actual percentages of the extent to which piezoelectric tiles canbe applied, and obtain the actual results of the extent to which non-renewable energy is provided, as well as the related costs.

6. RECOMMENDATION

The research recommends preparing a case study on one of the major warehouses to compare the situation before and after applying the piezoelectricity technology according to cost levels and obtaining a green warehouse, so we can test the research theoretical framework "The Research Model ".

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