Knowledge, Opinions and Interest of Drivers about the Additional Electricity Generator Model from Vehicle Movement within an Industrial Area
ความรู้ ความคิดเห็นและความสนใจของผู้ขับขี่ยวดยานต่อแบบจำลองการผลิตพลังงานไฟฟ้าเสริมจากการเคลื่อนที่ของยวดยานในพื้นที่โรงงานอุตสาหกรรม

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Abstract

This quantitative research aims to study the followings: (1) to determine the level of knowledge and interest in the electricity generator from vehicle movement model or EGM model among drivers in slaughter and food processing plant - Minburi I, CPF (Thailand) public limited company and (2) to determine the extent of any correlation between the attributes of the EGM model and the opinions of the drivers. The study used a sample of 174 drivers who drove the vehicles from 4 wheels up to 18 wheels and always visited this area by questionnaire. The statistical analysis applied measures such as mean, standard deviation, frequency, percentage, and Pearson's product moment correlation. The findings of the study revealed that the participating drivers showed knowledge of the EGM model rated at the good and excellent level, with 89% of the drivers scoring above 3.75 from 4.00. The drivers reported that the installation of the EGM model would be neither inconvenient (82%) nor would compromise traffic safety (90%). Moreover, participants' opinions worried about vehicle damaging and losing view with low level (96% and 98%). Analysis of correlation coefficients found direct correlation between convenience and traffic safety with a medium sized effect. Smaller effects were observed for inverse correlations between vehicle damaging and losing view, which were significance at the 0.1 level. All of the participating drivers expressed interest in having the EGM model installed in this area.

Keywords: electricity generator, vehicle movement, energy harvesting

บทคัดย่อ

การวิจัยนี้เป็นการวิจัยเชิงปริมาณ มีวัตถุประสงค์เพื่อ (1) ประเมินความรู้และความสนใจของผู้ขับขี่ยวดยานที่มีต่อแบบจำลองการผลิตพลังงานไฟฟ้าเสริมจากการเคลื่อนที่ของยวดยานในพื้นที่โรงงานแปรรูปเนื้อไก่และอาหารแปรรูปมีนบุรี 1 บริษัท ซีพีเอฟ (ประเทศไทย) จำกัด (มหาชน) และ (2) วิเคราะห์ความสัมพันธ์ของความคิดเห็นของผู้ขับขี่ยวดยานที่มีต่อคุณลักษณะของแบบจำลองดังกล่าว โดยวิธีสอบถามผู้ขับขี่ยวดยานประเภทตั้งแต่ 4 ล้อ ขึ้นไป ถึง 18 ล้อ

ที่เข้าออกพื้นที่โรงงานฯ เป็นประจำ จำนวน 174 ราย วิเคราะห์ข้อมูลด้วยสถิติค่าเฉลี่ย ส่วนเบี่ยงเบนมาตรฐาน ความถี่ ค่าร้อยละ และสัมประสิทธิ์สหสัมพันธ์ของเพียร์สัน ผลการวิจัย พบว่า กลุ่มผู้ตอบแบบสอบถามร้อยละ 89 มีความรู้ในแบบจำลองในระดับดีและยอดเยี่ยม ที่ค่าคะแนนเฉลี่ย 3.75 จากคะแนนเต็ม 4.00 ซึ่งหากมีการติดตั้งแบบจำลองจริงในพื้นที่โรงงาน ร้อยละ 82 และ 90 คิดว่าจะไม่ทำให้เกิดการเปลี่ยนแปลงด้านความสะดวกและความปลอดภัย นอกจากนี้ ร้อยละ 96 และ 98 มีความกังวลเกี่ยวกับการขับขี่ยวดยานผ่านแบบจำลองและการสูญเสียทัศนียภาพในระดับต่ำ โดยความปลอดภัย มีความสัมพันธ์แบบแปรผันตรงกับความสะดวก ในระดับปานกลาง และมีความสัมพันธ์แบบผกผันกับการสร้างความเสียหายให้กับยวดยาน และการสูญเสียทัศนียภาพ ในระดับต่ำ อย่างมีนัยสำคัญทางสถิติที่ระดับ 0.1 โดยผู้ตอบแบบสอบถามทั้งหมดมีความสนใจอยากให้ติดตั้งแบบจำลองนี้ในพื้นที่โรงงาน

คำสำคัญ: เครื่องกำเนิดไฟฟ้า, การเคลื่อนที่ของยวดยาน, การเก็บเกี่ยวพลังงาน

Introduction

The food industry relies upon the use of electricity at every stage within the production process. The principal electricity source in Thailand is power generated from fossil fuels, accounting for around 77% of the national supply according to the Department of Alternative Energy Development and Efficiency (2016). The food industry has consistently been the largest industrial consumer of electricity and the demand for power has been rising steadily during recent years (Energy Policy and Planning Office, 2016). From this problem, the Ministry of Energy’s renewable energy development plan over 10 years (2013-2021) has established alternative/renewable energy as a goal of 25% for all energy requirements in the country (Department of Alternative Energy Development and Efficiency, 2013) The reliance upon electricity in Thailand therefore means that further research into energy security approaches is essential, and innovation in the area of electricity generator is the key area to study. This research therefore proposes the investigation of a means of obtaining electricity generated from the movement of vehicles, which would serve as an alternative to fossil fuels as a source of electrical energy.

The model under examination involves electricity generator from vehicle movement and is known as the EGM model which is energy harvesting generator. As vehicles travel along roads they can be used to generate electricity, which can then be collected and stored. The mechanism by which this process takes place relies upon the interaction of air and water pressure, with ambient air used as the principal input to the system while the role of the water is to provide the generator rotation. The system’s advantages are that there is an inexhaustible supply of ambient air to serve as the input resource, while the use of a closed loop for the generator process allows maximum efficiency with minimal wastage of water. Figure 1 shows the underlying concept of the EGM model design.

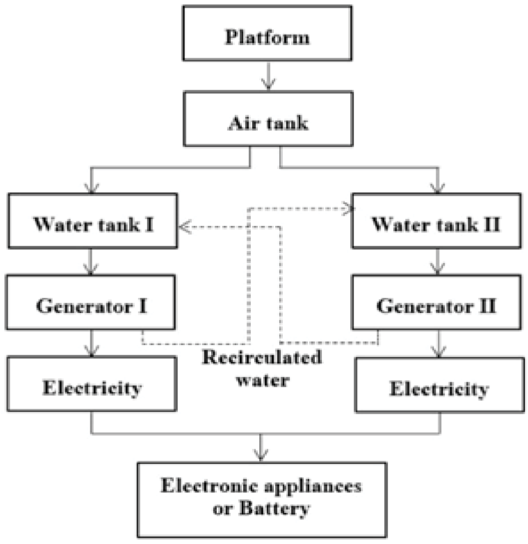

Figure 1 The design concept for the EGM model

This particular EGM model represents an ideal design to be used within the locality of the industrial zone with support from local drivers. The equipment itself comprises a metal platform to provide durability and strength, while the entire surface has a rubber covering to ensure the safety of the drivers and vehicles. To ensure a comfortable driving experience, the minimum platform length is designed to be at least 8 m and sloped. This makes it suitable for larger vehicles, typically with more than four wheels. As further safety features, the platform has easy pedestrian access and is illuminated during hours of darkness (Pornpongmetta, Thanuttamavong & Jintana, 2015)

The concept of the EGM model was inspired by the notion that vehicle movements could potentially generate electricity, leaving only the challenge of gathering and storing this energy for future use. In particular, the food industry which aims to use this source of power would also be able to provide the transport vehicles to generate the electricity since these are needed to move both raw materials and finished food products. This study was therefore performed using a Bangkok food processing plant owned by Charoen Pokphand Foods PLC. (CPF). Approximately 500 vehicles traveled in and out of the factory area every day, with vehicle types including a range of sizes from 4 wheels up to 18 wheels (CPF, 2013), making this location ideal for testing the effectiveness of the EGM model design to serve as an additional source of electrical energy for the food industry. The study aims to determine the levels of knowledge and interest of drivers who might use the EGM model. The feedback would therefore be helpful in informing any alterations to the prototype design which might improve the efficiency or usability of the device.

Objective

1. To determine the level of interest in the EGM model and knowledge of the EGM model among drivers visiting the CPF production plant near Bangkok.

2. To determine the extent of any correlation between the attributes of the EGM model and the opinions of the drivers.

Idea theory

Energy harvesting generator

EGM model is one of type energy harvesting generator which is used to convert the input ambient energy such as heat (thermoelectric modules), light (photovoltaic cells) and vibration (piezoelectric, electromagnetic) into electrical energy (Spies, Pollak & Mateu, 2015). Moreover, this generator type is kinetic energy harvesting, a particular transduction mechanism which is used to extract electrical energy from motion (Kazmierski & Beeby, 2011). The application of the energy harvesting generators are available in the environment energy sources to supply power such as solar, mechanical, and thermal energy (Priya & Inman, 2010).

The example generators by using the energy harvesting are the application for highway bridges to harvest the movement and vibration from vehicle movement. It generate electricity by piezoelectric with 13 μJ. The electricity is supplied to motion wireless sensor module of bridges (Ali, Friswell & Adhikari, 2011). Moreover, piezoelectric generator can generate the electricity by the vibrations of tall buildings, vehicle systems, railroads, ocean waves, and even human motions. The power is 10 to 100 mW (Zuo & Tang, 2013). In Japan, the East Japan Railway Company (JR East) researched a "power-generating floor", which is equipment for harvesting energy from footsteps that was installed in Tokyo at the railway station. The generated electricity is used for light bulbs (East Japan Railway Company, 2008). The generator which has characteristics and operation system is the same as EGM model. It is not appear in any research.

Innovation-Decision Process

Innovations can be defined as ideas, actions or items which are considered to be new to the person making the assessment (Everett, 1983). When defined in terms of product markets, an innovation is a new or radically upgraded product or service which has not previously been available. Innovation could therefore be the result of technical improvements in product design, or in the materials or techniques used for production, including the computer software employed in designing and making the product, and encompassing attributes such as ease of use, or other novel functional capabilities. To innovate in production therefore requires new technology or new knowledge, or involves new uses of existing knowledge and technology (OECD, 2005).

This study examines the levels of interest and knowledge of drivers with regard to the EGM model described, while the use of additional electricity generated through the movement of vehicles represents a technological innovation. In this case, there are five phases through which an individual (for the purposes of this study, the drivers) must pass with regard to decision making about innovations. These can be described as follows: i) the knowledge phase, becoming aware of the existence of the innovation and its function; ii) the persuasion phase, developing an opinion of the innovation, whether favorable or otherwise; iii) the decision phase, reaching a decision on whether to accept the innovation or not; iv) the implementation phase, beginning to use the innovation, and finally v) the confirmation phase, involving the reinforcement of the innovation's acceptance, except where new evidence leads to a change in opinion resulting in rejection of the innovation (Rogers, 1983).

Since the EGM model in this study was purely conceptual, the objective was to use the findings from the survey to develop an improved prototype version of the EGM model for further testing. The improved version should be more readily accepted by drivers since its early drawbacks in terms of ease of use would be eliminated. The study therefore focuses upon the initial two phases of the innovation-decision process, involving only knowledge and persuasion. The knowledge phase is evaluated through questions about the EGM model, while the persuasion phase is evaluated by determining the level of driver interest in having the EGM model available for use in their locality.

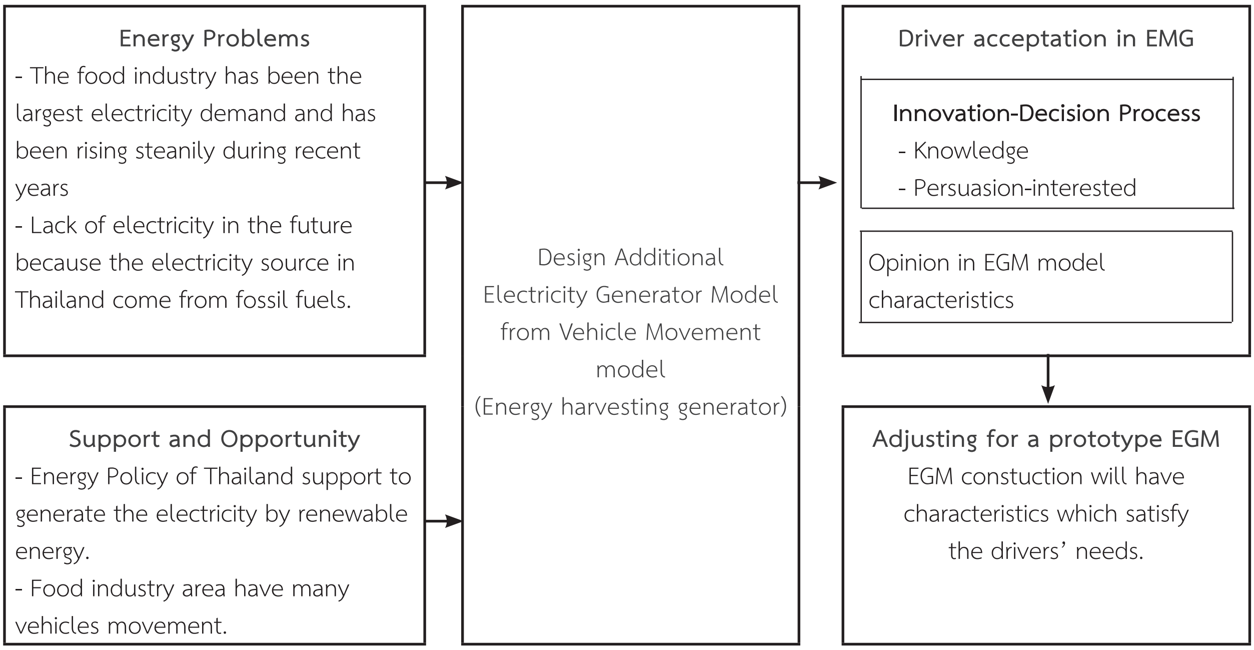

Figure 2 The conceptual framework for the study

Hypothesis

1. All of participating drivers has knowledge with good level and interested in having the EGM model installed in this area.

2. The correlations between the attributes of the EGM model and the opinions of the drivers have direct where positive elements were paired with other positive elements and inverse where positive elements were paired with other negative elements.

Methodology

This study applied a quantitative approach, using a questionnaire survey to obtain data from the drivers. The sample of 174 drivers was drawn from the population of CPF drivers; the research tool was a questionnaire, and the data analysis was carried out as described in the following section.

Population/ sample

The number of vehicles traveling to the CPF production plant during 2014 formed the basis for the design of the EGM model, in terms of determining how much traffic would be available for the generator of electricity. The data are shown, broken down by month, in Figure 3.

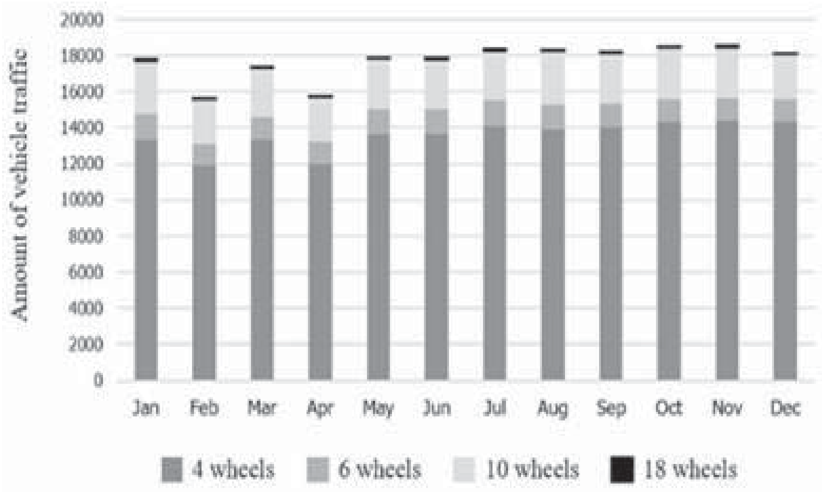

Figure 3 Vehicle traffic levels for CPF in 2014

The traffic levels are consistent on both a daily and monthly basis, with just under 500 vehicles per day. Broken down by vehicle type, 4-wheeled vehicles were easily the most common, followed respectively by 10-wheeled, 6-wheeled and 18-wheeled vehicles. The sampling therefore encompassed all vehicle types, but given the similarity of the days and months, no particular consideration was given to the selection of the time period.

The sample comprised 174 CPF drivers, driving vehicles of all types which population size was 484. The sample size was calculated using a method presented by the World Bank (2009) as follows:

$$n=\left[\frac{1}{N}+\frac{N-1}{N}\frac{1}{PQ}\left(\frac{k}{z_{1-\alpha/2}}\right)^2\right]^{-1}$$

$$n=\left(\frac{1}{484}+\frac{484-1}{484}\frac{1}{0.5(1-0.5)}\left(\frac{0.05}{1.645}\right)^2\right)^{-1}$$

$$n=174$$

Where N = population size

P = population proportion, Q = 1-P

k = desired level of precision

Z1-α /2 is the value of the normal standard

Coordinate the required level of confidence, 1-α.

Tools to collect data

The principal tool used to gather data was a questionnaire constructed with four sections. The first section comprised the demographic data of the participants, including age, education, gender, and type of vehicle driven. The second section comprised true or false questions designed to determine the level of the participants' knowledge about the EGM model. Participants were asked to first read some information explaining the model in simple terms, as shown in Figure 4 below. The third section investigated the opinions of the drivers regarding traffic safety and ease of use, with questions offering three possible responses, indicated positive, negative, and unchanged opinions. This section also comprised questions designed to ascertain the participants' opinions about potential vehicle damage and loss of view. The final section aimed to determine the participants' level of interest in installing the EGM model for their use. The data gathered in response to the questionnaire were then analyzed using SPSS statistical analysis software.

The example question which appeared in the questionnaire. The first, it determined the level of the participants' knowledge about the EGM model. The second, it investigated the opinions of the drivers regarding traffic safety.

Question 1: What is energy source of EGM model to generate the electricity?

a) Solar power

b) Heat

c) Vehicle movement

Question 2: How do you feel with traffic safety dimension, if there is the EGM model installed in terms of the driving experience?

a) Positive   b) No change   c) Negative

Figure 4 Document explaining the design and use of the EGM model

Data collection

The document shown in Figure 4 was given to the participating drivers in order to inform them of the principles behind the EGM model, along with information regarding its function, installation and usage. The document used pictures and simple wording to explain the facts. The information and survey questionnaire was given to the 174 sample drivers at three checkpoints at the CPF production plant. The data were thus collected, providing information on the participants' knowledge and opinions about the EGM model. The data were then checked for completeness before analysis was carried out.

Statistical analysis

The descriptive statistics presented were mean, standard deviation, frequency, percentage, and Pearson's product moment correlation. The (r^2) coefficient of determination referred to the effect size as indicated by Cohen (1988). A correlation coefficient smaller than 0.1 is considered to be trivial; 0.1 – 0.3 is small; 0.3 – 0.5 is moderate, while a coefficient in excess of 0.5 is considered large. Table 1 presents the equivalence ranges for the coefficients of determination.

Table 1

The equivalence ranges for the coefficients of determination (Cohen, 1988)

Absolute value of r	r squared	Effect size
0.1≤ |r|<0.3	0.01≤ r^2<0.09	Small
0.3 ≤ |r|<0.5	0.09≤ r^2<0.25	Moderate
|r|≥0.50	r^2≥0.25	Large

Findings

1. Demographic data

A very small proportion of the drivers were female, with 85% male. A majority were aged in the 36-45 years bracket at 43%. Around one quarter were educated to bachelor's degree level or higher. The data regarding age, gender, and education are shown in Figure 5.

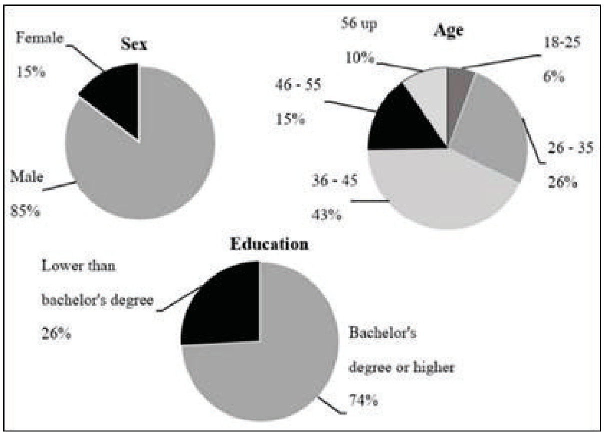

Figure 5 Sex, age and education ratios

2. Knowledge about the EGM model

The participants' knowledge about the EGM model was divided into four separate categories: usage, installation, function, and principle, as displayed in Table 2 which these knowledge was the understanding in EGM model from document explaining the design and use of the EGM model. The category with the highest knowledge level was usage, as the participants readily understood how to generate electricity through driving. Installation was the second most successful knowledge category, followed by the general principle, and how the system functions respectively. In total, 89% of the participants were able to answer at least one question about the EGM model, indicating some level of knowledge.

Table 2

Driver knowledge dimensions for the EGM model

(n = 174)

Elements of EGM model knowledge	Number of Respondents		Position
	Persons	(%)	
Usage	174	(100.00)	1
Installation	163	(93.68)	2
Principles	161	(92.53)	3
Function	155	(89.08)	4

The knowledge levels regarding the EGM model were classified as excellent, good, average, fair, and poor, with further classification by age, gender, and education. The results are shown in Figures 6, 7 and 8. The results reveal that a large majority of the respondents showed an excellent level of knowledge about the EGM model, whether classified by age, education, or gender. All of those participants educated to bachelor's degree level or higher were in the excellent category.

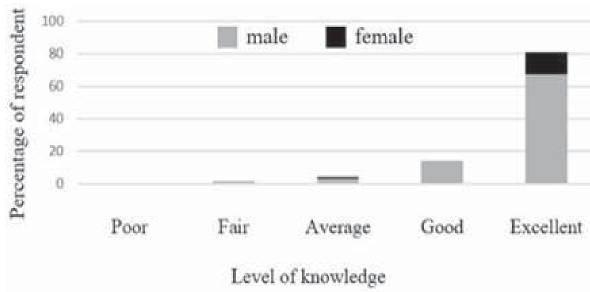

Figure 6 Participants' knowledge level by gender

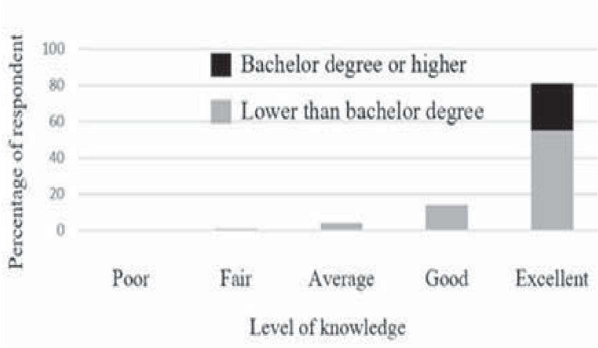

Figure 7 Participants' knowledge level by education

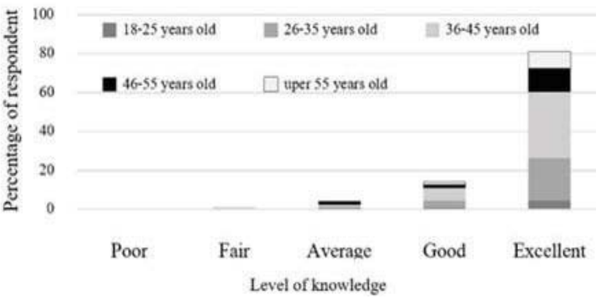

Figure 8 Participants' knowledge level by age

3. Participants' opinions about the EGM model

The drivers reported that the installation of the EGM model had neither negative nor positive effects upon convenience or traffic safety. The mean scores for these categories were 1.84 and 1.96 respectively, coming very close to a score of 2.00 which would represent no change; this reveals that drivers would feel no effects from having the EGM model installed in terms of the driving experience. Table 3 presents the findings.

Furthermore, the drivers reported little concern about the potential for damage to their vehicles or obstructed views in driving, with means scores of 1.06 and 1.01 respectively. Both these scores were close to the value of 1.00 which would represent the lowest level of concern.

Table 3

Opinions of participants regarding EGM model attributes (n=165)

Opinion of drivers dimensions	Respondent proportion in different level of opinions Person (%)			Mean score ± S.D.	Summary level
	Negative	Not changed	Positive		
Conveniences	30 (17.24)	142 (81.61)	2 (1.15)	1.84 ± 0.40	No changed
Traffic safety	12 (6.89)	157 (90.24)	5 (2.87)	1.96 ± 0.31	No changed
	Low	Medium	High		
Vehicle damaging	167 (95.98)	3 (1.72)	4 (2.30)	1.06 ± 0.33	Low
Losing views	171 (98.28)	3 (1.72)	0 (0.00)	1.01 ± 0.13	Low

The correlation coefficients for the participants' opinions about the EGM model ware analyzed, some small correlation was observed among outcomes regarding various pairs of opinions. Those pairs which showed significant correlation at the 1% level of significance were: i) convenience with traffic safety; ii) convenience with vehicle damage; iii) convenience with loss of view; iv) traffic safety with vehicle damage, and v) traffic safety with loss of view. The size effects for the correlation coefficients were small in all cases with the exception of convenience with traffic safety, which produced a medium sized effect.

Table 4

Matrix of correlation coefficients (r) showing participants' opinions (n = 165)

Opinion elements	(01)	(02)	(03)	(04)
(01) Convenience		0.337**	-0.230**	-0.160**
(02)Traffic safety			-0.212**	-0.243**
(03)Vehicle damage				-0.016
(04) Loss of view				

** Denotes significance at the 1% level.

Some of the correlational relationships can be described as direct, where if one element falls, the other will also fall. Others were inverse, denoting a rise in one element leading to a fall in the other. The results are shown below, referring to each of the correlational pairs earlier described:

1) Convenience α Traffic safety

2) Convenience α 1/vehicle damage

3) Convenience α loss of view

4) Traffic safety α 1/vehicle damage

5) Traffic safety α loss of view

In general, it can be stated that the relationships were direct where positive elements were paired with other positive elements, such as convenience with traffic safety, while the inverse relationships came when negative elements were paired with positive elements, such as vehicle damage with convenience. This suggests that the design should allow positive aspects to be enhanced while simultaneously reducing the negative aspects.

The results also showed that negative opinions were reduced to a greater extent than positive opinions were increased, while elements such as convenience and traffic safety were seen as essentially neutral. The vehicle damage category showed anxiety at a high level exceeding that of a medium level, while for loss of view, the situation was reversed with medium anxiety exceeding high level anxiety.

4. Interest levels in the EGM model

The persuasion phase from the innovation-decision process was evaluated by determining the participants' level of interest in having the EGM model installed. The questionnaire thus included the item worded as follows: "I am interested in the EGM model and have no objection to its installation on the factory's road". Furthermore, respondents were invited to offer their opinions and suggestions. Those in favor noted that energy security for the factory would be improved through this alternative energy source, with support levels for this viewpoint measured at 23.7%. Those against believed that while the electricity cost to the factory might be lowered, 5.3% thought the technology itself may be new, unreliable, and potentially expensive, while 60.5% advised that the location should be chosen carefully and the materials used should be strong and durable to ensure the project's success. A further 10.5% sated that they did not object and though the decision should be the responsibility of senior managers.

Discussion and Conclusion

The results of the study revealed that overall, the participants, comprising CPF drivers of all vehicle types, had excellent knowledge of the EGM model, and all expressed interest in having the system installed. It can thus be concluded that they were able to understand the general concept behind the design and the attributes of the model and use of the EGM model and its operation having studied the documents provided as part of the study. However, if EGM model will be constructed and installed in this area, the level of knowledge of drivers may change because in they will available to use a prototype EGM model. It may enhance the level knowledge.

The information document, illustrated in Figure 4, provided basic details about the EGM model using simple language and sketch diagrams to help drivers to understand the operation of the system. The results of the analysis showed that factors such as education, age or gender had no significant influence upon the level of understanding achieved. Although a high percentage of participants did not hold a university degree, they had sufficient ability to understand the explanation provided in the document and to understand the EGM model. This success can be attributed to the inclusion of both visual and textual material to convey the information, with the visual communication theory (Barry, 2002) explaining the benefits of the use of pictures which the results here clearly support. It has also been suggested that visual presentation should be favored when offering new products to the market since customers prefer to see information in this format rather than to read. Pavel (2012) noted that around 40% of people exhibit a better response to visual information when compared to text alone.

In addition to the clarity of information, another factor behind the drivers' support for the system was the fact that the EGM model is an approach which supports sustainable development, conserves resources, offers a clean source of energy, and assists in the prevention of activities which lead to climate change. This can therefore offer benefits to society, the economy, and the environment. This has been helpful to CPF, as the company has been named to the Dow Jones Sustainability Index in the Emerging Markets category since 2015, ranking within the top 5 from a total of 31 companies in the food sector (CPF, 2015). The EGM model can therefore add to achievements such as becoming the world's first sustainable chicken producer as measured by the ProSustain standard (DNV Business Assurance Group, 2012). It is clear that CPF has been taking its responsibilities in the field of sustainability very seriously, through an approach which has seen staff and suppliers playing a key role in terms of heightened awareness of issues such as clean technology, and sustainable alternative energy. The basic awareness levels of these issues would already be expected in CPF drivers so it is not surprising that the EGM model was readily understood and appreciated by these drivers.

The analysis of correlation coefficients revealed relationships between the opinions of the drivers which can guide the development of the prototype EGM system. Attributes related to the opinions revealed in the study can be considered by engineers responsible for the installation of the system, with factors such as the materials used and the safety features added playing a key role in ensuring that the system gains the support and confidence of the drivers. The EGM system will not compromise traffic safety or damage vehicles, and will be designed to ensure maximized convenience and ease of use.

In order to improve the design and the future operational capabilities of the EGM system, the designers should note that among all the opinions reported, the greatest concern of the drivers was that the system might potentially compromise convenience. This particular question drew the most significant outcome in terms of the difference between positive and negative feelings at 16.09%, while the second greatest area of concern was traffic safety. These areas should thus attract the greatest attention from designers in improving the EGM system. In contrast, the negative aspects such as vehicle damage were not particularly seen as a major concern by the drivers.

While the drivers will play an important role as users of the system, and must thus be involved in the consultation process where elements of the design will directly impact drivers, they generally considered that the decision making process regarding the implementation of such a scheme and the necessary investment would be the responsibility of senior managers.

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