JIMMA UNIVERSITY
INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
ENVIRONMENTAL ENGINEERING POSTGRADUATE PROGRAM

SIMULATION OF ELECTRICITY GENERATION FROM ASPHALTIC ROAD TRAFFIC FLOW BY USING SOLID WORK SOFTWARE: A CASE STUDY OF ADDIS ABABA/FINFINNEE CITY

By:

Wakoya Oljira Wertu

A Thesis submitted to Jimma University, Jimma Institute of Technology, Faculty of Civil and Environmental Engineering Chair in Partial fulfillment of the Requirements for the Degree of Masters of Science in Environmental Engineering.

May, 2021

Jimma, Ethiopia

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May, 2021

Jimma, Ethiopia

DECLARATION

This research is my original work and has not been presented for award of masters, degree in any other university.

I have identified all material in this thesis which is not my own work through appropriate referencing and acknowledgement.

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Candidate Signature Date

This research has been submitted for examination with our approval as university supervisors

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Advisor Signature Date

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Co-Advisor Signature Date

APPROVAL SHEET

The undersigned certify that the thesis entitled: **“**Simulation of electricity generation from asphaltic road traffic flow by using solid work software: A case study of Addis Ababa/Finfinnee City**”** is the work of Wakoya Oljira and we here by recommend for the acceptance by school of Post Graduate Studies of Jimma University in partial fulfillment of the requirements for Degree of Master of Science in Environmental Engineering.

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As member of board of examiners of the MSc. Thesis open defense examination, we certify that we have read, evaluated the thesis prepared by Wakoya Oljira and examined the candidate. We recommended that the thesis could be accepted as fulfilling the thesis requirement for the Degree of Master of Science in Environmental Engineering.

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Chairperson	Signature	Date

ABSTRACT

In the current scenario demand of power is increasing day to day with increasing population. On the other hand, energy crisis is also a main issue of today's life and all there is a shortage of optional energy resources due to its large usage. So, we have to sort out this problem with a technique which are not only to overcome this energy crisis. Many conventional resources are creating pollution so that's why focus is given to shifted towards eco-friendly solution. A large amount of kinetic energy is being wasted on roads on daily basis in different forms which can be used to generate power and this power can be store in batteries.

Man in his lifetime, uses energy in one form or the other. In fact, whatever happens in nature, results, out of the conversion of energy in one form or the other the blowing of the wind, the formation of the clouds and the flow of water are a few examples that stand testimony to this fact. The extensive usage of energy has resulted in an energy crisis, and there is a need to develop methods of optimal utilization, which can not only ease the crisis but also preserve the environment.

The main objective of this study was to simulate generation of electricity from Addis Ababa asphaltic traffic flow by using Solid work software, at sites in Addis Ababa city, this study attempts to show how energy will be tapes and used at a commonly used system, the road power generation. Road power generation (RPG) is one of the most recent power generation concepts. This simulation is shows how to converts the kinetic energy of the vehicles into electric energy by installing of Conventional set on asphaltic road. It takes the stroke motion of the vehicles and converts it to the rotary motion by crank mechanism and it generates the electricity.

This study also shows clearly, the working principle of the designed system, Data were collected from Ministry of transport, Addis Ababa city Road Authority and also recorded primary data were collected from road traffic flow to attain the aims of the study, simulation of the system was conducted using solid work software, the output power from pushing driving force of vehicle passing over the speed breaker arrangement for one-minute equal to 33.33watts produce. Taking the various criteria that determine the power generation, graphs are plotted. overall budget of the study is 25,000ETB. Lastly as a recommendation that governments and every stake holder should have to give attention for this renewable energy harvesting system.

Keywords: Eco-friend, energy crisis, power generation, sold work, traffic flow, and wasted energy.

ACKNOWLEDGEMENTS

First of all, I praise the Almighty God for blessing invaluable health and strengthen me to possess and walk unpaved way to reach this point in my life.

Next, I would like to present a great thanks to my Main Advisor Dr:-Ing Fikadu Fufa and co-advisor Mr:- Seifu Kebede who helped me this study in giving advice and guiding me how to start and proceed through the target plan and for their comments and productive critiques in keeping the progress as per schedule.

And also, I would like to say thanks for my Software assistance Mr. Leyikum for his advice and encourage me to do and accomplish this work at this time.

My next gratitude goes to Jimma University, Jimma institute of Technology for allowing me to take part in the Graduate Study Program of Environmental Engineering

Finally, I would like to thanks all my family for their inspiration and backing all the way through my study period.

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ACRONYMS

AARCA	Addis Ababa city road authority
AGM	Absorbed glass mat
DC	Direct current
FDRE	Federal democratic republic of Ethiopia
EPC	Engineering procurement and construction
EEP	Ethiopia electric power
GIS	Geographical information system
GPI	Global procurement initiative
GOE	Government of Ethiopia
GTP	Growth and transformation plan
IPP	Independent power producer
IPPs	Independent power projects
NGOs	None governmental organizations
PO	Power plants
PPP:	Public private partnership
RPG	Road power generation
GERD	Grand Ethiopian renaissance dam
GTP	Transformation plan
USTDA	Unite state trade and development agency
VEGV	Variable energy generator

CHAPTER ONE

INTRODUCTION

1.1. Background

Energy crisis is one of the main problems and issues which are under focus of these days. We have shortage of conventional resources of energy and most conventional resources like fossil fuels are not eco-friendly as they cause pollution. Now it's time to move towards solution of energy crisis with the factor in mind that solution should be eco-friendly. As population of the world increasing rapidly, vehicles which are related to population are also increasing on roads. When vehicle passes over the road a large amount of energy is being wasted in different forms such as friction and kinetic energy. In back days this method was of not much importance because relatively energy wasted on roads was not much but now due to high population and high traffic on roads this wasting energy is of prim importance and should be focused upon. Specially designed speed breakers could be implemented on roads which can generate power when any vehicle passes over them. When vehicle passes over the speed breaker it presses it down and due to Rack-Pinion this linear motion is converted into rotary motion and then this rotary motion can be used to operate DC generator to produce electricity. Batteries are used to save the energy and DC could be converted into AC using inverter. This idea could be implemented on roads where there is heavy traffic. (Tarannum*et al., 2016).*

Recently, in order to comply with the policies of energy conservation and use of renewable sources of energy the power is generated by wind energy and other renewable energy sources. This study mainly focuses on generating electrical energy from road traffic flow. The idea is a new technique to generate electrical energy from speed break Energy produced due to the vehicle motion in roads, cost effective without disturbing the current road design also even not disturbing the traffic flow. Road traffic flow power is extracted from speed break flow using turbines mechanism or sails to produce mechanical or electrical power. Vehicle speed break tiers are used for their mechanical power, road traffic flow energy as an alternative to fossil fuels, is abundant, renewable, widely distributed, produces no greenhouse gas emissions during operation and uses little road traffic flow. The effects on the environment are generally less problematic than those from other power sources.
The Government of Ethiopia, under its latest Growth and Transformation Plan (GTP), envisions transitioning from a developing country to a middle-income country by 2025.

Ethiopia's ability to achieve this ambitious goal in such key sectors as agriculture and industry is significantly constrained by current challenges in the power sector. Although Ethiopia is endowed with abundant renewable energy resources and has a potential to generate over 60,000 megawatts (MW) of electric power from hydroelectric, wind, solar and geothermal sources, currently it only has approximately 2,300 MW of installed generation capacity to serve a population of over 100 million people. The targets for increasing generation capacity to 10,000 MW established under the first iteration of the GTP was met by completion of two major hydro power plants in 2017 and 2018. The current GTP has a new target to increase generation capacity to over 17,000 MW by 2020, with an overall potential of 35,000 MW by 2037, which would help sustain Ethiopia's continued economic growth and enable it to become a regional renewable energy hub in East Africa. The Government of Ethiopia has determined that private sector investment is critical to achieve these aggressive power generation targets, but acknowledges that it lacks sufficient experience with independent power projects (IPPs). The Government also faces other major challenges in expanding the country's energy system, including the need to rehabilitate an aged distribution system with high losses and ensure more efficient operation and maintenance of the expanded system. It must also become a credit worthy purchaser of electricity from IPPs, address foreign exchange constraints, reform tariffs to allow for full-cost recovery, and deliver more power to the majority of the population living off-grid. *(Ethiopian Ministry of Water, Irrigation and Energy 2015).*

1.2. Statement of the problem

Electricity is used for various purposes including lighting, heating and cooling, transportation, manufacturing, to run data centers in service industries. Electricity has been traded similar to other commodities in the deregulated energy market. The main challenge of considering electricity as a commodity is its reliability. Disruption of energy supply would not affect simple household lighting as much as it would in hospitals and manufacturing industries. Some of the major reasons behind unreliable power supply would be variability in generation station due to the change in input power, unexpected disturbances in the system (like major faults), and unexpected increment in the energy demand. Electricity is an essential service, a vital input required for almost every business and personal activity. As businesses grow in a country, the country's overall economy continues to grow. Serious reliability problems could have overall economic impacts and results in bankruptcies, job losses, and even loss of life. The electricity trade can occur through wholesale transactions (bids and offers): which use supply and demand principles to set the price or through the long term trades which are similar to power purchase agreements between the sellers and the buyers. Larger initial investment makes higher per unit energy cost during its operation to the energy users. So that other renewable energy source is crucial to overcome those problems that's way this study initiate is to generate other source of renewable electricity from highway traffic flow. This energy sours are near to demand, so that it is easy to access, less maintenance cost, eco-friendly. In addition to this, it maintains energy crises due to kinetic energy loss especially more traffic flow concentrate areas like city and towns. The intention of this study is to use this environmental friendly renewable energy source for different electrical demand purposes.

The consumption of electric energy is needed for day to day life and also for development of every country. Different country generates electricity from different sources like hydro-power, geothermal and other renewable sources. But those source things still not satisfying the world power demand as well as our country. There are different cases for this reason, even though production of electricity from water, wind and thermal source are environmentally friend in some extent but it needs large area, capital, human resources and high maintenance cost because its located far from demand areas such as; towns, city and industry it may also displease terrestrial habitats, Relocate/shift human settlement and replace aquatic habitats typically, the hydro-power. Also wind energy is clean and environmentally friendly than hydro-power but the amount of energy produced is much less because it needs environment where wind is frequently turbulent and the other problem is fluctuation of energy because of wind power fluctuation these factors disturb world energy consumption in some extent. Therefore, production of electricity from highway traffic flow is the easiest, economically cheapest, and environmentally friendly, near to city/towns and industry. However, this study area has had limited research conducted about its production of electricity from highway traffic flow, including by regulatory bodies charged with the control of the production of electricity. In addition, production sources need to be identified and a map created to illustrate traffic flow concentrated sites. Finally, this study will be able to be used in the Master Plan of Addis Ababa city, Minster of Energy and Ministry of Road authority cooperatively.

Creating community awareness of their electricity consumption and services is one of the options for improving sustainable access of improving the Electricity supply covers and access has a number of consequences in addition to the fact that investigating the socioeconomics and other factors affecting household electricity consumption pattern provides guidance for policy makers and those in various agencies implementing projects. It also ensures the project capture the major points to be considered before installation begins and ensures the ongoing Provision of a service that is fundamental to improve health, reducing the burden of women and children carrying wood for energy source long distance, and enabling users to live a life a dignity. Power supply and services should not be as isolated factors.

Research gaps

The aim of generating renewable electricity from highway traffic flow pre-study is to develop and demonstrate a data and simulation model methodology to identify current potential of environmentally friendly energy production. The aim of this study was increase double the amount of electricity produces from 4.905watts per minute energy available studied by (*Noor Fatima et al., 2016).* but in this study for one pushing, force Power developed for one vehicle passing over the speed breaker arrangement for one minute it produce equal to 33.33watts and also in this study the design and maintenance accessibility gap fill the problem.

Also other such as; cost effectiveness and maintenance cost gaps will fill than studied, types, intensity and sources of renewable energy to save energy crises due to kinetic energy lose, main renewable electricity potential data and information gaps and strategies for future monitoring.

As an outcome, the report of the World's renewable electricity shortage – towards a global assessment" summarizes the key findings of the study. The methodology developed offers a baseline to measure progress, a framework for global assessment and a pathway towards sustainable solutions. This study will help bridge the gap between power supply and demand problems, the inclusive green economy and the interlinked issues of sustainable development.

1.3. Objective

1.3.1. General objective

The main objectives of this study is to generate electricity from asphaltic highway traffic flow by using Solid work software, at sites in Addis Ababa city

1.3.2. Specific objectives

The specific objectives of the study are

1. to design and simulate generation of renewable electric energy from asphaltic road traffic flow using Solid work 2019 software?
2. to determine amount of energy that can be generate from the asphaltic road traffic flow;
3. to optimize the parameter for maximum electric power generation from traffic flow;

1.4. Research questions

The study attempt to answer the following questions the following questions;

1. How to design and simulate generation of renewable electric energy from road traffic flow by solid work software?
2. How much energy can be generated from road traffic?
3. What are the parameters and mechanisms to optimize electric generation from traffic flow?

1.5. Justification

Further to achieve the development goals of the country access to improved electricity source is better to incorporate each element to understand and recommend the major factors which hider the vision of the long term programs for the provision of efficient power services is very crucial.

1.6. Scope of the study

This research focuses only on Renewable Energy generation from traffic flow, the mechanism to do this study is focused on data collection, resources need, design and simulation and interpretation of the result in the way to generate renewable electrical energy from highway traffic flow.

Also these study site focus only in Addis Ababa city which is suitable for generation of electricity from paved road by speed break from asphalt road traffic flow.

1.7. Limitations of the study

The main challenging limitations of this study are;

1) For simulations process: lack of daily well recorded input data for the model, Absence of reliable data like; the amount of vehicles cross Addis Abba city and the exact length of paved roads affect the scientific quality of the result obtained.

2) Difficulty to get conversion set component materials in local market to model and also there was no trail at all in Ethiopia such like this technology to compare with this result obtained rather than with hydro-electrical and geothermal energy that’s why simulation is preferred.

1.8. Plan for dissemination of findings

The results of the study will be presented with presence of external examiner, internal examiner, chairperson and the audiences during final defense. Finally, thesis findings will be disseminated through different ways, such as: through media, online or web based, written form including illustrations, graphs and figures, oral presentation at community meetings, scientific conferences and publications.

CHAPTER TWO

LITERATURE REVIEW

2.1. literature review relevant to the study

The thought of generating electricity basically started from South Africa, where, a businessman felt the need for a generation of electricity without compromising on any resources. For this purpose, the author thought of an idea and also brought into existence, the working model of this idea. The idea was to generate electricity using speed breakers. These speed breakers use the concepts of physics to convert the kinetic energy possessed by the vehicles running on the road into electrical energy, eventually generating electricity. This is where the plot for energy generating speed breakers was laid, later on; Guwahati took over this project to overcome its limitations. The practical implementation of the electricity generating speed breaker has been very less and the result of the few places where it is implemented is still not known. Although, there have been many surveys to support the implementation of this idea. One such survey was done by the Tamil Nadu electricity board. According to this survey, the electricity consumed by a remote village for 45 days is equal to the electricity consumed by all the street lights in one night in Chennai city. By this scenario, we can get an idea of the rate by which electricity is being consumed in Ethiopia to; also, this consumption rate is increasing day by day. Electricity and power can be called as the backbone for development and modernization of the country and therefore, rapid speed of development has led to a constant increase in the rate of electricity consumption. Taking into consideration this situation, it is mandatory that either consumption of electricity must be reduced or the generation of electricity must be increased. The consumption of electricity can be reduced only to a certain limit; beyond this limit the development can be hampered. But, by conservation, the amount of electricity conserved will be in very small amount, hence, increasing the generation of electricity is the right option. Now, this increase in generation of electricity would result in more and more proper use resource *(Brinda et al., 2018)*

As identified by *Aswathaman, (2016)* three different mechanisms are currently being used in power generation via speed breakers. These are: Roller type mechanism, the Rack- Pinion mechanism and Crank-shaft mechanism. *Singh et al, (2016)* discussed rack pinion mechanism to generate electricity. They proposed mechanism using chain sprocket and springs with rack pinion to generate electricity. Vehicle was passed over that mechanism and then due to rack pinion there was rotation in gears and shafts moves with chain sprocket movement. DC power was generated and stored in a battery and then using an inverter they changed that DC to AC power. *Das et al, (2018)* proposed mechanism in which electricity was produced by kinetic energy of speed breaker. The basic principle was when a car passes over the jump or dome which is a device used in place of jump the dome will go down due to weight of car, while Moving car possess kinetic energy that kinetic energy will be converted into rotational energy with the help of rack and pinion. A fly wheel is mounted on the shaft whose function is to make energy uniform. That shaft is connected through a belt with dynamos. These dynamos were used to convert mechanical energy in to electrical energy. The power is generated in both directions. They used Zener diode to generate power in opposite direction too *(Jyoti,et al, 2016).*

2.2. Theoretical review

A renewable electricity generation technology harnesses a naturally existing energy flux, such as wind, sun, heat, or tides, and converts that flux to electricity. Natural phenomena have varying time constants, cycles, and energy densities. To tap these sources of energy, renewable electricity generation technologies must be located where the natural energy flux occurs, unlike conventional fossil-fuel and nuclear electricity-generating facilities, which can be located at some distance from their fuel sources. Renewable technologies also follow a paradigm somewhat different from conventional energy sources in that renewable energy can be thought of as manufactured energy, with the largest proportion of costs, external energy, and material inputs occurring during the manufacturing process. Although conventional sources such as nuclear- and coal-powered electricity generation have a high proportion of capital-to-fuel costs, all renewable technologies, except for biomass-generated electricity (bio power), have less fuel costs. The trade-off is the ongoing and future cost of fossil fuel against the present fixed capital costs of renewable energy technologies.

Scale economics likewise differs for renewable and conventional energy production. Larger coal-fired and nuclear-powered generating facilities exhibit lower average costs of generation than do smaller plants, realizing economies of scale based on the size of the facility. Renewable electricity achieves economies of scale primarily at the equipment manufacturing stage rather than through construction of large facilities at the generating site. Large hydroelectric generating units are an exception and have on-site economies of scale, but not to the same extent as coal-and nuclear-powered electricity plants. *National Academy of Engineering, and National Research Council, (2010)*

Overview of Ethiopian electric power

Table 2.1 source; Energy resource potential of Ethiopian (Ethiopian Electrical Power)

Resource	**Unit**	**Exploitable reserve**	**Exploited percent**
Hydropower	MW	45,000	< 5%
Solar/day	kWh/m^2	4 – 6	< 1%
Wind: Power Speed	GW m/s	100 > 7	< 1%
Geothermal	MW	< 10,000	< 1%
Wood	Million tons	1120	50%
Agricultural waste	Million tons	15-20	30%
Natural Gas	Billion m^3	113	0%
Coal	Million tons	300	0%
Oil shale	Million tons	253	0%

Ethiopia’s Growth and Transformation Plan (GTP) outlines a 15-year plan with three 5-year phases to transform Ethiopia from a developing country to a middle income country by 2025. Under GTP I (2010-2015), the goal was to increase the installed generation capacity from 2,000 MW to 10,000 MW primarily through hydro power projects. With some of those projects still under construction, the country currently has approximately 4,500 MW of installed generation capacity. Under GTP II (2015-2020) the goal is to increase installed generation capacity by an additional 5,000 MW by 2022. Ethiopia Electric Power (EEP) is charged with maintaining more than fourteen hydropower and three wind power plants located in different parts of the country.

The Government of Ethiopia has focused on the construction and expansion of various power generating projects to deliver reliable power. Approximately 90% of the installed generation capacity is from hydropower while the remaining 8% and 2% is from wind and thermal sources respectively. The hydro dominated systems have been severely affected by drought, and the Government of Ethiopia (GOE) is now diversifying the generation mix with other sources such as solar, wind and geothermal that will result in a more climate-resilient power system. The Metahara solar independent power producer (IPP) project is expected to generate 100 MW following approval of the implementation agreement (IA) by the Ethiopian government during the second half of 2018. Enel Power, an Italian company, will operate the project. The government of Ethiopia is also working with the private sector to implement the Corbetti and Tulu Moye geothermal projects with over 1,000 MW of combined generation capacity. Ratification of IAs by the House of Peoples Representatives is the last critical step to concluding these two 520 MW projects. On August 19, 2018, Africa's first waste to energy facility, with a generation capacity of 25 MW of electricity, was inaugurated in Addis Ababa. This facility has the capacity to consume 420,000 tons of trash per year. *Ethiopian Electrical Power (December, 2016)*

The Grand Ethiopian Renaissance Dam (GERD), expected to be the largest dam in Africa and to generate 6,450 MW of electricity at full capacity, is reportedly 62% completed. The GOE has prioritized construction of the GERD, which is intended to serve as an engine for industrialization and economic development. Ethiopia exports electricity to Djibouti (up to 100 MW) and to Sudan (up to 100 MW) and has concluded power export deals with Kenya and South Sudan. Construction of an Ethio-Kenya-Tanzania transmission line is expected is completed in 2019. Ethiopia has plans to export up to 400 MW of electricity to Kenya and to Tanzania. The GOE plans to construct an additional 9,000 kilometers of distribution lines and to complete, in the next few years, construction of 102 kilometers of 66 KV transmission line, 3,706 kilometers of 132 KV transmission line, 4,546 kilometers of 230 KV transmission line, 2,947 kilometers of 400 KV transmission line and 61 kilometers of 500 KV transmission line. The total transmission line length has reached 19,664 km. Only 30% of the country has access to electricity, of which only 60% of households are connected to the grid. The GOE recognizes that partnership with the private sector via IPP agreements for power generation is crucial to meeting the country's needs. Ethiopia Electric Power (EEP) has developed procurement processes to select contractors and is awarding projects using a competitive bidding process. Under the Global Procurement Initiative (GPI), Crown Agents International, a U.S. based firm, has developed a procurement manual for EEP using a U.S. Trade and Development Agency (USTDA) grant. The procurement manual was launched in June 2018 during the visit of Gil Kaplan, Under Secretary of Commerce for International Trade. Power Africa has assisted EEP with the development of IPP tender documents and the legal and regulatory IPP framework. In February 2018, Ethiopia has enacted a proclamation that will regulate public private partnership (PPP) arrangements, in an effort to attract investment and in recognition that the private sector is essential to supporting the country's economic growth and improving the quality of public services, particularly in infrastructure. Ethiopia is drafting its feed-in tariff bill, which should offer independent power producers the option to sell renewable energy power to the national grid at specified rates. Engineering procurement and construction (EPC) contracts are still considered as unsolicited proposals when companies are providing turnkey solutions and bring the financing. Most new EEP projects are tendered. *Ethiopian Electrical Power (December, 2016)*

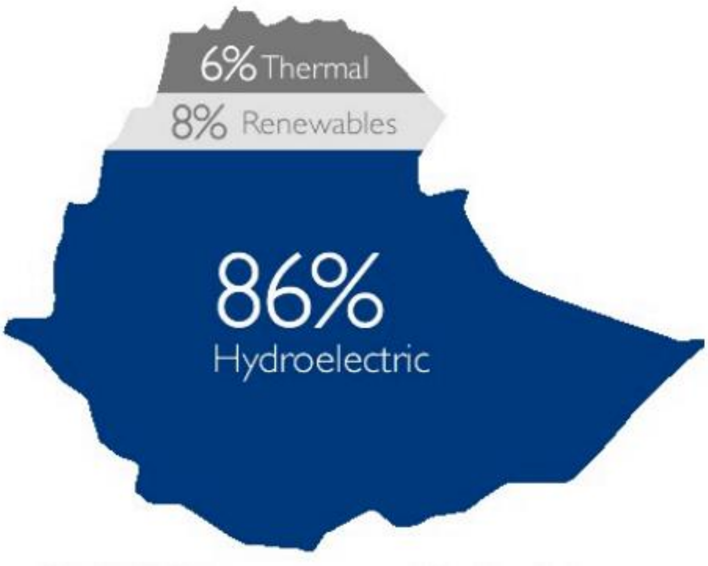


Figure 2.1: Energy source of Ethiopian, Ethiopian ministry of water, irrigation and energy December (2016)

Ethiopia electricity demand forecast

Total energy sales forecasted grow 4,925GWh in 2012 to 97,326GWh by 2037 in Base case presents an average annual compound growth rate of 12.7%, Biggest growth occurs in industry, in 2012 its 34% of totals sales and grow to 46% by 2037 and total energy sales forecasted grow 5,204GWh in 2012 to 142,884GWh by 2037 in High case Presents an average annual compound growth rate of 14.2% also Total energy sales forecasted grow 4,633GWh in 2012 to 54,019GWh by 2037 in Low case, Presents an average annual compound growth rate of 10.1%

Table 2.2: Existing and future domestic consumption by regional administration of Ethiopian electric power

Existing and future domestic electric power consumption by regional Administration							
New (EEPC) Zone	Sum of 2012	Sum of 2015	Sum of 2017	Sum of 2020	Sum of 2025	Sum of 2030	Sum of 2037
EASTERN A.A	172	341	550	797	1038	1399	2066
NOTHERN A.A	178	212	279	327	475	730	1207
SOTHERN A.A	320	513	744	846	973	1323	1956
WESTERN A.A	81	146	189	252	365	545	880
SOUTH EASTERN A.A	96	165	221	260	444	757	1350
SOTHERN	95	246	374	615	1055	1654	2647
EASTERN	47	271	427	735	1245	1846	2815
JIJIGA	11	30	60	64	82	113	164
SEMERA	14	62	132	310	677	1063	1638
NOTHERN EASTERN	39	205	401	645	764	959	1238
NOTHERN	87	129	265	461	700	849	1181
NOTHERN WESTERN	66	122	178	391	907	1262	1889
WESTERN	51	58	80	159	381	504	728
ASOSA	8	14	25	33	60	88	140
GAMBELA	7	8	10	25	66	115	188
Grand Total	1272	2524	3935	5918	9232	13210	20077

2.3. Advantages

Power generation using non-conventional energy sources which will help us to conserve the conventional energy sources to meet the future demand. By using this method, electricity will be generated throughout the year without depending on other factors and also there are several advantages this study such as; easy for maintenance and pollution free power generation, less floor area required and no obstruction to traffic, no need of manpower during power generation, we can have annual electricity generation with the help of this method without depending on other factors, which will help to preserve the conventional energy sources for our adjacent future demand. There is no usage of any fossil fuel hence electricity is generated by renewable means, it is economical and not difficult to install and this method is promising due to its good efficiency and energy recovery criteria.

2.4. The idea of electricity generation from speed breaker

The number of vehicles is increasing rapidly and if some of the Kinetic energy of these vehicles convert into rotational motion of generator then a considerable amount of electricity will be produced. At present, there is shortage of electricity leading to energy crisis. Can electricity be generated using speed breakers? Is this idea will be beneficial in any case? The answer is, yes, of course. This idea will be advantageous; for generating electricity for the traffic signals, streetlights, and then for many other purposes. The trans calm road bump, the speed breaker was invented by a British Engineer Graham Heeks, who dreamed up the concept after examining squeezable children's toys *(Knight, 2001).* Generally, when vehicle is in motion it produces various forms of energy like the “Heat Energy”, which is produced due to friction between tyres of vehicle’s wheel and the road i.e. rough surface, or when vehicle traveling with a high speed strikes the wind. This heat energy produced is always lost in environment and remains unused which is just the wastage of energy abundantly available around us. In this study, one such method is referred and explained in order to generate “Electrical Energy”. This method uses the principle of “Kinetic Energy to Electric Energy conversion”.

Now, one question can rise on the use of speed breakers, that, why only speed breakers should be used? And why not rough roads and uneven surface prove beneficial for this? The answer to this is simple, that rough surfaces are not that apt to provide sufficient torque which is necessary in order to produce electricity by rack and pinion method *(Anyaegbunam, 2015).*

2.5. Solid works simulation overview

Determine early in the design process if your product will work and how long it would last. Solid work simulation enables every designer, engineer to simulate and analyze design performance with fast, easy-to-use Solid Works Simulation CAD-embedded analysis solutions. You can quickly and easily employ advanced simulation techniques to optimize performance while you design with capabilities that cut down on costly prototypes, eliminate rework and delays, and save time and development costs.

With solid works simulation, can easily compare the performance of design configurations. The linear static analysis allows to get earlier in the design process, the stress, displacement and factor of safety distributions.

Failure Mode Fatigue easily carry out metal fatigue analysis on metal components with solid works simulation and fatigue analysis. Evaluate the impact of cyclic loads on the structural life of a product to ensure it meets requirements for performance quality and safety. Tightly integrated with Solid works CAD, metal fatigue analysis using solid works Simulation can be a regular part of your design process-reducing the need for costly prototypes, eliminating rework or delays, and saving time and development costs.

The trend tracker product development is often not a linear process. Product engineers create many design iterations to find the best one. This includes testing many different scenarios for materials, dimensions, configurations and etc. Solid works simulation offers an intuitive tool called the trend tracker that compares the impact of design changes on key criteria, such as maximum stress or maximum displacement, to quickly identify the best solution and shorten the product development process.

2.5.1. Solid work application

The solid works have wide range of applications in industries such as, Aerospace, Defense Automotive, Transportation, Machinery, Heavy Equipment, Consumer production, Mold and Tools design, Electronics, Sheet metal work, Process plant, Energy conservation, Construction and Medical tools and etc. Product design and other Engineering services, it helps to design various products and services, tests them in very cost effective way like model and prototype.

The DSS solid work crop also develops other software products, which is very much helps in various selections of engineering's especially for mechanical. they are 3D CAD, simulation, Product data management, technical communication, Electrical design and 3D experience this CAD models is not limited to mechanical engineering streams (Especially for Electrical and Civil) and product designer can convert new product ideas into reality.

According to MIT survey, solid works selected as high productivity (up to 95% than others) CAD software. It provides better design visualization, design better products, faster design iterations, improved communications, and design with less error, create more aesthetic design and products and also meets the client's/customer requirements. (Rakshit*et al*, Kamal Technical University 2016).

2.5.2. About designing of solid work

Solid works 2019 is a solid modeling computer-aided design (CAD) and computer-aided engineering (CAE) computer program that runs primarily on Microsoft windows. While it run solid works on MacOS, solid works is published by dassault Systems.

It is a solid modeler, and utilizes a parametric feature-based approach which was initially developed by PTC (Creo/Pro-Engineer) to create models and assemblies. The software is written on Para solid-kernel.

Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent.

Features refer to the building blocks of the part. They are the shapes and operations that construct the part. Shape-based features typically begin with a 2D or 3D sketch of shapes such as bosses, holes, slots, etc. This shape is then extruded to add or cut to remove material from the part. Operation-based features are not sketch-based, and include features such as fillets, chamfers, shells, applying draft to the faces of a part, etc.

Building a model in solid works usually starts with a 2D sketch (although 3D sketches are available for power users). The sketch consists of geometry such as points, lines, arcs, conics (except the hyperbola), and splines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity. The parametric nature of solid works means that the dimensions and relations drive the geometry, not the other way around. The dimensions in the sketch can be controlled independently, or by relationships to other parameters inside or outside the sketch.

In an assembly, the analog to sketch relations are mates. Just as sketch relations define conditions such as tangency, parallelism, and concentricity with respect to sketch geometry, assembly mates define equivalent relations with respect to the individual parts or components, allowing the easy construction of assemblies. Solid works also includes additional advanced mating features such as gear and cam follower mates, which allow modeled gear assemblies to accurately reproduce the rotational movement of an actual gear train.

Finally, drawings can be created either from parts or assemblies. View is automatically generated from the solid model, and notes, dimensions and tolerances can then be easily added to the drawing as needed. The drawing module includes most paper sizes and standards (ANSI, ISO, DIN, GOST, JIS, BSI and SAC).

2.5.2.1. Design process

The design process usually involves the following steps:

Identify the model requirements ⟹ Conceptualize the model based on the identified needs ⟹ Develop the model based on the concepts ⟹ Analyze the model ⟹ Prototype the model ⟹ Construct the model ⟹ Edit the model, if needed.

2.5.2.2 Design method

Before you actually design the model, it is helpful to plan out a method of how to create the model. After identify needs and isolate the appropriate the concepts, you can develop the model;

Sketches: - Create the sketches and decide how to dimension and where to apply relations.

Features: - Select the appropriate features, such as extrudes and fillets, determine the best Features to apply, and decide in what order to apply those features.

Assemblies: - Select the components to mate and the types of mates to apply.

2.5.2.3. Sketches

The sketch is the basis for most 3D creating a model usually begins with a sketch. From the sketch, we create features. We combine one or more features to make a part. Then, combine and mate the appropriate parts to create an assembly. From the parts or assemblies, we create drawings. A sketch is a 2D profile or cross section. To create a 2D sketch, use a plane or a planar face. In addition to 2D sketches, you can also create 3D sketches that include a Z axis, as well as the X and Y axes. There are various ways of creating a sketch. All sketches include the following elements:

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.1. Study area

Addis Ababa is a capital city of Ethiopia. It is located 9˚.02' latitude and 38˚.75' longitudes and it is situated at elevation 2405 meters above sea level. The city is head quarter office of African union (AU) and also different international, national organizations, institutes, none governmental (NGOs), different Industrial and markets are there. All these organizations and industries need electric power but the city can’t provide enough.

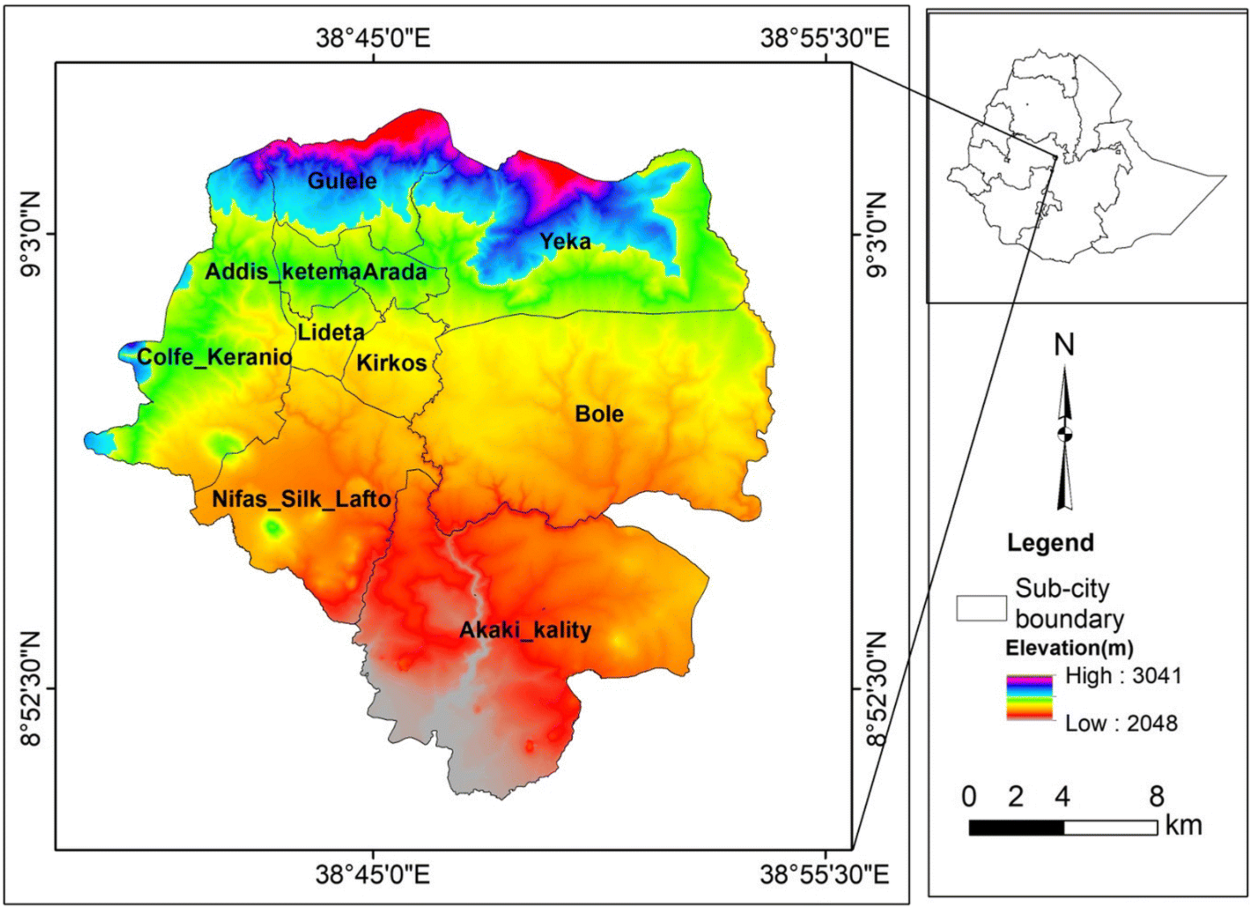


Figure 3.1: Map of study area

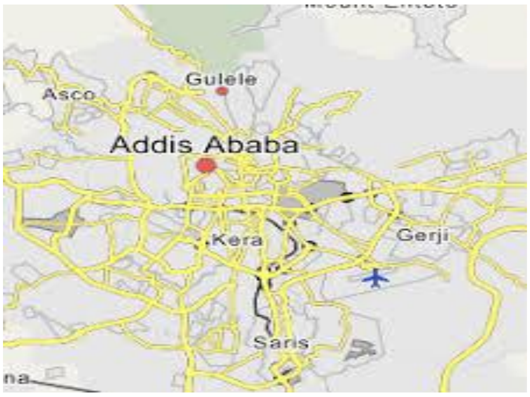


Figure 3.2: Map of road networks

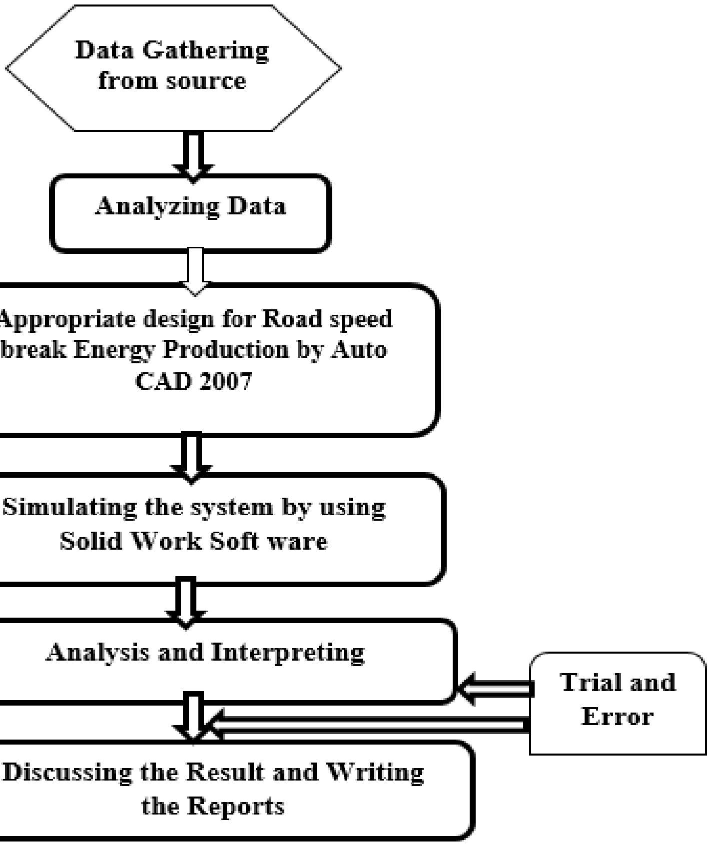


Figure 3.3: Flow chart of methodology

The Approach of this study is the amount of road traffic data flow was gathered from Addis Ababa city, from ministry of transportation and from map Arc GIS V 10.1 software. Data collected was analyzed and interpreted by plot graphs, tables charts by Microsoft word and Microsoft Excel 2010. Appropriate design for System of kinetic energy, Mechanical Energy and Electrical Energy was locating or produce using AutoCAD 2007 software, by considering design scientific mechanical simulation model by solid work software was done. Then finally checked by try and error and result was discussed and the report was written.

The aim of the study was appropriate pragmatic methodology for generation of electricity from highway traffic flow system. The methodology is based on the amount of traffic flow and paved road access availability. There is a large amount of energy loss from highway traffic flow this implies there is a lot of energy wastage, that's why we should have to use this energy wasted for electricity generation.

Due to the fast motion of vehicle on highways to over pass on device elements mechanism was designed i.e. due to vehicles speed over conversion set device installed on paved roads, the kinetic energy converted into mechanical energy. The turbines motion caused the generator (Dynamo) Mechanism to generate Electric current by converting mechanical energy to electrical energy. Kinetic energy of vehicles was used in the mechanism of generation of renewable electricity.

3.2. Research design and period

The study period was from July, 2019 to December, 2019, the design was done by using AutoCAD 2007 software and simulate by using solid work 2019 software use more available, applicable and appropriate to design.

3.3. Simulation models inputs and their preparation

3.3.1. Overall detail Ethiopian and Addis Ababa vehicles data

Table 3.1: Types and vehicles in region (up to June 30, 2007)

Type of Vehicles and number in the regions (up to June 2007) registration													
Region	**AF**	**BG**	**GA**	**HR**	**OR**	**SP**	**TG**	**AMR**	**DIR**	**AA**	**SOM**	**ETH**	**Total**
Ambulance	10	8	8	4	20	3	68	51	27	88	45	64	396
Automobile	46	95	21	1275	6270	10231	6565	8420	408	49674	54	453	83512
Bajaj	1166	185	185	536	5066	2995	2131	6175	8146	17248	5200	0	49033
Double Cabin	204	60	143	357	1569	223	1240	64	35	6900	51	1007	11853
Dry Cargo	406	26	59	357	5176	2001	632	130	468	9225	171	1474	20125
Dump Truck	0	0	0	20	51	0	0	55	26	510	25	1637	2324
Field Vehicle	233	55	48	176	1023	600	65	60	48	12086	39	1585	16018
Higher bus	204	6	2	2	400	281	199	540	56	2634	57	146	4527
Liquid	28	1	1	36	103	3592	840	47	57	861	49	376	5991
Medium Bus	37	23	45	445	5838	2856	0	20	19	4173	20	68	13544
Mini Bus	389	53	23	3	10175	2844	331	27	198	4044	40	183	18310
Motor Cycle	673	489	214	317	6045	15599	3884	1415	106	7442	383	585	37152
Not specified	1	38	0	1692	26324	2057	2111	27057	25	97200	3205	11858	282872
Others	47	44	0	7	636	12	244	35	42	9081	200	77	10425
Passenger	0	1	13	7	288	584	297	0	0	0	0	0	1190
Pick Up	147	43	24	336	1999	779	0	51	52	6599	25	150	10205
Power	0	4	2	0	311	1	4448	121	102	2011	50	798	7848
Quintal	0	0	0	72	0	17	431			895			1415
Semi trailer Dry	1	0	0	1	257	0	947	21	20	39	20	905	2211
Semi-Trailer Liquid	3	0	0	0	5	0	3631	26	33	51	25	112	3886
Tractor	43	0	0	0	213	0	25	13	0	105	0		399
Trailer	7	0	0	0	13	0	94	76		2130			2320
Trailer Dry	0	0	0	0	139		138	25	29	38	20	1060	1449
Trailer Liquid	0	0	0	0	1	0	1	25	27	50	25	319	448
Total other													0
Total	**3645**	**1131**	**788**	**5643**	**71922**	**44675**	**28322**	**44454**	**9924**	**233084**	**9704**	**129580**	**587453**

Table 3.2: Types and vehicles in region (up to June 30, 2008)

Type of vehicles and number in the regions (up to June 2008) registration												
Category	**AA**	**AM**	**AF**	**BN**	**DD**	**SO**	**TG**	**GM**	**HA**	**SN**	**OR**	**Total**
Ambulance	15229	0	26	27	7		69	8	4	5	160	**15535**
Automobile	122637	1341	46	27	1693	478	927	21	1275	10281	6372	**145098**
Bajaj	98	1108	1776	1146				185	536	4105	5146	**14100**
Tri Cycle	0	3605	0	0	0	0	0	0	0	0	16526	**20131**
Bus(< 12 Seats)	20847	5956	417	215	952	633	2799	0	0	0		**31819**
Bus(> 11 Seats)	12636	6781	276	171	375	434	1521	143	357	1257	2067	**26018**
Combiner	16	19			1	2	8	59	357	98	6322	**6882**
Dozer	14	0	3			1	5	0	20	1	252	**296**
Dry Cargo(<=10)	25898	1167	225	90	630	762	733	48	176	35	1063	**30827**
Dry Cargo(>10)	81641	3584	210	87	3290	1947	4372	2	2	0	509	**95644**
Dual Purpose Vehicle	36084	2804	314	231	870	335	1665	1	36	65	131	**42536**
Field Vehicle	41684	1433	277	128	348	718	1034	45	445	67	7162	**53341**
Grader	4	2			1	1		23	3	218	17517	**17769**
Forklift	16	0	2		3		2	214	317	30276	19880	**50710**
Gotach	665	0	0	0	48	0	308	0	1699	3133	1305	7158
Liquid Cargo	4745	201	33	2	186	98	621	13	7	1315	358	**7579**
Liquid Trailer	559	10						24	336	25	2188	**3142**
Motor Bicycle	16353	17154	864	2351	5331	931	5705	2	0	1	401	**49093**
Other	12117	320	39	1	93	33	524	0	72	3207	2	**16408**
Three wheel dry load	0		0	0	0	0	65	0	1	0	263	**329**
Three wheel public load	13			2	74	2	5046	0	0	0	7	**5144**
Tractor	715	213	44	114	16	3141	184	0	0	1	238	**4666**
Trailer	17133	248	8	1	296	1	2485	0	0	0	13	**20185**
Vehicle with Machinery	149	99	12	1	103	27	62	0	0	0	164	**617**
Not Specified	38416	991	20	6	2634	1134	187	0	0	0	1	**43389**
Total	**447669**	**47036**	**4592**	**4600**	**16951**	**10678**	**28322**	**788**	**5643**	**54090**	**88047**	**708416**

Table 3.3: Types and vehicles in region (up to June 30, 2009)

Type of vehicles and number in the regions (up to June 2009) registration											
Category	**AA**	**AM**	**AF**	**BN**	**DD**	**SO**	**TG**	**GM**	**HA**	**SN**	**OR**	**Total**
Ambulance	180	0	34	27	9	2	69	0	4	7	165	**497**
Automobile	171523	1485	55	34	1967	558	927	228	1275	51	6376	**184479**
Bajaj	0	2132	2302	0	0	0		0	536	4671	5152	**14793**
Tri Cycle	0	40	0	0	0	0	0	0	0	27	16861	**16928**
Bus(< 12 Seats)	25929	7146	442	260	1376	755	2799	0	0	50	126	**38883**
Bus(> 11 Seats)	14524	9747	372	229	457	537	1521	1375	357	178	2126	**31423**
Combiner	10	17	0	0	1	2	8	0	357	0	6322	**6717**
Dozer	0	0	3	0	0	1	5	0	20	0	252	**281**
Dry Cargo(<=10)	34446	1602	273	94	847	953	733	0	176	95	1067	**40286**
Dry Cargo(>10 Quintals)	105150	4099	224	92	3916	2152	4372	0	2	15	527	**120549**
Dual Purpose .V	43253	3443	339	255	1104	515	1665	0	36	21	131	**50762**
Field Vehicle	43681	1590	298	138	426	912	1034	0	445	16	7168	**55708**
Grader	5	2	0	0	1	1		0	3	0	17517	**17529**
Forklift	145	0	3	0	6	0	2	0	317	0	19880	**20353**
Not Specified	18370	8121	25	16	214	263	187		0	50762	13480	**91438**
Gotach	5178	0	0	0	57	0	308	0	1699	0	1305	**8547**
Liquid Cargo	5057	272	34	2	203	114	621	0	7	65	358	**6733**
Liquid Trailer	0	11	0	0	0	0		0	336	0	2189	**2536**
Motor Bicycle	21509	26442	1048	3237	5761	1157	5705	2166	0	4	642	**67671**
Other	9766	442	35	1	89	33	524	1353	72	22	3	**12340**
Three wheel dry load	8	0	0	6	2	166	65	0	1	0	263	**511**
Three wheel public load	506	0	0	1508	299	5145	5046	0	0	0	7	**12511**
Tractor	1027	281	46	124	20	0	184	0	0	1	239	**1922**
Trailer	23810	292	8	1	379	1	2485	0	0	0	13	**26989**
Vehicle with Machinery	367	135	14	1	109	27	62	0	0	0	164	**879**
Total	**524444**	**67299**	**5555**	**6025**	**17243**	**13294**	**28322**	**5122**	**5643**	**55985**	**102333**	**831265**

Table 3.4: Types and vehicles in region (up to June 30, 2010)

Type of vehicles and number in the regions (up to June 30.2010) registration												
Category	**AA**	**AM**	**AF**	**BN**	**DD**	**SO**	**TG**	**GM**	**HA**	**SN**	**OR**	**Total**
Ambulance	198	0	37	35	9	2	91	0	4	25	238	639
Automobile	184227	1485	59	49	2057	558	1421	228	1275	16162	4796	212317
Bajaj	0	2132	2644	0	289	0	0	0	536	8721	34339	48661
Tri Cycle	0	40	0	0	0	0	0	0	0	27	0	67
Bus(< 12 Seats)	26408	7146	448	324	1468	755	4768	0	0	709	14174	56200
Bus(> 11 Seats)	15242	9747	449	325	514	537	3335	1375	357	1144	22772	55797
Combiner	20	17	0	0	1	2	5	0	357	0	75	477
Dozer	16	0	3	3	0	1	5	0	20	0	0	48
Dry Cargo(<=10 Quintals)	37384	1602	289	101	890	953	1069	0	176	3070	7063	52597
Dry Cargo(>10 Quintals)	109952	4099	229	98	4089	2152	4886	0	2	1195	1810	128512
Dual Purpose Vehicle	44954	3443	348	301	1157	515	2063	0	36	1435	372	54624
Field Vehicle	45081	1590	303	148	447	912	1185	0	445	117	5421	55649
Grader	7	2	0	0	1	1	4	0	3	0	1	19
Forklift	188	0	4	1	6	0	13	0	317	0	2	531
Not Specified	18154	8121	32	25	222	263	602	0	0	1534	6020	34973
Gotach	5598	0	0	0	59	0	572	0	1699	0	0	7928
Liquid Cargo	6341	272	35	2	206	114	645	0	7	65	189	7876
Liquid Trailer	0	11	0	0	0	0	0	0	336	0	117	464
Motor Bicycle	22931	26442	1152	4129	5891	1157	10744	2166	0	49409	29378	153399
Other	9912	442	36	1	88	33	494	1353	72	36	1763	14230
Three wheel dry load	12	0	0	24	2	166	888	0	1	0	4	1097
Three wheel public load	375	0	0	1909	0	5145	9962	0	0	0	0	17391
Tractor	1059	281	46	134	21	0	265	0	0	7	503	2316
Trailer	25336	292	8	1	394	1	2793	0	0	0	302	29127
Vehicle with Machinery	543	135	15	1	113	27	115	0	0	0	0	949
Total	**553938**	**67299**	**6137**	**7611**	**17924**	**13294**	**45925**	**5122**	**5643**	**83656**	**129339**	**935888**

Table 3.5:Types and vehicles in region (up to June 30, 2011)

Type of Vehicles and number in the regions (up to June 30,2011 registration											
Description	**AA**	**AM**	**AF**	**BN**	**DD**	**SO**	**TG**	**GM**	**HA**	**SN**	**OR**	**Total**
Ambulance	253	0	38	44	7	14	164	0	4	28	365	917
Automobile	205773	1701	66	49	2246	609	1660	228	1275	80	6012	219699
Bajaj	0	4722	2889	0	2318	0	0	0	536	9307	48822	68594
Tri Cycle	0	37	0	0	0	0	0	0	0	27	0	64
Bus(< 12 Seats)	27357	8805	465	347	1607	837	5201	0	0	12503	3024	60146
Bus(> 11 Seats)	16698	12840	532	378	681	677	3886	1375	357	10029	38439	85892
Combiner	23	53	0	0	1	2	5	0	357	0	78	519
Dozer	17	0	3	3	0	1	5	0	20	0	0	49
Dry Cargo(<=10 Quintals)	41333	2396	301	102	993	1036	1163	0	176	102	1868	49470
Dry Cargo(>10 Quintals)	115023	4591	240	103	4313	2348	5030	0	2	153	7188	138991
Dual Purpose Vehicle	47278	3907	380	310	1370	684	2188	0	36	1438	97	57688
Field Vehicle	47059	1767	318	153	487	1037	1228	0	445	123	3299	55916
Grader	6	2	0	0	2	1	4	0	3	0	2	20
Forklift	237	0	4	1	8	0	18	0	317	0	2	587
Not Specified	18943	1462	34	48	248	0	396	436	1179	3118	7929	33793
Gotach	5756	0	0	0	67	2	613	0	1699	0	0	8137
Liquid Cargo	6703	318	35	2	226	148	650	0	7	65	437	8591
Liquid Trailer	0	14	0	0	0	0	0	0	336	0	187	537
Motor Bicycle	24700	40229	1181	4865	6689	1366	12358	2166	1178	54084	49903	198719
Other	10279	643	36	1	105	33	485	1353	72	38	2905	15950
Three wheel dry load	15	9625	0	39	7	233	1417	0	1	0	4	11341
Three wheel public load	368	0	0	2259	0	6106	12953	0	0	0	0	21686
Tractor	1199	392	51	136	21	0	304	0	0	10	530	2643
Trailer	26326	349	8	1	417	1	2891	0	0	0	217	30210
Vehicle with Machinery	738	148	17	1	125	25	132	0	0	0	0	1186
Total	**596084**	**94001**	**6598**	**8842**	**21938**	**15160**	**52751**	**5558**	**8000**	**91105**	**171308**	**1071345**

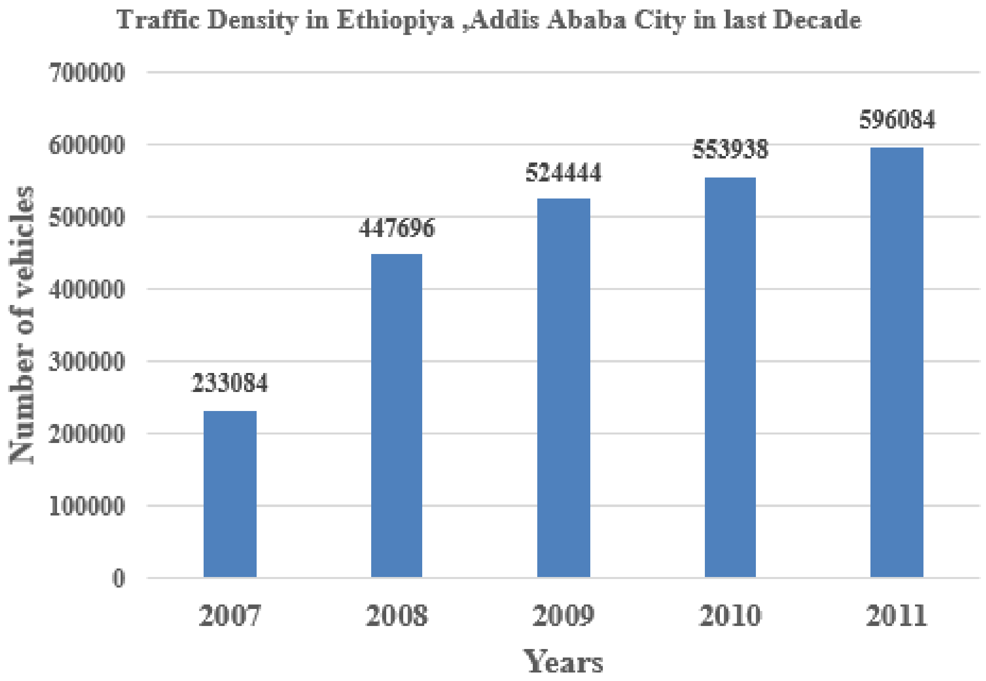


Figure: 3.4 Number of vehicles the period 2007-2011 in Addis Ababa city

3.3.2. Addis Ababa city paved road data

Hierarchy of road is determined by grouping roads according to the character of service they provide. The hierarchy resulting from this approach includes the following groupings; Controlled access arterial roads including freeway (traffic move function), Sub-arterial road (largely traffic movement function), Collection roads (traffic, transition and access function) and Local roads (largely property access function). According to Addis Ababa city Road Authority (AACRA) the total Addis Ababa city paved road is 1,164.50km. From those road hierarchies Controlled access arterial roads including freeway (traffic move function), Sub-arterial road (largely traffic movement function) and Collection roads (traffic, transition and access function) are suitable for this research study, because those pave roads are get more traffic flow access and also it is suitable for installation of conversion set mechanism.

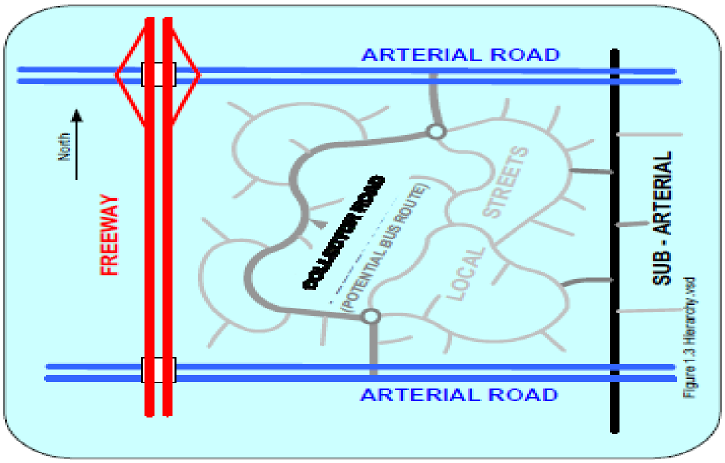


Figure: 3.5 Hierarchy of Addis Ababa city paved road; Addis Ababa city road authority (AACRA)

3.3.3. Speed of the vehicles

According to this study area the speed used was 30km/h because, Addis Ababa is city highly traffic congested, it means that even though its recommended up to 40kmph and 80kmph in highway but according to collected study data average 30kmph was chosen.

3.3.4. Three types of energies involved in this study

3.3.4.1. Kinetic energy

Energy possesses by a body due to virtue of its motion is call as Kinetic energy. The kinetic energy of an object of mass(m) traveling at a speed v is $\frac{1}{2}mv^2$. The kinetic energy of an object is directly proportional to the square of its speed. The kinetic energy of an object is completely described by magnitude alone (scalar quantity).

3.3.4.2. Mechanical energy

Mechanical energy is the energy associated with both the motion and position of an object. Objects possess mechanical energy when they are in motion or if they are at a zero potential energy position. An object gains energy, when some work will be done on it. The energy gains by the objects on which, work is done is known as mechanical energy.

3.3.4.3. Electrical energy

When energy is stored in charged particles which is in electric field, this energy is known to as electrical energy. The regions or areas which form an envelope around these charged particles is called as electric fields. The electric fields are a result of charged particles, and they exert force on other charged particles causing them to move in the electric field.

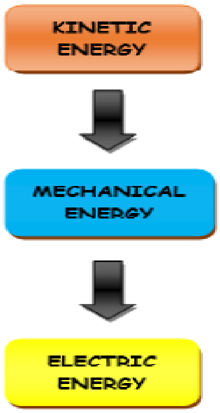


Figure 3.6 Types of energy involved order

3.3.5. Mechanism used

Mechanism of electric power generation

The device has two systems which convert raw mechanical energy to raw electrical energy. These two mechanisms use electrical and mechanical mechanisms to achieve this. These mechanisms are responsible to create the output electrical energy being consistent DC power. The detailed description of these two mechanisms is given below.

3.3.6. Mechanical system

In this system we make use of energy conversion mechanical components like gears, springs, shafts, rack and pinions. The combination of these yields the kind of output power we are looking for. The tradition requirement for producing electrical energy is a rotational motion coupled with an electric generator. The rotational motion is required to be very consistent and must have high torque and speed requirements to make the generator begin producing electrical power. Traditional requirements for producing a consistent electrical power are about 1800 RPM with up to 1HP (i.e.760W) of power. Most modern electric generators on the market have this typical requirement.

But in this study system, it is not nearly possible to get consistent rotation let alone get as much power requirement as a traditional electric generator (alternator) needs. To tackle this problem, wind turbine alternators is considered. These alternators are famous for using low RPM and producing a reasonable amount of electrical energy in the process. But even these alternators have a power producing rotation limit. They defer manufacturer to manufacturer. Typically, the average rating of these alternators is about 600 RPM. With the electrical power out of the way and made sure it can cope with low RPMs the above-mentioned electrical components will be used.

3.3.7. Electrical system

3.3.7.1. Generator

For this design it is possible to use either a DC or AC generator that can convert the hydraulic power into energy. The DC generator is ideal for charging batteries that will then be converted to AC, while the AC generators are more suited to connect directly to the load. For this reason, the DC generator is more suited for this location. The reason for this is because the location is considered a low flow low head site. This means that the instantaneous power produced by a generator is not very high. By using a DC generator, it is easier to store the energy in batteries and then power a load. Using the data acquired at the site, it was determined to design the system using the LV Hydro 48V generator from Solar-Catalog. This generator was chosen because it works at minimum and maximum flow for the site. It has a maximum power output of 1.2kW and works on a flow of 5 to 400 GPM. The turbine can be fitted with up to four nozzle inputs. The nozzles have sizes ranging from 1/8” to 1” diameter. ThestreamEngine"http://www.microhydropower.com/708serev%20SE%20Manual%20708newwire.Pdf), 2:30/10/23/2008).

It was determined to use four nozzles with a size of 1”. With this type of nozzle, the maximum amount of flow through the turbine is approximately 428 GPM. In order to get more flow another generator would need to be added. This was also a factor in choosing the type of the generator. The advantage of using four nozzles is that it allows the flow to be controlled using valves. This allow for the changing in seasonal flow. Given the generator and its output, it is now possible to size a charge controller. To find the maximum flow of the system, it is required to take data during the high season. For this reason, max power estimations cannot be made.

3.3.7.2. Charge controller

From the generator the power is sent to the charge controller, which ensures that the battery bank is properly charged to extend the life of the batteries. This is done by regulating the voltage that is sent to the battery bank. Since the power coming from the generator is continuous there must be a diversion load to prevent overcharging of the batteries. This diversion load is usually a water or air heater that is turned on to use the excess power that is being generated. The Flex charge NCHC-48-35C/D charge controller was chosen for several reasons. The controller has very small internal resistance and results in more efficient charging of the batteries. This controller also comes with a built in diversion contact that negates the need for a second controller for the diversion of the load, which is both convenient and cost effective. The product comes with a five years' warranty as well.

[Flex Charge. Ultra High Efficiency 60 or 100 Ampere Solar and Wind Charging System Controller<http://www.flexcharge.com/flexcharge_usa/products/nchc/nchc.htm]

3.3.7.3. Diversion load

For the diversion load the Ohmite DC 300-watt heating load was chosen. A quantity of four of these will be needed to ensure a large enough load. These were chosen due to cost and simplicity. If the customer has another DC load that would suffice as a diversion load and has a more practical use; it can be implemented. [John Drake Services, Inc. "31 water and air heating diversion loads for charge controllers" <http://www.solarseller.com'/diversion-load-heating-air-water-wind-hydro-solar-loads.htm>]

3.3.7.4. Battery system

When choosing batteries for this project research shows three main types of batteries for this application: lead acid (Wet Cell), gel cell, and absorbed glass mat (AGM). [East Penn Ent. "Valve-Regulated Lead-Acid" <http://www.mrsolar.com/pdf/mrsolar/Battery_Tech_Manual.pdf>] In order to decide which battery is best suited for this application; criteria must be developed to judge them by. The purpose of these batteries is to supply the surge power needed to operate appliances. These batteries could be called on to discharge a high percentage of their stored energy and must be ready to recharge again to complete another cycle. There is a general type of battery called a "Deep Cycle" battery that is designed just for this task. The first criterion is that the battery is considered "Deep Cycle." It is understood that these batteries are housed at the powerhouse at the proposed site. The powerhouse is poorly insulated and is not heated directly from any source. "Battery capacity (how many amp-hours it can hold) is reduced as temperature goes down, and increased as temperature goes up." [Northern Arizona Wind & Sun. "Deep Cycle Battery FAQ" <http://www.windsun.com/Batteries/Battery_FAQ.htm>] Because of this capacity loss in cold temperatures, the second criterion is set to be performance in cold weather. For some batteries the electrolytic fluid contained in them will evaporate overtime and must have the electrolytic fluid refilled. Because this upkeep is time consuming and can be hazardous if not done properly maintenance needs are set as the third criterion. When recharging a battery from a deep discharge certain battery types have very extensive limitations to how they are charged and at what rate. Since some batteries need to charge slowly, this is used this as our fourth criterion.

3.3.7.5. Inverter

The inverter is a very important element of the system. It will convert the DC power from the generator and batteries to AC power used in the electrical system. After comparing several inverters, the Outback FX3048T appears to be the best suited for this application. The 3000 VA inverter is capable of handling any load spikes that can be anticipated and has safeguards against low battery voltage. This inverter is also sealed to prevent damage from the environment and appears to be a very robust system that comes with a two year warranty. With accessories the inverter can house some of the necessary breakers that are vital to protecting the system. [Out back Power Systems. "FX and VFX Series Inverter/Charger Installation Manual" <http://www.outbackpower.com/pdfs/manuals/fx_vfx_installation.pdf>]

3.4. Materials required

Materials need

For future and further implementation and for this study simulation design model, there are several basic materials will require to generate electricity by the road speed breakers The main equipment was used as i.e., Transition case, Pine, Pulley, Spur gear shaft, ISO -spur gear 2M 40T 20PA 15FW---S40,ISO - Spur gear 2M 40T 20PA 30FW---S40A75H50L35.0N, ISO - Spur gear 2M 40T 20PA 15FW---S40A75H50L25.0N, ISO - Spur gear 2M 20T 20PA 15FW---S20A75H50L20.0N,ISO – Rack-spur-rectangular 2M 20PA 20FW 20PH 150L---SALL,ISO–Straight bevel gear 4M 40GT 12PT 20PA 40FW---50050H50MD35.0N ,Full spring ,Spring push plate ,ISO–Straight bevel pinion 4M20PT 12GT 20PA 20FW---20035H40MD25.0N ,ISO–Straight bevel pinion 4M20PT 12GT 20PA 20FW---20035H40MD25.0N ,ISO–Straight bevel pinion 4M30PT 12GT 20PA 20FW---30035H40MD15.0N ,ISO–Straight bevel pinion 4M20PT 12GT 20PA 20FW---20035H40MD25.0N,Bevel gear shaft2,Motor shaft ,Motor shaft ,Long shaft,Inafag-ucfl205, ISO-4014-M16*65*65-C, ISO-4034-M16-N.Rack and pinion, Ball bearings, Spur gear, Flywheel, Shaft, Spring, Battery, Generator or Dynamo, Machine cable.

Table 3.6 Transmission case component materials

Item. No.	Transmission case component materials	Quantity
1	Pin	1
2	Pulley	3
3	Spur gear shaft	3
4	ISO-spur gear 2M 40T 20PA 15FW---S40	3
5	ISO - Spur gear 2M 40T 20PA 30FW---S40A75H50L35.0N	3
6	ISO - Spur gear 2M 40T 20PA 15FW---S40A75H50L25.0N	3
7	ISO - Spur gear 2M 20T 20PA 15FW---S20A75H50L20.0N	3
8	ISO – Rack-spur-rectangular 2M 20PA 20FW 20PH 150L---SALL	3
9	ISO–Straight bevel gear 4M 40GT 12PT 20PA 40FW---50050H50MD35.0N	3
10	Full spring	3
11	Spring push plate	3
12	ISO–Straight bevel pinion 4M20PT12GT 20PA 20FW---20035H40MD25.0N	3
13	ISO–Straight bevel pinion 4M30PT 12GT 20PA 20FW---30035H40MD15.0N	3
14	ISO–Straight bevel pinion 4M20PT 12GT 20PA 20FW---20035H40MD25.0N	3
15	Bevel gear shaft2	3
16	Motor shaft	3
17	Long shaft	1
18	Inafag-ucfl205	3
19	ISO 4014-M16*65*65-C	6
20	ISO-4034-M16-N	6
21	ISO 3245-2522D-16,DE,NC,16	7

Software's need

A similar simulation of the system was model using solid work Software for mechanical simulation, Geographical information system Arc GIS map V 10.1 mapping for scientific highway traffic flow mapping information and to know the amount of traffic flow, Auto CAD 2007 for simulate components design and Microsoft word 2010, Microsoft excel 2010 and power points.

3.5. Data sources and data collection process

This process includes both secondary data (desk) and primary data (field investigation) for the gathering of important data in order to achieve the thesis objectives. It comprises the methods employed to achieve the theme. The deskwork includes literature review on modeling journals, books, and previous work, Traffic flow data, Paved road data and make ready computer code that help for modeling like Solid Work 2019, Arc GIS 10.3 since they were compatible to each other.

Generally, the main data sources were Ministry of Transport, Federal Democratic Republic of Ethiopia (FDRE) Transport Authority and Addis Ababa city Road Authority (AACRA).

3.6. Mathematical modeling

Generator Specs:

2kw power

600 RPM rotational speed

Efficiency 0.8

48V output power

24.5 kg.

Insulation class = F

Service life = more than 20 years

Shaft material = stainless steel

Shell material = aluminum alloy

Features:

Gear less, low start up torque and low RPM.

The design easy installation, maintenance and repair

Using a new set of ring power output devices, to overcome the traditional generator when the cable winding. Permanent magnet generator rotor using patented alternator, together with the special stator design, effectively reduce the generation of resistance torque, while allowing more wind turbines and generator has good matching characteristics, the unit runs reliability.

From the above we can calculate the torque required.

$T = \frac{P}{n}$ Where n = rotational speed (in rad/s)

P = power (in watts)

T = Torque (in N.m.)

$$T = \frac{2500\ W}{\frac{600*2\pi}{60}} = 39.788\ N.m.$$

We now require about 39.788 N.m. of torque to begin producing about 2 kw of electrical power.

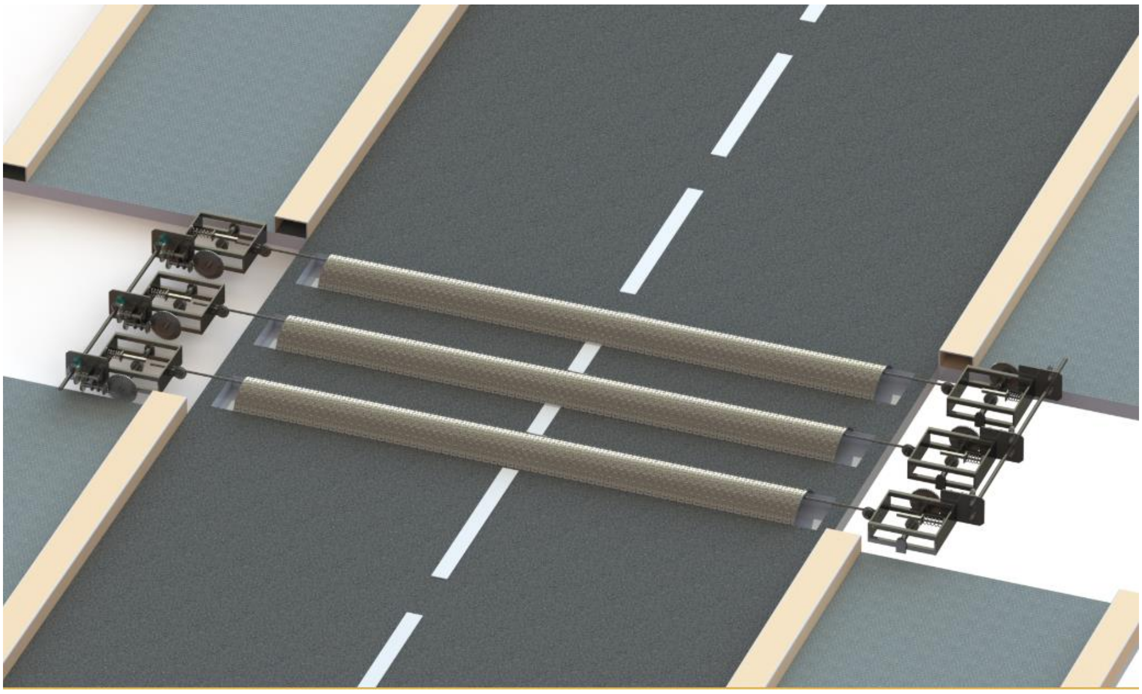


Figure 3.7 Installation of conventional set on asphaltic road

From this picture we can see that the rack and pinion is responsible for only producing rotational motion from linear motion. It transmits the linear motion which has high torque to rotary motion which has high torque and high speeds. The other gear sets, namely bevel and spur gear sets are just gearboxes that are responsible of changing those high speeds to manageable speeds by the AC generator.

One car presses the bumps or ramp 6 times by both front and back tire. The power conversion sets are 3 in the above picture. Therefore, it is possible to get consistent rpm from a single car passing. Let assume half weight of vehicle is 750kg, when vehicle presses the first conversion set, we get; $\text{Pressing Force} = 750\ kg.* 9.81N = 7357.5\ N = 7.36\ KN$.

The designed conversion set to pulled about 10cm or 0.01m from its resting place. Spur gear in use ISO - Spur gear; 2M 40T 20PA 30FW, ISO - Spur gear 2M 20T 20PA 15FW. The first is the one used to convert linear to rotary. It has a pitch diameter of 83mm. From this we calculate the amount of torque and rotational speed produced.

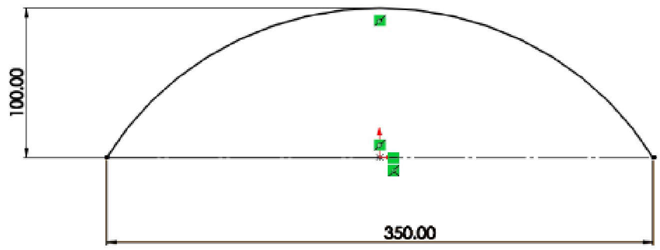
Rotational speed:

Rotates the gear about 20 cm of arc length, the gear has 83 mm pitch diameter.

Angle of rotation $(\alpha) = \frac{\text{Arc Length}}{r}$ Where r = pitch radius, α is in radians.

Angle of rotation $(\alpha) = \frac{.2\text{m}}{.415\text{ m}} = 0.4812 \text{ rad} = 27.5 \text{ degrees}$

The speed bump dimensions:



From beginning the press up to ending the pressing, let's calculate the speed of downward travel, the vehicle presses the bump half of the bump's width i.e. 175mm.

At start it has a speed of 30kph. Therefore, assuming a linear correlation of speed of vehicle with speed of the bump travel we consider the bump also travels at 30kph down wards. From the above observations we can calculate the time at which the bump is being pressed and actually transmitting rotation; $t = \frac{s}{v}$, Where s = downward travel =10cm,V=bump downward speed = 30 kph = 8.333 m/s.

From the above we get $t = \frac{1\text{m}}{\frac{8.33\text{m}}{\text{s}}} = 0.012\text{sec}$ therefore, we get a downward travel time of about 0.012 seconds at the given speeds.

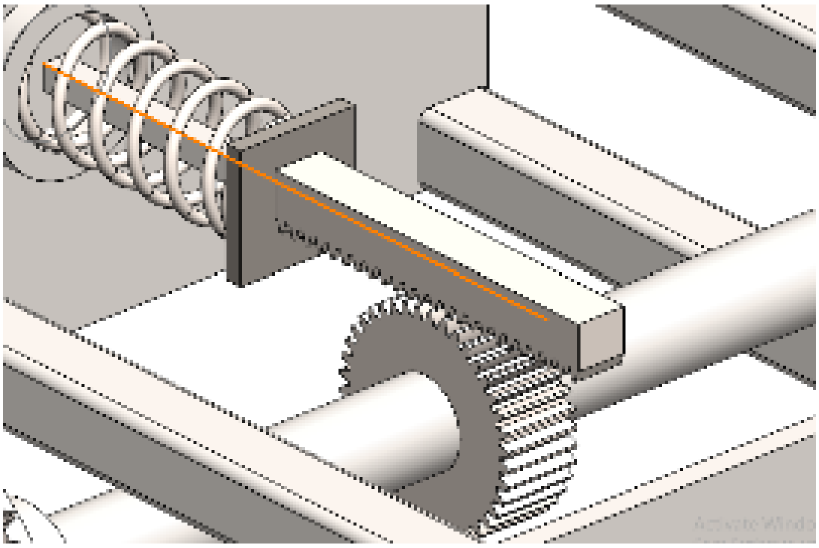


Figure 3.8 Rack and Pinion

$$n = \frac{v}{r} = \frac{8.333}{.0415} = 200.8\frac{\text{rad}}{\text{s}} = 1917.529\text{rpm}$$

This rotational speed appears for only the first 0.012 seconds on the first conversion set. For a single car passing through all three conversion sets yield for 1 car: n = 1917.529rpm, for 0.012 * 3 = 0.036sec.

The amount of torque required by the AC generator is calculated as follows, AC generator of choice DAXINYANG 2k.w, 48V generator with holder. specs are as follows;

From generator specification rated power (W) = 2000

Rated voltage (V) = AC 48V up to 96V as requested

Rated rotational speed (rpm) = 600

Net weight (kg) = 24.5 kg.

Start torque (N.m.) = 0.75, Let us use more than specification rated power 2kw or 2000watt to get sufficient torque; such as 2.5kw or 2500watt.

$$T = \frac{2500\text{watt}}{\frac{600*2\pi}{60}} = 39.788\ \text{N.m.}$$

We now require about 39.788 N.m. of torque to begin producing about 2kw of electrical power.

Mechanical system

The mechanical system consists of the above-mentioned components. Since the vehicles are going fast over the speed bumps. We expect to gain a lot of rotational power from one hit. The following are assumed data.

Vehicle speed: = About 30kph

Vehicle weight = 1500kg.

Vehicle pass speed = 1 car per second

Briefing about the mechanism

3.7. Simulation model

3.7.1. Solid work 2019

Solid works is a solid modeling computer-aided design (CAD) and computer-aided engineering (CAE) computer program that runs primarily on Microsoft windows. While it is possible to run solid works on Mac OS, it is not supported by solid works. Solid works is published by Dassault Systems.

Solid works is a solid modeler, and utilizes a parametric feature-based approach which was initially developed by PTC (Creo/Pro-Engineer) to create models and assemblies. The software is written on Para solid-kernel.

Trying to create simple simulation studies and then comparing the result to hand calculation of well-known problems. Although this is a good practice to gain confidence in the result obtained by solid works at time it is tedious and time consuming process. Solid works already contains an extensive library of simulation validation problems. It contains both verification problems. The verification problems compare result of solid works simulation studies to known analytical solution. Solid works Simulation provides the ideal virtual testing environment to evaluate your designs and help you make the right decisions for overall quality improvement. Efficiently evaluate performance, improve quality, and boost product innovation with the powerful and extensive suite of solid works simulation packages. You can set up virtual real-world environments to test your product designs before manufacture. Test against a broad range of parameters during the design process, such as durability, static and dynamic response, assembly motion, heat transfer, fluid dynamics, and plastics injection molding. All three software packages shorten the learning curve that will have you up and running quickly

3.7.2. Setup

1) Street Lights was providing with electricity generated.

2) Traffic Signals were run by using the electricity generate.

3) Sign boards on the roads can light from this generated electric.

4) Boards near the bus-stops were highlight by generated electric.

3.7.3. Parameters

All physical, mechanical, Electrical mechanisms and Speed, Loads, current, Voltage, parameters were considered in this study also graphical representation plot between load and current**,** between load and voltage and between load and power**,** and those result was interpreted When vehicles speed overpass onramp that installed along cross section of the roads, vehicles weight push down and the ramp pull cross sectional, so that this physical mechanisms change the rack and pinion to Mechanical rotation of the designed conventional set due to push of vehicles and pulled of rod, those mechanical rotation after pass by different size gears for the sake of redaction of rotational energy, finally those mechanical energy transfer to direct electrical energy (DC)by the helps of dynamos part, the amount of crated Electricity automatically stored in the battery and distributed to the electricity supply

3.7.4. Approach

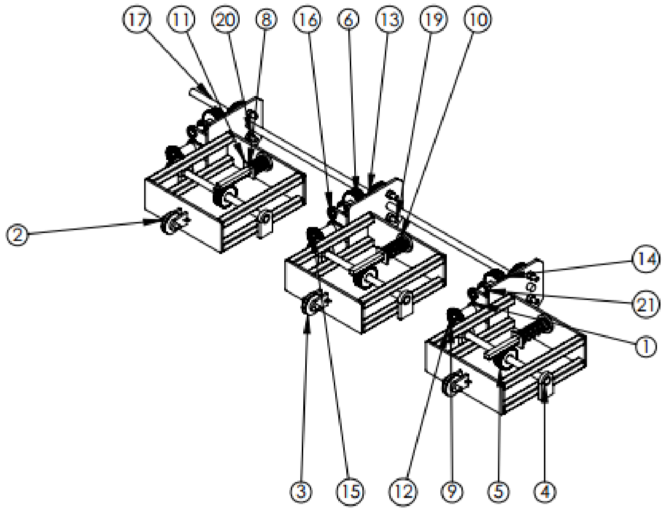
In this study, to understand the working principle of the Road Power Generation (RPG) designed system its practical implementation, and its advantages.

Working principle

Road power generation (RPG) is a system design to capture waste kinetic energy from speed vehicles. This simulation conversion set converts the waste kinetic energy of the vehicles into electric energy. This is done by pushing by vehicles load and pulled by ramp that installed on the road, this rod need 10cm very small push down y-axis direction and pull across cross-section x-axis direction automatically movement. The motion is transferred to a keyway conversion set system. From hundreds of wheel lies a single conversion set having used to drive machinery. The RPG included the method of driving three conversion set to another. The RPG conversion set system has been developed to achieve large amount of moment of inertia in relatively small space. The created rotational energy was converted into electricity which was fed into power grid. For this part dynamo create electricity from rotation energy get and the created electricity stored on battery. With the following block diagram, we can easily understand the overall working and components of conversion set.

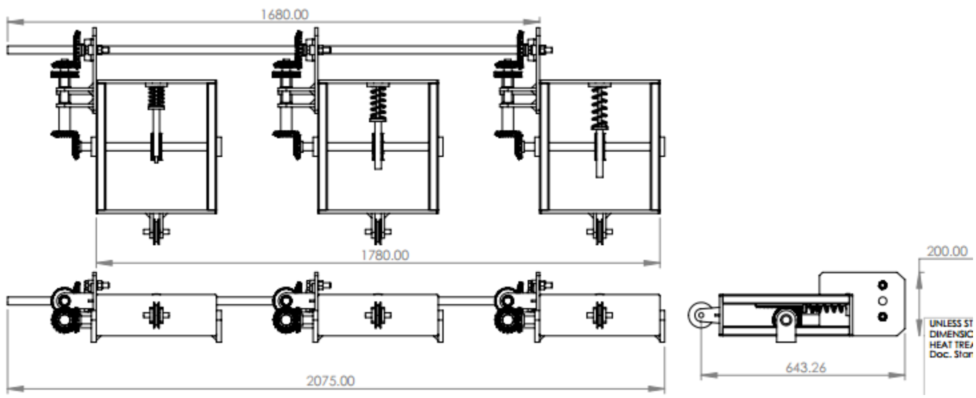
Table 3.7 Components of conversion set design

Item. No.	Transmission case component materials	Quantity
1	Pin	1
2	Pulley	3
3	Spur gear shaft	3
4	ISO-spur gear 2M 40T 20PA 15FW---S40	3
5	ISO - Spur gear 2M 40T 20PA 30FW---S40A75H50L35.0N	3
6	ISO - Spur gear 2M 40T 20PA 15FW---S40A75H50L25.0N	3
7	ISO - Spur gear 2M 20T 20PA 15FW---S20A75H50L20.0N	3
8	ISO – Rack-spur-rectangular 2M 20PA 20FW 20PH 150L---SALL	3
9	ISO–Straight bevel gear 4M 40GT 12PT 20PA 40FW---50050H50MD35.0N	3
10	Full spring	3
11	Spring push plate	3
12	ISO–Straight bevel pinion 4M20PT 12GT 20PA 20FW---20035H40MD25.0N	3
13	ISO–Straight bevel pinion 4M30PT 12GT 20PA 20FW---30035H40MD15.0N	3
14	ISO–Straight bevel pinion 4M20PT 12GT 20PA 20FW---20035H40MD25.0N	3
15	Bevel gear shaft2	3
16	Motor shaft	3
17	Long shaft	1
18	Inafag-ucfl205	3
19	ISO 4014-M16*65*65-C	6
20	ISO-4034-M16-N	6
21	ISO 3245-2522D-16,DE,NC,16	7



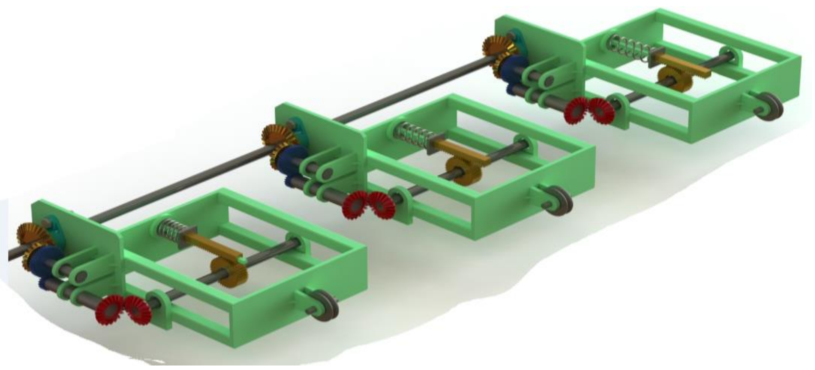
A)

Figure 3.9 A) Components of 2D conversional set orthogonal views



B)

Figure 3.9 B) Components of conversional set top views



C)

Figure 3.9 C) Components of 3D conversional set

(i) The units have minimum visual impact on their surrounding environment.

(ii) The road power generation (RPG) emits no noise.

(iii) The unit will have minimum cost of installation and maintenance.

(iv) This unit could be located at the close proximity to services and power grid.

(v) Possible answer for battery charging station.

(vi) Completely isolated street light or traffic light

CHAPTER FOUR

RESULTS AND DISCUSSION

In this case study we should have look at our assumptions and compensations of the assumptions to get what we are looking for. What we need is a more or less consistent rotational power supply from a mechanical system is about 600rpm from the combination of our mechanical systems. Cost of current generator is about 20,000ETB the link to purchase this item one-line price data: -

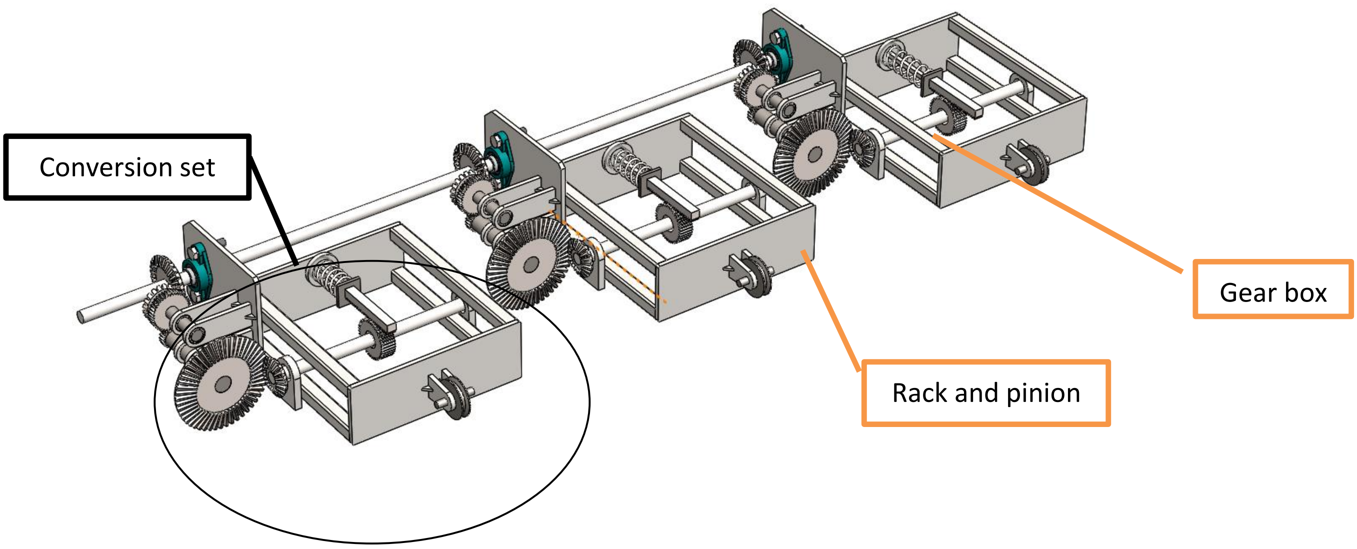


Figure 4.1(A) Detail components and design of conversional set

To talk about torque transferred to the generator we must first define the gearbox reduction ratios.

4.1. Simulation output for reduction ratio

Those output of simulation value help as an input to calculate reduction ratio of gears, our target is with this reduction ratio setup, the amount of speed transferred to the generator is completed dividing ratcheted spur velocity plot for motor side bevel velocity.

Table 4.1 Solid work software gear reduction motor side bevel velocity output:

Column 1	Column 2
Motor Side	**Bevel Velocity**
Time (sec)	**Angular Velocity (deg/sec)**
0.00000	0.00000
0.04000	21.48156
0.08000	41.41491
0.12000	59.80005
0.16000	76.63696
0.20000	91.92565
0.24000	105.66611
0.28000	117.85836
0.32000	128.50238
0.36000	137.59818
0.40000	145.14577
0.44000	151.14512
0.48000	155.59626
0.52000	158.49918
0.56000	159.85387
0.60000	159.66034
0.64000	157.91860
0.68000	154.62862
0.72000	149.79043
0.76000	143.40402
0.80000	135.46938
0.84000	125.98652
0.88000	114.95544
0.92000	102.37614
0.96000	88.24862
1.00000	72.57288
1.04000	55.34891
1.08000	36.57673
1.12000	16.25632
1.15000	0.00001
1.15000	0.00001
1.19000	0.00001
1.23000	0.00001
1.27000	0.00001
1.31000	0.00001
1.35000	0.00001
1.39000	0.00001
1.43000	0.00001
1.47000	0.00001
1.51	0.000

Column 1	Column 2
Motor Side	**Bevel Velocity**
Time (sec)	**Angular Velocity (deg/sec)**
1.55000	0.00001
1.59000	0.00001
1.63000	0.00001
1.67000	0.00001
1.71000	0.00001
1.75000	0.00001
1.79000	0.00001
1.83000	0.00001
1.87000	0.00001
1.91000	0.00001
1.95000	0.00001
1.99000	0.00001
2.03000	0.00001
2.07000	0.00001
2.11000	0.00001
2.15000	0.00001
2.19000	0.00001
2.23000	0.00001
2.27000	0.00001
2.30000	0.00001
2.30000	0.00001
2.34000	22.25568
2.38000	44.51137
2.42000	66.76705
2.46000	89.02274
2.50000	111.27842
2.54000	133.53411
2.58000	155.78980
2.62000	178.04548
2.66000	200.30117
2.70000	222.55685
2.74000	244.81254
2.78000	267.06823
2.82000	289.32391
2.86000	311.57960
2.90000	333.83529
2.94000	356.09097
2.98000	378.34666
3.00000	389.47450

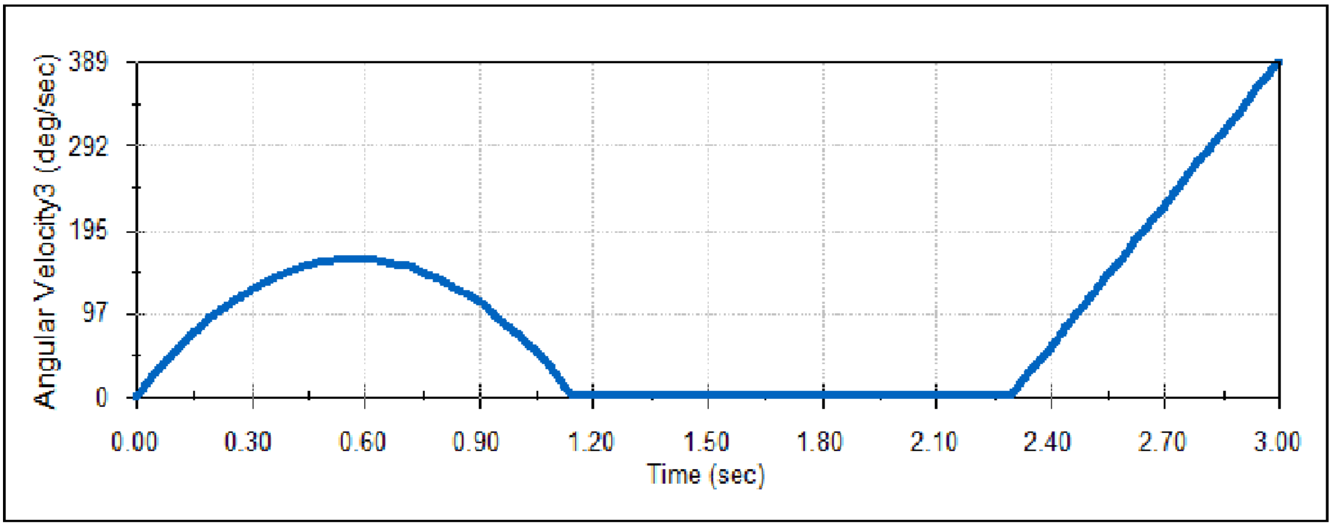


Figure 4.2 Solid work software gear reduction motor side bevel velocity output graph

From this Solid work software gear reduction motor side bevel velocity output graph shown as the amount of angular velocity from initial it increases and instantly become decrease as time increases and it came to initial but the velocity was not become reverse.

Table 4.2 Solid work software gear reduction ratcheted spur velocity plot output:

Column 1	Column 2
Ratcheted Spur	**Velocity Plot**
Time (sec)	**Angular Velocity2 (deg/sec)**
0.00000	0.00000
0.04000	64.44468
0.08000	124.24474
0.12000	179.40014
0.16000	229.91087
0.20000	275.77694
0.24000	316.99834
0.28000	353.57508
0.32000	385.50715
0.36000	412.79455
0.40000	435.43730
0.44000	453.43537
0.48000	466.78879
0.52000	475.49753
0.56000	479.56162
0.60000	478.98103
0.64000	473.75578
0.68000	463.88587
0.72000	449.37130
0.76000	430.21205
0.80000	406.40814
0.84000	377.95957
0.88000	344.86633
0.92000	307.12843
0.96000	264.74587
1.00000	217.71863
1.04000	166.04674
1.08000	109.73018
1.12000	48.76895
1.15000	0.00003
1.15000	0.00003
1.19000	68.11190
1.23000	131.31485
1.27000	189.60884
1.31000	242.99385
1.35000	291.46990
1.39000	335.03698
1.43000	373.69510
1.47000	407.44425
1.51000	436.28443

Column 1	Column 2
Ratcheted Spur	**Velocity Plot**
Time (sec)	**Angular Velocity2 (deg/sec)**
1.51000	436.28443
1.55000	460.21564
1.59000	479.23789
1.63000	493.35117
1.67000	502.55548
1.71000	506.85083
1.75000	506.23721
1.79000	500.71462
1.83000	490.28307
1.87000	474.94255
1.91000	454.69306
1.95000	429.53460
1.99000	399.46718
2.03000	364.49079
2.07000	324.60543
2.11000	279.81111
2.15000	230.10782
2.19000	175.49556
2.23000	115.97434
2.27000	51.54415
2.30000	0.00000
2.30000	0.00002
2.34000	66.76704
2.38000	133.53410
2.42000	200.30115
2.46000	267.06821
2.50000	333.83527
2.54000	400.60233
2.58000	467.36939
2.62000	534.13645
2.66000	600.90350
2.70000	667.67056
2.74000	734.43762
2.78000	801.20468
2.82000	867.97174
2.86000	934.73880
2.90000	1001.50585
2.94000	1068.27291
2.98000	1135.03997
3.00000	1168.42350

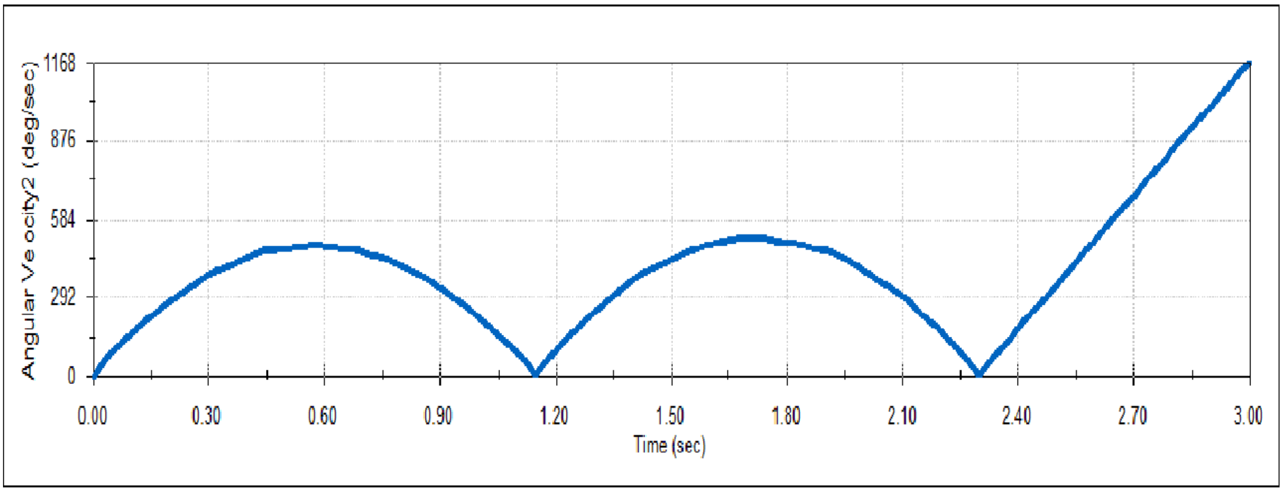


Figure 4.3 Solid work software gear reduction ratcheted spur velocity plot output graph

From this Solid work software gear reduction ratcheted spur velocity plot output graph shown as the amount of angular velocity from initial it increases and instantly become decrease as time increases and it came to 0 but the velocity was not become reverse

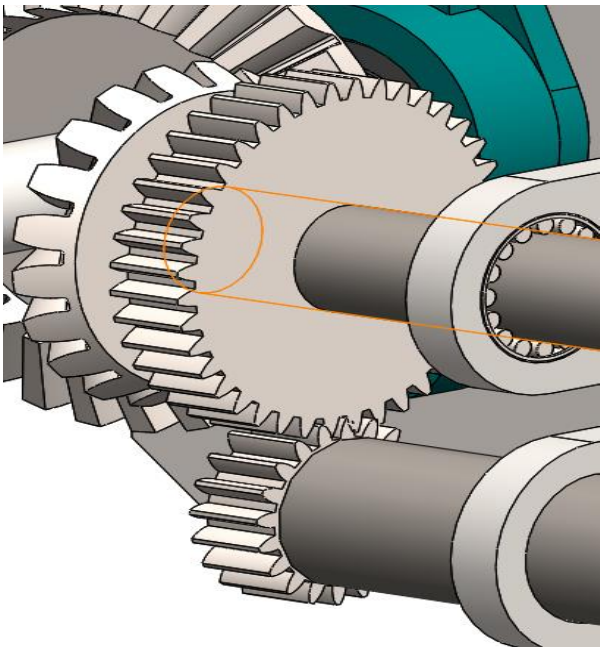


Figure 4.4 Redaction gear

This is the first reduction gear setup. It is a combination of pinion and gear bevels.

Gears: - Straight bevel gear 4M 20GT 12PT 20PA 40FW

Straight bevel pinion 4M20PT 12GT 20PA 20FW

Reduction ratio:- R1 $= \frac{20GT}{20GT} = 1$

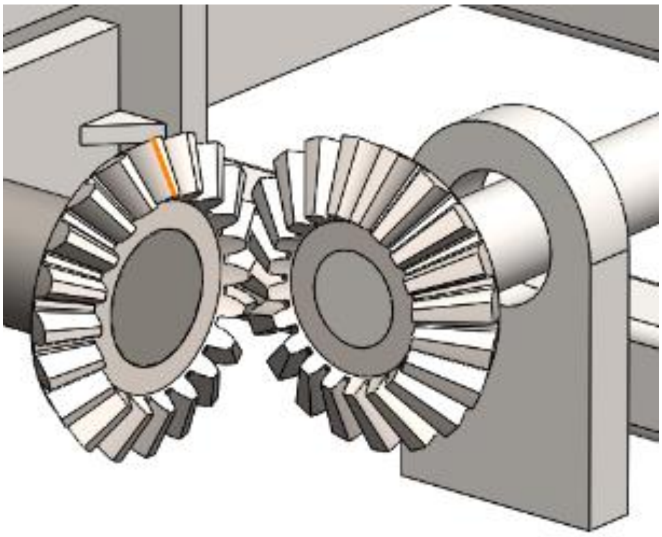


Figure 4.5 First redaction gear

This is the second reduction gear setup. It is a combination of pinion and gear spurs.

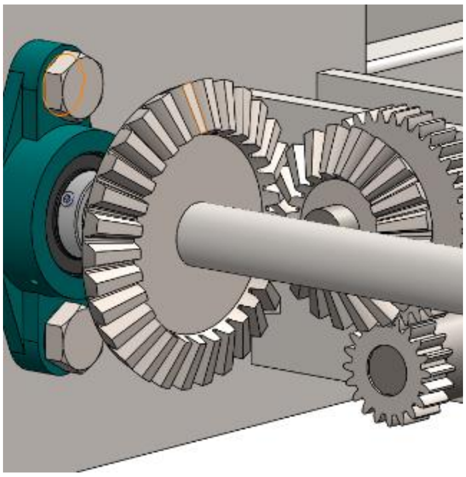


Figure 4.6 Second reduction gears

Gears: Spur gear 2M 40T 20PA 30FW

Spur gear 2M 20T 20PA 30FW

Reduction ratio: $R1 = \frac{40GT}{20GT} = 2$

This is the third reduction gear setup. It is a combination of pinion and gear bevels.

Gears: - Straight bevel gear 4M 30GT 12PT 20PA 40FW

Straight bevel pinion 4M20PT 12GT 20PA 20FW

Reduction ratio: $R1 = \frac{30GT}{20GT} = 1.5$

The combined reduction ratio is thus the multiplication of the above three sets which is

$R = 1 * 2 * 1.5 = 3$,

With this reduction ratio setup, the amount of speed transferred to the generator is thus:

$n = \frac{1917.529\text{RPM}}{3} = 639.176\text{RPM}$ This is inside our generator designed limit of electric power production. Remember that the generator only needs about 600 RPM to start producing. Thus, the extra 39.176 RPM from this mechanism doesn't interfere with the designs of the generator. When we come to the torque being transferred, since we are reducing the speed the starting torque is increased from what was before. The generator's starting torque is given to be about 0.75 Nm. Also, it is calculated that to get about 2KW of output power we require 39.788 Nm. Torque from the system is as follows. Pitch diameter of gear = 83 mm, Speed when pressing the bump = 1917.529 RPM, Pressing force = 7357.5 N, Then pressing torque is: - $T = 7357.5\text{ N} * 0.0415\text{ m} = 305.336\text{ N.m.}$

This torque value is more than enough to begin producing the 2K.w electrical power from the generator. Therefore, from our case study that takes one car with 1500 kg and one car per second in all three conversion sets. We get 639 RPM at 305.336 N.m. for about 0.036 seconds per car.

For continuous car passage between a second's difference, Time and number of cars that pass, For one car per second there are 3600 cars passing in an hour. For 8 hours peak traffic passage we then get: $\text{Number of cars in eight hours} = 3600 * 8 = 28800\text{ cars}$ pass every eight hours. We assume the three conversion sets decelerate from 639 rpm to about 600 rpm until the next car come and accelerates it back to 689 rpm.

Therefore, per 3 conversion set we get about 2 Kwh = 2000watt/60 = 33.33watt per minute. By providing 68-96 V

4.2. Output power calculation summery

To summarize our research assumptions, they study consider for 8hours From currently Paved Addis Ababa city road 1,164.50km, If we implement on half of this paved road 582.25km So in one minute this conversion set generate 33.33watt-minet/2kwh from three conversion set But the total conversion set is six, three left three right = 33.33watt-minet*2 = 66.66watt-minet/4kwh from six conversion set, During 8hours/480minets we generate = 31,996.8watt = 32kwh and if we provide the conversion set 50metter/0.5km far, each other in total 582.25km We provide 582km/2 = 291 Muti conversion set

The minimum we can generate renewable electricity from Addis Ababa traffic flow is = 31,996.8kwh*291 = 9,311,068.8 watt = 9,312Kwh When we compare the output result of this study with previous three researchers are; The results are taken on the basis that, 100 vehicle travelled at average speed of 70 km/hr at regular average wind speed of 4.5 m/s for the duration of 2hrs. The electric power generated from designed wind turbine is approximately 200 Watt

–hr. (Chandana S, Sindhu R. et al.” Power generation using windmill from vehicle movement in highways and use of smart solar tracking system with intelligent lighting control”)

Power developed for 1 vehicle passing over the speed breaker arrangement for one minute = 4.905 watts Power developed for 60 minutes (1 hr) = 294.3 Watts, Power developed for 24 hours = 7063.2 KW This power is sufficient to give light four street lights in the roads in the night time. (Noor.F, Jiyaul.M et al “Production of electricity by the method of road power generation” International Journal of Advances in Electrical and Electronics Engineering Volume1,Number 1)

Power developed for one vehicle passing over the speed breaker arrangement for one minute = 0.24525 watts, Power developed for one hour =14.715 watts, Power developed for one day = 0.35316 Kw. (Jyoti M, Pooja G ‘’Generation of Electricity through Speed Breaker Mechanism’’ The International Journal of Engineering and Science, Volume 5, 2016) From previous Researchers Experimental Investigation those parameters we consider blow;Jyoti.M, Pooja.Get.al“The International Journal of Engineering and Science” Volume 5, (2016), The experimental investigation is performed by placing the speed breaker arrangement in a pit. Vehicles move. Over the speed breaker arrangement and the voltage generated is measured by a multi meter and the various Readings are plotted in a graph.

The graphs are drawn for various parameters as shown below

1. Voltage generated (Vs) speed of vehicle
2. Voltage generated (Vs) Load
3. Current (Vs) Load
4. Power (Vs) Load

Table 4.3 Summary of voltage generated versus speed of vehicle

Sr. no	Speed of Vehicles(Km/h)	Voltage generated (Volts)
1	10	8.93
2	20	7.32
3	30	6.05
4	40	5.65
5	50	4.04

Table 4.4 Summary of load (L) versus current (C)

Load(Kg)	Current(mA)
15	0.25
20	0.97
25	2.03
30	3.11

Table 4.5 Summary of load (L) versus voltage (V)

Load(Kg)	Voltage(15)
15	2.0825
20	2.776
25	3.47
30	4.164

Table 4.6 Summary of Load (L) versus power (p)

Load(Kg)	Power(kw)
15	0.17658
20	0.23544
25	0.29430
30	0.35316

Those graphs and tables show as;

1. When speed (V) of vehicles increase the voltage (V) generated will be decrease
2. When load (L) of vehicles increase the current (C) generated will be decrease

4.3. Result and discussion

For academic research completed in the formation of this study, this design is believed to be the most cost effective and efficient generation of electricity from road traffic flow system for this location. Using the low flow and head parameters measured, this system can produce a minimum output power of 33.33watt/minute.

The end result we get from this research thesis "Generation of Electricity from road traffic flow A case study of Addis Ababa/Finfinne city" Study were 9,311,068.8watt = 9,312kwh these result is not as much as expensive renewable energy generation when we relate ho hydro power generation and wind turbine electricity generation, because when we compare the distribution to access area that wastage 30% loss of hydropower energy more reduced, it access nearly its production and also its maintenance cost is the most cheaper than others power generation and simple to maintain

The results are taken on the basis that, vehicles travelled at average speed of 30 km/hr, by considering Vehicle and man weight assumption 1500 Kg, one vehicle pass per second over the paved road. The electric power generated from designed conversion set is approximately 9,312Kwh from six conversion set, it means that the overall we can generate electricity power from Addis Ababa city traffic flow produced helps to burn for street lights in the roads in the night time.

The main critical think was this renewable electricity generation from traffic flow has no impact on environment, On the other hand, energy crisis is also a main issue of today's life and all there is a shortage of conventional energy resources due to its large usage. So, we have to sort out this problem with a technique which are not only overcome this energy crisis but also should be eco-friendly. Many conventional resources are creating pollution so that's why focus is towards eco-friendly solution.

Fig 4.7 Vehicle flow over speed break

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Road Power Generation is new type of unusual source of energy. This is a type of vibration harvesting wasted energy of vehicles speed by converting kinetic energy to electric energy. Road Power Generation (RPG) for battery charging station and it possible the electric vehicle can be recharge with green power and power coming from electric vehicles earned wasted kinetic energy. The higher frequency of passing vehicles provides higher capacity of electricity generated by road power generation.

"Electricity plays a very important role in our life”. Due to high population growth, the current power generation has become insufficient to fulfill our demand. In this study reliable technology to generate electricity from speed breakers, with this technique our natural resources can be conserve. In coming days, this will prove a great advantage to the world, since it was save a lot of electricity from power plants that gets wasted in illuminating the street lights. As the conventional sources are depleting very fast, it’s high time to think of alternative resources. So this study not only provides alternative but also adds to the economy of every country.

According to the data gathered the paved Addis Ababa city road is 1,164.50km, if this mechanism implemented on half of paved road 582.25km, in one minute this conversion set generate 33.33watt-minute/2kwh from three conversion set. Since the total conversion set are six, three left and three right = 33.33watt-minute*2 = 66.66watt-minute/4kwh from six conversion set. During 8hours/480minutes we generate = 31,996.8watt = 32kwh, and if we provide the conversion set 50metter/0.5km from each other in total 582.25km, provide 582km/2 = 29 conversion set provided. So that according to this study the minimum amount we can generate renewable electricity from Addis Ababa traffic flow is = 31,996.8kwh*291 = 9,311,068.8watt = 9,312Kwh, when we compare this study result with previous researcher on literature review chapter, generation of electricity by conversion set mechanism is more productive than flywheel mechanism.

Generally, we can overcome the crisis of natural power production resources in forth coming days and reduce the wastage of electricity also ultimately can conserve some of the natural resources from completely getting disappeared.

5.2. Recommendations

- Addis Ababa City electricity power need increases day to day the current supply and demand is not as much as satisfactory, as much expect for this city, were the different diplomat and big worldwide and continental meeting was held, so this must improve the future demand of electric power of the city, for streets lights, for households and also for small industry's needs.
- In order to study well the amount of simulation of electricity from road traffic flow and others, all important data should be recorded well accordingly.
- Government and different stakeholder as well as private organizations should invest on generation of renewable energy source.
- All responsible bodies should control Environmental pollution by nonrenewable energy sources and apply best minimized management practices.
- To generate electricity from road traffic flow was implement and it's relatively cost minimized mechanized renewable energy generation system.
- Most of components of this generation electricity from road traffic flow can be fabricate in local market.
- Properly design of paved road has the main critical thing to applicable on ground this mechanism.
- The generated electricity power can be stored and distributed to street light, light bill boards and other that need electricity.

REFERENCES

Abhishek Gupta, Nikita Mittal, Pushpendra Pal Singh, Ram Arora, RamkishanDhakar, Purab Chand, PiyushMangal International Journal of Electrical and Electronics 4(1):135-139

Ahmad Syed Arslan, Bilal Masood. "Power Scavenging from Moving Vehicles on Road" International Journal ofInnovation and Applied Studies. 2014; 9(4): 14-28.

AkashLiladharGorle, AkashNarendraPatil, AkshayVilasraoThawale, ShridharVinodGiri, BrindaDarjee, Leena. H. Patil, "Literature Review on Electricity Generation using Speed Breaker," International Journal of Advanced Research in Computer and Communication Engineering, 2(1):2018:50-58

AmolSheshraoFawad, Air Compression and Electricity Generation by Using Speed Breaker with Rack And Pinion Mechanism, International of Modern Engineering Research (IJMER), 5(1), 2015

Anderson, P.M. and Fouad, A.A.," Power System Control and Stability" Galgotia Publications, New Delhi, 2008.

Ankita, MeenuBala, Power Generation from Speed Breakers, "International Journal of Advance Research in Science and Engineering, (2013)

Ashok Kumar Sharma, Omkar Trivedi, UmeshAmberiya, Vikas Sharma (2012) "Development of speed breaker device for generation of compressed Air on highways in remote areas" "International journal of recent research and review". 1(7).

Aswathaman.V,Priyadharshini M "International Journal of Recent Research and Review,".1(2)2012

Aswathaman.V, Priyadharshini.M (2011) "Every speed breaker is now a source of power'' "International conference on Biology, Environment and Chemistry IPCBEE, vol.IACSIT press Singapore''

Arora, C.P., "Fundamentals of renewable energy systems" New Age international limited publishers, New Delhi, 2005.

Das CK, Syed Monowar Hossain, MS Hossan "Introducing speed breaker as a power generation unit for minor needs" Informatics, Electronics & Vision (ICIEV), 2013 International Conference on IEEE. 2013.

F. Noor, M. Jiyaul, "Production of Electricity by the Method of Road Power Generation" Int. J. of Advances in Electrical and Electronics Engineering, 1(1), 2011.

G. Ankit, B. Meenu, "*Power Generation from Speed Breaker. Int. J. of Advance Research in Sci. and Engineering" (2)*2, 2013.

Gagen, M.J., *"Novel acoustic sources from squeezed cavities in car tires*" J AcoustSoc Am, , 1999.794–801

Hamet, J.P., Besnard, F, et al *"New vehicle noise emission for French traffic noise prediction"* 71:861–9, 2010.

JyotiMaurya, PoojaGupta, Pooja Gupta, TarannumShahab, Amitabh Srivastava, *'Generation of Electricity through Speed Breaker Mechanism,*" The International Journal of Engineeringand Science (IJES), (2016)

JyotiMaurya ,Pooja Gupta , Pooja Gupta, TarannumShahab , Amitabh Srivastava *"Generation of Electricity through Speed Breaker Mechanism,"*The International Journal Of Engineering And Science 5(3),2016

K. Gogoi, *"Generation of electricity from speed breaker using crank shaft mechanism"*thesis submission www.scribd.com, 2010.

KiranKolhe and Amar Pandhare "*Electric Power Generation System from Speed Breaker by using Rack and Pinion Mechanism,*" International Journal of Current Engineering and Technology.7(3)2017

Kragh J, Plovsing B, et, al *"Nordic environmental noise prediction methods"* Delta, AV 1719/01, 2002.

Makarewicz, R., Gałuszka, M., "*Road traffic noise prediction based on speed-flow diagram"*. ApplAcoust; 72:190–5, 2011.

Makarewicz, R., Zołtowski, M., *Variations of road traffic noise in residential areas*, J AcoustSoc Am; 124:3568–75, 2008.

Mukherjee, D., Chakrabarti, S., *Fundamentals of renewable energy systems*, New Age international limited publishers, New Delhi, 2005.

Mukherje, D., Chakrabarti, S., *Non-conventional power plants*, New Delhi, 2005.

Nota, R., Barelds, R., *Engineering method for road traffic and railway noise after validation and fine-tuning*, Harmonoise WP 21-35, 2005.

Noor Fatima, Jiyaul Mustafa,*Production of electricity by the method of road Power generation,"* International Journal of Advances in Electrical and Electronics Engineering 2016

Padiyar, K.R., *Power System Dynamics and Control*, Interline Publishers Bangalore, 2005.

Raja, A.K., *Non-conventional power engineering, public printing service*, New Delhi, 2007.

R.Gupta, S.Sharma, "*A Revolutionary Technique of Power Generation from speed breaker*, International Journal of Engineering Research and technology, (2013)

Sharma, P.C., *Non-conventional power plants, Public printing service*, New Delhi, 2003.

S. Shakun, A. Ankit, "*Produce Electricity by the Use of Speed Breaker*" Journal o Engineering Researchand Studies, 1(2), 2011.

Singh Alok Kumar, et al. "*Generation of Electricity through Speed Breaker Mechanism*"*InternationalJournal of Innovations inEngineering and Technology IJIET*. 2013; 2(2): 20-24.

Watts, G., et al., *Effects of speed distribution on the Harmonoise model predictions*, Inter-Noise Conference, Prague; pp 21-34, 2004.

APPENDIX

Appendix 1. Data recording method

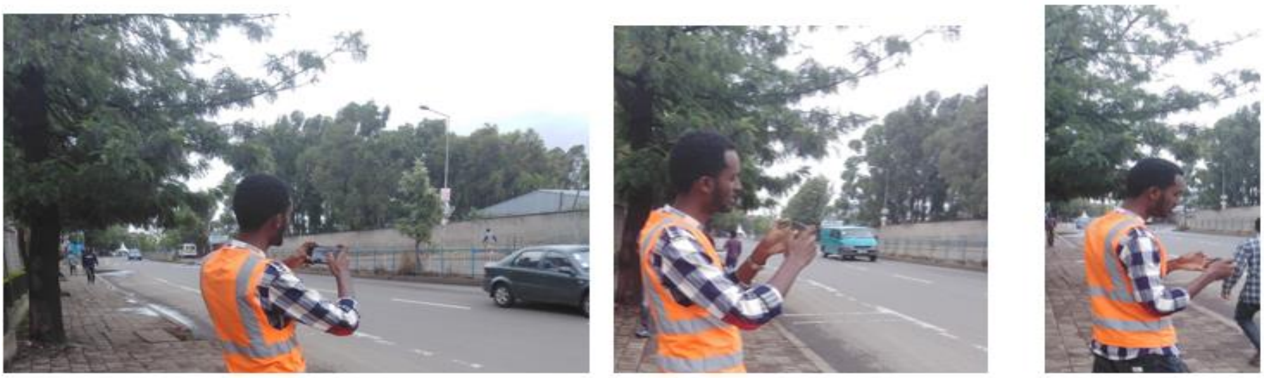


Figure A1: Traffic flow data recording methods

Appendix.A2**:** Traffic flow during 7:30AM-11:30AM Hours

Figure A2: Traffic flow at Megenagna squre, yereber Gerji and legehari (photo picked and Videos taken on 10-15/01/2019 at 3:00AM-7:30PM and 7:30PM-5:30PM)

Appendix A4 Traffic flow during 11:30AM-3:30AM hours

Figure A4: Traffic flow at Dembel city, CMC, Merkato, Megenagna, (photo picked and videos taken on 10-15/01/2019 at 3:00AM-7:30PM and 7:30PM-5:30PM)

Appendix A5: Traffic flow during 3:30AM-7:30PM

Figure A5: Traffic flow at Bole, Megenagna, African avenue and Meskel square (photo picked and videos taken on 15-25/01/2019 at 3:00AM-7:30PM and 7:30PM-5:30PM)

Appendix A6 Cross sectional speed break alignment

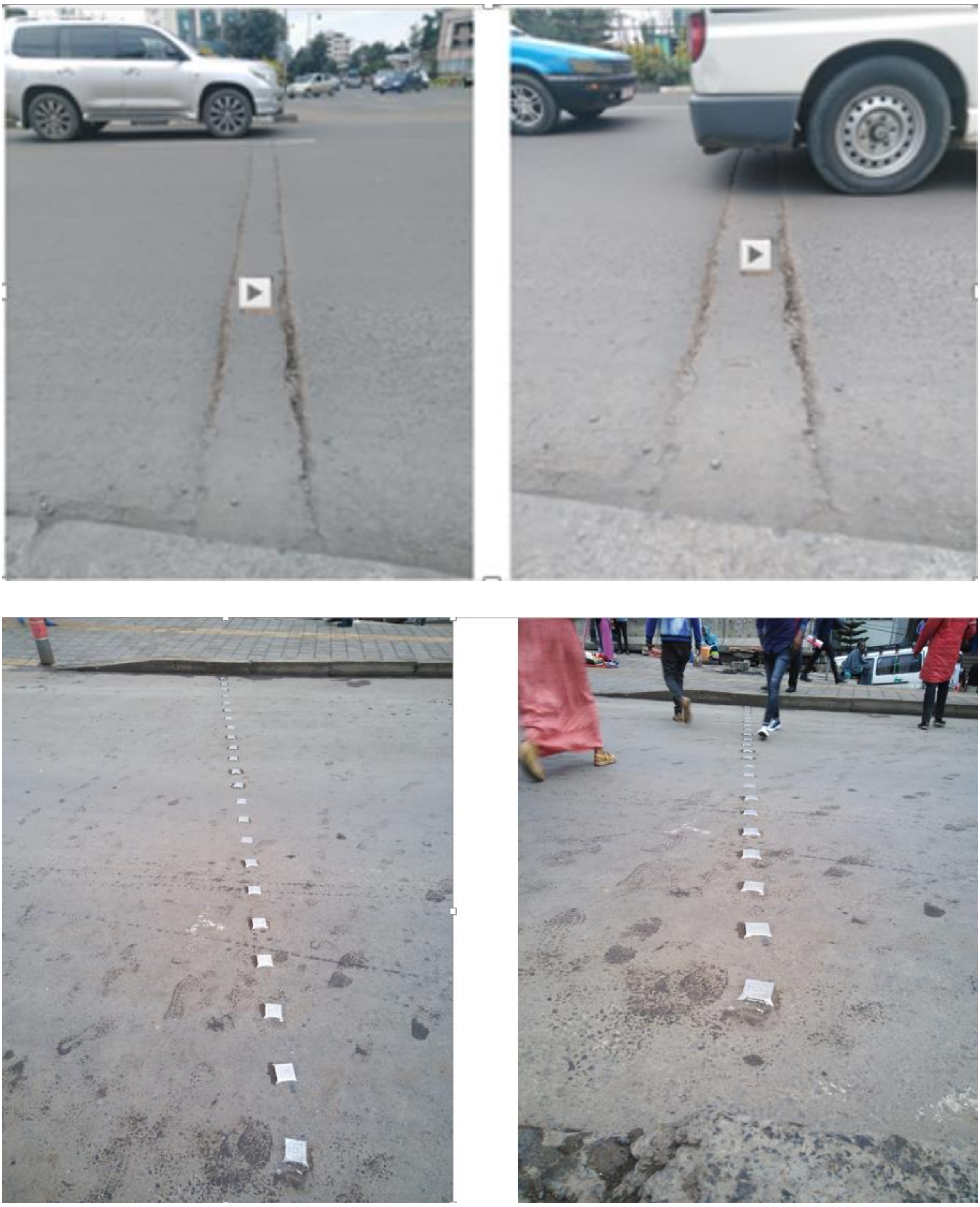
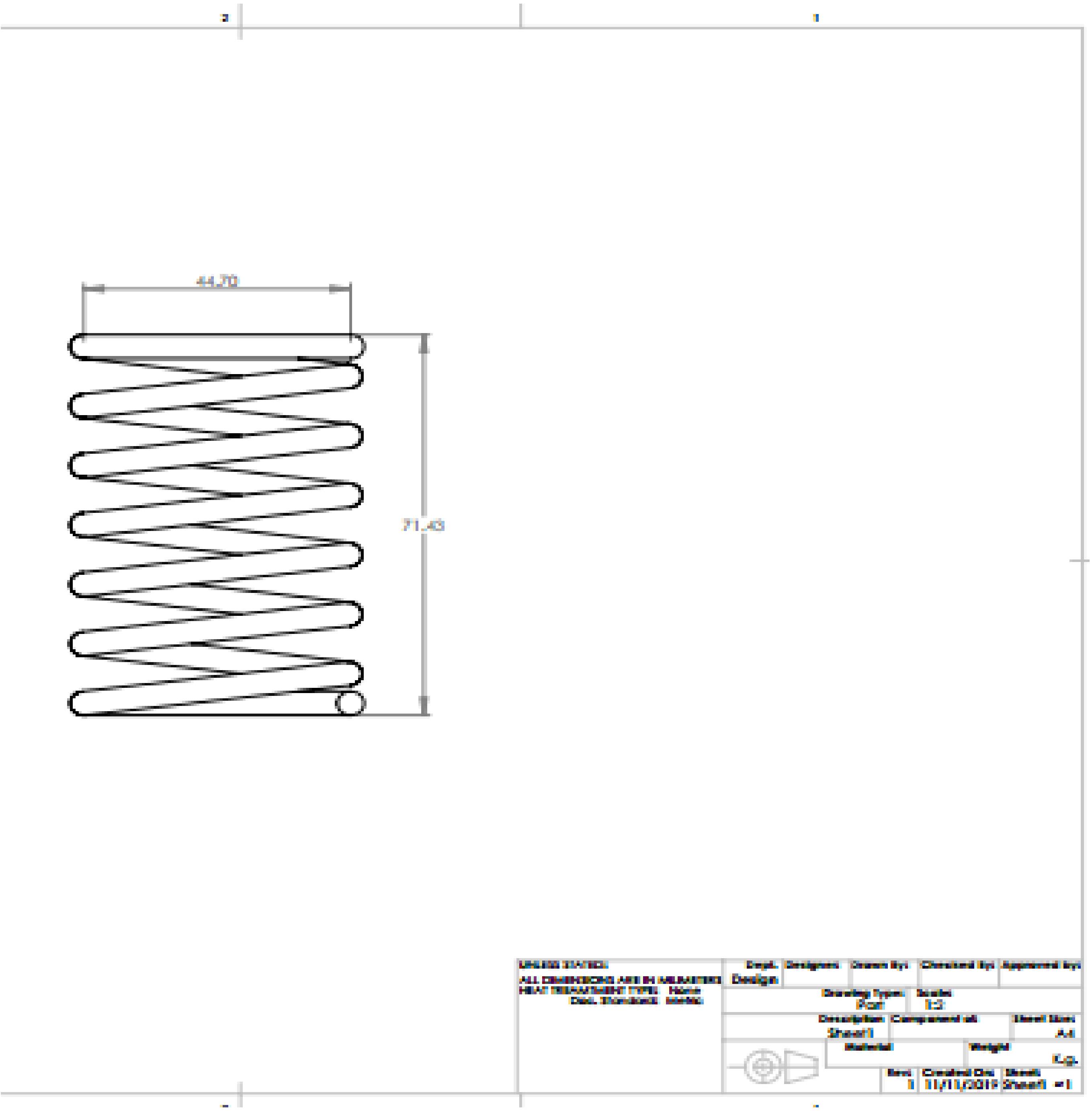


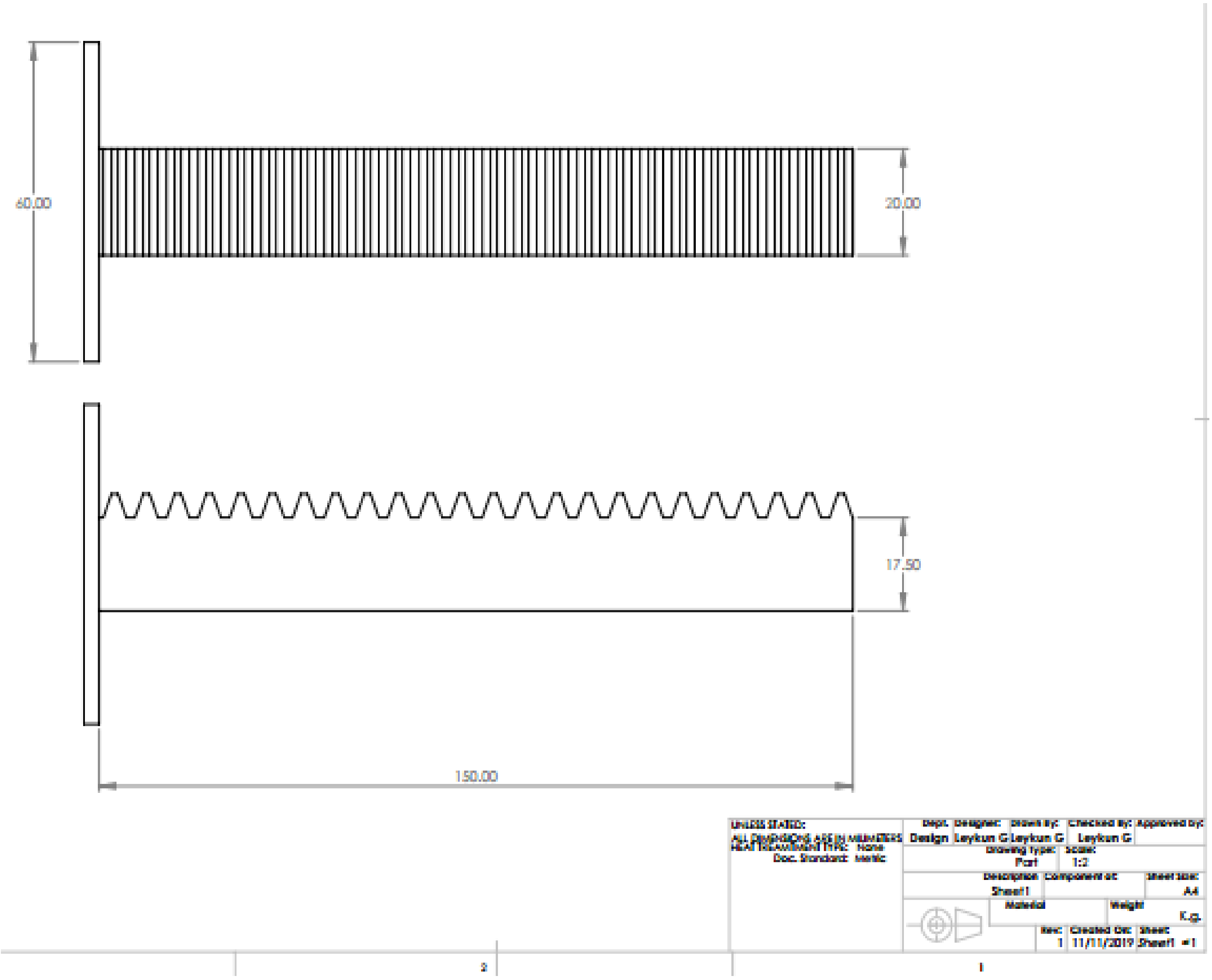
Figure A9: For Ramp installation alignment area looks like at saris squire (photo picked and videos taken on 10/01/2019 at 4:00Am)

Appendix 3

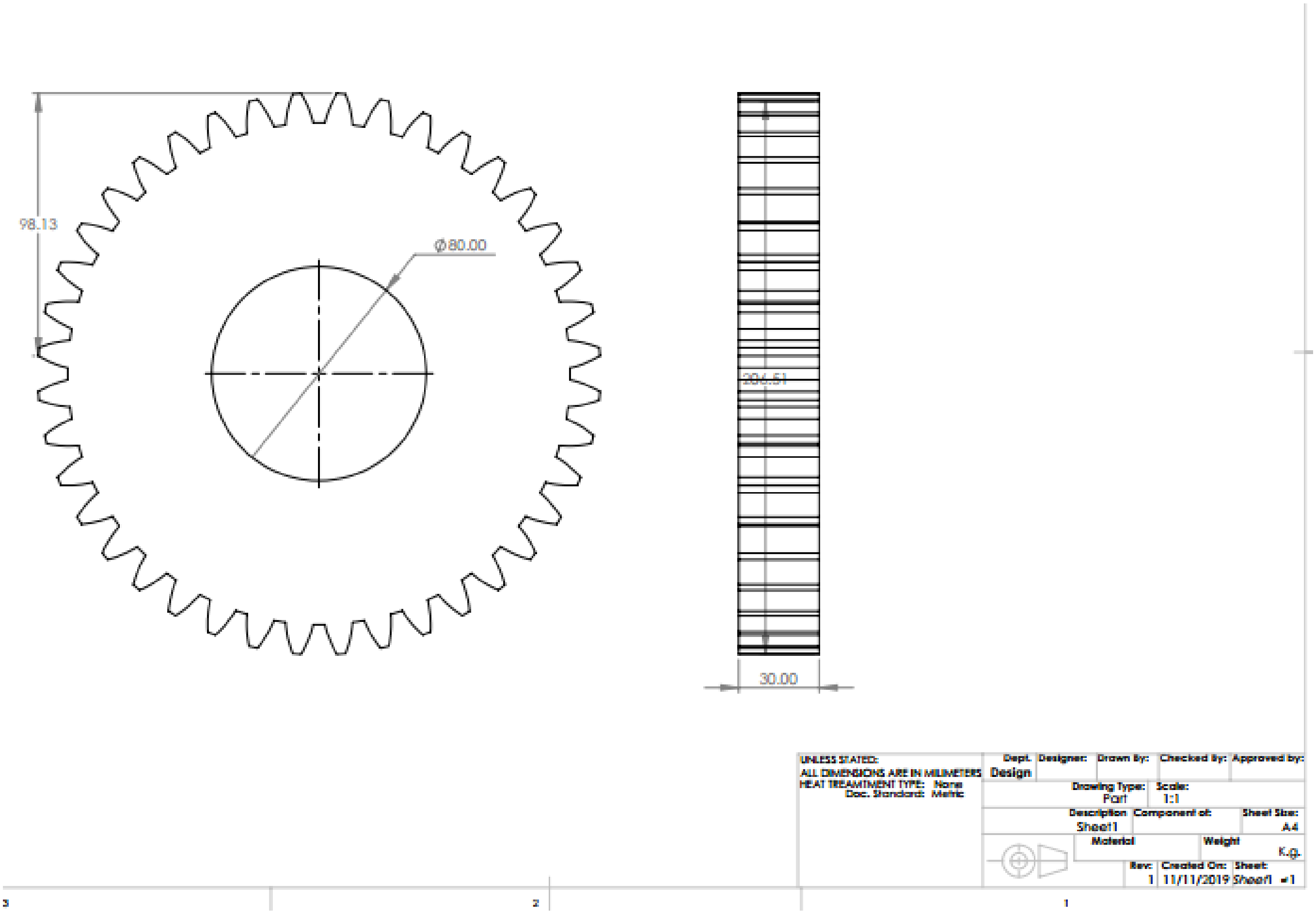
Appendix 3A Full spring



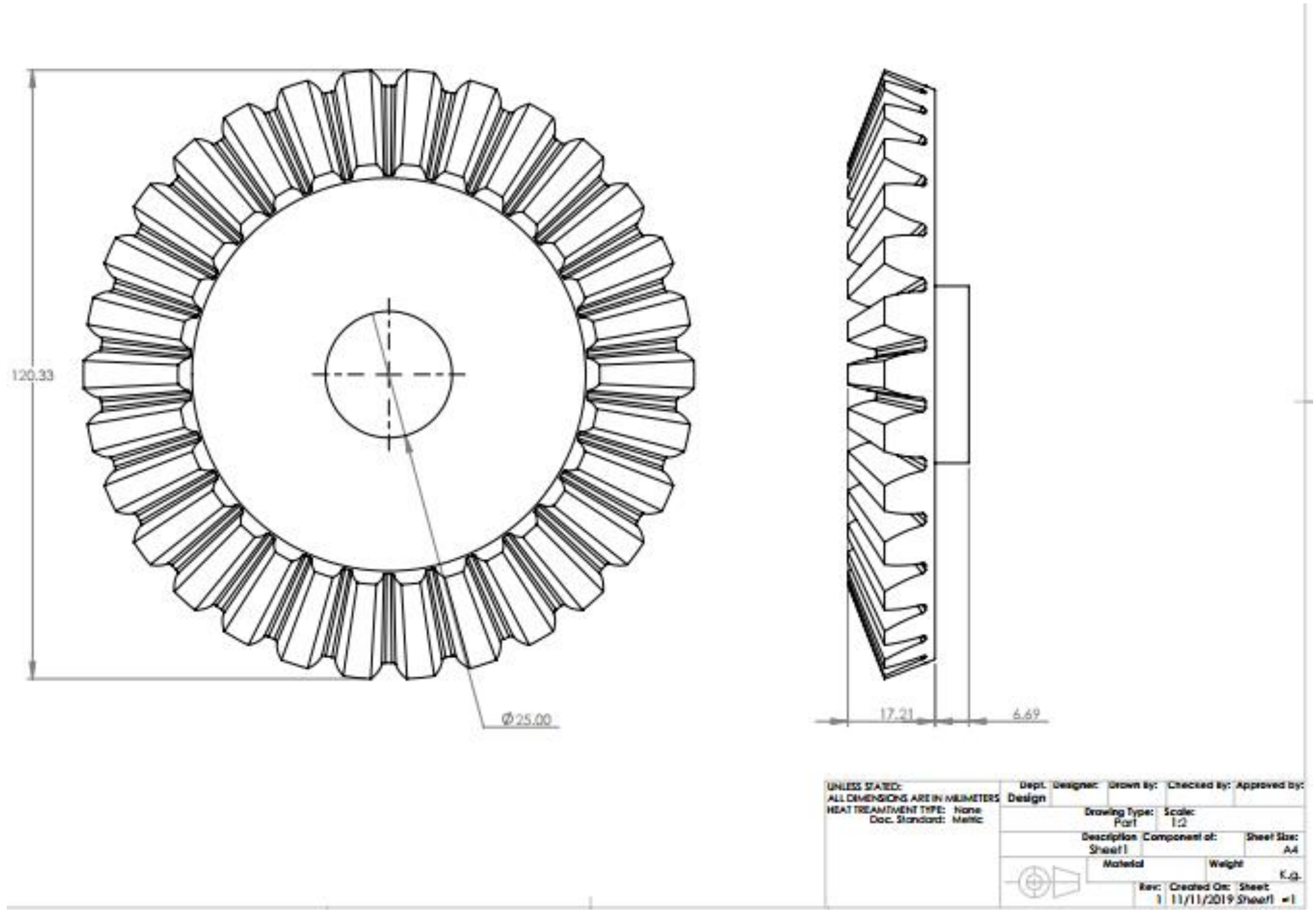
Appendix 2 BISO-Rack spur-rectangular 2M 20PA 20FW 20PH 150L---SALL



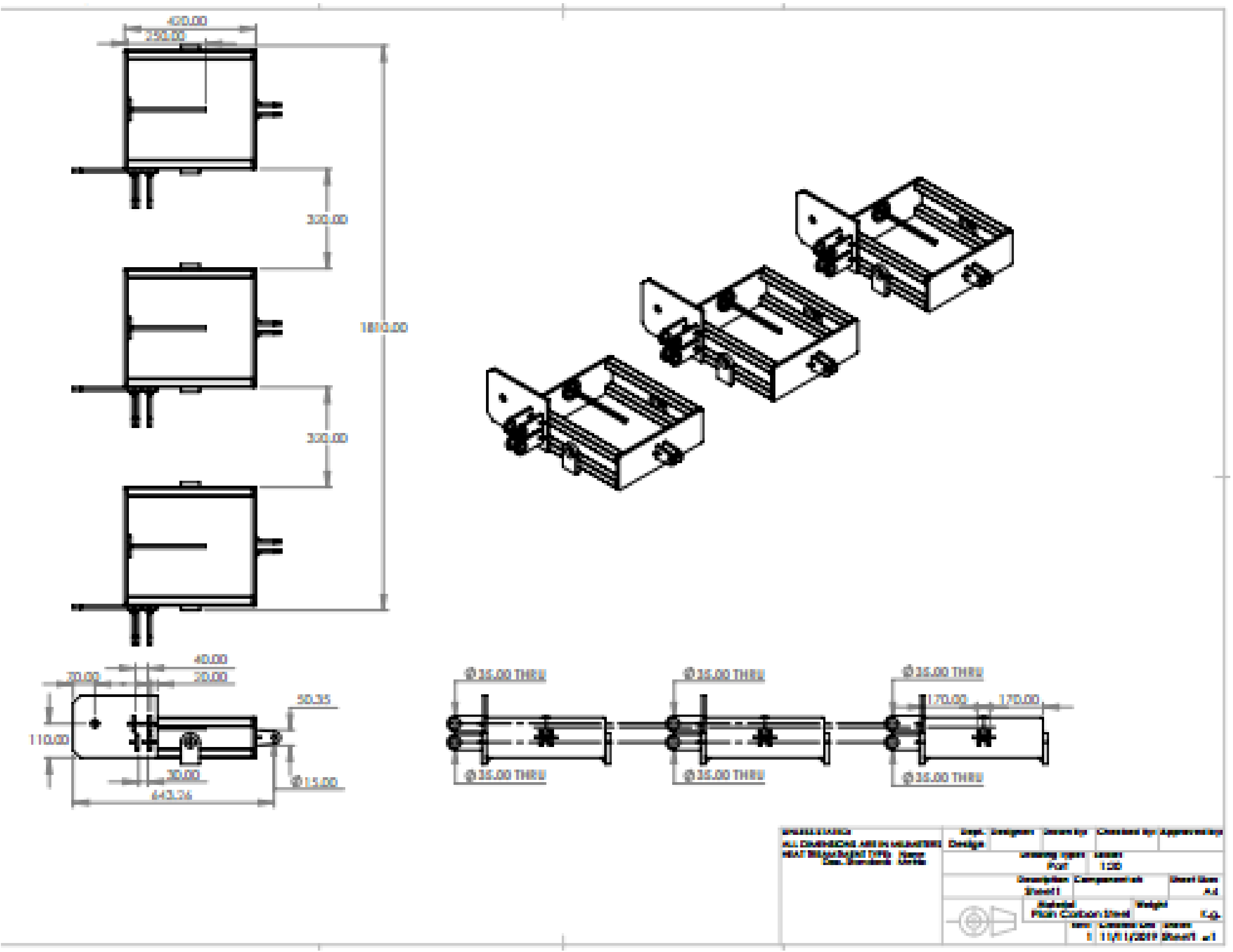
Appendix 2C Spur gear 2M 20T 20PA 15FW----S20A75H50L20.0N



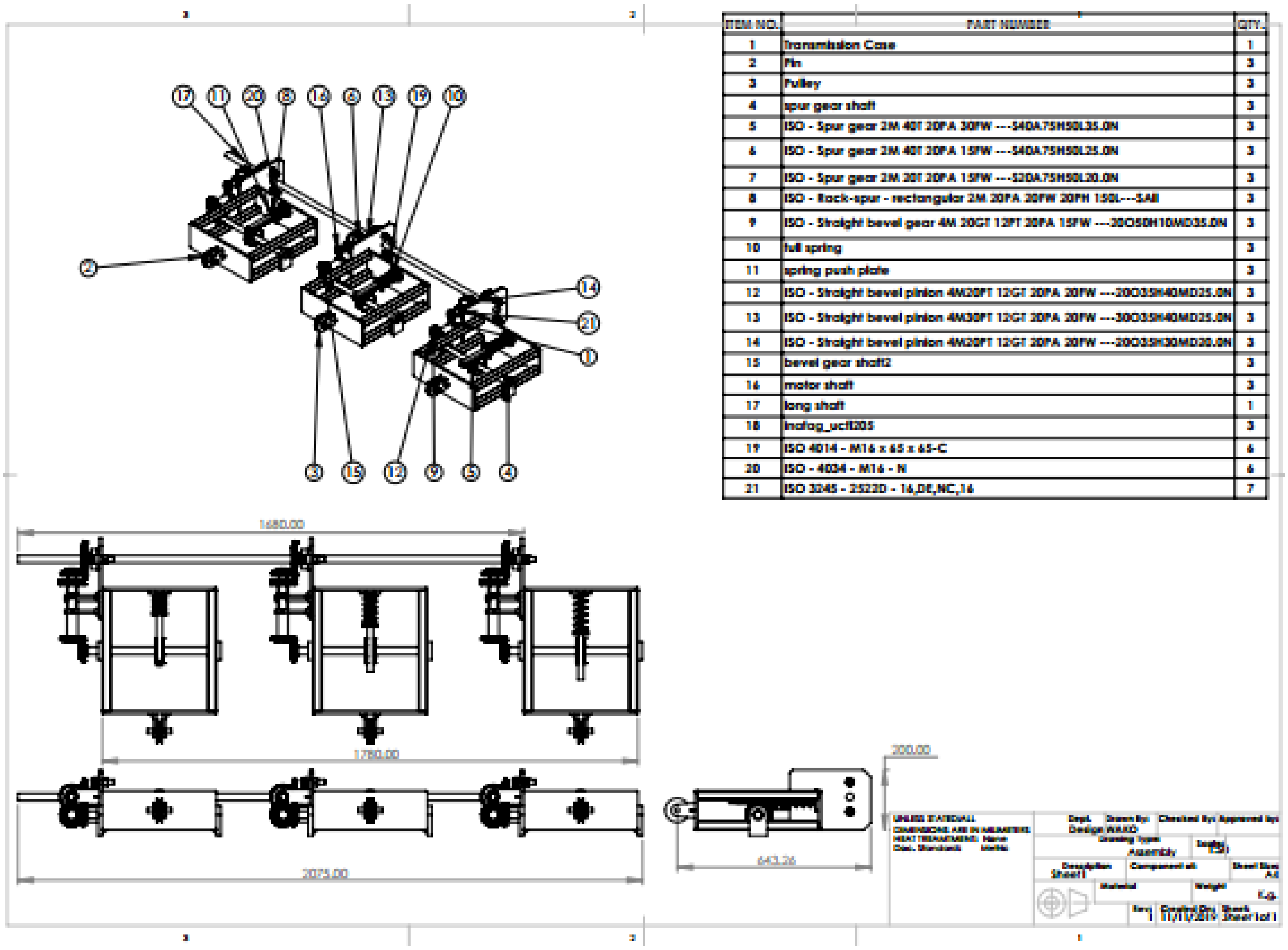
Appendix 2D Straight bevel pinion 4M30PT 12GT 20PA 20FW



Appendix 2E Transmission case



Appendix 2F Transmission unit 1



ITEM NO.	PART NUMBER	QTY.
1	Transmission Case	1
2	Pin	3
3	Pulley	3
4	spur gear shaft	3
5	ISO - Spur gear 2M 40T 20PA 30FW ---S40A75H50L35.0N	3
6	ISO - Spur gear 2M 40T 20PA 15FW ---S40A75H50L25.0N	3
7	ISO - Spur gear 2M 20T 20PA 15FW ---S20A75H50L20.0N	3
8	ISO - Rack-spur - rectangular 2M 20PA 20FW 20PH 150L---SAll	3
9	ISO - Straight bevel gear 4M 20GT 12PT 20PA 15FW ---20O50H10MD35.0N	3
10	full spring	3
11	spring push plate	3
12	ISO - Straight bevel pinion 4M20PT 12GT 20PA 20FW ---20O35H40MD25.0N	3
13	ISO - Straight bevel pinion 4M30PT 12GT 20PA 20FW ---30O35H40MD25.0N	3
14	ISO - Straight bevel pinion 4M20PT 12GT 20PA 20FW ---20O35H30MD20.0N	3
15	bevel gear shaft2	3
16	motor shaft	3
17	long shaft	1
18	Inafag_ucf205	3
19	ISO 4014 - M16 x 65 x 65-C	6
20	ISO - 4034 - M16 - N	6
21	ISO 3245 - 2522D - 16,DE,NC,16	7

Appendix 2G