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JIMMA INSTITUTE OF THECHNOLOGY

FACULTY OF ELECTRICAL AND COMPUTER ENGINEERING

(ELECTRICAL POWER ENGINEERING STREAM)

Potential Assessment and Feasibility Study of Standalone PV-Micro Hydro-Biogas Hybrid System for Rural tourist destination (Tulla-Dadiban village, Kafa zone Ethiopia)

A THESIS SUBMITED IN PARTIAL FULFILMENT OF THE REQUIRMENTS FOR MASTERS SCIENCE IN ELECTRICAL POWER ENGINEERING

BY

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JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF ELECTRICAL AND COMPUTER ENGINEERING

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A Thesis Submitted to Jimma Institute of Technology, School of Graduate Studies and Jimma University in Partial Fulfilment of the Requirement for the Degree of Master of Science in Electrical Power Engineering

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Declaration

I, declare that this study entitled Potential Assessment and Feasibility Study of Standalone PV-Micro Hydro-Biogas Hybrid System for Rural Tourist Destination (Study on Tulla-Dadiban Village, Kafa zone, Ethiopia) is my unique work and has not been displayed for a degree or diploma in any other universities, which all sources of materials utilized for the think about have been appropriately recognized.

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Abstract

The majority of Ethiopia's rural, isolated areas are not yet electrified. It is challenging and expensive to extend the grid infrastructure to these isolated places. Rural communities must therefore rely on local energy supply options. Kerosene is utilized for lighting in these places, diesel is utilized for processing and pumping, conventional biomass is utilized for cooking, and dry cells are utilized for radios and tape recorders. But the rising fetched of oil and the hurt that fossil fills do to the environment energize individuals to seek for other, more feasible (in a perfect world renewable) vitality sources. In this study, techno-economic feasibility of PV-micro hydro-Biogas hybrid system with storage battery is analysed to electrify Tulla-Dadiban village in Kafa zone Ethiopia. Also to show the economic feasibility comparison between grid extension and hybrid system cost is analysed. The feasibility of this paper is analysed using HOMER (Hybrid Optimization Model for Electrical Renewable) software.

Resource information about the gross head and flow rate of the river is obtained from direct measurement from the site and from ministry of water and energy of Ethiopia (MOWE). The paper utilized meteorological data obtained from National Meteorological Agency of Ethiopia, NASA and SWERA to estimate the solar energy potentials. The cost information for grid extension is taken from Ethiopian Electric Power Corporation and is analysed using interlinked Microsoft office excel-spread sheet prepared by Universal Electric Access Program. Estimating the electric load and forecasting for the community needs, such as, for stoves, lighting, CFL, radio, water pumps, television and flour mills, is done. Primary school and health clinic and tourism infrastructure are also considered for the community. Finally the resulting optimal system architecture included 10 kW hydro generator, 58 kW PV solar and a 15 kW biogas generator, with a cost of energy (COE) and total net present cost (NPC) of $0.109207/kWh and $376648.7/kWh, respectively. The breakeven grid extension distance is found to be 12.78 km, which implies that this hybrid energy system is cost-effective for areas greater than the breakeven distance.

Keywords— Homer, photovoltaic, hydro energy, biogas energy, PV-micro hydro-biogas hybrid, Standalone system

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Abbreviations

CFL Compact fluorescent lamp

CO_2 Carbon dioxide

COE Cost of energy

CSP Concentrating solar power

ECC Energy control centre

GERD Great Ethiopian Renaissance dam

GPS Global positioning system

GR Gasification ratio

GWh Giga watt hour

HOMER Hybrid optimization model electric renewables

HPP Hydro power plant

Kwh Kilowatt hour

LHV Lower heating value

MOWE Ministry of water and energy

Mtoe Million tons of oil equivalents

Mwh Megawatt hour

NASA National Aeronautics and Space Administration

NPC Net present cost

NMSA National Meteorological Service Agency

NREL National Renewable Energy Laboratory

PV Photo voltaic

RET Screen Renewable Energy Technologies Screen

RoR Run of river

SWERA Solar and Wind Energy Resource Assessment

Twh Terawatt hour

Chapter one

Introduction

1.1 Background of study

The vast majority of Ethiopia's people live in rural areas. The majority of them are not electrified. As a result, non-electrified rural areas can gain access to power through either a standalone system or by extending grid transmission lines. Despite Ethiopia's abundance of renewable energy resources, a chronic scarcity of electricity supplies in rural areas has emerged. One probable explanation is that these places are either remote from the national grid or have a low population density. Grid extension to Ethiopia's rural areas is difficult due to the country's limited economic capability, high transmission costs, and very low load factor in these areas [1]. Due to the high cost of fuel, which causes land degradation and deforestation, the inhabitants in these areas rely on kerosene, firewood, cow dung, and other traditional biogas resources to meet their energy needs. So this study attempted to change this scenario and discovered that using renewable energy as an energy source, such as micro hydro, photovoltaic (PV), and biogas hybrid power systems, is the solution to the above problem. Hybrid systems are the most widely used and cost-effective rural electrification energy sources [2]. As a result, giving electricity to the local community through a hybrid system will assist them enhance their lifestyle while simultaneously reducing deforestation and providing a good infrastructure. Different researchers evaluated the numerous configurations of renewable energy resources, such as solar energy, wind energy, micro hydropower, and their hybrid configurations, using various Technology options and methodologies. The primary goal of this study was to use HOMER software to examine the techno economic feasibility of a standalone Micro Hydro-PV-Biogas with storage battery hybrid system for the Tulla-dadiban tourist area.

1.2 Motivations

This study looked at the possibilities of solar radiation, biogas, and micro hydro power for rural populations in a tourism region named Tulla-dadiban hot springs in Gimbo woreda, Kafa Zone, Ethiopia. Dadiban holly hot spring is 52 kilometres from Bonga and 34 kilometres from Uffa town in the Gimbo district. It is a well-known hot spring in Ethiopia that is utilized to protect and cure many types of diseases, fungus, external parasite...etc. for the local community, as well as to provide recreational value for international tourists. Another attractive aspect of Dadiban holly

hot spring is that it is surrounded by natural forest and pure water. In addition, the forest is home to a variety of rare creatures and birds, which could provide further opportunities for tourists. As a result, tourists are drawn to it. This location is known as Holly Hot Springs because the locals regard it as a spiritual location. Tourist accommodation is in adjacent towns due to a lack of utilities such as electricity, hotels, lodging, restaurants, and others. They only visit and recreate during the day because their time is restricted. As a result, tourism to this location is poor. The community and government have lost a significant portion of their tourism revenue. Also, due to the difficulty of providing electric access by extending the grid, residents have house electric needs. However, by exploring for alternate resources, such as a standalone Solar-micro hydro-Biogas hybrid system as a source of energy to provide electric access to the rural community and for the anticipated infrastructure facilities for this tourism area, this difficulty can be mitigated. Lighting, water pumping, school and health clinic equipment load, television, radio, flour milling machinery, and local food (Injera) baking have been proposed as community loads. The simulation and optimization of this off-grid renewable energy system were performed using HOMER software input data such as electricity load, climatic data sources, the economics of the power components, and other parameters in which the NPC must be minimized to select an economically feasible power system.

1.3 Statement of a problem

Ethiopia has an abundance of renewable energy resources. However, most remote settlements in a country lack access to power. It is due to a lack of alternative energy supply choices other than grid extension. Extending the grid for this rural area is tough because the residents live far from the grid and are dispersed geographically. This necessitates the extension of transmission and distribution lines, as well as the installation of substations, which necessitates a longer time frame and more expenditure to connect rural areas/villages. Furthermore, to meet their energy demands, these people rely on kerosene, which is becoming increasingly expensive due to rising fuel prices, as well as firewood, cow dung, and other traditional biogas resources, which contribute to deforestation and soil degradation. As a result, other sources of energy, such as off-grid power supply, must be used to bridge the gap between grid power supply and the need for massive expenditure. The resources surrounding Gimbo woreda (Tulla-village) were surveyed and a feasibility study was conducted to evaluate the building of a Micro hydro-PV-biogas hybrid power plant in the area. These resources can be developed at a low cost and with

minimum environmental impact. All of these resources are required for the development of a Micro hydro-PV-Biogas power plant for rural electrification. The neighbourhood lacks access to electricity due to a tiny population of approximately 520 households and an inaccessible position that is far from the major grid. Despite possessing a year-round running river and other renewable resources, the Tulla-dadiban tourist area and the community surrounding this village lacked basic essentials such as light, portable water, education, and stable roads. As a result, the community prioritizes the micro hydro-PV-Biogas power project.

1.4 Research question

In general, the research and analysis has been guided by addressing and answering the following questions:

Resource Assessment- Is that micro hydro/PV/biogas hybrid system configuration optimal model for electrifying Tulla-dadiban tourist destination?

Technical and economic feasibility – Is that micro hydro/PV/biogas hybrid system configuration economically feasible model for electrifying Tulla-dadiban tourist destination?

What are the technical specifications of micro hydro/PV/biogas hybrid during the designing of the system?

What are the energy Consumption sectors in Tulla-dadiban Village?

1.5 Objectives of the study

1.5.1 General Objective- The main objective of this study is to design, model, and analyse the feasibility of standalone Micro-hydro /solar photovoltaic/ biogas hybrid power generation system for the rural tourist destination (Tulla-Dadiban village in Kafa zone Ethiopia).

1.5.2 Specific objectives

- Potential assessment of biogas energy, micro-hydro, and solar PV energy resources. And to demonstrate the techno-economic feasibility of an off-grid hybrid renewable energy system for sustainable remote rural electrification of a village in remote areas of Tulla-dadiban tourism destination in Kafa zone Ethiopia. By performing simulation, optimization, and sensitivity analysis. Assess the current power demand and forecast the load growth of the community around the village.
- Designing and simulating power generation system using HOMER software.

- Analyse sensitivity; evaluate the technical and economic feasibility of the hybrid System by using HOMER.

1.6 Scope of study

The scope of this study is to evaluate the potential, technical and economic feasibility of a rural detached micro-hydro-photovoltaic-biogas hybrid system in the tourism region where Tula-Dadiban uses the HOMER software. This study will explore renewable energy options to meet the energy needs of the village. This study collects and analyses relevant data and information to study and select the most suitable configuration, recommends appropriate measures and necessary measures to install the system to meet current electricity needs and close to the village.

1.7 Significance of the study

The purpose of this work is to conduct a feasibility study and potential assessment for a standalone Micro Hydro-PV-Biogas Hybrid, Off-Grid Energy System in Ethiopian Rural Area. This study can be used as a problem-solving strategy by government and non-governmental groups for comparable and related initiatives, as well as rural electrification. This research focuses on using abundant renewable energy sources such as solar energy, biomass, and micro hydro to solve electrification challenges such as long-distance grid extensions, power supply shortages, and emission reduction. The provision of affordable electricity generated primarily by renewable energies has a direct relationship with poverty alleviation in the country. This research provides an economic analysis to assess energy production. By reducing emissions, a micro hydro/solar PV/biogas hybrid energy system is the ideal answer for the Tulla Dadiban tourist attraction area.
In general, this study will provide a solution to the community's power need for the Tulla-dadiban tourist destination town and the tourism area. Also, if there is a responsible body/governmental or non-governmental group that can work on the project's practical implementation.

1.8 Site location of study area

Tulla-Dadiban is located in the Kafa zone of Ethiopia's Southwest Ethiopian people regional state. It is located at 7°29'0"N 36°14'8"E and has an elevation of 1390 m. The "Gojeb River" was chosen as the water resource to be hybridized with the hamlet's solar and biogas resources for hydropower generating for the communities living in the "Tulla-dadiban and Dadiban holly hot spring tourist destination village." The site is 52 kilometres from Bonga and 34 kilometres from Uffa, both in the Gimbo district.

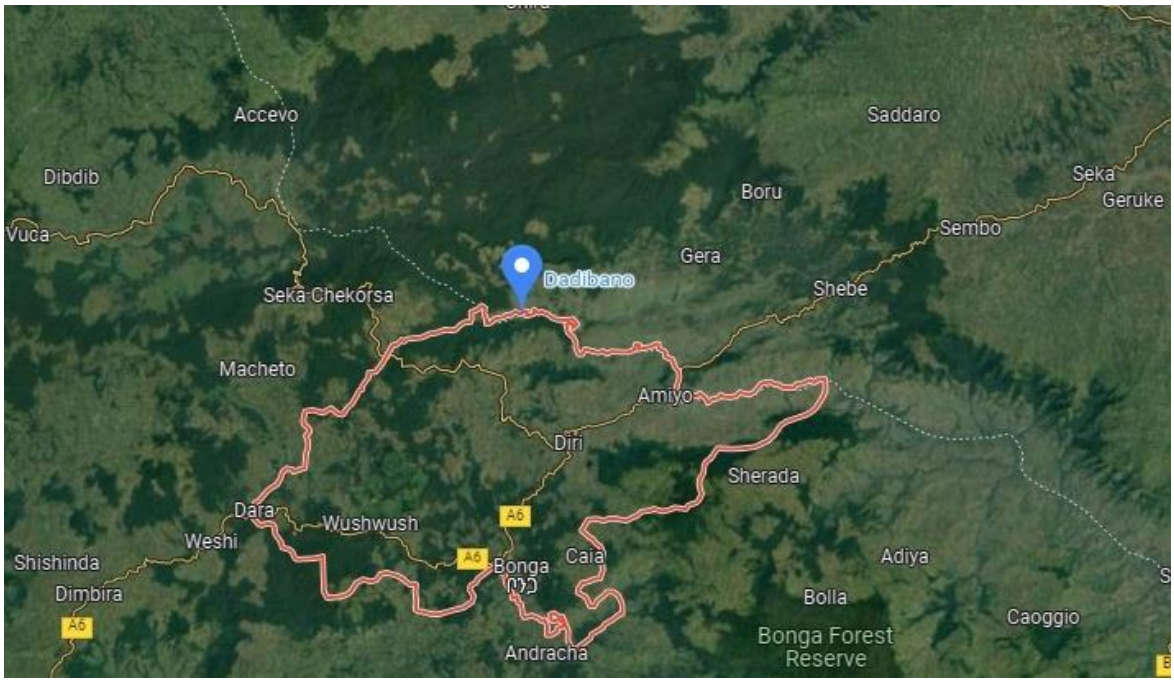


Figure 1.1 Map of the study area taken from Google earth.

Chapter two

Theoretical background and literature review

2.1 Renewable energies

Renewable energy is energy derived from renewable resources that replenish themselves on a human timeframe, such as sunshine, wind, rain, tides, waves, and geothermal heat. Biogas, hydropower, solar, and wind power are the current sources of renewable energy. In comparison to human energy use, renewable energy flows are enormous. As a result, in theory, renewable energy can meet all of our energy needs today and in the future. Currently, traditional biomass contributes for 14% of global primary energy, whereas hydropower accounts for 20% of global electricity [3]. Due to technological advancement over the last ten years, modern renewable energy supply has become competitive in many situations; further technological advancement and industrial learning will continue to drive costs down; and when environmental costs and supply security are considered, renewable energy has even wider markets. Within a century, rerouting a small percentage of naturally existing renewable energy flows might meet all of the world's energy needs [4].

The new renewable energy policy will undoubtedly account for the majority of the energy sector's future growth. Switching to renewable energy will thus help us meet the twin goals of cutting greenhouse gas emissions, which will minimize the effects of future extreme weather and climate change, and ensuring dependable, quick, and cost-effective energy delivery. Investing in renewable energy can considerably improve our energy security. Renewable energy sources are those that are constantly replenished by nature and are derived from other natural movements and mechanisms of the environment, such as geothermal and tidal energy, or directly from the sun (such as thermal, photochemical, and photoelectric energy), or indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or both. The definition of renewable energy excludes fossil fuels, waste from fossil sources, and trash from inorganic sources. Figure 2.1 depicts a high-level overview of renewable energy sources.

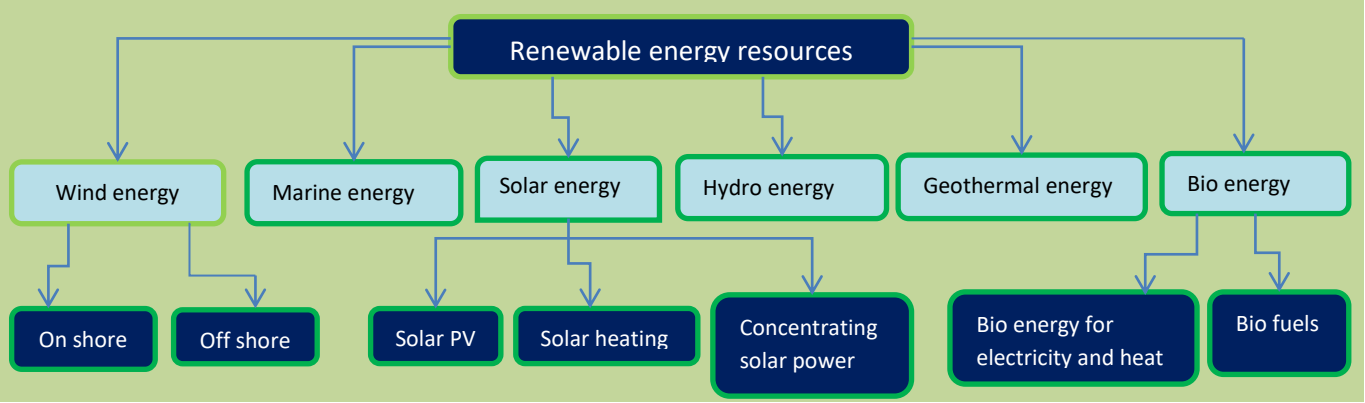


Figure 2.1 Overview of renewable energy resource

Globally, the use of renewable energy has skyrocketed. The renewable energy electricity sector grew by 26% between 2005 and 2010. It currently provides 20% of the world's energy [5]. Although hydroelectric power produces 84% of the world's renewable electricity, other more contemporary renewable energy generation sources have also risen rapidly, increasing their output between 2005 and 2010. Wind has increased the most rapidly in absolute terms. By the end of 2011, installed capacity for solar photovoltaic systems had increased by around 70 GW, expanding at a 50% annual rate. Some of the numerous and abundant renewable energy sources available in Ethiopia include hydro, wind, sun, geothermal, and biomass. Hydropower has a potential of 45 GW, followed by wind at 10 GW, geothermal at 5 GW, and solar at 4.5 to 7.5 GW. Reserves of fossil fuels are also essential. For example, over 4 trillion cubic feet of natural gas and nearly 300 million tons of coal are held in reserve [2]. Despite its wealth of potential, the country has one of the world's lowest rates of access to renewable energy [2]. In 2015, biomass supplied 45.8 million tons of oil equivalents (Mtoe) of the nation's total primary energy supply. According to the Ethiopian ministry of water, irrigation, and electricity, only about 25% of houses are connected to the electric grid. By 2014, the estimated per-person power consumption in the country was 70 kWh, and by 2017, it had climbed to over 100 kWh. This amount, however, is significantly less than Africa's average per-person energy use (500 kWh per capita) [2]. To solve this issue, the Ethiopian government established energy sector strategic goals such as universal access to electricity, increased energy efficiency, the growth of decentralized off-grid power generation, and the export of electricity to neighbouring countries. A number of significant projects, notably Koysha and the Great Ethiopian Renaissance Dam (GERD), are

currently being developed to enhance the nation's energy production [2] and strengthen the nation's position as a major producer and exporter of renewable energy to eastern Africa.

2.1.1 Hydro power

Hydropower is one of the most sought-after types of electrical energy since it is environmentally friendly and has a lot of potential around the world. It is a type of energy derived from the movement of moving water. Turbines can be used to convert the energy generated by flowing water into power. The most common source of hydropower is dams, although alternative technologies that harness wave and tidal power are gradually becoming more prevalent. The natural water flows of rivers, which are pushed by gravity as they move from higher to lower elevations, can be used to generate hydropower. Hydropower is the most frequent renewable energy source and a prominent player in many African power systems. Hydropower is intriguing due to its enormous expansion potential, environmental friendliness, and lower average cost of electricity generation than any other energy producing technology [2]. Small power plants have received a lot of attention in the field of hydroelectric power in recent years. Using the motion power of water to generate electricity is not a new idea; it has been done for over a century, and most countries have some type of water-generated electricity source. Small hydropower plants, being a mature technology, can be used to generate sustainable power in rural areas all over the world. Hydropower plant (HPP) scales range from a few watts to many GW. Itaipu in Brazil, with 14,000 MW, and Three Gorges in China, with 22,400 MW, are the largest projects, producing between 80 and 100 TW h/yr. Hydropower plants are always site-specific and take into account the river system in which they are located. More than half of the world's hydropower is generated in five countries: China, Brazil, Canada, the United States, and Russia [6]. If current projects proceed as planned, hydropower installed capacity will increase by around 180 GW during the next ten years. This increase is about equivalent to one-quarter of the installed capacity. China will account for one-third of this increase, with Turkey having the largest capacity expansions. Brazil and India are also building substantial amounts of capacity. Hydropower plants are classified into three types based on their style of operation and the type of water flow. Run-of-River (RoR), storage (reservoir), and pumped storage HPPs range in size from tiny to huge, depending on the hydrology and terrain of the watershed. A RoR HPP primarily receives its energy for the production of electricity from the available river flow. Since the generation profile is dependent on the local river flow conditions and precipitation and

runoff, there may be noticeable daily, monthly, or seasonal fluctuations in the generation. Such a hydroelectric plant might have some short-term storage, enabling certain demand profile adjustments. Hydropower facilities with reservoirs are known as storage hydropower because they store water for later use. The reservoir decreases dependency on the variability of the inflow because the producing stations are located downstream and connected to it via pipelines. The kind and design of reservoirs are influenced by geography. Hydropower stations with pumped storage can be used as storage spaces but not as energy generators. In such a system, water is typically pumped during off-peak hours from a lower reservoir into an upper reservoir, and the flow is then reversed to generate power at the daily peak load time. Despite being a net energy consumer due to pumping process losses, such a plant can benefit large-scale energy storage systems. Actually, the largest-capacity grid energy storage option that is currently widely accessible worldwide is pumped storage [6]. Hydropower is a tried-and-true and highly developed technology with over a century of expertise. Hydropower nowadays is a very versatile power technology with one of the best conversion efficiencies of all energy sources (90% water to wire), thanks to its direct conversion of hydraulic energy to electricity. There is still room for advancement through operational enhancement, impact mitigation, adaptation to shifting social and environmental needs, and the creation of more robust and reasonably priced technology solutions. In order to convert the potential energy of water at a height into electrical energy, hydropower plants use mechanical energy to drive a turbine at a lower level [6]. Hydroelectricity is produced by processing and controlling the flow of water through a dam. This is one of the most encouraging renewable energy sources. As a result, the hydropower output may be calculated using the following formula while accounting for the gross head, flow rate, and turbine efficiency statistics [1].

$$P_n = H_g * P_{water} * g * Q_d * \eta_t \quad (2.1)$$

P_n = Nominal power,

P_{water} = Density of water,

η_t = Hydro system efficiency

H_g = Gross head and

g = Acceleration due to gravity.

Due to their cost-effectiveness, environmental friendliness, and fuel independence, small run-of-river hydro turbines are an excellent choice for electrifying rural areas. A modest hydropower project needs both water flow and a drop in height known as a head to produce useable electricity [7]. Water is recognized as a source of power when it can perform useful tasks in the natural world, such as turning water wheels and generating electricity at a rate that enables the most efficient and economical production of power.

2.1.2 Solar power

Solar thermal systems use the sun's energy to create hot water, while solar photovoltaic (PV) and concentrating solar power (CSP) systems use it to generate electricity. Systems built all throughout the world over the past few decades provide as proof that these technologies are technologically viable [6]. Solar photovoltaic (PV) technology uses the sun's energy to generate electricity directly. The core element of a PV system is the PV cell, a semiconductor device that converts solar energy into direct current power. PV cells are combined to form a PV module, which can generate up to 200 W. PV modules are just one component of a PV system that also includes a variety of other, more application-specific parts like inverters, batteries, electrical parts, and mounting options. Since PV systems are so modular, it is possible to connect modules to produce electricity in quantities ranging from a few watts to tens of megawatts. The most established solar PV technology is those based on silicon. PV cells used for concentration have extremely high efficiency of up to 40%. There is still research being done on other technologies, like organic PV cells [6]. PV solar combines two benefits. One advantage of manufacturing modules at large facilities is that economies of scale are possible. PV is a relatively modular technology, on the other hand. PV has the benefit over concentrated solar power (CSP) in that it harnesses both the direct and diffuse components of sunlight, so it can still generate power even when the sky is partly cloudy. Compared to CSP, this capacity enables effective implementation across many more global regions [8]. Applications for off-grid and grid-connected solar systems are the two primary types. Off-grid PV systems have significant potential for commercial use in non-electrified regions of developing countries, and during the past several years, off-grid centralized PV mini-grid systems have become a dependable alternative to village electrification. Centralized systems for local power supply have a number of technological advantages in terms of electrical performance, reduced storage requirements, energy availability, and dynamic behaviour. The hybrid PV-wind-diesel systems or centralized PV mini-grid systems with a diesel

generator set as an optional balancing solution may be the most cost-effective options. These kinds of solutions are important for lowering and preventing the use of diesel generators in outlying locations [6]. Grid-tied PV systems feed the generated electricity to the power grid after using an inverter to convert it from direct current to alternating current. System expenses are lower compared to installations that are off the grid since energy storage is not necessary because the grid acts as a buffer. Grid-connected PV systems can be used for either distributed or centralized applications. Grid-connected distributed PV systems are set up to supply electricity to a customer who is connected to the grid or straight to the electrical grid. These systems have a number of benefits, including reduced distribution losses in the electric grid due to installation at the point of use, no need for additional land for the PV system, lower mounting costs if the system is mounted on an existing building, and the PV array itself being used as cladding or roofing material, as in building-integrated PV. Household systems typically range in size from 1 to 4 kW, while rooftop systems on commercial and industrial buildings often range in capacity from 10 kW to several MW. The functions of centralized power plants are performed by centralized PV systems that are connected to the grid. The only purpose of such a system on the electrical grid is to deliver bulk power, and the power it provides is not connected to any particular electricity client. Typically larger than 1 MW and put on the ground are centralized systems. The economic advantages of these systems include the cost-effectiveness of the PV components and system balance on a large scale, as well as the optimization of installation and operational costs through bulk purchase. Additionally, centralized PV systems may be more reliable than scattered PV systems since they can have maintenance and monitoring systems, which may cost less overall [6]. The capacity of the world's solar power generation reached 100 GW at the end of the year with new installations totalling 30.2 GW, an increase of 43.3% over the previous year. Concentrating solar power (CSP) systems generate electricity by concentrating direct-beam solar irradiance to heat a liquid, solid, or gas that is then used in a subsequent process for electricity generation. Large-scale CSP plants often focus sunlight by reflection rather than lenses, which refract light. Concentration can either be to a line or a point, as in trough or linear Fresnel systems, or to a point (point focus), as in central receiver or dish systems. Applications for CSP range from modest distributed systems with tens of kW to enormous centralized power facilities with hundreds of MW. The first commercial CSP plants were the 354 MW solar energy facilities in California that are still in operation today [8]. At the

beginning of 2009, there were more than 700 MW of grid-connected CSP plants deployed across the world, and another 1500 MW were being built. Most plants that have been put into operation use parabolic trough technology. A growing number of plants that are being built or announced have a central receiver. In 2012, the market for concentrating solar thermal power (CSP) grew further, with the total global capacity rising by more than 60% to over 2550 MW. In comparison to 2011, the market doubled, with most of the 970 MW installed coming from Spain. Solar heating and cooling systems collect solar thermal energy and use it to provide hot water, room heating, cooling, and pool heating for household, commercial, and industrial usage. By the end of 2012, a rough estimate of 282 GWth of operational solar thermal capacity has been made. Globally, glazed water collectors can now hold 255 GWth. In order of total installed capacity, the top operating countries were China, Germany, Turkey, Brazil, and India. The global radiation incidence on the PV is commonly calculated using the formula below [9].

$$P_{PV} = \gamma_{PV} f_{PV} \left(\frac{G_T}{G_T, S_{TC}}\right) .... \quad 2.2$$

Where, γ_{PV} is the rated capacity of PV array, meaning it is power output under standard test conditions (S_{TC}) [kW].

f_{PV} = Is the PV de rating factor [%]

G_T= is the solar radiation incident on the PV array in the current time step [kW/m2]

G_T, S_{TC} = is the incident radiation at standard test conditions [1 kW/m2]

αp = is panel temperature coefficient [V_{ov}/k]

Tc = is Cell operational temperature [k]

Tc, S_{TC}= is Cell temperature at standard conditions [k]

2.1.3 Wind power

Wind power is defined as the process by which wind energy is converted into a useful form by a wind turbine, such as wind turbines that generate electricity, windmills that generate mechanical power, wind pumps or dewatering or sail-powered ships. At the beginning of the 20th century, the first wind turbines used to generate electricity were built. Since the 1970s, technology has gradually improved. At the end of the 1990s, wind energy has become one of the most important sources of sustainable energy [6]. The industry has struggled to build wind turbines and power plants that can do this conversion at a reasonable cost because the kinetic energy of the moving

air must first be converted in the generator and then converted into electricity to generate electricity from the wind. .

Theoretically, as the wind speed increases, so does the kinetic energy that can be drawn from the wind. The design of wind turbines focuses on making the most of the wind speed experienced by the wind turbine while considering many factors to reduce the cost of wind power. However, turbines absorb only a small part (40-50%) of the available energy. The purpose of wind turbine design is to reduce the cost and use of equipment, improve equipment and reliability, and improve the wind farm while increasing the turbine size. Between the 1970s and 1980s, research was conducted on offshore wind turbines with horizontal and vertical axis designs.

Although variants varied, particularly the number of blades and the orientation of the blades, the horizontal axis design eventually prevailed. Onshore wind farms, often referred to as wind farms; often have multiple onshore wind turbines. These wind farms usually have a capacity between 5 and 300 MW, although there are smaller and larger ones. Compared to onshore wind energy, offshore wind energy costs are higher and equipment is cheaper. Incentives for the development of wind turbines include: superior onshore energy sources; the ability to use larger wind turbines; the possibility of building larger power plants than on the coast; and the potential to reduce the need for ground transmission [10]. In terms of power reliability, the power conversion of wind turbines is very important. There are three types of power converters for large power lines connected to turbines. In the early days, stall-controlled and step-controlled turbines were often used in conjunction with high-speed asynchronous generators. In these installations, wind turbines are consumers of reactive power that must be supplied by the grid. This model was replaced by a modern turbine gearbox. Double-fed induction generators and full-power converter synchronous generators are the two most common configurations, and both are almost always combined with a pitch-controlled rotor.

These speed changes provide a number of power advantages over previous turbine designs by essentially separating the rotating mass of the turbine from the electrical system. These turbines can provide real power and restore the work needed by grid operators, as well as some troubleshooting capacity. With the addition of approximately 45 GW of new installed power in 2012, the total wind power capacity increased by 19% to approximately 283 GW. As many as 44 countries increased capacity in 2012; by the end of the year, at least 64 of them were reported to

have an installed capacity of more than 10 MW; and 24 of them have more than 1 GW of operation. From the end of 2007 to 2012, total wind power generation capacity grew by an average of 25% annually. Joint trade between the US and China in 2012 was about 60%. Germany, India and the UK are second and third, but the gap is huge. Italy, Spain, Brazil, Canada and Romania are also among the ten potential new countries [10].

The most important factor in predicting turbine performance at a site is the wind resource. Since the wind power is now proportional to the cube of its speed, doubling the wind speed results in eight times the power. The weather itself varies with the time of year, the season, the date, the altitude of the earth, and the type of terrain.

In general, wind energy is the specific kinetic energy contained in moving air. Wind energy can be used directly in mills, sailboats or pumped from generators. Kinetic energy is released when an object with mass rotates or is translated at a certain speed. When the air moves, the kinetic energy of the moving air can be determined by the formula [11].

$$E_k = \frac{1}{2} m u^2 \qquad 2.3$$

Where m is the air mass and $\bar{u}$is the mean wind speed over a suitable time period. The wind power can be obtained by differentiating the kinetic energy in wind with respect to time, i.e.:

$$P_w = \frac{dE_k}{dt} = \frac{1}{2} m \bar{u}^2 \qquad 2.4$$

However, only a small portion of wind power can be converted into electrical power. When wind passes through a wind turbine and drives blades to rotate, the corresponding wind mass flow rate is

$$m = p\mathrm{A}\bar{u}. \qquad 2.5$$

Where p is the air density and A is the swept area of blades Substituting equation (5) into (4), the available power in wind P_w can be expressed as

$$P_w = \frac{1}{2} p\mathrm{A}\bar{u}^3. \qquad 2.6$$

The test of the above model shows that to get more wind power, faster wind speed, longer blades must have larger pores and faster airspeed. Since wind power output is proportional to the cube

of the average wind speed, a small change in wind speed will cause a large change in wind power [12].

2.1.4 Biomass

Biomass products include agricultural residues, forest crops (in the form of sawdust, charcoal, residues), agricultural crops, energy crops, animal manure, agro-industrial and food processing residues, municipal solid waste and other biological resources. These resources can be used directly for energy needs (fire, electricity, manure, etc.) and better (such as biogas, biofuels, bioelectricity, hydrogen, etc.) for both domestic use and business and transportation. Biomass is the oldest form of fuel used in human history and was the main source of global fuel economy until the mid-18th century [13]. It constitutes 35% of the primary energy used in developing countries, approximately 14% of the total primary energy consumption in the world, and is the only renewable energy source.

It is used for various energy needs such as electricity generation, home heating, fuel and process heating for factories. It is the oldest oil used by humans and was the mainstay of the global oil industry until the mid-18th century [14]. Biomass energy comes from three sources: agricultural residues, forest residues and energy crops. High fossil fuel prices and national security concerns have fuelled interest in the development of bio-based fuels across the continent. Therefore, studies have shown that biomass-based energy can help reduce emissions [15]. Biomass is a general term that includes physical or vegetable biomass and fine biomass or animal biomass/cow dung. Research shows that renewable energy from biomass sources can play an important role in the current global strategy to reduce carbon emissions by replacing half of fossil fuels. The research identified six biomass resource groups for energy production: crops grown on residual crops, crops grown on degraded land, agricultural residues, forest residues, animal manure, and organic waste [16]. The cultivation of biomass energy is believed to have many benefits for the energy security and livelihoods of rural households. A recent study shows that biomass energy is important not only for energy use in sub-Saharan Africa, but also for employment and poverty reduction.

The author's conclusion is that the production and use of more biomass energy should first be encouraged, rather than withdrawn as the so-called "renewable fuel". A case study of a farming village in Shandong, China, shows that biomass produced from agricultural residues provides

livelihoods, increases villagers' income and reduces greenhouse gas emissions. Using India as an example, a study was conducted on electricity generation using biomass gasification and found that biomass energy has many advantages such as wide availability and distribution, making it a leader in renewable energy sources [2]. From the perspective of industrialized countries, a study using French data analysed the choice of local electricity and gas consumption and concluded that wood looks competitive and good at a time of rising oil prices and increasing demand to combat global warming on the environment. The authors see wood as an excellent alternative to polluting fossil fuels, providing local production resources and sustainable materials for the EU.

Therefore, biomass is recognized worldwide as a renewable energy with the greatest potential to meet the energy needs of modern people in industrialized and developing countries [17]. In addition, the use of forest biomass has become an important strategy in the United States to meet various environmental and energy needs. While biomass is beneficial to the world's energy balance, it is used in important and ineffective processes in developing countries, and it also causes negative effects on human health, environment and health. Biomass-based electrical schemes currently provide more than 9GigaWatts of the world's power generation capacity [18].

2.2 Standalone and hybrid energy sources

2.2.1 Standalone energy sources and its features

Standalone energy sources generate electricity independently and are therefore called standalone generators. These are better for rural areas where the grid is weak and no other energy source is available. Most photovoltaic installations in remote areas of the world are standalone power supplies, as they are often the best choice for applications away from the grid. Examples include manufacturers of power supplies and precision electronics for lighting and other remote applications, emergency services or military applications. The disadvantages of standalone systems are low capacity, high battery costs and low energy storage capacity force people to throw away the product and use more electricity.

Such a standalone renewable energy must have sufficient storage capacity to process large amounts of energy. It has disadvantages when compared to the Hybrid Renewable Energy System (HRES). It has a single generator [19].

The main disadvantage associated with the independence of resources is that they are unreliable and do not work well due to their interactions and weaknesses, which often leads to system

growth and therefore increased investment, cost [20].

2.2.2 Hybrid energy sources and its features

The biggest advantage of renewable energy is that it can create hybrid systems with other energy sources. In general, a hybrid energy system is a system with two or more different energy sources working together to provide electricity or heat [21].

Hybrid renewable energy can operate on or off the grid. Independent grids are used, along with diesel generators, to generate electricity in rural and remote areas. In a hybrid power system, electricity generation (photovoltaic panels, wind turbines, hydro turbines, and biomass generators) and battery storage devices must be built to meet the needs of homes, farms or facilities far or near, rural or urban.

In general, hybrid power systems are designed to ensure the reliability of electrical power sources and/or because renewable energy can be cut off at any time in a power system with a renewable energy source. The main purpose is to increase the strength of the load. They aim to reduce the cost of electrical energy in the electrical power produced by similar electronic devices [2].

Research shows that researches are concentrated on photovoltaic/grid, photovoltaic/hydroelectric, photovoltaic/hydroelectric/diesel engine and photovoltaic/biogas generator. Today, the use of fossil fuels to produce energy is harmful in terms of carbon emissions [23].

The most popular idea in the world is renewable energy because of its low carbon and usage pattern. When we do research, we look at global trends in hybrid or standalone renewable energy systems. Since renewable energy systems depend on natural conditions, it is not possible to get good results from every system. For example, the sunshine hours will be different, and the base hybrid photovoltaic/hydro/biogas system will provide continuous hydro and biogas during the absence of sunshine. In such a hybrid system, a biogas generator is operated to ensure safety when there is no water and sun exposure [5].

Some of the advantages of hybrid renewable energy systems are Continuous power supply, making the best use of renewable energy sources, low maintenance cost, high efficiency, power management and low emission.

Continuous power supply: Another successful example is the hybrid solar and battery system. As the associated batteries store energy, hybrid solar systems deliver constant power. In the absence of the sun and energy production throughout the evening and night, this is also helpful. The uninterruptible power source is still available and the batteries have a backup device.

Hybrid Hydro and Solar System: This is a healthy example. Hydro energy can be used instead when there is no solar radiation in the evening and other energy sources are insufficient or inefficient. As a result, the system's ability to produce energy continuously is guaranteed [24].

Making the best use of renewable energy sources: Hybrid Solar and Battery System: Because batteries are incorporated into the system to store energy, extra energy produced on sunny days is not wasted. Since they store energy on good days and use it on poor ones, these systems maximize the utilization of renewable energy. Balance is preserved.

A small hybrid electricity system that combines solar or wind technologies—or can even employ just one system—offers a number of benefits. The summer time wind speed is low since the sun's rays are greatest and brightest during this time. Winter time winds are strong because there is less sun energy available. The balance is preserved [12].

Low maintenance cost: When compared to traditional generators, hybrid solar and battery systems are less expensive to maintain. Fuel is not utilized, and maintenance is not necessary frequently.

Hydro and Solar Hybrid System: Because they don't have any moving parts, PV systems have the lowest maintenance and failure costs. Manufacturers of PV systems can therefore guarantee a lifespan of around 25 years. Hybrid energy systems are now practicable and cost-effective because to improvements in power electronics converters and automatic control systems, which also reduce the need for maintenance [25].

High efficiency: Under certain circumstances, hybrid solar/hydro/biogas systems outperform conventional generators that lose fuel. Systems that combine solar, hydro, and biogas operate effectively under all circumstances without wasting fuel.

System that combines solar, hydro, and biogas is particularly suited for industrial facilities. An important benefit is the minimization of the yearly cost system and the chance of power supply loss [26].

Power management: Depending on the devices they are connected to, a hybrid system's energy supply can self-adjust depending on whether it is a high-power plant or a dwelling that requires less electricity [27].

Low emission: By utilizing renewable resources to their fullest potential, hybrid energy systems seek to lower the emission rate. Clean and renewable resources have a number of benefits, including a decreased reliance on fossil fuels, access to free resources, and a decrease in the amount of harmful emissions into the atmosphere [11].

2.3. Design and modelling considerations of hybrid energy sources

2.3.1. Potential and feasibility assessment

The key concerns of the feasibility research and potential evaluation for rural electrification are the technical and resource potential.

The theoretical potential of energy in a location is represented by potential sources. Analysis of resources, business, technology, market potential, and production based on data and cost projections is on-going [28].

Technical potential calculates a RE technology's capacity after taking topographic restrictions, land-use restrictions, and system performance into consideration (solar PV, wind, etc.). By excluding areas that are not technically possible for development, this is evaluated using GIS. Using available resources, available land, and a variety of system assumptions, technology-specific system modelling determines the maximum amount of electric power that may be generated.

To determine areas of research that might help in the creation of improved electronic devices, feasibility study can be started. The business analysis research areas are technology cost, incentives, and energy costs, among others, and are based on the feasibility analysis. Developers will be asked to declare their interest in the locations with the greatest potential for economic development during the next round of the REZ process.

Economic, technological, social, and environmental issues have hampered the adoption of new energy sources made from renewable resources. The analysis of the amount of energy that can be produced from various sources and its effects on the environment should be done in order to evaluate the potential of renewable energy.

The development of techniques for forecasting future energy usage as well as for calculating and evaluating environmental effect is the basis of this analysis. The theoretical and practical

potential for the production of renewable energy must be distinguished. According to [28], the theoretical potential is constrained by what is currently economically practical, environmental and land-use constraints and potential conflicts with other businesses. Figure2.2 [21] shows the schematic representation of energy potential and the distinction between theoretical, technical, realistic and realizable potentials. The whole physical amount of energy for a certain source is its theoretical potential.

- The whole physical amount of energy for a certain source is its theoretical potential.
- Technical potential: How much energy can be used given current technology.
- Technical potential: How much energy can be used given current technology.
- Realistic potential: The amount of potential that can actually be used when obvious obstacles and obstacles like social acceptance, environmental factors, and local disputes have been taken into account.
- Realizable potential is the amount of energy that can be used in a specific amount of time. The economic situation and the production capacity of the world market both affect this energy potential.

Hydro power potential- In recent years, hydroelectric power plants have emerged as one of the principal energy sources for producing electricity. Hydroelectric power accounted for roughly 16% of the world's electricity consumption in 2012. Compared to other electricity sources, hydropower provides a number of advantages. Water is one of the factors that make hydroelectric power a renewable source of energy. Hydroelectricity is a quick and simple way to transfer energy into electrical output [29].

The projected 283 GW of power generation capacity in Africa, approximately 8% of the world's capacity, can produce about 1,200 TWh annually. This quantity of electricity is more than three times what sub-Saharan Africa now uses. However, less than 10% of the technology's potential energy has been utilized thus far [2]. As a result, the over 620 million people in sub-Saharan Africa who depend on renewable energy sources to meet their daily energy demands have limited access to energy.

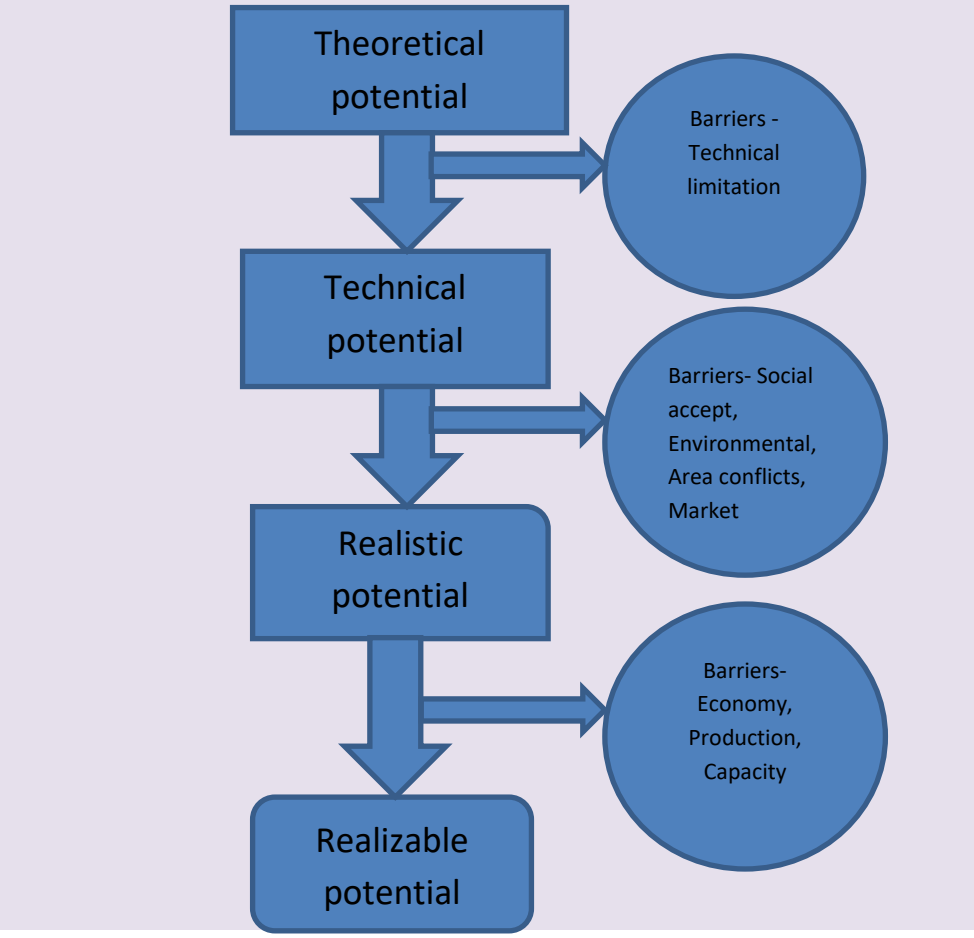


Figure 2.2 Schematic presentation of energy potential

Most of the nations in this region have an average energy access rate of less than 20%. One of the nations in sub-Saharan Africa, Ethiopia is blessed with an abundance of rivers, lakes, and water resources, which account for 20% of the continent's total technically possible potential. With this potential, Ethiopia is frequently referred to as Africa's powerhouse. Less than 10% of the nation's potential has, however, been used thus far [2]. The nation's surface runoff produces over 122 billion cubic meters of water annually. Many North African rivers, including the Abbay (Blue Nile) River, Atbara River, Sobat River, Shebele River, and Juba River, originate in the Ethiopian highlands. Eight of Ethiopia's eleven major river basins have been identified for their potential to provide hydroelectric electricity. Around 300 hydropower plant sites with a combined technical power potential of 159,300 GWh/year have been identified in the eight river basins. 102 of those possible sites are big scale (capacity greater than 60 MW), and the remaining 102 are small scale (capacity lower than 40 MW) [2]. 14 hydroelectric plants, which

make up over 85% (3.8 GW) of Ethiopia's total installed capacity and the country's main energy source, provided the majority of the country's 4.5 GW of installed capacity for power generation in 2018 [30]. The nation's theoretical annual hydropower capacity is 954 TWh, with a potential of 286 TWh, according to estimations [31]. The country has begun construction on a number of large hydroelectric projects, including the enormous 2,160 MW Gilgel Gibe IV (Koysha) hydropower project and the 6,500 MW Ethiopian Renaissance Dam (GERD) being developed at Abbay (Blue Nile). It will be the largest lake in Africa and the sixth-largest lake in the entire planet [2]. A significant renewable energy source that can assist nations in making the shift to a more energy-efficient environment is hydropower. In light of this, the Ethiopian government has acknowledged hydroelectric electricity as a financially sound and eco-friendly choice [12]. However, as the drought worsens, hydroelectric power plants become less reliable; to address this issue, the nation must diversify its electricity mix and add comparable energy sources, such as wind and solar, to it.

Solar energy potential - Solar energy is the energy that the sun radiates and is utilized to excite electrons by tapping into light photons [29]. Solar energy is currently employed worldwide and has seen significant growth thanks to numerous energy investment firms. The NASA Surface Meteorology and NASA solar energy webpage provides daily averages of the sun radiation measured on horizontal surfaces. The average daily global solar radiation is 6kWh/m2. Between July and September, there is a relatively low level of global radiation because it is gloomy and rainy throughout this time. In addition, the clearness Index's average monthly value is approximately 0.612. The solar radiation percentage in the upper atmosphere that reaches a particular point on earth as a solar radiation existence information provider on the earth's surface is known as the "clearness index" [40]. Solar radiation and cleanness index data can be acquired by entering the research location's latitude, longitude, and time zone [29]. If the information is provided correctly, the average radiation per hour will be used to assess the viability of solar installation panels as a renewable option for the load. For the finest photovoltaic panel data, 5–6 hours of typical exposure per year are needed [31].

Africa has a large amount of solar energy potential, with much of the continent experiencing yearly irradiance levels above 2000 kWh/m2. According to estimates, Africa's theoretical solar PV capacity could produce more than 660,000 TWh of power annually, which is more than the

entire continent requires. However, the installed capacity of solar photovoltaic systems is only 5 GW, or less than 1% of the total installed capacity of the planet. Solar energy has the potential to rank among the most significant energy sources in Africa if it is properly designed, implemented, and governed [2]. East Africa is thought to have the biggest theoretical potential of all the African regions, with over 200,000 two produced year. East African nation of Ethiopia has an abundance of solar energy. 5.2 kWh/m2/day is the national average for yearly irradiance [21]. The country's most populous northern, central, and western highlands receive little sunlight, whereas the Rift Valley, western, and eastern parts receive more than 6 kWh/m2/day of annual irradiance on average [2]. Only approximately 14 MW of solar energy is used in the country, despite the fact that there is enough of sunlight, for communications, lighting, water pumps in rural areas, and heating in large towns. Enel Green Power (EGP) was chosen as the preferred bidder for one of the projects in Metehara in Ethiopia's recent announcement of the first tender for the construction, ownership, and operation of three 100 MW photovoltaic solar projects. The remaining regions around Clay and Humera did not benefit [2]. A 125 MW solar power plant, the first phase of Scaling Solar Gad in the Somali area, and the first phase of Scaling Solar Dicheto in the Afar region are also planned for installation by the nation [32]. However, until recently, PV-based technologies (such as thread radio remote sensing and antifreeze) were only used in free projects in rural areas of the country to supply the demand for electricity [33]. As a direct option for rural families that are off-grid and not covered by short-term concentration projects, off-grid solar solutions should thus be given priority by the government for rural households with lower electricity needs. One of Ethiopia's tourism spots is Tulla-dadiban. The photovoltaic power capacity is 70.0 Kw, the installation average output is 58.7 Kw, and the capacity is 20..7%, according to the location of the research area, 29°34/ latitude and 79°54/ longitude, and solar radiation data provided by HOMER. The total production is 97,171kWh/year.

Biomass energy potential – A renewable source of power and fuel with a wide range of applications is bioenergy. It takes days for the anaerobic fermentation of biomass by bacteria to produce a mixture of combustible gases according to the theory of bioenergy. The fermentation of biomaterials occurs naturally in marshes and other low-oxygen environments, such as swamps [34]. Remains from agriculture are a reliable source of bioenergy. For instance, heat can be used to process wood and crops to create energy, biodiesel from vegetable and animal oils, or ethanol

from starch. Animals can also produce bioenergy. Biogas is created when animal dung in the soil breaks down and composts.

Human activities such as the fermentation of sewage or household trash can also produce biogas. Anaerobic techniques currently in use generate less waste than aerobic fermentation [29].
Stable biomass is the largest energy source in sub-Saharan Africa, accounting for around 70% of the continent's total energy consumption. In sub-Saharan Africa, solid biomass accounts for around 280 million tons of oil equivalents each year, or 90% of household energy use. Gas wood, straw, charcoal, or dried animal and human waste make up the majority of this fuel, which is typically used for cooking. A projected 730 million people in sub-Saharan Africa's population of 915 million people no longer have access to simple cooking facilities [2]. Although biomass has a significant advantage for the global mix of renewable energy sources, it is typically used inefficiently in sub-Saharan African countries, leading to excessive deforestation that has a negative impact on the environment, human fitness, and social wellness. Therefore, the efficient and environmentally friendly use of biomass to provide modern electricity services to the arena's poor remains essential for the growth of community [9]. One of the developing nations in sub-Saharan Africa with a high level of household energy use is Ethiopia. This consumption is frequently made pleasant through excessive biomass burning. According to statistics from the International Monetary Fund from 2010, 83.2% of Ethiopia's population lives in rural areas, where modern electricity options are infrequent and people primarily rely on traditional biomass electricity sources, including wood, cow dung, and agricultural waste, for cooking and heating. Even if there is a sizable amount of power accessibility in urban areas, the majority of utilities are still powered by traditional biomass energy sources. In rural regions, all households utilize traditional biomass for cooking, with the exception of 0.2% of kerosene-using households and 1.2% of charcoal-using households [35]. Table 2.1 presents Ethiopia's anticipated exploitable biomass potential and actual exploited potential separately.

The model's prediction of the nation's energy demand shows that it will increase by 3.5% annually from 194 TWh in 2000 to more than 527 TWh by 2030 [2].

Table2.1 Ethiopia estimated exploitable biomass potential and currently exploited potential

No	Resource	Exploitable potential (million tons per year)	Currently exploited (million tons per year)
1	Woody biomass	74	60
2	Crop residue	38	4.9
3	Dung	29.8	7
	Grand total	141.8	71.9

A World Bank analysis predicts that by 2025, there would be a significant increase in the number of renewable energy power plant installations, with roughly 500 MW of biomass capacity being added to the mix [24].

One of Ethiopia's rural tourist spots is Tulla-dadiban. After satisfying the demand for cooking, the research area's average monthly biomass yield is 1.88t/day. The resource contains 287 kWh of energy every day, and with the thermal engine operating at 30% efficiency, 86 kWh of electrical energy per day can be produced, resulting in a maximum 3.86 kW electrical generator.

2.3.2. Percentage of energy not utilized

Utilizing renewable energy sources has improved recently in terms of appeal, cost, and importance. To ensure continuity in delivering the demand, a storage system and/or backup source are required because to the variable and intermittent nature of renewable sources [20]. In order to overcome any inherent restrictions, hybrid energy systems combine two or more energy conversion sources (electricity/heat generating, and/or storage devices) [12]. This hybrid system can be regarded as a hybrid renewable energy system if one of these energy sources is renewable. When hybrid systems function well, the system's total efficiency rises and it becomes a more dependable source of energy. Hybrid renewable energy systems can also dramatically lower production costs and environmental implications. The use of hybrid systems, which combine renewable energy sources with backup energy sources and energy storage, lessens the constraints of renewable energy sources and creates investment opportunities where there might otherwise be none. The best qualities of various, yet complimentary resources are combined to create hybrid systems [36]. A criterion to control the power flow between various sources should be defined for systems where more than one energy source is employed to supply a load.

This management strategy ought to specify the order in which the energy should be distributed among the various sources. The goal for the system under consideration in this study is to use

renewable energy sources (such PV panels) and energy stored in battery banks as efficiently as possible. These standalone hybrid systems can address demand-generation mismatches by using one or more non-renewable (such as micro turbines) or renewable but schedulable (such as biomass) standby resources in the event that these sources are unable to meet the load demand. If the amount of energy generated is greater than what is needed to power the load and the battery, if one is present in the hybrid system, is full and unable to store any more energy, there will be excess energy that must be either discharged or used for ancillary services (or another purpose) in order to keep the system's power balance. When developing standalone hybrid systems, several configurations can be used to efficiently use the available renewable energy sources and to meet client demands. It is feasible to use any number of renewable energy sources together, however it might be necessary to add a backup source and/or storage system. A feasibility study based on life cycle cost analysis and consideration of the site's climatic data should be carried out to determine the configuration that is best suitable for each location.

The high capital cost of renewable energy systems in comparison to conventional ones is one of its disadvantages. Some steps that can be made to lower their capital costs include the use of hybrid systems that integrate many energy sources and the size optimization of each component used in these systems. One strategy for lowering the cost of energy (COE) production for freestanding hybrid systems can be thought of as the efficient use of any excess energy that hasn't been used by the load or to recharge the battery. In fact, if the extra energy is not released, it could cause an overload, which could harm the battery. Additionally, it could result in over voltage’s in freestanding hybrid systems, which might then negatively impact any attached equipment. The conventional method of dealing with this surplus energy is to use dump loads to consume it. When the target voltage of the battery bank is attained, a controller typically diverts the excess power away from the battery banks and sends it towards the designated (dedicated) dump load. These resistors' values should be chosen to allow for adequate current flow. As the majority of the manufacturers of this power electronic interfaced renewable energy systems typically include these diversion control circuits inside their products [9]. The diversion control circuit may be included in the charger regulator circuit, the inverter circuit, or the rectifier circuit. Many scholars have proposed alternate solutions to deal with this extra power in various regions throughout the world instead of dumping it through a dump load.

According to a study by Demiroren and Yilmaz [37], the best scenario for meeting the island of Gokceada's electrical needs is one that is built using wind turbines. It was discovered that the extra energy constructs around 64.2% of the overall electrical production for this optimum scenario.

Sen and Bhattacharyya [37] discovered that 25% of the total energy produced by a hybrid system, which is built using a PV system, wind turbines, a hydropower system, and bio-diesel generators, goes to dump loads in another study done for the instance of remote locations in India.

Ipsakis et al. [38] observed that with a standalone system made of solar panels and wind turbines without any storage device, extra energy is accessible 56.4% of the time. Simulated trials were used to conduct this evaluation in the Greek district of Xanthi. Rehman and Al-Hadhrami [39] discovered that the extra energy from a PV/battery/diesel generator hybrid system was 0.67% of the total generated energy, where the PV penetration was 21%. This study was also carried out for Saudi Arabia. They claimed that if the PV penetration rose to 42%, this percentage would rise to 9.94%. In a PV/diesel generator/battery system with a 20% PV penetration, an examination of a case study for a rural remote area in India showed that there was 0.48% extra energy[38]. According to Moghavvemi et al. [40], 16.3% of the total energy generated was generated in excess but was not used. A hybrid PV/battery/diesel generator system was used to power a remote-controlled commercial large-scale FM transmitter.

It can be deduced from the studies that have already been reviewed in this section that the amount of excess energy produced by any hybrid renewable energy system depends on the types of energy sources used in the hybrid system, the sizes of these components, the availability and profiles of the meteorological quantities, and the variations in the load profile with respect to variations in meteorological quantities.

2.4 Hybrid energy system modelling and optimization tools

Hybrid system solution is complicated and for that reason it calls for software equipment which can be used for design, analysis, simulation, reasonably priced and optimization planning. Now day’s simulation has been given international utility. Consequently software’s are growing to be reasonably-priced and smooth to learn. A number of software programs have been advanced to triumph over issues regarding to greatest designing or sizing which leads to set up cost high.

Some major hybrid system simulation software's tools are tabulated in table 2.2, with their manufacturer or growing institutions and availability.

A. HOMER- HOMER means Hybrid Optimization Model for Electric Renewable. It is most widely used Software. HOMER is developed for National Renewable Energy Laboratory (NREL) USA by Mistaya Engineering, Canada in 1993 [12]. It works on three principles Simulation, Optimization and Sensitivity analysis. Simulation performs energy balance calculations based on system configuration. Optimization operation displays list of configurations based on total net present cost. The system takes account the calculations for installation, replacement, operation and maintenance, fuel and real interest costs. Sensitivity analysis determines varying factors such as biomass price, interest rate.

HOMER evaluates design for standalone and grid connected power system. It displays simulation results in a various forms of tables and graphs which help to compare configurations and evaluate them on their economic merits [41].

B. RET Screen- Renewable Energy Technologies Screen (RET Screen) is developed in Canada by Ministry of Natural Resources for evaluating economic and environmental cost. It is freely available tool. It has database of a global climate more than5000 ground Stations energy resource maps, hydrology data, product data. Two versions of RET Screen are available, RET Screen Plus and RET Screen4. Energy performance study is done by RET Screen Plus. RET Screen plus is a Windows-based energy management software tool. RET Screen4 is based on Microsoft excel and works on energy project analysis. It provides energy analysis, cost analysis, sensitivity or risk analysis, emission analysis, financial analysis for user listed below [42].

C. PVsyst- PVsyst is used for grid-connected, stand-alone, pumping and DC-grid systems. It performs sizing, simulation and data analysis [43].This software has multi-language interface in English, French, German, Spanish and Italian. Working platform of this software is Windows 7, windows 8, Vista. PVsyst proposes multiple objects to illustrate shading parameters and capability to define multiple PV fields and simulate PV systems with assorted directions. This gives output as graphs of the behaviour of components, behaviour of electrical PV array under partial shading, on graph comparison with clear day model, generation of metro hourly synthetic files from monthly values, quick metro calculations on hourly metro plots and irradiation calculation. Its latest Version 6.35 is release on 24.03.2015 [44].

Table 2.2 free version tool software

Software name	Manufacturer/Developing institute	Advantages
HOMER	Mistaya Engineering, Canada	• It has hourly data handling capacity. • It provides results in graphical and tabular form. • HOMER is easy to understand, freely accessible. • Graphs can import in users documents. • It can consider sales or purchase of electricity from grid. • Computational time is very less.
RET Screen	Natural Resources Canada	• Main strength is financial analysis. • Easy to use due to EXCEL based software.
PVsyst	Institute of Environmental Sciences (ISE), University of Geneva, Switzerland	• It draws Loss Diagram to identify the weaknesses of the system design. • This system analyses the real running parameters of the system, identify very little mistuning. • All result graphs, tables can be exported to other software. • Rough estimation of cost available.
iHOGA	University of Zaragoza, Spain	• It uses genetic algorithms to optimize hybrid systems in lesser time • It do probability analysis • Very accurate models for resources, for components and for economical calculations • optimizes the slope of the PV panels • Any case of net-metering can be simulated by iHOGA

D. iHOGA

It is modified Hybrid Optimization by Genetic Algorithm. And it is developed by University of Zaragoza, Spain. It is formerly called as HOGA. It is the modified version of the iGRHYSO. There are two version of iHOGA, EBU and PRO. EDU version of iHOGA is freely available have some limitations but PRO is a priced version without any limitations. This software (iHOGA) is available only in Spanish language. It only runs in Windows XP, Vista, 7 or 8. This software is used for temperature effect on photovoltaic generation and production by wind turbines. It calculates life cycle emissions. This tool also considers different types of sales/purchase of electricity from grid. Data exportation is available in this software. It gives highly accurate models. It uses multi or mono objective optimization using Genetic Algorithm. Version 2.2 is released on November 2013 [44].

2.5 Literature review

Different research efforts for the application of renewable energy options have been conducted for the access of renewable energy resource potentials and stand-alone hybrid systems. The following different authors were conducted for a range of hybrid systems at different times, sites and different countries; however, the methodology applied for the simulation was HOMER.

Zelalem G. [45] has carried out techno economic assessment of sun PV/diesel hybrid energy machine for a hypothetical rural school via the use of HOMER software program to deliver peak load of 11kw for twenty-four hours according to day. In his observe he has compared best diesel electricity deliver gadget to that of solar PV/diesel hybrid system with battery financial institution and confirmed that the hybrid gadget is value powerful and environmentally friendly because the solar PV covers around ninety five% of energy demand and the diesel generator is used to cover best 5% of electricity call for. Similarly, the look at conducted sensitivity evaluation considering uncertainty in variables: sun radiation and diesel fuel charge. Right here, the look at handiest considered energy deliver for the college, teachers' resident, barber and most useful layout and cell charging shops for earnings era of the school. The have a look at did no longer bear in mind the close by community although the school located in rural vicinity.

This take a look at covers most effective the energy supply side. The impact of call for side management on energy supply could not be studied.

20 cities in five of China's typical climate zones have been chosen in [46]. Regarding weather and energy prices, a full-year simulation is used to compare the technical, financial, and environmental performance of three different network-level grid-connected renewable strength prototypes, including biogas, wind, and simple photovoltaic devices. Then, a comprehensive assessment index is created, integrating all of the technical, financial, and environmental overall performance parameters, to evaluate the potential of the power systems. To serve as a guide for China's green development and policy-making, the advantages and disadvantages of improving renewable electricity systems in unique locations were examined. Because the whole assessment index of BG in most towns is better than that of PV and WT, it is noticed that biogas energy machines have comprehensive benefits in costs and energy production for most cities.

From both a techno-economic and diffusion theoretical perspective, [47] looks into why small wind turbines have largely gone unreported from Kenyan mini-grids. A techno-economic model is used to examine the viability of a hybrid PV/wind device, and based on theories of innovation

and the diffusion of technology, a conceptual framework is developed and put into practice for evaluating the Kenyan mini-grid zone's environment and classifying identified challenges. The situation as a result suggests an interdisciplinary approach to researching the role of tiny wind energy in power systems converting to renewable sources.

At typical wind speeds above four.5 m/s, the techno-financial modelling predicts that PV/wind hybrids have both technological and economic potential, but limited importance below. Hybrid PV/wind solutions are severely hampered by extensive limits in the technical, financial, and systemic sectors that are confronted by various stakeholders of the Kenyan mini-grid area.

The purpose of the study [48] is to look into the performance and cost benefits that can result from combining anaerobic digestion methods with CSP flowers. The CSP part of the Ottana solar project in Italy is used as an example to show the abilities of a hybrid CSP-biogas plant. A simulation model for the hybrid system performance analysis is now more sophisticated, and the results of the version inside the anaerobic digester's capacity and the biogas storage capacity on the key performance indices are assessed. Additionally, distinct operating methods for power storage control are contrasted, and the study of the practical need for power curtailment is completed. Finally, a preliminary economic analysis is completed. The outcomes demonstrate the benefits and improvements in plant capacity component and performance brought about by correct biogas section sizing. Therefore, a biogas section of a size that can supply a portion of the nominal thermal power input required by the power block results in the best arrangement, even in terms of cost. Micro grid is regarded as the future power system configuration, which can be operated by connecting to the bulk power grid, as well as in stand-alone mode for serving micro grid loads during failures of upstream grid.

In this work [49], a financial model for running a multi-party, community-based micro grid that includes generators and essential loads owned by various parties is proposed. The community-based multi-party micro grid addressed in this work has a different structure and, as a result, different operating objectives from most operational micro grids that have a single owner of key loads and on-site generators. To simulate the interaction between the community micro grid operator (referred to as mini-ISO) and various stakeholders for deriving adequate market clearing outcomes during the micro grid's normal operation condition, an iterative bi-level model is developed. On the other hand, a centralized energy management model is proposed to simulate the micro grid operation during major disruption events with limited generation resources and

competing needs from multiple owners' critical loads. Numerical simulations evaluate the effectiveness of the proposed operation framework for the community-based multi-party micro grid.

Advanced hybrid PV/wind/battery hybrid system studied by Bizuayehu.T [50], to replace the current diesel generator for Ethiopia's Kebri Dehar and Degehabur cities. Every city is dispersed across the entire nation. He identified two potential sources of power: a hybrid system (a standalone solar, wind, and battery system), and the extension of a new transmission line from the nearest national grid substation to the chosen communities. Additionally, he planned to use the HOMER simulation program as a design tool for both possibilities. The simulation results of a hybrid system made up of solar, wind, and batteries showed that the first-class option had an energy production value of zero.422 and 0.441 US dollars per kilowatt-hour for the towns of Kebri Dehar and Degehabur, respectively. For the towns of Kebri Dehar and Degehabur, the simulation results for the grid extension of strength fee are 1.172 and 0.869 $/kWh, respectively.

Clint [51] Talk about off-grid hybrid solar and wind technology's use in rural areas. The hybrid system consists of a PV array, a wind turbine, and the energy electronics tool that was described in his work. The study aimed to advance a green and cost-effective hybrid power system configuration to prolong the life of the rural network that is now not connected to the main grid. The author came to the conclusion that hybrid renewable energy resources and/or their assets are cost-competitive, notwithstanding the necessity of a significant capital investment in these resources.

A study conducted by [21] presented the design specifications for a hybrid power generation system that uses solar PV and wind turbines to supply electricity to a model network of 100 residences, a fitness centre, and standard professors. Investigating the location of interest's potential for solar and wind energy was how the examination got started. The device with the configured PV, wind turbine, diesel generator, battery, and convertor was proven by the best simulation outcome. The complete NPC and COE for this design are $103,914 and $.302 per kWh, respectively, for an 84 % renewable fraction, and diesel fuel is used 1,955 litters annually, so it operates for 633 hours per year.

[52] Completed a feasibility assessment for a freestanding solar/wind-based hybrid electricity generator to supply power to Ethiopian rural areas. In order to meet the power demand for a model network of 200 households, this article provided a simulation of PV, wind, diesel, and

battery systems. The study demonstrated the most cost-effective configuration using a hybrid diesel generator/battery and converter without the use of a contribution from renewable resource fractions. Additionally, it offered many cost-effective diesel generator/PV and converter combinations; in this instance, the dispatch method used was the load following method. The author's conclusion is that the strength configurations mentioned above can be installed inside the areas where those sources are mentioned.

Regarding off-grid Wind/Diesel generator hybrid electricity systems to supply power for populations inside the hot coastal areas of Dhahran, a paper was presented in [53] for Saudi Arabia. This study considers the supply of energy, primarily from wind energy, for a hypothetical network of 100 families. The author considered a wind/diesel and battery hybrid system as a solution because wind sources are intermittent sources of energy and consequently cause fluctuations in energy supply.

Including the help of [54], a hybrid system including PV, wind, micro-hydro, and diesel generator simulation was given for the Sundargarh district of Orissa kingdom, India. In this case analysis, two simulations were completed: the first involved a wind/sun PV and diesel generator combination, and the second involved a wind/PV/small hydro and diesel generator combination. The authors also suggested that the two biggest factors affecting the device are variations in family demand and wind-related electricity fluctuations. Elhassan, et al [55] described the design and implementation of green renewable strength powered power machine for household uses in Khartoum, the capital of Sudan. The simulation pastime turned into accomplished for character households and for a group of 10 to 25 families. The power supplied from PV/battery mixture for the singular users became luxurious than wind/PV for organization of families.

In the northern rural area of the kingdom of Saudi Arabia, S.Rehman et al. [56] presented the feasibility analysis of the hybridization of wind turbine to an existing off-grid diesel strength plant. The study's main goal was to reduce the amount of diesel generators that were used by merging them with wind generators, which would also reduce environmental pollution. Sensitive characteristics and wind speed that may have an impact on the power machine throughout the course of its lifetime were also taken into account when conducting sensitivity study. The simulation's conclusion indicates that, with wind speeds of less than 6 m/s and gasoline costs of $0.01 per litter, installing a wind turbine to the existing diesel generator proved impossible.

To evaluate the options for off-grid electrification inside the remote villages in the state of Bhutan, [57] conducted a study. The examination was conducted in four unique American locations. Additionally, only light and communication offerings were thought to be under stress. The paper's primary objective shifted to the improvement of hybrid power-generating units. The cheapest energy generation for Gasa and Lunana was a PV/battery system, while the Getena area's diesel/PV/battery hybrid device was the most affordable. Utilizing a wind/battery machine is now better for the Yangtse website.

According to [58] the study that was researched and became devoted to the observation of techno-economic hybrid (wind and diesel generator) schemes for a rural Algerian village. The observation was made in order to reduce fuel consumption by adding a wind turbine to the structures of the existing diesel power plants. The author came to the conclusion that the present diesel-operated plant, which costs 0.05 to 0.179 cents per litter, is more cost-effective than the hybrid device for wind speeds below 5 m/s. At wind speeds of 5.48 m/s, 0% yearly potential shortage, 0% minimum renewable fraction, and $0.162/clutter gasoline, the viability of the hybrid vehicle is guaranteed.

In the Democratic Republic of the Congo, Kasukana, et al. [59] looked into the viability of using hybrid renewable energy systems as the primary source of electricity for cell phone towers. The evaluation was conducted for Kamina, Mbuji-Mayi, and Kabinda, three unique places that aren't explicitly connected to the grid. The authors' potential configuration options include PV-wind turbines, diesel generators, PV and wind schemes that have been configured, as well as studies of the techno-economic and environmental effects. The ideal hybrid device for Kabinda consists of two wind turbines, 11kW of PV, 82 batteries, and a 7.5kW converter; the NPC and COE are $196,975 and $0.372 per kWh, respectively.

Kingdom [35] provided a report on how nascent technology is enabling ecologically friendly energy sources like wind, hydro, solar, and biogas to take off quickly. The appropriate and cost-effective installation in remote locations with continuous or sporadic access to the micro grid electricity is another benefit of those renewable energy sources. The interconnected strength machine denotes a modelling-based mode association with structures using the biogas, hydro, and PV technologies. To keep the voltage and frequency stable, the distributed management system is used. The dynamic overall performance of PV and hydro is also measured with the aid

of this paper, after the incident of strange disturbances over a fast trade in electric powered load [60]. There are numerous energy flowers which include hydro, solar, nuclear, thermal etc. but some demerits like carbon dioxide gas exhaust pollutants, the demerits like global warming demand of excessive fuel rate etc. To keep away from the elements the author evolved biomass strength plant thinking about the cost of fuel day and night to fulfil the requirements of power and surroundings involvement which inspire to implementation of renewable energy in India [61]. In India, a significant project is needed for rural electrification. Due to a high transmission and distribution gap, the economic impossibility of dealing with remote and unknown villages, the spread of the populace in small villages, the poor economic health of the national service, and other factors, it is difficult to distribute energy to remote villages in rural areas by constructing electricity distribution grids. [62]. the use of biogas and biofuels was covered in this study. The document [63] provides a brief summary of verbal exchanges with respect to different fuel supplies and their effects on the operation, environment, and financial dependency of the plant. The study's first findings indicated that delivering biofuels or power efficiently would have the greatest economic benefits, and that power technology would become more durable and require less upkeep.

Although the researchers indicated above employed HOMER as an optimization tool to realize their study, the hybrid system setups were evaluated utilizing varied load needs, applications, study locations, and climatic data. Some of the experiments were conducted in locations with no electricity at all, while others were conducted in places with access to electricity via a diesel generator. Based on the available climatic data, the number of residences, service centers, and consumer load profiles, each hybrid power system must be developed uniquely for the site. This paper also used the same software to design and optimize the off-grid hybrid power system, in addition to providing electricity to a large number of households for lighting, cooking, communication, water supply, irrigation supply, school, health service, and forecasted tourism infrastructure loads.

Limited master's level research has been conducted in hybrid renewable energy potential assessment for rural villages with fewer than 200 households and in a few sites around the country. This paper, however, differs from related studies in terms of application, load demand, climatic data, geographical location, and the number of families included. Furthermore, the

majority of the above HRES-based studies focused on addressing the need for residential and communal energy in rural areas, and those that consider tourism are not available. Nowadays, tourism is also the backbone of the Ethiopian economy. The expected tourism infrastructure load for the Tulla-dadiban holly hot spring tourism region is also included in this report.

Chapter three

Methodology

HOMER optimization software was utilized in this study to simulate the operation of the system depending on the components chosen. During this process, HOMER will calculate the energy balance based on the system design, which includes a variety of component numbers and sizes. The components used for the investigation are a PV array system, micro hydropower, a biogas generator, and a converter. The load on the case study area is first identified in this study. By analysing the load profile, a hybrid system configuration design based on available potential can be provided to fulfil the needs of the load.

Determine the components of the configuration that will be designed next. The following stage is to determine the resources data after determining the schematic. The hourly load data for the day can then be entered into the hybrid optimization software. Several characteristics, such as scale variability, which is the type of daily load for a year, can be set throughout the data input process. In addition to these criteria, there are operating system requirements such as economics, optimizations, limitations, and system control. Once these characteristics are met, the next step is to enter the system configuration's sensitivity analysis parameters in the form of capital cost, replacement cost, and operation and maintenance cost. The final step is to do optimization and sensitivity analysis calculations depending on the parameters that have been determined. Optimization will result in numerous hybrid system designs. The sensitivity analysis, however, will only determine one configuration. The hybrid system configuration is the recommendation system. The software will display an incorrect recommendation or evaluation if the calculation is not running. In most cases, simulation errors occur as a result of an incorrect or unfulfilled parameter. As a result, a review of the parameter sensitivity analysis of the system configuration is required, because the capital cost, replacement cost, and operation and maintenance cost are all important factors in determining the appropriate configuration. The Ethiopian Meteorological Service Agency, the Ministry of Water and Energy (MOWE), NASA, SWERA, and direct measurements from the site were the primary data sources for this study. The stream heads are measured directly from the sites using a meter and GPS. The NMSA (National Meteorological Service Agency) and NASA (National Aeronautics and Space Administration) provided the sunshine duration and solar radiation.

The assessment and evaluation of societal loads, as well as predicted tourism area infrastructure, are carried out on the site. Local markets, websites, and [64] are searched for capital, operational and replacement costs, life duration, and any extra information about components. Thus, the stream flow rate and river head, solar radiation, biogas energy, load data, and market survey are compiled in a suitable manner for entry into the HOMER software. The technique is shown in Fig 3.1 to help you understand the Layout of the HOMER optimization model steps of this study.

To design a micro Hydro-PV-Biogas hybrid power system, inputs such as hourly load profile, flow data, monthly solar radiation value for a PV system, initial cost of each component (renewable energy generators, converter), annual real interest rate project lifetime, and so on must be provided [65]. The site's flow rate data was obtained from MOWE. Using a portable GPS, the gross head was measured during the field survey. The sun radiation data for the research area were obtained from the NASA meteorological department's online database. The capital cost of each piece of equipment was taken from the website and adjusted to local currency by factoring in transportation and other charges.

3.1 Estimating load demand of the village

The location's pre-feasibility investigation revealed that there were around 520 households in Tulla-dadiban village. In this study, the village community's electric load demand is classified into household/domestic sector, commercial loads, tourism infrastructure facility load, public load (elementary school; health clinic); and religious load demand. The total electric load estimated for the above-mentioned appliances was added together to determine the required load to be supplied by the system. Despite the fact that the current situation is below the poverty level, peak appliance operation hours have been proposed. The approach to load assessment was based on the electric appliances that will be used by each sector. The first step in calculating the load is determining which appliances must be used by rural family dwellings and the tourism infrastructure that must be built while taking into account the current and future status of the local community as well as the country's energy system architecture. Table 3.1 summarizes the above energy consumption sectors.

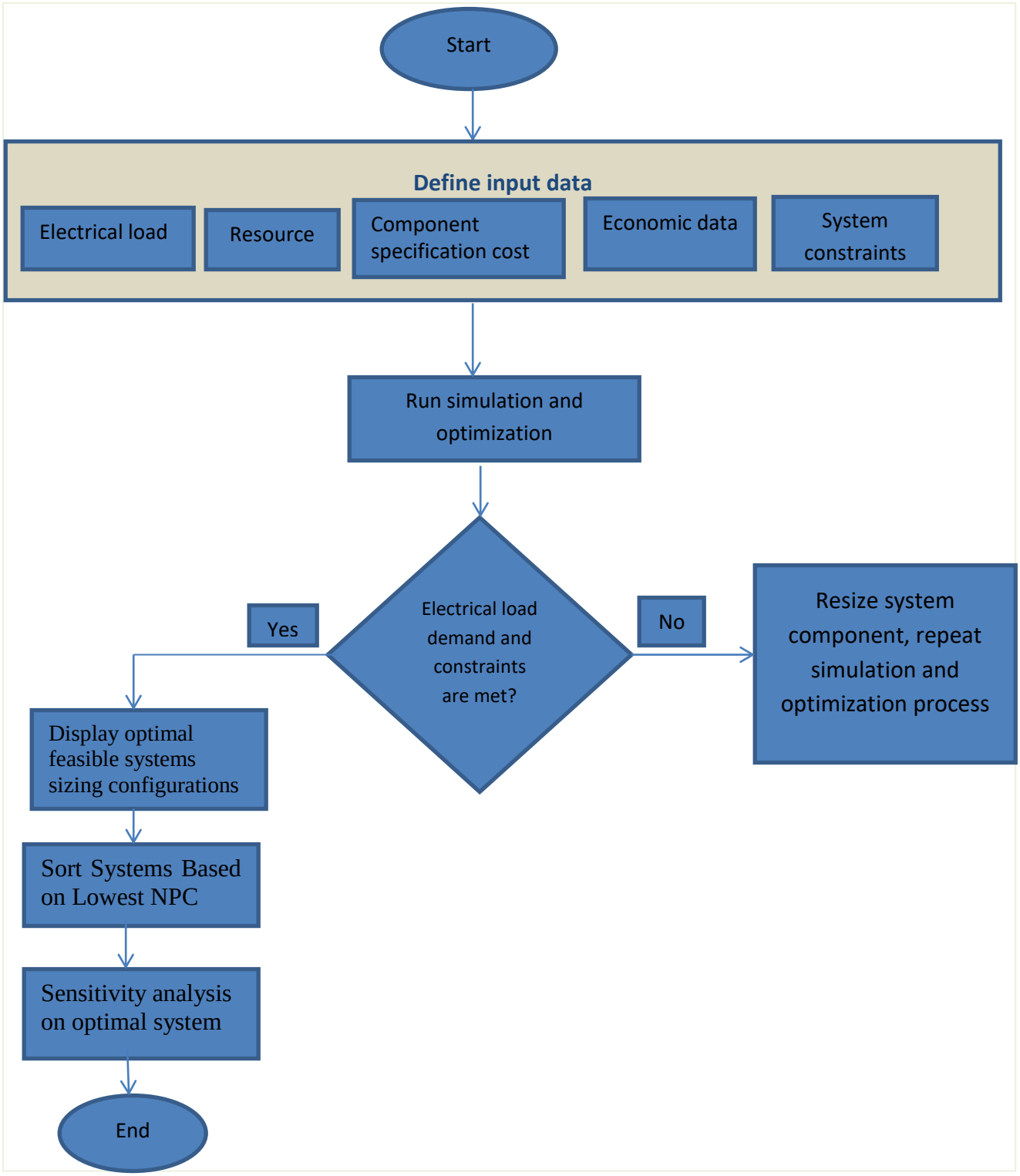


Figure 3.1 Layout of the HOMER optimization model

Table 3.1 Energy consumption sectors of the village

Load type	Sub branch	Appliance	Rated power (watt)	Total quantity	Usage Hour	Total energy (Wh/day)
Public	School	CFL	15	40	5	3000
		Fan	40	10	4	1600
		TV	65	4	4	1040
		Radio	11	4	4	176
		Mobile charger	12	40	5	2400
	Health	CFL	15	9	4	540
		Fan	40	10	4	1600
		Refrigerator	500	4	2	4000
		TV	65	10	4	2600
		Radio	12	5	4	240
		Mobile charger	12	8	5	480
	Straight light	CFL	15	30	4	1800
Domestic		CFL	15	1040	6	93600
		TV	65	520	7	236600
		Radio	12	520	6	37440
		Mobile charger	12	520	4	24960
		Water pump	450	1	3	1350
		Fan	40	300	4	48000
Tourism infrastructure	Housing	CFL	15	50	6	4500
		TV	65	10	6	3900
		Refrigerator	500	5	4	10000
		Fan	40	20	5	4000
	Refreshment	Speaker	250	4	7	7000
		Water pump	450	1	3	1350
Commercial	Shops	CFL	15	10	6	900
		Fan	40	5	2	400
		Refrigerator	500	6	4	12000
		Mini diary	3000	2	3	18000
		Flour mill	4800	1	4	19200
Agricultural	Agricultural	Water irrigation pump	2200	4	3	26400
		Cutting machine	1500	4	4	24000
		Trashing machine	4000	3	4	48000
Total						641.076kWh/day

It is necessary to import the load data into HOMER hourly load profile for the entire year. Based on hourly expected load for different months, a load profile of 8,760 hours is produced for a year. As a result, the village's total daily energy requirement is 641.076kWh/day. The anticipated total

yearly energy usage of the village is, 641.076kWh × 365 = 233.993MWh/year. The villages load profile is shown in the figure 3.2 below.

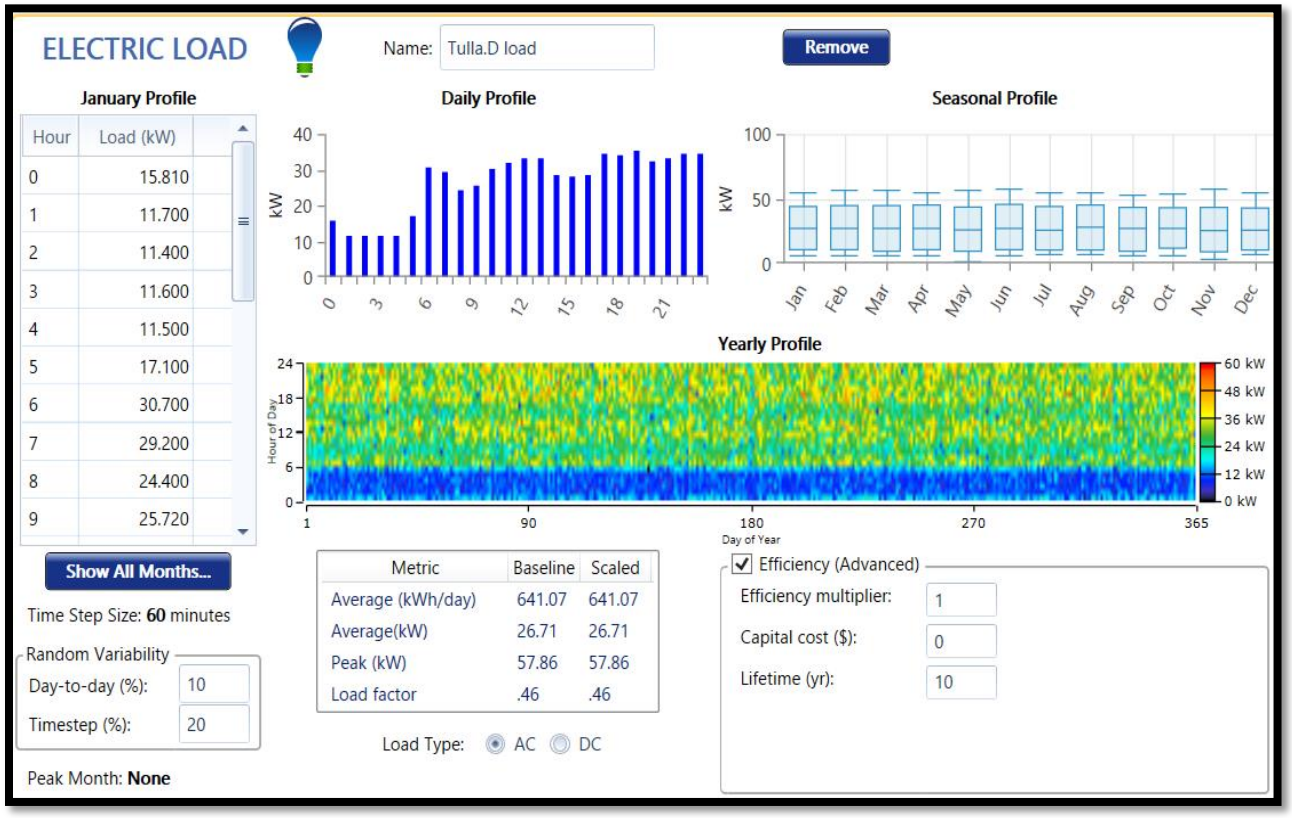


Figure 3.2 Load profile of Tulla-dadiban village

3.2. Village's energy resource estimation and hybrid components

3.2.1. Micro hydro resource assessment

The generation of power from water is dependent on a combination of head and flow. Both must be available in order to generate power. Water is redirected from a stream into a pipeline, then downhill and into the turbine (flow). The vertical descent (head) causes pressure at the pipeline's bottom end. The force that drives the turbine is created by the pressurized water that emerges from the end of the pipe. The turbine, in turn, drives the generator, which generates electricity. More flow or head generates more electricity. Due to turbine and system inefficiencies, electrical power output will always be somewhat less than water power input. The difference in elevation between the water intake and the turbine generates water pressure or head. Head can be described in terms of vertical distance (feet or meters) or pressure (pounds per square inch (psi). Due to friction between the water and the pipe, the net head is the pressure available at the turbine when water is flowing, which is always smaller than the pressure when the water flow is

switched off (static head). Net head is also affected by pipe diameter. Flow is the amount of accessible water stated as a 'volume per unit of time', such as gallons per minute (gpm), cubic meters per second (m3 /s), or litters per minute (lpm). The maximum flow for which the hydro system is designed is referred to as the design flow. It will almost certainly be less than the stream's maximum flow (especially during the rainy season), higher than the minimum flow, and a compromise between potential electricity output and system cost. The stream flow rate and height of water fall at the specified site are the relevant parameters for this study to assess and estimate the micro hydro power generation potential. The hydropower potential for the chosen village can be computed using the available head and flow rate. When a site with a long rainy season and a good topography for hydropower has been selected, the first duty is to assess the availability of an adequate water supply. The least amount of water accessible throughout the year was established in order to adequately assess the minimum continuous power production to be expected from the micro-hydropower system.

3.2.2. Calculating power from micro hydro power plant

To determine the hydropower potential of a stream, the flow quantity of water available from the stream (for power generation) and the available head must be known. The amount of water accessible for power generation is the amount of water (in m3 or litres) that can be diverted into the pipeline (penstock) in a certain amount of time through an intake. Normally, this is stated in cubic meters per second (m3 /s) or litres per second (l/s). The vertical difference in level (in meters) through which the water descends is referred to as the head. The flow of water in the selected river is 14.3 m^3/s and the head is 76 m, as determined by the Ministry of Water and Energy Bureau and by measuring on-site. The theoretical power (P) available from a particular head of water is proportional to the head, and this is expressed in the equation below [66].

$$P = m \text{ x } g \text{ x } H_{net} \text{ x } \boldsymbol{\eta} \qquad 3.1$$

Where:

P is the power measured in Watts (W), m is the mass flow rate in kilograms per second (numerically the same as the flow rate in litters per second because one kilogram of water weights one kilogram), g is the gravitational constant, which is 9.81m/s^2, is the overall efficiency, and H_{net} is the net head. This is the gross head measured physically at the site, less any head losses. To keep things simple, say that head losses are 10%, hence $H_{net} = H_{gross}$x

0.9η the product of all component efficiencies, which are typically the turbine drive system and generator. A typical small hydro system would have a turbine efficiency of 85%, a drive efficiency of 95%, and a generator efficiency of 93%, for an overall system efficiency of 0.85 x 0.95x 0.93 = 0.751.

As a result, we had a rather low gross head of 76 meters and a turbine capable of handling a maximum flow rate of 14.3 m^3/s. The system's maximum power output would be obtained by first converting the gross head to the net head and multiplying it by 0.9, as follows: H_{net} = H_{gross} x 0.9 = 76 x 0.9 = 68.4 m. The flow rate in m3/s is then converted to litters/second by multiplying it by 1000, yielding 14.3m^3/s= 14,300 litters per second. Given that one litter of water weighs one kilogram, m is the same numerical value as the flow rate in litters per second, in this case 14,300 kg/s. To determine the power from hydro, do the following:

$P = m$ x g x H_{net} x η= 14,300 x 9.81 x 68.4 x 0.751 = 7,206,113.2572W = 7.206 MW

3.2.3. Solar resource assessment of the village

The next stage is to investigate the village's solar resource potential in order to meet electrical load demand. By entering GPS coordinates, HOMER runs on directly imported solar resources from NASA's Surface Methodology and Solar Energy database. This information was used to analyse the site's solar energy potential. NASA surface metrology at latitude 7.5°N and longitude 36.5°E provides the clearing index and daily radiation for the village. The monthly solar resource for a photovoltaic system is shown in Fig3.3. The average solar radiation of the village is used to calculate the site's solar energy potential. The village's 22-year monthly average solar resource ranges from 5.870kWh/m2/d in March and 4.410kWh/m2/d in July, Ethiopia's summer.

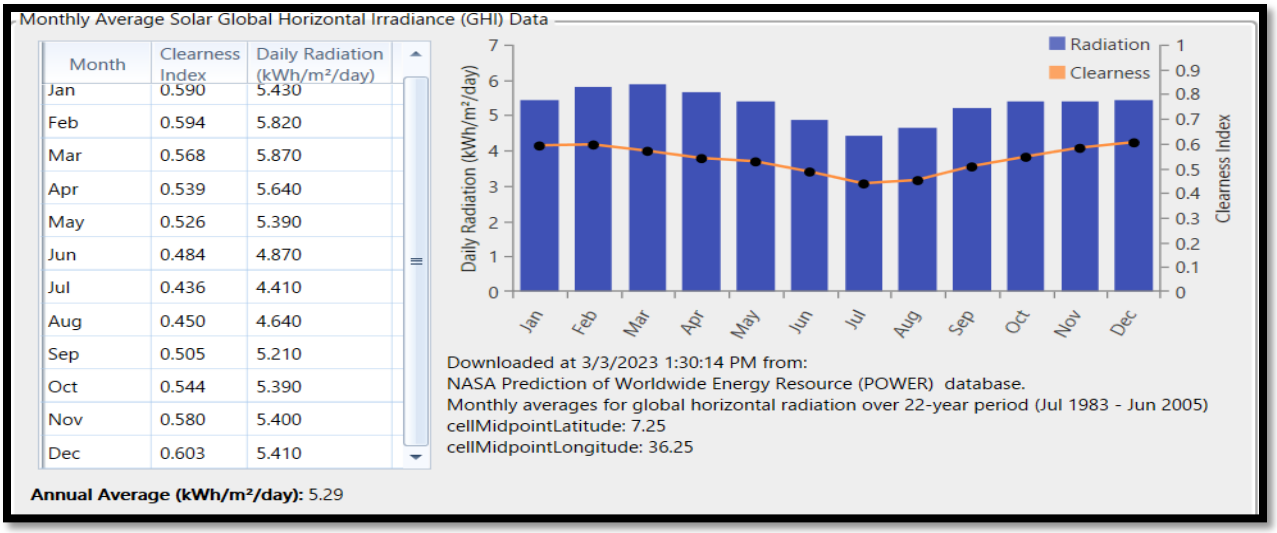


Figure 3.3 Tulla-dadiban villages monthly solar resource from NASA

NASA provides the clearance index. According to the analysis, the average solar radiation for the village is 5.29 kWh/m2/ day. See Table 3.2 for more information.

Table 3.2 Villages average solar radiation from NASA

Month	Clearness Index	Average Radiation/(kwh/m²/day)
January	0.590	5.430
February	0.594	5.820
March	0.568	5.870
April	0.539	5.640
May	0.526	5.390
June	0.484	4.870
July	0.436	4.410
August	0.450	4.640
September	0.505	5.210
October	0.544	5.390
November	0.580	5.400
December	0.603	5.410
	Selected annual average	5.29kwh/m²/day

3.2.4. Estimating PV output of the village

Solar radiation, in its broadest sense, refers to the complete frequency range of electromagnetic radiation emitted by the sun. A number of criteria are used to calculate the amount of effective solar radiation that can be turned into energy. In the solar resource input window, we specify the global horizontal radiation for each time step. That is the entire amount of solar radiation that

strikes the earth's horizontal surface. However, the power output of the PV array is determined by the amount of radiation impacting the PV array's surface, which is not always horizontal. The PV array's orientation can be described using two parameters: a slope and an azimuth. Because the slope is the angle created between the panel's surface and the horizontal, a slope of zero indicates a horizontal orientation, while a slope of 90° suggests a vertical orientation. As a result, HOMER use the following equation to determine the global radiation incident on the PV array while neglecting the effect of temperature [50].

$$P_{PV} = \gamma PV\ fPV\left(\frac{GT}{GT,STC}\right)[1 + \alpha p(Tc - Tc,STC)] \quad 3.2$$

Where**, ,** γPV denotes power output under standard test conditions (STC) [kW].

fPV, denotes the PV de rating factor [%].

The solar radiation impacting on the PV array in the current time step is denoted by GT [kW/m^2].

The incident radiation at standard test conditions [1 kW/m^2] is denoted by GT, STC,

αp , denotes the panel temperature coefficient [v_{ov}/k].

Cell operational temperature [k] is denoted by TC.

Cell temperature at standard circumstances [k] is denoted by TC, STC.

HOMER assumes that the temperature coefficient of power is 0 if the effect of temperature on the PV array is neglected. As a result, the PV power output can be computed using the equation below [62].

$$P_{pv} = \gamma PV\ fPV\left(\frac{GT}{GT,STC}\right) \quad 3.3$$

3.2.5 Biogas resource assessment of the village

The biogas resource for electricity generation in this study is coffee husk and animal dung. The average daily manure and coffee husk available for biogas production were entered into HOMER. According to a survey conducted in the research area, the hamlet has 14 wet milling stations and 18 dry milling stations for a total of 32 milling stations. Table 3.3 shows information acquired from the Kafa zone of Agriculture, coffee, tea, and spices office 2021. Private firms, cooperatives, or states own these coffee milling stations. The wet method yields 0.6 kg of pulp and 0.103 kg of mucilage (DM basis) for each unit weight of green coffee beans produced, while the dry approach yields 0.933 kg of husk [67].

Table 3.3 Wet and dry milling stations in the.

Wet milling stations				**Dry milling stations**			
Private	Cooperative	State	Total	Private	Cooperative	State	Total
8	6	-	14	11	4	3	18

This amounts to 312,060 Mg DM and 289,748 Mg VS of husk, 85,976 Mg DM and 75,925 Mg VS of pulp, and 14,764 Mg DM and 12,564 Mg VS of mucilage per year [68]. The energy potential per year from husk, pulp, and mucilage was calculated to be 160,729 KWh, 64,898 KWh, and 12,887 KWh, for a total of 238.514 Mwh/year based on the SMY obtained at the end of the digestion period (35 days) in the BMP test. Table3.4. Cows (213), horses (12), mules (29) and goats (557) made up the total livestock population of 520. Daily dung production is 10 kg/day for cows, mules, and horses, and 1 kg/day for goats. With a recovery ratio of 0.7 and a gas yield per kg of wet manure of $0.036 m^3$/kg, the total biogas yield was calculated to be $78\, m^3$/day[20]. Finally, assuming that 1 kWh of energy requires $0.73\, m^3$ of biogas [69], the overall potential for creating power from the livestock dung produced on site was 107kWh/day, or 39.055 Mwh/year.

Table 3.4 the essential potential from biogas.

Substrate	**Residue production ratio**	**Biomass yield (m^3 year)**	**Methane yield (m^3 year)**	**Electricity production Kwh/ year**
Husk	0.923	289,765	46,069,906	160,729
Total	-	-	-	160,729

Table 3.5 presents a detailed assessment of the available manure resource's potential for producing biogas and energy. HOMER requires the cost of biomass, gasification ratio (GR), and lower heating value (LHV) as inputs for biomass resources.

Table 3.5 Detail assessment of potential for generating biogas and electricity from the available resource

Livestock	**Population**	**Dung Availability (kg/head/day)**	**Total Dung (kg/day)**	**Total Dung**	**Total Gas Yield (m^3/day)**	**Potential Power Yield (kwh/day)**
Cows	213	10	2130	1491	53.7	74
Horse	12	10	120	84	3	4
Mule	29	10	290	203	7.3	10
Goat	557	1	557	390	14	19
Total	**811**	-	**3097**	**2168**	**78**	**107**

The gasification ratio represents the quantity of biogas produced per unit mass of biomass, whereas the LHV represents the amount of energy available in 1 kilogram of biogas to fuel the biogas generator. The GR and LHV in this investigation were 0.05 kg/kg and 5.5 MJ/kg, respectively [70]. The entire biomass resources are displayed in the figure below by taking into account the number of animals and coffee wastes from enterprises. The total energy produced by coffee husks and animals is 277.569 MWh/year. According to the estimation, around 6 ton every day can be detected as shown in the graph.

Figure 3.4 Total biomass resource of Tulla-dadiban

3.2.6 Calculating power output from biogas.

The degree of degradation (n_{oDM}) was calculated as the ratio of gas produced m_{biogas} to volatile solids loaded (Equation (3.4)). [71].

$$n_{oDM} = \frac{m_{biogas}}{m \times c_{vs}} \qquad 3.4$$

In which m is the dry mass of substrate injected and c_{vs} is the concentration of volatile solids in the substrate. The molar masses of methane (M_{CH4}) and carbon dioxide (M_{CO2}) were used to calculate the mass of the biogas (Equation (3.5)) based on their relative concentrations in the biogas, assuming the biogas was only consisted of methane and carbon dioxide [72].

$$m_{biogas} = v_{biogas}\left(\frac{M_{co_2}.C_{co_2}}{22.4\cdot100} + \frac{M_{cH_4}.c_{cH_4}}{22.4\cdot100}\right) \quad 3.5$$

In which v_{biogas} is the volume of biogas measured, C_{co_2} is the carbon dioxide concentration in the biogas, and c_{cH_4} is the methane concentration in the biogas. The energy recovery (ER) rate was calculated by dividing the calorific value of the methane generated by the calorific value of the batch's input substrates. The findings of Equation (3.6) [73] can be used to estimate the gross energy (GE) of substrates.

$$\text{GE} = 0.0239\text{MJ}^{-1}\cdot XP + 0.0398\text{MJ}^{-1}\cdot XL + 0.0201\text{MJ}^{-1}\cdot XF + 0.0175\text{MJ}^{-1}\cdot NfE \quad 3.6$$

In which XP represents crude protein, XL represents crude fat, XF represents crude fibber, NfE represents nitrogen free extract NfE (g kg^{-1}, dry mass basis), and GE represents gross energy (MJ kg1). The specific energy content of component t parameters varies, as illustrated by the equation's fixed coefficients.

3.3. Hybrid system component's characteristics and unit costs

3.3.1. Micro hydro power plant unit cost

The capital cost of an MHP plant must be determined as part of the economic analysis phase. One of the most significant issues in developing-country investment analysis of hydropower projects is the lack of a quick and reliable basis for evaluating capital costs. The considerable unpredictability of KW and KWH pricing for small hydropower systems around the world prevents reliable cost prediction for small hydropower plants in Ethiopia, where there is essentially no expertise in this field [30].

It is difficult to provide information on the anticipated costs of micro hydro schemes, according to [74], because hydro power, unlike other kinds of renewable energy, is particularly site specific, and so costs vary greatly from site to site. However, if the project is integrated with existing irrigation diversion systems, where infrastructure, such as the weir, is still present and in excellent shape, the costs can usually be significantly reduced.

For this study, I do not do a detailed economic analysis, but rather provide an overview of the overall costs associated with MHP development. The following are general work items involved in the construction of the MHP plant. A scheme's costs can be broken down into four categories:

- Civil works: All physical/engineering works related to water abstraction and return, as well as any building costs to house the machinery.
- Machinery: All of the machinery (plant) required to convert water power into electrical power from a turbine, waterwheel, and so on to the generator. Screens may be included if necessary.
- Electrical works: This includes the control panel and control system, wiring and grid connection, as well as metering if necessary.
- External costs: the cost of a consultant to design and supervise the project, as well as the cost of licensing, planning approval, and so on.

According to [75], with a 7.5% contingency of the overall cost, the total installation cost after all necessary increments is 83,900 birr, or 4,400 Birr/kw. According to [96], the realistic investment unit cost for MHP is US$2000/KW. MH plants for power generation schemes ranged in price from USD 1136 to USD 5630, with an average installation cost of USD 3085 [75]. According to [76], the cost per kilowatt of installed power often rises as project size decreases due to fixed costs and economies of scale. A number of capital cost estimates have been provided, ranging from £1,000 to £4,500 per installed kilowatt, depending on the amount of civil engineering necessary.

3.3.2. Solar PV module types and cost

Sun Power PV module model X21-345 was chosen for this study because universities and independent research laboratories around the world compared the performance of Sun Power solar panels against other technologies, and Sun Power solar panels were the clear leader in each case [29].

Sun of Power model X21-345 with efficiency 21.5% costs $2/Watt. Other costs, including as labour, installation, construction costs, and civil work, also contribute significantly to capital costs (Soft costs or other costs) account for 22% of total module costs [52]. PV capital cost is typically expressed as:

$$\text{PVcapitalcost (KW)} = \text{PVsyst} + \text{Softcosts or other cost.} \quad 3.7$$

3.3.3. Biogas system cost

Syngas is thought to be used as a source of energy production from gas turbines. The cost of fuel is not considered in this scenario because the fuel is animal waste and coffee waste from coffee milling plants, both of which are abundant. However, the transportation cost from coffee grinding stations to the site is regarded to be the biomass price, which is $16.9/tonne. The start-up cost of a biomass generator is considered to be 1600 $/kW, with replacement and running costs of 1250 $/kW and 0.1 $/h, respectively. The biogas generator's life is assumed to be 20,000 hours, with a lower heating value of 5.5MJ/kg and a carbon content of 5% [25].

3.3.4. Converter size

Power conditioning units are electronic devices that are classified as DC-DC/AC or AC/DC. DC/DC converters are electrical devices that convert direct current (DC) voltage or current to required voltage and frequency outputs. The DC/AC converter is used to convert the hybrid system's DC voltage or current to an AC voltage output. A power inverter is a sort of power converter. The AC/DC power converter is known as a rectifier because it operates as the inverse of an inverter. Inverters for solar electric systems are further classified into three varieties based on their application: stand-alone or off-grid inverters, grid-connected inverters, and hybrid power Grid interactive inverters.

In this project, we will employ hybrid power inverters, which are ideal for combining solar, hydro, and biogas generators. Inverter prices vary according to size. In this scenario, the Sunny Island (system) converter is a bidirectional inverter for stand-alone systems. If the battery does not offer enough electrical energy, this converter can disconnect loads automatically. The converter has a lifetime of 20 years and an efficiency of 96% [77].

3.3.5. Storage batteries

A battery is an electrochemical device that stores Direct Current (DC) electrical energy for later use. The storage battery selected is the Surrette6CS25P from Rolls/Surrette, which is a very high capacity battery with New Generation series 5000 benefits and characteristics. Dual case replaceable cells with a tiny footprint and a life expectancy of more than ten years (depending on maintenance and application) were used. This battery is available in the HOMER tool library. The following properties of the chosen battery were acquired from the HOMER modelling program. This battery has a nominal capacity of 174 Kwh, a maximum charge current of 41 A, a

lifetime throughput of 195,701 kWh, a minimum state of charge of 40%, and a round-trip battery efficiency of 80. The capital cost is $1212 when transportation and taxes are factored in. In this project, the approximate cost of replacement and O&M is $1212 [78].

3.4. Mathematical methods and software tools for designing of hybrid energy system

In order to supply electricity consistently and affordably, the design of a hybrid energy system (HES) must be optimal. Due to the complexity and diversity of hybrid energy systems, there is currently no straightforward way for determining the ideal combination of HES that is well suited for a certain application. Modelling the HES is the only approach to find a solution to this challenge. This allows for a good notion of the system's performance at the lowest potential cost of generating. There are two approaches to designing HES: traditional methods and software-based alternatives [79].

3.4.1. Conventional approach

Based on experience with existing systems, this method gives pragmatic guidance on best practices for hybrid system sizing and operation. These methods are the rule of thumb method and the Ampere hour method. They do, however, have restrictions. It is inaccurate and may not be appropriate for large projects. It can only provide broad intuitive or "rough" estimations and recommendations that may be improved by a computer-based strategy, and the process is time demanding in comparison to the computer-based approach.

3.4.2. Software based hybrid energy system modelling

The use of computer software for the design and analysis of hybrid energy systems is the natural continuation of mathematical models describing hybrid energy systems and the accompanying step-by-step procedural algorithm that is adopted and implemented in a given computer program. The majority of these software programs mimic a predetermined hybrid system using a mathematical description of the component characteristic behaviour and system energy flow, and they frequently include financial costing of the system design. These programs are useful for evaluating a specific hybrid system design and viewing the consequences of manually adjusting component sizes and parameters. Many of these software tools, however, required a hybrid system that had been predesigned through other techniques. There are some software tools available for designing and analysing hybrid systems. Hybrid2, HOMER, RET Screen, and In My Back Yard (IMBY) [80] are a few examples.

The program's strengths and weaknesses are derived from several sources and classified in terms of software availability (free or commercial), accuracy, capability for economic analysis, and suitability for hybrid design optimization. As a result, HOMER is the most effective method for modelling an off-grid hybrid energy system (Micro hydro-Solar PV-biogas generator) [38]. It is the greatest strategy for making informed decisions regarding designing and building a hybrid energy system since it is efficient and methodical. The software application may identify system configuration, system components and sizing, resource cost and availability, and the vast array of technology options accessible. Its key benefit over other hybrid energy system design software is that it can readily assist in simplifying complex hybrid energy designs and making informed decisions in tough scenarios. HOMER simulated the system's operation by doing energy balance calculations for each of the 8,760 hours in a year. HOMER estimated the flows of energy to and from each component of the system for each hour by comparing the hour's electric and thermal demand to the energy that the system can deliver. HOMER will be used to determine how to operate the generators and whether to charge or discharge the batteries for each hour in systems that involve batteries or fuel-powered generators. HOMER will perform these energy balance calculations for each system configuration under consideration and then determine whether a configuration is feasible, i.e., whether it can meet the electric demand under the specified conditions, and estimate the cost of installing and operating the system over the project's lifetime. Capital, replacement, operation and maintenance, fuel, and interest are all factored into the system cost calculations. The program has the capacity to optimize the system. From a set of possibilities, the optimization method produced the optimum potential system design [81]. Another intriguing feature of the software is its capacity to perform sensitivity analysis. The sensitivity analysis will show how the outcomes of simulation and optimization vary with changes in uncontrollable inputs like biogas generator costs and sun radiation.

3.5. System architecture

The selection and sizing of components, as well as the most appropriate control and management technique, must be obtained in the design of a mini-grid system. Over the previous three decades, numerous hybrid energy system topologies have been built in a range of nations [20]. This has given me the essential experience to determine the advantages and disadvantages of various configurations. As a result, good performance models have been established that can prioritize the functionality of power supply systems in order to realize cost savings and increase system

reliability. Table 3.6 describes the overall system design. The configurations of hybrid power systems can be classified. There are three types of configurations: series, switched, and parallel [30]. Parallel Configuration is one of the system configurations listed above. Figure 3.5 depicts how current hybrid energy system software simulations and designs are based on this model architecture. The parallel architecture allows all energy sources to supply the load separately depending on need, as well as combining the various energy sources to meet an increased level of demand. When excess energy is available from the other generators, the bi-directional inverter charges the battery (serving as a rectifier) and functions as a DC-AC converter (inverter) under regular operation. The primary benefit of this system is better system efficiency and reliability due to efficient operation and sizing of generation components to meet demand. The main disadvantages of this system are its complexity, which necessitates the necessity to automate the many controls, as well as specific training to operate the system [82]. In this centralized design, there are some approaches such as substation, control centre, and both. Substations are critical components of power generating, transmission, and distribution systems.

Table 3.6 System architecture

Component	Name	Size	Unit
Generator	Generic Biogas Genset (size-your-own)	15	kw
PV	Sun Power X21-335-BLK	58.0	kw
Storage	Surrette 6 CS 25P	42	strings
System converter	System Converter	36.9	kw
Hydroelectric	10kW Generic	10	kw
Dispatch strategy	HOMER Cycle Charging		

Substations convert voltage from high to low or low to high as needed. However, in a small grid energy system, substations are costly due to high installation costs, the requirement for maintenance and repairs for each substation, and the additional human power (operators) required for each substation. In general, connecting a substation to a system is neither economically possible nor inexpensive.

The energy control centre (ECC) has typically served as the decision-making hub for the micro grid's electric transmission and linked system. The ECC performs the functions required for monitoring and coordinating the physical and operational aspects of the power system on a minute-by-minute basis. Load demand prediction, renewable generation resource integration, electrical power-load balancing, and responsive load demand are all components of the proposed

design. EMSs operate in micro grids (MGs) by taking into account problem limits, power set-points of generation resources, and potential shortages or surpluses of power generation. In the suggested structure, many characteristics such as load demand and renewable power generation are regarded as uncertainties. To deal with the uncertainties, central control (Bidirectional inverter) is used [21].

3.5 Hybrid system designing

A hybrid power system for Tulla-dadiban village has been designed, combining micro-hydro with photovoltaic and biogas generators. The section describes how to model a hybrid system using the optimization software HOMER. The section begins by describing the critical inputs that indicate the technical requirements, resource data, and costs relevant for modelling the system in HOMER.

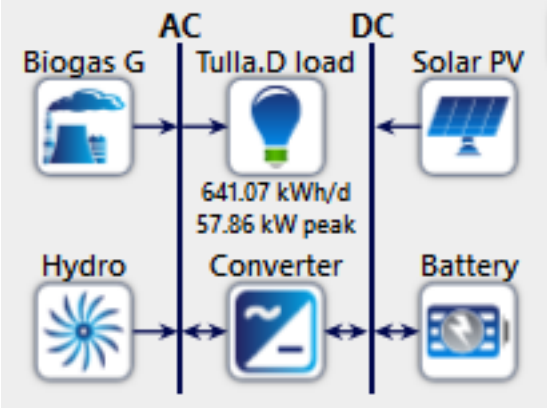


Figure 3.5 Parallel configuration hybrid systems as simulated in homer

3.5.1 System inputs

HOMER system analysis necessitates knowledge of the resources, economic restrictions, and control mechanisms. Design variables such as PV array size, convertor size, dispatch method, available head (m), flow data (water head and flow rate), and average solar radiation (KWh/m^2/day) will be included in the input data. The most significant factors in system design are the local load demand, component technical details and costs, limits, controls, and kind of dispatch strategy. The droop mode is utilized to enable parallel functioning of the AC linked voltage source without engaging any communication. The performance of the multiple connected converters is coordinated using active and reactive power statics.

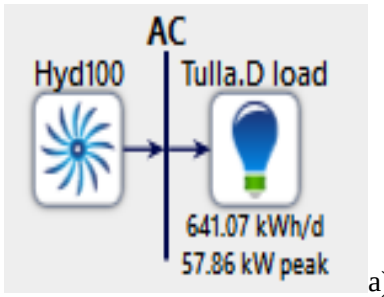
Chapter four

Simulation results and discussion

This chapter would provide specifics on the optimization results for the chosen hybrid power system of a typical 520 households and would be thoroughly addressed. After entering all of the input variables into the modelling tool, the software is run repeatedly to ensure that the results are feasible. The optimization findings are presented in the form of an overall and categorized representation of the most viable power system architecture that meets the load and input restrictions set by the modeller. Seven alternative hybrid system models are developed for comparison, and various component sizes are addressed. From top to bottom, the plausible alternatives are listed in ascending order of net present cost. The categorized tables for each model indicated the least cost effective combination from all component configurations, whilst the overall optimization results displayed all of the affordable system possibilities based on their NPC. After simulation, power solutions are chosen based on the lowest net present cost. On top of these factors from the stated models, lower energy costs, a higher renewable fraction, and lower excess electricity generation might be utilized to compare power generation schemes in order to assess their technical viability, and the results achieved are described.

4.1 Simulations result and the system outputs

Different types of configurations are developed in various sizes to allow for comparative examination in terms of COE, NPC, and RF. Different sources, such as micro hydro, SPV, and biogas-based generating systems, are explored for configuration. Based on these resources, various types of configurations are presented here, and the analysis, including LCOE, is evaluated, including Standalone Micro hydro, standalone biogas, standalone solar PV-battery storage, solar PV-micro hydro hybrid system, solar PV-biogas hybrid system, Biogas-micro hydro hybrid system, and micro hydro-biogas-solar PV-battery storage hybrid system. Figure 4.1 depicts the use of the HOMER simulation tool to implement several configurations. It demonstrates how various sources and loads are coupled to AC and DC buses to construct various types of configurations.



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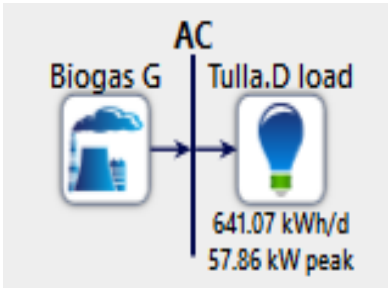

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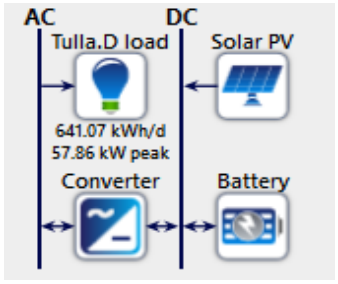

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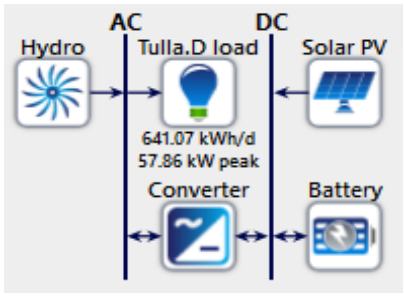

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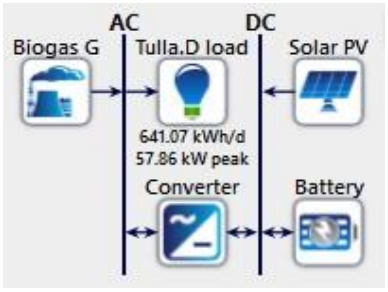

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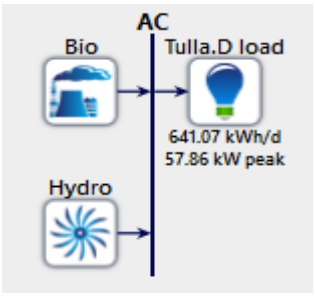

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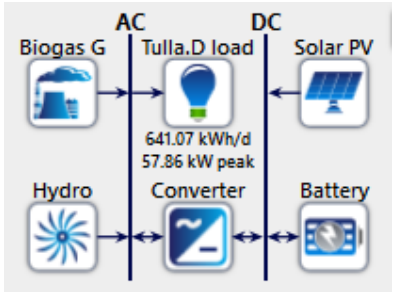

g).

Figure 4.1 Different types of configurations

4.1.1 Standalone micro hydro

The Generic Hydro 100kWhaving a nominal capacity of 60.42 kW is used and the optimization result is analysed. The system net present cost is 717,817.70$, levilised cost of energy is 0.2091$, capacity shortage0%, excess electricity 5985kWh/year, the renewable penetration 100% and consumption 233,991KWh/year which is described in figure 4.2 below

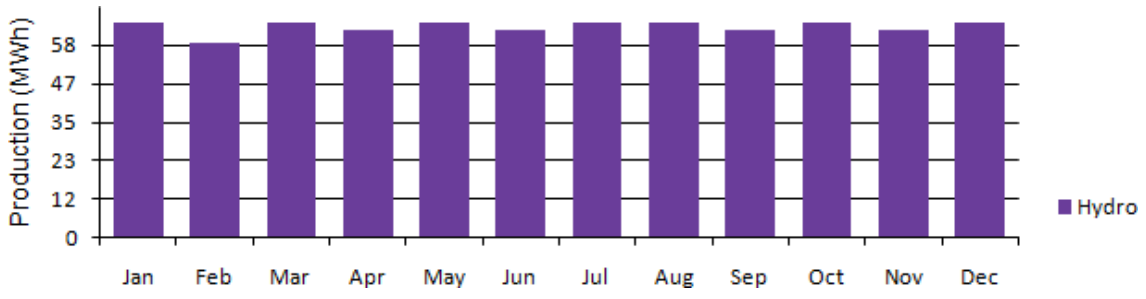

Figure 4.2 Monthly electricity productions.

4.1.1.1 Sensitivity analysis

Sensitivity analysis shows that total 3 combinations, based on different sensitivity variables, are possible. The arrangement of all combinations is such that the one having lowest COE is coming first and soon. Table 4.1 shows the result on the basis of sensitivity analysis.

Table 4.1 Sensitivity analysis

Interest Rate (%)	M Hydro (kW)	NPC ($)	LCOE ($/kWh)	Operating cost ($/yr)	CAPEX ($)	Ren Frac (%)
6	60.4296	770911.3	0.209151	18795	474845	100
7	60.4296	742363.3	0.222898	18795	474845	100
8	60.4296	717817.7	0.237302	18795	474845	100

Due to the use of hydro renewable energy resource only the renewable fraction is 100% and the maximum renewable penetration is 10,618%. Due to not yearly availability of water this model is not selected for our case.

4.1.6 Standalone biogas

For this model Generic Biogas Genset generator 60kw is used. The system net present cost is 629,171.6$, Levilised cost of energy is 0.2103 $, capacity shortage is 0 %, the excess electricity 5960kWh/year which is 1.85%, the renewable fraction is 100% and consumption 233,991Kwh/year is described in the figure 4.3 below.

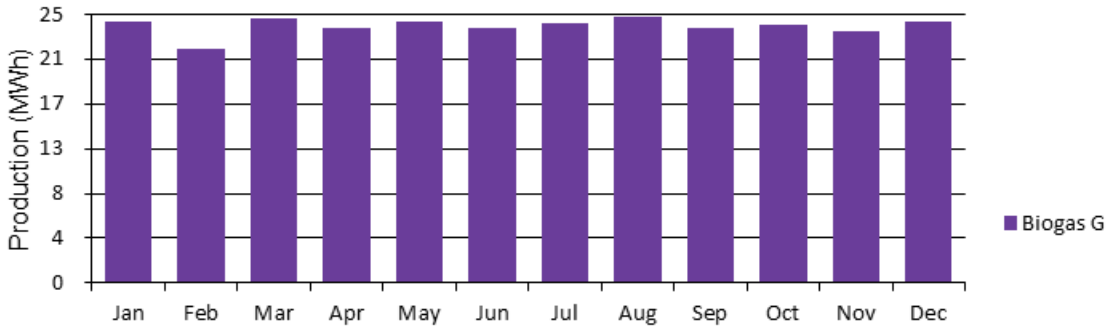

Figure 4.3 The Monthly electricity productions

There is no unmet electric load is 0kwh/year and the capacity shortage is 139kwh/yr. Due to the use of renewable energy resources biomass the renewable fraction is 100%. Sensitivity analysis for this model is shown below.

4.1.6.1 Sensitivity analysis

Sensitivity result shows that total 9 combinations, based on different sensitivity variables, are possible. The arrangement of all combinations is such that the one having lowest COE is coming first and so on. Table 4.2 shows result on the basis of sensitivity analysis. From the results it is clear that for minimum COE of $0.206494/kWh, NPC is $761118.4 and for minimum NPC of $693,725.8 COE is $0.208295/kWh. Though in both case RF is 100% and 1638kg/year CO_2 emission is there. And also due to sustainability economical point of view this model is not recommended.

Table 4.2 Sensitivity analysis

Interest Rate (%)	Biomass Price ($/tonne)	Biogas G (kW)	NPC ($)	LCOE ($/kWh)	Operating cost ($/yr)	CAPEX ($)	Ren Frac (%)
6	16.7	60	761118.4	0.206494	44539.15	59520	100
7	16.7	60	693725.8	0.208295	44557.32	59520	100
8	16.7	60	635598.9	0.210121	44562.23	59520	100
6	20	60	807640.3	0.219116	47492.47	59520	100
7	20	60	735761.8	0.220916	47510.63	59520	100
8	20	60	673778	0.222743	47515.54	59520	100
6	22	60	835835.3	0.226765	49282.36	59520	100
7	22	60	761238.1	0.228566	49300.52	59520	100
8	22	60	696916.8	0.230392	49305.43	59520	100

4.1.7 Standalone solar PV-battery storage

The Sun Power PV system has a nominal capacity of 550 kW with the annual production of 921,744 kWh/year is used. The system net present cost is $727,761.8, Levilised cost of energy is $0.2437, capacity shortage 612kwh/year which is 0.262 % and the renewable fraction is 100% is described in the figure 4.4 below.

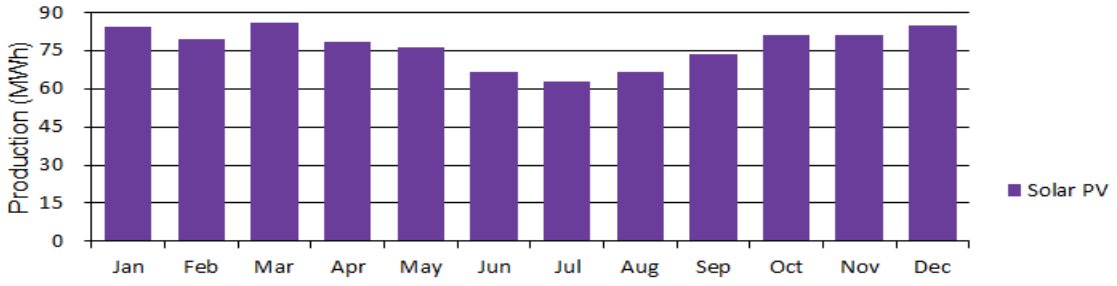

Figure 4.4 The Monthly electricity productions

The unmet electric load is 380kwh/year. Due to the use of renewable energy resources solar PV the renewable fraction is 100% and the maximum renewable penetration is 2534%.

4.1.7.1 Sensitivity analysis

Sensitivity result shows that total 3 combinations, based on different sensitivity variables, are possible. The arrangement of all combinations is such that the one having lowest COE is coming first and so on. Table 4.3 shows result on the basis of sensitivity analysis.

Table 4.3 Sensitivity analysis

Interest Rate (%)	Solar PV (kW)	Battery (#)	Converter (kW)	NPC ($)	LCOE ($/kWh)	Operating cost ($/year)	CAPEX ($)	Ren Frac (%)
6	550	188	65.82211	727761.8	0.243698	22588.32	439007.3	100
7	550	188	66.12036	700283.6	0.25723	22408.35	439146	100
8	550	186	65.34673	676343.1	0.271233	22403.93	437186.2	100

From the above results it is clear that for minimum COE of $0.243698/kWh, NPC is $727761.8 and for minimum NPC of $676343.1, COE is $0.271233/kWh.

4.1.2 Biogas-micro hydro hybrid system

For this model Biogas generator 35kW Generic, Hydro generator of 49kw are evaluated. The system net present cost is $785,128.70, Levilised cost of energy is 0.2079$, capacity shortage 1452kwh/year which is 0.620 %, renewable penetration 100% and consumption 233,870kwh/year is described in the figure 4.5 below.

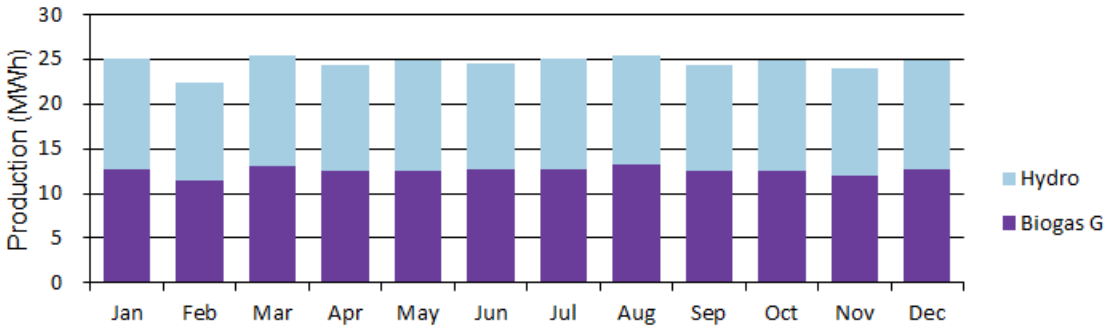

Figure 4.5 The Monthly electricity productions

4.1.2.1 Sensitivity analysis

Sensitivity result shows that total 9 combinations, based on different sensitivity variables, are possible. The arrangement of all combinations is such that the one having lowest COE is coming first and so on. Table 4.4 shows result on the basis of sensitivity analysis.

Table 4.4 Sensitivity analysis

Interest Rate (%)	Biomass Price ($/tonne)	Biogas G (kW)	Hydro (kW)	NPC ($)	LCOE ($/kWh)	Operating cost ($/yr)	CAPEX ($)	Ren Frac (%)
6	16.7	35	20.43619	765972.6	0.207918	42215.96	100970	100
7	16.7	35	20.43619	702364.5	0.210998	42252.1	100970	100
8	16.7	35	20.43619	647510.4	0.21417	42277.29	100970	100
6	20	35	20.43619	790391.4	0.214547	43766.13	100970	100
7	20	35	20.43619	724428.6	0.217626	43802.26	100970	100
8	20	35	20.43619	667550.1	0.220798	43827.45	100970	100
6	22	35	20.43619	805190.6	0.218564	44705.61	100970	100
7	22	35	20.43619	737800.8	0.221643	44741.75	100970	100
8	22	35	20.43619	679695.4	0.224815	44766.94	100970	100

From the above results it is clear that for minimum COE of $0.207918/kWh, NPC is $765972.6 and also for maximum COE of $0.224815/kwh, NPC is $679695.

4.1.3 Micro hydro- solar PV –storage battery hybrid system

For this model Hydro generator 10kW Generic, solar PV Sun PowerX21-335-BLK of 200 KW and Surrette 6 CS 25P 781 kw/h of storage battery are evaluated. The system net present cost is $531517.2, Levilised cost of energy is 0.1779$, capacity shortage 650kwh/year which is 0.278 %, renewable penetration 100% and consumption 233,662kwh/year is described in the figure 4.6 below.

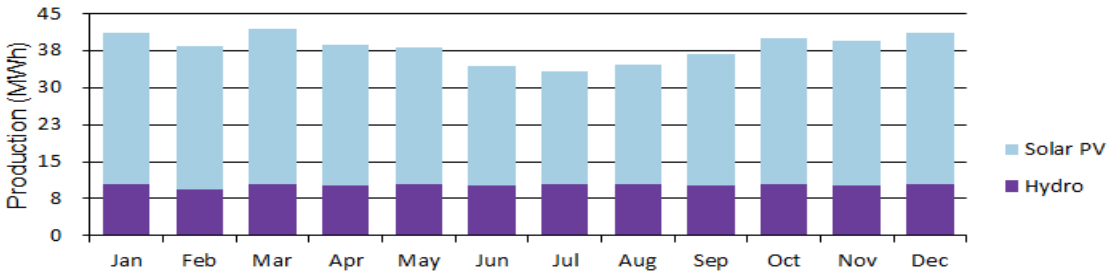

Figure 4.6 The Monthly electricity productions

4.1.3.1 Sensitivity analysis

Sensitivity analysis shows that total 3 combinations, based on different sensitivity variables, are possible. The arrangement of all combinations is such that the one having lowest COE is coming first and soon. Table 4.5 shows the result on the basis of sensitivity analysis. From the results it is clear that for minimum COE of $0.1779/kWh, NPC is $531517.3 and for minimum NPC of $484430.6, COE is $0.194216/kWh.

Table 4.5 Sensitivity analysis

Inflation Rate (%)	Solar PV (kW)	Battery (#)	Hydro (kW)	Converter (kW)	NPC ($)	LCOE ($/kWh)	Operating cost ($/yr)	CAPEX ($)	Ren Frac (%)
6	200	113	10.9872	51.26526	531517.3	0.177945	21143.03	261238.3	100
7	200	113	10.9872	51.26526	506363.2	0.185958	21034.29	261238.3	100
8	200	113	10.9872	51.26526	484430.6	0.194216	20908.38	261238.3	100

4.1.4 Solar PV –biogas-Storage battery hybrid system

For this model Biogas generator15kW Generic, solar PV Sun PowerX21-335-BLK of 308 KW and Surrette6CS25P781 kw/h of storage battery are evaluated. The system net present cost is $541,413, Levilised cost of energy is 0.1810$, capacity shortage 47.2kwh/year which is 0.0202 %, renewable penetration 100% and consumption 233,968kwh/year is described in the figure 4.7 below.

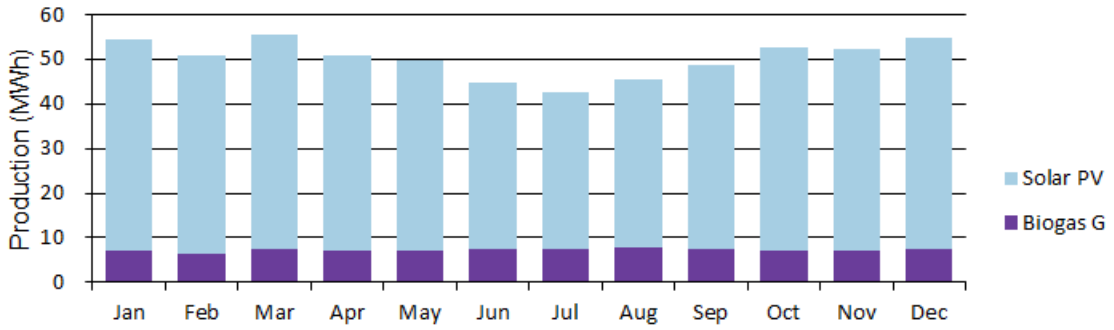

Figure 4.7 The Monthly electricity productions

4.1.4.1 Sensitivity analysis

Sensitivity analysis shows that total 9 combinations, based on different sensitivity variables, are possible. The arrangement of all combinations is such that the one having lowest COE is coming first and soon. Table 4.6 shows the result on the basis of sensitivity analysis.

Table 4.6 Sensitivity analysis

Interest Rate (%)	Biomass Price ($/tonne)	Solar PV (kW)	Biogas G (kW)	Battery (#)	NPC ($)	LCOE ($/kWh)	Operating cost ($/year)	CAPEX ($)	Ren Frac (%)
6	16.7	308.012	15	87	541413.3	0.18102	21905.4	261388.6	100
7	16.7	309.4872	15	86	515493.1	0.189063	21834.28	261045.5	100
8	16.7	308.2276	15	87	493055.9	0.197415	21747.13	260910.1	100
6	20	308.5124	15	87	552122.4	0.1846	22743.88	261379.4	100
7	20	310.6698	15	86	525363.5	0.192681	22621.15	261746.1	100
8	20	310.9329	15	86	502098.3	0.201033	22497.03	261947.5	100
6	22	310.0489	15	86	558558.6	0.186752	23237.4	261506.7	100
7	22	308.1142	15	87	531434.6	0.194909	23232.65	260691	100
8	22	311.6714	15	86	507512.4	0.2032	22973.04	262280.3	100

From the above results it is clear that for minimum COE of $0.18102/kWh, NPC is $541,413.3 and for minimum NPC of $507,512.4, COE is $0.2032/kWh.

4.1.1 Micro hydro/PV solar/biogas with storage battery

For this model Hydro generator 10kW Generic, Generic Biogas Genset Biogas generator of 15kw, solar PV Sun PowerX21-335-BLK of 58 KW and Surrette 6 CS 25P 290 kw/h of storage battery are evaluated. The system net present cost is $326,648.7, Levilised cost of energy is

0.1092$, capacity shortage31.1kwh/year which is 0.0133%, renewable penetration 100%and consumption 233,985kwh/year is described in the figure 4.8 below.

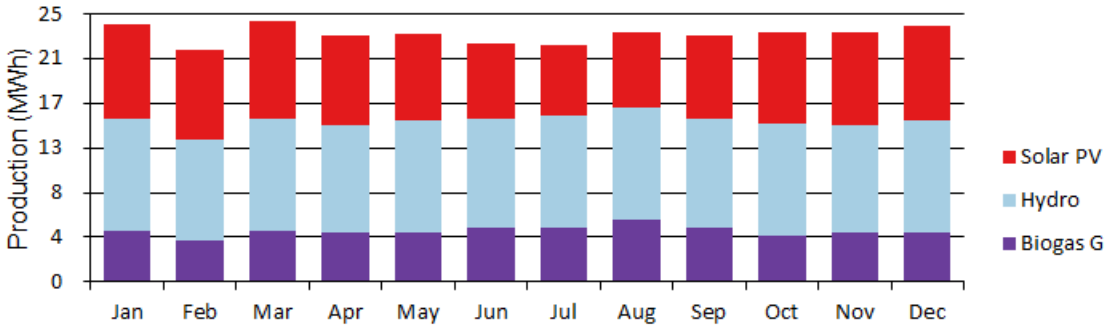

Figure 4.8 The Monthly electricity productions

As shown in the optimization result the unmet electric load is 5.86kwh/year. Due to the use of renewable energy resources solar PV and biomass and hydro the renewable fraction is 100% and the maximum renewable penetration is 1,699%. The electrical summary of this model is described in the tables below.

Table 4.7 Production Summary

Production	Kwh/year	Percent (%)
SunPowerX21-335-BLK	97171	35.1
Generic Biogas Genset (size-your-own)	57163	20.6
Hydro	122,716	44.3
Total	257026	100

Table 4.8 Excess and Unmet

Quantity	Value	Unit
Excess Electricity	33618	kWh/year
Unmet Electric Load	5.68	kWh/year
Capacity Shortage	31.1	kWh/year

4.1.1.1 Sensitivity analysis

Sensitivity analysis shows that 9 combinations are possible here. In these combinations it is found that rating (kW) of individual system is almost same but the combination

having minimum COE, is existing on first position. Sensitivity results of the system are shown in table 4.9.

Table 4.9 Sensitivity analysis

Interest Rate (%)	Biomass Price ($/tonne)	Solar PV (kW)	Biogas G (kW)	Battery (#)	Hydro (kW)	NPC ($)	LCOE ($/kWh)	Operating cost ($/yr)	CAPEX ($)	Ren Frac (%)
6	16.7	58.20394	15	42	10.9872	376648.7	0.109207	14294.76	143913.8	100
7	16.7	57.98136	15	42	10.9872	359831.3	0.113626	14269.45	143541.1	100
8	16.7	52.94459	15	43	10.9872	344850.6	0.118048	14337.43	141801.7	100
6	20	57.17892	15	43	10.9872	385226	0.112074	14913.33	144583.6	100
7	20	51.4081	15	43	10.9872	366508	0.116076	15094.46	140603.4	100
8	20	51.98984	15	43	10.9872	350732.5	0.120403	14903.77	141638	100
6	22	61.85603	15	43	10.9872	389732.8	0.11358	15125.82	146374	100
7	22	61.05538	15	42	10.9872	371859.7	0.118038	15176.3	145001.4	100
8	22	50.32058	15	44	10.9872	356070.2	0.122539	15312.42	142613.5	100

From the above table, it is observed that by increasing the annual interest rate, total NPC will decrease and COE will increase. It also shows that to obtain minimum COE i.e. $0.109207/kWh, biomass price and interest rate should be $16.7/tonne and 6% respectively. At this stage renewable fraction is found to be 100%. It is also found that at biomass price of $22/tonne and interest rate of 6%, there is a change in system configuration and COE is increased to $0.11358/kWh, though the maximum NPC is obtained. Further graphical representation is also used to represent sensitivity results in a better way. For graphical representation, graphs can be represented in different ways as:

Optimal system type plot- To find optimal system, four parameters is considered, namely COE, NPC, RF and carbon emissions. Fig 4.9 shows the optimal system on the basis of COE. It shows that for all sensitivity variables, COE is different. Minimum COE is found to be $0.109207/kWh at biomass price of $16.7/tonne and interest rate of 6% whereas the maximum COE is found to be $0.12259/kWh at biomass price of $22/tonne and interest rate of 8%.

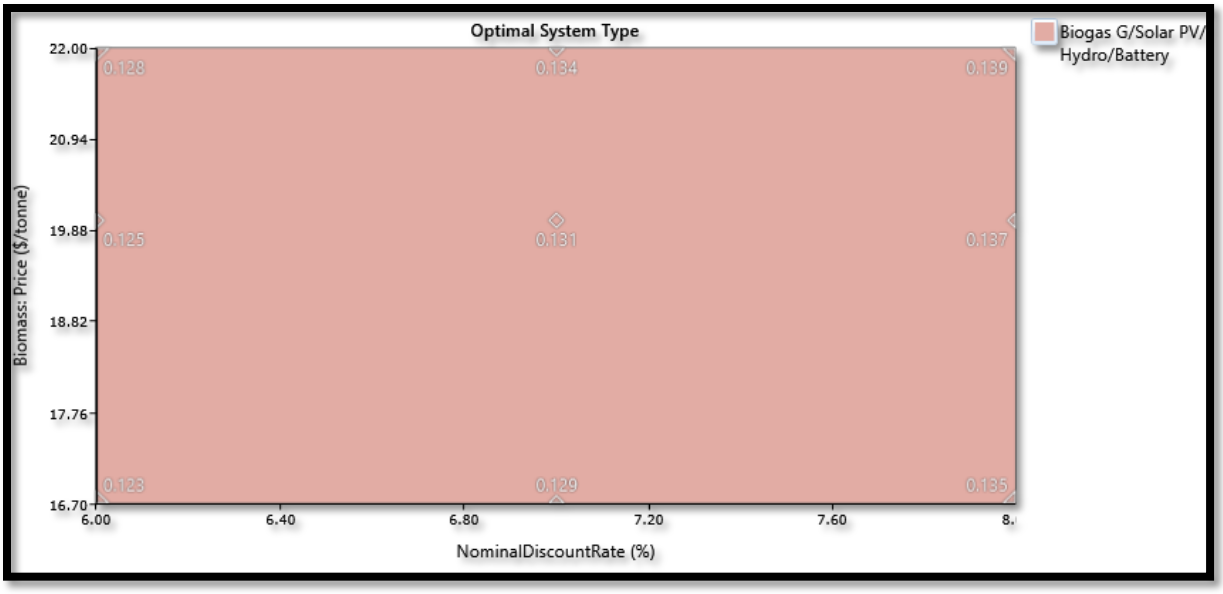

Figure 4.9 Optimal system types

Surface plot- For surface plot, two values are considered named as primary and superimposed. On the basis of sensitivity variables, surface plot is shown for total NPC as primary value and LCOE as superimposed value. Fig 4.10 shows the surface plot. It is observed that for different biomass prices of $16.7/tonne, $20/tonne, $22/tonne and annual interest rate of 6%, 7%, 8%, LCOE is $0.1029/kWh and NPC is $378643at biomass price of $16.7/tonne and interest rate of 6%. It is also found that for a fixed value of biomass price and increasing value of interest rate to 8%, the total NPC will decrease to $344850.6.

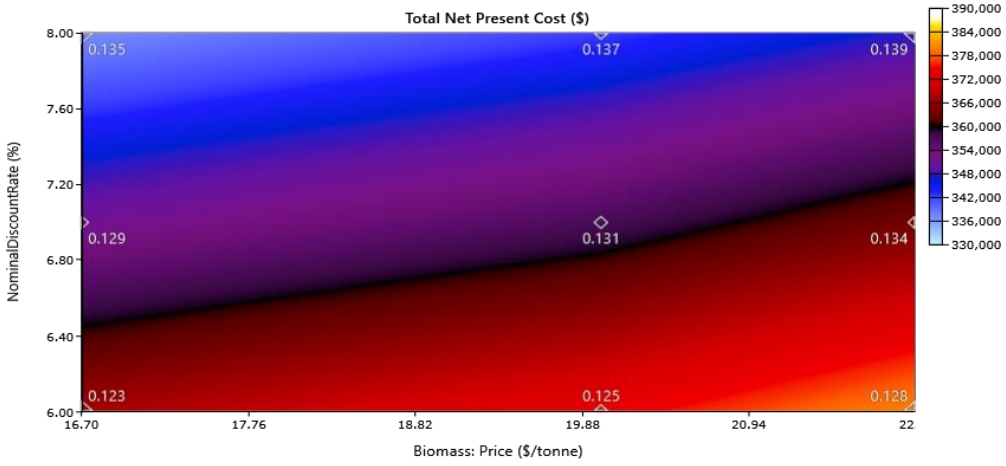

Figure 4.10 Surface plot

Fig 4.11 also shows the surface plot between COE and CO_2 emission. It shows that for different biomass prices of $16.7/tonne, $20/tonne, $22/tonne and annual interest rate of 6%,7%,8%, CO_2emissions and LCOE are 398.916kg/year, $0.123 for biomass price of $16.7/tonne and interest rate of 6%.CO_2 emissions is 434.737kg/year for a fixed value of biomass price and increasing value of interest rate to 8%, COE will also increase to $0.129.

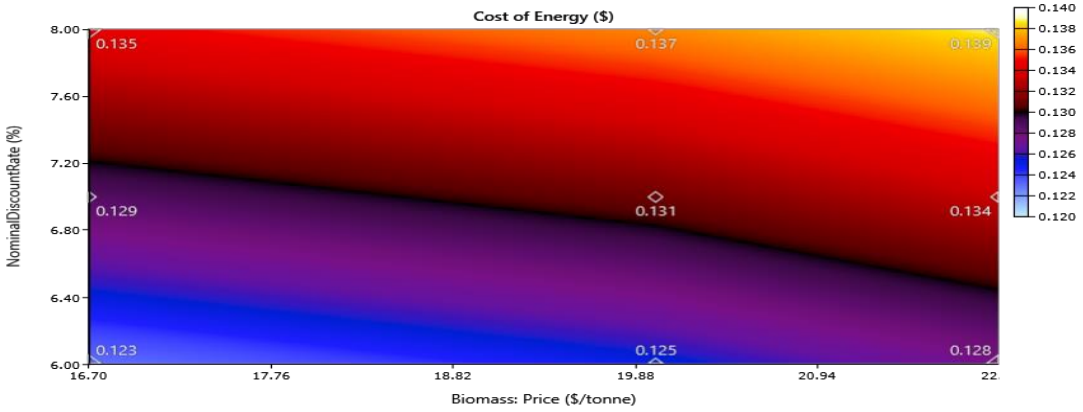

Figure 4.11 surface plot

Line graph- In line graph, plot of COE and RF is shown at 6% interest rate and variable biomass prices. Fig 4.12 shows that from biomass price of $16.7/tonne to $22/tonne, RF is same as100% on the other side, COE increases continuously.

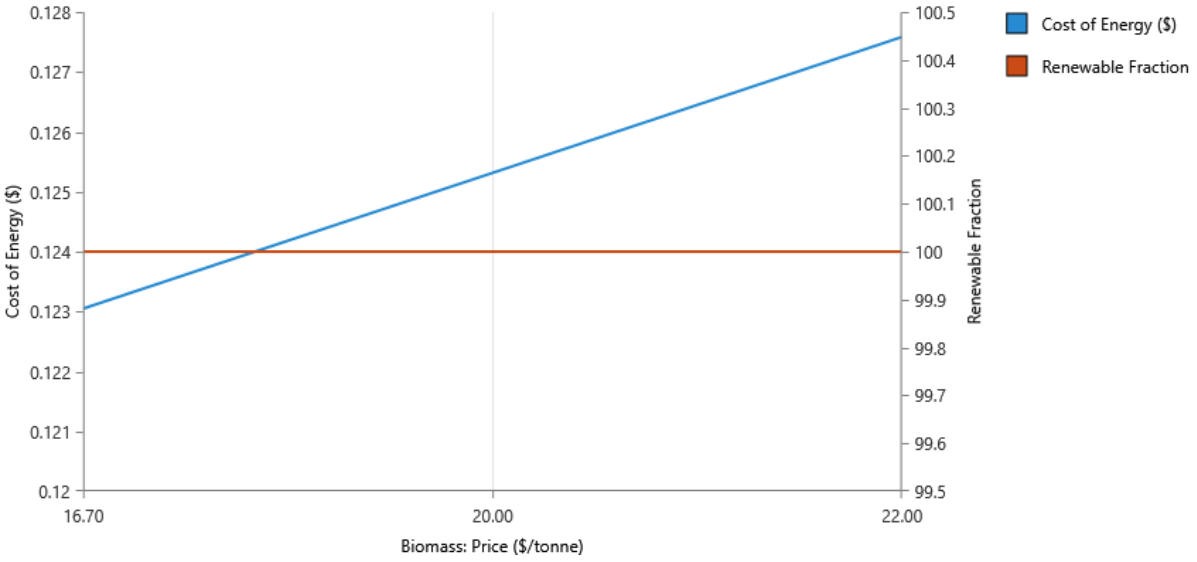

Figure 4.12 Line graph interest rate of 6%

Fig 4.13 also shows the line graph at 7% interest rate. Here RF is constant i.e.100% for all values of biomass price but COE is continuously increasing as biomass price is increasing.

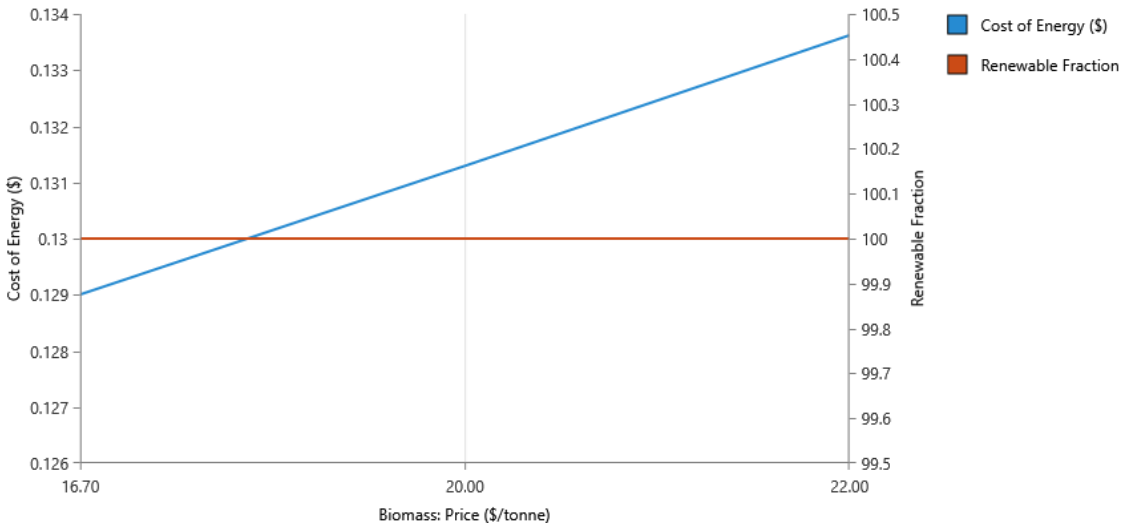

Figure 4.13 Line graph interest rate of 7%

4.1.1.2 Optimization result

From sensitivity analysis, three best configurations are selected by considering economy and environment as the major concerns. Details of three configurations are shown in table 4.10.

Table 4.10 Optimization result

Solar PV (kW)	Biogas G (kW)	Battery (#)	Hydro (kW)	NPC ($)	LCOE ($/kWh)	Operating cost ($/yr)	CAPEX ($)	Ren Frac (%)
58.20394	15	42	10.9872	326648.7	0.109207	14294.76	143913.8	100
57.32727	15	43	10.9872	326773.6	0.109248	14278.63	144244.8	100
56.83322	15	42	10.9872	326998.1	0.109324	14351.34	143539.8	100
55.84047	15	44	10.9872	327219.3	0.109396	14299.35	144425.6	100
60.68157	15	41	10.9872	327219.6	0.109398	14332.77	143998.7	100
58.50908	15	44	10.9872	327798.4	0.10959	14279.27	145261.5	100

From the above table it is clear that by considering economy and environment as the major factors, three configurations can be selected. Starting the analysis from the third configuration it has COE $0.231589/kWh, CO_2 emission 458.6364kg/year and total NPC

$700382.8 at biomass price of $22/tonne and interest rate of 8%. Second configuration has COE $0.223944/kWh, CO_2emission 438.8737kg/year and total NPC$745,680.8 at biomass price of $20/tonne and interest rate of 7%. So based on economical aspect either of these two configurations can be selected. On the other side, first configuration consists as maximum NPC $785,128.7, CO_2 emission as minimum 398.9157 kg/year and COE $0.213072/kWh at biomass price of $16.7/tonne and interest rate of 6%. So by considering environment related issues as the major concern, first configuration can also be selected as carbon emissions are less with minimum of LCOE as $0.213072/kWh. Due to using renewable energy resources the RF is the same 100% for all configurations.

4.2 Economic analysis using the break-even grid extension distance

The HOMER was used to perform the calculation for this comparative parameter. This comparison parameter was one of several outputs provided by the program following the simulation, providing a mechanism to compare the optimal hybrid solar PV-micro hydro-Biogas hybrid system and the grid expansion option. This distance, as shown in fig. 4.14, is the point at where the total net present cost of the two choices overlaps. The break-even grid extension distance was calculated to be 12.78 kilometres.

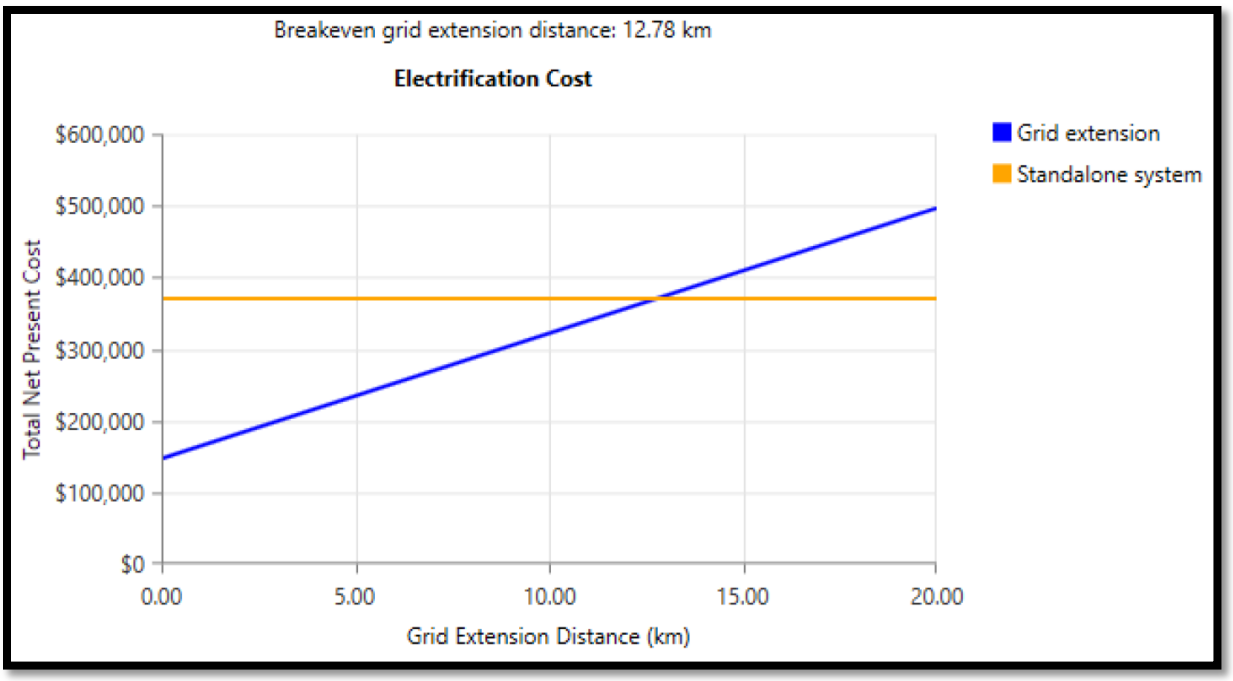

Figure 4.14 Breakeven grid extension distance

Which is smaller than the village's actual distance from the nearest grid tower (32 km)? Given the break-even grid extension distance achieved for this analysis, it is clear that using an off-grid hybrid generation system is more cost-effective than extending grid supplies over the 32 km stretch to satisfy the load at the study site.

The grid extension strategy would have been more economically viable if the actual distance between the village and the nearest grid tower had been less than the break-even grid expansion distance.

4.3 Engineering economic analysis

The economic analysis can be performed once the technical requirements of a hybrid system application have been defined and a hybrid system design has been finalized. The economic evaluation considers both the system's costs and advantages. According to Trading Economics global macro models and analysts' forecasts, Ethiopia's interest rate is predicted to be 9% by the end of this quarter. According to our econometric models, the Ethiopian interest rate will trend around 8% in 2024 and 7% in 2025 in the long run [83]. Table 4.11 depicts the replacement and O&M expenses as a nominal cash flow of the project over a 25-year period. Here, we can see that the battery is replaced after 9 and 18 years, and the converters are replaced after 19 years. The O&M costs for the hydro, biogas generator, and battery will be incurred on a yearly basis. Because the PV lifetime is equivalent to the project lifetime, there are no replacement or O&M costs. The selected biogas generator for the case study has a longer lifespan than the project and requires no replacement. Net present value (NPC): The present value of the cost of installing and operating the system over the project's lifetime (also known as lifecycle cost). In this study, the project lifetime was set at 25 years.

Table 4.11 Cash flow throughout 25 years

Project Lifetime	**25 years**
Real Interest Rate	7.0%

Year	1	2	3	4	5	6	7	8	9	10
10kW Generic	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)
Generic Biogas Gen set (size-your-own)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)
Other	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)
Sun Power X21-335-BLK	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)
Surrette 6 CS 25P	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)
System Converter	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)

Year	11	12	13	14	15	16	17	18	19	20
10kW Generic	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)
Generic Biogas Gen set (size-your-own)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)
Other	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)
Sun Power X21-335-BLK	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)
Surrette 6 CS 25P	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)
System Converter	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)

Year	21	22	23	24	25
10kW Generic	($400.00)	($400.00)	($400.00)	($400.00)	($400.00)
Generic Biogas Gen set (size-your-own)	($588.45)	($588.45)	($588.45)	($588.45)	($588.45)
Other	($5,335)	($5,335)	($5,335)	($5,335)	($5,335)
Sun Power X21-335-BLK	($289.91)	($289.91)	($289.91)	($289.91)	($289.91)
Surrette 6 CS 25P	($210.00)	($210.00)	($210.00)	($210.00)	($210.00)
System Converter	($3.69)	($3.69)	($3.69)	($3.69)	($3.69)

Chapter five
Conclusion and recommendation

5.1 Conclusion

This paper discusses a hybrid power generation system consisting of solar PV micro hydro and biogas with battery storage to achieve a cost effective system configuration that is supposed to supply electricity to a model community of 520 households to improve the lives of people in the rural area of Tulla-dadiban tourist destination where electricity from the main grid has not yet reached. The software's output provided various options for workable hybrid systems with varying amounts of renewable resource penetration, which their selection sorted by modifying the net present cost of each set up. This study proposes a micro hydro/PV/Biogas hybrid system from a technical standpoint. According to simulation results, hydropower accounts for 47.7% of total energy consumption, PV modules account for just 24.2%, and biogas accounts for only 28.1% of total load consumption. From an economic standpoint, it is discovered that for the village under investigation, which is characterized by average stream flow 14.3 m3sand the head is 76 m, biomass fuel consumption of 226.3tonn/year, and solar radiation 5.29 kWh/m^2/day.

The COE of the possible systems in this study, which is roughly 0.109207/KWh, is more than Ethiopia's current grid pricing of $0.096/kWh. However, given the country's lack of electricity (less than 30% coverage) and the absence of energy usage in rural areas (less than 2% coverage), this expense should not be considered crucial?

Other considerations should be made, such as the role of a standalone hybrid system in protecting the environment from degradation, improving the quality of life for people living in rural areas, developing clean energy, the future situation with regard to fossil fuel sources, and its contribution to reducing pollutant emissions into the environment.

Finally, we can conclude that this hybrid power system is an excellent option solution because it is inexpensive and appealing for electrifying the selected rural village under the condition of involving local trained people in system maintenance and receiving some funds or donations from the government or non-governmental organizations. Because it is environmentally beneficial, this energy system reduces pollution and deforestation. Furthermore, provide useful information to the government and non-governmental organizations (NGOs) regarding the country's technology potential for a rural electrification initiative in Ethiopia. Furthermore, this work can be used as a model for comparable research operations at other places.

5.2 Recommendations

In terms of the environment, employing renewable energy resources is the greatest option. Ethiopia has a large potential for renewable energy resources that can be utilised for off-grid rural electrification. However, there are other problems, such as the rural community's low purchasing power, unfavourable conditions for the use of renewable energies, a lack of understanding about how to use these resources, and so on. As a result, I urge that the government, non-governmental organizations, and private sectors work together to address these challenges by employing more flexible techniques to improve Ethiopia's existing dismal rural electrification status. In general, this research will provide direction and advice to any volunteer, NGO, or UEAP who wishes to work on a project centred on the Gojeb Rivers of the Tulla-dadiban site.

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Apendix1 the overall optimization table

Solar PV (kW)	Biogas G (kW)	Battery (#)	Hydro (kW)	Converter (kW)	NPC ($)	LCOE ($/kWh)	Operating cost ($/yr)	CAPEX ($)	Ren Frac (%)
58.20394	15	42	10.9872	37.44075	376648.7	0.109207	14294.76	143913.8	100
57.32727	15	43	10.9872	37.29945	376773.6	0.109248	14278.63	144244.8	100
56.83322	15	42	10.9872	37.99244	376998.1	0.109324	14351.34	143539.8	100
55.84047	15	44	10.9872	37.43873	377219.3	0.109396	14299.35	144425.6	100
60.68157	15	41	10.9872	36.89286	377219.6	0.109398	14332.77	143998.7	100
58.50908	15	44	10.9872	36.59632	377798.4	0.10959	14279.27	145261.5	100
57.14777	15	41	10.9872	37.29992	377815.8	0.109598	14491.77	142562.4	100
57.14777	15	41	10.9872	37.29992	377815.8	0.109598	14491.77	142562.4	100
53.1461	15	45	10.9872	36.97577	377819.4	0.109597	14397.5	143770.9	100
53.1461	15	45	10.9872	36.97577	377819.4	0.109597	14397.5	143770.9	100
61.92405	15	44	10.9872	37.686	377902.1	0.109624	14124.85	147339	100
61.92405	15	44	10.9872	37.686	377902.1	0.109624	14124.85	147339	100
61.13783	15	41	10.9872	39.21964	377906.7	0.109628	14285.46	145290.5	100
61.13783	15	41	10.9872	39.21964	377906.7	0.109628	14285.46	145290.5	100
63.35741	15	42	10.9872	36.94871	377969.1	0.109648	14230.5	146055.6	100
63.35741	15	42	10.9872	36.94871	377969.1	0.109648	14230.5	146055.6	100
58.92026	15	41	10.9872	37.00067	377974.6	0.10965	14451.29	143238.6	100
58.92026	15	41	10.9872	37.00067	377974.6	0.10965	14451.29	143238.6	100
51.13467	15	43	10.9872	37.42832	378012.8	0.109663	14593.72	141456.1	100
51.13467	15	43	10.9872	37.42832	378012.8	0.109663	14593.72	141456.1	100
53.32436	15	44	10.9872	38.04788	378016.3	0.109663	14430.08	143551.5	100
53.32436	15	44	10.9872	38.04788	378016.3	0.109663	14430.08	143551.5	100
55.81651	15	45	10.9872	36.48904	378028.9	0.109666	14335.51	144773	100
55.81651	15	45	10.9872	36.48904	378028.9	0.109666	14335.51	144773	100
57.33551	15	40	10.9872	36.85089	378068.3	0.109683	14583.67	141640	100
57.33551	15	40	10.9872	36.85089	378068.3	0.109683	14583.67	141640	100
57.29856	15	40	10.9872	37.35348	378087.9	0.109689	14568.26	141856.7	100
57.29856	15	40	10.9872	37.35348	378087.9	0.109689	14568.26	141856.7	100
59.25642	15	44	10.9872	37.45816	378096.3	0.109689	14244.32	146006	100
59.25642	15	44	10.9872	37.45816	378096.3	0.109689	14244.32	146006	100
53.71701	15	42	10.9872	37.04639	378169.8	0.109717	14589.55	141666.4	100
53.71701	15	42	10.9872	37.04639	378169.8	0.109717	14589.55	141666.4	100
53.56386	15	43	10.9872	36.12395	378218.4	0.109732	14569.83	141967	100
53.56386	15	43	10.9872	36.12395	378218.4	0.109732	14569.83	141967	100
58.48044	15	41	10.9872	37.35804	378247.9	0.109742	14475.5	143202.5	100
58.48044	15	41	10.9872	37.35804	378247.9	0.109742	14475.5	143202.5	100
58.96887	15	44	10.9872	39.17123	378371.7	0.109781	14213.9	146670.3	100
58.96887	15	44	10.9872	39.17123	378371.7	0.109781	14213.9	146670.3	100

55.85751	15	40	10.9872	37.21523	378560.6	0.109848	14662.12	141129.5	100
55.85751	15	40	10.9872	37.21523	378560.6	0.109848	14662.12	141129.5	100
57.42334	15	45	10.9872	35.51017	378584.0	0.109852	14356.72	145057	100
57.42334	15	45	10.9872	35.51017	378584.0	0.109852	14356.72	145057	100
57.47274	15	40	10.9872	39.11012	378667.6	0.109883	14543.44	142753.7	100
57.47274	15	40	10.9872	39.11012	378667.6	0.109883	14543.44	142753.7	100
58.35641	15	40	10.9872	36.37162	378835.3	0.109939	14624.38	141886.8	100
58.35641	15	40	10.9872	36.37162	378835.3	0.109939	14624.38	141886.8	100
58.84226	15	40	10.9872	37.08907	378990.4	0.109991	14592.92	142443.9	100
58.84226	15	40	10.9872	37.08907	378990.4	0.109991	14592.92	142443.9	100
54.55049	15	40	10.9872	38.30952	379249.9	0.110079	14723.27	141037.2	100
54.55049	15	40	10.9872	38.30952	379249.9	0.110079	14723.27	141037.2	100
58.34146	15	46	10.9872	38.05563	379309.3	0.110093	14225.24	147462.9	100
58.34146	15	46	10.9872	38.05563	359309.3	0.110093	14225.24	147462.9	100
63.62691	15	39	10.9872	38.20468	379382.0	0.110123	14473.39	144363.5	100
63.62691	15	39	10.9872	38.20468	379382.0	0.110123	14473.39	144363.5	100
58.07164	15	39	10.9872	37.75092	379492.9	0.11016	14698.47	141597.1	100
58.07164	15	39	10.9872	37.75092	379492.9	0.11016	14698.47	141597.1	100
58.03159	15	41	10.9872	41.33456	379928.1	0.110304	14478.44	144845.1	100
58.03159	15	41	10.9872	41.33456	379928.1	0.110304	14478.44	144845.1	100
66.52876	15	40	10.9872	39.47015	380053.1	0.110349	14312.85	147086.8	100
66.52876	15	40	10.9872	39.47015	380053.1	0.110349	14312.85	147086.8	100
63.98955	15	44	10.9872	38.62778	380075.5	0.110351	14186.29	148727.1	100
63.98955	15	44	10.9872	38.62778	380075.5	0.110351	14186.29	148727.1	100
55.76361	15	47	10.9872	37.53042	380176.7	0.110383	14342.39	146832.9	100
55.76361	15	47	10.9872	37.53042	380176.7	0.110383	14342.39	146832.9	100
50.55449	15	47	10.9872	36.61023	380194.3	0.11039	14564.68	144008.8	100
50.55449	15	47	10.9872	36.61023	380194.3	0.11039	14564.68	144008.8	100
47.61088	15	44	10.9872	40.5447	380289.5	0.110425	14722.68	142084.3	100
47.61088	15	44	10.9872	40.5447	380289.5	0.110425	14722.68	142084.3	100
52.97715	15	47	10.9872	37.97042	380361.2	0.110445	14441.08	145755.7	100
52.97715	15	47	10.9872	37.97042	380361.2	0.110445	14441.08	145755.7	100
60.36036	15	47	10.9872	36.94079	380578.8	0.110518	14229.87	148673.2	100
60.36036	15	47	10.9872	36.94079	380578.8	0.110518	14229.87	148673.2	100
58.2535	15	43	10.9872	44.13978	380584.6	0.110522	14294.6	147851.6	100
58.2535	15	43	10.9872	44.13978	380584.6	0.110522	14294.6	147851.6	100
42.67891	15	46	10.9872	36.56892	381049.7	0.110679	14979.08	139566.8	100
42.67891	15	46	10.9872	36.56892	381049.7	0.110679	14979.08	139566.8	100
55.25098	15	48	10.9872	36.5447	381235.9	0.110737	14416.96	146938.7	100
55.25098	15	48	10.9872	36.5447	381235.9	0.110737	14416.96	146938.7	100
60.63249	15	38	10.9872	37.32319	381471.6	0.110824	14839.25	141776.2	100
60.63249	15	38	10.9872	37.32319	381471.6	0.110824	14839.25	141776.2	100

45.62739	15	47	10.9872	38.91118	381509.7	0.110831	14761.18	142812.3	100
45.62739	15	47	10.9872	38.91118	381509.7	0.110831	14761.18	142812.3	100
52.85288	15	39	10.9872	36.74334	382051.3	0.111019	15123.04	138728	100
52.85288	15	39	10.9872	36.74334	382051.3	0.111019	15123.04	138728	100
60.89808	15	42	10.9872	47.37744	382610.7	0.1112	14302.74	149773.6	100
60.89808	15	42	10.9872	47.37744	382610.7	0.1112	14302.74	149773.6	100
65.69305	15	39	10.9872	42.24769	382802.4	0.111271	14519.54	147194	100
65.69305	15	39	10.9872	42.24769	382802.4	0.111271	14519.54	147194	100
65.46521	15	49	10.9872	38.10208	383634.9	0.111539	14117.85	153161.5	100
65.46521	15	49	10.9872	38.10208	383634.9	0.111539	14117.85	153161.5	100
56.96852	15	50	10.9872	37.84292	383823.7	0.111603	14385.2	149932.5	100
56.96852	15	50	10.9872	37.84292	383823.7	0.111603	14385.2	149932.5	100
49.68006	15	49	10.9872	41.70396	384684.6	0.11189	14636.95	147575.2	100
49.68006	15	49	10.9872	41.70396	384684.6	0.11189	14636.95	147575.2	100
54.72971	15	50	10.9872	40.07403	384719.9	0.111902	14454.72	149940.1	100
54.72971	15	50	10.9872	40.07403	384719.9	0.111902	14454.72	149940.1	100
65.70535	15	47	10.9872	43.5291	384796.9	0.111928	14127.86	154195.5	100
65.70535	15	47	10.9872	43.5291	384796.9	0.111928	14127.86	154195.5	100
69.80707	15	41	10.9872	45.44973	384865.3	0.11196	14291.23	152175.4	100
69.80707	15	41	10.9872	45.44973	384865.3	0.11196	14291.23	152175.4	100
79.64723	15	40	10.9872	43.20781	385052.7	0.112019	14095.93	154859.4	100
79.64723	15	40	10.9872	43.20781	385052.7	0.112019	14095.93	154859.4	100
72.92282	15	48	10.9872	41.10165	385434.3	0.112141	13943.72	157186.8	100
72.92282	15	48	10.9872	41.10165	385434.3	0.112141	13943.72	157186.8	100
87.99029	15	45	10.9872	39.62235	385527.9	0.112172	13650.4	161029.9	100
87.99029	15	45	10.9872	39.62235	385527.9	0.112172	13650.4	161029.9	100
40.35898	15	46	10.9872	40.47665	385622.2	0.112211	15278.1	140316.8	100
40.35898	15	46	10.9872	40.47665	385622.2	0.112211	15278.1	140316.8	100
59.68266	15	50	10.9872	41.75194	385877.7	0.112289	14306.02	152998.7	100
59.68266	15	50	10.9872	41.75194	385877.7	0.112289	14306.02	152998.7	100
58.9991	15	37	10.9872	38.53741	387671.8	0.112903	15401.46	140789.5	100
58.9991	15	37	10.9872	38.53741	387671.8	0.112903	15401.46	140789.5	100
74.60172	15	36	10.9872	37.31695	387811.5	0.112953	14957.91	146599.2	100
74.60172	15	36	10.9872	37.31695	387811.5	0.112953	14957.91	146599.2	100
71.24032	15	44	10.9872	50	388059.4	0.113019	14136.26	157350.5	100
71.24032	15	44	10.9872	50	388059.4	0.113019	14136.26	157350.5	100
50	15	39	10.9872	41.66667	389126.5	0.113391	15600.09	139705	100
50	15	39	10.9872	41.66667	389126.5	0.113391	15600.09	139705	100
49.93456	15	40	10.9872	45.87471	389151.0	0.113396	15388.71	142431.6	100
49.93456	15	40	10.9872	45.87471	389151.0	0.113396	15388.71	142431.6	100
49.60235	15	54	10.9872	38.83745	389153.2	0.113384	14780.68	150206.5	100
49.60235	15	54	10.9872	38.83745	389153.2	0.113384	14780.68	150206.5	100

79.52193	15	42	10.9872	32.61877	389305.9	0.113437	14693.18	151477.8	100
79.52193	15	42	10.9872	32.61877	389305.9	0.113437	14693.18	151477.8	100
59.83042	15	49	10.9872	50	389853.8	0.113619	14374.3	156102	100
59.83042	15	49	10.9872	50	389853.8	0.113619	14374.3	156102	100
51.25632	15	52	10.9872	44.72222	389891.0	0.113631	14689.98	152103.7	100
51.25632	15	52	10.9872	44.72222	389891.0	0.113631	14689.98	152103.7	100
50	15	52	10.9872	33.33333	390617.6	0.113874	15206.3	146230	100
50	15	52	10.9872	33.33333	390617.6	0.113874	15206.3	146230	100
43.94895	15	40	10.9872	38.67795	391791.8	0.114288	16072.46	136331.8	100
43.94895	15	40	10.9872	38.67795	391791.8	0.114288	16072.46	136331.8	100
52.62493	15	37	10.9872	39.56377	391794.0	0.114288	15915.96	138334.6	100
52.62493	15	37	10.9872	39.56377	391794.0	0.114288	15915.96	138334.6	100
71.875	15	52	10.9872	44.79167	392002.4	0.114337	14110.67	161620.6	100
71.875	15	52	10.9872	44.79167	392002.4	0.114337	14110.67	161620.6	100
66.03736	15	51	10.9872	32.75555	393155.1	0.114722	14911.31	152538.5	100
66.03736	15	51	10.9872	32.75555	393155.1	0.114722	14911.31	152538.5	100
50	15	52	10.9872	50	393298.7	0.11477	14809.78	153980	100
50	15	52	10.9872	50	393298.7	0.11477	14809.78	153980	100
61.55003	15	54	10.9872	46.55346	393793.2	0.114936	14433.05	159290.4	100
61.55003	15	54	10.9872	46.55346	393793.2	0.114936	14433.05	159290.4	100
47.67897	15	37	10.9872	34.68691	397070.5	0.11606	16684.1	133791.8	100
47.67897	15	37	10.9872	34.68691	397070.5	0.11606	16684.1	133791.8	100
30	15	48	10.9872	45.41667	397319.4	0.116117	16261.04	139448.8	100
30	15	48	10.9872	45.41667	397319.4	0.116117	16261.04	139448.8	100
64.5249	15	35	10.9872	50	400259.8	0.117119	15895.54	147061.5	100
64.5249	15	35	10.9872	50	400259.8	0.117119	15895.54	147061.5	100
66.51786	15	57	10.9872	50	400831.0	0.117288	14491.72	165578.2	100
66.51786	15	57	10.9872	50	400831.0	0.117288	14491.72	165578.2	100
64.74198	15	62	10.9872	41.38206	401976.0	0.117671	14645.77	164754	100
64.74198	15	62	10.9872	41.38206	401976.0	0.117671	14645.77	164754	100
100	15	52	10.9872	33.33333	402028.6	0.117689	14299.73	169230	100
100	15	52	10.9872	33.33333	402028.6	0.117689	14299.73	169230	100
78.9938	15	61	10.9872	39.11671	402445.6	0.117828	14314.65	169456.4	100
78.9938	15	61	10.9872	39.11671	402445.6	0.117828	14314.65	169456.4	100
25	15	52	10.9872	37.5	402800.3	0.117947	16907.36	136667.5	100
25	15	52	10.9872	37.5	402800.3	0.117947	16907.36	136667.5	100
75.86024	15	34	10.9872	47.37744	403398.9	0.11817	15891.18	150256.2	100
75.86024	15	34	10.9872	47.37744	403398.9	0.11817	15891.18	150256.2	100
100	15	52	10.9872	50	403433.1	0.118158	13803.35	176980	100
100	15	52	10.9872	50	403433.1	0.118158	13803.35	176980	100
58.26213	15	67	10.9872	36.5129	406423.7	0.119158	15091.08	163509.1	100
58.26213	15	67	10.9872	36.5129	406423.7	0.119158	15091.08	163509.1	100

50	15	67	10.9872	42.36111	408795.0	0.119951	15361.15	162427.9	100
50	15	67	10.9872	42.36111	408795.0	0.119951	15361.15	162427.9	100
48.84061	15	36	10.9872	49.63667	409710.1	0.120298	17149.83	140477.7	100
48.84061	15	36	10.9872	49.63667	409710.1	0.120298	17149.83	140477.7	100
75	15	65	10.9872	33.33333	411525.8	0.120864	15128.72	168130	100
75	15	65	10.9872	33.33333	411525.8	0.120864	15128.72	168130	100
149.2041	15	50	10.9872	38.02039	418031.4	0.12305	13735.68	192443.4	100
149.2041	15	50	10.9872	38.02039	418031.4	0.12305	13735.68	192443.4	100
149.3503	15	49	10.9872	38.41645	418135.4	0.123086	13786.73	191894.8	100
149.3503	15	49	10.9872	38.41645	418135.4	0.123086	13786.73	191894.8	100
148.9997	15	50	10.9872	38.33871	418156.3	0.123092	13741.22	192497.4	100
148.9997	15	50	10.9872	38.33871	418156.3	0.123092	13741.22	192497.4	100
148.6412	15	51	10.9872	37.90462	418394.7	0.12317	13725.98	192930.6	100
148.6412	15	51	10.9872	37.90462	418394.7	0.12317	13725.98	192930.6	100
148.2021	15	49	10.9872	38.16911	418833.2	0.123322	13891.62	191251.6	100
148.2021	15	49	10.9872	38.16911	418833.2	0.123322	13891.62	191251.6	100
147.5864	15	50	10.9872	37.7504	418860.7	0.12333	13868.58	191573.7	100
147.5864	15	50	10.9872	37.7504	418860.7	0.12333	13868.58	191573.7	100
147.4931	15	50	10.9872	38.2562	419109.0	0.123413	13872.97	191765.9	100
147.4931	15	50	10.9872	38.2562	419109.0	0.123413	13872.97	191765.9	100
148.1112	15	52	10.9872	38.16297	419142.0	0.123419	13731.53	193606.9	100
148.1112	15	52	10.9872	38.16297	419142.0	0.123419	13731.53	193606.9	100
147.8799	15	52	10.9872	37.00477	419143.3	0.12342	13782.08	192962	100
147.8799	15	52	10.9872	37.00477	419143.3	0.12342	13782.08	192962	100
148.4532	15	51	10.9872	38.91343	419249.4	0.123457	13762.92	193313.2	100
148.4532	15	51	10.9872	38.91343	419249.4	0.123457	13762.92	193313.2	100
148.8847	15	52	10.9872	38.68428	419322.2	0.123479	13698.83	194205.1	100
148.8847	15	52	10.9872	38.68428	419322.2	0.123479	13698.83	194205.1	100
148.0604	15	49	10.9872	38.76571	419713.8	0.123617	13943.91	191463.8	100
148.0604	15	49	10.9872	38.76571	419713.8	0.123617	13943.91	191463.8	100
147.0177	15	51	10.9872	38.61111	419978.8	0.123703	13882.62	192512.3	100
147.0177	15	51	10.9872	38.61111	419978.8	0.123703	13882.62	192512.3	100
146.4994	15	52	10.9872	37.90218	420039.7	0.123722	13869.25	192744.2	100
146.4994	15	52	10.9872	37.90218	420039.7	0.123722	13869.25	192744.2	100
147.072	15	49	10.9872	36.64142	420084.2	0.123742	14085.72	190021.4	100
147.072	15	49	10.9872	36.64142	420084.2	0.123742	14085.72	190021.4	100
147.5859	15	49	10.9872	39.45421	420439.0	0.12386	13992.67	191565.7	100
147.5859	15	49	10.9872	39.45421	420439.0	0.12386	13992.67	191565.7	100
148.4188	15	47	10.9872	37.33318	420460.5	0.123874	14166.69	189362.6	100
148.4188	15	47	10.9872	37.33318	420460.5	0.123874	14166.69	189362.6	100
150	15	51	10.9872	37.80193	420499.6	0.123878	13845.48	193507.9	100
150	15	51	10.9872	37.80193	420499.6	0.123878	13845.48	193507.9	100

146.3106	15	52	10.9872	36.19991	420540.5	0.12389	13977.13	191865.8	100
146.3106	15	52	10.9872	36.19991	420540.5	0.12389	13977.13	191865.8	100
149.0053	15	47	10.9872	38.46922	420659.8	0.12394	14119.86	190160.6	100
149.0053	15	47	10.9872	38.46922	420659.8	0.12394	14119.86	190160.6	100
150	15	50	10.9872	37.2058	420669.3	0.123936	13943.02	192430.7	100
150	15	50	10.9872	37.2058	420669.3	0.123936	13943.02	192430.7	100
144.8313	15	51	10.9872	37.558	420715.9	0.123952	14057.26	191016.9	100
144.8313	15	51	10.9872	37.558	420715.9	0.123952	14057.26	191016.9	100
145.6468	15	50	10.9872	38.21649	420769.8	0.123971	14070.77	190898.2	100
145.6468	15	50	10.9872	38.21649	420769.8	0.123971	14070.77	190898.2	100
147.1279	15	54	10.9872	37.49465	420978.6	0.124031	13809.73	194443.9	100
147.1279	15	54	10.9872	37.49465	420978.6	0.124031	13809.73	194443.9	100
150	15	51	10.9872	38.63545	421215.6	0.124118	13871.17	193895.5	100
150	15	51	10.9872	38.63545	421215.6	0.124118	13871.17	193895.5	100
146.988	15	48	10.9872	38.27226	421284.0	0.124148	14185.86	189941.1	100
146.988	15	48	10.9872	38.27226	421284.0	0.124148	14185.86	189941.1	100
149.7967	15	52	10.9872	38.03046	421413.6	0.124182	13853.4	194320.7	100
149.7967	15	52	10.9872	38.03046	421413.6	0.124182	13853.4	194320.7	100
145.8927	15	52	10.9872	40.0081	421429.1	0.124188	13923.16	193444.4	100
145.8927	15	52	10.9872	40.0081	421429.1	0.124188	13923.16	193444.4	100
149.9025	15	48	10.9872	38.04539	421430.4	0.124196	14100.69	191176.3	100
149.9025	15	48	10.9872	38.04539	421430.4	0.124196	14100.69	191176.3	100
150	15	51	10.9872	39.21799	421445.7	0.124195	13867.98	194166.4	100
150	15	51	10.9872	39.21799	421445.7	0.124195	13867.98	194166.4	100
150	15	50	10.9872	38.76806	421523.5	0.124222	13953.01	193157.1	100
150	15	50	10.9872	38.76806	421523.5	0.124222	13953.01	193157.1	100
150	15	48	10.9872	38.53648	421613.6	0.124287	14100.38	191449.5	100
150	15	48	10.9872	38.53648	421629.1	0.124287	14100.38	191449.5	100
150	15	48	10.9872	39.00369	421629.1	0.124349	14098.08	191666.7	100
150	15	48	10.9872	39.00369	421630.4	0.124349	14098.08	191666.7	100
150	15	46	10.9872	36.01793	421630.4	0.124469	14357.68	188678.3	100
150	15	46	10.9872	36.01793	421645.7	0.124469	14357.68	188678.3	100
142.1038	15	50	10.9872	38.3866	421645.7	0.124507	14315.73	189347.5	100
142.1038	15	50	10.9872	38.3866	421723.5	0.124507	14315.73	189347.5	100
145.024	15	47	10.9872	37.22392	421723.5	0.124526	14443.25	187750.1	100
145.024	15	47	10.9872	37.22392	421713.6	0.124526	14443.25	187750.1	100
139.3647	15	53	10.9872	35.40849	421629.1	0.124567	14350.65	189102.7	100
139.3647	15	53	10.9872	35.40849	421629.1	0.124567	14350.65	189102.7	100
143.6532	15	53	10.9872	38.63106	421630.4	0.124567	14079.5	192573.9	100
143.6532	15	53	10.9872	38.63106	421630.4	0.124567	14079.5	192573.9	100
146.7815	15	55	10.9872	38.66404	421645.7	0.124586	13847.14	195628.3	100
146.7815	15	55	10.9872	38.66404	421645.7	0.124586	13847.14	195628.3	100

137.9715	15	53	10.9872	38.43711	421723.5	0.124683	14316.93	189870.1	100
137.9715	15	53	10.9872	38.43711	421723.5	0.124683	14316.93	189870.1	100
35.4342	15	37	10.9872	38.1886	421713.6	0.124747	19019.96	129787.4	100
35.4342	15	37	10.9872	38.1886	421629.1	0.124747	19019.96	129787.4	100
144.5776	15	49	10.9872	39.18478	421629.1	0.124785	14325.6	190056.6	100
144.5776	15	49	10.9872	39.18478	421630.4	0.124785	14325.6	190056.6	100
150	15	54	10.9872	39.09422	421630.4	0.124776	13822.04	196508.8	100
150	15	54	10.9872	39.09422	421645.7	0.124776	13822.04	196508.8	100
147.1017	15	46	10.9872	41.02275	421645.7	0.124804	14357.77	189672.4	100
147.1017	15	46	10.9872	41.02275	421723.5	0.124804	14357.77	189672.4	100
141.8609	15	50	10.9872	40.24093	421723.5	0.12482	14329.99	190098	100
141.8609	15	50	10.9872	40.24093	421713.6	0.12482	14329.99	190098	100
150	15	52	10.9872	33.33333	421629.1	0.124871	14181.17	192230	100
150	15	52	10.9872	33.33333	421629.1	0.124871	14181.17	192230	100
150	15	50	10.9872	40.29267	421630.4	0.124902	14056.35	193866.1	100
150	15	50	10.9872	40.29267	421630.4	0.124902	14056.35	193866.1	100
143.2384	15	56	10.9872	37.70262	421645.7	0.125069	14059.25	194351.4	100
143.2384	15	56	10.9872	37.70262	421645.7	0.125069	14059.25	194351.4	100
140.5506	15	44	10.9872	38.25855	421723.5	0.125108	14887.16	183773.5	100
140.5506	15	44	10.9872	38.25855	421723.5	0.125108	14887.16	183773.5	100
145.0734	15	46	10.9872	39.22421	421713.6	0.125154	14576.65	187903	100
145.0734	15	46	10.9872	39.22421	421629.1	0.125154	14576.65	187903	100
150	15	52	10.9872	50	421629.1	0.125115	13632	199980	100
150	15	52	10.9872	50	421630.4	0.125115	13632	199980	100
150	15	43	10.9872	38.6006	421630.4	0.125204	14620.88	187479.3	100
150	15	43	10.9872	38.6006	421645.7	0.125204	14620.88	187479.3	100
144.2869	15	56	10.9872	39.58866	421645.7	0.125225	13989.69	195710.7	100
144.2869	15	56	10.9872	39.58866	421723.5	0.125225	13989.69	195710.7	100
150	15	50	10.9872	43.46656	421723.5	0.125393	14055.74	195342	100
150	15	50	10.9872	43.46656	421713.6	0.125393	14055.74	195342	100
150	15	56	10.9872	40.16428	421629.1	0.125479	13823.34	198606.4	100
150	15	56	10.9872	40.16428	421629.1	0.125479	13823.34	198606.4	100
143.6505	15	56	10.9872	41.48585	421630.4	0.125572	14024.43	196300.2	100
143.6505	15	56	10.9872	41.48585	421630.4	0.125572	14024.43	196300.2	100
150	15	57	10.9872	38.08251	421645.7	0.125978	13953.25	198438.4	100
150	15	57	10.9872	38.08251	421645.7	0.125978	13953.25	198438.4	100
75	15	78	10.9872	41.66667	421723.5	0.126009	15215.94	182405	100
75	15	78	10.9872	41.66667	421723.5	0.126009	15215.94	182405	100
150	15	52	10.9872	33.33333	421713.6	0.126097	14465.17	192230	100
150	15	52	10.9872	33.33333	421629.1	0.126097	14465.17	192230	100
145.3576	15	61	10.9872	38.79389	421629.1	0.126306	13921.07	199833.7	100
145.3576	15	61	10.9872	38.79389	421630.4	0.126306	13921.07	199833.7	100

138.1627	15	44	10.9872	41.41522	421630.4	0.126429	15165.85	184142.9	100
138.1627	15	44	10.9872	41.41522	421645.7	0.126429	15165.85	184142.9	100
150	15	52	10.9872	50	421645.7	0.126397	13929	199980	100
150	15	52	10.9872	50	421723.5	0.126397	13929	199980	100
133.7869	15	58	10.9872	40.59306	421723.5	0.126792	14569.92	192947.8	100
133.7869	15	58	10.9872	40.59306	421713.6	0.126792	14569.92	192947.8	100
62.5	15	78	10.9872	50	421629.1	0.126865	15563.05	180530	100
62.5	15	78	10.9872	50	421629.1	0.126865	15563.05	180530	100
131.25	15	45	10.9872	37.37374	421630.4	0.126967	15623.6	179883.8	100
131.25	15	45	10.9872	37.37374	421630.4	0.126967	15623.6	179883.8	100
150	15	59	10.9872	36.12916	421645.7	0.126947	14125.89	199130.1	100
150	15	59	10.9872	36.12916	421645.7	0.126947	14125.89	199130.1	100
37.5	15	78	10.9872	33.33333	421723.5	0.127213	17150.13	161280	100
37.5	15	78	10.9872	33.33333	421723.5	0.127213	17150.13	161280	100
140.8203	15	65	10.9872	36.39323	421713.6	0.128001	14317.28	199830.2	100
140.8203	15	65	10.9872	36.39323	421629.1	0.128001	14317.28	199830.2	100
131.25	15	58	10.9872	45.83333	421629.1	0.128021	14756.97	194217.5	100
131.25	15	58	10.9872	45.83333	421630.4	0.128021	14756.97	194217.5	100
150	15	65	10.9872	41.66667	421630.4	0.128646	13947.07	206505	100
150	15	65	10.9872	41.66667	421645.7	0.128646	13947.07	206505	100
140.2446	15	41	10.9872	45.94482	421645.7	0.12901	15714.39	184806.9	100
140.2446	15	41	10.9872	45.94482	421723.5	0.12901	15714.39	184806.9	100
125	15	65	10.9872	33.33333	421723.5	0.129779	15411.93	191130	100
125	15	65	10.9872	33.33333	421713.6	0.129779	15411.93	191130	100
48.19064	15	32	10.9872	38.36115	421629.1	0.130102	20113.98	131735.6	100
48.19064	15	32	10.9872	38.36115	421629.1	0.130102	20113.98	131735.6	100
100	15	52	10.9872	33.33333	421630.4	0.130705	17327.47	169230	100
100	15	52	10.9872	33.33333	421630.4	0.130705	17327.47	169230	100
25	15	78	10.9872	41.66667	421645.7	0.131451	18288.6	159405	100
25	15	78	10.9872	41.66667	421645.7	0.131451	18288.6	159405	100
56.98279	15	31	10.9872	44.74629	421723.5	0.131557	19969.88	137949.1	100
56.98279	15	31	10.9872	44.74629	421723.5	0.131557	19969.88	137949.1	100
100	15	52	10.9872	50	421713.6	0.131682	16949.7	176980	100
100	15	52	10.9872	50	421629.1	0.131682	16949.7	176980	100
68.62102	15	30	10.9872	44.65795	421629.1	0.132241	19777.62	142461.6	100
68.62102	15	30	10.9872	44.65795	421630.4	0.132241	19777.62	142461.6	100
125	15	78	10.9872	41.66667	421630.4	0.132468	14926.71	205405	100
125	15	78	10.9872	41.66667	421645.7	0.132468	14926.71	205405	100
61.25	15	30	10.9872	35	421645.7	0.132589	20473.38	134580	100
61.25	15	30	10.9872	35	421723.5	0.132589	20473.38	134580	100
150	15	37	10.9872	40.97222	421723.5	0.133103	16747.48	183782.1	100
150	15	37	10.9872	40.97222	421713.6	0.133103	16747.48	183782.1	100

144.529	15	37	10.9872	36.112	421629.1	0.133131	17125.94	179005.4	100
144.529	15	37	10.9872	36.112	421629.1	0.133131	17125.94	179005.4	100
131.25	15	45	10.9872	29.29293	421630.4	0.133547	17461.5	176126.2	100
131.25	15	45	10.9872	29.29293	421630.4	0.133547	17461.5	176126.2	100
139.2997	15	62	10.9872	29.76655	421645.7	0.135478	16550.34	193649.3	100
139.2997	15	62	10.9872	29.76655	421645.7	0.135478	16550.34	193649.3	100
137.5	15	78	10.9872	50	421723.5	0.135553	14895.99	215030	100
137.5	15	78	10.9872	50	421723.5	0.135553	14895.99	215030	100
125	15	39	10.9872	50	421713.6	0.1379	18303.91	178080	100
125	15	39	10.9872	50	421629.1	0.1379	18303.91	178080	100
146.875	15	78	10.9872	32.29167	421629.1	0.137778	15723.93	211108.1	100
146.875	15	78	10.9872	32.29167	421630.4	0.137778	15723.93	211108.1	100
150	15	36	10.9872	31.28157	421630.4	0.138141	18340.86	178475.9	100
150	15	36	10.9872	31.28157	421645.7	0.138141	18340.86	178475.9	100
50	15	103	10.9872	33.33333	421645.7	0.138402	17754.09	187030	100
50	15	103	10.9872	33.33333	421723.5	0.138402	17754.09	187030	100
50	15	103	10.9872	50	421723.5	0.139242	17344.36	194780	100
50	15	103	10.9872	50	421713.6	0.139242	17344.36	194780	100
100	15	103	10.9872	33.33333	421629.1	0.142603	16937.08	210030	100
100	15	103	10.9872	33.33333	421629.1	0.142603	16937.08	210030	100
100	15	103	10.9872	33.33333	421630.4	0.142678	16955.24	210030	100
100	15	103	10.9872	33.33333	421630.4	0.142678	16955.24	210030	100
100	15	103	10.9872	50	421645.7	0.14294	16409.47	217780	100
100	15	103	10.9872	50	421645.7	0.14294	16409.47	217780	100
100	15	103	10.9872	50	421723.5	0.143012	16427.15	217780	100
100	15	103	10.9872	50	421723.5	0.143012	16427.15	217780	100
37.5	15	52	10.9872	25	434545.1	0.145295	23306.88	136605	100
37.5	15	52	10.9872	25	434545.1	0.145295	23306.88	136605	100
150	15	103	10.9872	33.33333	447049.9	0.149456	16742.08	233030	100
150	15	103	10.9872	33.33333	447049.9	0.149456	16742.08	233030	100
150	15	103	10.9872	50	447338.4	0.149552	16158.39	240780	100
150	15	103	10.9872	50	447338.4	0.149552	16158.39	240780	100
150	15	103	10.9872	33.33333	449260.9	0.150195	16915.04	233030	100
150	15	103	10.9872	33.33333	449260.9	0.150195	16915.04	233030	100
150	15	103	10.9872	50	449391.6	0.150239	16319	240780	100
150	15	103	10.9872	50	449391.6	0.150239	16319	240780	100
150	15	37	10.9872	25.69444	456663.7	0.15273	21902.37	176677.9	100
150	15	37	10.9872	25.69444	456663.7	0.15273	21902.37	176677.9	100
75	15	26	10.9872	41.66667	472534.9	0.158206	25950.14	140805	100
75	15	26	10.9872	41.66667	472534.9	0.158206	25950.14	140805	100
75	15	78	10.9872	25	477506.8	0.159659	23691.1	174655	100
75	15	78	10.9872	25	477506.8	0.159659	23691.1	174655	100

25	15	78	10.9872	25	480978.7	0.16082	25761.91	151655	100
25	15	78	10.9872	25	480978.7	0.16082	25761.91	151655	100
150	15	65	10.9872	25	487246.0	0.162916	22567.7	198755	100
150	15	65	10.9872	25	487246.0	0.162916	22567.7	198755	100
39.30623	15	29	10.9872	46.82174	492392.6	0.164937	28412.7	129183	100
39.30623	15	29	10.9872	46.82174	492392.6	0.164937	28412.7	129183	100
50	15	155	10.9872	33.33333	494448.1	0.165302	20794.07	228630	100
50	15	155	10.9872	33.33333	494448.1	0.165302	20794.07	228630	100
50	15	155	10.9872	50	496691.6	0.166052	20363.32	236380	100
50	15	155	10.9872	50	496691.6	0.166052	20363.32	236380	100
125	15	78	10.9872	25	497089.2	0.166209	23423.75	197655	100
125	15	78	10.9872	25	497089.2	0.166209	23423.75	197655	100
59.375	15	26	10.9872	48.95833	500059.9	0.167484	28400.35	137008.1	100
59.375	15	26	10.9872	48.95833	500059.9	0.167484	28400.35	137008.1	100
100	15	155	10.9872	33.33333	506479.1	0.169324	19936.01	251630	100
100	15	155	10.9872	33.33333	506479.1	0.169324	19936.01	251630	100
100	15	155	10.9872	50	507425.2	0.16964	19403.76	259380	100
100	15	155	10.9872	50	507425.2	0.16964	19403.76	259380	100
100	15	155	10.9872	33.33333	509239.0	0.170247	20151.91	251630	100
100	15	155	10.9872	33.33333	509239.0	0.170247	20151.91	251630	100
100	15	155	10.9872	50	510071.7	0.170525	19610.79	259380	100
100	15	155	10.9872	50	510071.7	0.170525	19610.79	259380	100
75	15	26	10.9872	25	524913.9	0.175717	30653.83	133055	100
75	15	26	10.9872	25	524913.9	0.175717	30653.83	133055	100
150	15	155	10.9872	33.33333	530709.2	0.177424	20032.23	274630	100
150	15	155	10.9872	33.33333	530709.2	0.177424	20032.23	274630	100
150	15	155	10.9872	50	530997.6	0.177521	19448.54	282380	100
150	15	155	10.9872	50	530997.6	0.177521	19448.54	282380	100
150	15	155	10.9872	33.33333	532486.0	0.178019	20171.23	274630	100
150	15	155	10.9872	33.33333	532486.0	0.178019	20171.23	274630	100
150	15	155	10.9872	50	532599.7	0.178056	19573.87	282380	100
150	15	155	10.9872	50	532599.7	0.178056	19573.87	282380	100
58.51907	15	24	10.9872	40.31051	577509.8	0.193605	34929.53	130993.2	100
58.51907	15	24	10.9872	40.31051	577509.8	0.193605	34929.53	130993.2	100
37.5	15	26	10.9872	33.33333	579307.9	0.194255	35955.19	119680	100
37.5	15	26	10.9872	33.33333	579307.9	0.194255	35955.19	119680	100
	15	134	10.9872	36.45833	590735.8	0.197731	31326.1	190283.1	100
	15	134	10.9872	36.45833	590735.8	0.197731	31326.1	190283.1	100
	15	134	10.9872	35.9375	590749.2	0.197735	31346.09	190040.9	100
	15	134	10.9872	35.9375	590749.2	0.197735	31346.09	190040.9	100
	15	134	10.9872	35.67708	590843.4	0.197767	31362.94	189919.8	100
	15	134	10.9872	35.67708	590843.4	0.197767	31362.94	189919.8	100

	15	134	10.9872	35.41667	590965.9	0.197808	31381.99	189798.8	100
	15	134	10.9872	35.41667	590965.9	0.197808	31381.99	189798.8	100
	15	135	10.9872	36.19792	591743.2	0.198066	31351.79	190962	100
	15	135	10.9872	36.19792	591743.2	0.198066	31351.79	190962	100
	15	135	10.9872	36.65365	591788.2	0.198081	31338.74	191173.9	100
	15	135	10.9872	36.65365	591788.2	0.198081	31338.74	191173.9	100
	15	135	10.9872	36.97917	591841.5	0.198099	31331.07	191325.3	100
	15	135	10.9872	36.97917	591841.5	0.198099	31331.07	191325.3	100
	15	135	10.9872	35.67708	591873.8	0.19811	31380.96	190719.8	100
	15	135	10.9872	35.67708	591873.8	0.19811	31380.96	190719.8	100
	15	136	10.9872	36.45833	592597.9	0.198348	31346.6	191883.1	100
	15	136	10.9872	36.45833	592597.9	0.198348	31346.6	191883.1	100
	15	136	10.9872	35.9375	592611.3	0.198352	31366.6	191640.9	100
	15	136	10.9872	35.9375	592611.3	0.198352	31366.6	191640.9	100
	15	137	10.9872	36.97917	592638.4	0.198357	31268.24	192925.3	100
	15	137	10.9872	36.97917	592638.4	0.198357	31268.24	192925.3	100
	15	136	10.9872	35.41667	592828.0	0.198425	31402.49	191398.8	100
	15	136	10.9872	35.41667	592828.0	0.198425	31402.49	191398.8	100
	15	136	10.9872	37.5	592859.3	0.198435	31329.16	192367.5	100
	15	136	10.9872	37.5	592859.3	0.198435	31329.16	192367.5	100
	15	139	10.9872	36.45833	593155.2	0.198521	31202.45	194283.1	100
	15	139	10.9872	36.45833	593155.2	0.198521	31202.45	194283.1	100
	15	139	10.9872	35.41667	593385.3	0.198598	31258.34	193798.8	100
	15	139	10.9872	35.41667	593385.3	0.198598	31258.34	193798.8	100
	15	139	10.9872	37.73438	593532.9	0.198647	31185.58	194876.5	100
	15	139	10.9872	37.73438	593532.9	0.198647	31185.58	194876.5	100
	15	132	10.9872	36.45833	593557.9	0.198693	31672.02	188683.1	100
	15	132	10.9872	36.45833	593557.9	0.198693	31672.02	188683.1	100
	15	132	10.9872	35.9375	593571.3	0.198698	31692.02	188440.9	100
	15	132	10.9872	35.9375	593571.3	0.198698	31692.02	188440.9	100
	15	132	10.9872	35.41667	593788.0	0.19877	31727.91	188198.8	100
	15	132	10.9872	35.41667	593788.0	0.19877	31727.91	188198.8	100
	15	136	10.9872	34.375	594011.1	0.198821	31532.94	190914.4	100
	15	136	10.9872	34.375	594011.1	0.198821	31532.94	190914.4	100
	15	139	10.9872	38.80208	594152.2	0.198854	31195.19	195373	100
	15	139	10.9872	38.80208	594152.2	0.198854	31195.19	195373	100
	15	142	10.9872	35.41667	594245.7	0.198871	31137.91	196198.8	100
	15	142	10.9872	35.41667	594245.7	0.198871	31137.91	196198.8	100
	15	142	10.9872	37.5	594277.1	0.198882	31064.58	197167.5	100
	15	142	10.9872	37.5	594277.1	0.198882	31064.58	197167.5	100
	15	136	10.9872	40.10417	594407.7	0.198953	31355.56	193578.4	100
	15	136	10.9872	40.10417	594407.7	0.198953	31355.56	193578.4	100

	15	132	10.9872	38.80208	594554.9	0.199027	31664.76	189773	100
	15	132	10.9872	38.80208	594554.9	0.199027	31664.76	189773	100
	15	139	10.9872	34.375	594568.4	0.198994	31388.79	193314.4	100
	15	139	10.9872	34.375	594568.4	0.198994	31388.79	193314.4	100
	15	133	10.9872	36.19792	594817.8	0.199116	31717.47	189362	100
	15	133	10.9872	36.19792	594817.8	0.199116	31717.47	189362	100
	15	133	10.9872	36.80556	594879.9	0.199137	31700.23	189644.6	100
	15	133	10.9872	36.80556	594879.9	0.199137	31700.23	189644.6	100
	15	133	10.9872	35.67708	594948.3	0.19916	31746.63	189119.8	100
	15	133	10.9872	35.67708	594948.3	0.19916	31746.63	189119.8	100
	15	132	10.9872	34.375	594971.1	0.199166	31858.36	187714.4	100
	15	132	10.9872	34.375	594971.1	0.199166	31858.36	187714.4	100
	15	133	10.9872	37.23958	594992.7	0.199175	31693.27	189846.4	100
	15	133	10.9872	37.23958	594992.7	0.199175	31693.27	189846.4	100
	15	136	10.9872	33.33333	596208.6	0.199556	31742.73	190430	100
	15	136	10.9872	33.33333	596208.6	0.199556	31742.73	190430	100
	15	129	10.9872	35.41667	596705.3	0.199768	32143.87	185798.8	100
	15	129	10.9872	35.41667	596705.3	0.199768	32143.87	185798.8	100
	15	129	10.9872	37.5	596736.6	0.199779	32070.54	186767.5	100
	15	129	10.9872	37.5	596736.6	0.199779	32070.54	186767.5	100
	15	142	10.9872	41.66667	596800.7	0.199726	31110.43	199105	100
	15	142	10.9872	41.66667	596800.7	0.199726	31110.43	199105	100
	15	149	10.9872	35.41667	597179.9	0.199828	30929.37	201798.8	100
	15	149	10.9872	35.41667	597179.9	0.199828	30929.37	201798.8	100
	15	142	10.9872	33.33333	597626.3	0.200002	31478.14	195230	100
	15	142	10.9872	33.33333	597626.3	0.200002	31478.14	195230	100
	15	149	10.9872	39.58333	598434.5	0.200248	30875.95	203736.3	100
	15	149	10.9872	39.58333	598434.5	0.200248	30875.95	203736.3	100
	15	129	10.9872	41.66667	599260.3	0.200623	32116.39	188705	100
	15	129	10.9872	41.66667	599260.3	0.200623	32116.39	188705	100
	15	142	10.9872	45.83333	599401.5	0.200597	31162.32	201042.5	100
	15	142	10.9872	45.83333	599401.5	0.200597	31162.32	201042.5	100
	15	129	10.9872	33.33333	600085.8	0.2009	32484.1	184830	100
	15	129	10.9872	33.33333	600085.8	0.2009	32484.1	184830	100
	15	155	10.9872	37.5	600168.9	0.200798	30711.92	207567.5	100
	15	155	10.9872	37.5	600168.9	0.200798	30711.92	207567.5	100
	15	155	10.9872	41.66667	602692.6	0.201643	30757.77	209505	100
	15	155	10.9872	41.66667	602692.6	0.201643	30757.77	209505	100
	15	155	10.9872	33.33333	603518.2	0.201919	31125.48	205630	100
	15	155	10.9872	33.33333	603518.2	0.201919	31125.48	205630	100
	15	155	10.9872	33.33333	603518.2	0.201919	31125.48	205630	100
	15	155	10.9872	33.33333	603518.2	0.201919	31125.48	205630	100

	15	129	10.9872	50	604461.8	0.202365	32220.16	192580	100
	15	129	10.9872	50	604461.8	0.202365	32220.16	192580	100
	15	155	10.9872	50	607894.2	0.203383	30861.55	213380	100
	15	155	10.9872	50	607894.2	0.203383	30861.55	213380	100
	15	155	10.9872	50	607894.2	0.203383	30861.55	213380	100
	15	155	10.9872	50	607894.2	0.203383	30861.55	213380	100
150	15	136		49.81754	614763.4	0.205803	30326.01	227095.2	100
150	15	136		49.81754	614763.4	0.205803	30326.01	227095.2	100
150	15	135		49.59872	614884.4	0.205849	30406.02	226193.4	100
150	15	135		49.59872	614884.4	0.205849	30406.02	226193.4	100
149.8683	15	133		50	614888.1	0.205864	30521.62	224719.4	100
149.8683	15	133		50	614888.1	0.205864	30521.62	224719.4	100
150	15	131		49.99305	614994.3	0.205911	30650.6	223176.8	100
150	15	131		49.99305	614994.3	0.205911	30650.6	223176.8	100
149.6301	15	134		50	615090.9	0.205927	30483.47	225409.8	100
149.6301	15	134		50	615090.9	0.205927	30483.47	225409.8	100
150	15	132		49.4444	615112.6	0.205944	30617.23	223721.6	100
150	15	132		49.4444	615112.6	0.205944	30617.23	223721.6	100
150	15	137		49.48916	615136.1	0.205921	30304.53	227742.5	100
150	15	137		49.48916	615136.1	0.205921	30304.53	227742.5	100
150	15	137		49.12652	615431.4	0.20602	30340.82	227573.8	100
150	15	137		49.12652	615431.4	0.20602	30340.82	227573.8	100
150	15	139		50	615584.1	0.206062	30195.83	229580	100
150	15	139		50	615584.1	0.206062	30195.83	229580	100
150	15	128		50	615770.4	0.206187	30898.81	220780	100
150	15	128		50	615770.4	0.206187	30898.81	220780	100
149.232	15	138		50	615901.8	0.206177	30310.9	228426.7	100
149.232	15	138		50	615901.8	0.206177	30310.9	228426.7	100
148.854	15	136		49.90525	616013.6	0.20623	30461.86	226608.8	100
148.854	15	136		49.90525	616013.6	0.20623	30461.86	226608.8	100
149.2807	15	134		49.25419	616144.6	0.206283	30605.6	224902.3	100
149.2807	15	134		49.25419	616144.6	0.206283	30605.6	224902.3	100
148.237	15	132		50	616222.1	0.206319	30747.25	223169	100
148.237	15	132		50	616222.1	0.206319	30747.25	223169	100
150	15	133		48.62059	616242.3	0.206316	30672.99	224138.6	100
150	15	133		48.62059	616242.3	0.206316	30672.99	224138.6	100
148.745	15	133		49.66412	616489.4	0.206408	30699.52	224046.5	100
148.745	15	133		49.66412	616489.4	0.206408	30699.52	224046.5	100
148.5512	15	136		49.46134	616745.3	0.206477	30546.14	226263.1	100
148.5512	15	136		49.46134	616745.3	0.206477	30546.14	226263.1	100
148.5016	15	130		49.57806	616767.1	0.206515	30920.87	221494.5	100
148.5016	15	130		49.57806	616767.1	0.206515	30920.87	221494.5	100

148.8766	15	138		49.50324	616797.9	0.20648	30411.87	228032.3	100
148.8766	15	138		49.50324	616797.9	0.20648	30411.87	228032.3	100
150	15	130		48.6421	616907.9	0.206558	30912.01	221748.6	100
150	15	130		48.6421	616907.9	0.206558	30912.01	221748.6	100
147.1682	15	134		50	617023.3	0.206582	30723.22	224277.4	100
147.1682	15	134		50	617023.3	0.206582	30723.22	224277.4	100
148.506	15	131		48.99703	617072.2	0.206608	30903.14	222026.4	100
148.506	15	131		48.99703	617072.2	0.206608	30903.14	222026.4	100
148.0202	15	137		50	617151.5	0.20661	30514.85	227069.3	100
148.0202	15	137		50	617151.5	0.20661	30514.85	227069.3	100
150	15	155		50	617221.8	0.206529	29322.64	242380	100
150	15	155		50	617221.8	0.206529	29322.64	242380	100
147.434	15	133		49.30396	617574.7	0.206771	30844.69	223276	100
147.434	15	133		49.30396	617574.7	0.206771	30844.69	223276	100
150	15	146		49.67213	617759.9	0.206749	29939.89	235027.5	100
150	15	146		49.67213	617759.9	0.206749	29939.89	235027.5	100
146.6295	15	136		49.20317	618232.3	0.206978	30741.01	225259	100
146.6295	15	136		49.20317	618232.3	0.206978	30741.01	225259	100
150	15	140		47.65263	619626.7	0.207409	30534.88	229288.5	100
150	15	140		47.65263	619626.7	0.207409	30534.88	229288.5	100
148.172	15	142		48.92239	619662.3	0.207422	30432.09	230638	100
148.172	15	142		48.92239	619662.3	0.207422	30432.09	230638	100
144.8077	15	133		50	621250.4	0.208026	31201.42	222391.5	100
144.8077	15	133		50	621250.4	0.208026	31201.42	222391.5	100
143.7483	15	140		49.21813	621570.8	0.208094	30854.97	227140.7	100
143.7483	15	140		49.21813	621570.8	0.208094	30854.97	227140.7	100
150	15	155		47.39583	621658.2	0.208013	29764.42	241169.1	100
150	15	155		47.39583	621658.2	0.208013	29764.42	241169.1	100
150	15	147		47.39583	622019.6	0.208168	30293.34	234769.1	100
150	15	147		47.39583	622019.6	0.208168	30293.34	234769.1	100
149.2701	15	134		46.72832	622394.8	0.208375	31186.79	223722.9	100
149.2701	15	134		46.72832	622394.8	0.208375	31186.79	223722.9	100
146.1251	15	151		48.69792	623065.4	0.20852	30216.9	236792.1	100
146.1251	15	151		48.69792	623065.4	0.20852	30216.9	236792.1	100
144.1102	15	136		47.53212	625444.4	0.209413	31456.63	223323.1	100
144.1102	15	136		47.53212	625444.4	0.209413	31456.63	223323.1	100
150	15	129		45.83333	626326.2	0.209718	31813.53	219642.5	100
150	15	129		45.83333	626326.2	0.209718	31813.53	219642.5	100
143.2423	15	147		50	626344.3	0.209666	30780.08	232871.5	100
143.2423	15	147		50	626344.3	0.209666	30780.08	232871.5	100
148.7571	15	125		50	627603.6	0.210188	32056.94	217808.3	100
148.7571	15	125		50	627603.6	0.210188	32056.94	217808.3	100

	15	103	10.9872	41.66667	628270.4	0.21061	36012.88	167905	100
	15	103	10.9872	41.66667	628270.4	0.21061	36012.88	167905	100
	15	103	10.9872	33.33333	628907.6	0.210824	36365.85	164030	100
	15	103	10.9872	33.33333	628907.6	0.210824	36365.85	164030	100
	15	103	10.9872	33.33333	628907.6	0.210824	36365.85	164030	100
	15	103	10.9872	33.33333	628907.6	0.210824	36365.85	164030	100
142.1875	15	155		50	629631.8	0.210732	30574.56	238786.3	100
142.1875	15	155		50	629631.8	0.210732	30574.56	238786.3	100
	15	142	10.9872	28.125	630549.0	0.211021	34243.04	192808.1	100
	15	142	10.9872	28.125	630549.0	0.211021	34243.04	192808.1	100
145.1198	15	128		47.80857	630567.2	0.211188	32311.63	217516.1	100
145.1198	15	128		47.80857	630567.2	0.211188	32311.63	217516.1	100
	15	103	10.9872	50	633472.0	0.212354	36116.65	171780	100
	15	103	10.9872	50	633472.0	0.212354	36116.65	171780	100
	15	103	10.9872	50	633472.0	0.212354	36116.65	171780	100
	15	103	10.9872	50	633472.0	0.212354	36116.65	171780	100
142.1875	15	155		47.39583	633979.3	0.212187	31009.38	237575.3	100
142.1875	15	155		47.39583	633979.3	0.212187	31009.38	237575.3	100
137.7982	15	138		50	634221.9	0.212402	32155.46	223167.2	100
137.7982	15	138		50	634221.9	0.212402	32155.46	223167.2	100
139.5833	15	144		46.52778	634971.1	0.212589	31900.64	227173.8	100
139.5833	15	144		46.52778	634971.1	0.212589	31900.64	227173.8	100
	15	116	10.9872	28.125	637452.8	0.213527	36410.21	172008.1	100
	15	116	10.9872	28.125	637452.8	0.213527	36410.21	172008.1	100
134.375	15	155		50	639585.0	0.214117	31634.3	235192.5	100
134.375	15	155		50	639585.0	0.214117	31634.3	235192.5	100
137.5	15	26	10.9872	33.33333	653651.4	0.219223	38172.41	165680	100
137.5	15	26	10.9872	33.33333	653651.4	0.219223	38172.41	165680	100
146.875	15	26	10.9872	48.66453	654696.4	0.21956	37359.12	177121.5	100
146.875	15	26	10.9872	48.66453	654696.4	0.21956	37359.12	177121.5	100
125	15	142		50	678963.9	0.227505	35865.69	220480	100
125	15	142		50	678963.9	0.227505	35865.69	220480	100
135.6771	15	125		50	680434.9	0.228048	36660.44	211791.5	100
135.6771	15	125		50	680434.9	0.228048	36660.44	211791.5	100
137.5	15	155		41.66667	681020.2	0.227953	35066.32	232755	100
137.5	15	155		41.66667	681020.2	0.227953	35066.32	232755	100
125	15	26	10.9872	25	691615.2	0.231909	41895.11	156055	100
125	15	26	10.9872	25	691615.2	0.231909	41895.11	156055	100
25	15	26	10.9872	25	699900.7	0.234949	46141.69	110055	100
25	15	26	10.9872	25	699900.7	0.234949	46141.69	110055	100
150	15	103		50	708724.1	0.23773	39734.8	200780	100
150	15	103		50	708724.1	0.23773	39734.8	200780	100

125	15	26	10.9872	41.66667	711689.0	0.238853	42859.17	163805	100
125	15	26	10.9872	41.66667	711689.0	0.238853	42859.17	163805	100
25	15	26	10.9872	41.66667	711739.6	0.239067	46461.55	117805	100
25	15	26	10.9872	41.66667	711739.6	0.239067	46461.55	117805	100
50	15	103	10.9872	33.33333	730099.4	0.24512	42482.54	187030	100
50	15	103	10.9872	33.33333	730099.4	0.24512	42482.54	187030	100
150	15	226		48.88349	736154.4	0.246475	34223.69	298660.8	100
150	15	226		48.88349	736154.4	0.246475	34223.69	298660.8	100
50	15	155	10.9872	33.33333	736202.0	0.246905	39705.69	228630	100
50	15	155	10.9872	33.33333	736202.0	0.246905	39705.69	228630	100
150	15	226		48.50467	736452.6	0.246573	34260.79	298484.7	100
150	15	226		48.50467	736452.6	0.246573	34260.79	298484.7	100
150	15	224		48.11725	737458.2	0.246917	34478.71	296704.5	100
150	15	224		48.11725	737458.2	0.246917	34478.71	296704.5	100
150	15	223		47.87217	737607.9	0.246967	34561.92	295790.6	100
150	15	223		47.87217	737607.9	0.246967	34561.92	295790.6	100
150	15	223		49.26087	738632.8	0.247318	34591.58	296436.3	100
150	15	223		49.26087	738632.8	0.247318	34591.58	296436.3	100
150	15	229		48.77476	739399.1	0.247557	34293.72	301010.3	100
150	15	229		48.77476	739399.1	0.247557	34293.72	301010.3	100
149.6087	15	227		48.14228	739671.4	0.247655	34477.28	298936.2	100
149.6087	15	227		48.14228	739671.4	0.247655	34477.28	298936.2	100
149.9645	15	222		47.43559	739723.4	0.247679	34807.15	294771.2	100
149.9645	15	222		47.43559	739723.4	0.247679	34807.15	294771.2	100
150	15	228		47.503	740460.0	0.247911	34485.55	299618.9	100
150	15	228		47.503	740460.0	0.247911	34485.55	299618.9	100
150	15	221		48.18316	741136.2	0.248163	34951.78	294335.2	100
150	15	221		48.18316	741136.2	0.248163	34951.78	294335.2	100
149.6904	15	223		48.40851	741148.9	0.248163	34830.56	295897.5	100
149.6904	15	223		48.40851	741148.9	0.248163	34830.56	295897.5	100
150	15	222		46.90482	741234.5	0.248183	34943.38	294540.8	100
150	15	222		46.90482	741234.5	0.248183	34943.38	294540.8	100
150	15	216		48.43834	741249.2	0.248229	35264.24	290453.8	100
150	15	216		48.43834	741249.2	0.248229	35264.24	290453.8	100
149.2246	15	225		47.87315	741582.9	0.248305	34775.57	297034.3	100
149.2246	15	225		47.87315	741582.9	0.248305	34775.57	297034.3	100
150	15	217		47.57099	741648.4	0.24835	35264.45	290850.5	100
150	15	217		47.57099	741648.4	0.24835	35264.45	290850.5	100
150	15	202		50	741738.1	0.248483	36121.82	279980	100
150	15	202		50	741738.1	0.248483	36121.82	279980	100
149.4658	15	226		46.78511	743171.1	0.248827	34868.13	297439.3	100
149.4658	15	226		46.78511	743171.1	0.248827	34868.13	297439.3	100

150	15	219		47.05445	743339.6	0.248909	35290.37	292210.3	100
150	15	219		47.05445	743339.6	0.248909	35290.37	292210.3	100
149.3504	15	224		48.85007	743368.9	0.24891	34937.81	296746.5	100
149.3504	15	224		48.85007	743368.9	0.24891	34937.81	296746.5	100
150	15	230		48.25719	743571.5	0.248958	34576.36	301569.6	100
150	15	230		48.25719	743571.5	0.248958	34576.36	301569.6	100
149.0637	15	227		49.07603	743708.3	0.249022	34778.71	299119.7	100
149.0637	15	227		49.07603	743708.3	0.249022	34778.71	299119.7	100
149.3996	15	231		49.38977	743884.2	0.249066	34518.64	302620.1	100
149.3996	15	231		49.38977	743884.2	0.249066	34518.64	302620.1	100
	15	129	10.9872	22.91667	744225.0	0.249248	44138.55	179986.3	100
	15	129	10.9872	22.91667	744225.0	0.249248	44138.55	179986.3	100
150	15	223		46.0995	744257.6	0.249191	35146.59	294966.3	100
150	15	223		46.0995	744257.6	0.249191	35146.59	294966.3	100
149.5117	15	204		48.17792	744629.9	0.249432	36306.73	280508.1	100
149.5117	15	204		48.17792	744629.9	0.249432	36306.73	280508.1	100
148.9555	15	222		48.09106	744794.0	0.249398	35216.27	294611.9	100
148.9555	15	222		48.09106	744794.0	0.249398	35216.27	294611.9	100
149.3697	15	220		47.94572	745704.1	0.249711	35403	293134.8	100
149.3697	15	220		47.94572	745704.1	0.249711	35403	293134.8	100
148.8912	15	225		47.30899	746585.6	0.249989	35199.44	296618.7	100
148.8912	15	225		47.30899	746585.6	0.249989	35199.44	296618.7	100
148.8228	15	222		47.6824	746825.6	0.250082	35394.84	294360.8	100
148.8228	15	222		47.6824	746825.6	0.250082	35394.84	294360.8	100
150	15	206		46.35417	747237.3	0.250269	36434.3	281484.7	100
150	15	206		46.35417	747237.3	0.250269	36434.3	281484.7	100
150	15	238		50	747246.2	0.250163	34299.77	308780	100
150	15	238		50	747246.2	0.250163	34299.77	308780	100
148.9382	15	222		47.16133	747256.4	0.250221	35443.34	294171.6	100
148.9382	15	222		47.16133	747256.4	0.250221	35443.34	294171.6	100
148.7878	15	224		50	748106.9	0.250518	35286.87	297022.4	100
148.7878	15	224		50	748106.9	0.250518	35286.87	297022.4	100
148.6959	15	227		48.42007	748675.9	0.250692	35204.41	298645.4	100
148.6959	15	227		48.42007	748675.9	0.250692	35204.41	298645.4	100
148.8893	15	220		47.43316	748915.1	0.250788	35690.12	292675.5	100
148.8893	15	220		47.43316	748915.1	0.250788	35690.12	292675.5	100
149.4262	15	231		46.81896	749821.8	0.251052	35075.68	301436.8	100
149.4262	15	231		46.81896	749821.8	0.251052	35075.68	301436.8	100
147.4427	15	213		49.89294	753636.5	0.252449	36460.12	287553.9	100
147.4427	15	213		49.89294	753636.5	0.252449	36460.12	287553.9	100
148.4959	15	221		46.75094	753916.4	0.252466	36057.75	292977.3	100
148.4959	15	221		46.75094	753916.4	0.252466	36057.75	292977.3	100

148.2525	15	215		46.98498	754658.0	0.252757	36491.5	288174.2	100
148.2525	15	215		46.98498	754658.0	0.252757	36491.5	288174.2	100
147.5229	15	227		47.76657	755204.4	0.252898	35781.09	297802	100
147.5229	15	227		47.76657	755204.4	0.252898	35781.09	297802	100
147.7999	15	222		47.38274	756995.1	0.253514	36238.07	293750.9	100
147.7999	15	222		47.38274	756995.1	0.253514	36238.07	293750.9	100
147.503	15	219		47.85396	757635.8	0.253755	36469.47	291433.5	100
147.503	15	219		47.85396	757635.8	0.253755	36469.47	291433.5	100
145.9496	15	214		48.58792	758156.8	0.253977	36852.34	287060.2	100
145.9496	15	214		48.58792	758156.8	0.253977	36852.34	287060.2	100
146.8702	15	223		48.68914	759101.2	0.25423	36326.18	294730.7	100
146.8702	15	223		48.68914	759101.2	0.25423	36326.18	294730.7	100
146.6507	15	225		46.77139	761334.6	0.254967	36453.39	295338	100
146.6507	15	225		46.77139	761334.6	0.254967	36453.39	295338	100
150	15	187		49.46977	761471.0	0.255244	38623.47	267733.4	100
150	15	187		49.46977	761471.0	0.255244	38623.47	267733.4	100
147.6467	15	196		48.99837	763035.9	0.255729	38284.48	273631.8	100
147.6467	15	196		48.99837	763035.9	0.255729	38284.48	273631.8	100
125	15	129		41.66667	765398.1	0.256671	43743.84	206205	100
125	15	129		41.66667	765398.1	0.256671	43743.84	206205	100
150	15	239		44.55452	765892.1	0.256379	35893.88	307047.8	100
150	15	239		44.55452	765892.1	0.256379	35893.88	307047.8	100
50	15	103	10.9872	50	768090.1	0.258023	44848.16	194780	100
50	15	103	10.9872	50	768090.1	0.258023	44848.16	194780	100
144.4242	15	220		47.58357	770662.1	0.258179	37546.53	290691.5	100
144.4242	15	220		47.58357	770662.1	0.258179	37546.53	290691.5	100
145.3133	15	234		47.26028	772480.1	0.258704	36792.37	302150.2	100
145.3133	15	234		47.26028	772480.1	0.258704	36792.37	302150.2	100
144.0227	15	206		48.20458	776573.1	0.26027	38876.92	279595.6	100
144.0227	15	206		48.20458	776573.1	0.26027	38876.92	279595.6	100
143.2423	15	220		49.64839	779698.8	0.261255	38220.85	291108	100
143.2423	15	220		49.64839	779698.8	0.261255	38220.85	291108	100
150	15	181		45.83333	783549.1	0.262717	40858.33	261242.5	100
150	15	181		45.83333	783549.1	0.262717	40858.33	261242.5	100
50	15	155	10.9872	50	785698.7	0.2637	42971.4	236380	100
50	15	155	10.9872	50	785698.7	0.2637	42971.4	236380	100
150	15	273		44.79167	798045.4	0.267015	36272.73	334358.1	100
150	15	273		44.79167	798045.4	0.267015	36272.73	334358.1	100
144.048	15	197		50	798221.8	0.267652	41067.44	273242.1	100
144.048	15	197		50	798221.8	0.267652	41067.44	273242.1	100
144.3382	15	188		48.25212	808613.5	0.271222	42496.71	265362.8	100
144.3382	15	188		48.25212	808613.5	0.271222	42496.71	265362.8	100

148.7571	15	173		50	820004.1	0.275203	44103.9	256208.3	100
148.7571	15	173		50	820004.1	0.275203	44103.9	256208.3	100
100	15	155		50	840025.0	0.282136	48551.02	219380	100
100	15	155		50	840025.0	0.282136	48551.02	219380	100
139.5833	15	214		46.52778	840999.1	0.281978	43636.85	283173.8	100
139.5833	15	214		46.52778	840999.1	0.281978	43636.85	283173.8	100
150	15	351		50	848687.8	0.28373	35163.52	399180	100
150	15	351		50	848687.8	0.28373	35163.52	399180	100
137.5	15	238		41.66667	851003.4	0.285155	43169.29	299155	100
137.5	15	238		41.66667	851003.4	0.285155	43169.29	299155	100
137.5	15	295		50	872485.8	0.292236	40979.52	348630	100
137.5	15	295		50	872485.8	0.292236	40979.52	348630	100
137.7982	15	200		50	889798.9	0.298688	48268.37	272767.2	100
137.7982	15	200		50	889798.9	0.298688	48268.37	272767.2	100
50	15	52	10.9872	33.33333	912202.8	0.307276	59919.54	146230	100
50	15	52	10.9872	33.33333	912202.8	0.307276	59919.54	146230	100
150	15	155		45.95343	918327.9	0.308774	53024.38	240498.3	100
150	15	155		45.95343	918327.9	0.308774	53024.38	240498.3	100
150	15	155		45.68318	918981.1	0.308986	53085.31	240372.7	100
150	15	155		45.68318	918981.1	0.308986	53085.31	240372.7	100
150	15	155		44.79167	923227.9	0.310405	53449.95	239958.1	100
150	15	155		44.79167	923227.9	0.310405	53449.95	239958.1	100
150	15	154		46.58965	923627.0	0.310608	53478.35	239994.2	100
150	15	154		46.58965	923627.0	0.310608	53478.35	239994.2	100
150	15	154		46.02144	924756.2	0.310977	53587.36	239730	100
150	15	154		46.02144	924756.2	0.310977	53587.36	239730	100
150	15	155		50	924780.4	0.311027	53381.95	242380	100
150	15	155		50	924780.4	0.311027	53381.95	242380	100
150	15	154		46.27423	925050.6	0.311086	53601.19	239847.5	100
150	15	154		46.27423	925050.6	0.311086	53601.19	239847.5	100
150	15	155		43.37262	928802.6	0.312241	53937.66	239298.3	100
150	15	155		43.37262	928802.6	0.312241	53937.66	239298.3	100
149.4271	15	155		45.53226	929105.4	0.312432	53903.41	240039	100
149.4271	15	155		45.53226	929105.4	0.312432	53903.41	240039	100
149.2459	15	155		46.40811	931100.8	0.313131	54034.16	240362.9	100
149.2459	15	155		46.40811	931100.8	0.313131	54034.16	240362.9	100
149.7643	15	154		45.34381	931159.4	0.313134	54121.39	239306.5	100
149.7643	15	154		45.34381	931159.4	0.313134	54121.39	239306.5	100
149.3526	15	155		45.80696	931292.9	0.31319	54067.22	240132.4	100
149.3526	15	155		45.80696	931292.9	0.31319	54067.22	240132.4	100
148.9425	15	155		46.04653	935575.0	0.31464	54408.23	240055.2	100
148.9425	15	155		46.04653	935575.0	0.31464	54408.23	240055.2	100

150	15	153		45.80106	935692.3	0.3147	54513.45	238827.5	100
150	15	153		45.80106	935692.3	0.3147	54513.45	238827.5	100
149.0164	15	155		47.06796	937151.1	0.315193	54491.71	240564.1	100
149.0164	15	155		47.06796	937151.1	0.315193	54491.71	240564.1	100
149.3348	15	154		46.19741	937419.1	0.315284	54595.46	239505.8	100
149.3348	15	154		46.19741	937419.1	0.315284	54595.46	239505.8	100
149.3395	15	154		46.00413	937918.9	0.31545	54641.43	239418.1	100
149.3395	15	154		46.00413	937918.9	0.31545	54641.43	239418.1	100
149.3546	15	154		45.74802	938894.9	0.315777	54726.55	239305.9	100
149.3546	15	154		45.74802	938894.9	0.315777	54726.55	239305.9	100
150	15	154		40.45139	942989.4	0.316895	55216.29	237139.9	100
150	15	154		40.45139	942989.4	0.316895	55216.29	237139.9	100
	15	52	10.9872	33.33333	945526.0	0.319261	64325.52	123230	100
	15	52	10.9872	33.33333	945526.0	0.319261	64325.52	123230	100
	15	52	10.9872	33.33333	945526.0	0.319261	64325.52	123230	100
	15	52	10.9872	33.33333	945526.0	0.319261	64325.52	123230	100
150	15	153		48.51565	946152.4	0.318294	55232.96	240089.8	100
150	15	153		48.51565	946152.4	0.318294	55232.96	240089.8	100
150	15	152		45.38585	946249.9	0.318276	55417.02	237834.4	100
150	15	152		45.38585	946249.9	0.318276	55417.02	237834.4	100
	15	52	10.9872	50	951713.9	0.32135	64203.32	130980	100
	15	52	10.9872	50	951713.9	0.32135	64203.32	130980	100
	15	52	10.9872	50	951713.9	0.32135	64203.32	130980	100
	15	52	10.9872	50	951713.9	0.32135	64203.32	130980	100
148.094	15	155		45.37601	952974.8	0.320551	55824.29	239353.1	100
148.094	15	155		45.37601	952974.8	0.320551	55824.29	239353.1	100
148.9664	15	153		46.02614	954981.6	0.321266	56051.39	238456.7	100
148.9664	15	153		46.02614	954981.6	0.321266	56051.39	238456.7	100
148.3749	15	154		45.8754	955782.1	0.321525	56078.2	238914.5	100
148.3749	15	154		45.8754	955782.1	0.321525	56078.2	238914.5	100
150	15	151		46.64742	957300.8	0.322081	56298.19	237621	100
150	15	151		46.64742	957300.8	0.322081	56298.19	237621	100
147.6826	15	155		46.32806	958830.2	0.322573	56262.51	239606.5	100
147.6826	15	155		46.32806	958830.2	0.322573	56262.51	239606.5	100
150	15	150		42.76696	965497.0	0.324753	57143.08	235016.6	100
150	15	150		42.76696	965497.0	0.324753	57143.08	235016.6	100
50	15	52	10.9872	50	968802.9	0.32662	63740.92	153980	100
50	15	52	10.9872	50	968802.9	0.32662	63740.92	153980	100
146.319	15	155		44.4326	973714.1	0.327586	57544.84	238097.9	100
146.319	15	155		44.4326	973714.1	0.327586	57544.84	238097.9	100
145.8618	15	155		43.03957	979664.6	0.329535	58077.45	237239.8	100
145.8618	15	155		43.03957	979664.6	0.329535	58077.45	237239.8	100

131.25	15	252		47.91667	981325.5	0.329587	52485.38	310386.3	100
131.25	15	252		47.91667	981325.5	0.329587	52485.38	310386.3	100
147.6095	15	152		43.99996	984657.6	0.33134	58557.96	236090.3	100
147.6095	15	152		43.99996	984657.6	0.33134	58557.96	236090.3	100
150	15	148		47.39583	986603.2	0.332126	58750.93	235569.1	100
150	15	148		47.39583	986603.2	0.332126	58750.93	235569.1	100
146.7672	15	153		45.79821	989074.6	0.332879	58805.8	237339.1	100
146.7672	15	153		45.79821	989074.6	0.332879	58805.8	237339.1	100
150	15	147		49.97626	1006167	0.338838	60250.08	235969	100
150	15	147		49.97626	1006167	0.338838	60250.08	235969	100
147.6544	15	149		45.26544	1008416	0.339552	60556.57	234299.5	100
147.6544	15	149		45.26544	1008416	0.339552	60556.57	234299.5	100
146.0938	15	151		48.84094	1017000	0.342564	61029.06	236844.2	100
146.0938	15	151		48.84094	1017000	0.342564	61029.06	236844.2	100
142.9579	15	155		45.04847	1025973	0.345517	61731.42	236838.2	100
142.9579	15	155		45.04847	1025973	0.345517	61731.42	236838.2	100
150	15	155		33.33333	1028391	0.344618	62093.35	234630	100
150	15	155		33.33333	1028391	0.344618	62093.35	234630	100
150	15	465		50	1032095	0.345045	42376.55	490380	100
150	15	465		50	1032095	0.345045	42376.55	490380	100
150	15	142		44.46965	1038936	0.349943	63326.7	229408.4	100
150	15	142		44.46965	1038936	0.349943	63326.7	229408.4	100
142.1875	15	155		47.39583	1046885	0.352783	63309.67	237575.3	100
142.1875	15	155		47.39583	1046885	0.352783	63309.67	237575.3	100
142.1875	15	155		50	1049913	0.353863	63451.81	238786.3	100
142.1875	15	155		50	1049913	0.353863	63451.81	238786.3	100
150	15	140		40.45139	1064315	0.358413	65583.29	225939.9	100
150	15	140		40.45139	1064315	0.358413	65583.29	225939.9	100
50	15	52	10.9872	16.66667	1065891	0.357497	72548.31	138480	100
50	15	52	10.9872	16.66667	1065891	0.357497	72548.31	138480	100
135.6771	15	173		50	1067702	0.359689	63951.19	250191.5	100
135.6771	15	173		50	1067702	0.359689	63951.19	250191.5	100
150	15	139		50	1078159	0.36353	66381.52	229580	100
150	15	139		50	1078159	0.36353	66381.52	229580	100
142.5964	15	149		43.74189	1085316	0.365809	66809.66	231264.3	100
142.5964	15	149		43.74189	1085316	0.365809	66809.66	231264.3	100
100	15	52	10.9872	16.66667	1086443	0.36439	72356.79	161480	100
100	15	52	10.9872	16.66667	1086443	0.36439	72356.79	161480	100
100	15	52	10.9872	16.66667	1087400	0.364724	72431.65	161480	100
100	15	52	10.9872	16.66667	1087400	0.364724	72431.65	161480	100
150	15	103		33.33333	1094029	0.367405	70482.16	193030	100
150	15	103		33.33333	1094029	0.367405	70482.16	193030	100

150	15	52	10.9872	16.66667	1105454	0.370767	72044.78	184480	100
150	15	52	10.9872	16.66667	1105454	0.370767	72044.78	184480	100
150	15	52	10.9872	16.66667	1110788	0.372555	72462.01	184480	100
150	15	52	10.9872	16.66667	1110788	0.372555	72462.01	184480	100
137.5	15	155		41.66667	1117253	0.376646	69191.34	232755	100
137.5	15	155		41.66667	1117253	0.376646	69191.34	232755	100
125	15	295		41.66667	1120144	0.376439	61105.93	339005	100
125	15	295		41.66667	1120144	0.376439	61105.93	339005	100
50	15	52	10.9872	16.66667	1130390	0.379536	77593.9	138480	100
50	15	52	10.9872	16.66667	1130390	0.379536	77593.9	138480	100
142.1875	15	147		50	1139919	0.384685	70993.27	232386.3	100
142.1875	15	147		50	1139919	0.384685	70993.27	232386.3	100
50	15	103	10.9872	16.66667	1142935	0.383337	75383.53	179280	100
50	15	103	10.9872	16.66667	1142935	0.383337	75383.53	179280	100
150	15	238		33.33333	1142992	0.383011	65863.91	301030	100
150	15	238		33.33333	1142992	0.383011	65863.91	301030	100
50	15	103	10.9872	16.66667	1144126	0.383761	75476.73	179280	100
50	15	103	10.9872	16.66667	1144126	0.383761	75476.73	179280	100
100	15	103	10.9872	16.66667	1161796	0.389664	75059.77	202280	100
100	15	103	10.9872	16.66667	1161796	0.389664	75059.77	202280	100
150	15	129		45.83333	1163477	0.392799	73833.04	219642.5	100
150	15	129		45.83333	1163477	0.392799	73833.04	219642.5	100
100	15	103	10.9872	16.66667	1165112	0.390776	75319.17	202280	100
100	15	103	10.9872	16.66667	1165112	0.390776	75319.17	202280	100
150	15	155		33.33333	1176573	0.395221	73685.09	234630	100
150	15	155		33.33333	1176573	0.395221	73685.09	234630	100
150	15	103	10.9872	16.66667	1187505	0.398286	75271.66	225280	100
150	15	103	10.9872	16.66667	1187505	0.398286	75271.66	225280	100
150	15	103	10.9872	16.66667	1190080	0.39915	75473.14	225280	100
150	15	103	10.9872	16.66667	1190080	0.39915	75473.14	225280	100
100	15	155		33.33333	1203690	0.404702	77605.58	211630	100
100	15	155		33.33333	1203690	0.404702	77605.58	211630	100
139.5833	15	144		46.52778	1219094	0.41188	77594.7	227173.8	100
139.5833	15	144		46.52778	1219094	0.41188	77594.7	227173.8	100
50	15	155	10.9872	16.66667	1220628	0.409396	78206.98	220880	100
50	15	155	10.9872	16.66667	1220628	0.409396	78206.98	220880	100
50	15	155	10.9872	16.66667	1226202	0.411265	78643.06	220880	100
50	15	155	10.9872	16.66667	1226202	0.411265	78643.06	220880	100
125	15	209		50	1243430	0.419915	75829.04	274080	100
125	15	209		50	1243430	0.419915	75829.04	274080	100
100	15	155	10.9872	16.66667	1245455	0.417723	78349.92	243880	100
100	15	155	10.9872	16.66667	1245455	0.417723	78349.92	243880	100

100	15	155	10.9872	16.66667	1248771	0.418835	78609.33	243880	100
100	15	155	10.9872	16.66667	1248771	0.418835	78609.33	243880	100
134.375	15	155		50	1252329	0.423478	79567.24	235192.5	100
134.375	15	155		50	1252329	0.423478	79567.24	235192.5	100
150	15	124		50	1254367	0.424122	81104.47	217580	100
150	15	124		50	1254367	0.424122	81104.47	217580	100
150	15	351		33.33333	1268387	0.424677	68601.48	391430	100
150	15	351		33.33333	1268387	0.424677	68601.48	391430	100
	15	103	10.9872	16.66667	1268690	0.426354	87020.2	156280	100
	15	103	10.9872	16.66667	1268690	0.426354	87020.2	156280	100
	15	103	10.9872	16.66667	1268690	0.426354	87020.2	156280	100
	15	103	10.9872	16.66667	1268690	0.426354	87020.2	156280	100
150	15	155	10.9872	16.66667	1271164	0.426345	78561.81	266880	100
150	15	155	10.9872	16.66667	1271164	0.426345	78561.81	266880	100
150	15	155	10.9872	16.66667	1273739	0.427209	78763.3	266880	100
150	15	155	10.9872	16.66667	1273739	0.427209	78763.3	266880	100
	15	155	10.9872	16.66667	1282421	0.430319	84840.06	197880	100
	15	155	10.9872	16.66667	1282421	0.430319	84840.06	197880	100
	15	155	10.9872	16.66667	1282421	0.430319	84840.06	197880	100
	15	155	10.9872	16.66667	1282421	0.430319	84840.06	197880	100
125	15	181		41.66667	1318879	0.44587	83786.59	247805	100
125	15	181		41.66667	1318879	0.44587	83786.59	247805	100
100	15	103		50	1426908	0.484402	97715.21	177780	100
100	15	103		50	1426908	0.484402	97715.21	177780	100
150	15	124		33.33333	1435536	0.484457	95882.93	209830	100
150	15	124		33.33333	1435536	0.484457	95882.93	209830	100
150	15	465		33.33333	1451794	0.486085	75814.52	482630	100
150	15	465		33.33333	1451794	0.486085	75814.52	482630	100
	15	52	10.9872	16.66667	1478305	0.500006	106609.3	115480	100
	15	52	10.9872	16.66667	1478305	0.500006	106609.3	115480	100
	15	52	10.9872	16.66667	1478305	0.500006	106609.3	115480	100
	15	52	10.9872	16.66667	1478305	0.500006	106609.3	115480	100
150	15	103		50	1612328	0.548968	110420.7	200780	100
150	15	103		50	1612328	0.548968	110420.7	200780	100
100	15	103		33.33333	1749971	0.594382	123593.6	170030	100
100	15	103		33.33333	1749971	0.594382	123593.6	170030	100
150	15	103		33.33333	1760982	0.597624	122655.7	193030	100
150	15	103		33.33333	1760982	0.597624	122655.7	193030	100
125	15	142		50	1762924	0.600856	120660.4	220480	100
125	15	142		50	1762924	0.600856	120660.4	220480	100
125	15	129		41.66667	1858708	0.634281	129269.9	206205	100
125	15	129		41.66667	1858708	0.634281	129269.9	206205	100

150	15	103		50	1612328	0.548968	110420.7	200780	100
150	15	103		50	1612328	0.548968	110420.7	200780	100
100	15	103		33.33333	1749971	0.594382	123593.6	170030	100
100	15	103		33.33333	1749971	0.594382	123593.6	170030	100
150	15	103		33.33333	1760982	0.597624	122655.7	193030	100
150	15	103		33.33333	1760982	0.597624	122655.7	193030	100
125	15	142		50	1762924	0.600856	120660.4	220480	100
125	15	142		50	1762924	0.600856	120660.4	220480	100
125	15	129		41.66667	1858708	0.634281	129269.9	206205	100
125	15	129		41.66667	1858708	0.634281	129269.9	206205	100