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Optimization of Energy Consumption in Jericho Wastewater Treatment Plant

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This thesis was prepared under the supervision of Dr. Maher Abu-Madi and has been approved by all members of the Examination Committee.

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Abstract

The accelerated expansion and development in Palestine, has resulted in increasing of water consumption, and consequently in generation of large quantities of wastewater from various sources. This wastewater has been seeping into the ground, which leads to the problems of ground water, soil, health and environment. These problems must be reduced and need a serious solution. Building wastewater treatment plants is the most suitable solution.

In the whole water-wastewater cycle, wastewater treatment systems considering as the most energy consuming part. The energy demand of wastewater treatment systems depends on the site of the plant, type of the treatment process, aeration system, and its size (population served, organic or hydraulic load), age of the plant, experience of its managers, effluent quality requirement, etc. All stages of wastewater treatment plants and sludge treatment require energy for pumping, mixing and aeration of wastewater and sludge disposal.

In Palestine there are several determinants related to the field of energy used as a result of many factors, such as the energy prices which considered as the highest in the world, and the other effective factor is the fully controlled of energy sector by Israeli occupation, where the Palestinian people are exposed to daily violence committed. The most important challenge facing the wastewater treatment plants is the amount of energy consumed specifically operational cost (most of treatment plants have an operational cost reach to 70%from total cost) .For all this reasons, we should find the best possible ways for optimization of energy consumption in wastewater treatment plants, at the same time this ways should be environmentally friendly. As a case study, the wastewater treatment plant in Jericho was taken.

In this research the main aim is to optimize and reduce the energy consumption in Jericho wastewater treatment plant, and the specific objectives are (1)use the best way to increase energy efficiency in the Jericho wastewater treatment plants.(2) Identify areas for conservation and to determine where energy is being used inefficiently, and trying to find suitable way to make energy efficiency through energy management, improving equipment, run the equipment for fewer hours.(3) Finding suitable design to decrease the energy consumption in Palestinian wastewater treatment plants.

The general findings of this research are: (1) the amount of wastewater influent to Jericho wastewater treatment plant had been very low in 2015and this is due to the low number of building connected to sewer network, it served 3200 capita, but the influent increased in WWTP due increasing of connection rate it reaches 1250 house connections, approximately 6250 capita served. In 2020 it is expected to connect all the city and served 36000 capita and the annual amount of treated wastewater will reach around 311000 m^3 and can cover most of the agricultural lands at the east of Jericho city, which famous with palm trees planting.

(2) In Jericho WWTP the energy consumption (kWh/m^3) considered to be high in the first operational year, which means that the WWTP working inefficiently at first. But it was noticed that the energy consumption decreased with years, this is due to the increase of the number of population served by WWTP, thus growing in the influent of the WWTP, and therefore the energy consumed is divided by a larger quantity of flow rate, and this is confirmed with the concept of (economies of scale).

(3) When the energy consumption compared in two years 2015 (the first operating year) and 2016 the second year, taking in consideration that the total load of wastewater entered to the WWTP hugely increased, it has been observed in contrast of expectations that the energy consumption decreased despite the increasing of the total load of wastewater entering the WWTP, this marked decrease due to the organization of the operation of the WWTP, and had an efficiency operational plan of the WWTP.

(4) The WWTP divided into seven stages; grit chamber, reactor, final clarifier, disinfection, utility facility, gravity thickener, garden facility. The energy consumption in each stage was calculated for years (2015, 2016), and 2020 target year. It is clear that the reactor stage, which contain aeration blower is the most energy consuming stage, according to the energy consumption value and literature, it reaches 465 (kWh/day), the reactor represents 68% of the total consumption, while the other stages represent together 32%. In WWTP there are four aeration blowers, only two of them work all the time, while the other two are rarely turned on.

(5)From the calculation of energy consumption for every Kg of water quality the results are obtained show that the most energy consumption between the three water qualities is total Nitrogen (TN), it consumed energy18 times more than the other wastewater quality for one kilogram. It was noticed that the WWTP has a very good effluent quality corresponded with the Palestinian recommendations and guidelines.

الخلاصة

إن التطور والنمو المتسارع في فلسطين أدى إلى زيادة في كميات المياه المستهلكة وبالتالي زيادة في كميات المياه العادمة الناتجة من مختلف القطاعات . هذه المياه تتسرب إلى المياه الجوفية مما يؤدي إلى مشاكل بيئية وصحية تؤثر على الإنسان والتربة والبيئة, حيث تبين أن الحل الأمثل لعلاج هذه المشكلة هو بناء محطات معالجة المياه العادمة .

تعتبر أنظمة معالجة المياه العادمة أحد أهم الأنظمة المستهلكة للطاقة , حيث كل مراحل معالجة المياه العادمة ومعالجة الحمأة تحتاج إلى طاقة بمختلف أشكالها من أجل ضخ المياه بين المراحل المختلفة وتشغيل أنظمة التهوية والمعالجة وغيرها , وتعتمد كمية الطاقة المستهلكة في المحطة على عدة عوامل أهمها موقع المحطة, التعداد السكاني, جودة المياه المعالجة,العمر الزمني للمحطة, وخبرة العاملين فيها وغيرها من العوامل.

في فلسطين تعتبر أسعار الطاقة والمحروقات الأعلى عالميا, بالإضافة إلى أن الاحتلال الإسرائيلي متحكم وبشكل كبير في قطاع الطاقة والمحروقات , وبالتالي يعتبر التحدي الأكبر الذي يواجه قطاع معالجة المياه العادمة هو كمية الطاقة المستهلكة وبالتحديد التكلفة التشغيلية للمحطة والتي تصل إلى 70 % من التكلفة الكلية, وكنتيجة لها التحدي, أصبح من الضروري إيجاد أفضل الطرق للاستخدام الأمثل لمصادر الطاقة في محطات معالجة المياه العادمة واستخدامها بشكل فعال على أن تكون هذه الحلول صديقة للبيئة . تم أخذ محطة معالجة المياه العادمة في أريحا كحالة دراسية.

أهداف هذا البحث: (1) إيجاد طرق الاستخدام الأمثل للطاقة في محطة وتقليل استهلاكها وإيجاد الطريقة المثلى لرفع كفاءة استخدام الطاقة في محطة معالجة أريحا. (2) تحديد أماكن استهلاك الطاقة الأعلى في المحطة وبطريقة غير فعالة وإيجاد الطريقة المناسبة لجعل استهلاك الطاقة أكثر كفاءة من خلال الإدارة الصحيحة لتشغيل المحطة وتطوير المعدات المستخدمة في المحطة وتشغيل المعدات لعدد ساعات أقل ومن ثم إيجاد السياسة المناسبة لتقليل استهلاك الطاقة في محطات معالجة المياه العادمة الفلسطينية.

أهم النتائج العامة في هذا البحث هي : (1)كانت كميات المياه العادمة الداخلة للمحطة في عام 2015 قليلة جدا وهذا بسبب قلة البيوت المربوطة بشبكة الصرف الصحي, حيث كانت تخدم 3200 نسمة ولكن ارتفعت كميات المياه الداخلة للمحطة في عام 2016 حيث أصبحت تخدم 6250 نسمة ومن المتوقع أن تخدم 36000 نسمة في عام 2020. (2) كان استهلاك الطاقة في المحطة عاليا في السنة التشغيلية الأولى , مما يعني أن المحطة لم تكن تعمل بكفاءة , ولكن تناقص الاستهلاك خلال السنوات التالية بسبب زيادة عدد السكان المخدومين وتقسيم الاستهلاك الكلي على عدد أكبر من السكان. (3) عند مقارنة النتائج بين عامل 2015و2016 مع الأخذ بعين الاعتبار أن كمية المياه العادمة الداخلة للمحطة ارتفعت بشكل واضح , فقد لوحظ وعلى عكس التوقعات أن استهلاك الطاقة في بعض المراحل تناقص بالرغم من زيادة التدفق الداخل للمحطة وهذا يعود لتنظيم تشغيل المحطة وتشغيلها بكفاءة عالية. (4) عند حساب الطاقة المستهلكة في مراحل المعالجة المختلفة تم إيجاد أن مرحلة المعالجة الحيوية هي الأعلى استهلاكا في جميع المراحل تحديدا التهوية حيث تصل نسبة الاستهلاك فيها إلى 68% من مجموع الاستهلاك الكلي , بينما تشكل بقية مراحل المعالجة 32 % من الاستهلاك الكلي في المحطة

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LIST OF ABBREVIATIONS

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
EPA	Environmental Protection Agency
KWh	kilo watt hour
L/c/d	Liters Per Capita per Day
O&M	Operation and maintenance
PCBS	Palestinian Central Bureau of Statistics
PSI	Palestinian Standards Institute
PWA	Palestinian Water Authority
TN	Total Nitrogen
TSS	Total Suspended Solids
WHO	World Health Organization
WWTP	Waste Water Treatment Plant

Table of Content

Table of Figures

List of Tables

Chapter One: Introduction

1.1 Background

In recent years, the demand for energy around the world has been increasing, and it is the first interest for decision makers to control the energy sources and look for new resources to use. The combustion of the conventional source of energy (oil) causes pollution for the environment, destroys the ozone layer, deteriorates the green house effect increasing the temperature of the earth, increases acid rain, … etc.

A municipal wastewater treatment plant contains of three treatment stages: The first one is the primary stage responsible of suspended solid and grit removal, the second is secondary stage responsible of organic pollution removal, and the last one tertiary stage responsible of nitrogen and phosphorus removal and this is advanced stage. The primary stage consists of collection of wastewater and pumping, screening, grit removal and sedimentation, it considers as low energy demand stage except the wastewater pumping. In literature, there is a widely data about primary treatment process and energy consumption at this stage. Energy consumption of wastewater collection and pumping ranges from 0.045 to 0.14 kWh/m^3 in Hungary, 0.1 to 0.37 kWh/m^3 in Australia, and 0.02 to 0.1 kWh/m^3 in Canada (Yifan, G.,et al,2011).

The highest energy consumption stage of the wastewater treatment plants is the secondary treatment. The most important categories in secondary treatment plants are aeration and mixing of activated sludge as they are the most energy consumers in this treatment stage and in the whole treatment plant. It represents around 60-65% of the total operating costs of wastewater treatment plants (Plappally& Lienhard, 2012).

Conventional activated sludge treatment systems consume in average 0.46 kWh/m^3 in Australia, 0.33–0.60 kWh/m^3 in USA, while it is 0.269 kWh/m^3 in China, and 0.30–1.89 kWh/m^3 in Japan. Oxidation ditch in secondary treatment stage has higher energy consumption of 0.4–1.5 kWh/m^3 in different country (Rivas,et al, 2008).

Tertiary wastewater treatment stage consists of thickening of nutrient removal processes (denitrification, nitrification, and bio Phosphorus removal). It consumes higher amount of energy In Japan the energy consumption ranging between 0.39to 3.74 KWh/m^3. While in conventional WWTPs in United States consume 0.43 (KWh/m^3).

The improvement of energy efficiency in water and wastewater facilities consider as the most important issues in water cycle, it produces a group of environmental, economic, health, and other interests like decreasing of energy costs, operational and maintenance cost. Government and water sector can realize significant cost savings by increasing the efficiency of the pumps and aeration equipment at a water or wastewater treatment plant. In the United States a 10 % of the energy used in water and wastewater reduced, resulting save around 400 million dollars and 5 billion kWh annually. There are other ways to reduce energy costs such as shifting energy use away from peak demand times to times when the electricity is cheaper or using renewable energy in wastewater treatment plants to covering the energy need in it (U.S. EPA, 2011).

“At Goose Creek Sewage Treatment Plant in West Chester, Pennsylvania, a 2010 energy audit showed that treatment equipment (such as aerators, blowers, and pumps) accounts for approximately 95 %of the facility’s electricity consumption. To identify possible energy conservation and efficiency opportunities, the facility developed an inventory of its major equipment. The inventory includes descriptions and quantity of equipment, nameplate horsepower, estimates of run hours, and calculations of kWh/yr. The inventory revealed that blowers account for 57 percent of the total energy use of all treatment equipment at the plant” (U.S. EPA, 2013).

On the other hand optimization of energy consumption in WWTPs has a significant role in preserving the environment through decreasing air pollution and GHG emissions, it achieved by declining consumption of fossil fuels as based energy source, when the fossil fuel is burned to generate electricity, it produced approximately 40% of the world emissions of carbon dioxide (CO_2), 67% of sulfur dioxide, and 23% of nitrogen oxide (NOx) emissions. Theses emissions leads to real environmental problems such as smog, acid rain, and airborne particulate matter that can cause respiratory problems for many people (U.S. EPA, 2013).

1.2 Research Problem

The energy sources in Palestine are very limited, there is no coal whatsoever, no oil or natural gas, and all energy consumed is imported from Israel. The demand for energy has grown continuously in recent years and it is expected to increase sharply (e.g. annual growth rate 12% of electricity, and more than 20% for petroleum). There is lack in electricity supply and > 13% of Palestinians are still not connected to the networks (4.5% without electricity, 8.5 % have partial electricity for 8hrs/day). These people are concentrated in the rural areas (Khoudary, 2011).

These days the demand for energy is increasing, and the development of energy sources should be the first goal for the decision makers. For example, extracting energy from biosolids is considered one of the most important approaches in energy technologies in all over the world, this is due to its advantage as a source of clean energy, cheap, environmentally friendly, and it is economic benefits.

In Palestine where energy prices are considered the highest in the world, and the energy sector is fully controlled by Israel and the Palestinian people are suffering the daily violence committed by the Israeli occupation forces, the most important challenges facing the wastewater treatment plants is the amount of energy consumed specifically operational cost (most of treatment plants have an operational cost reach to 70%from total cost). For all this reasons, we should find the best possible ways for optimization of energy consumption in wastewater treatment plants (Jericho WWTP),at the same time this ways should be environmentally friendly, and to know if is it possible to run the equipment in wastewater treatment plants for fewer hours.

As a result, energy consumption in water and wastewater sector will increase due to many factors, like the increasing in the contaminant load to be treated, population growth, and increasingly of health and environmental protection standards for effluent quality water reuse. These changes lead to more energy consumption and more energy intensive processes. Thus, the optimization of energy consumption, efficiency of design and equipment and technology operations, energy recovery, and good management of wastewater treatment plants. Certainly, higher energy efficiency means lower energy consumption, lower operating cost for WWTPs, and lower greenhouse gas emissions.

The wastewater treatment plant in Jericho was taken as a case study for several reasons, the most important of which is that the Jericho WWTP has a highly rate of energy consumption and it is relatively newly opened p, the data that related to energy consumption in different stage are available, where there is a program for working hours of each category. Moreover, the Jericho WWTP uses solar energy as an energy source; this gives an impression of the impact of using renewable energy sources in treatment plants.

1.3 Aim and Objectives

The main aim of the research is to study and optimize the energy consumption in Jericho wastewater treatment plant. The specific objectives are:

1- To assess the energy consumption at different stages of the wastewater treatment process.
2- To identify the stages for conservation and to determine where energy is being used inefficiently, and to learn the best way to increase energy efficiency in the Palestinian wastewater treatment plants.
3- To recommend alternative methods for decreasing the energy consumption in Jericho wastewater treatment plant.

1.4Thesis Outline

This research consists of six chapters. Chapter one presents an introduction of the thesis, aims and objectives and the research problems. Chapter two presents literature review of previous studies and study area. Chapter three presents the study area. Chapter four presents methodology used in research to obtain the goal of this research. Chapter five includes the main results of this research and a discussion of these results. And finally the conclusion and recommendations are included in Chapter six.

Chapter Two: Literature Review

2.1 General Background

The accelerated expansion and development of Palestine has resulted in increasing of water consumption. And consequently in generation of large quantities of wastewater from various sources such as residential areas, commercial establishments and different industries. Due to the absence of wastewater treatment plants, the wastewater has been seeping into the ground through the overflows of the deteriorated cesspits and latrines that is commonly used in Palestine. And the wastewater is flows directly to the “Wadis” through open drain in different routes causing serious environmental and health problems. The main damaging consequences of the wastewater routes are smells, soil contamination, and polluting of existing aquifers.

In view of these bad conditions, along with fast increasing of the environmental and health problem. The buildup of wastewater treatment plants become a pressing necessity so as to solve all problems that mentioned above.

The main objective of the wastewater industry has been fulfillment the standards of water quality to meet the major role of it, which is protect the environmental and public health, so the WWTP are designed to achieves certain effluent requirements quality without taking in to account any energy considerations. However, this situation was different in the recent years in the framework of 20-20-20 goals defined for climate and energy (Panepinto et al., 2016).

In the past, all efforts were heading forgetting high quality water. These technologies are efficiently, but in terms of energy consumption it is not efficient. The activated sludge technology considers as the most popular biological treatment in WWTPs, this is due to its high effectiveness and its excellent performance. On the other hand it uses big amounts of energy representing higher than 40% of the total energy required to operate the WWTP. The amount of energy consumption in WWTPs depends on many factors like the site of the plant, type of the treatment process, aeration system, and its size (population served, organic or hydraulic load), age of the plant, experience of its managers, effluent quality requirement, etc. The most important issues in WWTPS is to decrease the energy consumption and at the same time keeping the quality of effluent water as required. So the optimization of energy consumption in WWTP can be achieved by reducing the energy consumption in the different stages and categories, and recovering energy from the same WWTP (Silvestre et al., 2015).

2.2 Wastewater Treatment

Wastewater treatment is the process of converting wastewater that is no longer suitable for use into water that can be discharged back into the environment. Wastewater production comes from several sources including bathing, washing, using the toilet, and rainwater runoff.

The aim of wastewater treatment is to reduce the contaminants like bacteria, chemicals, nutrients and other toxins, to achieve acceptable levels to make the water safe to discharge back in to the environment. Wastewater consist of different types of problems each problem requires different methods to remove contaminants to acceptable levels

2.2.1 Mechanical Treatment

“Mechanical treatment is the simplest form of wastewater treatment. Firstly it is remove larger pollutants such as solid materials, e.g. plastics and fabrics. This is done by passing waste water through a sieve or screen that not allows large particles to pass through it. In addition to this, further removal of suspended solids, such as sand and coffee grounds, is achieved by passing the wastewater on a grit chamber. A reduction of the flow velocity causes heavier particles to sink to the basin floor. Further mechanical treatment involves allowing the wastewater settle in a basin, letting smaller particles sink to the basin floor creating sludge. This sludge, referred to as primary sludge, is removed from the basin floor by scrapes and transported to further sludge treatment. The mechanical treatment processes only remove about one third of the oxygen consuming pollutants. Furthermore, none of the nitrogen and phosphorus content is removed. Mechanical treatment is hence considered to be only a preliminary wastewater treatment method” (Andersson& Holmberg, 2006).

2.2.2 Biological Treatment

The main concept of biological treatment in wastewater treatment plants is degrading the organic matter by microorganisms, then the degraded matter linked in to flock particles and braked from the water be settling and then creating sludge. ”The biological degradation can occur under both aerobic and anaerobic conditions. Under anaerobic conditions, no oxygen is present in the process causing some microorganisms to use nitrate as their oxidizer. The organic substances are oxidized into carbon dioxide and water, while some part of the matter is degraded into methane gas. Under aerobic conditions oxygen is present in the process. The organic material is oxidized into mainly carbon dioxide and water. Some part of the organic material is used for growth of the bacteria. Biological treatment during aerobic conditions is usually performed as either fixed film process or activated sludge process. Biological treatment using the fixed film process is achieved by allowing the wastewater pass through a material, which is oxygenized. A culture of microorganisms grows on the material, consuming the organic matter in the wastewater. When the layer of microorganisms on the substrate grows thicker, the wastewater transports the microorganisms to the effluent. The microorganisms are then separated from the wastewater by an adjacent settler creating sludge” (Andersson& Holmberg, 2006).

2.3 Wastewater Treatment Stages

In wastewater treatment plants, wastewater go through five processing stages, preliminary treatment, primary treatment, secondary treatment, disinfection and sludge treatment . 85%-95% of pollutent removes in primary and secondary treatments, then the wastewater goes to disinfection process and finally discharged in to environment. The treatment of the sludge consist of stabilization process and then dewatered. The produced material from this process known as biosolids, it is used as fertilizer used to improve the situation of lands and vegitation Figure (2.1) explains the treatment process through different stages and how all the various unit processes sequentially follow and tie into each other (Spellman, 2003).

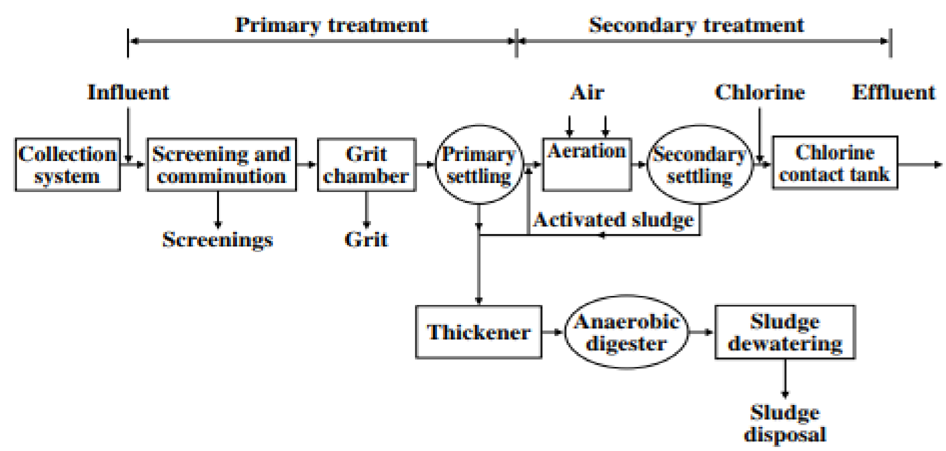

Figure (2.1): Wastewater treatment process providing primary and secondary treatment using activated sludge (Spellman, 2003).

2.3.1Preliminary Treatment

As mentioned before preliminary stage is the first stage in WWTP, the wastewater enters the treatment plant and hold many kinds of material and trash, this stage remove these materials from wastewater before it goes to the next stage, so the main goal of this stage is to protect the equipment of WWTP from damage and prevent clogs, jams, or another mechanical problems it may be caused by this material. When these substances remove from wastewater, it will save spaces in the treatment plants, each process in preliminary stage specialized to remove a specific type of enters material (Spellman, 2003).

2.3.1.1 Screening

The role of the screening is to eliminate large particles, like rocks, branches, cans, roots, leaves, from enters to the downstream processes. The main function of screening is to eliminate large solids, such as rags, cans, rocks, branches, leaves, roots, from the influent before it moves on to downstream processes. “A bar screen traps trash as wastewater influent passes through. Usually, a bar screen consists of a chain of parallel, evenly spaced bars or a perforated screen placed in a channel. The wastewater passes through the screen and the large solids are trapped on the bars for removal. The screenings must be removed commonly enough to prevent accumulation that will chunk the screen and cause the water level in front of the screen to build up" (Spellman, 2003).

2.3.1.2 Grit Removal

The grit removal removes the heavy inorganic solids that could cause extreme mechanical damages. The basic basis of grit removal works that depends on the information that the grit heavier than the organic substances located in wastewater. Grit removal may be achieved in grit chambers or by the centrifugal separation of sludge. Processes use gravity and velocity, aeration, or centrifugal force to separate the solids from the wastewater (Spellman, 2003).

2.3.2 Primary Treatment (Sedimentation)

The main objective of primary treatment is to decrease the organic load by eliminate a huge amount of suspended, settable, and floatable materials. The clarification unit usually removes (25-35) % BOD, (40-60) % TSS, (90-95) % settleable solids, then the wastewater enters the settling tank, by velocity in settling tank the solids that are heavier than water settle in the bottom of the tank, and the substances lighter than the water float on the top. Settled solids are removed as sludge and floating solids are removed as scum. Wastewater leaves the sedimentation tank over an effluent weir and on to the next step in treatment. Detention time, temperature, tank design, and condition of the equipment control the efficiency of the process. Clarifiers used may be rectangular or circular (Spellman, 2003).

2.3.3 Secondary Treatment

In wastewater treatment plants the main role of secondary treatment is to increase BOD removal more than the achievable in primary treatment. The concept of secondary treatment is to use the capability of microorganisms to transformation the organic wastes in to stabilized, low energy substances. There are three kinds of secondary treatment; trickling filter and RBC, activated sludge process, which follow primary treatment, the third kind is oxidation ponds or lagoons

In secondary treatment the organic wastes such as suspended, dissolved, and colloidal substances convert to steady solids by biological processes and then discharged to the environment which can be also removed organic wastes without causing damage. The quality of the effluent should not exceed 30mg/L BOD and 30mg/L TSS.

The processes in secondary treatment is divided in to two types, the first one is fixed film system, the processes of fixed film use a biological growth that is involved to some form of media. Wastewater moves over the film or media and when the wastewater get in touch with media the organisms eliminate and oxidize the organic substances. There are many kinds of film used such as stone, redwood, synthetic materials, and much other material. The fixed film devices could be trickling filters or RBC. The second process is suspended growth system, it uses the biological growth which is mixed with wastewater, and the suspended growth contains activated sludge process (Spellman, 2003).

2.3.3.1 Activated Sludge

The fundamental parts of activated sludge sewage treatment system contain an aeration tank and secondary settling tank, firstly the effluent from primary treatment is mixed with solids recycled from the secondary clarifier and then goes in to the aeration tank, and then the air is injected into the mixture through diffusers sited in the base of the tank. The wastewater goes to aerated tank, and the microorganisms metabolize and biologically flocculate the organics substances. The activated sludge determined from the aerated mixed liquor under stable condition in the final clarifier and then comes back to the aeration tank. As results the quantity of organisms would become huge, so from time to time it must be removed. The solid the settled in the base of the tank must be removed .the floating parts in final settling tank is the effluent of the wastewater treatment plant. Figure (2.2) illustrates the activated sludge process (Spellman, 2003).

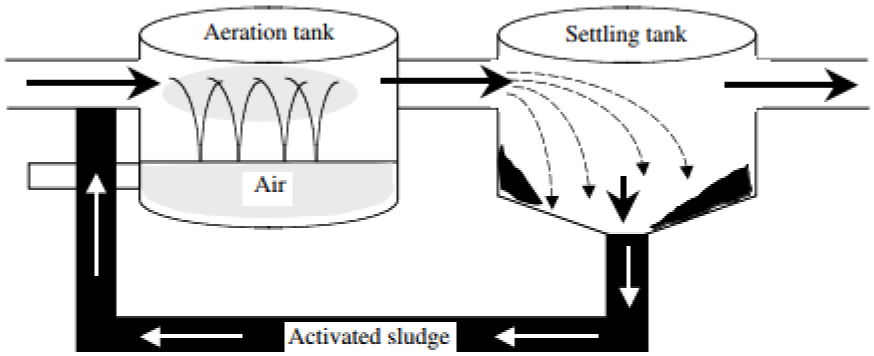

Figure (2.2): Activated sludge process (Spellman, 2003).

2.3.4 Disinfection

The main objective of disinfection is to make the treated wastewater safe when it discharged to the environment, especially when this treated water used for agriculture or swimming or other human uses. This purpose will be achieved when chlorine used in chlorination disinfection to decrease the number of organisms in the wastewater, so the pathogenic organisms will decreases to a level that is not causes infection and diseases when discharged to the water body. The chlorine is discharged into a chorine tank, the wastewater stays in the tank for 30 minutes to kill diseases and infections that the wastewater may contains. The chlorine may be as gas or solids or liquid hypochlorite form and it is a very effective material. It reacts with organic matters and different chemical like ammonia. The chlorine reacts with any reducing agent (sulfide, nitrite, iron) present in wastewater, and also reacts with ammonia to form chloramines and chloroganics(Spellman, 2003).

2.3.5 Advanced Wastewater Treatment

The aim of advanced stage in wastewater treatment plant is to remove and decrease more contaminants from wastewater than the previous stages, the contaminants consist of (dissolved solid, suspended solid). It consists nitrification and phosphorus removal. This treatment is done to increase the ordinary secondary treatment because secondary treatment remove 85_95% of BOD and TSS in municipal wastewater, which means that after the secondary treatment the residual BOD and TSS will be 30 mg/L or less, and to achieve high water quality standards, This level of BOD and TSS in secondary effluent may not avoid violation of water quality standards the plant may not make allow. As a result, advanced wastewater treatment is regularly used to remove extra pollutants from treated wastewater. The treatment facilities use advanced wastewater treatment to achieve the requirements of water quality standards, the high quality standard requirement in many cases, for example secondary wastewater treatment not effective some times to protect and save the environment and aquatic life, when periodic flow events appear in a stream; the stream can't supply the quantity of dilution that the effluent needed to protect and save the required DO level for aquatic organism survival(Spellman, 2003).

2.4 Energy Consumption in Wastewater Treatment Plant

2.4.1 Energy patterns in wastewater treatment plant

In wastewater treatment process, different type of energy are used like electrical, manual, fuel, chemical etc, some of them can be considered as indirect energy like Chemical energy, where human or manual energy considered as renewable energy and others as non-renewable energy.

Estimation of electrical energy input

The electrical energy input is estimated by taking into account the electrical load of the pump/motor (kW), operation time in hours (h) for which the motor is operated and total amount of wastewater treated (Eq. 1).

$$Ep= \frac{P \times T}{Q} \qquad (1)$$

Where,

Ep is the electrical energy kWh/m3,

Q the total flow of wastewater in m3/day

P the rated power of the electrical motor in kilo Watt (kW)

T is the operation hours in a day (h/day) (Singh, et al., 2012)

2.4.2 Energy usage in wastewater treatment plant stages

Stage 1: Preliminary treatment

1. Screening: Screening represents a small part of the total energy use at a treatment plant, with most mechanically cleaned units handling 15mgd or less being driven by a 0.56kW motor. On this basis, screening power represents approximately 0.01% to 0.1% of total wastewater treatment plant energy requirement (NEWRI, 2009).
2. Grit chambers: Grit removal is also not necessarily a major energy consumer in wastewater treatment facilities although it can consume a significant amount of energy if excessive air is supplied to aerated grit chambers. Aerated grit chambers, which are higher energy consumers in comparison to the horizontal-flow type due to the power required to operate air compressors, generally consume about 1% of the total wastewater treatment plant power (NEWRI, 2009).
3. Pumping: Pumping is a significant energy consumer in a wastewater treatment plant. Pumping energy requirements could range from 15% to 50% or more of total plant energy. Thus, optimizing pumping operations should be a major consideration in the evaluation of energy use reduction.

Stage 2: Primary Treatment

Primary treatment energy demands include those for the skimming and scraper devices and for sludge pumping. Primary treatment consumes in the order of 1% or less of total plant energy used including that required for scraping, skimming and pumping. An important energy use reduction related to the operation of the primary settling tank is to minimize wastewater head loss. Energy requirements for sludge collection can be evaluated for either circular or rectangular tanks, but in both cases the energy consumption is relatively minor (NEWRI, 2009).

Approximately 25% of the total energy consumed within a wastewater treatment plant in China can be qualified to the pretreatment stage, where energy use is mostly due to pumping against gravity at the inlet of the plant. In some cases, the use of air in the grit chamber during pretreatment can also enlarge energy use for pretreatment (Smith& Liu, 2017).

Stage 3: Secondary Treatment

Energy demands directly associated with the secondary treatment process at an activated sludge plant include operation of the aeration system, operation of the secondary clarifier sludge collectors, and pumping of sludge for recycle and/or wasting. Aeration is easily the highest energy consumer at an activated sludge wastewater treatment plant. It can consume as much as 50% of total plant energy needed (NEWRI, 2009).

In China the general secondary treatment processes used are biological and involve significant aeration, which leads to huge energy require. Biological treatment stage can be consumedabout 60–70% of energy used inside a plant. In Beijing's Gaobeidian treatment plant 58% of energy is used in anaerobic-anoxic-oxic secondary treatment.

As mentioned before, 50–70% of the total energy consumption in wastewater treatment plants are in aeration alone uses in China. Given that aeration of wastewater is the major energy user in Chinese wastewater treatment plants, so it is important to focusing on energy efficiency in this stage through optimization of the process inactivated sludge significantly(Smith& Liu, 2017).

Stage 4: Sludge Treatment

1- Thickening

The energy consumption for sludge thickening varies greatly, depending on the sludge to be thickened and the process utilized. Typically, energy use for gravity thickening is approximately 0.1 to 0.2% of total plant energy use, while for dissolved-air flotation thickening the proportion can be in the 2-10% range (NEWRI, 2009).

"In china sludge treatment contributes 4.1–13.9% to the total energy consumption within a wastewater treatment plant. The main processes used for sludge treatment are thickening, conditioning and dewatering. Gravity thickening is the most common thickening method. These types of thickeners require electricity to run sludge scrapers that rotate on the bottom of the tank but use less electricity than other thickening methods like centrifuge thickening, which uses centrifugal force to increase the rate at which particles settle. For example, gravity thickening uses 0.0019–0.0021 kWh m–3 for plants servicing over 50 000 people, compared to 0.015–0.035 kWh /m^3 for thickening centrifuge and floating" (Smith, & Liu, 2017).

Stage 5: Advanced wastewater treatment

1-The energy consumed in advanced wastewater treatment is huge because of the nutrient removal processes. The advanced wastewater treatment processes are extremely energy demanding. The energy demand ranging from 0.39 up to 3.74 kWh/m^3 in Japan while conventional municipal WWTPs in USA typically consume 0.43 kWh/m^3, which is similar to the energy consumption in Taiwan (0.41 kWh/m^3), New Zealand (0.49 kWh/m3), and Hungary (0.45–0.75 kWh/m3). According to Water Environment Federation (WEF), dual media filters accounts for 13% of the energy consumption on average, with the highest proportion of about 17% and the lowest of about 10% in an advanced WWTP (Yifan, et al., 2017).

2- Disinfection

Chlorine is the most generally used disinfectant in a wastewater treatment plant. Chlorination represents a minor energy consumer in wastewater treatment facilities. It consumes less than 1% of total wastewater treatment plant energy consumption (NEWRI, 2009).

2.5Benefits of improving energy efficiency in wastewater treatment plants

Optimization of energy consumption in wastewater treatment plants can produce major environmental, economic, and other benefits, including:

1. Reduce energy costs: when the efficiency of the equipment like pumps and aeration used in water and wastewater treatment plants is increased , the water sector and the governments can make a significant energy saving which leads to huge cost saving. For example in the United States, 10% decreasing in energy consumption in water and wastewater facilities causes to save 400$ million and 5 billion kWh annually. There is another ways or procedure to decrease the energy costs, like moving energy use away from peak demand period to period when electricity is cheaper, other solution using biogas and solar cells as a source of renewable energy(U.S. EPA, 2011).
2. Progress energy and water security: improve the energy efficiency at wastewater treatment plants lead to decline the consumption of electricity, and as results helping to keep away from the need to build new power plants. Other benefits for energy efficiency which is decrease the danger of water shortages, and make sure a dependable and continuous water supply.

3. Extend the life of infrastructure and equipment: when the energy efficiency in wastewater treatment improving, this leads to extend the life and less repair and maintenance for the equipment uses in wastewater treatment plants, the other side that the efficiency of energy in wastewater increase the life of presented infrastructure due to lower demand, and avoid the requirement for costly future expansions (U.S. EPA, 2012).
4. Care for public health: increase energy efficiency in wastewater facilities can lead to reduce the environmental pollution, air and water pollution by reducing the load on power plants that generate electricity through burning fossils fuels which pollute the air by anoxic gases, resulting cleaner air and save human health. Through equipment improvement, the wastewater treatment plant can increase their capacity for treating wastewater, and reducing the house gas emission, and reduce the danger of waterborne diseases (U.S. EPA, 2012).

4- Save environment from air pollution and GHG emissions. The main source of energy uses in wastewater treatment plant fossil fuel through combustion to generate electric energy ,and fossils fuel burning accounts around 40% of the world emissions of carbon dioxide(CO_2) and GHG emissions, it also accounts for 67 % and 23 % of the nation's sulfur dioxide (SO2) and nitrogen oxide (NOx) emissions, respectively. When the energy efficiency improved the consumption will decreases so the combustion of fossil fuel will decreases and as results decreases GHG emissions and air pollution(U.S. EPA, 2013).

2.6Energy Consumption in WWTPs in Different Countries

In USA the unit electricity consumption for WWTPs of 0.52 kWh/m^3. The electricity consumption by wastewater treatment is predictable to account for 0.6% of the annual electricity consumption in 2008.But in Asian countries shows lower energy intensity for wastewater treatment (0.31 kWh/m^3 for China, 0.304 kWh/m^3 for Japan and 0.243 for Korea). Though three Asian countries, China shows higher energy intensity and lower proportion (only 0.25%).This is a relatively low percentage in China which seems to be caused by large amount of total population and energy use. In addition, energy consumption of WWTPs has a strong relevance with treatment levels adopted. Today there are still some gaps in monitoring and treating wastewater in China. However, in current years, the regulations about effluent are becoming more stringent to prompt the adequate treatment (Yifan, et al., 2017)

In European countries, the energy consumption for wastewater treatment are similar between Sweden and Germany, which is around 0.42 kWh/m^3, while in South Africa the energy consumption of WWTPs in varies between 0.079-0.41 kWh/m3 with the most widely used technologies of lagoon and trickling filters (Yifanet al.,2017).

In China the average energy consumption of 1856 WWTPs in 2009 was 0.254KWh/m^3, 0.26 kWh/m^3 in Japan and 0.20 kWh/m^3 in USA, taking in to accounts different factors such as scales of the plants and operation rate on the energy consumption (Xie & Wang, 2009). In India the total energy consumption is 1.07 kWh/m^3 of wastewater treated (Singh et al., 2012).

2.7The correlation between plant size and energy consumption

In Murcia Region (Spain), 90 WWTPs had been studied to establish the relationship between size and energy consumption for them, the most energy consumer was aeration type plants with nutrient removal processes (predominantly Nitrogen removal) and tertiary treatment for water reuse, it was established that the increase in energy consumption ratio (kWh/m^3) is proportional to the square of WWTP size decrease.

This is because of the fact that the energy costs per unit for larger WWTPs are lower, and this is the concept of economy of scale that is an efficient solutions, other efficient solution is the use of cost synergies, the opportunity to adjust treatment processes in a range of different lines according to seasonal variations and the effective use of cogeneration systems that allow the production of electricity for use on site or sale to the grid, so it is better to design WWTPs to be as large as possible, attempting to concentrate effluent from several urban area such that the energy consumption is one third that of small WWTPs. The advantages become obvious when taking into account that energy costs represent more than 50% of total operation costs in a WWTP, and that this will increase in line with forecasted general increases in energy costs (Arturo et al., 2014).

There is significant effect of the scales of different wastewater treatment plants on the energy consumption in the plants, when the scales of the plants increase, the energy consumption decreased, and this is due to scale effect during the operation of the plants. When the wastewater enters to the plants increases, the equipment and devices operated during the treated stages can work with higher efficiency and the treatment environment is comparatively more stable with fewer change in the amount of water and pollutants concentration, thus providing a better condition for the growth of the microorganisms in the sludge and improving the treatment capacity.

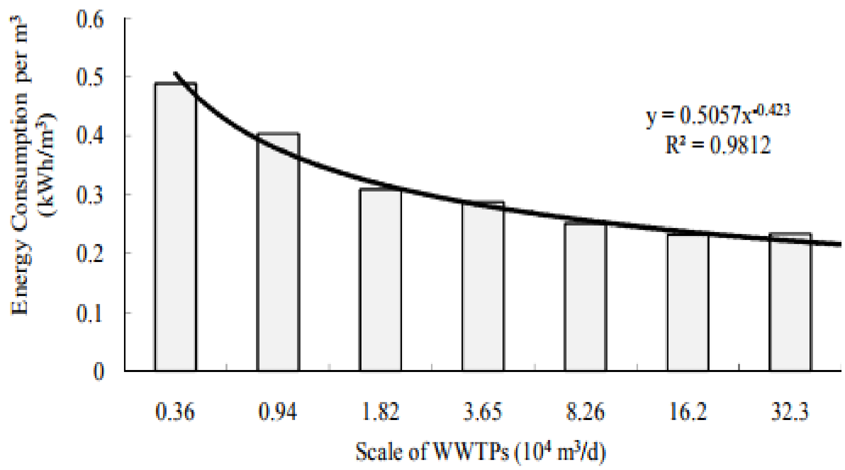

Figure (2.3): Relation between scales of WWTPs and energy consumption (kwh/m^3). (Xie& Wang. 2009).

In north china it was found that the aeration, pumping and sludge treatment categories had 80% of the total energy consumption, aeration consumed the half of the total energy consumption. The study of energy consumption in the WWTP should be focused on aeration. In small scale plants, the total energy amount of the plant is 1.046 kWh/m^3 of wastewater treated (Xie& Wang, 2009).

2.8 Minimizing Energy Consumption in WWTPs

Wastewater is usually considered as a potential energy source. The main energy source in WWTP is the biogas produced in the digester. The use of biogas for digester heating and electricity generation is viewed as a sustainable way of recovering energy from WWTPs, A

WWTP with pre-settling and sludge digestion on average consumes 40% less net energy compared to that without sludge digestion. It used in different countries such as Strass (Austria), Steinhof (Germany) Sheboygan (America). In the Netherlands, sludge digestion is a common practice at many WWTPs, producing 95 million Nm^3 biogas in 2006, which was converted in a CHP system to electricity (143 mWh) and heat (used for heating the digestion reactor) (Scott et al.,2011).

The improvements of the sustainability of the sector through energy recovery using hydropower turbines at the outlets of wastewater treatment plants (WWTPs) were studied in case study in Ireland and the UK. Flow and head data in outlet pipes were collected from over 100 plants in Ireland and the UK. It was found that the Flow is the most important parameter for hydropower potential at WWTP outlets. Of the 100 plants evaluated in Ireland, only 14 were found to have usable power output (>3 kW). These plants are all relatively large, and the greatest potential was found at Ireland's two biggest plants, Ringsend and Carrigrennan.

It is clear that the head is an important parameter for hydropower generation, but it was found to have a small impact on hydropower potential at WWTP outlets. This is because most plants being designed with low elevations such that gravity flow is achieved. Also, treatment plants are mostly located close to or at similar elevations to the receiving water bodies to reduce construction costs for the outlet pipes, so the head available at WWTPs is typically very small (Power et al.,2014).

To have effective management of the operation in WWTPs, after upgrading, a continuous monitoring of energetic performances, and in particular of the operating conditions is required: a field determination of lost power, hours of operation, stability of solutions, manpower requirement are some fundamental aspects that must be specifically verified, at start-up and in the steady situation, in order to evaluate the progress of the plant performances over the time (Panepinto et al., 2016).

Petros Gikas found that the activated sludge(aeration) for municipal wastewater consume 60% of the total energy in wastewater treatment plant , and to decrease this consumption it should be eliminate the aeration needs as possible. “The proposed process is based on enhanced primary solids removal, based on advanced microsieving and filtration processes, by using a proprietary rotating fabric belt Micro Screen (pore size: 100-300 mm) followed by a proprietary Continuous Backwash Up flow Media Filter or cloth media filter. About 80-90% reduction in TSS and 60 - 70% reduction in BOD_5 has been achieved by treating raw municipal wastewater with the above process” (Gikas, 2017).

Chapter Three: Study Area

3.1 Overview

The study area is Jericho WWTP which located in Jericho city, it is located in the east of the West Bank. Jericho is bordered by the Jordan River to the east, An Nuwei'ma town and Ein al Sultan camp to the north, Ein al Duyuk al Foqa town to the west, and Aqbat Jaber camp and Al Nabi Musa to the south. It is located at an altitude of 273m below sea level. The present population of the Jericho district is estimated at 43,620 Palestinians, living in the city of Jericho, and in the four villages (AI-Auja, An-Nuwe'ma, Dyouk AI-Tahta and Dyouk AI-Fouqa) and the two refugee camps (Ein AI-Sultan and Aqbat Jaber). The growth rate for the West Bank, in general was 3.0% in 2006 (PCBS, 2007). It is extends over 37,481 Donums, Known as the city with the lowest population, Jericho is inhibited by 69 persons/km^2 which implies a potential for future expansion. Figure (3.1) show an aerial image for Jericho city and it points out Jericho WWTP.

3. 2Water Resources

Groundwater is used as the main source of water supply for the Palestinian in the Jericho city either by wells or springs. Water of wells is taken from the quaternary aquifers. The aquifers are recharged from seasonal rainfall through the outcropping mountainous areas in west bank. The eastern basin is considered the main source of water for shallow wells through direct infiltrations from the surface runoff or by lateral flow from the mountain aquifers. The working agricultural wells are 28 out of 93 wells. The remaining wells are non-pumping and abandoned wells. Ein AI-Sultan spring is the main water source for Jericho. It has an output of 680 m^3/hr and a salinity of 600 fractions in one million. It provides a steady output throughout the year. It is used equally for drinking water and for irrigating (Abu Sebai, 2016).

Figure (3.1) Aerial photo for city of Jericho

3.3 Climate

Supposing from the locality of Jericho city, surrounded by mountains with ground elevation of minus 300 m below sea level, it is hot in summertime with temperature exceeding 40^0C, on the other hand it is cold and comfortable with temperature down to 15^0C. Annual rainfall is 50 to 400 mm and most of rain falls concentrate during October to March, and the average annual humidity is 52% (PHG, 2010), The quantity of rainfall in the Jericho area is less than that of the mountains and the coastal regions, thus Jericho area relies entirely for drinking and irrigation on subterranean wells and springs such as the Ein AI-Sultan spring. Table 3.1 gives the monthly climatic data for Jericho as reported by the office of meteorological data of the Ministry of Transport.

Table (3.1): Average monthly climatic data for Jericho (2006-2010) (PWA, 2011)

Month	Max. Temp. (°C)	Min. Temp. (°C)	Relative Humidity (%)	Rainfall (mm)	Daily Sunshine (hrs)	Pan Evap. (mm/day)	Wind speed (km/hr)	Pressure (mbar)
January	20.2	9.3	60.5	30.56	6.0	2.3	7.44	1044.8
February	22.2	10.8	60.5	38.14	6.3	2.7	6.00	1043.0
March	26.0	13.3	53.0	8.26	7.6	4.4	6.34	1040.7
April	30.1	16.7	44.7	15.76	8.8	6.4	7.78	1037.9
May	34.6	20.2	41.2	0.24	10.2	7.8	8.32	1036.1
June	38.6	23.7	42.0	0	11.8	10.1	8.32	1032.9
July	39.4	25.0	42.7	0	11.7	10.1	8.12	1030.3
August	38.6	26.3	45.2	0	11.2	9.3	6.62	1030.4
September	37.0	24.8	49.0	0.05	9.7	7.7	6.00	1034.8
October	34.0	22.0	48.0	5.58	8.0	5.6	4.68	1040.0
November	29.5	15.3	51.3	15.05	7.6	3.5	3.38	1043.9
December	22.8	11.3	56.6	16.75	6.0	2.6	4.13	1045.3
Average Total (mm)	**31.1**	**18.2**	**49.6**	**130**	**8.7**	**6.04 2205**	**6.43**	**1038.3**

3.4 Wastewater Collection and Treatment System in Jericho City

Before opening Jericho WWTP in 2014, neither wastewater collection networks nor wastewater treatment facilities are available on Jericho city. Cesspits are the commonly used method of wastewater disposal; cesspits serve either a single house. The average size of the cesspits ranges between 10 to 40 cubic meters; the soil in the Jericho district is sandy, high in salinity, and low in clay and organic matter. Therefore, cesspits in Jericho are usually built with all their sides (except bottom) lined with concrete to prevent them from collapsing. There are some wastewater treatment units at the household or complex building scale; examples include some security forces camps, Jericho hospital and two hotels. As most of the geological formation of Jericho is Quaternary rocks and Jericho falls mainly over the Loessial Serozem soil type of relatively high infiltration rates, the frequency of cesspit emptyingdepends on water consumption and wastewater generation rates, disposal practices and methods of construction of the cesspits.

Evacuation of the cesspits is being performed using vacuum tankers. Usually the septage isdisposed in the nearby Wadies and agricultural lands. These are causing social andenvironmental problems as to the frequent emptying anddirect infiltration of the sewageinto the ground. Figure 2.2 shows the Jericho Wastewater Collection, Treatment System, and reuse project. The location ofthe WWTP is at the eastern boundary of JerichoMunicipality slightly south of Wadi AI-Qilt.

The wastewater collection system is to be located underneath the roads and streets withinthe city of Jericho and is to flow by gravity to the WWTP to be located within themunicipal boundary far east of Jericho city and few hundred meters south of Wadi Qilt.The total length of the sewer pipes needed to serve the whole project area of Jericho isestimated at 80 km including trunk and branch pipes, which cannot be covered by thisproject. Therefore, three densely populated areas were extracted as prioritized sewerdevelopment areas (Zone I, Zone 2, and Zone 2 of Figure 3.2) covering around 60% of thetotal population.

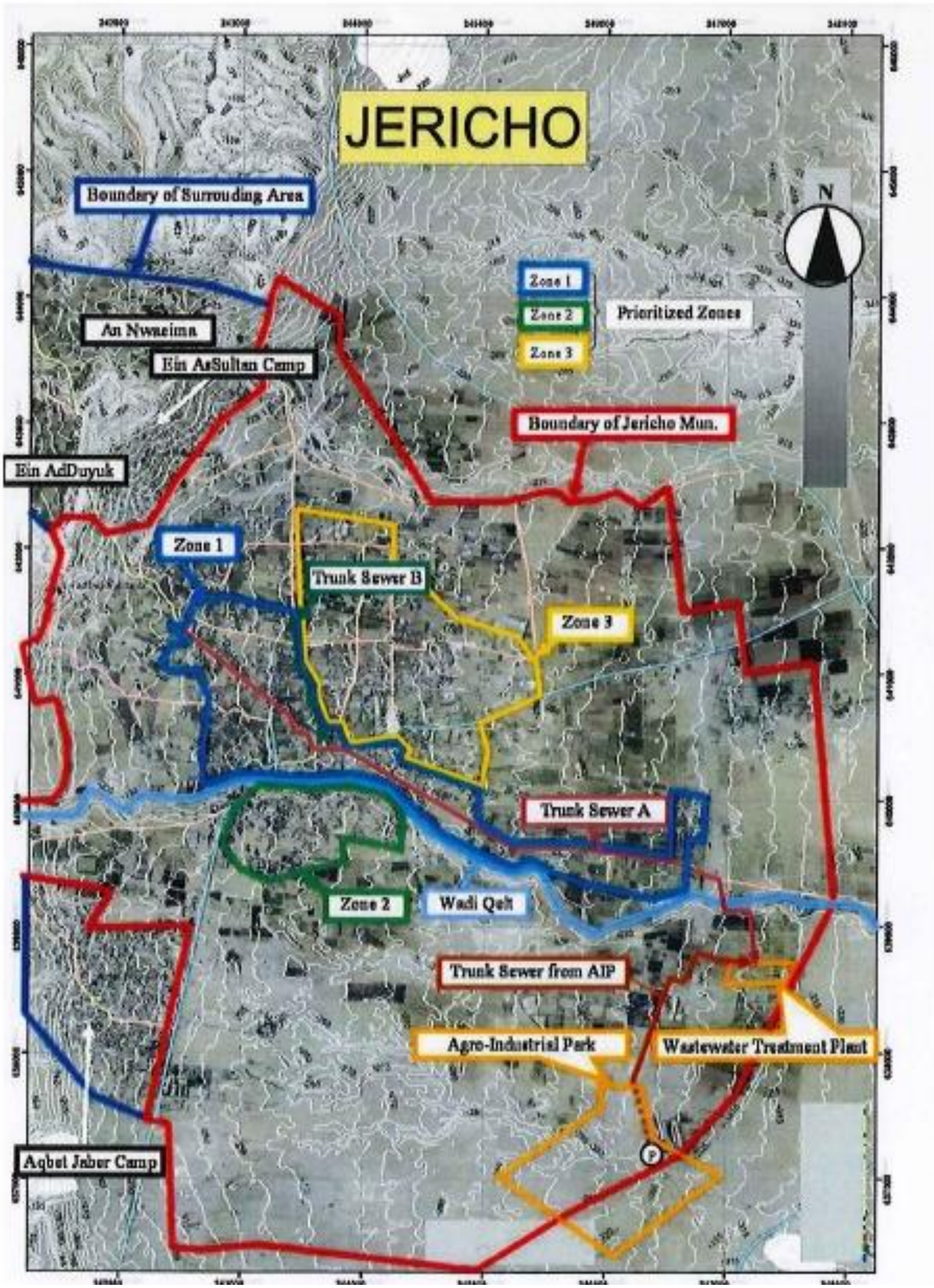

Figure (3.2): Jericho Wastewater Collection, Treatment System, and reuse project. (PWA,2011)

3.5 Treatment Process

The primary treatment reactor is Oxidation Ditch with a retention period is 24 hours. Since the expected treatment load is high owing to high incoming wastewater concentration, the treatment method is corresponding to extended aeration method. Disinfection tank and treated wastewater storage tank for reuse purposes are among the other proposed components of the Jericho WWTP. Further, Solar Panel with output of 100 kW and with an area of 1,000 m^2 is proposed from viewpoint of environmental consideration and to have O&M cost mitigation.

The first phase has been designed for daily maximum flow 9,800 m^3/day and the final phase for 14,400 m^3/day.

The mechanical-biological treatment includes the following main components:

Fine screen

Aerated grit and grease removal

Extended aeration tanks

Final sedimentation tanks (Clarifier)

Disinfection stage

Treated water tank

Figure (3.3), (3.4), (3.5), (3.6) shows some photos from Jericho WWTP in different stages:

Figure (3.3): Screening in Jericho WWTP

Figure (3.4): Reactors in Jericho WWTP

Figure (3.5): Clarifier in Jericho WWTP

Figure (3.6): Solar panels in Jericho WWTP

With this technology, the first stage will achieve a reduction rate of around 33% in terms of BODs and COD removal and approximately 64% in terms ofTSS removal. The components of sludge treatment are:

- Sludge thickener
- Sludge draying beds

Figure 3.7 is the layout plan of the WWTP.

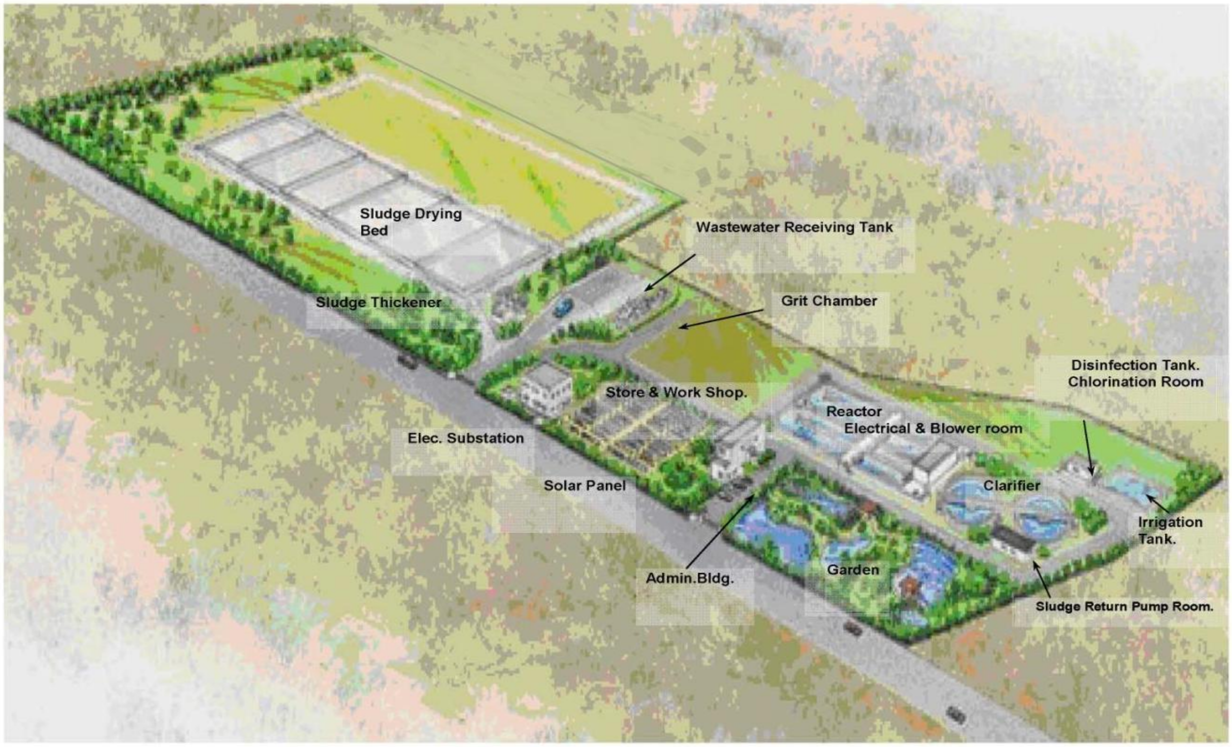

Figure (3.7): Layout of Jericho WWTP

3.6 WWTPDesigned Capacity and Quality

The design wastewater flow and wastewater quality for the target year 2020 and for the ultimate plan 2025(100% connection) are set and listed in Table (3.2).

Table (3.2): Design wastewater flow and wastewater quality for the target year 2020

Item	Wastewater amount and quality			Effluent quality
	Daily average	Daily maximum	Hourly maximum	
Wastewater amount (m3/ day)	6600	9800	19100	
BOD (mg\l)	500			20
TSS (mg\l)	500			30
TN (mg\l)	75			25

3.7 Energy Resources in WWTP

Jerusalem Electric District Company (JEDCO) is to provide the power supply to JerichoWWTP; in addition there is a solar panel that provides the most part of energy consumption in WWTP. At the same time electric generator is to be provided for emergency. The watersupply is to be provided by Jericho municipality, which is also to provide other requiredmunicipal services.

Chapter Four: Methodology

4.1 Literature

First of all, the related literature was reviewed and the key points weresummarized; e.g. stages of the treatment plants, the energy consumed in each stage, which stage consumed most of the energy, what the others did to optimize the energy consumption in wastewater treatment.

4.2 Field Visits

The Jericho wastewater treatment plants was visited several times to investigate the environmental situation and Collecting the data and information related to the proposed project such as maps, designs, drafts, climatic and weather condition, from the concerned institutions along with the technical and illustrative details that show the topography and the nature of the area of study.

4.3 Inventory of all historical plant performance and energy consumption

The data of 2015 and 2016 was obtained from Jericho municipality to evaluate the plant performance and energy consumption in each category in every stage at the WWTP. These data were used to determine the energy consumption as kWh in different units. Data obtained was included:

1. Monthly reports for WWTP which contains average, minimum, and maximum daily flow, total energy consumed, the amount of energy produced by solar cells, and the treatment cost.

Table in (Annex Ī) is a form of a monthly report that has been prepared in WWTP; it shows all data change monthly as previous mention.

2. Effluent qualities (BOD, TSS, TN) as shown in Table (4.1).

Table (4.1): wastewater qualities in Jericho WWTP

Wastewater quality	Influent	Effluent	Removal
BOD (mg\l)	500	20	480
TSS (mg\l)	500	30	470
TN (mg\l)	75	25	50

3. Motor power factor for each category in WWTP.

Table (4.2): Motor power factor for each category used in WWTP

Category	Motor Power	
Grit Chamber		
	Mechanical Fine Screen	2.2
	Grit Collector	1.1
	Grit Removal Pump	2.2
	Floor Drain Pump	1.5
	Grit Separator	0.75
	Oil Discharge Pump	0.75
	Scum Screen	0.4
	Mixer	1.5
	Waste water pump	3.7
	for Vacuum	
	Conveyor	2.2
Reactor		
	Reactor Tank Mixer	3.7
	Aeration Blower	55
	Air Supply Valve	0.2
Final Clarifier		
	Clarifier	0.75
	Return Sludge Pump	15
	Waste Sludge Pump	5.5
	Scum Pump	3.7
	Floor Drain Pump	1.5
Disinfection		
	Hypochlorite Pump	0.2
Utility Facility		
	Utility Water Supply Unit	7.4
	Defoaming Pump	3.7
	Auto Strainer	0.1
Gravity Thickener		
	Thickener	0.4
	Thickened Sludge Pump	5.5
Garden Facility		
	Circular Pump	1.5

4. Operation hours for each category during each month over two years (2015, 2016) according to taken table from the WWTP that are necessary to calculate its energy consumption were collected. The Tablein Annex Īshow the operation hours for each category over two years taking in consideration that the year 2014 did not account in energy calculation because it is considered as a pilot phase.
5. Drawings of the whole WWTP contain hydraulic profile, elevations, and layout,the head is an important parameter for hydropower generation, and can generate energy if the elevation in plant is large.(Annex Ī)

4.4 Calculation of Energy Consumption in WWTP

From the previous table the data obtained from it for each category was the monthly operation hours, but to calculate the energy consumption as (kWh) it will be need the power factor for each category which is shown in Table (4.2).

Energy consumption per month = operation hours for category * motor power……………… (1)

(kWh/month) = (h/month) * (kW)

This equation valid when the electrical equipment works in ideal condition which means it is works with perfect efficiency, but in reality these ideal condition did not exist, wherefore it was assumed that the efficiency of electrical equipment in the first five years of WWTP was 85%, and decreases by 5% every five years, therefore the energy consumption will increases due to decreases of efficiency over years.

Energy consumption = (operation hours for category * motor power /0.85………………. (2)

(kWh/month) = (h/month) * (kW)

Then the energy consumption was calculated as (kWh/month) in (2015, 2016, 2020, and 2025) taking in consideration that the efficiency assumed in 2020 to be 80%, and in 2025 to be 75%.
Through this hypothesis it was identified that the energy consumption increases over years due to the decline efficiency of these electrical tools.

4.5 Calculation of Energy Consumption for Each Category in WWTP

The energy consumption was calculated in detail for each category of the WWTP over two years (2015, 2016) and the expectation of energy consumption for 2020 (target year of WWTP), using the Excel program where the following steps were followed for each category:

1- Energy consumption (kWh/month) = (motor power * total hour per month) /0.85………. (3)
2- Energy consumption (kWh/day) = energy consumption (kWh/month)/ (30 or31 day)…… (4)
3- Total load (m^3/day): it was taken from the monthly reports of WWTP.
4- The amount of quality parameters removal (BOD, TSS, TN) as (kg/kWh).
5- Energy consumption (kWh/kg ($_{BOD,\ldots,\ TN}$)).
All calculations for each category in WWTP in annex ($\overline{\text{II}}$)

4.6 Calculation of Energy Consumption for Each Quality Parameter (BOD, TSS, TN)

The main goals of the wastewater treatment plants is to protect human health, and the environment, and to reduce the pollution transported, and diluted in water through reducing the concentration of quality parameters in the effluent of WWTP.

The indicator of energy consumption for each kg removal of wastewater quality in the WWTP will be calculated. From the data taken from the WWTP, the removal of quality parameters of the wastewater enters the WWTP is known.

4.6.1 Calculation of energy consumption for BOD removals

To calculate the energy consumption for each kilogram of BOD removed from the influent of WWTP, it needed to calculate the quantity of kilograms removed as (kg/day), through this equation:

Amount of kg removed (kg/day) $= \frac{\text{total load (m3/day)} * \text{BOD removal 480 (mg/liter)}}{1000}$............................ (5)

This calculation will be for every month in two years 2015, 2016. Then the energy consumption for each kilogram removed will be calculated by dividing energy consumption as (kWh/day) as mention in equation (4) over amount of kg removed of BOD (kg/day).

Energy consumption (kWh/kg) = $\frac{\text{energyconsumption (kwh/day)}}{\text{kilogramsremovedofBOD(kg/day)}}$…………………..………….. (6)

4.6.2 Calculation of Energy Consumption for TSS Removal

The energy consumption for TSS removals will be calculated depending on the calculation of the number of kilograms removed from the wastewater enter the WWTP, as mentioned previously the energy consumption was calculated as (kWh/day) in two years (2015,2016).

Amount of kg removed (kg/day) =$\frac{\text{total load (m3/day)}*\text{TSS removal 470 (mg/liter)}}{1000}$............... (7)

The energy consumption for each kilogram removed will be calculated by dividing energy consumption as (kWh/day) as mention in equation (4) over amount of kg removed of TSS (kg/day).

4.6.3 Calculation of Energy Consumption for TN removal

the energy consumption for TSS removals will be calculated depending on the calculation of the number of kilograms removed from the wastewater enter the WWTP, as mentioned previously the energy consumption was calculated as (kWh/day) in two years (2015,2016).

Amount of kg removed (kg/day) =$\frac{\text{total load (m3/day)}*\text{TN removal 50 (mg/liter)}}{1000}$............... (8)

So the energy consumption as (kWh/kg TN) was calculated by dividing the energy consumption as (kWh/day) over amount of kg removed of TN (kg/day).

4.7 Calculation of Energy Consumption for Each Stage

Jericho wastewater treatment plant divided to different stages, each stage contains group of categories, this division was adopted in calculation of energy consumption for the WWTP, and this stage was divided to seven stages as follow:

1- Grit chamber stage contains:

- Mixer for Vacuum
- Pump for vacuum
- Fine Screen
- Grit Collector
- Grit Removal
- Floor Drain
- Grit Separator
- Oil Discharge Pump
- Scum Screen
- Screening Conveyor

2- Reactor stage contains:

- Reactor Tank mixer
- Aeration Blower
- Air supply valve

3- Final clarifier stage contains:

- Clarifier
- Return Sludge Pump
- Waste Sludge Pump
- Floor Drain Pump
- Scum Pump

4- Disinfection stage contains:

- Hypochlorite Pump

5- Utility facility stage contains:

- Utility Water Supply Unit
- Defoaming Pump
- Auto strainer

6- Gravity thickener stage contains:

- Thickener

– Thickened Sludge Pump

7- Garden facility stage contains:

– Circular Pump

By using EXCEL program, it was prepared a separated table for seven stages by accumulations of categories tables which join the same stage. All calculation tables in annex ($\overline{\text{II}}$)

4.8 Calculation of Energy Consumption for the Whole Plant

After calculation for different stages in WWTP, the different stages were collected together as a whole plant for three years 2015, 2016, the target year 2020, and the ultimate year 2025. The steps of calculation for different year were different in some parts due to different input data; the procedure for these years was as follows:

4.8.1 Calculation for the second operation year 2016

The total load of WWTP as (kWh/ m^3) was calculated by dividing the total load of energy consumption (kWh/day) over the total load of influent of WWTP (m^3/day), the total load as (kWh/ m^3) considered the most important indicator of energy consumption in WWTP, due to its direct association with the principle of economy of scale that is clear indicator of energy efficiency in WWTPs.

The data obtained from the WWTP showed that the number of home connections intercepted with the treatment plant is equal to 1250 connections and therefore the number of population served by the WWTP was calculated by multiplying this number by an approximate number of people per connections, at average of five persons per connections (1250*5=6250 capita).

The average consumption as (L/C/D) was calculated in this year:

Average consumption (L/C/D) = $\frac{\text{WWTP load(m3/day)}}{population\ served\ (capita)} \times 1000$………………...…… (9)

For the amount of quality parameters removed as (kg/day) it's the same in stage and categories, but the amount of energy consumption for each kilograms removed equal the total of energy consumption in different stages and categories. Tables show the calculation in 2016 in annex ($\bar{\text{II}}$)
From the data obtained the energy consumption per capitaper day was calculated as follow:
Energy consumption (kWh/capita.day)= energy consumption (kwh/day)/ population served (capita).

4.8.2 Calculation for the first operational year 2015

For the total load of WWTP as (kWh/m^3) the same calculation as 2016. In order to reach the number of served population in the first year of operation, it was depended on the average consumption as (L/C/D) calculated in 2016, because this average consumption considered more accurate than the average consumption in 2015 according to the following equation:

Population in 2015 (capita) = $\frac{total\ load(\mathrm{m3/day})}{average\ consumption(\mathrm{L/C/D})\mathrm{in\ 2016}} \times 1000$……………… (10)

For the amount of quality parameters removed as (kg/day) it's the same in stage and categories, but the amount of energy consumption for each kilograms removed equal the total of energy consumption in different stages and categories. Table show the calculation in 2016in annex ($\bar{\text{II}}$)

4.8.3 Calculation for the target year 2020

The population served in 2020 expected to be 36000 capita according to data taken from the WWTP, the average consumption (L/C/D) was taken the same as in 2016, so the total load of influent of WWTP as (m^3/day) was calculated as follow:

Total load (m^3/day) = $\frac{\mathrm{average\ consumption\ (L/C/D)\times population(capita)}}{1000}$…………………… (11)

To calculate the energy consumption as (kWh/day), the energy equation was used

$$\mathbf{E}=\frac{\boldsymbol{\rho}\times\boldsymbol{g}\times\boldsymbol{h}\times\boldsymbol{Q}}{\boldsymbol{\mu}}$$

E = energy (kW)

ρ = density (kg/m^3) (~ 1000 kg/m^3 for water)

q = wastewater flow (m^3/day)

g = acceleration of gravity (9.81 m/s^2)

h = falling height, head (m)

The values ofρ, g ,h will be constant over years, while μ will be different it will decrease by years

If the values of $\frac{\boldsymbol{\rho}\times\boldsymbol{g}\times\boldsymbol{h}}{\boldsymbol{\mu}}$supposed to be constant **A**

$Energy_{2016}$= A×Q_{2016}

$A= \frac{\text{Energy2016}}{\text{Q2016}}$

The constant A was calculated for twelve month in 2016, so to calculate energy in 2020 taking in to consideration that the efficiency is supposed to be 80%

$Energy_{2020}$ (kwh/day) = A×Q×0.80

Total load (kwh/m^3) = $\frac{\text{total load (kwh/day)}}{\mathit{influentload}(\text{m3/day})}$

Table show the calculation in 2020 in Annex ($\bar{\text{I}}\bar{\text{I}}$)

4.8.4 Calculation for the ultimate year 2025

The calculation procedure for 2025 is the same as 2020 but the difference that the expected served population in this year will be 64,000 capita. The Table in Annex ($\bar{\text{I}}\bar{\text{I}}$) shows the calculations in 2025.

Chapter Five: Results and Discussion

5.1 Introduction

In this chapter the data collected and results obtained will be presented and discussed with emphasis on the energy consumption in Jericho WWTP and how to optimize the energy consumption in the different treatment stages.

5.2 Average Water Consumption in Jericho City

Average water consumption for Jericho city calculated depending on daily influent of WWTP and the population of Jericho city it was around (80 L/C/D). This number is considered to be little compared with the actual average water consumption in Jericho city, where it is the highest consumed area in west bank it reaches (205 L/C/D), this is due to the nature of the individual's life in the Jericho city where a large part of the water consumed goes to non-domestic uses such as garden irrigation, car washing, water pools and others. Therefore, the amount of wastewater discharged from houses to the WWTP is relatively low compared to the actual average water consumption in Jericho city.

5.3 Energy Consumption in Different Years as (kWh/m^3)

The wastewater treatment plant was officially operated by Jericho municipality in June 2014. The first step of the project was the assessment of the daily operation program, flow rate, quality of the influent and effluent of the treatment plant, the number of operation hours, consumption rate for every categories in WWTP, Population Served, for two years (2015, 2016), and calculated these data for design year 2020, taking in to consideration efficiency that decrease every year. The energy consumption was calculated for the WWTP for two years (2015, 2016) and for design year 2020 as (kWh/m^3) during twelve months as shown in Table (5.1)

Table (5.1): Energy consumption in WWTP

Energy consumption (KWh/ m^3)			
Year / Month	2015	2016	2020
Jan	3.2	1.4	1.1
Feb	3.3	1.7	1.4
Mar	3.3	1.7	1.3
Apr	3.8	1.3	1.1
May	3.2	1.5	1.2
June	2.3	1.6	1.3
July	3.6	1.7	1.3
Aug	2.3	1.5	1.2
Sep	2.1	1.3	1.0
OCT	1.5	1.2	1.0
Nov	1.8	1.1	0.8
Dec	1.6	1.1	0.9

From the results shown in the above table it was noticed that the energy consumption decreased with years, this is due to the increase of the number of population served by WWTP, thus growing in the influent of the WWTP, and therefore the energy consumed is divided by a larger quantity of flow rate.

And this is confirmed with the concept of (economies of scale) that says the cost advantage that arises with increased output of a product. Economies of scale arise because of the inverse relationship between the quantity produced and per-unit fixed costs; the greater the quantity of a good produced, the lower the per-unit fixed cost because these costs are spread out over a larger number of goods. Economies of scale may also reduce variable costs per unit because of operational efficiencies.

So when the flow rate increases, the lower per cubic meter of wastewater fixed cost because these costs (energy consumption) are spread out over a large number of cubic meters of wastewater.

Figure (5.1) explains how increasing the amount of flow has a significant impact on the average consumption (kWh/m^3) per different years.

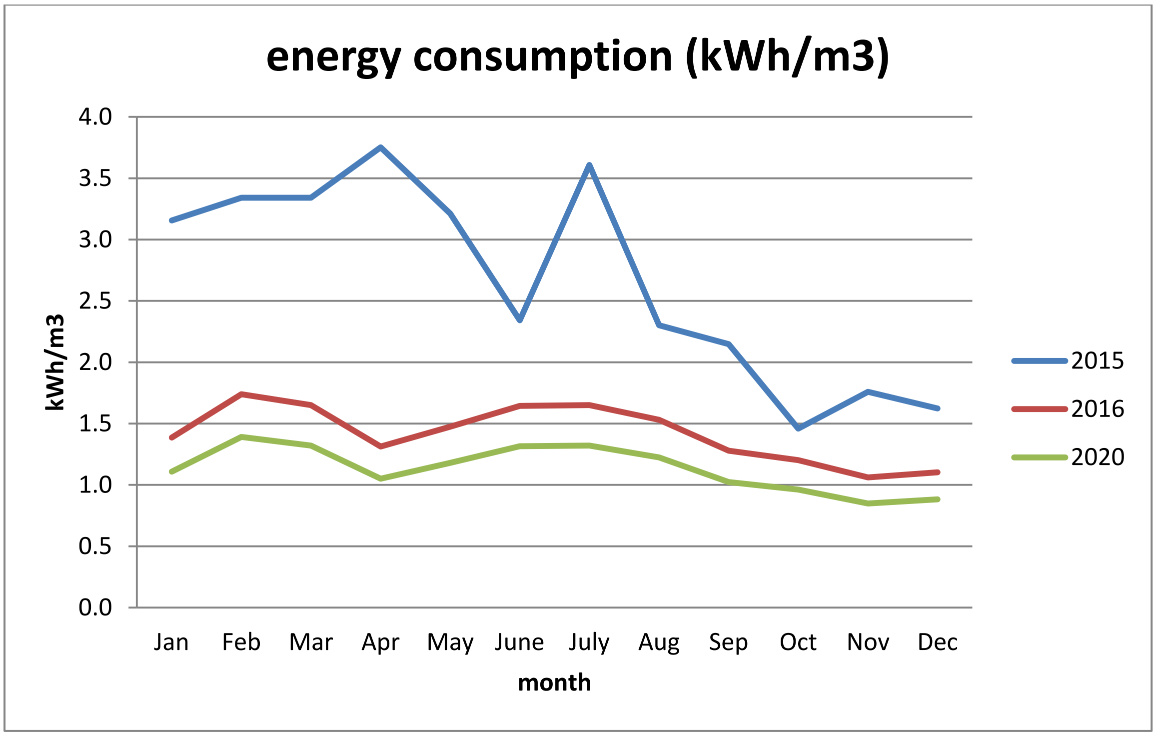

Figure (5.1): Average consumption (kWh/m^3) in different years

When comparing the energy consumption between the Jericho WWTP and other plants in different countries, it is clear that consumption in Jericho WWTP is very high, while in USA it reaches 0.52 (kWh/m^3), in Asian country like China, Korea and Japan they consumed 0.31 (kWh/m^3), the consumption in European country reaches to 0.42 (kWh/m^3), which means that the Jericho WWTP works inefficiently (Yifan, et al., 2017).

5.4 Energy Consumption in Different Years as (kWh/day)

When the average daily energy consumption (kWh/day) is compared between 2015 and 2016, we notice that the average consumption increased from 618 kwh/day in 2015 to 673 kwh/day in 2016 because the WWTP wasn't working with full capacity which reaches to 6,600 m^3/day, so the WWTP working inefficiently in first two years. Table (5.2) shows the average daily consumption in different years.

Table (5.2): Average daily energy consumption (kWh/day)

year / month	2015	2016	2020	2025
Jan	618	673	3102	4879
Feb	813	756	3485	5482
Mar	948	796	3670	5772
Apr	636	771	3553	5588
May	624	758	3494	5496
Jun	557	689	3176	4996
Jul	603	676	3114	4898
Aug	540	636	2929	4606
Sep	488	638	2938	4621
Oct	534	649	2991	4704
Nov	541	629	2898	4558
Dec	660	580	2671	4202

However when the amount of energy consumed for the year 2020, which is target year was calculated, it was found that the energy consumption increased significantly for two reasons; the first one increasing in the amount of influent of WWTP, the second one is the efficiency factor which decreases over time. In the project the efficiency was assumed at the beginning work year 85% and decreasing by 5% every five years.

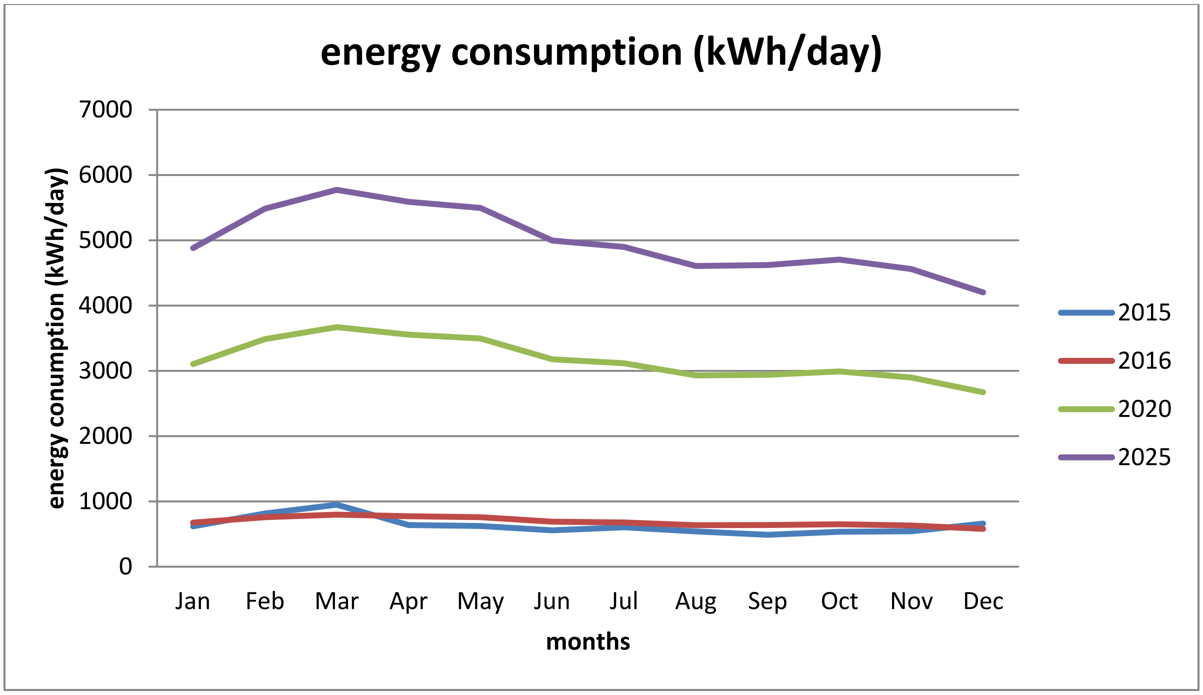

Figure (5.2): Energy consumption (kWh/day)

The energy consumption in the ultimate year 2025 which are expected to serve 60,400 capita and have an influent reaches to 6,600 m^3/day, significantly increased 35% over the target year 2020 due to increasing influent and decreasing efficiency to 75%.Figure (5.2) shows how energy consumption (kWh/day) increased when the influent increase.

5.5 Energy Consumption in Different Years as (kWh/year)

The energy consumption as (kWh/year) was calculated for two years 2015, 2016, and even calculated for the target year 2020 and the ultimate year 2025, and the results were as shown in the table (5.3).

Table (5.3): Energy consumption (kWh/year).

Year	2015	2016	2020	2025
Energy consumption (kWh)	229,761	250,821	1,159,111	1,823,186

It is obvious from the table above that the energy consumption increased by years, this is due to increase of the population served and therefore increased in the influent of the WWTP.

Figure (5.3) shows that the consumption in 2015 and 2016 convergent due to the approximate quantity of influent in this two years, but there is a great jump in the energy consumption between 2016 and 2020 because 2020 considered as a target year of WWTP, then in 2025 it was seen an increasing in energy consumption due to increasing of the population served by WWTP, knowing that 2025 is the ultimate year of the WWTP.

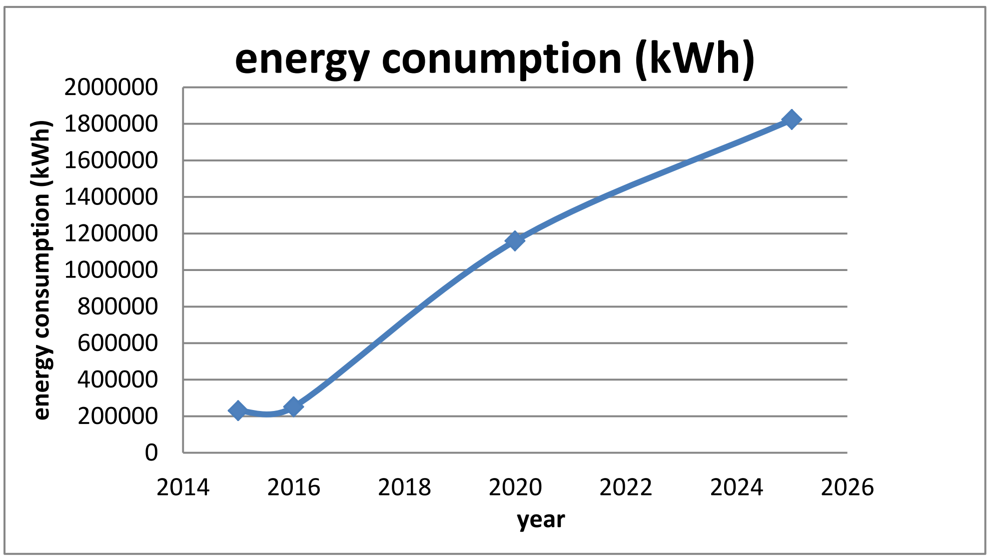

Figure (5.3): Energy consumption (kWh/year)

5.6 Energy Consumption in Different Stages in WWTP

The WWTP divided to seven stages; grit chamber, reactor, final clarifier, disinfection, utility facility, gravity thickener, garden facility. The energy consumption in each stage was calculated for years (2015, 2016), 2020 target year.

Table (5.4) shows the energy consumption (kWh/day) in every stage in year 2016, it is clear that the reactor stage which contain aeration blower is the most energy consuming stage according to the energy consumption value and literature.

Table (5.4): Energy consumption in different stages of WWTP (kWh/day)

Year	Month	different stages						
		Grit Chamber	Reactor	Final Clarifier	Disinfection	Utility Facility	Gravity Thickener	Garden Facility
2016	Jan	78.4	393.2	96.0	0.2	100.5	3.0	1.9
	Feb	84.1	467.2	91.5	0.2	110.5	2.8	0.1
	Mar	75.5	512.9	97.1	0.2	101.2	7.4	2.1
	Apr	73.1	513.1	79.2	0.2	101.1	3.2	1.1
	May	72.9	491.6	79.0	0.2	110.9	3.3	0.3
	Jun	83.4	487.2	71.5	0.2	45.1	1.9	0.0
	Jul	69.6	487.2	80.9	0.2	35.5	2.2	0.3
	Aug	59.6	459.5	58.4	0.2	57.5	0.0	0.3
	Sep	57.4	440.2	72.0	0.3	65.8	1.4	0.4
	Oct	64.4	460.2	76.1	2.6	43.5	1.7	0.4
	Nov	68.8	426.3	72.3	2.8	55.1	2.1	1.5
	Dec	59.9	435.7	65.0	2.6	14.8	0.9	0.9

Based on the above value the average energy consumption for the reactor stage equal 465kWh/day, while it is equal 78 kWh/day in final clarifier, and equal one kWh/day in disinfection and garden facility. Figures (5. 4), (5. 5) explain the difference of energy consuming in different stages and illustrates the largest energy consumer in treatment stages.

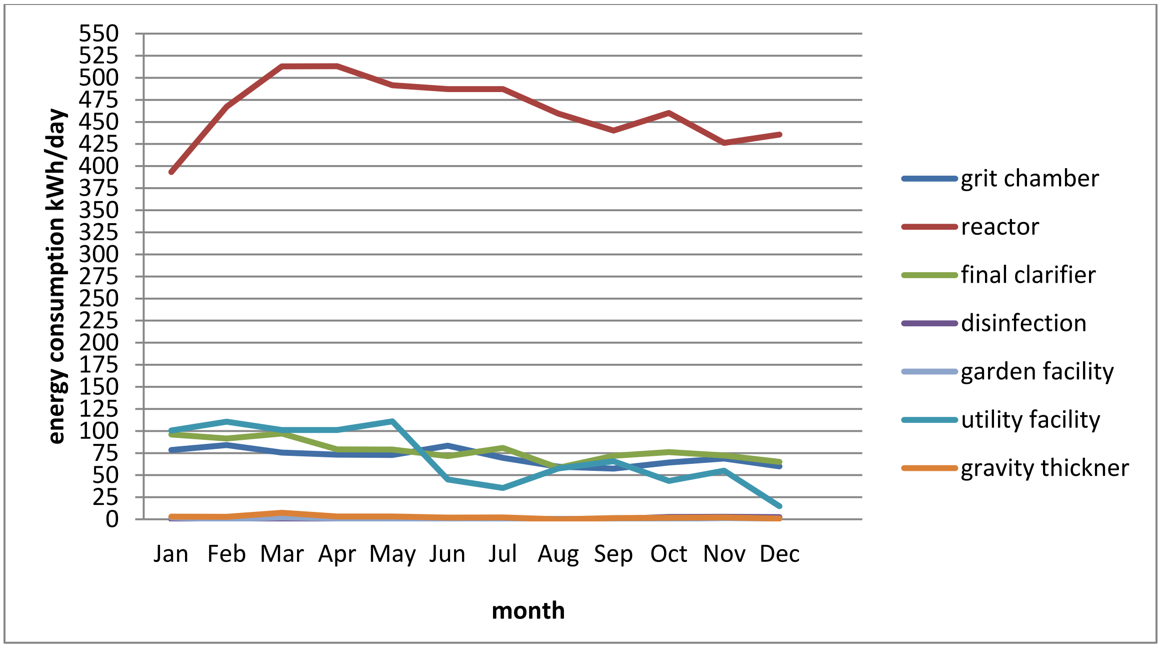

Figure (5. 4): Energy consumption in different stages

From Figure (5. 5) the reactor represents 68% of the total consumption, while the other stages represent together 32%. In WWTP there is four aeration blowers, only two of them work all the time, while the other two are rarely turned on.

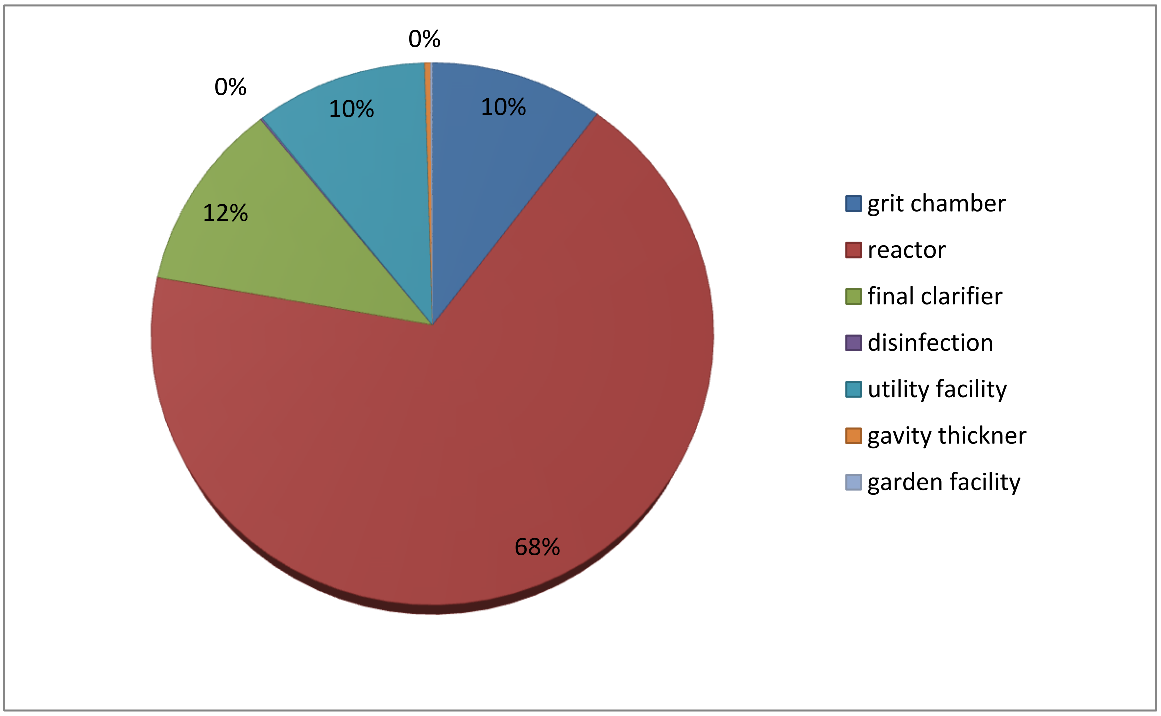

Figure (5. 5): Percentages of energy consumption in treatment stages

It is clearly that the energy consumption increases from 2015 to 2016 in total due to increases of the influent of the WWTP. For example the energy consumption in reactor increases by 23%.

Table (5.5): Energy consumption in different stages of WWTP in two years 2015, 2016 (kWh/day)

energy consumption in different stages (kWh/day)							
Year \ Stage	Grit chamber	Reactor	Final clarifier	Disinfection	Utility facility	Gravity thickener	Garden facility
2015	52	354	114	0	104	2	3
2016	71	465	78	1	70	2	1

5.7 Energy Consumption in Different Categories in WWTP

Jericho WWTP divided to seven stages according to the design, and every stage consist different categories. The following chart explains these details:

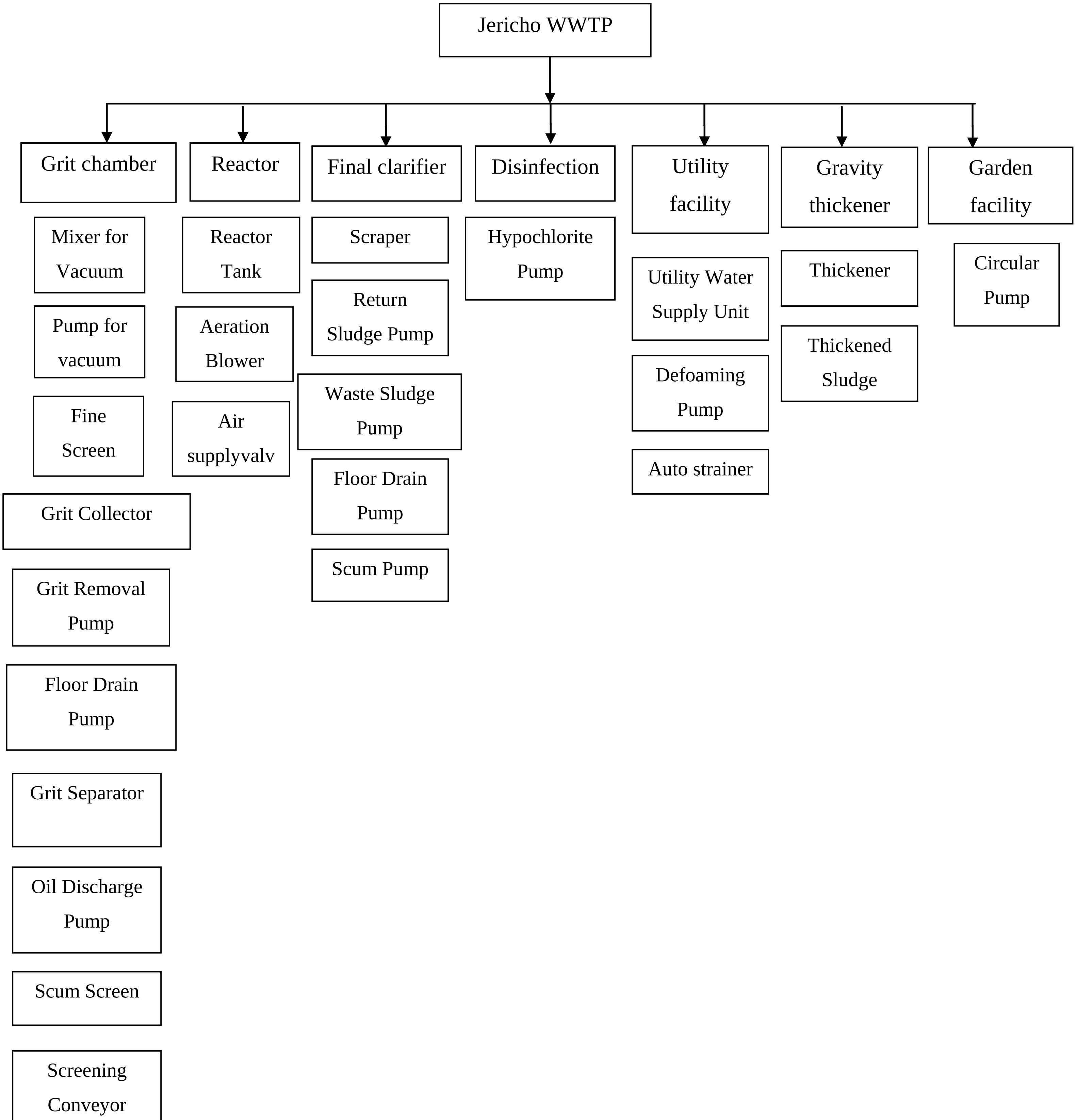

Figure (5.6): flowchart for Jericho wastewater treatment plant

5. 7.1 Energy consumption in different categories in grit chamber stage

Grit chamber stage contain number of categories (Mixer for Vacuum, Wastewater pump for vacuum, Fine Screen, Grit Collector, Grit Removal Pump, Floor Drain Pump, Grit Separator, Oil Discharge Pump, Scum Screen, Screening Conveyor) the energy consumption for all these categories was calculated .

1-Mixer for vacuum

Mixer of vacuum one of the categories of grit chamber, the energy consumption of it was calculated for two years 2015and it was 6 kWh/day and in 2016 it was 9 kWh/day. From these results it is notice that the consumption increase due to increases of the influent of the WWTP from 196 m^3/day in 2015 to 486 m^3/day in 2016.

2-Wastewater pump for vacuum

The energy consumption of wastewater pump of vacuum in 2015 was 2 kWh/day while in 2016 increases to 6 kWh/day; in other words, consumption increased by twice from 2015 to 2016, and this is a results of population served by WWTP.

3-Fine screen

It was noticed that the energy consumption by fine screen decreased, where it was in 2015 9 kWh/daywhile in 2016 it was 5 kWh/day, according to the data taken from the WWTP the total hours that the fine screen operated in 2015 higher than the total hours operated in 2016 and this is explain why the consumption decreased in 2016.

4- Grit collector

Grit collector considered as the most consumed category in grit chamber stage, the consumption in 2015 was 20 kWh/day and increased to 33kWh/day in 2016. The energy consumption expected to increases when the influentof WWTP increases.

5- Grit removal pump

The energy consumption of grit removal pump around 5kwh/day in 2015 and grow to 9kWh/day in 2016 due to increasing of influent that the WWTP received.

6- Floor drain pump

There are two floor drain pumps in Jericho WWTP, and it was noticed that the energy consumption decreases when the flow of wastewater increases, in 2015 the consumption around 1kWh/day, while in 2016 it was 0.24kWh/day, this is due to reducing of operation hours of it, this is due to the organization of plant hours and the possibility of controlling quantities of wastewater entering the plant.

7- Grit separator

The energy consumption of grit separator in 2015 was 1.8kWh/day, where it reaches 3.5kwh/day in 2016. This growing due to increases of operation hours of it

8- Oil discharge pump

There are two pumps for oil discharge in WWTP, the energy consumption of it in 2015 was 2.2kWh/dayand in 2016 was0.83kWh/day,this is significantly reduced in consumption due to organization of operation hours of WWTP.

9-Scum screen

The energy consumption of scum screen decreases from 1.3kWh/day in 2015 to 0.5kWh/day in 2016, and this is ahuge reduction because organizing and thereby reduce working hours of it.

10-Screening conveyor

When we see the energy consumption of screening conveyor it is obvious that the energy does not change in two years of operation, where it was 5kWh/day in 2015 and 6kWh/day in 2016.

5.7.2 Energy Consumption of Grit ChamberStage

The energy consumption of grit chamber stage calculated in detail as described previously, it is found that in this stage the most energy consumer was grit collector with percentage 46%, while the floor drain pump had the lowest percentage of energy consumer around 0%, the other categories appeared with different percentage as shown in Figure (5.7).

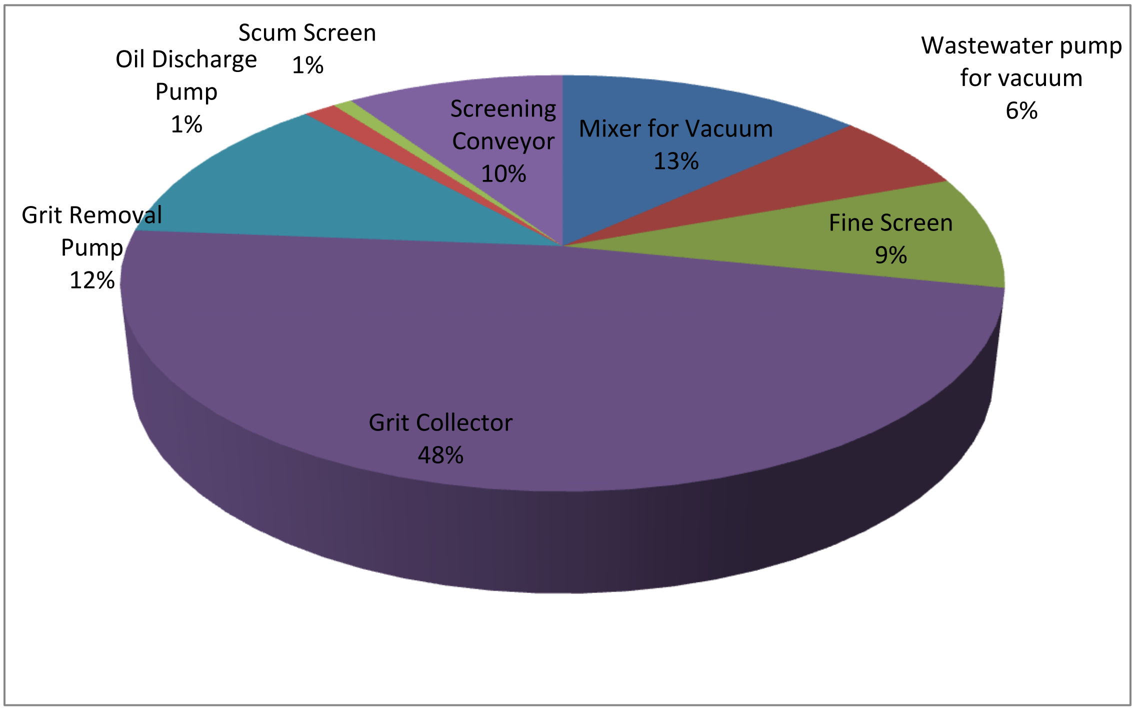

Figure (5.7): Percentage of energy consumption for each category in grit chamber stage

When the energy consumption compared between 2015and 2016, it is obviously notice that the consumption increased when the population served by WWTP, and therefore the influent, this is due to turn on equipment for longer hours and with full capacity. Figure (5.8) shows the difference between consumption of two years.

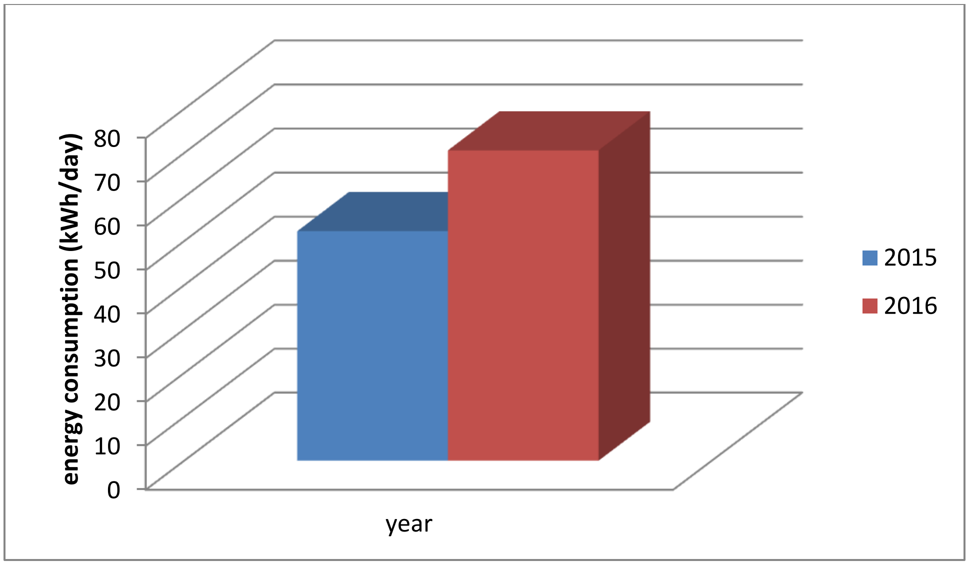

Figure (5.8): Comparison of energy consumption for grit chamber stage in 2015, 2016

5.7.3 Energy consumption in different categories in reactor stage

Reactor stage contains three categories (8 of reactor tank mixer, and 4aeration blower, air supply valve). Air supply valve not accounted as energy consumer.From the previous this stage is the most energy consumer in wastewater treatment processes, the energy consumption for all these categories was calculated.

1- Reactor Tank mixer

Reactor tank mixer considered as a higher category consumed energy in whole WWTP. The energy consumption of it in 2015 was 267kWh/day,while in 2016 it was 232kWh/day**.**

It is supposed to increase in the amount of energy consumption with increasing of the influent, but in this case there is a difference as a result that Jericho WWTP was a new WWTP and the year 2015 considered the first year of operation and the operation program of it worked in an inefficient way, while it difference in 2016 because the WWTP has undergone an effective operating system.

2- Aeration blower

The energy consumption of the aeration blower in 2015 was 87kWh/day, while in 2016 it was 232kWh/day, and there is a huge difference between two years due to a great height of total load (m^3/day) where it was in 2015 around 253 m^3/day, and in 2016 around 492m^3/day, which means that the load as m^3/day almost doubled. Knowing that this category has the largest motor power, this explains their high consumption.

5.7.4 Energy consumption in reactor stage

As shown in previous the reactor stage considered as the most energy consuming stage It is found that in this stage that the reactor tank mixer and the aeration blower had nearly the same values of energy consumption (kWh/day) as shown it Figure (5.9).

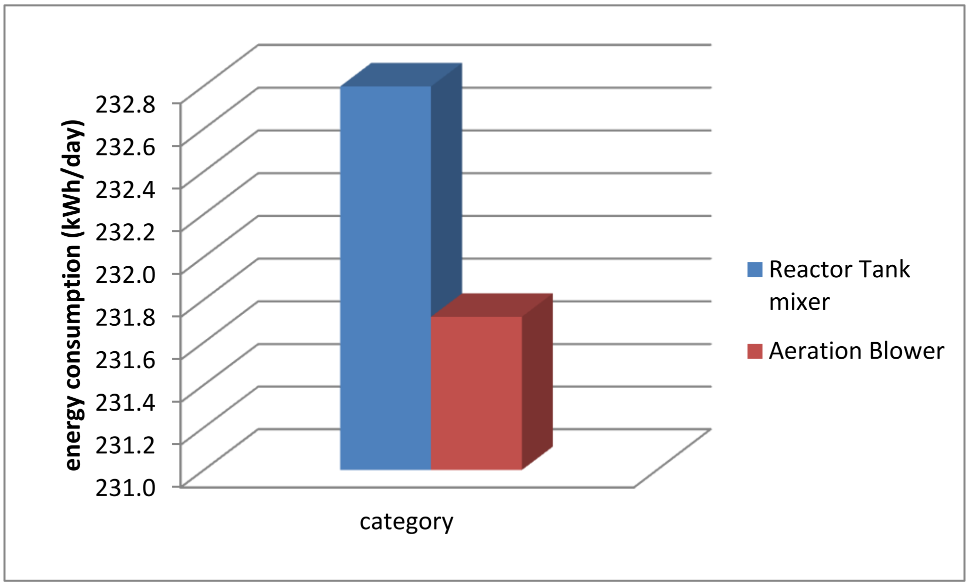

Figure (5.9): Energy consumption in reactor stage

When the energy consumption compared in two years 2015 (the first operation year) and 2016 the second year, taking in consideration that the total load of wastewater entered to the WWTP hugely increased, it has been observed in contrast of expectations that the energy consumption decreased, despite the increasing of total load of wastewater entering the WWTP, but when we take a look at the table of work hours of the WWTP it was noticed that the working hours of this stage decreased in 2016,especially in reactor tank mixer where the average total working hours in 2015 was 1870 hour/month, while it was 1630 hour/month in 2016, this marked decreases due to the organization of the operation of WWTP. Figure (5.10) explains the decrease in energy consumption in two different years.

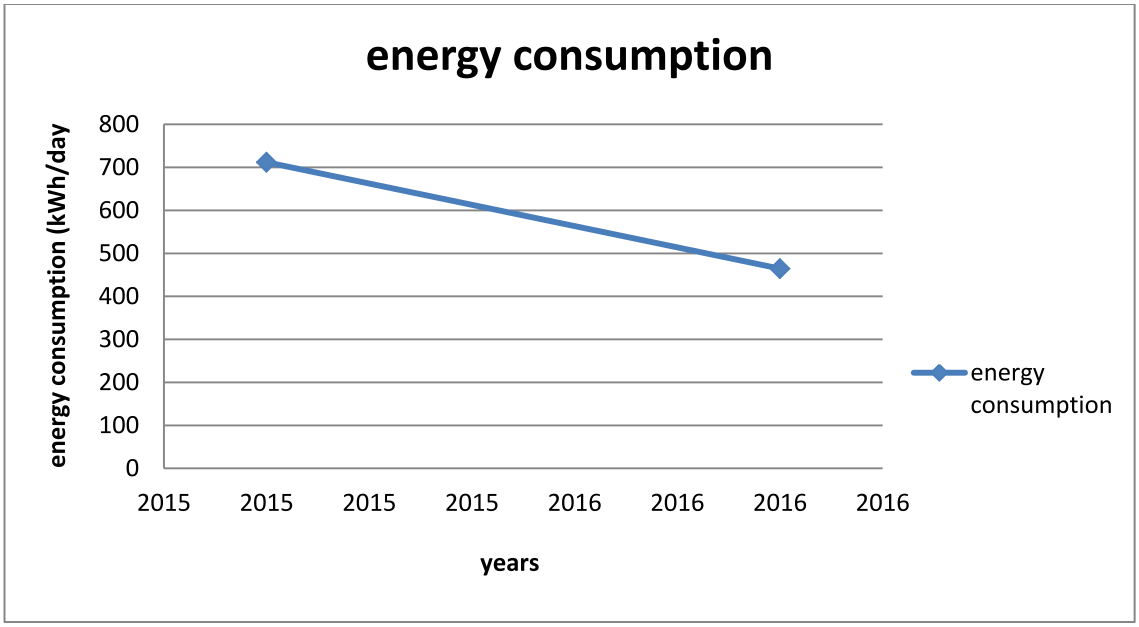

Figure (5.10): Decreases in energy consumption in reactor stagein two different years.

5.7.5 Energy consumption in different categories in final clarifier stage

Final clarifier stage contain number of categories (clarifier, return sludge pump, waste sludge pump, scum pump, floor drain pump) the energy consumption for all these categories was calculated.

1-Scraper

There are two scrapers in WWTP; the energy consumption for scrapers were calculated for twelve months in two years (2015, 2016). In 2015 the consumption was 22kWh/day, while in 2016 it was 21kWh/day, almost no difference between two years.

2- Return sludge pump

The WWTP have four return sludge pumps, the energy consumption for these pumps in 2015 were 85 kWh/day, but in 2016 decreased by almost half it were 45kWh/day, this is due to organization of WWTP operating hours.

3- Waste sludge pump

The WWTP have three waste sludge pumps, the energy consumption in 2015 was 7kWh/day, and in 2016 was 12 kWh/day, this increases due to increases of output of sludge as a result of growth of wastewater entering the WWTP.

4-Scum pump

There are two scum pumps in WWTP, the energy consumption of scum pump almost to be zero kWh/day, while in 2015it was 0.06 kWh/day and in 2016 it was 0.003 kWh/day.

5- Floor drain pump

There are two floor drain pumps in WWTP, the energy consumption in 2015 was 0.01kWh/day and in 2016 was 0.003kWh/day, and their consumption is very low compared to other categories.

5.7.6 Energy consumption in final clarifier stage

It is found that in this stage the most energy consumer was return sludge pump with percentage 58%,scraper 27% and waste sludge pump 15%, while the floor drain pump and scum pump had the lowest percentage of energy consumer nearly 0%, but in general, this stage is not considered to be the most energy intensive stage of the WWTP. Figure (5.11) shows the different percentages of energy consumption in this stage.

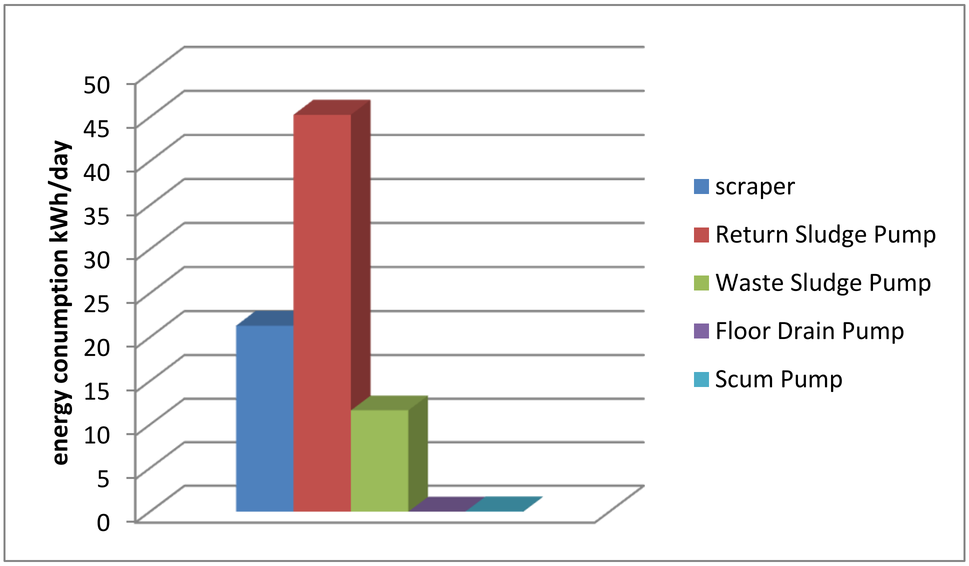

Figure (5.11): Energy consumption in final clarifier stage

5.7.7 Energy consumption in disinfection stage

Disinfection stage contain one category, which is hypochlorite pump, WWTP have three pumps. The energy consumption for this stage in 2015 was 0.15kWh/day, and in 2016 was 0.8 kWh/day. Figure (5.12) explains the energy consumption in two years during twelve months; it is obvious that there is a huge jump in energy consumption in 2016; this is due to increases in operation hours of these months**.**

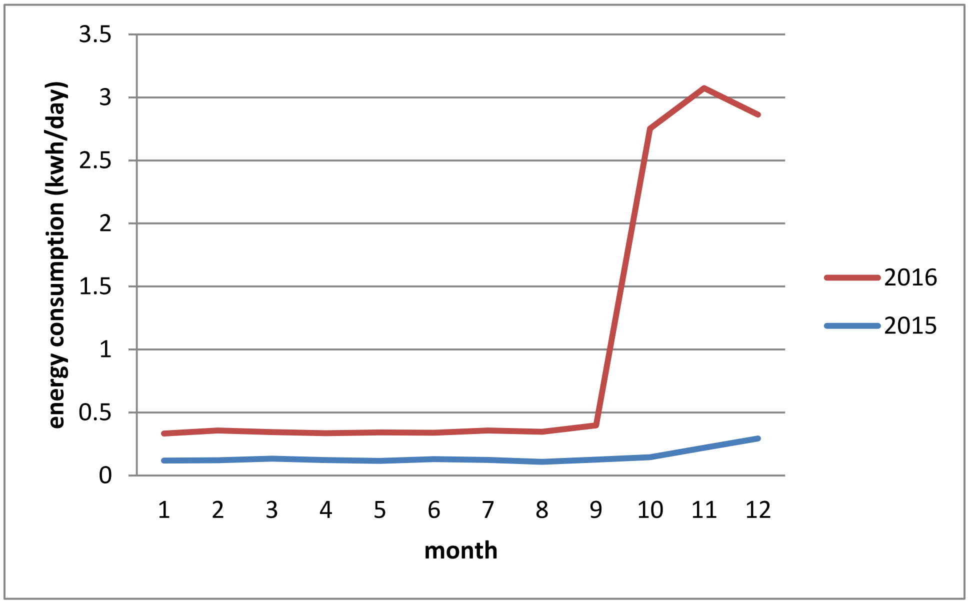

Figure (5.12): Energy consumption in disinfection stage

5.7.8 Energy consumption in different categories in utility facility stage

Utility facility stage contains number of categories (utility water supply unit, defoaming pump, auto strainer) auto strainerdoes not accounted as energy consumer the energy consumption for all categories was calculated, the results as follow.

1- Utility water supply unit

The energy consumption of utility water supply unit in 2015 was 92kwh/day while in 2016 it was reached 62 kWh/day;it is noticeable that there is a decrease in energy consumption due to the reduction of operating hours of this category.

2- Defoaming pump

There are two defoaming pumps in WWTP, the energy consumption of it in 2015 was 12kWh/day and in 2016 it was 8kWh/day, there is a decrease in energy consumption between 2015, 2016 due to decreases in operation hours of these pumps.

5.7.9 Energy consumption in utility facility stage

It is found that in this stage the largest energy consumer was utility water supply unit with average 62kWh/day, defoaming pump 9kWh/day, while the auto strainer had not any energy consumption. Figure (5.13) explain the energy consumption in different categories of utility facility stage.

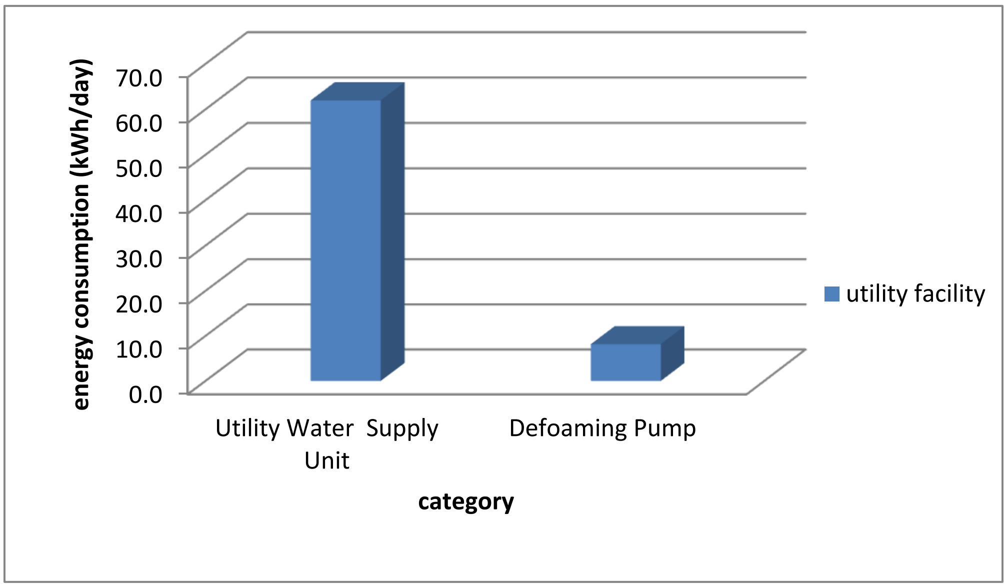

Figure (5.13): Energy consumption in utility facility stage

When looking at energy consumption on the level of whole stage in different years it was found that the energy consumption decrease from 10,462kWh/day in 2015 to 7,062kWh/day in 2016, this indicates that the plant has begun to operate effectively, despite the increase in wastewater load, but consumption is decreasing due to effective hours operational program. Figure (5.14) explains the decrease in energy consumption between 2015, 2016.

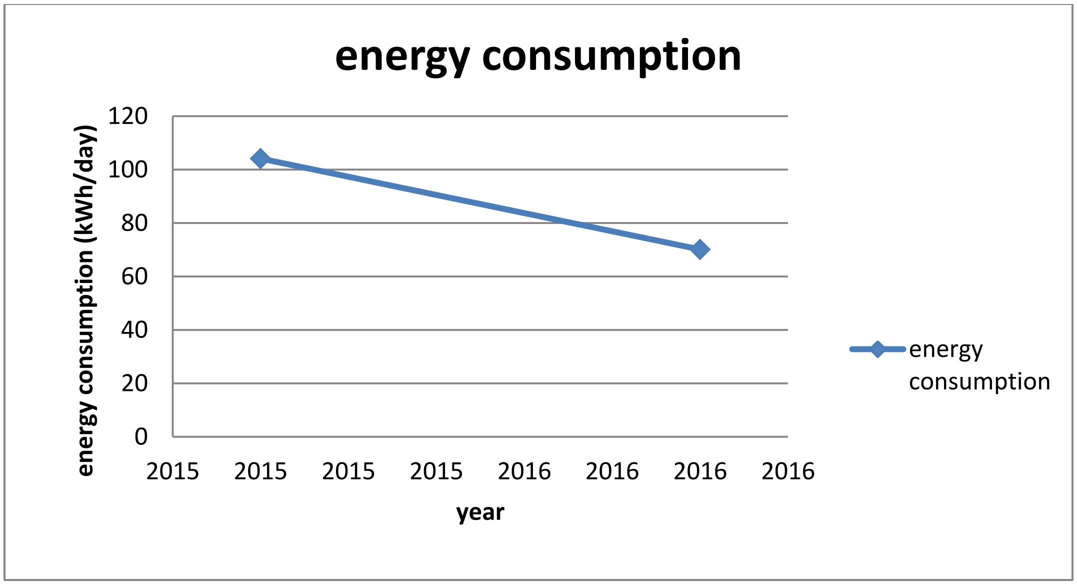

Figure (5.14): Energy consumption in Utility facility stage in different years

5.7.10 Energy consumption in different categories in gravity thickener stage

Gravity thickener stage contains two categories (thickener, thickened sludge pump) the energy consumption for the two categories was calculated as follow.

1-Thickener

There are two thickeners in WWTP. The energy consumption in thickener in 2015 was two kWh/day, and in 2016 was1.5 kWh/day, there is a slight decrease in energy consumption between 2015 and 2016. In general it is considered a little energy consumption category.

2- Thickened sludge pump

The WWTP have three thickened sludge pump, the energy consumption in 2015 was0.5 kWh/day, and in 2016 was one kWh/day, it is noticeable that there is an increase in consumption by increasing the amount of wastewater entering the WWTP.

5.7.11 Energy consumption in gravity thickener stage

It is found that in this stage the most energy consumer was thickener with percentage 62% and average energy consumption1.53kWh/day which is very low consuming, thickened sludge pump 38%and average energy consumption0.96kwh/day, this is shown in Figure (5.15).

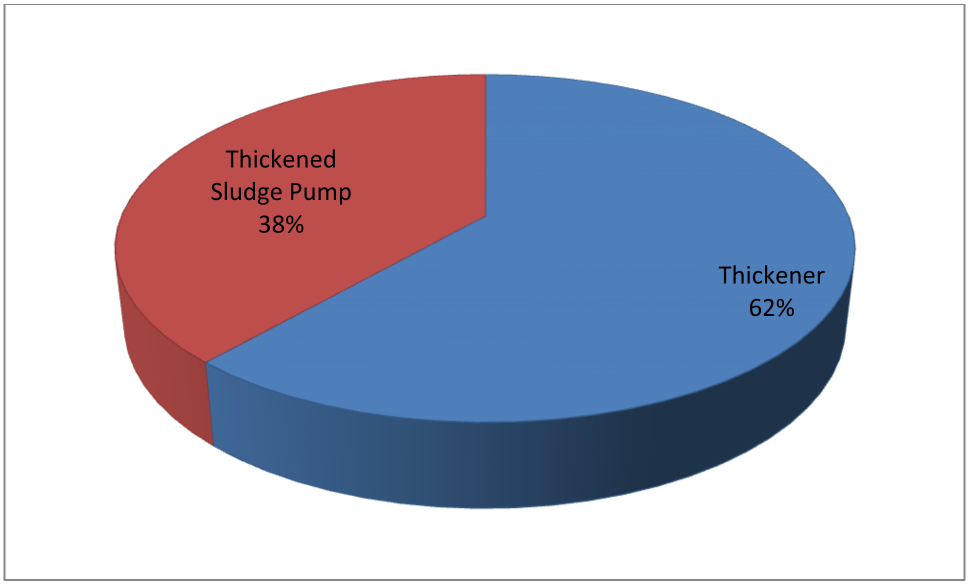

Figure (5.15): Energy consumption in Gravity thickener stage

5.7.12 Energy consumption in garden facility stage

It is the last stage in WWTP, this stage contains two circular pumps, the energy consumption in 2015 was 3 kWh/day and in 2016 was 0.7kWh/day, and it is obvious that there is a huge decreasing in energy consumption between two years due to effective hour's operational program.

5.7.13 Energy consumption for lighting and ventilation

The amount of energy consumed on this part is estimated around 10% of the total consumption of the plant. This is a relatively high percentage because the wastewater treatment plant in the city of Jericho is located in a very hot area; each unit of pumps and control rooms is equipped with ventilation units. Ventilation units and air conditioners therefore have a significant role in being a major energy consumer.

5.8 Wastewater quality in Jericho WWTP

The quality of the effluent that the Jericho WWTP designed for was very high in comparison with the current standards in Palestine, taking into consideration that this treated water is currently used for agricultural purposes. Table (5.6) displays the quality of the influent and effluent in Jericho WWTP:

Table (5.6): Wastewater quality in wastewater treatment plant

Wastewater quality	Influent	effluent	removal
BOD (mg\l)	500	20	480
TSS (mg\l)	500	30	470
TN (mg\l)	75	25	50

It is known that the greater the removal of wastewater, the greater the amount of energy consumed to treat this wastewater, in this research the energy consumption for each quality was calculated for different years in all stages and categories.

5.9 Comparisons of Energy Consumption for Different Wastewater Quality

After calculation of energy consumption for every Kg of water quality these results are obtained:

Table (5.7): energy consumption per wastewater quality

Wastewater quality / year	BOD removal (kg/day)	total load (KWh/kgBOD)	TSS removal (kg/day)	total load (KWh/kgTSS)	TN removal (kg/day)	total load (KWh/kgTN)
2015	121	6	118	6	13	55
2016	236	3	231	3	25	28
2020	1361	1	1332	1	142	23

The most energy consumption between the three water qualities is total Nitrogen (TN); it consumed energy18 times more than the other wastewater quality for one kilogram.

It is obvious from the previous Table (5.7) that the energy consumption decrease by the years, this explains by concept of economies of scale, as the number of serviced population increases over time, thus increasing in the amount of treated water, which reduces the cost per cubic meter. Figure (5.16) explain that the total Nitrogen is the most consuming energy in comparison with the other wastewater quality.

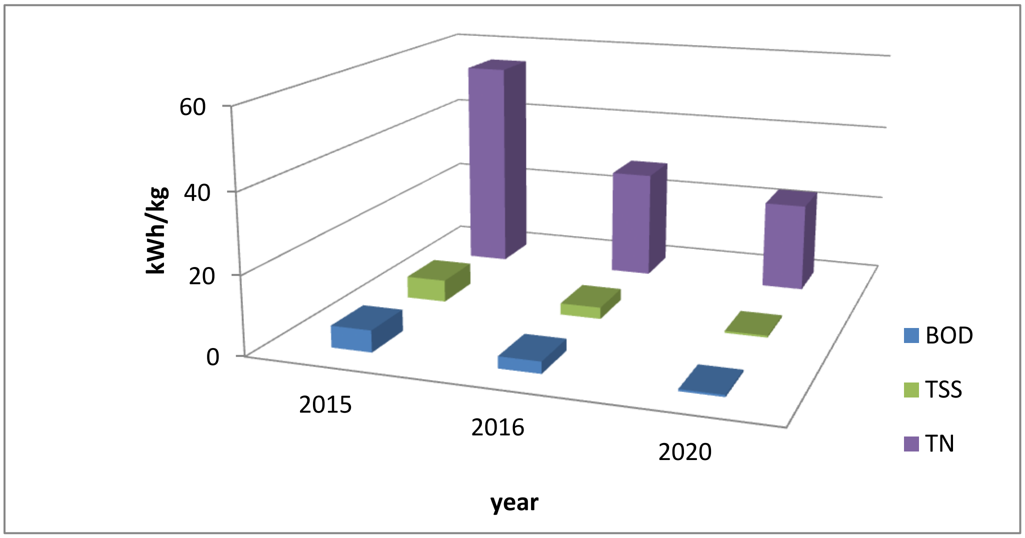

Figure (5.16): Wastewater quality in different years

5.10 Energy Consumption vs. BOD Removal

5.10.1 Energy consumption vs. BOD removal in different years

The energy consumption vs. BOD removal was calculated as (kWh/kgBOD) in different years, when the amount of kilograms of BOD enters to the WWTP was calculated, it was found that there is a huge increases of it due to increases of the influent of the WWTP, in 2015 it was 121 kg/day, and in 2016 it was 236kg/day which means it was doubled. However if we looked at quantity in 2020 according to the calculation it reached 1361 kg/day, because in this year the WWTP will work with full capacity with daily average flow 6,600 m^3/day.

When the energy consumption calculated for each kilogram of BOD it was found to be less than one year to another, with an increase in the amount of influent of WWTP. This is normal because it follows a rule of economies of scale, the greater the quantity of kilograms enters to the

WWTP, the lower the per-unit fixed cost because these costs are spread out over a larger number of kilograms, where the energy consumption in 2015 was 6 kWh/kgBOD, and in 2016 was 3kWh/kgBOD, while in 2020 it will be 1kWh/kgBOD. Figure (5.17) explain the huge decrease in energy consumption by years.

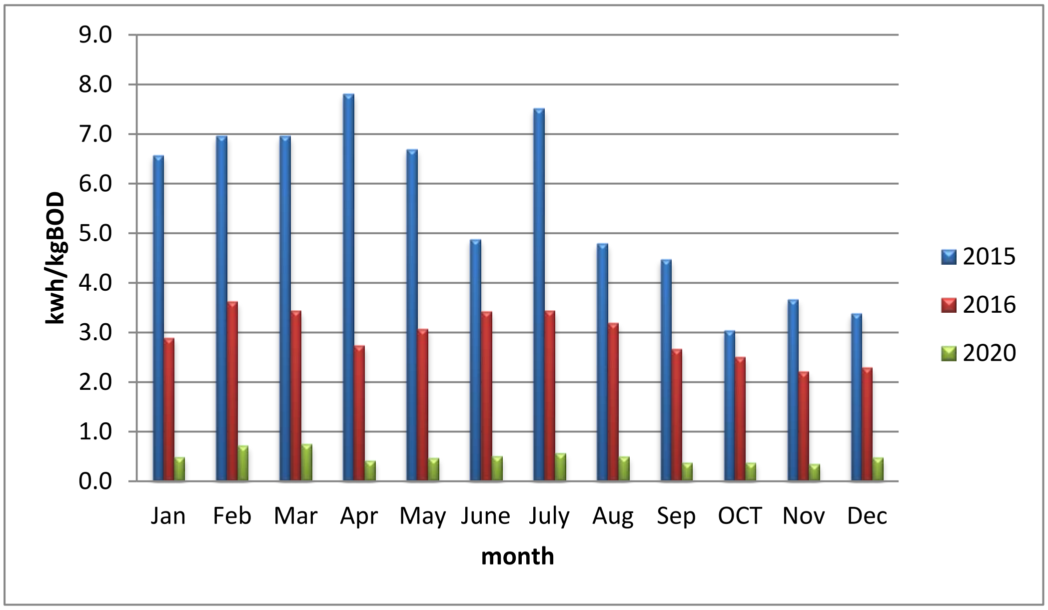

Figure (5.17): Energy consumption as (kWh/kgBOD) in different years

5.10.2 Energy Consumption vs. BOD Removal in Different Stages

The energy consumption in WWTP in different stages vs. BOD removal was calculated as follow:

1- Grit chamber

The energy consumption in grit chamber stage was 0.3 (kWh/kgBOD), this is considered as a little energy consumption, but when we take a look at categories in this stage the most category consuming energy as (kWh/kgBOD) was grit collector with energy consumption 0.14 (kWh/kgBOD).

2- Reactor

The energy consumption of reactor was 2 (kWh/kgBOD) considered as a huge energy consumption, the most category consuming energy in this stage was aeration blower with 1.03 (kWh/kgBOD).

3- Final clarifier

The energy consumption of final clarifier was 0.3 (kWh/kgBOD) considered as a little energy consumption, the most category consuming energy in this stage was return sludge pump with 0.2 (kWh/kgBOD).

4- Disinfection

The energy consumption in this stage almost zeros (kWh/kg BOD), so it was neglected.

5- Utility facility

In utility facility the energy consumption was 0.3 (kWh/kgBOD), but the most energy consuming categories was utility watersupply unitwith energy consumption 0.28(kWh/kgBOD).

6- Gravity thickener

The energy consumption in this stage is neglected,it is approaching zero value.

7- Garden facility

The energy consumption in garden facility was 0.003 (kWh/kgBOD).

When comparing the consumption of different stages in the WWTPas (kWh/kgBOD), it was found that reactor stage has the greatest effect on consumption as Figure (5.18) shows.

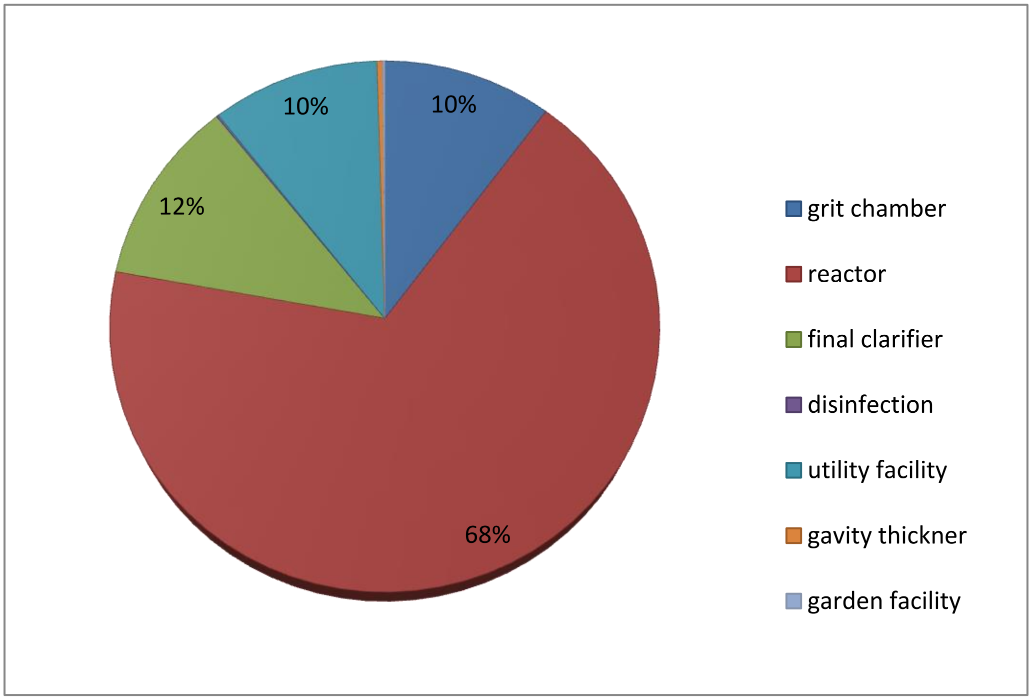

Figure (5.18): Energy consumption as (kWh/kgBOD) in different stages.

5.11 Energy Consumption vs. TSS Removal

5.11.1 Energy Consumption vs. TSS Removal in Different Years

The energy consumption vs. TSS removal was calculated as (kWh/kgTSS) in different years, when the amount of kilograms of TSS enters to the WWTP was calculated, it was found that there is a huge increases of it due to increases of the influent of the WWTP, while in 2015 it was 118 kg/day, while in 2016 it was 231 which means it was doubled,but the calculated quantity in 2020 was 1332 kg/day, because in this year the WWTP will work with full capacity with daily average flow 6,600 m^3/day.

When the energy consumption calculated for each kilogram of TSS it was found to be less than one year to another, with an increase in the amount of influent of WWTP. This is normal because it follows a rule of economies of scale, the greater the quantity of kilograms enters to the WWTP, the lower the per-unit fixed cost because these costs are spread out over a larger number of kilograms, where the energy consumption in 2015 was 6 kWh/kgTSS, and in 2016 was 3kWh/kgTSS, while in 2020 it will be 1kwh/kgTSS. Figure (5.19) explains the huge decrease in energy consumption by years.

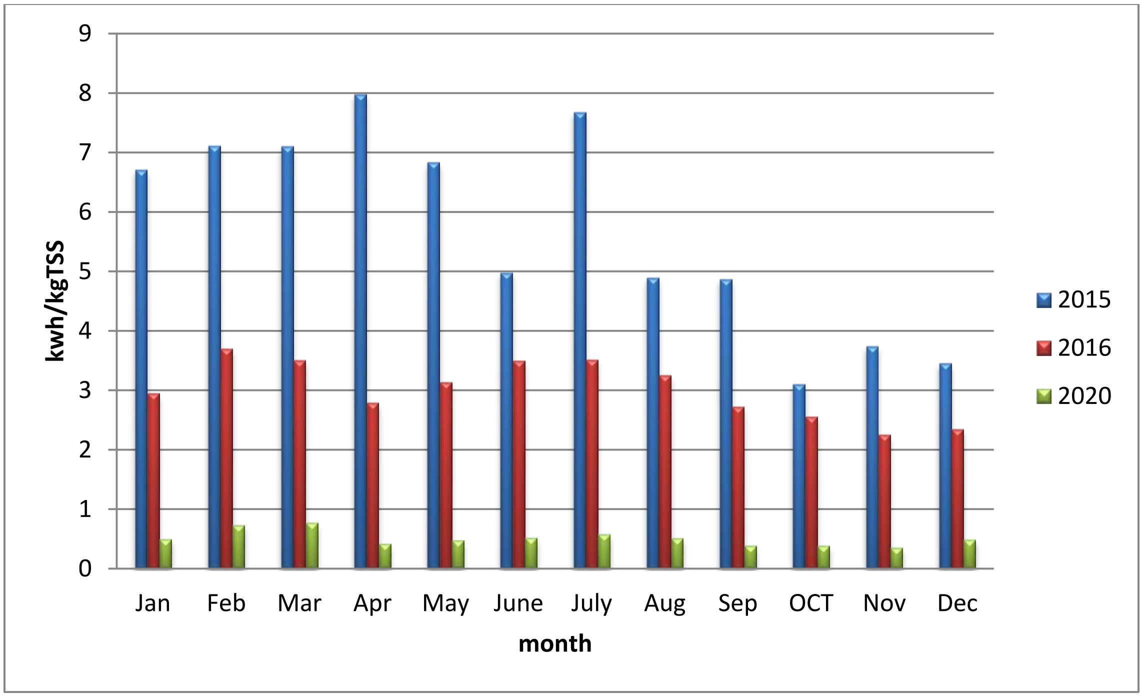

Figure (5.19): Energy consumption as (kWh/kgTSS) in different years

5.11.2 Energy consumption vs. TSS removal in different stages

The energy consumption in WWTP in different stages vs. TSS removal was calculated as follow:

1- Grit chamber

The energy consumption in grit chamber stage was 0.3 kWh/kgTSS, this is considered as a little energy consumption, but when we take a look at categories in this stage the most category consuming energy as (kWh/kgTSS) was grit collector with energy consumption 0.15 kWh/kgTSS

2- Reactor

The energy consumption of reactor was 2 (kWh/kgTSS) considered as a huge energy consumption, the most category consuming energy in this stage was aeration blower with 1.05 (kWh/kgTSS).

3- Final clarifier

The energy consumption of final clarifier was 0.3 (kWh/kgTSS) considered as a little energy consumption, the most category consuming energy in this stage was return sludge pump with 0.2 (kWh/kgTSS).

4- Disinfection

The energy consumption in this stage almost zeros (kWh/kgTSS), so it was neglected.

5- Utility facility

In utility facility the energy consumption was 0.3(kWh/TSS), but the most energy consuming categories was utility watersupply unit with energy consumption 0.3(kWh/kgTSS).

6- Gravity thickener.

The energy consumption in this stage is neglected, it is approaching zero value.

7-Garden facility.

The energy consumption in garden facility was 0.003 (kWh/kgTSS).

5.12 Energy Consumption vs. TN Removal

5.12.1 Energy consumption vs. TN removal in different years

Total Nitrogen considered as the most wastewater quality consuming energy to remove it. The quality of the effluent should not exceed 50 mg/l, the removal 25 mg/l, where there is no need to remove more.

The energy consumption vs. TN removal was calculated as (kWh/kgTN) in different years, when the amount of kilograms of TN enters to the WWTP was calculated, it was found that there is a huge increases of it due to increases of the influent of the WWTP, where in 2015 it was 13 kg/day, while in 2016 it was 25kg/day which means it was doubled,but the quantity in 2020 according to the calculation it reached 142 kg/day, because in this year the WWTP will work with full capacity with daily average flow 6,600 m^3/day.

When the energy consumption calculated for each kilogram of TN it was found to be less than one year to another, with an increase in the amount of influent of WWTP. This is normal because it follows a rule of economies of scale, the greater the quantity of kilograms enters to the WWTP, the lower the per-unit fixed cost because these costs are spread out over a larger number of kilograms, where the energy consumption in 2015 was 55kWh/kgTN, this is consider as a huge amount of energy consuming for every kilogram of TN, and in 2016 was 28kWh/kgTN, while in 2020 it will be 23kWh/kgTN. Figure (5.20) explain the huge decrease in energy consumption by years.

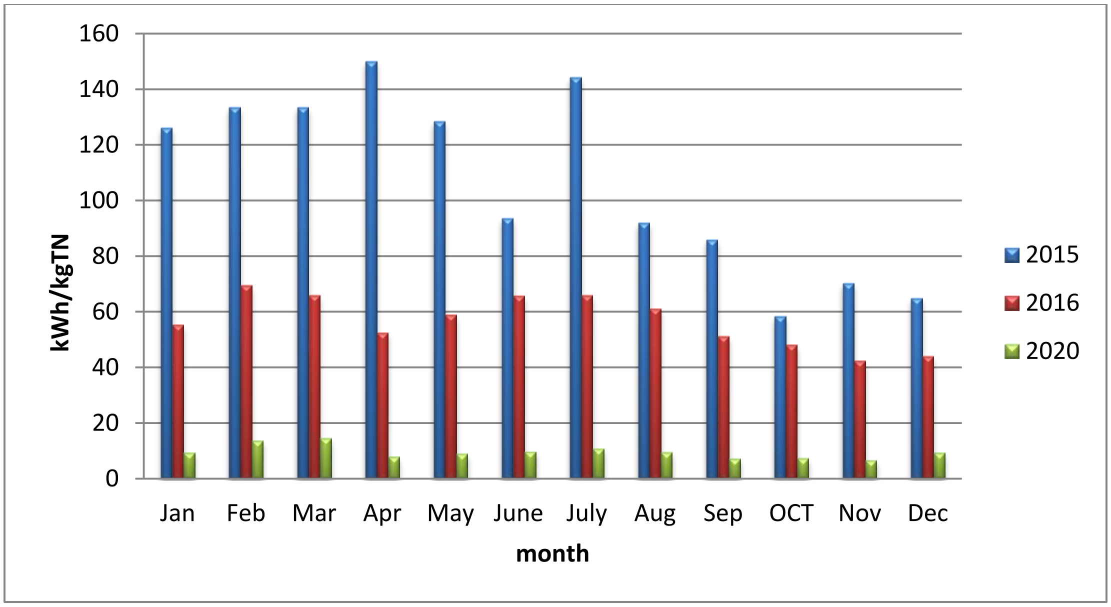

Figure (5.20): Energy consumption as (kWh/kgTN) in different years

5.12.2 Energy consumption vs. TN removal in different stages

The energy consumption in WWTP in different stages vs. TN removal was calculated as follow:

1- Grit chamber

The energy consumption in grit chamber stage was 3 kWh/kg TN, this is considered as large energy consumption, but when we take a look at categories in this stage the most category consuming energy as (kWh/kg TN) was grit collector with energy consumption 1.4 kWh/kg TN.

2- Reactor

The energy consumption of reactor was 19 (kWh/kg TN) considered as the most energy consumer, the most category consuming energy in this stage was aeration blower with 10 (kWh/kg TN).

3- Final clarifier

The energy consumption of final clarifier was 3.2 (kWh/kg TN) considered as a little energy consumption comparison with other stages, the most category consuming energy in this stage was return sludge pump with 2 (kWh/kg TN).

4- Disinfection

The energy consumption in this stage is very small reaches 0.03 (kWh/kgTN), it is the lowest energy consumption comparison with other stages.

5- Utility facility

In utility facility the energy consumption was 3(kWh/kgTN), but the most energy consuming categories was utility water supply unit with energy consumption 2.7(kWh/kgTN).

6- Gravity thickener

The energy consumption in this stage is considered as a little energy consumer it reaches 0.1(kWh/kgTN).

7-Garden facility

The energy consumption in garden facility reaches to zero.

5.13Comparisons of Energy Consumption for Different Seasons

When the energy consumption as (kWh/day) was calculated in different years and in different months, it was noticed that the energy consumption in winter and in spring higher the energy consumption in summer and in autumn, it reaches 796(kWh/day) in spring, and 580 kWh/day in autumn. This is due to several reasons; the first one that in winter and in spring Jericho city receives a large number of arrivals and tourists in this period of the year because of its warm climate at this time, so the water consumption increase and the influent of WWTP increase. While in summer the climate very hot, so there is to arrivals at this period, so there is no excess consumption at this period.

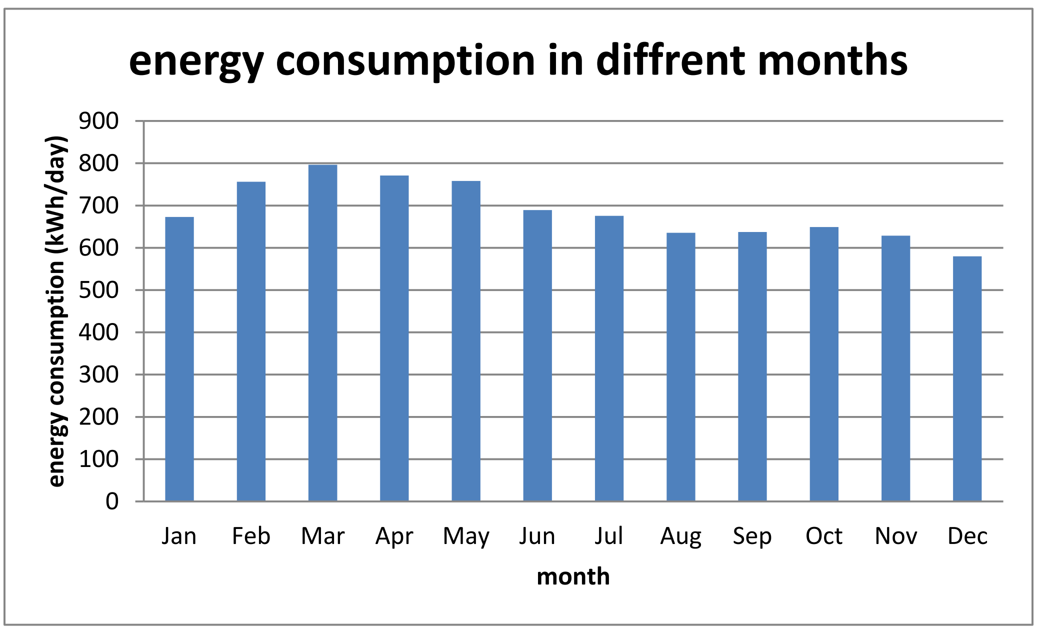

Figure (5.21): Energy consumption in different months

Chapter Six:Conclusions and Recommendations

6.1 Conclusions

1. It was obvious that the amount of wastewater influent to Jericho wastewater treatment plant had been very low in 2015due to the low number of buildings connected to sewer network where 3,200 capitawere served.The influent increased due to increasing the connection rate it reaches 1,250 house connections, approximately 6,250 capita served. In 2020 it is expected to connect all the city and serve 36,000 capita and the annual amount of treated wastewater will reach around 3 million m^3 and can cover most of agricultural lands at the east of Jericho city, which is famous with palm trees planting.

2. In Jericho WWTP the energy consumption as (kWh/m^3) considered to be high in first operational year, which means that the WWTP working inefficiently at first,but it was noticed that the energy consumption decreased with years, this is due to the increase of the number of population served by WWTP, thus growing in the influent of the WWTP.So when the flow rate increases, the lower per cubic meter of wastewater fixed cost because these costs (energy consumption) are spread out over a large number of cubic meters of wastewater.

3. From the results of energy consumption as (kWh/day) in different years the energy consumption increased significantly for two reasons; the first one increasing in the amount of influent of WWTP, the second is the efficiency factor which decreases over time. In the project the efficiency was assumed at the beginning work year 85% and decreasing by 5% every five years.

4. The WWTP divided to seven stages; grit chamber, reactor, final clarifier, disinfection, utility facility, gravity thickener, garden facility. The energy consumption in each stage was calculated for years (2015, 2016), 2020 target year. It is clear that the reactor stage which contain aeration blower is the most energy consuming stage according to the energy consumption value and literature, it reaches 465kwh/day, and the reactor represents 68% of the total consumption, while

the other stages represent together 32%. In WWTP there are four aeration blowers, only two of them work all the time, while the other two are rarely turned on.

5. When the energy consumption compared in two years 2015 (the first operation year) and 2016 the second year, in different categories and stages, taking in consideration that the total load of wastewater entered to the WWTP hugely increased, it has been observed in contrast of expectations that the energy consumption in some categories like reactor tank mixer decreased, despite the increasing of total load of wastewater entering the WWTP,it decreased from 267 kWh/day in 2015 to 232 KWh/day in 2016 this marked decreases due to the organization of the operation of WWTP, and had an efficiency operational plan of WWTP.

6. From calculation of energy consumption for every kg of water quality (BOD, TSS, TN) the results are obtained show that the most energy consumption between the three water qualities is total Nitrogen (TN), it consumed energy18 times more than the other wastewater quality for one kilogram. It was noticed that the WWTP had a very good effluent quality corresponded with the Palestinian recommendations.

6.2 Recommendations

1**.** To have energy efficiency in Jericho WWTP, it should work with full capacity, so the role ofJericho municipality to encourage people to connect sewage to the wastewater collection system.

2. The current institutional framework of sewage treatment facilities in West Bank needs further categories operations. For a correct management of the operation, after its improvement, a continuous monitoring of energetic performances, and in particular of the operating conditions is required: a field determinationof absorbed power, hours of operation, stability of solutions, manpower requirement are some fundamental aspects that mustbe specifically verified.

3. The efficiency of the equipment used in WWTPs decreases with time, Thus after a specified period of time when the efficiency is less than 60%, replacing this tools is the most efficient solution.

4. When designing wastewater treatment plants, it is best to be designed at low altitudes so that wastewater pumps are not used from one stage to another, so the energy consumption will be decreased.

5. It is a better and efficiency solution to design WWTPs to be as large as possible, attempting to Concentrate effluent from several urban areas such that the energy consumption is one third that of smallWWTPs as found in literature. And this is obviously clear when taking into account that energy costs represent more than50% of total operation costs in a WWTP.

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ANNEX (Ī)

(1.1): Monthly Report from Jericho WWTP

(1.2): HYDRAULIC PROFILE

(1.3): Layout of Jericho WWTP

(1.1): Monthly Report from Jericho WWTP

التقرير الشهري لمحطة معالجة الصرف الصحي

التاريخ: 01 / 12 / 2014 - 31 / 12 / 2014 (31 يوم)

كميات المياه المعالجة					
		أقل كمية/يوم	أعلى كمية/يوم	إجمالي	معدل يومي
إجمالي كمية المياه الداخلة	متر مكعب	70.00	1080.00	6610.00	213.23
إجمالي كمية المياه الخارجة	متر مكعب	30.00	450.00	6150.00	198.39
تنكات النضح	متر مكعب	0.00	183.00	1715.00	55.32

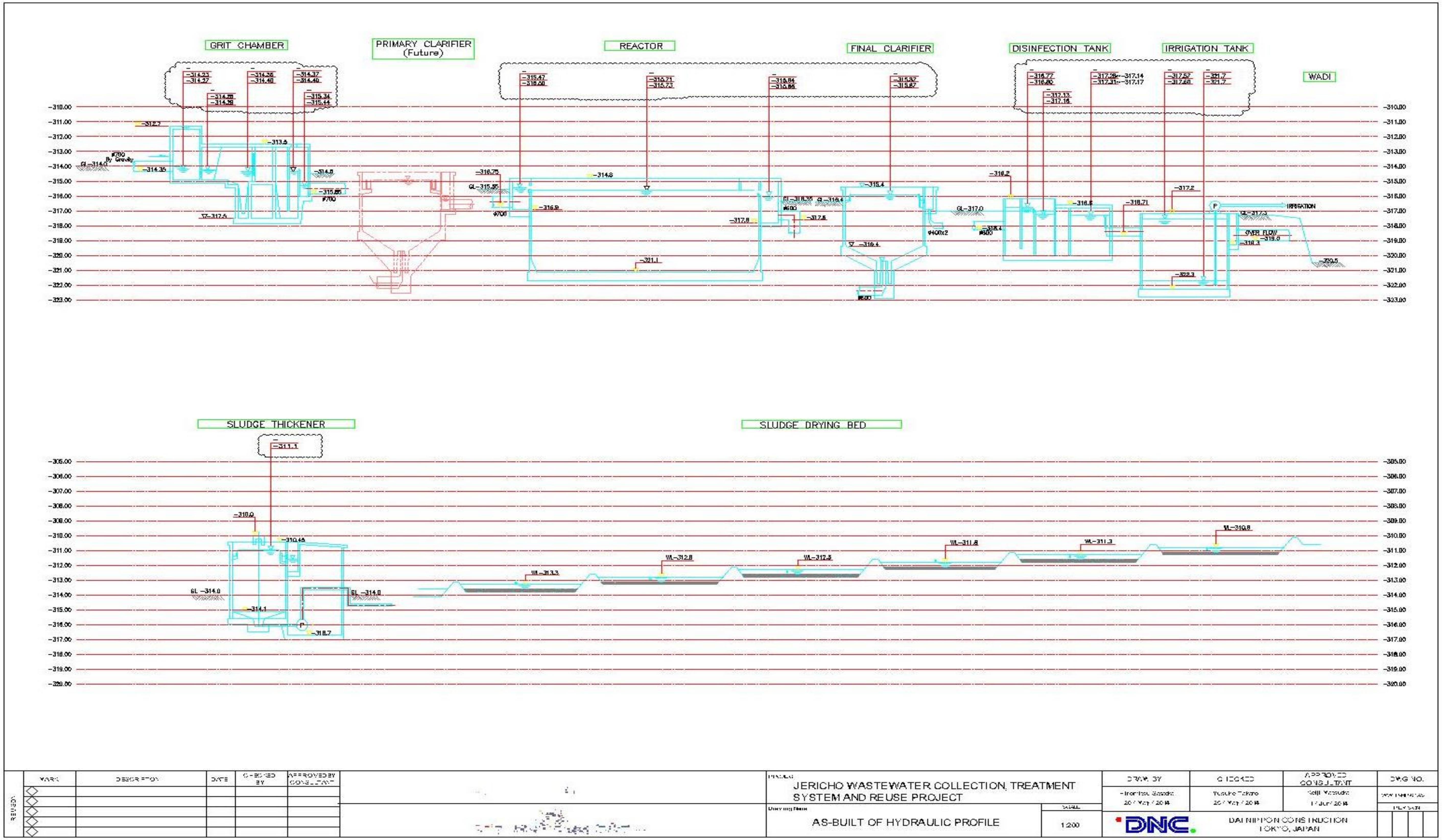
حساب كميات الطاقة					
		قراءة سابقة	قراءة حالية	الإجمالي	معدل يومي
إستهلاك شركة الكهرباء	ك.واط/ساعة	73242.00	83778.00	10536.00	339.87
كمية الطاقة المنتجة من الخلايا الشمسية	ك.واط/ساعة	88348.00	99573.00	11225.00	362.10
كمية الطاقة الفائضة	ك.واط/ساعة	39144.00	44285.00	5141.00	165.84
إجمالي الإستهلاك	ك.واط/ساعة			16620.00	554.00

حساب تكاليف المعالجة					
	قراءة سابقة	قراءة حالية	الإستهلاك	سعر الوحدة	التكلفة/شيكل
إستهلاك شركة الكهرباء (كيلوواط/ساعة)	73242.00	83778.00	10536.00	0.79	8323.44
كمية الطاقة الفائضة (كيلوواط/ساعة)	39144.00	44285.00	5141.00		
استهلاك مياه شرب (متر مكعب)	0.00	20.00	20.00	1.00	20.00
استهلاك كلور للتعقيم (لتر)	908.60	855.00	53.60	1.30	69.68
استهلاك سولار للمولد الكهربائي (لتر)	3895.00	3877.00	18.00	6.42	115.56
رواتب موظفين					0
مشتريات					0
إجمالي التكلفة					8528.68

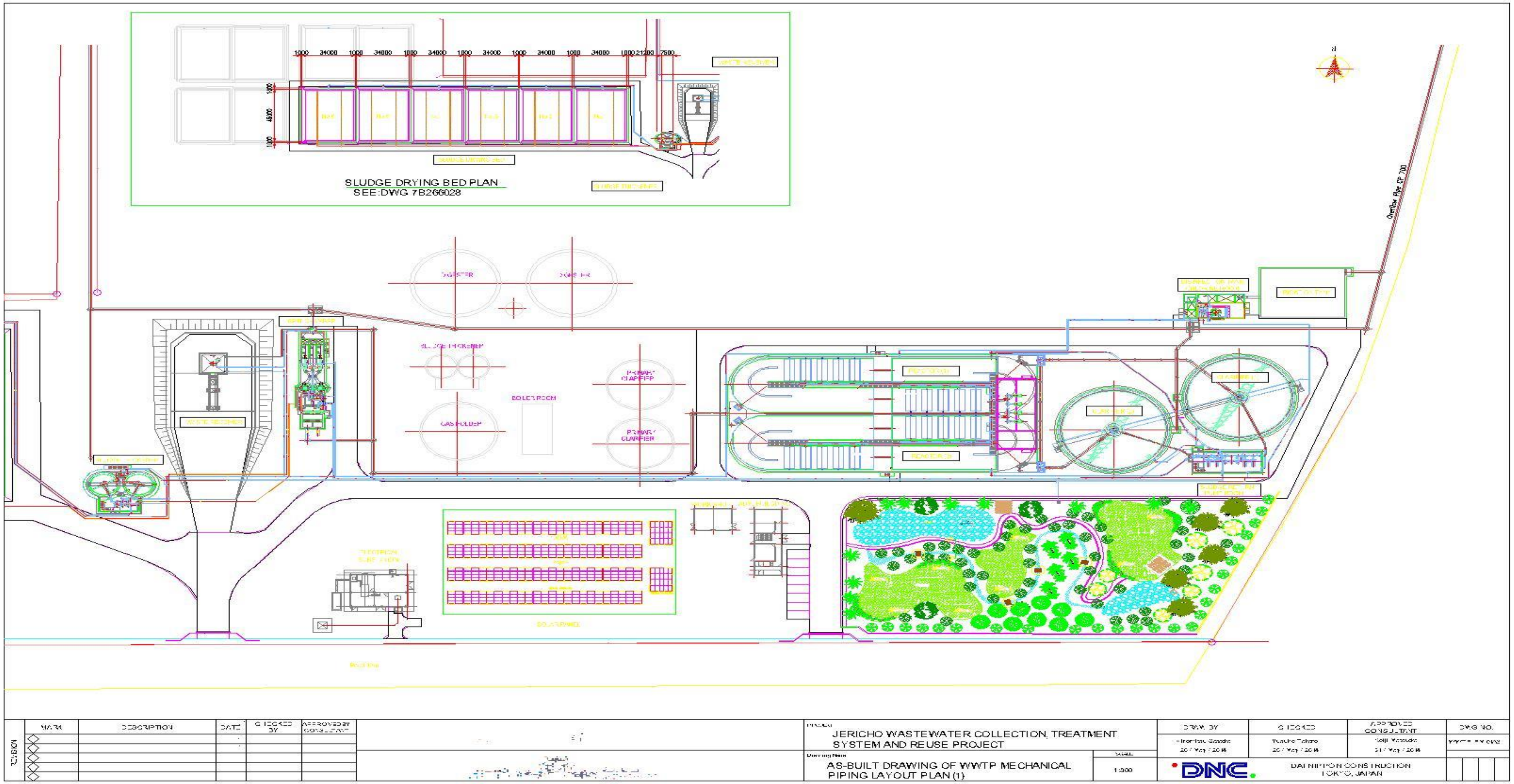
مؤشرات الأداء	
تكلفة المتر المكعب من المياه المعالجة (شيكل/متر مكعب)	1.29
إستهلاك الكهرباء لكل متر مكعب مياه معالجة (كيلو واط.ساعة/متر مكعب)	2.51

عدد الزائرين	13
عدد الزائرين للشهر المقبل	

(1.2): HYDRAULIC PROFILE



(1.3): Layout of Jericho WWTP



ANNEX (ĪĪ)

(2.1): **Calculations for 2015**

(2.2): **Calculations for 2016**

(2.3): **Calculations for 2020**

(2.4): **Calculations for 2025**

Calculations for 2015

Mixer for Vacuum										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	1.5	457.24	14.75	93.99	0.16	92.03	0.16	9.79	1.51
	Feb	1.5	266.82	9.53	116.74	0.08	114.27	0.08	12.16	0.78
	Mar	1.5	159.18	5.13	136.26	0.04	133.42	0.04	14.19	0.36
	Apr	1.5	136.24	4.54	81.44	0.06	79.74	0.06	8.48	0.54
	May	1.5	77.65	2.50	93.21	0.03	91.27	0.03	9.71	0.26
	June	1.5	159.71	5.32	114.24	0.05	111.86	0.05	11.90	0.45
	July	1.5	97.06	3.13	80.21	0.04	78.54	0.04	8.36	0.37
	Aug	1.5	52.94	1.71	112.57	0.02	110.22	0.02	11.73	0.15
	Sep	1.5	61.41	2.05	109.12	0.02	100.22	0.02	11.37	0.18
	OCT	1.5	61.94	2.00	175.59	0.01	171.93	0.01	18.29	0.11
	Nov	1.5	254.12	8.47	147.52	0.06	144.45	0.06	15.37	0.55
	Dec	1.5	454.59	14.66	195.10	0.08	191.03	0.08	20.32	0.72

Wastewater pump for vacuum										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	3.7	81.40	2.63	93.99	0.03	92.03	0.03	9.79	0.27
	Feb	3.7	84.45	3.02	116.74	0.03	114.27	0.03	12.16	0.25
	Mar	3.7	40.92	1.32	136.26	0.01	133.42	0.01	14.19	0.09
	Apr	3.7	18.28	0.61	81.44	0.01	79.74	0.01	8.48	0.07
	May	3.7	39.18	1.26	93.21	0.01	91.27	0.01	9.71	0.13
	June	3.7	49.62	1.65	114.24	0.01	111.86	0.01	11.90	0.14
	July	3.7	45.71	1.47	80.21	0.02	78.54	0.02	8.36	0.18
	Aug	3.7	21.76	0.70	112.57	0.01	110.22	0.01	11.73	0.06
	Sep	3.7	33.52	1.12	109.12	0.01	100.22	0.01	11.37	0.10
	OCT	3.7	119.27	3.85	175.59	0.02	171.93	0.02	18.29	0.21
	Nov	3.7	86.62	2.89	147.52	0.02	144.45	0.02	15.37	0.19
	Dec	3.7	171.07	5.52	195.10	0.03	191.03	0.03	20.32	0.27

Fine Screen										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	2.2	137.95	4.45	93.99	0.05	92.03	0.05	9.79	0.45
	Feb	2.2	204.47	7.30	116.74	0.06	114.27	0.06	12.16	0.60
	Mar	2.2	1094.56	35.31	136.26	0.26	133.42	0.26	14.19	2.49
	Apr	2.2	193.86	6.46	81.44	0.08	79.74	0.08	8.48	0.76
	May	2.2	340.35	10.98	93.21	0.12	91.27	0.12	9.71	1.13
	June	2.2	210.42	7.01	114.24	0.06	111.86	0.06	11.90	0.59
	July	2.2	288.59	9.31	80.21	0.12	78.54	0.12	8.36	1.11
	Aug	2.2	105.08	3.39	112.57	0.03	110.22	0.03	11.73	0.29
	Sep	2.2	112.59	3.75	109.12	0.03	100.22	0.04	11.37	0.33
	OCT	2.2	126.05	4.07	175.59	0.02	171.93	0.02	18.29	0.22
	Nov	2.2	125.79	4.19	147.52	0.03	144.45	0.03	15.37	0.27
	Dec	2.2	181.44	5.85	195.10	0.03	191.03	0.03	20.32	0.29

Grit Collector										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	1.1	962.18	31.04	93.99	0.33	92.03	0.34	9.79	3.17
	Feb	1.1	1378.75	49.24	116.74	0.42	114.27	0.43	12.16	4.05
	Mar	1.1	1853.05	59.78	136.26	0.44	133.42	0.45	14.19	4.21
	Apr	1.1	961.01	32.03	81.44	0.39	79.74	0.40	8.48	3.78
	May	1.1	961.53	31.02	93.21	0.33	91.27	0.34	9.71	3.19
	June	1.1	225.18	7.51	114.24	0.07	111.86	0.07	11.90	0.63
	July	1.1	0.00	0.00	80.21	0.00	78.54	0.00	8.36	0.00
	Aug	1.1	0.00	0.00	112.57	0.00	110.22	0.00	11.73	0.00
	Sep	1.1	0.00	0.00	109.12	0.00	100.22	0.00	11.37	0.00
	OCT	1.1	0.00	0.00	175.59	0.00	171.93	0.00	18.29	0.00
	Nov	1.1	0.00	0.00	147.52	0.00	144.45	0.00	15.37	0.00
	Dec	1.1	762.75	24.60	195.10	0.13	191.03	0.13	20.32	1.21

Grit Removal Pump										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	2.2	117.25	3.78	93.99	0.04	92.03	0.04	9.79	0.39
	Feb	2.2	204.73	7.31	116.74	0.06	114.27	0.06	12.16	0.60
	Mar	2.2	435.08	14.03	136.26	0.10	133.42	0.11	14.19	0.99
	Apr	2.2	70.40	2.35	81.44	0.03	79.74	0.03	8.48	0.28
	May	2.2	97.06	3.13	93.21	0.03	91.27	0.03	9.71	0.32
	June	2.2	97.84	3.26	114.24	0.03	111.86	0.03	11.90	0.27
	July	2.2	113.36	3.66	80.21	0.05	78.54	0.05	8.36	0.44
	Aug	2.2	99.65	3.21	112.57	0.03	110.22	0.03	11.73	0.27
	Sep	2.2	94.47	3.15	109.12	0.03	100.22	0.03	11.37	0.28
	OCT	2.2	102.49	3.31	175.59	0.02	171.93	0.02	18.29	0.18
	Nov	2.2	96.54	3.22	147.52	0.02	144.45	0.02	15.37	0.21
	Dec	2.2	197.48	6.37	195.10	0.03	191.03	0.03	20.32	0.31

Floor Drain Pump										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	1.5	30.88	1.00	93.99	0.01	92.03	0.01	9.79	0.10
	Feb	1.5	94.94	3.39	116.74	0.03	114.27	0.03	12.16	0.28
	Mar	1.5	95.29	3.07	136.26	0.02	133.42	0.02	14.19	0.22
	Apr	1.5	11.29	0.38	81.44	0.00	79.74	0.00	8.48	0.04
	May	1.5	19.24	0.62	93.21	0.01	91.27	0.01	9.71	0.06
	June	1.5	24.88	0.83	114.24	0.01	111.86	0.01	11.90	0.07
	July	1.5	17.12	0.55	80.21	0.01	78.54	0.01	8.36	0.07
	Aug	1.5	7.94	0.26	112.57	0.00	110.22	0.00	11.73	0.02
	Sep	1.5	0.35	0.01	109.12	0.00	100.22	0.00	11.37	0.00
	OCT	1.5	13.24	0.43	175.59	0.00	171.93	0.00	18.29	0.02
	Nov	1.5	16.24	0.54	147.52	0.00	144.45	0.00	15.37	0.04
	Dec	1.5	11.65	0.38	195.10	0.00	191.03	0.00	20.32	0.02

Grit Separator										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	0.75	39.97	1.29	93.99	0.01	92.03	0.01	9.79	0.13
	Feb	0.75	53.47	1.91	116.74	0.02	114.27	0.02	12.16	0.16
	Mar	0.75	148.85	4.80	136.26	0.04	133.42	0.04	14.19	0.34
	Apr	0.75	24.18	0.81	81.44	0.01	79.74	0.01	8.48	0.09
	May	0.75	30.35	0.98	93.21	0.01	91.27	0.01	9.71	0.10
	June	0.75	46.24	1.54	114.24	0.01	111.86	0.01	11.90	0.13
	July	0.75	50.03	1.61	80.21	0.02	78.54	0.02	8.36	0.19
	Aug	0.75	40.76	1.31	112.57	0.01	110.22	0.01	11.73	0.11
	Sep	0.75	39.62	1.32	109.12	0.01	100.22	0.01	11.37	0.12
	OCT	0.75	43.94	1.42	175.59	0.01	171.93	0.01	18.29	0.08
	Nov	0.75	41.21	1.37	147.52	0.01	144.45	0.01	15.37	0.09
	Dec	0.75	81.97	2.64	195.10	0.01	191.03	0.01	20.32	0.13

Oil Discharge Pump										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	0.75	96.44	3.11	93.99	0.03	92.03	0.03	9.79	0.32
	Feb	0.75	98.12	3.50	116.74	0.03	114.27	0.03	12.16	0.29
	Mar	0.75	125.47	4.05	136.26	0.03	133.42	0.03	14.19	0.29
	Apr	0.75	43.24	1.44	81.44	0.02	79.74	0.02	8.48	0.17
	May	0.75	61.15	1.97	93.21	0.02	91.27	0.02	9.71	0.20
	June	0.75	61.68	2.06	114.24	0.02	111.86	0.02	11.90	0.17
	July	0.75	61.68	1.99	80.21	0.02	78.54	0.03	8.36	0.24
	Aug	0.75	41.74	1.35	112.57	0.01	110.22	0.01	11.73	0.11
	Sep	0.75	54.35	1.81	109.12	0.02	100.22	0.02	11.37	0.16
	OCT	0.75	67.24	2.17	175.59	0.01	171.93	0.01	18.29	0.12
	Nov	0.75	42.71	1.42	147.52	0.01	144.45	0.01	15.37	0.09
	Dec	0.75	30.09	0.97	195.10	0.00	191.03	0.01	20.32	0.05

Scum Screen										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	0.4	51.67	1.67	93.99	0.02	92.03	0.02	9.79	0.17
	Feb	0.4	52.47	1.87	116.74	0.02	114.27	0.02	12.16	0.15
	Mar	0.4	67.11	2.16	136.26	0.02	133.42	0.02	14.19	0.15
	Apr	0.4	31.34	1.04	81.44	0.01	79.74	0.01	8.48	0.12
	May	0.4	44.89	1.45	93.21	0.02	91.27	0.02	9.71	0.15
	June	0.4	44.52	1.48	114.24	0.01	111.86	0.01	11.90	0.12
	July	0.4	40.61	1.31	80.21	0.02	78.54	0.02	8.36	0.16
	Aug	0.4	25.88	0.83	112.57	0.01	110.22	0.01	11.73	0.07
	Sep	0.4	32.56	1.09	109.12	0.01	100.22	0.01	11.37	0.10
	OCT	0.4	39.72	1.28	175.59	0.01	171.93	0.01	18.29	0.07
	Nov	0.4	26.59	0.89	147.52	0.01	144.45	0.01	15.37	0.06
	Dec	0.4	21.08	0.68	195.10	0.00	191.03	0.00	20.32	0.03

Screening Conveyor										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	2.2	158.40	5.11	93.99	0.05	92.03	0.06	9.79	0.52
	Feb	2.2	230.09	8.22	116.74	0.07	114.27	0.07	12.16	0.68
	Mar	2.2	762.49	24.60	136.26	0.18	133.42	0.18	14.19	1.73
	Apr	2.2	87.22	2.91	81.44	0.04	79.74	0.04	8.48	0.34
	May	2.2	170.82	5.51	93.21	0.06	91.27	0.06	9.71	0.57
	June	2.2	48.14	1.60	114.24	0.01	111.86	0.01	11.90	0.13
	July	2.2	25.36	0.82	80.21	0.01	78.54	0.01	8.36	0.10
	Aug	2.2	3.11	0.10	112.57	0.00	110.22	0.00	11.73	0.01
	Sep	2.2	2.85	0.09	109.12	0.00	100.22	0.00	11.37	0.01
	OCT	2.2	59.27	1.91	175.59	0.01	171.93	0.01	18.29	0.10
	Nov	2.2	39.34	1.31	147.52	0.01	144.45	0.01	15.37	0.09
	Dec	2.2	207.06	6.68	195.10	0.03	191.03	0.03	20.32	0.33

Reactor Tank mixer										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	3.7	6915.08	223.07	93.99	2.37	92.03	2.42	9.79	22.78
	Feb	3.7	10834.47	386.95	116.74	3.31	114.27	3.39	12.16	31.82
	Mar	3.7	12536.91	404.42	136.26	2.97	133.42	3.03	14.19	28.49
	Apr	3.7	8566.59	285.55	81.44	3.51	79.74	3.58	8.48	33.66
	May	3.7	7277.25	234.75	93.21	2.52	91.27	2.57	9.71	24.18
	June	3.7	7350.38	245.01	114.24	2.14	111.86	2.19	11.90	20.59
	July	3.7	8059.04	259.97	80.21	3.24	78.54	3.31	8.36	31.12
	Aug	3.7	7431.34	239.72	112.57	2.13	110.22	2.17	11.73	20.44
	Sep	3.7	6396.21	213.21	109.12	1.95	100.22	2.13	11.37	18.76
	OCT	3.7	7035.66	226.96	175.59	1.29	171.93	1.32	18.29	12.41
	Nov	3.7	6735.31	224.51	147.52	1.52	144.45	1.55	15.37	14.61
	Dec	3.7	8114.75	261.77	195.10	1.34	191.03	1.37	20.32	12.88

Aeration Blower										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	55	1824.71	58.86	93.99	0.63	92.03	0.64	9.79	6.01
	Feb	55	1617.65	57.77	116.74	0.49	114.27	0.51	12.16	4.75
	Mar	55	2174.12	70.13	136.26	0.51	133.42	0.53	14.19	4.94
	Apr	55	2633.53	87.78	81.44	1.08	79.74	1.10	8.48	10.35
	May	55	3021.76	97.48	93.21	1.05	91.27	1.07	9.71	10.04
	June	55	2238.82	74.63	114.24	0.65	111.86	0.67	11.90	6.27
	July	55	2711.18	87.46	80.21	1.09	78.54	1.11	8.36	10.47
	Aug	55	2484.71	80.15	112.57	0.71	110.22	0.73	11.73	6.84
	Sep	55	2750.00	91.67	109.12	0.84	100.22	0.91	11.37	8.06
	OCT	55	3183.53	102.69	175.59	0.58	171.93	0.60	18.29	5.61
	Nov	55	2685.29	89.51	147.52	0.61	144.45	0.62	15.37	5.82
	Dec	55	4561.76	147.15	195.10	0.75	191.03	0.77	20.32	7.24

Clarifier										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	0.75	668.38	21.56	93.99	0.23	92.03	0.23	9.79	2.20
	Feb	0.75	594.26	21.22	116.74	0.18	114.27	0.19	12.16	1.75
	Mar	0.75	647.03	20.87	136.26	0.15	133.42	0.16	14.19	1.47
	Apr	0.75	638.03	21.27	81.44	0.26	79.74	0.27	8.48	2.51
	May	0.75	679.59	21.92	93.21	0.24	91.27	0.24	9.71	2.26
	June	0.75	638.47	21.28	114.24	0.19	111.86	0.19	11.90	1.79
	July	0.75	765.44	24.69	80.21	0.31	78.54	0.31	8.36	2.96
	Aug	0.75	660.71	21.31	112.57	0.19	110.22	0.19	11.73	1.82
	Sep	0.75	657.09	21.90	109.12	0.20	100.22	0.22	11.37	1.93
	OCT	0.75	682.76	22.02	175.59	0.13	171.93	0.13	18.29	1.20
	Nov	0.75	640.76	21.36	147.52	0.14	144.45	0.15	15.37	1.39
	Dec	0.75	661.15	21.33	195.10	0.11	191.03	0.11	20.32	1.05

Return Sludge Pump										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	15	3190.59	102.92	93.99	1.10	92.03	1.12	9.79	10.51
	Feb	15	2940.00	105.00	116.74	0.90	114.27	0.92	12.16	8.63
	Mar	15	3308.82	106.74	136.26	0.78	133.42	0.80	14.19	7.52
	Apr	15	3017.65	100.59	81.44	1.24	79.74	1.26	8.48	11.86
	May	15	3045.88	98.25	93.21	1.05	91.27	1.08	9.71	10.12
	June	15	2557.06	85.24	114.24	0.75	111.86	0.76	11.90	7.16
	July	15	3134.12	101.10	80.21	1.26	78.54	1.29	8.36	12.10
	Aug	15	2908.24	93.81	112.57	0.83	110.22	0.85	11.73	8.00
	Sep	15	1789.41	59.65	109.12	0.55	100.22	0.60	11.37	5.25
	OCT	15	1886.47	60.85	175.59	0.35	171.93	0.35	18.29	3.33
	Nov	15	1916.47	63.88	147.52	0.43	144.45	0.44	15.37	4.16
	Dec	15	1447.06	46.68	195.10	0.24	191.03	0.24	20.32	2.30

Waste Sludge Pump										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	5.5	214.82	6.93	93.99	0.07	92.03	0.08	9.79	0.71
	Feb	5.5	333.88	11.92	116.74	0.10	114.27	0.10	12.16	0.98
	Mar	5.5	213.53	6.89	136.26	0.05	133.42	0.05	14.19	0.49
	Apr	5.5	143.65	4.79	81.44	0.06	79.74	0.06	8.48	0.56
	May	5.5	220.00	7.10	93.21	0.08	91.27	0.08	9.71	0.73
	June	5.5	497.59	16.59	114.24	0.15	111.86	0.15	11.90	1.39
	July	5.5	0.00	0.00	80.21	0.00	78.54	0.00	8.36	0.00
	Aug	5.5	214.18	6.91	112.57	0.06	110.22	0.06	11.73	0.59
	Sep	5.5	0.00	0.00	109.12	0.00	100.22	0.00	11.37	0.00
	OCT	5.5	185.06	5.97	175.59	0.03	171.93	0.03	18.29	0.33
	Nov	5.5	438.71	14.62	147.52	0.10	144.45	0.10	15.37	0.95
	Dec	5.5	162.41	5.24	195.10	0.03	191.03	0.03	20.32	0.26

Floor Drain Pump										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	1.5	0.71	0.02	93.99	0.00	92.03	0.00	9.79	0.00
	Feb	1.5	0.35	0.01	116.74	0.00	114.27	0.00	12.16	0.00
	Mar	1.5	0.35	0.01	136.26	0.00	133.42	0.00	14.19	0.00
	Apr	1.5	0.35	0.01	81.44	0.00	79.74	0.00	8.48	0.00
	May	1.5	0.35	0.01	93.21	0.00	91.27	0.00	9.71	0.00
	June	1.5	0.00	0.00	114.24	0.00	111.86	0.00	11.90	0.00
	July	1.5	0.00	0.00	80.21	0.00	78.54	0.00	8.36	0.00
	Aug	1.5	0.35	0.01	112.57	0.00	110.22	0.00	11.73	0.00
	Sep	1.5	0.18	0.01	109.12	0.00	100.22	0.00	11.37	0.00
	OCT	1.5	0.35	0.01	175.59	0.00	171.93	0.00	18.29	0.00
	Nov	1.5	0.71	0.02	147.52	0.00	144.45	0.00	15.37	0.00
	Dec	1.5	0.00	0.00	195.10	0.00	191.03	0.00	20.32	0.00

Scum Pump										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	3.7	1.74	0.06	93.99	0.00	92.03	0.00	9.79	0.01
	Feb	3.7	1.31	0.05	116.74	0.00	114.27	0.00	12.16	0.00
	Mar	3.7	1.31	0.04	136.26	0.00	133.42	0.00	14.19	0.00
	Apr	3.7	1.31	0.04	81.44	0.00	79.74	0.00	8.48	0.01
	May	3.7	1.31	0.04	93.21	0.00	91.27	0.00	9.71	0.00
	June	3.7	0.87	0.03	114.24	0.00	111.86	0.00	11.90	0.00
	July	3.7	1.31	0.04	80.21	0.00	78.54	0.00	8.36	0.01
	Aug	3.7	7.84	0.25	112.57	0.00	110.22	0.00	11.73	0.02
	Sep	3.7	1.31	0.04	109.12	0.00	100.22	0.00	11.37	0.00
	OCT	3.7	1.31	0.04	175.59	0.00	171.93	0.00	18.29	0.00
	Nov	3.7	2.18	0.07	147.52	0.00	144.45	0.00	15.37	0.00
	Dec	3.7	0.87	0.03	195.10	0.00	191.03	0.00	20.32	0.00

Hypochlorite Pump										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	0.2	3.65	0.12	93.99	0.00	92.03	0.00	9.79	0.01
	Feb	0.2	3.39	0.12	116.74	0.00	114.27	0.00	12.16	0.01
	Mar	0.2	4.14	0.13	136.26	0.00	133.42	0.00	14.19	0.01
	Apr	0.2	3.67	0.12	81.44	0.00	79.74	0.00	8.48	0.01
	May	0.2	3.58	0.12	93.21	0.00	91.27	0.00	9.71	0.01
	June	0.2	3.88	0.13	114.24	0.00	111.86	0.00	11.90	0.01
	July	0.2	3.84	0.12	80.21	0.00	78.54	0.00	8.36	0.01
	Aug	0.2	3.34	0.11	112.57	0.00	110.22	0.00	11.73	0.01
	Sep	0.2	3.76	0.13	109.12	0.00	100.22	0.00	11.37	0.01
	OCT	0.2	4.49	0.14	175.59	0.00	171.93	0.00	18.29	0.01
	Nov	0.2	6.59	0.22	147.52	0.00	144.45	0.00	15.37	0.01
	Dec	0.2	9.11	0.29	195.10	0.00	191.03	0.00	20.32	0.01

Utility Water Supply Unit										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	7.4	3997.74	128.96	93.99	1.37	92.03	1.40	4.90	26.34
	Feb	7.4	3040.96	108.61	116.74	0.93	114.27	0.95	9.79	11.09
	Mar	7.4	5296.66	170.86	136.26	1.25	133.42	1.28	12.16	14.05
	Apr	7.4	2116.40	70.55	81.44	0.87	79.74	0.88	14.19	4.97
	May	7.4	2685.76	86.64	93.21	0.93	91.27	0.95	8.48	10.21
	June	7.4	1872.64	62.42	114.24	0.55	111.86	0.56	9.71	6.43
	July	7.4	2666.61	86.02	80.21	1.07	78.54	1.10	11.90	7.23
	Aug	7.4	2112.05	68.13	112.57	0.61	110.22	0.62	8.36	8.15
	Sep	7.4	2059.81	68.66	109.12	0.63	100.22	0.69	11.73	5.86
	OCT	7.4	2405.44	77.59	175.59	0.44	171.93	0.45	11.37	6.83
	Nov	7.4	2527.32	84.24	147.52	0.57	144.45	0.58	18.29	4.61
	Dec	7.4	2767.60	89.28	195.10	0.46	191.03	0.47	15.37	5.81

Defoaming Pump										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	3.7	66.60	2.15	93.99	0.02	92.03	0.02	9.79	0.22
	Feb	3.7	463.59	16.56	116.74	0.14	114.27	0.14	12.16	1.36
	Mar	3.7	264.22	8.52	136.26	0.06	133.42	0.06	14.19	0.60
	Apr	3.7	298.18	9.94	81.44	0.12	79.74	0.12	8.48	1.17
	May	3.7	464.89	15.00	93.21	0.16	91.27	0.16	9.71	1.54
	June	3.7	382.62	12.75	114.24	0.11	111.86	0.11	11.90	1.07
	July	3.7	487.09	15.71	80.21	0.20	78.54	0.20	8.36	1.88
	Aug	3.7	411.79	13.28	112.57	0.12	110.22	0.12	11.73	1.13
	Sep	3.7	457.49	15.25	109.12	0.14	100.22	0.15	11.37	1.34
	OCT	3.7	385.67	12.44	175.59	0.07	171.93	0.07	18.29	0.68
	Nov	3.7	338.66	11.29	147.52	0.08	144.45	0.08	15.37	0.73
	Dec	3.7	454.01	14.65	195.10	0.08	191.03	0.08	20.32	0.72

Thickener										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	0.4	46.02	1.48	93.99	0.02	92.03	0.02	9.79	0.15
	Feb	0.4	26.54	0.95	116.74	0.01	114.27	0.01	12.16	0.08
	Mar	0.4	48.56	1.57	136.26	0.01	133.42	0.01	14.19	0.11
	Apr	0.4	24.19	0.81	81.44	0.01	79.74	0.01	8.48	0.10
	May	0.4	44.33	1.43	93.21	0.02	91.27	0.02	9.71	0.15
	June	0.4	147.76	4.93	114.24	0.04	111.86	0.04	11.90	0.41
	July	0.4	74.35	2.40	80.21	0.03	78.54	0.03	8.36	0.29
	Aug	0.4	47.15	1.52	112.57	0.01	110.22	0.01	11.73	0.13
	Sep	0.4	0.00	0.00	109.12	0.00	100.22	0.00	11.37	0.00
	OCT	0.4	25.79	0.83	175.59	0.00	171.93	0.00	18.29	0.05
	Nov	0.4	81.65	2.72	147.52	0.02	144.45	0.02	15.37	0.18
	Dec	0.4	90.12	2.91	195.10	0.01	191.03	0.02	20.32	0.14

Thickened Sludge Pump										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	5.5	9.06	0.29	93.99	0.00	92.03	0.00	9.79	0.03
	Feb	5.5	11.00	0.39	116.74	0.00	114.27	0.00	12.16	0.03
	Mar	5.5	8.41	0.27	136.26	0.00	133.42	0.00	14.19	0.02
	Apr	5.5	12.29	0.41	81.44	0.01	79.74	0.01	8.48	0.05
	May	5.5	15.53	0.50	93.21	0.01	91.27	0.01	9.71	0.05
	June	5.5	31.71	1.06	114.24	0.01	111.86	0.01	11.90	0.09
	July	5.5	7.76	0.25	80.21	0.00	78.54	0.00	8.36	0.03
	Aug	5.5	9.71	0.31	112.57	0.00	110.22	0.00	11.73	0.03
	Sep	5.5	0.00	0.00	109.12	0.00	100.22	0.00	11.37	0.00
	OCT	5.5	9.71	0.31	175.59	0.00	171.93	0.00	18.29	0.02
	Nov	5.5	24.59	0.82	147.52	0.01	144.45	0.01	15.37	0.05
	Dec	5.5	27.18	0.88	195.10	0.00	191.03	0.00	20.32	0.04

Circular Pump										
year	month	power load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	1.5	81.18	2.62	93.99	0.03	92.03	0.03	9.79	0.27
	Feb	1.5	218.12	7.79	116.74	0.07	114.27	0.07	12.16	0.64
	Mar	1.5	113.29	3.65	136.26	0.03	133.42	0.03	14.19	0.26
	Apr	1.5	61.94	2.06	81.44	0.03	79.74	0.03	8.48	0.24
	May	1.5	36.35	1.17	93.21	0.01	91.27	0.01	9.71	0.12
	June	1.5	34.24	1.14	114.24	0.01	111.86	0.01	11.90	0.10
	July	1.5	41.12	1.33	80.21	0.02	78.54	0.02	8.36	0.16
	Aug	1.5	40.59	1.31	112.57	0.01	110.22	0.01	11.73	0.11
	Sep	1.5	97.94	3.26	109.12	0.03	100.22	0.03	11.37	0.29
	OCT	1.5	110.82	3.57	175.59	0.02	171.93	0.02	18.29	0.20
	Nov	1.5	96.88	3.23	147.52	0.02	144.45	0.02	15.37	0.21
	Dec	1.5	39.35	1.27	195.10	0.01	191.03	0.01	20.32	0.06

grit chamber stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	2133.4	68.8	94.0	0.7	92.0	0.7	9.79	7.0
	Feb	2668.3	95.3	116.7	0.8	114.3	0.8	12.16	7.8
	Mar	4782.0	154.3	136.3	1.1	133.4	1.2	14.19	10.9
	Apr	1577.1	52.6	81.4	0.6	79.7	0.7	8.48	6.2
	May	1842.2	59.4	93.2	0.6	91.3	0.7	9.71	6.1
	June	968.2	32.3	114.2	0.3	111.9	0.3	11.90	2.7
	July	739.5	23.9	80.2	0.3	78.5	0.3	8.36	2.9
	Aug	398.9	12.9	112.6	0.1	110.2	0.1	11.73	1.1
	Sep	431.7	14.4	109.1	0.1	100.2	0.1	11.37	1.3
	OCT	633.2	20.4	175.6	0.1	171.9	0.1	18.29	1.1
	Nov	729.1	24.3	147.5	0.2	144.4	0.2	15.37	1.6
	Dec	2119.2	68.4	195.1	0.4	191.0	0.4	20.32	3.4

reactor stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	8739.8	281.9	94.0	3.0	92.0	3.1	9.79	28.8
	Feb	12452.1	444.7	116.7	3.8	114.3	3.9	12.16	36.6
	Mar	14711.0	474.5	136.3	3.5	133.4	3.6	14.19	33.4
	Apr	11200.1	373.3	81.4	4.6	79.7	4.7	8.48	44.0
	May	10299.0	332.2	93.2	3.6	91.3	3.6	9.71	34.2
	June	9589.2	319.6	114.2	2.8	111.9	2.9	11.90	26.9
	July	10770.2	347.4	80.2	4.3	78.5	4.4	8.36	41.6
	Aug	9916.0	319.9	112.6	2.8	110.2	2.9	11.73	27.3
	Sep	9146.2	304.9	109.1	2.8	100.2	3.0	11.37	26.8
	OCT	10219.2	329.7	175.6	1.9	171.9	1.9	18.29	18.0
	Nov	9420.6	314.0	147.5	2.1	144.4	2.2	15.37	20.4
	Dec	12676.5	408.9	195.1	2.1	191.0	2.1	20.32	20.1

final clarifier stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	4076.2	131.5	94.0	1.4	92.0	1.4	9.79	13.4
	Feb	3869.8	138.2	116.7	1.2	114.3	1.2	12.16	11.4
	Mar	4171.0	134.5	136.3	1.0	133.4	1.0	14.19	9.5
	Apr	3801.0	126.7	81.4	1.6	79.7	1.6	8.48	14.9
	May	3947.1	127.3	93.2	1.4	91.3	1.4	9.71	13.1
	June	3694.0	123.1	114.2	1.1	111.9	1.1	11.90	10.3
	July	3900.9	125.8	80.2	1.6	78.5	1.6	8.36	15.1
	Aug	3791.3	122.3	112.6	1.1	110.2	1.1	11.73	10.4
	Sep	2448.0	81.6	109.1	0.7	100.2	0.8	11.37	7.2
	OCT	2756.0	88.9	175.6	0.5	171.9	0.5	18.29	4.9
	Nov	2998.8	100.0	147.5	0.7	144.4	0.7	15.37	6.5
	Dec	2271.5	73.3	195.1	0.4	191.0	0.4	20.32	3.6

disinfection stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	3.6	0.1	94.0	0.0	92.0	0.0	9.79	0.0
	Feb	3.4	0.1	116.7	0.0	114.3	0.0	12.16	0.0
	Mar	4.1	0.1	136.3	0.0	133.4	0.0	14.19	0.0
	Apr	3.7	0.1	81.4	0.0	79.7	0.0	8.48	0.0
	May	3.6	0.1	93.2	0.0	91.3	0.0	9.71	0.0
	June	3.9	0.1	114.2	0.0	111.9	0.0	11.90	0.0
	July	3.8	0.1	80.2	0.0	78.5	0.0	8.36	0.0
	Aug	3.3	0.1	112.6	0.0	110.2	0.0	11.73	0.0
	Sep	3.8	0.1	109.1	0.0	100.2	0.0	11.37	0.0
	OCT	4.5	0.1	175.6	0.0	171.9	0.0	18.29	0.0
	Nov	6.6	0.2	147.5	0.0	144.4	0.0	15.37	0.0
	Dec	9.1	0.3	195.1	0.0	191.0	0.0	20.32	0.0

utility facility stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	4064.3	131.1	94.0	1.4	92.0	1.4	9.79	26.6
	Feb	3504.6	125.2	116.7	1.1	114.3	1.1	12.16	12.5
	Mar	5560.9	179.4	136.3	1.3	133.4	1.3	14.19	14.7
	Apr	2414.6	80.5	81.4	1.0	79.7	1.0	8.48	6.1
	May	3150.7	101.6	93.2	1.1	91.3	1.1	9.71	11.8
	June	2255.3	75.2	114.2	0.7	111.9	0.7	11.90	7.5
	July	3153.7	101.7	80.2	1.3	78.5	1.3	8.36	9.1
	Aug	2523.8	81.4	112.6	0.7	110.2	0.7	11.73	9.3
	Sep	2517.3	83.9	109.1	0.8	100.2	0.8	11.37	7.2
	OCT	2791.1	90.0	175.6	0.5	171.9	0.5	18.29	7.5
	Nov	2866.0	95.5	147.5	0.6	144.4	0.7	15.37	5.3
	Dec	3221.6	103.9	195.1	0.5	191.0	0.5	20.32	6.5

gravity thickner stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	55.1	1.8	94.0	0.0	92.0	0.0	9.79	0.2
	Feb	37.5	1.3	116.7	0.0	114.3	0.0	12.16	0.1
	Mar	57.0	1.8	136.3	0.0	133.4	0.0	14.19	0.1
	Apr	36.5	1.2	81.4	0.0	79.7	0.0	8.48	0.1
	May	59.9	1.9	93.2	0.0	91.3	0.0	9.71	0.2
	June	179.5	6.0	114.2	0.1	111.9	0.1	11.90	0.5
	July	82.1	2.6	80.2	0.0	78.5	0.0	8.36	0.3
	Aug	56.9	1.8	112.6	0.0	110.2	0.0	11.73	0.2
	Sep	0.0	0.0	109.1	0.0	100.2	0.0	11.37	0.0
	OCT	35.5	1.1	175.6	0.0	171.9	0.0	18.29	0.1
	Nov	106.2	3.5	147.5	0.0	144.4	0.0	15.37	0.2
	Dec	117.3	3.8	195.1	0.0	191.0	0.0	20.32	0.2

garden facility stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	81.2	2.6	94.0	0.0	92.0	0.0	9.79	0.3
	Feb	218.1	7.8	116.7	0.1	114.3	0.1	12.16	0.6
	Mar	113.3	3.7	136.3	0.0	133.4	0.0	14.19	0.3
	Apr	61.9	2.1	81.4	0.0	79.7	0.0	8.48	0.2
	May	36.4	1.2	93.2	0.0	91.3	0.0	9.71	0.1
	June	34.2	1.1	114.2	0.0	111.9	0.0	11.90	0.1
	July	41.1	1.3	80.2	0.0	78.5	0.0	8.36	0.2
	Aug	40.6	1.3	112.6	0.0	110.2	0.0	11.73	0.1
	Sep	97.9	3.3	109.1	0.0	100.2	0.0	11.37	0.3
	OCT	110.8	3.6	175.6	0.0	171.9	0.0	18.29	0.2
	Nov	96.9	3.2	147.5	0.0	144.4	0.0	15.37	0.2
	Dec	39.4	1.3	195.1	0.0	191.0	0.0	20.32	0.1

Total plant(2015)														
year	month	total load	total load	total load	total load	population	water consumption	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	m3/day	KWh/ m3	capita	l/c/d	KWh/capita.day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2015	Jan	19154	618	196	3.2	3200	61	0.19	94	7	92	7	10	76
	Feb	22754	813	243	3.3	3200	76	0.25	117	7	114	7	12	69
	Mar	29399	948	284	3.3	3200	89	0.30	136	7	133	7	14	69
	Apr	19095	636	170	3.8	3200	53	0.20	81	8	80	8	8	72
	May	19339	624	194	3.2	3200	61	0.19	93	7	91	7	10	66
	June	16724	557	238	2.3	3200	74	0.17	114	5	112	5	12	48
	July	18691	603	167	3.6	3200	52	0.19	80	8	79	8	8	69
	Aug	16731	540	235	2.3	3200	73	0.17	113	5	110	5	12	48
	Sep	14645	488	227	2.1	3200	71	0.15	109	4	100	5	11	43
	OCT	16550	534	366	1.5	3200	114	0.17	176	3	172	3	18	32
	Nov	16224	541	307	1.8	3200	96	0.17	148	4	144	4	15	34
	Dec	20455	660	406	1.6	3200	127	0.21	195	3	191	3	20	34

Calculations for 2016

Mixer for Vacuum											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	1.5	359.12	11.58	485.81	233.19	0.05	228.33	0.05	24.29	0.48
	Feb	1.5	411.71	14.70	434.83	208.72	0.07	204.37	0.07	21.74	0.68
	Mar	1.5	395.65	12.76	482.58	231.64	0.06	226.81	0.06	24.13	0.53
	Apr	1.5	301.59	10.05	587.33	281.92	0.04	276.05	0.04	29.37	0.34
	May	1.5	355.94	11.48	514.26	246.84	0.05	241.70	0.05	25.71	0.45
	Jun	1.5	251.65	8.39	419.33	201.28	0.04	197.09	0.04	20.97	0.40
	Jul	1.5	344.82	11.12	409.35	196.49	0.06	192.39	0.06	20.47	0.54
	Aug	1.5	250.94	8.09	415.16	199.28	0.04	195.13	0.04	20.76	0.39
	Sep	1.5	145.41	4.85	498.33	239.20	0.02	234.22	0.02	24.92	0.19
	Oct	1.5	208.59	6.73	539.68	259.05	0.03	253.65	0.03	26.98	0.25
	Nov	1.5	110.29	3.68	592.67	284.48	0.01	278.55	0.01	29.63	0.12
	Dec	1.5	112.59	3.63	525.81	252.39	0.01	247.13	0.01	26.29	0.14

Wastewater pump for vacuum											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	3.7	183.69	5.93	485.81	233.19	0.03	228.33	0.03	24.29	0.24
	Feb	3.7	202.85	7.24	434.83	208.72	0.03	204.37	0.04	21.74	0.33
	Mar	3.7	214.60	6.92	482.58	231.64	0.03	226.81	0.03	24.13	0.29
	Apr	3.7	199.36	6.65	587.33	281.92	0.02	276.05	0.02	29.37	0.23
	May	3.7	157.58	5.08	514.26	246.84	0.02	241.70	0.02	25.71	0.20
	Jun	3.7	135.81	4.53	419.33	201.28	0.02	197.09	0.02	20.97	0.22
	Jul	3.7	112.31	3.62	409.35	196.49	0.02	192.39	0.02	20.47	0.18
	Aug	3.7	50.06	1.61	415.16	199.28	0.01	195.13	0.01	20.76	0.08
	Sep	3.7	53.11	1.77	498.33	239.20	0.01	234.22	0.01	24.92	0.07
	Oct	3.7	72.26	2.33	539.68	259.05	0.01	253.65	0.01	26.98	0.09
	Nov	3.7	43.09	1.44	592.67	284.48	0.01	278.55	0.01	29.63	0.05
	Dec	3.7	67.47	2.18	525.81	252.39	0.01	247.13	0.01	26.29	0.08

Fine Screen											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	2.2	135.88	4.38	485.81	233.19	0.02	228.33	0.02	24.29	0.18
	Feb	2.2	149.08	5.32	434.83	208.72	0.03	204.37	0.03	21.74	0.24
	Mar	2.2	121.13	3.91	482.58	231.64	0.02	226.81	0.02	24.13	0.16
	Apr	2.2	199.55	6.65	587.33	281.92	0.02	276.05	0.02	29.37	0.23
	May	2.2	252.35	8.14	514.26	246.84	0.03	241.70	0.03	25.71	0.32
	Jun	2.2	196.96	6.57	419.33	201.28	0.03	197.09	0.03	20.97	0.31
	Jul	2.2	166.16	5.36	409.35	196.49	0.03	192.39	0.03	20.47	0.26
	Aug	2.2	102.24	3.30	415.16	199.28	0.02	195.13	0.02	20.76	0.16
	Sep	2.2	107.93	3.60	498.33	239.20	0.02	234.22	0.02	24.92	0.14
	Oct	2.2	197.74	6.38	539.68	259.05	0.02	253.65	0.03	26.98	0.24
	Nov	2.2	317.84	10.59	592.67	284.48	0.04	278.55	0.04	29.63	0.36
	Dec	2.2	203.18	6.55	525.81	252.39	0.03	247.13	0.03	26.29	0.25

Grit Collector											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	1.1	1086.28	35.04	485.81	233.19	0.15	228.33	0.15	24.29	1.44
	Feb	1.1	964.51	34.45	434.83	208.72	0.17	204.37	0.17	21.74	1.58
	Mar	1.1	998.02	32.19	482.58	231.64	0.14	226.81	0.14	24.13	1.33
	Apr	1.1	935.65	31.19	587.33	281.92	0.11	276.05	0.11	29.37	1.06
	May	1.1	913.00	29.45	514.26	246.84	0.12	241.70	0.12	25.71	1.15
	Jun	1.1	1179.46	39.32	419.33	201.28	0.20	197.09	0.20	20.97	1.88
	Jul	1.1	962.56	31.05	409.35	196.49	0.16	192.39	0.16	20.47	1.52
	Aug	1.1	962.56	31.05	415.16	199.28	0.16	195.13	0.16	20.76	1.50
	Sep	1.1	931.51	31.05	498.33	239.20	0.13	234.22	0.13	24.92	1.25
	Oct	1.1	961.14	31.00	539.68	259.05	0.12	253.65	0.12	26.98	1.15
	Nov	1.1	931.76	30.06	592.67	284.48	0.11	278.55	0.11	29.63	1.01
	Dec	1.1	962.69	31.05	525.81	252.39	0.12	247.13	0.13	26.29	1.18

Grit Removal Pump											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	2.2	301.01	9.71	485.81	233.19	0.04	228.33	0.04	24.29	0.40
	Feb	2.2	313.18	11.18	434.83	208.72	0.05	204.37	0.05	21.74	0.51
	Mar	2.2	294.28	9.49	482.58	231.64	0.04	226.81	0.04	24.13	0.39
	Apr	2.2	218.71	7.29	587.33	281.92	0.03	276.05	0.03	29.37	0.25
	May	2.2	224.92	7.26	514.26	246.84	0.03	241.70	0.03	25.71	0.28
	Jun	2.2	378.92	12.63	419.33	201.28	0.06	197.09	0.06	20.97	0.60
	Jul	2.2	255.46	8.24	409.35	196.49	0.04	192.39	0.04	20.47	0.40
	Aug	2.2	199.55	6.44	415.16	199.28	0.03	195.13	0.03	20.76	0.31
	Sep	2.2	196.96	6.57	498.33	239.20	0.03	234.22	0.03	24.92	0.26
	Oct	2.2	198.52	6.40	539.68	259.05	0.02	253.65	0.03	26.98	0.24
	Nov	2.2	195.15	6.51	592.67	284.48	0.02	278.55	0.02	29.63	0.22
	Dec	2.2	162.28	5.23	525.81	252.39	0.02	247.13	0.02	26.29	0.20

Floor Drain Pump											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	1.5	6.71	0.22	485.81	233.19	0.00	228.33	0.00	24.29	0.01
	Feb	1.5	3.88	0.14	434.83	208.72	0.00	204.37	0.00	21.74	0.01
	Mar	1.5	17.12	0.55	482.58	231.64	0.00	226.81	0.00	24.13	0.02
	Apr	1.5	6.88	0.23	587.33	281.92	0.00	276.05	0.00	29.37	0.01
	May	1.5	5.29	0.17	514.26	246.84	0.00	241.70	0.00	25.71	0.01
	Jun	1.5	7.06	0.24	419.33	201.28	0.00	197.09	0.00	20.97	0.01
	Jul	1.5	15.53	0.50	409.35	196.49	0.00	192.39	0.00	20.47	0.02
	Aug	1.5	0.00	0.00	415.16	199.28	0.00	195.13	0.00	20.76	0.00
	Sep	1.5	6.18	0.21	498.33	239.20	0.00	234.22	0.00	24.92	0.01
	Oct	1.5	5.29	0.17	539.68	259.05	0.00	253.65	0.00	26.98	0.01
	Nov	1.5	11.12	0.37	592.67	284.48	0.00	278.55	0.00	29.63	0.01
	Dec	1.5	4.41	0.14	525.81	252.39	0.00	247.13	0.00	26.29	0.01

Grit Separator											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	0.75	160.41	5.17	485.81	233.19	0.02	228.33	0.02	24.29	0.21
	Feb	0.75	117.97	4.21	434.83	208.72	0.02	204.37	0.02	21.74	0.19
	Mar	0.75	111.53	3.60	482.58	231.64	0.02	226.81	0.02	24.13	0.15
	Apr	0.75	82.68	2.76	587.33	281.92	0.01	276.05	0.01	29.37	0.09
	May	0.75	91.59	2.95	514.26	246.84	0.01	241.70	0.01	25.71	0.11
	Jun	0.75	137.74	4.59	419.33	201.28	0.02	197.09	0.02	20.97	0.22
	Jul	0.75	94.76	3.06	409.35	196.49	0.02	192.39	0.02	20.47	0.15
	Aug	0.75	77.12	2.49	415.16	199.28	0.01	195.13	0.01	20.76	0.12
	Sep	0.75	94.06	3.14	498.33	239.20	0.01	234.22	0.01	24.92	0.13
	Oct	0.75	76.85	2.48	539.68	259.05	0.01	253.65	0.01	26.98	0.09
	Nov	0.75	77.12	2.57	592.67	284.48	0.01	278.55	0.01	29.63	0.09
	Dec	0.75	62.65	2.02	525.81	252.39	0.01	247.13	0.01	26.29	0.08

Oil Discharge Pump											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	0.75	28.06	0.91	485.81	233.19	0.00	228.33	0.00	24.29	0.04
	Feb	0.75	12.44	0.44	434.83	208.72	0.00	204.37	0.00	21.74	0.02
	Mar	0.75	28.41	0.92	482.58	231.64	0.00	226.81	0.00	24.13	0.04
	Apr	0.75	14.74	0.49	587.33	281.92	0.00	276.05	0.00	29.37	0.02
	May	0.75	11.29	0.36	514.26	246.84	0.00	241.70	0.00	25.71	0.01
	Jun	0.75	7.68	0.26	419.33	201.28	0.00	197.09	0.00	20.97	0.01
	Jul	0.75	16.85	0.54	409.35	196.49	0.00	192.39	0.00	20.47	0.03
	Aug	0.75	52.15	1.68	415.16	199.28	0.01	195.13	0.01	20.76	0.08
	Sep	0.75	39.09	1.30	498.33	239.20	0.01	234.22	0.01	24.92	0.05
	Oct	0.75	44.03	1.42	539.68	259.05	0.01	253.65	0.01	26.98	0.05
	Nov	0.75	51.26	1.71	592.67	284.48	0.01	278.55	0.01	29.63	0.06
	Dec	0.75	42.79	1.38	525.81	252.39	0.01	247.13	0.01	26.29	0.05

Scum Screen											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	0.4	16.42	0.53	485.81	233.19	0.00	228.33	0.00	24.29	0.02
	Feb	0.4	7.86	0.28	434.83	208.72	0.00	204.37	0.00	21.74	0.01
	Mar	0.4	17.04	0.55	482.58	231.64	0.00	226.81	0.00	24.13	0.02
	Apr	0.4	9.41	0.31	587.33	281.92	0.00	276.05	0.00	29.37	0.01
	May	0.4	6.96	0.22	514.26	246.84	0.00	241.70	0.00	25.71	0.01
	Jun	0.4	4.71	0.16	419.33	201.28	0.00	197.09	0.00	20.97	0.01
	Jul	0.4	10.40	0.34	409.35	196.49	0.00	192.39	0.00	20.47	0.02
	Aug	0.4	31.11	1.00	415.16	199.28	0.01	195.13	0.01	20.76	0.05
	Sep	0.4	22.82	0.76	498.33	239.20	0.00	234.22	0.00	24.92	0.03
	Oct	0.4	25.79	0.83	539.68	259.05	0.00	253.65	0.00	26.98	0.03
	Nov	0.4	27.06	0.90	592.67	284.48	0.00	278.55	0.00	29.63	0.03
	Dec	0.4	24.24	0.78	525.81	252.39	0.00	247.13	0.00	26.29	0.03

Screening Conveyor											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	2.2	152.19	4.91	485.81	233.19	0.02	228.33	0.02	24.29	0.20
	Feb	2.2	171.60	6.13	434.83	208.72	0.03	204.37	0.03	21.74	0.28
	Mar	2.2	142.87	4.61	482.58	231.64	0.02	226.81	0.02	24.13	0.19
	Apr	2.2	225.69	7.52	587.33	281.92	0.03	276.05	0.03	29.37	0.26
	May	2.2	240.19	7.75	514.26	246.84	0.03	241.70	0.03	25.71	0.30
	Jun	2.2	201.88	6.73	419.33	201.28	0.03	197.09	0.03	20.97	0.32
	Jul	2.2	178.33	5.75	409.35	196.49	0.03	192.39	0.03	20.47	0.28
	Aug	2.2	121.91	3.93	415.16	199.28	0.02	195.13	0.02	20.76	0.19
	Sep	2.2	126.05	4.20	498.33	239.20	0.02	234.22	0.02	24.92	0.17
	Oct	2.2	206.54	6.66	539.68	259.05	0.03	253.65	0.03	26.98	0.25
	Nov	2.2	329.48	10.98	592.67	284.48	0.04	278.55	0.04	29.63	0.37
	Dec	2.2	214.56	6.92	525.81	252.39	0.03	247.13	0.03	26.29	0.26

Reactor Tank mixer											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	3.7	7026.52	226.66	485.81	233.19	0.97	228.33	0.99	24.29	9.33
	Feb	3.7	6345.28	226.62	434.83	208.72	1.09	204.37	1.11	21.74	10.42
	Mar	3.7	7648.55	246.73	482.58	231.64	1.07	226.81	1.09	24.13	10.23
	Apr	3.7	7051.76	235.06	587.33	281.92	0.83	276.05	0.85	29.37	8.00
	May	3.7	7015.20	226.30	514.26	246.84	0.92	241.70	0.94	25.71	8.80
	Jun	3.7	6774.05	225.80	419.33	201.28	1.12	197.09	1.15	20.97	10.77
	Jul	3.7	7261.14	234.23	409.35	196.49	1.19	192.39	1.22	20.47	11.44
	Aug	3.7	6804.08	219.49	415.16	199.28	1.10	195.13	1.12	20.76	10.57
	Sep	3.7	6650.42	221.68	498.33	239.20	0.93	234.22	0.95	24.92	8.90
	Oct	3.7	7724.73	249.18	539.68	259.05	0.96	253.65	0.98	26.98	9.23
	Nov	3.7	6945.12	231.50	592.67	284.48	0.81	278.55	0.83	29.63	7.81
	Dec	3.7	7759.99	250.32	525.81	252.39	0.99	247.13	1.01	26.29	9.52

Aeration Blower											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	55	5163.53	166.57	485.81	233.19	0.71	228.33	0.73	24.29	6.86
	Feb	55	6735.88	240.57	434.83	208.72	1.15	204.37	1.18	21.74	11.06
	Mar	55	8250.00	266.13	482.58	231.64	1.15	226.81	1.17	24.13	11.03
	Apr	55	8340.59	278.02	587.33	281.92	0.99	276.05	1.01	29.37	9.47
	May	55	8224.12	265.29	514.26	246.84	1.07	241.70	1.10	25.71	10.32
	Jun	55	7842.35	261.41	419.33	201.28	1.30	197.09	1.33	20.97	12.47
	Jul	55	7842.35	252.98	409.35	196.49	1.29	192.39	1.31	20.47	12.36
	Aug	55	7441.18	240.04	415.16	199.28	1.20	195.13	1.23	20.76	11.56
	Sep	55	6554.71	218.49	498.33	239.20	0.91	234.22	0.93	24.92	8.77
	Oct	55	6541.76	211.02	539.68	259.05	0.81	253.65	0.83	26.98	7.82
	Nov	55	5842.94	194.76	592.67	284.48	0.68	278.55	0.70	29.63	6.57
	Dec	55	5745.88	185.35	525.81	252.39	0.73	247.13	0.75	26.29	7.05

Clarifier											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	0.75	661.32	21.33	485.81	233.19	0.09	228.33	0.09	24.29	0.88
	Feb	0.75	617.47	22.05	434.83	208.72	0.11	204.37	0.11	21.74	1.01
	Mar	0.75	656.12	21.17	482.58	231.64	0.09	226.81	0.09	24.13	0.88
	Apr	0.75	638.56	21.29	587.33	281.92	0.08	276.05	0.08	29.37	0.72
	May	0.75	657.09	21.20	514.26	246.84	0.09	241.70	0.09	25.71	0.82
	Jun	0.75	635.03	21.17	419.33	201.28	0.11	197.09	0.11	20.97	1.01
	Jul	0.75	659.47	21.27	409.35	196.49	0.11	192.39	0.11	20.47	1.04
	Aug	0.75	661.68	21.34	415.16	199.28	0.11	195.13	0.11	20.76	1.03
	Sep	0.75	641.82	21.39	498.33	239.20	0.09	234.22	0.09	24.92	0.86
	Oct	0.75	656.38	21.17	539.68	259.05	0.08	253.65	0.08	26.98	0.78
	Nov	0.75	635.21	21.17	592.67	284.48	0.07	278.55	0.08	29.63	0.71
	Dec	0.75	656.38	21.17	525.81	252.39	0.08	247.13	0.09	26.29	0.81

Return Sludge Pump											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	15	1731.18	55.84	485.81	233.19	0.24	228.33	0.24	24.29	2.30
	Feb	15	1505.29	53.76	434.83	208.72	0.26	204.37	0.26	21.74	2.47
	Mar	15	1697.65	54.76	482.58	231.64	0.24	226.81	0.24	24.13	2.27
	Apr	15	1323.53	44.12	587.33	281.92	0.16	276.05	0.16	29.37	1.50
	May	15	1383.53	44.63	514.26	246.84	0.18	241.70	0.18	25.71	1.74
	Jun	15	1290.00	43.00	419.33	201.28	0.21	197.09	0.22	20.97	2.05
	Jul	15	1422.35	45.88	409.35	196.49	0.23	192.39	0.24	20.47	2.24
	Aug	15	1145.29	36.94	415.16	199.28	0.19	195.13	0.19	20.76	1.78
	Sep	15	1208.82	40.29	498.33	239.20	0.17	234.22	0.17	24.92	1.62
	Oct	15	1350.00	43.55	539.68	259.05	0.17	253.65	0.17	26.98	1.61
	Nov	15	1298.82	43.29	592.67	284.48	0.15	278.55	0.16	29.63	1.46
	Dec	15	1147.06	37.00	525.81	252.39	0.15	247.13	0.15	26.29	1.41

Waste Sludge Pump											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	5.5	581.06	18.74	485.81	233.19	0.08	228.33	0.08	24.29	0.77
	Feb	5.5	437.41	15.62	434.83	208.72	0.07	204.37	0.08	21.74	0.72
	Mar	5.5	654.18	21.10	482.58	231.64	0.09	226.81	0.09	24.13	0.87
	Apr	5.5	412.18	13.74	587.33	281.92	0.05	276.05	0.05	29.37	0.47
	May	5.5	408.29	13.17	514.26	246.84	0.05	241.70	0.05	25.71	0.51
	Jun	5.5	220.00	7.33	419.33	201.28	0.04	197.09	0.04	20.97	0.35
	Jul	5.5	425.76	13.73	409.35	196.49	0.07	192.39	0.07	20.47	0.67
	Aug	5.5	0.00	0.00	415.16	199.28	0.00	195.13	0.00	20.76	0.00
	Sep	5.5	308.00	10.27	498.33	239.20	0.04	234.22	0.04	24.92	0.41
	Oct	5.5	353.29	11.40	539.68	259.05	0.04	253.65	0.04	26.98	0.42
	Nov	5.5	232.29	7.74	592.67	284.48	0.03	278.55	0.03	29.63	0.26
	Dec	5.5	210.94	6.80	525.81	252.39	0.03	247.13	0.03	26.29	0.26

Floor Drain Pump											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	1.5	0.18	0.01	485.81	233.19	0.00	228.33	0.00	24.29	0.00
	Feb	1.5	0.00	0.00	434.83	208.72	0.00	204.37	0.00	21.74	0.00
	Mar	1.5	0.00	0.00	482.58	231.64	0.00	226.81	0.00	24.13	0.00
	Apr	1.5	0.35	0.01	587.33	281.92	0.00	276.05	0.00	29.37	0.00
	May	1.5	0.18	0.01	514.26	246.84	0.00	241.70	0.00	25.71	0.00
	Jun	1.5	0.00	0.00	419.33	201.28	0.00	197.09	0.00	20.97	0.00
	Jul	1.5	0.00	0.00	409.35	196.49	0.00	192.39	0.00	20.47	0.00
	Aug	1.5	0.18	0.01	415.16	199.28	0.00	195.13	0.00	20.76	0.00
	Sep	1.5	0.18	0.01	498.33	239.20	0.00	234.22	0.00	24.92	0.00
	Oct	1.5	0.00	0.00	539.68	259.05	0.00	253.65	0.00	26.98	0.00
	Nov	1.5	0.00	0.00	592.67	284.48	0.00	278.55	0.00	29.63	0.00
	Dec	1.5	0.00	0.00	525.81	252.39	0.00	247.13	0.00	26.29	0.00

Scum Pump											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	3.7	1.31	0.04	485.81	233.19	0.00	228.33	0.00	24.29	0.00
	Feb	3.7	1.31	0.05	434.83	208.72	0.00	204.37	0.00	21.74	0.00
	Mar	3.7	1.31	0.04	482.58	231.64	0.00	226.81	0.00	24.13	0.00
	Apr	3.7	2.61	0.09	587.33	281.92	0.00	276.05	0.00	29.37	0.00
	May	3.7	1.31	0.04	514.26	246.84	0.00	241.70	0.00	25.71	0.00
	Jun	3.7	0.44	0.01	419.33	201.28	0.00	197.09	0.00	20.97	0.00
	Jul	3.7	0.44	0.01	409.35	196.49	0.00	192.39	0.00	20.47	0.00
	Aug	3.7	1.74	0.06	415.16	199.28	0.00	195.13	0.00	20.76	0.00
	Sep	3.7	1.31	0.04	498.33	239.20	0.00	234.22	0.00	24.92	0.00
	Oct	3.7	0.87	0.03	539.68	259.05	0.00	253.65	0.00	26.98	0.00
	Nov	3.7	1.31	0.04	592.67	284.48	0.00	278.55	0.00	29.63	0.00
	Dec	3.7	0.87	0.03	525.81	252.39	0.00	247.13	0.00	26.29	0.00

Hypochlorite Pump											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	0.2	6.68	0.22	485.81	233.19	0.00	228.33	0.00	24.29	0.01
	Feb	0.2	6.61	0.24	434.83	208.72	0.00	204.37	0.00	21.74	0.01
	Mar	0.2	6.52	0.21	482.58	231.64	0.00	226.81	0.00	24.13	0.01
	Apr	0.2	6.38	0.21	587.33	281.92	0.00	276.05	0.00	29.37	0.01
	May	0.2	7.01	0.23	514.26	246.84	0.00	241.70	0.00	25.71	0.01
	Jun	0.2	6.31	0.21	419.33	201.28	0.00	197.09	0.00	20.97	0.01
	Jul	0.2	7.22	0.23	409.35	196.49	0.00	192.39	0.00	20.47	0.01
	Aug	0.2	7.41	0.24	415.16	199.28	0.00	195.13	0.00	20.76	0.01
	Sep	0.2	8.16	0.27	498.33	239.20	0.00	234.22	0.00	24.92	0.01
	Oct	0.2	80.85	2.61	539.68	259.05	0.01	253.65	0.01	26.98	0.10
	Nov	0.2	85.62	2.85	592.67	284.48	0.01	278.55	0.01	29.63	0.10
	Dec	0.2	79.65	2.57	525.81	252.39	0.01	247.13	0.01	26.29	0.10

Utility Water Supply Unit											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	7.4	2652.68	85.57	485.81	233.19	0.37	228.33	0.37	24.29	3.52
	Feb	7.4	2657.91	94.93	434.83	208.72	0.45	204.37	0.46	21.74	4.37
	Mar	7.4	2798.94	90.29	482.58	231.64	0.39	226.81	0.40	24.13	3.74
	Apr	7.4	2754.54	91.82	587.33	281.92	0.33	276.05	0.33	29.37	3.13
	May	7.4	3013.98	97.23	514.26	246.84	0.39	241.70	0.40	25.71	3.78
	Jun	7.4	1009.88	33.66	419.33	201.28	0.17	197.09	0.17	20.97	1.61
	Jul	7.4	1000.31	32.27	409.35	196.49	0.16	192.39	0.17	20.47	1.58
	Aug	7.4	1782.96	57.51	415.16	199.28	0.29	195.13	0.29	20.76	2.77
	Sep	7.4	1974.49	65.82	498.33	239.20	0.28	234.22	0.28	24.92	2.64
	Oct	7.4	1197.93	38.64	539.68	259.05	0.15	253.65	0.15	26.98	1.43
	Nov	7.4	1460.85	48.69	592.67	284.48	0.17	278.55	0.17	29.63	1.64
	Dec	7.4	218.52	7.05	525.81	252.39	0.03	247.13	0.03	26.29	0.27

Defoaming Pump											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	3.7	462.72	14.93	485.81	233.19	0.06	228.33	0.07	24.29	0.61
	Feb	3.7	435.73	15.56	434.83	208.72	0.07	204.37	0.08	21.74	0.72
	Mar	3.7	338.66	10.92	482.58	231.64	0.05	226.81	0.05	24.13	0.45
	Apr	3.7	277.28	9.24	587.33	281.92	0.03	276.05	0.03	29.37	0.31
	May	3.7	424.85	13.70	514.26	246.84	0.06	241.70	0.06	25.71	0.53
	Jun	3.7	343.88	11.46	419.33	201.28	0.06	197.09	0.06	20.97	0.55
	Jul	3.7	98.81	3.19	409.35	196.49	0.02	192.39	0.02	20.47	0.16
	Aug	3.7	0.87	0.03	415.16	199.28	0.00	195.13	0.00	20.76	0.00
	Sep	3.7	0.44	0.01	498.33	239.20	0.00	234.22	0.00	24.92	0.00
	Oct	3.7	149.74	4.83	539.68	259.05	0.02	253.65	0.02	26.98	0.18
	Nov	3.7	193.27	6.44	592.67	284.48	0.02	278.55	0.02	29.63	0.22
	Dec	3.7	239.41	7.72	525.81	252.39	0.03	247.13	0.03	26.29	0.29

Thickener											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	0.4	49.08	1.58	485.81	233.19	0.01	228.33	0.01	24.29	0.07
	Feb	0.4	55.06	1.97	434.83	208.72	0.01	204.37	0.01	21.74	0.09
	Mar	0.4	166.49	5.37	482.58	231.64	0.02	226.81	0.02	24.13	0.22
	Apr	0.4	47.62	1.59	587.33	281.92	0.01	276.05	0.01	29.37	0.05
	May	0.4	45.93	1.48	514.26	246.84	0.01	241.70	0.01	25.71	0.06
	Jun	0.4	44.80	1.49	419.33	201.28	0.01	197.09	0.01	20.97	0.07
	Jul	0.4	48.28	1.56	409.35	196.49	0.01	192.39	0.01	20.47	0.08
	Aug	0.4	0.00	0.00	415.16	199.28	0.00	195.13	0.00	20.76	0.00
	Sep	0.4	25.13	0.84	498.33	239.20	0.00	234.22	0.00	24.92	0.03
	Oct	0.4	35.67	1.15	539.68	259.05	0.00	253.65	0.00	26.98	0.04
	Nov	0.4	38.35	1.28	592.67	284.48	0.00	278.55	0.00	29.63	0.04
	Dec	0.4	2.26	0.07	525.81	252.39	0.00	247.13	0.00	26.29	0.00

Thickened Sludge Pump											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	5.5	43.35	1.40	485.81	233.19	0.01	228.33	0.01	24.29	0.06
	Feb	5.5	22.65	0.81	434.83	208.72	0.00	204.37	0.00	21.74	0.04
	Mar	5.5	63.41	2.05	482.58	231.64	0.01	226.81	0.01	24.13	0.08
	Apr	5.5	48.53	1.62	587.33	281.92	0.01	276.05	0.01	29.37	0.06
	May	5.5	56.29	1.82	514.26	246.84	0.01	241.70	0.01	25.71	0.07
	Jun	5.5	11.00	0.37	419.33	201.28	0.00	197.09	0.00	20.97	0.02
	Jul	5.5	18.76	0.61	409.35	196.49	0.00	192.39	0.00	20.47	0.03
	Aug	5.5	0.00	0.00	415.16	199.28	0.00	195.13	0.00	20.76	0.00
	Sep	5.5	17.47	0.58	498.33	239.20	0.00	234.22	0.00	24.92	0.02
	Oct	5.5	17.47	0.56	539.68	259.05	0.00	253.65	0.00	26.98	0.02
	Nov	5.5	25.88	0.86	592.67	284.48	0.00	278.55	0.00	29.63	0.03
	Dec	5.5	25.88	0.83	525.81	252.39	0.00	247.13	0.00	26.29	0.03

Circular Pump											
year	month	power load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kW	kWh/month	kWh/day	(m3/day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	1.5	58.76	1.90	485.81	233.19	0.01	228.33	0.01	24.29	0.08
	Feb	1.5	3.18	0.11	434.83	208.72	0.00	204.37	0.00	21.74	0.01
	Mar	1.5	65.82	2.12	482.58	231.64	0.01	226.81	0.01	24.13	0.09
	Apr	1.5	33.00	1.10	587.33	281.92	0.00	276.05	0.00	29.37	0.04
	May	1.5	9.35	0.30	514.26	246.84	0.00	241.70	0.00	25.71	0.01
	Jun	1.5	0.00	0.00	419.33	201.28	0.00	197.09	0.00	20.97	0.00
	Jul	1.5	8.12	0.26	409.35	196.49	0.00	192.39	0.00	20.47	0.01
	Aug	1.5	9.00	0.29	415.16	199.28	0.00	195.13	0.00	20.76	0.01
	Sep	1.5	13.06	0.44	498.33	239.20	0.00	234.22	0.00	24.92	0.02
	Oct	1.5	13.59	0.44	539.68	259.05	0.00	253.65	0.00	26.98	0.02
	Nov	1.5	45.35	1.51	592.67	284.48	0.01	278.55	0.01	29.63	0.05
	Dec	1.5	27.53	0.89	525.81	252.39	0.00	247.13	0.00	26.29	0.03

grit chamber stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	2429.8	78.4	233.2	0.3	228.3	0.3	24.29	3.2
	Feb	2355.1	84.1	208.7	0.4	204.4	0.4	21.74	3.9
	Mar	2340.6	75.5	231.6	0.3	226.8	0.3	24.13	3.1
	Apr	2194.3	73.1	281.9	0.3	276.0	0.3	29.37	2.5
	May	2259.1	72.9	246.8	0.3	241.7	0.3	25.71	2.8
	Jun	2501.9	83.4	201.3	0.4	197.1	0.4	20.97	4.0
	Jul	2157.2	69.6	196.5	0.4	192.4	0.4	20.47	3.4
	Aug	1847.6	59.6	199.3	0.3	195.1	0.3	20.76	2.9
	Sep	1723.1	57.4	239.2	0.2	234.2	0.2	24.92	2.3
	Oct	1996.8	64.4	259.0	0.2	253.6	0.3	26.98	2.4
	Nov	2094.2	68.8	284.5	0.2	278.6	0.2	29.63	2.3
	Dec	1856.9	59.9	252.4	0.2	247.1	0.2	26.29	2.3

reactor stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	12190.0	393.2	233.2	1.7	228.3	1.7	24.29	16.2
	Feb	13081.2	467.2	208.7	2.2	204.4	2.3	21.74	21.5
	Mar	15898.6	512.9	231.6	2.2	226.8	2.3	24.13	21.3
	Apr	15392.4	513.1	281.9	1.8	276.0	1.9	29.37	17.5
	May	15239.3	491.6	246.8	2.0	241.7	2.0	25.71	19.1
	Jun	14616.4	487.2	201.3	2.4	197.1	2.5	20.97	23.2
	Jul	15103.5	487.2	196.5	2.5	192.4	2.5	20.47	23.8
	Aug	14245.3	459.5	199.3	2.3	195.1	2.4	20.76	22.1
	Sep	13205.1	440.2	239.2	1.8	234.2	1.9	24.92	17.7
	Oct	14266.5	460.2	259.0	1.8	253.6	1.8	26.98	17.1
	Nov	12788.1	426.3	284.5	1.5	278.6	1.5	29.63	14.4
	Dec	13505.9	435.7	252.4	1.7	247.1	1.8	26.29	16.6

final clarifier stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	2975.0	96.0	233.2	0.4	228.3	0.4	24.29	4.0
	Feb	2561.5	91.5	208.7	0.4	204.4	0.4	21.74	4.2
	Mar	3009.2	97.1	231.6	0.4	226.8	0.4	24.13	4.0
	Apr	2377.2	79.2	281.9	0.3	276.0	0.3	29.37	2.7
	May	2450.4	79.0	246.8	0.3	241.7	0.3	25.71	3.1
	Jun	2145.5	71.5	201.3	0.4	197.1	0.4	20.97	3.4
	Jul	2508.0	80.9	196.5	0.4	192.4	0.4	20.47	4.0
	Aug	1808.9	58.4	199.3	0.3	195.1	0.3	20.76	2.8
	Sep	2160.1	72.0	239.2	0.3	234.2	0.3	24.92	2.9
	Oct	2360.5	76.1	259.0	0.3	253.6	0.3	26.98	2.8
	Nov	2167.6	72.3	284.5	0.3	278.6	0.3	29.63	2.4
	Dec	2015.3	65.0	252.4	0.3	247.1	0.3	26.29	2.5

disinfection stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	6.7	0.2	233.2	0.0	228.3	0.0	24.29	0.0
	Feb	6.6	0.2	208.7	0.0	204.4	0.0	21.74	0.0
	Mar	6.5	0.2	231.6	0.0	226.8	0.0	24.13	0.0
	Apr	6.4	0.2	281.9	0.0	276.0	0.0	29.37	0.0
	May	7.0	0.2	246.8	0.0	241.7	0.0	25.71	0.0
	Jun	6.3	0.2	201.3	0.0	197.1	0.0	20.97	0.0
	Jul	7.2	0.2	196.5	0.0	192.4	0.0	20.47	0.0
	Aug	7.4	0.2	199.3	0.0	195.1	0.0	20.76	0.0
	Sep	8.2	0.3	239.2	0.0	234.2	0.0	24.92	0.0
	Oct	80.8	2.6	259.0	0.0	253.6	0.0	26.98	0.1
	Nov	85.6	2.8	284.5	0.0	278.6	0.0	29.63	0.1
	Dec	79.6	2.6	252.4	0.0	247.1	0.0	26.29	0.1

utility facility stage									
year	month	total load kWh/month	total load kWh/day	BOD removal (kg/day)	total load (KWh/kgBOD)	TSS removal (kg/day)	total load (KWh/kgTSS)	TN removal (kg/day)	total load (KWh/kgTN)
2016	Jan	3115.4	100.5	233.2	0.4	228.3	0.4	24.29	4.1
	Feb	3093.6	110.5	208.7	0.5	204.4	0.5	21.74	5.1
	Mar	3137.6	101.2	231.6	0.4	226.8	0.4	24.13	4.2
	Apr	3031.8	101.1	281.9	0.4	276.0	0.4	29.37	3.4
	May	3438.8	110.9	246.8	0.4	241.7	0.5	25.71	4.3
	Jun	1353.8	45.1	201.3	0.2	197.1	0.2	20.97	2.2
	Jul	1099.1	35.5	196.5	0.2	192.4	0.2	20.47	1.7
	Aug	1783.8	57.5	199.3	0.3	195.1	0.3	20.76	2.8
	Sep	1974.9	65.8	239.2	0.3	234.2	0.3	24.92	2.6
	Oct	1347.7	43.5	259.0	0.2	253.6	0.2	26.98	1.6
	Nov	1654.1	55.1	284.5	0.2	278.6	0.2	29.63	1.9
	Dec	457.9	14.8	252.4	0.1	247.1	0.1	26.29	0.6

garden facility stage									
year	month	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	58.8	1.9	233.2	0.0	228.3	0.0	24.29	0.1
	Feb	3.2	0.1	208.7	0.0	204.4	0.0	21.74	0.0
	Mar	65.8	2.1	231.6	0.0	226.8	0.0	24.13	0.1
	Apr	33.0	1.1	281.9	0.0	276.0	0.0	29.37	0.0
	May	9.4	0.3	246.8	0.0	241.7	0.0	25.71	0.0
	Jun	0.0	0.0	201.3	0.0	197.1	0.0	20.97	0.0
	Jul	8.1	0.3	196.5	0.0	192.4	0.0	20.47	0.0
	Aug	9.0	0.3	199.3	0.0	195.1	0.0	20.76	0.0
	Sep	13.1	0.4	239.2	0.0	234.2	0.0	24.92	0.0
	Oct	13.6	0.4	259.0	0.0	253.6	0.0	26.98	0.0
	Nov	45.4	1.5	284.5	0.0	278.6	0.0	29.63	0.0
	Dec	27.5	0.9	252.4	0.0	247.1	0.0	26.29	0.0

Total plant(2016)															
year	month	total load	total load	total load	total load	constant a	population	water consumption	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		kWh/month	kWh/day	(m3/day)	KWh/ m3	(E/Q)	capita	(l/c/day)	KWh/capita.day	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2016	Jan	20868	673	486	1.4	1.4	6250	78	0.11	233	3	228	3	24	28
	Feb	21179	756	435	1.7	1.7	6250	70	0.12	209	4	204	4	22	35
	Mar	24688	796	483	1.7	1.7	6250	77	0.13	232	3	227	4	24	33
	Apr	23131	771	587	1.3	1.3	6250	94	0.12	282	3	276	3	29	26
	May	23506	758	514	1.5	1.5	6250	82	0.12	247	3	242	3	26	29
	Jun	20680	689	419	1.6	1.6	6250	67	0.11	201	3	197	3	21	33
	Jul	20950	676	409	1.7	1.7	6250	65	0.11	196	3	192	4	20	33
	Aug	19702	636	415	1.5	1.5	6250	66	0.10	199	3	195	3	21	31
	Sep	19127	638	498	1.3	1.3	6250	80	0.10	239	3	234	3	25	26
	Oct	20119	649	540	1.2	1.2	6250	86	0.10	259	3	254	3	27	24
	Nov	18899	629	593	1.1	1.1	6250	95	0.10	284	2	279	2	30	21
	Dec	17971	580	526	1.1	1.1	6250	84	0.09	252	2	247	2	26	22

Calculations for 2020

plant															
year	month	total load	population	water consumption	constant a	total load	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		m3/day	capita	(l/c/day)	(E/Q)	KWh/ m3	(kWh/day)	(kWh/month)	(kWh/capita.day)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2020	Jan	2798	36000	78	1.4	1.1	3102	96160	0.09	1343.2	2.3	1315.2	0.7	139.9	22.2
	Feb	2505	36000	70	1.7	1.4	3485	101078	0.10	1202.2	2.9	1177.2	0.8	125.2	27.8
	Mar	2780	36000	77	1.7	1.3	3670	113764	0.10	1334.2	2.8	1306.4	0.4	139.0	26.4
	Apr	3383	36000	94	1.3	1.1	3553	106589	0.10	1623.8	2.2	1590.0	0.5	169.2	21.0
	May	2962	36000	82	1.5	1.2	3494	108317	0.10	1421.8	2.5	1392.2	0.5	148.1	23.6
	June	2415	36000	67	1.6	1.3	3176	95292	0.09	1159.4	2.7	1135.2	0.6	120.8	26.3
	July	2358	36000	65	1.7	1.3	3114	96539	0.09	1131.8	2.8	1108.2	0.5	117.9	26.4
	Aug	2391	36000	66	1.5	1.2	2929	90787	0.08	1147.8	2.6	1123.9	0.4	119.6	24.5
	Sep	2870	36000	80	1.3	1.0	2938	88138	0.08	1377.8	2.1	1349.1	0.4	143.5	20.5
	OCT	3109	36000	86	1.2	1.0	2991	92709	0.08	1492.1	2.0	1461.0	0.4	155.4	19.2
	Nov	3414	36000	95	1.1	0.8	2898	86930	0.08	1638.6	1.8	1604.5	0.5	170.7	17.0
	Dec	3029	36000	84	1.1	0.9	2671	82811	0.07	1453.8	1.8	1423.5	0.0	151.4	17.6

Calculations for 2025

plant														
year	month	total load	population	water consumption	constant a	total load	total load	total load	BOD removal	total load	TSS removal	total load	TN removal	total load
		m3/day	capita	(l/c/day)	(E/Q)	KWh/ m3	(kwh/day)	(kWh/month)	(kg/day)	(KWh/kgBOD)	(kg/day)	(KWh/kgTSS)	(kg/day)	(KWh/kgTN)
2025	Jan	4694.9	60400	78	1.4	1.0	4879.1	151252.3	2253.5	2.2	2206.6	2.2	234.7	20.8
	Feb	4202.2	60400	70	1.7	1.3	5482.3	158986.6	2017.1	2.7	1975.0	2.8	210.1	26.1
	Mar	4663.7	60400	77	1.7	1.2	5772.3	178940.8	2238.6	2.6	2191.9	2.6	233.2	24.8
	Apr	5676.0	60400	94	1.3	1.0	5588.5	167654.9	2724.5	2.1	2667.7	2.1	283.8	19.7
	May	4969.8	60400	82	1.5	1.1	5495.9	170373.2	2385.5	2.3	2335.8	2.4	248.5	22.1
	June	4052.4	60400	67	1.6	1.2	4996.2	149885.7	1945.2	2.6	1904.6	2.6	202.6	24.7
	July	3956.0	60400	65	1.7	1.2	4898.3	151847.2	1898.9	2.6	1859.3	2.6	197.8	24.8
	Aug	4012.1	60400	66	1.5	1.1	4606.5	142800.3	1925.8	2.4	1885.7	2.4	200.6	23.0
	Sep	4815.9	60400	80	1.3	1.0	4621.1	138633.4	2311.6	2.0	2263.5	2.0	240.8	19.2
	OCT	5215.5	60400	86	1.2	0.9	4704.0	145822.8	2503.4	1.9	2451.3	1.9	260.8	18.0
	Nov	5727.6	60400	95	1.1	0.8	4557.8	136732.9	2749.2	1.7	2692.0	1.7	286.4	15.9
	Dec	5081.4	60400	84	1.1	0.8	4201.8	130255.5	2439.1	1.7	2388.3	1.8	254.1	16.5