# METHOD AND SYSTEM FOR OPTIMIZING ENERGY UTILIZATION IN A WASTE-WATER TREATMENT PLANT

## TECHNICAL FIELD

**[001]** The present disclosure generally relates to use of renewable energy in waste-water treatment plants and more particularly, to a method and system for optimizing energy utilization in a waste-water treatment plant.

## BACKGROUND

**[002]** Waste-water treatment plants (WWTP) are used to treat waste-water using physical, chemical, biological processes, or a combination thereof to a desirable quality for reuse. Generally, WWTPs employing physical processes to treat waste-water consume high amounts of energy to remove pollutants from the waste-water which is mostly purchased from the grid. As such, energy forms the major component of operational expense (i.e., OPEX), for example almost 20% to 50% in operating WWTPs. Moreover, the source of grid energy is usually fossil fuel incineration which results in greenhouse gas (GHG) emission thereby contributing to global warming. Therefore, reducing dependency on grid energy is required to help address environmental concerns and ensure long-term operational sustainability.

**[003]** Conventionally, operational strategies integrate use of renewable energy along with grid energy for reducing energy consumed from the grid. More specifically, solar energy is used along with grid energy to operate WWTP. In such cases, even though the dependency on grid energy is reduced, total energy consumed for operating the WWTP remain the same. In general, such techniques provide optimized scheduling strategies for operating the WWTP while considering peak electricity price avoidance to reduce the operational costs. Such scheduling strategies resulted in a peak shift of the operating schedule of the WWTP thereby reducing operational costs for operating the WWTP. Although this reduces costs incurred in operating the WWTP, the total energy required for operation of WWTPs still remains high and as such, has environmental impacts. Moreover, scheduling strategies include operation of WWTPs at off-peak hours and in such cases, solar energy has to be stored for use during the operation of the WWTP. This results in an increase in battery size for storing the solar energy thereby resulting in increased capital expenditure (i.e., CAPEX) for procuring and maintaining the battery.

**[004]** In view of the above discussion, there is a need to achieve energy neutrality whilst reducing overall energy consumption of the WWTP thereby decreasing carbon footprint of WWTPs by reducing GHG emission.

## SUMMARY

**[005]** In an embodiment, a method for operating a waste-water treatment plant (WWTP) is disclosed. The method includes receiving, by a processor, waste-water treatment plant related data, water demand data and solar data. The method includes obtaining, by the processor, one or more data prediction models comprising at least one of: a solar profile prediction model, an energy profile prediction model, an effluent profile prediction model, and a water demand prediction model. The method includes determining, by the processor, an optimized usage of the WWTP using one or more objective functions derived based, at least in part, on the one or more data prediction models. The method includes determining, by the processor, one or more control parameters for operating the WWTP based, at least in part, on the optimized usage of the WWTP.

**[006]** In another embodiment, a system for operating a waste-water treatment plant (WWTP) is disclosed. The system includes a memory configured to store instructions and a processor configured to execute the instructions stored in the memory and thereby cause the system to receive waste-water treatment plant related data, water demand data and solar data. The system is caused to obtain one or more data prediction models comprising at least one of: a solar profile prediction model, an energy profile prediction model, an effluent profile prediction model, and a water demand prediction model. The system is caused to determine an optimized usage of the WWTP using one or more objective functions derived based, at least in part, on the one or more data prediction models. The system is caused to determine one or more control parameters for operating the WWTP based, at least in part, on the optimized usage of the WWTP.

**[007]** The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[008]** The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, serve to explain the disclosed principles. The same numbers are used throughout the figures to reference like features and components. Some embodiments of device and/or methods in accordance with embodiments of the present subject matter are now described, by way of example only, and with reference to the accompanying figures, in which:

**[009]** **FIG. 1** illustrates an example representation of an environment, in which at least some example embodiments of the disclosure can be implemented;

**[010]** **FIG. 2** illustrates a system for optimizing energy utilization in a waste-water treatment plant, in accordance with an embodiment of the present disclosure;

**[011]** **FIGS. 3A, 3B** and **3C** illustrate a first objective function, a second objective function and a third objective function, respectively derived based on data prediction models, in accordance with an embodiment of the present disclosure;

**[012]** **FIG. 4** illustrates a graph plot depicting reduction in total energy consumed by the WWTP when solar energy is efficiently integrated with grid energy, in accordance with an embodiment of the present disclosure;

**[013]** **FIG. 5** is a flowchart illustrating a method for optimizing energy utilization in a waste-water treatment plant, in accordance with an embodiment of the present disclosure; and

**[014]** **FIG. 6** shows a block diagram of a general-purpose computer for optimizing energy utilization in a waste-water treatment plant, in accordance with an embodiment of the present disclosure.

**[015]** It should be appreciated by those skilled in the art that any block diagrams herein represent conceptual views of illustrative systems embodying the principles of the present subject matter. Similarly, it will be appreciated that any flow charts, flow diagrams, state transition diagrams, pseudo code, and the like represent various processes which may be substantially represented in computer readable medium and executed by a computer or processor, whether or not such computer or processor is explicitly shown.

## DETAILED DESCRIPTION

**[016]** In the present document, the word “exemplary” is used herein to mean “serving as an example, instance, or illustration”. Any embodiment or implementation of the present subject matter described herein as “exemplary” is not necessarily to be construed as preferred or advantageous over other embodiments.

**[017]** While the disclosure is susceptible to various modifications and alternative forms, specific embodiment thereof has been shown by way of example in the drawings and will be described in detail below. It should be understood, however that it is not intended to limit the disclosure to the particular forms disclosed, but on the contrary, the disclosure is to cover all modifications, equivalents, and alternative falling within the spirit and the scope of the disclosure.

**[018]** The terms “comprises”, “comprising”, or any other variations thereof, are intended to cover a non-exclusive inclusion, such that a setup, device, or method that comprises a list of components or steps does not include only those components or steps but may include other components or steps not expressly listed or inherent to such setup or device or method. In other words, one or more elements in a device or system or apparatus proceeded by “comprises… a” does not, without more constraints, preclude the existence of other elements or additional elements in the device or system or apparatus.

**[019]** In the following detailed description of the embodiments of the disclosure, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration specific embodiments in which the disclosure may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosure, and it is to be understood that other embodiments may be utilized and that changes may be made without departing from the scope of the present disclosure. The following description is, therefore, not to be taken in a limiting sense.

**[020]** The term ‘waste-water’ as used herein refers to water that is contaminated or polluted. More specifically, water contaminated with a specific level of impurities and unfit for a particular use is waste-water. Some sources of waste-water include, but not limited to, rain water, domestic sewage, industrial sewage, and agricultural waste. In general, sewage generated from any domestic, industrial processes, or any other form of settlements which are collected and treated in a WWTP is waste-water. Further, the term ‘optimizing energy

utilization' refers to efficiently reducing total energy consumed by the WWTP for treating waste-water. More specifically, the total energy is an aggregation of the solar energy and the grid energy required for operating the WWTP which is significantly reduced. Such optimization in energy utilization for operating the WWTP may be achieved by efficiently integrating the use of solar energy in the WWTP and minimizing pollutants in effluent of the WWTP to reduce dependency on the grid as will be explained in detail with reference to **FIGS. 1-5**.

**[021]** **FIG. 1** illustrates a simplified representation of an environment **100**, in which at least some example embodiments of the disclosure can be implemented. The environment **100** exemplarily depicts waste-water from houses **102**, industries **104,** rain water **106** and agricultural lands **108** flowing into a Waste-Water Treatment Plant (WWTP) **110**. Houses **102** may be a source of domestic sewage which include food scraps, chemicals, human waste and used water from sinks, toilets, washing machines, showers, and the like. Industrial wastes obtained from manufacturing and/or chemical processes are released by the industries **104** as industrial sewage to WWTPs such as, WWTP **110**. Rain water **106** is usually run-off water which collects pollutants as it flows through roofs, pavements, gutters, streets, pipes, open channels, waste-lands and landfills. Surface run-off water from agricultural lands **108** carries silts, animal wastes, pesticides, and fertilizers to nearby water bodies which is also a source of contaminated water. The waste-water from the houses **102**, the industries **104,** rain water **106** and the agricultural lands **108** include pollutants such as, but not limited to, sand, dissolved solids, suspended solids, sediments, excessive nutrients, pathogenic microorganisms, oil, microplastics, fuel residues from automobiles, organic and inorganic chemical compounds, and the like. It shall be noted that the environment **100** is shown for exemplary purposes and as such, only elements essential to the invention are disclosed and other elements are not disclosed. However a person skilled in the art will understand that various other elements may be included in the WWTP **110**.

**[022]** The WWTP **110** treats or purifies the waste-water through a combination of physical, chemical, and biological processes to remove the pollutants from the waste-water and ensures treated water (i.e., effluent) may be reused for purposes **116** such as, agricultural irrigation, industrial processes, non-potable urban applications (such as toilet flushing, and fire protection), groundwater recharge, and the like. More specifically, the WWTP **110** treats the waste-water to remove as much pollutants as possible prior to reusing in the environment **100**.

The treatment of waste-water in the WWTP **110** involves aeration of the waste-water to allow aerobic biodegradation of organic materials in the waste-water. In general, oxygen provided by aeration in the WWTP **110** is utilized by bacteria in the wate-water to break the organic materials comprising carbon to form carbon dioxide and water that may be reused.

**[023]** Generally, the WWTP **110** employs pumps and blowers for aeration and such physical processes to treat waste-water consume high amounts of energy to remove pollutants from the waste-water. However, the claimed invention is not limited to WWTP **110** using physical process alone and can be applied to any WWTP **110** which consumes energy from the grid **112**. The energy for operating the WWTP **110** is mostly purchased from the grid **112**. In addition, renewable energy such as and not limited to, solar energy stored by photovoltaic panels **114** may be used for operating the WWTP **110**. As energy forms the major component of operational expense (i.e., OPEX) in operating WWTPs, efficient utilization of energy by the WWTP **110** to treat waste-water must be ensured. The renewable energy source, for example, solar energy needs to be effectively utilized along with grid energy to reduce total energy consumption of the WWTP **110**.

**[024]** Various embodiments of the present disclosure disclose a system **150** employing a method for optimizing energy utilization in the WWTP **110**. More specifically, the system **150** generates optimal control parameters for the WWTP **110** such that total energy for operating the WWTP **110** reduces. More specifically, an energy peak of the WWTP **110** is shifted to off-peak hours which in addition to process optimization leads to reduction in overall energy used by the WWTP **110.** Moreover, the system **150** is configured to efficiently integrate use of solar energy with grid energy to operate the WWTP **110** which reduces the WWTPs dependency on the grid **112** and increases usage of solar power while significantly reducing a size of battery storing solar energy. The system **150** for optimizing energy utilization in WWTP is explained in detail next with reference to **FIG. 2**.

**[025]** **FIG. 2** illustrates the system **150** for optimizing energy utilization in a waste-water treatment plant, in accordance with an embodiment of the present disclosure. In an embodiment, the system **150** is a standalone processor embodied within a control system capable of controlling the operations of the WWTP **110**. In another embodiment, the system **150** may be a remote server capable of receiving parameters related to operation of the WWTP **110** and generating optimized control parameters for operating the WWTP **110**.

**[026]** The system **150** is depicted to include a processor **202**, a memory **204**, an Input/Output module **206,** and a communication interface **208**. It shall be noted that, in some embodiments, the system **150** may include more or fewer components than those depicted herein. The various components of the system **150** may be implemented using hardware, software, firmware or any combinations thereof. Further, the various components of the system **150** may be operably coupled with each other. More specifically, various components of the system **150** may be capable of communicating with each other using communication channel media (such as buses, interconnects, etc.). It is also noted that one or more components of the system **150** may be implemented in a single server or a plurality of servers, which are remotely placed from each other.

**[027]** In one embodiment, the processor **202** may be embodied as a multi-core processor, a single core processor, or a combination of one or more multi-core processors and one or more single core processors. For example, the processor **202** may be embodied as one or more of various processing devices, such as a coprocessor, a microprocessor, a controller, a digital signal processor (DSP), a processing circuitry with or without an accompanying DSP, or various other processing devices including, a microcontroller unit (MCU), a hardware accelerator, a special-purpose computer chip, or the like. The processor **202** includes a model management module **210**, a prediction module **212** and a process optimization module **214** which are explained in detail later.

**[028]** In one embodiment, the memory **204** is capable of storing machine executable instructions, referred to herein as instructions **205**. In an embodiment, the processor **202** is embodied as an executor of software instructions. As such, the processor **202** is capable of executing the instructions **205** stored in the memory **204** to perform one or more operations described herein. The memory 2**04** can be any type of storage accessible to the processor **202** to perform respective functionalities, as will be explained in detail with reference to **FIGS. 2** to **5**. For example, the memory **204** may include one or more volatile or non-volatile memories, or a combination thereof. For example, the memory **204** may be embodied as semiconductor memories, such as flash memory, mask ROM, PROM (programmable ROM), EPROM (erasable PROM), RAM (random access memory), etc. and the like.

**[029]** In an embodiment, the processor **202** is configured to execute the instructions **205** for: (1) generating one or more data prediction models, (2) predicting solar energy profile for a day, (3) predicting energy demand profile for a day, (4) predicting water demand profile for a day,

(5) determining a first set of parameters for a first objective function based on a first set of constraints, (6) determining a second set of parameters for a second objective function based on a second set of constraints, (7) optimizing one or more objective functions such as, the first objective function and the second objective function, (8) determining an optimized usage of the WWTP based on the one or more objective function, (3) determining one or more control parameters for operating the WWTP based on the optimized usage.

**[030]** In an embodiment, the I/O module **206** may include mechanisms configured to receive inputs from and provide outputs to peripheral devices such as, devices tracking WWTP related data, and/or an operator of the system **150**. The term 'operator of the system **150**' as used herein may refer to one or more individuals, whether directly or indirectly, associated with managing the WWTP **110**. To enable reception of inputs and provide outputs to the system **150**, the I/O module **206** may include at least one input interface and/or at least one output interface. Examples of the input interface may include, but are not limited to, a keyboard, a mouse, a joystick, a keypad, a touch screen, soft keys, a microphone, and the like. Examples of the output interface may include, but are not limited to, a display such as a light emitting diode display, a thin-film transistor (TFT) display, a liquid crystal display, an active-matrix organic light-emitting diode (AMOLED) display, a microphone, a speaker, a ringer, and the like.

**[031]** In an embodiment, the communication interface **208** may include mechanisms configured to communicate with other entities in the environment **100**. In other words, the communication interface **208** is configured to collate data for processing by the processor **202**. For example, the communication interface **208** is configured to receive water and solar data. The waste-water treatment plant related data includes, but not limited to, influent data, effluent data, and WWTP component data. The influent data includes information related to amount of waste-water generated, flow rate and concentration of waste-water quality parameters such as, Chemical Oxygen Demand (COD), Total Kjeldahl Nitrogen (TKN) i.e., a measure of organic nitrogen and ammonia, Total suspended solids (TSS), Biological Oxygen Demand (BOD), Ammonium ($NH_4$), nitrate ($NO_3$), total phosphorus (TP), phosphate ($PO_4$), etc. The influent data depend on many factors such as, but not limited to, a storage capacity, a type of sewer system, a number of person equivalents, type of industrial discharge, a soil type in specific region, rainfall patterns, temperature, and the like. The effluent data includes information related to flow rate and concentration of waste-water quality parameters in the effluent such as, dissolved oxygen, carbonaceous biochemical Oxygen Demand, TKN, TSS, $NH_4$, $NO_3$, $PO_4$,

total phosphorus, etc. The WWTP component data includes information related to components in the WWTP **110**, such as, number of pumps, number of aerators, number of blowers, maximum operating speed of pumps, maximum operating speed of aerators, maximum operating speed of blowers, efficiency of pumps, efficiency of aerators, efficiency of blowers, etc.

**[032]** The water demand data includes information related to historical values of recycled water demand over different periods of time, for example, water demand for specific days (i.e., weekday/weekend), water demand for specific months (i.e., monsoon/summer) or water demand for specific time in a day (i.e., morning, afternoon, evening), and the like. The solar data includes information related to historical values of solar irradiation, number of photovoltaic cells, capacity of the photovoltaic cells and historical weather data. The historical values of solar irradiation may include values of solar irradiation measured over a period of time, for example, years, months, days or specific time. In one illustrative example, solar irradiation measured over a specific time, for example, 9 AM to 2 PM for the past one month may constitute historical values of solar irradiation. In another illustrative example, solar irradiation values measured for an entire day in a past year for the same month constitutes historical values of solar irradiation. In an embodiment, the waste-water treatment plant related data and the solar data are forwarded to the processor **202** which performs one or more operations described herein to optimize energy utilization in the WWTP **110**.

**[033]** The system **150** is depicted to be in operative communication with a database **220**. In one embodiment, the database **220** is configured to store one or more data prediction models in a data prediction model pool **222**. More specifically, the data prediction models include at least one of: a solar profile prediction model, an energy profile prediction model, an effluent profile prediction model, and a water demand prediction model. In an example, an energy profile prediction model may correspond to a model used for energy profile prediction during summer. In another illustrative example, the solar profile prediction model may correspond to a model generated for a specific month, for example, month of December. Accordingly, the database **220** is configured to store a variety of prediction models based on different specifications. Further, the database **220** may also include a historical profile pool **224** which includes historical information related to solar energy profiles, energy demand profiles, and water demand profiles predicted for different periods of time, for example, profiled determined for a day, a month, a year, etc. In an embodiment, the historical profile pool **224** includes

historical values of solar irradiation, historical weather data, historical water demand data, historical influent data, historical effluent data, historical WWTP component data which may be used for updating the data prediction models or for analysis of working profile of the WWTP **110**.

**[034]** The database **220** may include multiple storage units such as hard disks and/or solid-state disks in a redundant array of inexpensive disks (RAID) configuration. In some embodiments, the database **220** may include a storage area network (SAN) and/or a network attached storage (NAS) system. In one embodiment, the database **220** may correspond to a distributed storage system, wherein individual databases are configured to store custom information, such as scheduling policies, list of WWTP components, specification of WWTP components, etc.

**[035]** In some embodiments, the database **220** is integrated within the system **150**. For example, the system **150** may include one or more hard disk drives as the database **220**. In other embodiments, the database **220** is external to the system **150** and may be accessed by the system **150** using a storage interface (not shown in **FIG. 2**). The storage interface is any component capable of providing the processor **202** with access to the database **220**. The storage interface may include, for example, an Advanced Technology Attachment (ATA) adapter, a Serial ATA (SATA) adapter, a Small Computer System Interface (SCSI) adapter, a RAID controller, a SAN adapter, a network adapter, and/or any component providing the processor **202** with access to the database **220**.

**[036]** As already explained, the communication interface **208** is configured to receive waste-water treatment plant related data and solar data. The communication interface **208** forwards the waste-water treatment plant related data and the solar data to the processor **202**. The modules of the processor **202** in conjunction with the instructions in the memory **204** are configured to process the waste-water treatment plant related data and the solar data for determining control parameters for efficiently operating the WWTP **110**. The processor **202** is configured to forward the waste-water treatment plant related data and the solar data to the model management module **210**.

**[037]** In an embodiment, the model management module **210** in conjunction with the instructions **205** in the memory **204** is configured to generate one or more data prediction models based on the waste-water treatment plant related data and the solar data. The one or

more data prediction models may be generated using deep learning, machine learning, statistical modeling and other techniques known in the art. Some examples of the data prediction models include, but not limited to, a solar profile prediction model, an energy profile prediction model, an effluent profile prediction model, and a water demand prediction model. These data prediction models may be used for predicting as will be explained in detail later.

**[038]** In an embodiment, solar profile prediction model is generated based on the solar data. More specifically, historical values of solar irradiation, number of photovoltaic cells, capacity of the photovoltaic cells and historical weather data from defined time intervals may be used to generate solar profile prediction model. In an embodiment, the energy profile prediction model may be generated based at least on WWTP component data. In an example, an energy profile prediction model may be generated based on the WWTP component data collated over a past month/season and another energy profile prediction model may be generated based on WWTP component data collated from a previous day. In an embodiment, the effluent profile prediction model is generated based on the influent data and the effluent data. For example, a first effluent profile prediction model is generated for monsoon seasons and a second effluent profile prediction model is generates for summer season due to difference in rainfall, influent and effluent concentrations.

**[039]** In an embodiment, the water demand prediction model is generated based on storage capacity of the WWTP, amount of waste-water generated, flow rate of the influent, flow rate of the effluent, and the water demand data. It shall be noted that two different data prediction models described above may be combined to generate a single data prediction model. In one illustrative example, the effluent profile prediction model and water demand prediction model may be combined to generate a data prediction model that predicts effluent profile based on the water demand data. Further, the data prediction models described above are for exemplary purposes and the one or more data prediction models may include more data prediction models than those described herein. For example, a data prediction model may be generated based on weather conditions alone to optimally operate the WWTP **110** based on weather prediction. The processor **202** is configured to store the data prediction models in the data prediction model pool **222** of the database **220**.

**[040]** In an embodiment, the model management module **210** is configured to monitor a performance of each data prediction model of the one or more data prediction models at a predefined time. The term ‘performance’ as used herein refers to metrics that indicate an

efficiency of the data prediction model. Some examples of performance measures determined for the data prediction models include, but not limited to, accuracy (e.g., root mean squared error, average error, median error, average absolute error, coefficient determination, mean absolute error, mean percentage error and relative square error), precision, recall, specificity, receiver operating characteristics (ROC) curve, and the like.

**[041]** As such, the performance of each data prediction model is compared with a threshold to determine a deviation in performance. In an example, the performance of the water demand profile prediction model may be determined as a numerical difference between predicted water demand value and actual water demand value as an average error. The actual water demand value may be determined based on an amount of treated water consumed or reused from the WWTP **110**. When this average error indicating the performance deviates from the threshold, for example, exceeds an average threshold value that may be predefined, a deviation in performance is observed. In an embodiment, the performance of the data prediction models may be determined at predefined times. More specifically, the data prediction models may be evaluated to determine the performance in different time intervals, for example, every hour, every day or any such time interval as may be predefined by the operator of the system **150** for efficient working of the system **150**.

**[042]** In an embodiment, the data prediction model with the deviation in performance is updated to meet the threshold. In general, the data prediction model may be updated with corresponding data, for example, solar data, influent data, effluent data, WWTP component data, respectively to meet the performance requirements. In one illustrative example, the solar profile prediction model may be generated based on solar data collated over a previous month and may indicate a deviation in performance. In such cases, the solar profile prediction model is updated with solar data collated till a preceding day to ensure the performance of the solar prediction model is updated to meet the threshold.

**[043]** In an embodiment, the prediction module **212** is configured to obtain the one or more data prediction models from the database **220.** The prediction module **212** in conjunction with the instructions stored in the memory **204** and the data prediction models stored in the pool **222** is configured to predict data profiles for a day. For example, the solar profile prediction model predicts the solar profile for a day based on the solar data, the energy demand profile prediction model predicts an energy demand profile for a day based on the WWTP component data, the water demand prediction model predicts the water demand profile for the day based on a

storage capacity in the WWTP, and amount of waste-water and the water demand data, and the effluent profile prediction model predicts the effluent profile for a day based on influent data and effluent data. It shall be noted that a data prediction model may be selected for predicting the data profile based on inputs received from the operator of the system **150**. For example, if the WWTP **110** is to be operated on cloudy day, the solar profile prediction model generated for cloudy days may be obtained from the database **220** based on inputs provided by the operator via the I/O module **206**.The predicted profiles (i.e., the solar profile, energy demand profile, water demand profile and the effluent profile) are forwarded to the process optimization module **214**.

**[044]** The process optimization module **214** in conjunction with the instructions stored in the memory **204** is configured to determine an optimized usage of the WWTP **110**. The term 'optimized usage of the WWTP' as used herein indicates making efficient use of the WWTP **110** by maximizing use of solar energy, minimizing pollutants in the effluent and minimizing overall energy used by the WWTP. In other words, the WWTP is operated in an efficient manner to increasingly use the solar energy and reduce the total energy consumed while operating the WWTP as will be explained hereinafter.

**[045]** In an embodiment, the optimized usage of the WWTP is determined using one or more objective functions. The objective of the one or more objective functions formulated is to optimize the energy usage in a WWTP **110** and maximize usage of solar energy generated whilst meeting effluent permits and thus, reduce grid consumption to achieve net zero. As such, the one or more objective functions may be formulated as a minimizing problem or a max-min problem for optimizing energy usage in the WWTP **110.** In an embodiment, the one or more objective functions are derived based on the one or more data prediction models. In a non-limiting embodiment, the optimized usage of the WWTP **110** may be determined using two objective functions, such as, a first objective function **310** (shown in **FIG. 3A**) and a second objective function **340** (shown in **FIG. 3B)**, as a min-max problem. More specifically, the first objective function is associated with a first set of parameters related to at least: a solar energy profile, an energy demand profile, and a water demand profile for maximizing use of solar energy. An example of the first objective function $f_1(x)$ for maximizing use of solar energy is shown below by Equation (1):

$$f_1(x) = \max \begin{matrix}(f(S_t, N_p, Efficiency_{pump}, storage\ available,\\ transition\ state,\\ amount\ of\ waste\ water\ generated,\\ demand\ for\ recycled\ water)\end{matrix} \quad \text{---------- Equation (1)}$$

Where, $S_t$ is the solar profile

$N_p$ is the number of pumps in the WWTP

**[046]** The parameters in the first objective function **310** are solar profile, number of pumps, efficiency of the pumps, storage available, transition state, amount of waste water generated and demand for recycled water. In an embodiment, the first set of parameters (for example, the parameters in Equation (1)) are determined based on a first set of constraints. The first set of constraints are related to at least water storage constraints and water demand constraints and may be specified by the operator of the system **150** (i.e., an operator of the WWTP **110**). In an embodiment, each parameter of the first set of parameters may be indicated as a range of values that may be possible for parameter based on the first set of constraints. The first set of constraints for determining parameters of the first objective function **310** is as shown below by Equations (2) and (3).

$$l_{min}^m \leq l_t^m \leq l_{max}^m \quad \text{---------- Equation (2)}$$

$$Q_t^{min} \leq q_t \leq Q_t^{max} \quad \text{---------- Equation (3)}$$

**[047]** Equation (2) specifies the storage constraints and Equation (3) specifies the water demand constraints in which

$l_{min}^m$: Minimum level in a tank 'm'

$l_t^m$ : level in tank 'm' at timestep 't'

$l_{max}^m$: Maximum level in tank 'm'

$Q_t^{max}$: Maximum required demand for treated water

$Q_t^{\min}$: Minimum required demand for treated water

$q_t$: Discharge of treated water at timestep 't'

**[048]** In an example, the number of pumps and efficiency of pumps may be determined based on the storage constraints and water demand constraints for the day. For example, if the water demand constraint indicates a low demand for treated water, only a select set of pumps (e.g., 10 pumps of 50 available pumps) may be used for operating the WWTP **110**. In an

embodiment, the second objective function **340** is associated with a second set of parameters related to at least: an influent flowrate, a returned sludge flow, a pH of effluent, an average temperature, an average airflow rate, and an effluent profile for minimizing pollutants in the effluent and minimizing overall energy used by the WWTP (see, **FIG. 3B**). An example of the second objective function $f_2(x)$ for minimizing amount of energy used and minimizing amount of pollutants in the effluent is shown below by Equation (4).

$$f_2(x) = Min\ (f(w_1y_1, w_2y_2, w_3y_3, w_4y_4, w_5y_5)) \text{ ---------- Equation (4)}$$

Where

$y_1$ : dissolved oxygen

$y_2$: effluent-carbonaceous Biochemical Oxygen Demand

$y_3$ : Effluent-Total suspended solids

$y_4$ : Effluent- Total Phosphorus

$y_5$ : Effluent- Total K-Nitrogen

$w_i$: Weights ($0 \leq w_i \leq 1$)

**[049]** More specifically, the second objective function **340** include parameters that minimize the amount of energy used for aeration (i.e., minimize the dissolved oxygen levels) and minimize the amount of pollutants in the effluent. In an embodiment, the second set of parameters are determined based on a second set of constraints related to an amount of dissolved oxygen and effluent concentration. In general, key pollutants in the effluents of the WWTP **110** are determined based on norms, type of WWTP and end use of treated water. Accordingly, the dissolved oxygen limits or a range of values possible for the second set of parameters are determined using mathematical and empirical methods for specifying the second set of constraints. As such, optimal parameters from a global minima that ensure the optimized usage of the WWTP is determined using the one or more objective functions. In an embodiment, the one or more objective functions may be solved using machine learning models, neural network models or statistical models for determining optimized usage of the WWTP **110.** It shall be noted that the first objective function **310** and the second objective function **340** represented by Equation (1) and (2) are for exemplary purposes and the first objective function **310** and the second objective function **340** may include fewer or more parameters than those depicted in corresponding equations. For example, the second objective function may not include weight values as shown by Equation (4).

**[050]** It shall be noted that a single objective function may be utilized to optimize energy utilization in a waste-water treatment plant. In one embodiment, the third objective function **360** is a combination of the first objective function **310** and the second objective function **340** (see, **FIG. 3C**). Accordingly, the third objective function **360** is a min-max problem associated with a third set of parameters related to at least: a solar energy profile, an energy demand profile, a water demand profile, an influent flowrate, a returned sludge flow, a pH of effluent, an average temperature, an average airflow rate, and an effluent profile. Moreover, the third set of parameters for the third objective function **360** are determined based on a third set of constraints which in essence is a combination of the first set of constraints and the second set of constraints. Further, it shall be noted that use of a single objective function (i.e., the third objective function) or two objective functions (i.e., the first objective function and the second objective function) for solving the optimization problem are for exemplary purposes and more than two objective functions may be formulated based on different data profiles or various combination of data profiles for determining optimized usage of the WWTP **110**.

**[051]** In an embodiment, the process optimization module **214** is configured to determine one or more control parameters for operating the WWTP **110** based on the optimized usage of the WWTP **110**. More specifically, the control parameters specify values for operating various components of the WWTP **110** based on the optimal parameters for optimized usage of the WWTP **110**. In an embodiment, the one or more control parameters for operating the WWTP **110** includes at least one of: a schedule for operating components of the WWTP **110**, a number of components of the WWTP **110**, a rate of operating the components of the WWTP **110**, and water quality control points. The water quality control points indicate critical limits for pollutants in the effluent, for example, maximum/minimum turbidity. In one illustrative example, the control parameter may indicate number of pumps/blowers/aerators that need to be turned on for specific period of time (for example, pumps A, B, C and blowers C, D and E) and the rate at which the pumps/blowers/aerators need to be operated (for example, pump A at constant speed of ‘x’ rpm, pump B at ‘x’ rpm for 2 hours and the ‘y’ rpm for the remaining hours, blower C at ‘y’ rpm for 5 hours, etc.). A plot depicting integration of solar energy along with grid energy for optimizing energy utilization in the WWTP **110** is shown and explained next with reference to **FIG. 4**.

**[052]** **FIG. 4** illustrates a graph plot **400** depicting reduction in total energy consumed by the WWTP **110** when solar energy is efficiently integrated with grid energy for operating the

WWTP, in accordance with an embodiment of the present disclosure. A plot **402** represents power drawn from the grid and plot **404** represents solar energy used by the WWTP. The total energy drawn by WWTP in conventional techniques is exemplarily depicted by **406**. It shall be noted that the plot **400** is shown for exemplary purposes to represent energy reduction achieved by efficient integration of solar energy with grid energy and process optimization achieved by optimizing objective functions.

**[053]** As already explained with reference to **FIG. 2**, one or more objective functions are optimized to determine an optimized usage of the WWTP. In other words, the optimal usage of the WWTP ensures maximizing the usage of solar energy, minimizing the effluents and minimizing the overall amount of energy consumed for operating the WWTP. The optimized usage of the WWTP may be achieved by effectively integrating solar energy with grid energy by process optimization. The process optimization ensures a peak shift for operating the WWTP is implemented by providing optimal schedules for operation. As shown in **FIG. 3**, the operating schedule of the WWTP are determined such that peak of the solar energy (shown by plot **402**) coincides with the peak of the grid energy (shown by plot **404**). More specifically, the optimized operating schedules of the WWTP ensure that peak time for drawing power from the grid is shifted by 't' time period to coincide with peak of solar energy usage thus, maximizing usage of solar energy while reducing energy drawn from the grid (see, reduction in grid energy shown by **408** in **FIG. 4**). Moreover, as apparent from the plot **400**, the process optimization performed by the system **150** (i.e., process optimization module **214**) ensures that total energy used for operating the WWTP is reduced (depicted by **410** in **FIG. 4**) thereby optimizing energy utilization in a waste-water treatment plant by effectively integrating renewable energy (i.e., solar energy with grid energy) with grid energy. In other words, energy drawn from grid alone is reduced (i.e., energy reduction shown by **408** and **410**) by efficient integration of the solar energy and process optimization. It shall be noted that the plot **400** is exemplary and optimization indicates reduction in energy drawn from the grid and overall energy consumption by the WWTP. A method depicting efficient integration of solar energy with grid energy to optimally operate a WWTP for achieving energy efficiency is explained next with reference to **FIG. 5**.

**[054]** **FIG. 5** is a flowchart illustrating a method **500** for operating a waste-water treatment plant (WWTP), in accordance with an embodiment of the present disclosure. The method **500** depicted in the flow diagram may be executed by, for example, the system **150**

shown and explained with reference to **FIGS. 2-4**. Operations of the flow diagram, and combinations of operation in the flow diagram, may be implemented by, for example, hardware, firmware, a processor, circuitry and/or a different device associated with the execution of software that includes one or more computer program instructions. The operations of the method **500** are described herein with help of the system **150**. It is noted that the operations of the method **500** can be described and/or practiced by using one or more processors of a system/device other than the system **150**. The method **500** starts at operation **502.**

**[055]** At operation **502** of the method **500**, waste-water treatment plant related , water demand data and solar data are received by a system such as, the system **150** shown and explained with reference to **FIG. 2**. As already explained, the system **150** may be embodied within a control system configured to control operations of the WWTP or maybe a remote standalone server that provides control parameters to a control system managing operation of the WWTP. The waste-water treatment plant related data includes, but not limited to, influent data, effluent data, and WWTP component data.

**[056]** At operation **504** of the method **500**, one or more data prediction models comprising at least one of: a solar profile prediction model, an energy profile prediction model, an effluent profile prediction model, and a water demand prediction model are obtained. The one or more data prediction models are generated based on the waste-water treatment plant related data and the solar data and stored in a database such as, the database **220.** For example, solar profile prediction model is generated based on the solar data, the energy profile prediction model may be generated based at least on WWTP component data, the water demand prediction model is generated based on storage capacity of the WWTP, amount of waste-water generated, flow rate of the influent, flow rate of the effluent, and the water demand data and the effluent profile prediction model is generated based on the influent data and the effluent data.

**[057]** At operation **506** of the method **500**, an optimized usage of the WWTP is determined using one or more objective functions derived based, at least in part, on the one or more data prediction models. More specifically, the data prediction model are configured to predict data profiles for a day. For example, the solar profile prediction model predicts the solar profile for a day, the energy demand profile prediction model predicts an energy demand profile for a day, the water demand prediction model predicts the water demand profile for the day and the effluent profile prediction model predicts the effluent profile for a day. The predicted profiles

are used for determining parameters of the one or more objective function. In an embodiment, the optimized usage of the WWTP **110** may be determined using two objective functions, such as, a first objective function and a second objective function, as a min-max problem. More specifically, the first objective function is associated with a first set of parameters related to at least: a solar energy profile, an energy demand profile, and a water demand profile for maximizing use of solar energy (*see,* Equation (1)) and the second objective function is associated with a second set of parameters related to at least: an influent flowrate, a returned sludge flow, a pH of effluent, an average temperature, an average airflow rate, and an effluent profile (*see,* Equation (4)) for minimizing pollutants in the effluent and minimizing overall energy used by the WWTP. As such, the first set of parameters are determined based on a first set of constraints and the second set of parameters are determined based on a second set of constraints. As such, the optimized usage of the WWTP is determined by optimizing the objective function (i.e., the first objective function and the second objective function) as a min-max problem. More specifically, optimal parameters that ensure the optimized usage of the WWTP is determined by optimizing the one or more objective functions (for example, the first objective function and the second objective function). In some example embodiment, a single objective function is generated by combining the first set of parameters and the second set of parameters. However, it shall be noted that more than two objective functions may be formulated based on different data profiles or various combination of data profiles for determining optimized usage of the WWTP.

**[058]** At operation **508** of the method **500**, one or more control parameters for operating the WWTP are determined based, at least in part, on the optimized usage of the WWTP. Some example of the one or more control parameters include, but not limited to, a schedule for operating components of the WWTP, a number of components of the WWTP, a rate of operating the components of the WWTP, and water quality control points.

**[059]** The sequence of operations of the method **500** need not be necessarily executed in the same order as they are presented. Further, one or more operations may be grouped together and performed in form of a single step, or one operation may have several sub-steps that may be performed in parallel or in sequential manner.

**[060]** The disclosed method with reference to **FIG. 5**, or one or more operations of the flow diagram **500** may be implemented using software including computer-executable instructions stored on one or more computer-readable media (e.g., non-transitory computer-readable media,

such as one or more optical media discs, volatile memory components (e.g., DRAM or SRAM), or non-volatile memory or storage components (e.g., hard drives or solid-state non-volatile memory components, such as Flash memory components) and executed on a computer (e.g., any suitable computer, such as a laptop computer, net book, Web book, tablet computing device, smart phone, or other mobile computing device). Such software may be executed, for example, on a single local computer

**[061]** **FIG. 6** shows a block diagram of a general-purpose computer for optimizing energy utilization in a waste-water treatment plant, in accordance with an embodiment of the present disclosure. The computer system **600** may comprise a central processing unit ("CPU" or "processor") **602**. The processor **602** may comprise at least one data processor. The processor **602** may include specialized processing units such as integrated system (bus) controllers, memory management control units, floating point units, graphics processing units, digital signal processing units, etc. The computer system **600** may be analogous to the system **150** (shown in **FIG. 2**).

**[062]** The processor **602** may be disposed in communication with one or more input/output (I/O) devices (not shown) via I/O interface **601**. The I/O interface **601** may employ communication protocols/methods such as, without limitation, audio, analog, digital, monoaural, RCA, stereo, IEEE-1394, serial bus, universal serial bus (USB), infrared, PS/2, BNC, coaxial, component, composite, digital visual interface (DVI), high-definition multimedia interface (HDMI), Radio Frequency (RF) antennas, S-Video, VGA, IEEE 802.n /b/g/n/x, Bluetooth, cellular (e.g., code-division multiple access (CDMA), high-speed packet access (HSPA+), global system for mobile communications (GSM), long-term evolution (LTE), WiMax, or the like), etc.

**[063]** Using the I/O interface **601**, the computer system **600** may communicate with one or more I/O devices. For example, the input device **610** may be an antenna, keyboard, mouse, joystick, (infrared) remote control, camera, card reader, fax machine, dongle, biometric reader, microphone, touch screen, touchpad, trackball, stylus, scanner, storage device, transceiver, video device/source, etc. The output device **611** may be a printer, fax machine, video display (e.g., cathode ray tube (CRT), liquid crystal display (LCD), light-emitting diode (LED), plasma, Plasma display panel (PDP), Organic light-emitting diode display (OLED) or the like), audio speaker, etc.

**[064]** In some embodiments, the computer system **600** is connected to the remote devices **612** through a communication network **609**. The remote devices **612** may be peripheral devices tracking WWTP related data. The processor **602** may be disposed in communication with the communication network **609** via a network interface **603**. The network interface **603** may communicate with the communication network **609**. The network interface **603** may employ connection protocols including, without limitation, direct connect, Ethernet (e.g., twisted pair 10/100/1000 Base T), transmission control protocol/internet protocol (TCP/IP), token ring, IEEE 802.11a/b/g/n/x, etc. The communication network **609** may include, without limitation, a direct interconnection, local area network (LAN), wide area network (WAN), wireless network (e.g., using Wireless Application Protocol), the Internet, etc. Using the network interface **603** and the communication network **609**, the computer system **600** may communicate with the remote devices **612**. The network interface **603** may employ connection protocols include, but not limited to, direct connect, Ethernet (e.g., twisted pair 10/100/1000 Base T), transmission control protocol/internet protocol (TCP/IP), token ring, IEEE 802.11a/b/g/n/x, etc.

**[065]** The communication network **609** includes, but is not limited to, a direct interconnection, an e-commerce network, a peer to peer (P2P) network, local area network (LAN), wide area network (WAN), wireless network (e.g., using Wireless Application Protocol), the Internet, Wi-Fi, 3GPP and such. The first network and the second network may either be a dedicated network or a shared network, which represents an association of the different types of networks that use a variety of protocols, for example, Hypertext Transfer Protocol (HTTP), Transmission Control Protocol/Internet Protocol (TCP/IP), Wireless Application Protocol (WAP), etc., to communicate with each other. Further, the first network and the second network may include a variety of network devices, including routers, bridges, servers, computing devices, storage devices, etc.

**[066]** In some embodiments, the processor **602** may be disposed in communication with a memory **605** (e.g., RAM, ROM, etc. not shown in **FIG. 6**) via a storage interface **604**. The storage interface **604** may connect to memory **605** including, without limitation, memory drives, removable disc drives, etc., employing connection protocols such as serial advanced technology attachment (SATA), Integrated Drive Electronics (IDE), IEEE-1394, Universal Serial Bus (USB), fiber channel, Small Computer Systems Interface (SCSI), etc. The memory drives may further include a drum, magnetic disc drive, magneto-optical drive, optical drive,

Redundant Array of Independent Discs (RAID), solid-state memory devices, solid-state drives, etc.

**[067]** The memory **605** may store a collection of program or database components, including, without limitation, user interface **606**, an operating system **607**, web server **608,** etc. In some embodiments, computer system **600** may store user/application data, such as, the data, variables, records, etc., as described in this disclosure. Such databases may be implemented as fault-tolerant, relational, scalable, secure databases such as Oracle ® or Sybase®.

**[068]** The operating system **607** may facilitate resource management and operation of the computer system **600**. Examples of operating systems include, without limitation, APPLE MACINTOSH® OS X, UNIX®, UNIX-like system distributions (e.g., BERKELEY SOFTWARE DISTRIBUTION™ (BSD), FREEBSD™, NETBSD™, OPENBSD™, etc.), LINUX DISTRIBUTIONS™ (e.g., RED HAT™, UBUNTU™, KUBUNTU™, etc.), IBM™ OS/2, MICROSOFT™ WINDOWS™ (XP™, VISTA™/7/8, 10 etc.), APPLE® IOS™, GOOGLE® ANDROID™, BLACKBERRY® OS, or the like.

**[069]** In some embodiments, the computer system **600** may implement a web browser **608** stored program component. The web browser **608** may be a hypertext viewing application, for example MICROSOFT® INTERNET EXPLORER™, GOOGLE® CHROME™, MOZILLA® FIREFOX™, APPLE® SAFARI™, etc. Secure web browsing may be provided using Secure Hypertext Transport Protocol (HTTPS), Secure Sockets Layer (SSL), Transport Layer Security (TLS), etc. Web browsers **608** may utilize facilities such as AJAX™, DHTML™, ADOBER FLASH™, JAVASCRIPT™, JAVA™, Application Programming Interfaces (APIs), etc. In some embodiments, the computer system **600** may implement a mail server stored program component. The mail server may be an Internet mail server such as Microsoft Exchange, or the like. The mail server may utilize facilities such as ASP™, ACTIVEX™, ANSI™ C++/C#, MICROSOFT®, .NET™, CGI SCRIPTS™, JAVA™, JAVASCRIPT™, PERL™, PHP™, PYTHON™, WEBOBJECTS™, etc. The mail server may utilize communication protocols such as Internet Message Access Protocol (IMAP), Messaging Application Programming Interface (MAPI), MICROSOFT® exchange, Post Office Protocol (POP), Simple Mail Transfer Protocol (SMTP), or the like. In some embodiments, the computer system **600** may implement a mail client stored program component. The mail client may be a mail viewing application, such as APPLE® MAIL™, MICROSOFT® ENTOURAGE™, MICROSOFT® OUTLOOK™, MOZILLA® THUNDERBIRD™, etc.

**[070]** Furthermore, one or more computer-readable storage media may be utilized in implementing embodiments consistent with the present disclosure. A computer-readable storage medium refers to any type of physical memory on which information or data readable by a processor may be stored. Thus, a computer-readable storage medium may store instructions for execution by one or more processors, including instructions for causing the processor(s) to perform steps or stages consistent with the embodiments described herein. The term "computer-readable medium" should be understood to include tangible items and exclude carrier waves and transient signals, i.e., be non-transitory. Examples include Random Access Memory (RAM), Read-Only Memory (ROM), volatile memory, non-volatile memory, hard drives, CD (Compact Disc) ROMs, DVDs, flash drives, disks, and any other known physical storage media.

**[071]** Various embodiments of the present disclosure provide numerous advantages. Embodiments of the present disclosure provide a method for efficient utilization of renewable energy to achieve energy neutrality in WWTPs. The efficient usage of solar energy is integrated with grid energy to minimize power consumption from the grid and maximize utilization of the solar energy. Further, the total energy consumption of the WWTP is reduced by process optimization thereby reducing the operational expense (OPEX) of the WWTP. Moreover, process optimization for efficiently integrating the solar energy with the grid energy ensures a peak shift in operating times of the WWTP, thereby the solar energy is efficiently used and capital expenditure (CAPEX) in installing huge batteries and maintain them is precluded. As the usage of solar energy reduces the dependency on grid, the environmental impact of operating WWTPs is reduced as emission of GHGs are significantly reduced.

**[072]** It will be understood by those within the art that, in general, terms used herein, and are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). For example, as an aid to understanding, the detail description may contain usage of the introductory phrases "at least one" and "one or more" to introduce recitations. However, the use of such phrases should not be construed to imply that the introduction of a recitation by the indefinite articles "a" or "an" limits any particular part of description containing such introduced recitation to inventions containing only one such recitation, even when the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should

typically be interpreted to mean “at least one” or “one or more”) are included in the recitations; the same holds true for the use of definite articles used to introduce such recitations. In addition, even if a specific part of the introduced description recitation is explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean at least the recited number (e.g., the bare recitation of “two recitations,” without other modifiers, typically means at least two recitations or two or more recitations).

**[073]** While various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following detailed description.

**WE CLAIM:**

1. A method for operating a waste-water treatment plant (WWTP)(110), the method comprising:

receiving, by a processor (202), waste-water treatment plant related data, water demand data and solar data;

obtaining, by the processor (202), one or more data prediction models comprising at least one of: a solar profile prediction model, an energy profile prediction model, an effluent profile prediction model, and a water demand prediction model;

determining, by the processor (202), an usage of the WWTP (110) using one or more objective functions (310, 340) derived based, at least in part, on the one or more data prediction models; and

determining, by the processor (202), one or more control parameters for operating the WWTP (110) based, at least in part, on the determined usage of the WWTP (110).

2. The method as claimed in claim 1, wherein a first objective function (310) of the one or more objective functions is associated with a first set of parameters related to at least: a solar energy profile, an energy demand profile, and a water demand profile for maximizing use of solar energy.

3. The method as claimed in claim 2, wherein the solar energy profile for a day is predicted by the solar profile prediction model based on the solar data; and

wherein the energy demand profile for a day is predicted by the energy profile prediction model based on at least WWTP component data; and

wherein the water demand profile for a day is predicted by the water demand prediction model based on at least: a storage capacity in the WWTP (110), amount of waste-water and the water demand data.

4. The method as claimed in claim 2, wherein the first set of parameters are determined based on a first set of constraints related to at least water storage constraints and water demand constraints.

5. The method as claimed in claim 1, wherein a second objective function (340) of the one or more objective functions is associated with a second set of parameters related to at least: an influent flowrate, a returned sludge flow, a pH of effluent, an average temperature, an average airflow rate, and an effluent profile for minimizing pollutants in the effluent and minimizing overall energy used by the WWTP (110).

6. The method as claimed in claim 5, wherein the effluent profile is predicted by the effluent profile prediction model based on influent data and effluent data.

7. The method as claimed in claim 5, wherein the second set of parameters are determined based on a second set of constraints related to an amount of dissolved oxygen and effluent concentration.

8. The method as claimed in claim 1, wherein a third objective function (360) of the one or more objective functions is associated with a third set of parameters related to at least: a solar energy profile, an energy demand profile, a water demand profile, an influent flowrate, a returned sludge flow, a pH of effluent, an average temperature, an average airflow rate, and an effluent profile for efficiently utilizing energy by the WWTP (110).

9. The method as claimed in claim 1, wherein the one or more control parameters for operating the WWTP (110) comprises at least one of: a schedule for operating components of the WWTP (110), a number of components of the WWTP (110), a rate of operating the components of the WWTP (110), and water quality control points.

10. The method as claimed in claim 1, wherein a performance of each data prediction model of the one or more data prediction models is evaluated at a predefined time and compared with a threshold to determine a deviation in performance.

11. The method as claimed in claim 10, wherein the data prediction model of the one or more data prediction models with deviation in the performance is updated to meet the threshold.

12. The method as claimed in claim 1, wherein the waste-water treatment plant related data comprises at least: influent data, effluent data, and WWTP component data; and

wherein the one or more data prediction models are generated based, at least in part, on the waste-water treatment plant related data and the solar data.

13. A system (150) for operating a waste water treatment plant (WWTP) (110), the system (150) comprising:

a memory (204) configured to store instructions (205); and

a processor (202) configured to execute the instructions (205) stored in the memory (204) and thereby cause the system to:

receive waste-water treatment plant related data, water demand data and solar data;

obtain one or more data prediction models comprising at least one of: a solar profile prediction model, an energy profile prediction model, an effluent profile prediction model, and a water demand prediction model;

determine an usage of the WWTP (110) using one or more objective functions derived based, at least in part, on the one or more data prediction models; and

determine one or more control parameters for operating the WWTP (110) based, at least in part, on the determined usage of the WWTP (110).

14. The system as claimed in claim 13, wherein a first objective function (310) of the one or more objective functions is associated with a first set of parameters related to at least: a solar energy profile, an energy demand profile, and a water demand profile for maximizing use of solar energy.

15. The system (150) as claimed in claim 14, wherein the solar energy profile for a day is predicted by the solar profile prediction model based on the solar data; and

wherein the energy demand profile for a day is predicted by the energy profile prediction model based on at least WWTP component data; and

wherein the water demand profile for a day is predicted by the water demand prediction model based on at least: a storage capacity in the WWTP, amount of waste-water and the water demand data.

16. The system (150) as claimed in claim 14, wherein the first set of parameters are determined based on a first set of constraints related to at least water storage constraints and water demand constraints.

17. The system (150) as claimed in claim 13, wherein a second objective function (340) of the one or more objective functions is associated with a second set of parameters related to at least: an influent flowrate, a returned sludge flow, a pH of effluent, an average temperature, an average airflow rate, and an effluent profile for minimizing pollutants in the effluent and minimizing overall energy used by the WWTP (110).

18. The system (150) as claimed in claim 17, wherein the effluent profile is predicted by the effluent profile prediction model based on the influent data and the effluent data.

19. The system (150) as claimed in claim 17, wherein the second set of parameters are determined based on a second set of constraints related to an amount of dissolved oxygen and effluent concentration.

20. The system (150) as claimed in claim 13, wherein a third objective function (360) of the one or more objective functions is associated with a third set of parameters related to at least: a solar energy profile, an energy demand profile, a water demand profile, an influent flowrate, a returned sludge flow, a pH of effluent, an average temperature, an average airflow rate, and an effluent profile for efficiently utilizing energy by the WWTP (110).

21. The system (150) as claimed in claim 13, wherein the one or more control parameters for operating the WWTP (110) comprises at least one of: a schedule for operating components of the WWTP (110), a number of components of the WWTP (110), a rate of operating the components of the WWTP (110), and water quality control points.

22. The system (150) as claimed in claim 13, wherein a performance of each data prediction model of the one or more data prediction models is evaluated at a predefined time and compared with a threshold to determine a deviation in performance.

23. The system (150) as claimed in claim 22, wherein the data prediction model of the one or more data prediction models with deviation in the performance is updated to meet the threshold.

24. The system (150) as claimed in claim 13, wherein the waste-water treatment plant related data comprises at least influent data, effluent data, and WWTP component data; and

wherein the one or more data prediction models are generated based, at least in part, on the waste-water treatment plant related data and the solar data.