Enhancement of Energy Efficiency in Wastewater Treatment Plants

Pramendra Shekhar Pandey[1] , Madhumati Kumari Yadav[2]
[1]PG Student [2]Assistant Professor [1,2]Department of Civil Engineering
[1,2]Bhilai Institute of Technology, Durg, Chhattisgarh, India97171 39094

Abstract:- **Urban domestic waste water treatment systems are energy intensive and also a direct or indirect source of Greenhouse gases (GHGs) emissions. In developed countries as per estimates it has been found that Waste water treatment plants (WWTPs) consume about 1 to 3% of the total electric energy output. Increase in energy prices and continuously deteriorating quality of environment because of generation of energy forced the policy makers and other stakeholders to adopt suitable measures which not only increases the energy efficiency of WWTPs but also achieving the desired effluent quality at the same time. Waste water treatment requires lot of energy during several stages i.e. collection, pumping, treatment, handling, storage, disposal etc. On the other hand, waste water/sewage contains energy in different forms namely potential, chemical and thermal. The aim of this paper is to study the application of process modification techniques and management practices to achieve energy efficiency in some of WWTPs in the state of Chhattisgarh. Technical and management strategies are suggested to enhance the energy efficiency of the WWTPs. With the implementation of technical strategies about 184046 kWh of energy can be saved monthly which is around 18.17 % of the monthly electrical energy consumption and as a result ₹14.9 Million can be saved annually which otherwise have to be paid in the form of electricity bills. Anaerobic digestion helps in recovery of chemical energy entrapped in wastewater and about 157 MkJ/day of fuel value can be obtained with the recovery of methane gas. This energy can be used for heating, production of electricity through heat turbines which can be used within the WWTP premises and also transmitted to the grids if required.**

Keywords:- *Wastewater, Greenhouse Gases, Energy Management, Urban Local Bodies, Waste Activated Sludge, Aeration, Management Strategies And Heat Recovery.*

I. INTRODUCTION

Wastewater treatment systems are designed to treat the domestic sewage generated from the colonies or towns. For their operation energy is required which is generally provided by electricity distribution systems. The most common is the use of electrical energy to provide oxygen for aerobic biological system, such as activated sludge treatment. From the data available WWTPs consume about 1% to 3 %of the electrical energy output of a developed country. Wastewater contains different form of energy i.e., potential, thermal, chemical etc. embedded in it. If the efforts are made to harness the embedded energy, energy crisis can be countered as this energy can be used for operation of WWTP. Moreover, with the adoption of modern technologies, process modification and optimization techniques energy efficiency of the WWTPs can be enhanced resulting in lesser consumption of energy for their operation.

As per report of Central Pollution Control Board (CPCB) domestic waste water generation from urban centers in the country is about 4754 MLD. Currently country has capacity to treat approximately 37% of its waste water generated. Thus, there is a big gap in treatment of domestic waste water generated from urban centers.

As only one-third of the wastewater generated from urban areas in India is being treated there is a huge scope for the development of WWTPs in the country to treat such large quantity of wastewater. Energy crisis is the major problem which not only India but other developed and developing countries are facing. In such situation consumption of significant amount of energy in the operation of WWTPs would have made the situation worse. Thus, it becomes imperative to adopt energy efficient strategies in every fields of development including wastewater treatment.

II. PRINCIPLE AND METHODOLOGY

Following WWTPs in the state of Chhattisgarh have been visited during the course of study: -

1. Municipal Corporation Bilaspur STP of capacity 54 MLD at Domuhani, Bilaspur
2. Municipal Corporation Bilaspur STP of capacity 17 MLD at Chilhati, Bilaspur
3. NRDA STP of capacity 20 MLD at Sector-28, Nava Raipur Atal Nagar
4. Prakash Industries Limited, Champa Residential Colony STP of capacity 500 KLD, Hathnevra, Champa
5. Ambuja Cements Limited, Bhatapara Cement Works STP of capacity 500 KLD at Bhatapara

The aforesaid first three WWTPs are designed and operated to treat domestic wastewater/sewage generated from towns of Bilaspur and Nava Raipur Atal Nagar whereas the latter two are catering the need of residential colonies of industrial establishments within their vicinity. Electric energy consumption in above WWTPs which have been observed during study is summarized as follows: -

S. No.	STP Location	Avg. daily electricity consumption (Current scenario)	Avg. daily electricity consumption (Projected scenario)	Avg. monthly electricity consumption (Projected scenario)
1.	Domuhani	750 kWh	18000 kWh	540000 kWh
2.	Chilhati	750 kWh	7050 kWh	211500 kWh
3.	Nava Raipur	735 kWh	7500 kWh	225000 kWh
4.	PIL Champa	100 kWh	810 kWh	24300 kWh
5.	Bhatapara Cement works	30 kWh	400 kWh	12000 kWh
	Total	2365 kWh	33760 kWh	1012800 kWh

From the above it can be observed that there is a huge consumption of electrical energy in the above WWTPs.

Moreover, no any attempts have been made to recover the energy entrapped in wastewater. Further during the visit records of maintenance of electrical consumption was also found to be hard. In our country there is general perception that the WWTPs are installed only to treat the wastewater so that the desired quality of effluent can be achieved. But there is no intention to apply energy efficiency measures in the operation of WWTPs, though on small scale it has been implemented but not wholeheartedly. As most of the WWTPs installed for treatment of wastewater generated from urban areas in our country are operated by Urban Local Bodied (ULBs) which do not have expertise in energy efficiency as a result these WWTPs have now become extensive energy consumers.

In Chhattisgarh state per capita annual consumption of electricity is around 1724 kWh. Population of Chhattisgarh as per census 2011 is about 2.56 crore. Thus, the total consumption of electricity in the state is around 44134 GWh. Percentage consumption of electricity by the aforesaid WWTPs can be calculated as follows-

Percentage consumption in the current scenario = (2365 kWh X 365/44134 GWh) X 100
= 0.002 %

Percentage consumption in the projected scenario = (33760 kWh X 365/44134 GWh) X 100
= 0.028 %

In the current situation, the WWTPS which have been studied during the study have found to be consuming about 0.02% of the total electric energy consumed in the state and the projected consumption of the above WWTPs when operating at their designed capacity will be about 0.028 % of the electric energy consumption of the state. Although, the energy consumption seems to be insignificant in comparison to the total energy consumed in the state but with the implementation of energy efficient measures significant amount of energy can be saved as several WWTPs projects are in the planning state and will be implemented very soon.

Methodology proposed to be adopted for achieving energy efficiency in WWTPs:

The energy saving strategies can be proposed in the following aspects:
1. Technical strategies
2. Management strategies
3. Emerging Technologies

Technical strategies: -

The technical strategies can be implemented at various stages of wastewater treatment and with their implementation energy efficiency can be achieved either by application of more energy efficient equipment or by energy recovery embedded in wastewater. The implementation of technical strategies at different stages in wastewater treatment is briefed as below:

1. **Enhancing motor efficiency: -**

Following are the ways by which the energy efficiency of motors can be enhanced: -
a. Replacing oversized motors with an appropriate high efficiency motor can result in savings.
b. Improving active energy efficiency by simply stopping motors when they are no longer need to be running. This method may require improvements to be made in terms of automation, training or monitoring, and operator incentives may have to be offered.
c. Monitoring and correcting all the components in drive chains, starting with those on the larger motors, which may affect the overall efficiency. This may involve, for example, aligning shafts or couplings as required. An angular offset of 0.6 mm in a coupling can result in a power loss of as much as 8%.
d. When the application requires varying the speed, a Variable Speed Drive (VSD) provides a very efficient active solution as it adapts the speed of the motor to limit energy consumption.
e. Periodical lubrication preferable to lifetime lubrication.
f. Provision of grease relief in motor bearings casings to permit exit of excess grease.
g. Periodical checking of external or internal grease accumulations, excessive motor temperature, dirt build up, shaft alignment, bearing play and excessive noise or vibration.
h. The motor should be checked for amperage, proper voltage and resistance to ground.

ISSN No:-2456-2165

Implementation of the above measures in the WWTPs studied during the project-

In the WWTPs standard efficiency motors have been employed having efficiency in the range 75-85% depending upon the rated power of the motors. With the replacement of standard efficiency motors with high efficiency motors having energy efficiency in the range 85-90% significant amount of electrical energy can be conserved and results in cost savings.

By considering the example of Domuhani STP, the total projected monthly energy consumption by standard efficiency motors is 351792 kWh (as per Table 3.2). If these motors are replaced with high efficiency motors having 4-5 % more efficiency than those already installed the total electrical energy that can be saved can be calculated as follows- Savings in energy = (4/100) x 351792 kWh

Saving in energy = 4/100 x 351792 (considering high efficiency motors have 4% higher energy efficiency)
= 14070 kWh

Saving in terms of money = 6.75 x 12 x 14070
= ₹11,39,670

Similarly saving in terms of electricity consumption and money in other WWTPs is tabulated as below:

Table: Reduction in energy consumption achieved by replacement of motors

S. No.	WWTPs	Avg. monthly electricity consumption by motors (Projected scenario)	Reduction in electric energy consumption with adoption of HE motors (4% reduction is assumed)	Money which can be saved per year as a result of implementation*
1.	Domuhani STP	351792 kWh	14070 kWh	Rs. 1139670
2.	Chilhati STP	133632 KWh	5345 kWh	Rs. 432945
3.	NRDA STP	135000 kWh	5400 kWh	Rs. 437400
4.	PIL Residential Colony STP	8940 kWh	360 kWh	Rs. 29160
5.	Bhatapara Cement Works STP	2664 kWh	105 kWh	Rs. 8505

*Commercial electricity tariff in C.G. state is considered as Rs. 6.75/-

2. **Enhancing the pumping efficiency in WWTPs: -**

Following are the ways by which the energy efficiency in pumping can be achieved:

a. **Maintenance: -** Proper maintenance of pumps includes the following:
- Replacing worn impellers
- Inspection and repair of bearing.
- Replacement of bearing lubrication
- Replacement/inspection of packing seals and mechanical seals.
- Replacement of Wear ring and impeller.
- Regular checking of pump/motor alignment.
- Avoiding throttling losses.

b. **Monitoring: -** It can determine clearances that need to be adjusted, indicate blockage, clogged or gas-filled pumps or pipes, impeller damage, inadequate suction, operation outside preferences, or worn out pumps.

c. **VFDs: -** Variable Frequency Drives (VFDs) are being used to vary the speed of pump to match the variable flow conditions. VFDs control the speed of motors by varying the frequency of the power delivery to the motors which results in close match of the electrical power input to the pump with the hydraulic power needed to pump the water.

d. **Controls: -** Provision of remote controls enable pumping systems to be started and stopped relatively quickly and accurately.

e. **More efficient pumps: -** Mismatch between the pump capacity and its operation results in inefficient operation. Sometimes it can be more efficient to buy a new pump because newer models are more efficient.

f. **Multiple pumps for varying load: -** Provision of multiple pumps is often the most cost-effective and most energy-efficient solution for varying loads, particularly in a static head-dominated system. Parallel pumps offer redundancy and increased reliability.

g. **Replacement of belt drives: -** Often it is better to replace the pump by a direct driven system, resulting in increased savings of up to 8% of pumping systems energy usage with payback periods as short as 6 months.

h. **Precision castings, surface coatings or**

i. **Improvement of sealing: -** The sealing arrangements on pumps contribute to the power absorbed. Use of gas barrier seals, balanced seals, and no-contacting labyrinth seals can help to optimize pump efficiency.

Implementation of the above measures in the WWTPs studied during the project:

From the experiences and practices it is already established that better operation and maintenance of machinery and equipment enhances energy efficiency and reduces cost. Typical energy savings for operations and maintenance are estimated to be between 2% and 7% of pumping electricity use. The payback usually is less than one year.

ISSN No:-2456-2165

By considering the example of Domuhani STP, the total projected monthly energy consumption by different types of pumps employed at different stages is around 188666 kWh (as per Table 3.3). With the adoption of better operation and maintenance practices the total electrical energy that can be saved can be calculated as follows:

Around 3773 kWh of electricity can be saved (considering 2% lesser consumption of electricity as a result of better O&M practices).

Savings in energy = 2/100 x 188666 kWh (considering 2% lesser consumption of electricity as a result of better O&M practices)
= 3773 kWh
Saving in terms of money = 6.75 x 12 x 3773
= ₹ 3,05,613

Similarly saving in terms of electricity consumption and money in other WWTPs can be tabulated as below:

Table : Reduction in energy consumption achieved by better operation and maintenance practices

S. No.	WWTPs	Avg. monthly electricity consumption by pumps (Projected scenario)	Reduction in electric energy consumption (2% reduction is assumed)	Money which can be saved per year as a result of implementation
1.	Domuhani STP	188666 kWh	3773 kWh	Rs. 305613
2.	Chilhati STP	77628 KWh	1550 kWh	Rs. 125550
3.	NRDA STP	78000 kWh	1560 kWh	Rs. 126360
4.	PIL Residential Colony STP	19140 KWh	380 kWh	Rs. 30780
5.	Bhatapara Cement Works STP	8598 KWh	170 kWh	Rs. 13770

3. **Enhancing the aeration efficiency: -**
Strategies to enhance energy efficiency in aeration system are discussed as below: -

a. The oxygen added to the aeration process should be controlled and adjusted by on-line measurements considering the variability of the influent wastewater.
b. Tapered aeration will reduce the rate of oxygen supply along the length of a basin. It can be accomplished by providing more diffusers at the inlet to the basin where the organic loading is highest and decreasing the number of the diffusers along the length of the basin. Tapered aeration better matches the oxygen demand across the basin by providing more air to the inlet of the basin where it is needed and less air near the end of the basin where the food- to- microorganisms (F/M) ratio is lower, thereby saving energy.
c. Provision of intermittent aeration assists in energy savings by reducing the operation hours of aeration system. This methodology involves momentarily stopping air flow to an aeration zone or cycling air flow from zone to zone.
d. Provision of automated dissolved oxygen control can helps in achieving significant energy saving.
e. Replacement of coarse bubble diffusers with fine bubble diffuser reduces the energy consumption in blowers of aerators.

Implementation of the above measures in the WWTPs studied during the project:

With the application of tapered aeration with little modification in Domuhani STP, significant amount of energy can be saved which is otherwise consumed for supply of air to the aeration system. Incoming BOD of sewage is 134 mg/l and that of effluent is 13.4 mg/l. Hence the amount of BOD removed in the aeration system is equal to 121 mg/l. Thus, the total air requirement of the aeration tank can be calculated as follows: -

Air required = 100 m^3 X 121 X 10^{-6} kg/l X 54 MLD
= 653400 m^3/day

Whereas, after tapered aeration system, the total air requirement of the aeration tank can be calculated as
Air required = 75 m^3 X 121 X 10^{-6} kg/l X 54 MLD
= 490050 m^3/day

Hence, the percentage reduction in air requirement is
= (653400-490050)/653400
= 25%

As a result of reduction in requirement of air in the system, consumption of electricity is reduced in the same proportion.
Similarly saving in terms of electricity consumption and money in other WWTPs can be tabulated as below:

ISSN No:-2456-2165

Table: Reduction in energy consumption achieved by adoption of tapered aeration system

S. No.	WWTPs	Amount of air required as per current scenario (m^3/day)	Expected requirement of air after tapered aeration (m^3/day)	Avg. monthly consumption of electricity in the aeration system (kWh)	Money which can be saved per year as a result of implementation (25% lesser consumption)
1.	Domuhani STP	653400	490050	345600	Rs. 6998400
2.	Chilhati STP	205700	154275	129600	Rs. 2624400
3.	NRDA STP	242000	181500	130000	Rs. 2632500
4.	PIL Residential Colony STP	6050	4540	10290	Rs. 208372
5.	Bhatapara Cement Works STP	6050	4540	2664	Rs. 53946

4. Energy efficiency in solids/sludge processing: -

Technical strategies for enhancing energy efficiency in sludge/solids processing is as follows: -

a. Coagulation and flocculation should be avoided in wastewater treatment process as far as possible. Coagulation and flocculation lead to generation of huge quantity of sludge which is not only difficult to handle but also, requires energy for its handling and disposal. Moreover, coagulation and flocculation employed the use of mixers and propellers for mixing which are electrically operated.
b. Adopt anaerobic digestion of sludge/solids instead of aerobic digestion. As a result of anaerobic digestion, digestor gases are released, which can be used for energy recovery. Digestor gas contains 40 to 75 % methane, with 60% commonly. An effective way to use biogas is in a combined heat and power application. All of the biogas is directed to and burned in an engine/turbine that in turn powers an electrical generator. The electricity can be used at STP site and surplus electricity if any would be transmitted to the grid. The waste heat can be recovered and will be used to heat the anaerobic digestor.
c. Aerobic-anoxic digestion of sludge would be preferred to aerobic digestion. In aerobic digestion the nitrogenous matter in the digesting sludge is transformed to nitrates. In aerobic-anoxic operation, the aeration to the digestor is turned on and off alternatively. During the anoxic periods, denitrification occurs, converting the nitrates that accumulated during the aerobic period into Nitrogen gas. A 20% reduction in oxygen is obtained. There is no need of mixing during the anoxic period, further reducing energy use if high concentration of MLSS is maintained in the digestor.
d. Operation at low dissolved concentration (0.1 to 0.5 mg/l) induces simultaneous nitrification- denitrification, as a result there is no need for alternating aeration cycles.
e. Co-digestion of wastewater/sewage sludge with other biowastes such as food waste and fat, grease and oil (FOG). According to the literature, co-digestion will enhance the biogas production by 50-185% (sewage sludge co-digested with food waste) and, 100-410% (sewage sludge co-digested with FOG).

Implementation of the above measures in the WWTPs studied during the project-

As already discussed, solids in wastewater have considerable amount of thermal energy entrapped in themselves. During the visit it was observed that no any attempts have been made to harness the thermal energy of solids of wastewater. Thermal energy can be harnessed by gas recovery with the application of sludge digestor. The following approximate values may be used as a basis for estimating the amount of gas produced by digestion:

About 60% of the suspended solids are removed by sedimentation; 75% by chemical coagulation and settling; and 90% by complete treatment, such as by activated sludge or the trickling filters, preceded and followed by sedimentation.

About 70% of the suspended solids in the sewage are volatile, and the reduction of volatile matter in the sludge, is about 65%. In digestion the amount of gas produced is about 0.6 cu. m per kg of volatile matter present in the sludge, or is about 0.9 cu. m per kg of volatile matter reduced. The gas produced usually contains 65% methane, 30% carbon dioxide and trace amounts of other gases. The heat content of methane is approximately 36000 kJ/m^3.

Sludge digestion and recovery of gas can be proposed as energy recovery and energy efficiency measure for Domuhani, Chilhati and NRDA STP as they are treating huge quantity of wastewater having considerable amount of solids required to be digested. Whereas, the above seams non-feasible for smaller STPs like PIL resisdential colony STP and Bhatapara Cement Works STP as they have smaller setup and treat very small quantity of wastewater.

Considering the sewage incoming to STPs have 200 mg/l of suspended solids and with the assumption that 90% of suspended solids removed after treatment,

The suspended solids removed
= 90%*200 mg/l = 180 mg/l
Assuming volatile solids to be equal to 70% of suspended solids, Volatile solids removed
= 70%*180 mg/l = 126 mg/l

ISSN No:-2456-2165

Now assuming the volatile solids is reduced by 65% in the sludge by digestion, we have Volatile solids reduced
= 65%*126 mg/l = 81.9 mg/l
∴ Volatile matter reduced per million litre of sewage
= 81.9 kg.
Now, assuming that 0.9 cu. m. of gas is produced per kg of volatile matter reduced, we have The gas produced per million litre of sewage
= 0.9*81.9 cu. m. = 73.71 cu. m.
Now as per above, the amount of gas produced and the fuel value projected to be obtained in Domuhani STP is as follows
Total amount of gas produced = 54 MLD X 73.71 m^3
= 3980.34 m^3
Amount of methane gas produced = 0.65 m^3 X 3980.34
= 2587 m^3
Fuel value obtained = 36000 kJ/m^3 X 2587
= 93.13 MkJ
Similarly amount of gas produced and fuel value which can be obtained from other WWTPs can be tabulated as follows:

Table: Amount of gas produced and the fuel value obtained

S. No.	WWTPs	Design capacity (MLD)	Total amount of gases produced (cubic metre)	Amount of methane gas produced (65% of total gas produced) (cubic metre)	Fuel value obtained (@36000kJ/cu. m.)
1.	Domuhani STP	54	3980.34	2587	93.13 MkJ
2.	Chilhati STP	17	1253	814	29,3 MkJ
3.	NRDA STP	20	1474	958	34.5 MkJ
	Total		**6707.34**	**4359**	**156.9 MkJ**

From the above it can be realized that if harnessed significant amount of thermal energy can be recovered. This energy can be used for heating, production of electricity through heat turbines which can be used within the WWTP premises and also transmitted to the grids if required.

III. MANAGEMENT STRATEGIES

Many actions could be considered to achieve a better management towards energy efficiency in the plant. Following are the management strategiesby which energy efficiency can be achieved:-

1. Creation of energy sustainability team. This team can involve determining their present baselines; conducting energy audit; identifying priorities; setting improvement goals, and benchmark with other WWTPs elsewhere and set target to implement the action plans, like Energy Conservation Measures (ECMs).
2. Monitoring the electrical usage in the plant.
3. Introduction of modern lightening systems to reduce the electricity consumption in auxiliary units of the plant.

Emerging Technologies For Enhancing Energy Efficiency in WWTPs: -

Persistent investigations and researches have led to the development of non-conventional approaches in the field of energy efficiency. Some of the emerging technologies that can be implemented for energy recovery and in turn enhancing the efficiency of WWTPs are discussed as below: -

1. **Heat energy recovery from wastewater:** Thermal energy can be recovered from raw wastewater or effluent by exploiting the often-significant temperature differential between wastewater and the ambient conditions. This temperature difference (at least 3-5˚C) can be recovered for use in heating and cooling systems, which is generally used for buildings at the plant, and sometimes in the buildings of areas surrounding the plant. Heat pump uses electricity to recover low-temperature heat from the wastewater, and to make this heat available at suitable temperatures for both heating and cooling. The thermal energy reserves in wastewater after treatment are dependent on the temperature, flow rate, heat transfer efficiency, and specific heat capacity of the water. This can be expressed theoretically:

$$E=\rho\times Q\times Cp\times \Delta T$$

Where, E is the thermal energy reserve (kcal), ρ is the density of the wastewater (kg/m^3), Q is the effluent flowrate (m^3), Cp is the specific heat of the wastewater (kcal/kg˚C), ΔT is the temperature that can be extracted (˚C).

2. **Advancement in Sludge Treatment Process: -**Some of the emerging technologies for energy recovery in sludge processing is briefed as follows: -

a. **Phosphorus Recovery** from sewage sludge that can be sold to farmers as fertilizers.
b. **The Omni Processor:** A process that can treat sewage sludge and can generate a surplus of electrical energy if the input materials have the right level of dryness.
c. **Thermal Depolymerisation:** Produces light hydrocarbons from sludge.

Miscellaneous measures that can be adopted to increase the energy efficiency or to reduce the energy consumption in WWTPs: -

The measures are summarized as follows: -

1. As far as possible WWTPs should be designed preferably with gravity flow which requires lesser pumping and in turn reduces the energy consumption for pumping. Although, topography is constraint while considering this criterion.
2. Energy audit of the WWTPs should be regularly carried out to assess the performance of energy management system.
3. Use of renewable sources of energy such as solar energy, wind energy etc. for lightening and other purposes in the WWTPs.

4. Instead of discharging the treated water into natural water bodies, provisions should be made to utilize the treated water in irrigation, landscaping, industrial purposes etc. This can lead to reduction of load on water treatment facilities which are entrusted to provide fresh water for such purposes which results not only in conservation of water but also reduces the consumption of energy in water treatment facilities. Thus, achieving energy efficiency indirectly.

IV. RESULTS AND DISCUSSIONS

With the implementation of energy efficiency measures which are proposed in chapter -4, the combined reduction in energy consumption and monetary savings are tabulated in the following table:

Table: Combined reductions in energy consumption and resultant monetary savings

S.No.	WWTPs	Energy efficiency achieved in motors			Energy efficiency achieved in motors			Energy efficiency achieved in aeration			Total reduction in electricity consumption	Total saving of money per year as a result of implementation
		Avg. monthly electricity consumption by motors (Projected scenario) (kWh)	Reduction in electric energy consumption with adoption of HE motors (4% reductionis assumed) (kWh)	Money which can be saved per year asa result of implementation*	Avg. monthly electricity consumption by pumps (Projected scenario) (kWh)	Reduction in electric energy consumption (2% reduction is assumed) (kWh)	Money which can be saved per year as a result of implementation	Avg. monthly consumption of electricity in the aeration system (kWh)	Reduction in consumption of electricity in the tapered aeration system (kWh)	Money which can be saved per year as a result of implementation		
1	2	3	4	5	6	7	8	9	10	11	4+7+10	5+8+11
1.	Domuhani STP	351792	14070	Rs. 1139670	188666	3773	Rs. 305613	345600	86400	Rs. 6998400	104243	Rs. 8443683
2.	Chilhati STP	133632	5345	Rs. 432945	77628	1550	Rs. 125550	129600	32400	Rs. 2624400	36090	Rs. 2923290
3.	NRDA STP	135000	5400	Rs. 437400	78000	1560	Rs. 126360	130000	32500	Rs. 2632500	39460	Rs. 3196260
4.	PIL Residential Colony STP	8940	360	Rs. 29160	19140	380	Rs. 30780	10290	2572	Rs. 208372	3312	Rs. 268312
5.	Bhatapara Cement Works STP	2664	105	Rs. 8505	8598	170	Rs. 13770	2664	666	Rs. 53946	941	Rs. 76221
Total		632028	25280	Rs. 2047680	372032	7433	Rs. 602073	618154	154538	Rs. 12517618	184046	Rs. 14907766

From the above table it is observed that with the implementation of technical strategies to achieve ene rgy efficiency about 184046 kWh of energy can be saved monthly. Percentage reduction in monthly electricity consumption in the five WWTPs is

Percentage reduction in monthly electricity consumption = (184046/1012800) x 100 = 18.17 %

Hence, if the technical strategies are implemented effectively around 18.17 % reduction in monthly electricity consumption can be achieved. As a result, 14.9 Million Rs. can be saved annually which otherwise have to be paid in theform of electricity bills.

Further by recovering chemical energy in the form of methane gas fuel value to the tune of about 157 MkJ can be obtained (as per Table 4.4). If harnessed strategically, this energy can be used for heating, production of electricity through heat turbines which can be used within the WWTP premises and also transmitted to the grids if required.

V. CONCLUSION

The energy efficiency can be achieved with the adoption and implementation of technical and management strategies discussed in details earlier. Application of high efficiency motors and pumps, optimum aeration of wastewater, energy recovery from sludge and implementation of energy management system will be the best to realize the aim of energy efficient wastewater treatment system.

As only one-third of the wastewater generated from urban areas in India is being treated there is a huge scope for the development of WWTPs in the country to treat such large quantity of wastewater. Energy crisis is the major problem which not only India but other developed and developing countries are facing. In such situation consumption of significant amount of energy in the operation of WWTPs would have made the situation worse. Thus, it becomes imperative to adopt energy efficient strategies in every fields of development including wastewater treatment.

In Chhattisgarh state per capita annual consumption of electricity is around 1724 kWh. In the current situation, the WWTPS which have been studied during the study have found to be consuming about 0.002 % of the total electric energy consumed in the state and the projected consumption of the above WWTPs when operating at their designed capacity will be about 0.03 % of the electric energy consumption of the state. Although, the energy consumption seems to be insignificant in comparison to the total energy consumed in the state but with the implementation of energy efficient measures significant amount of energy can be saved as several WWTPs projects are in the planning state and will be implemented very soon.

Application of energy efficient measures in the design and operational stage of proposed STPs and at operational stages of existing WWTPs will result in significant conservation of energy which not only leads to reduction of financial burden on the state but also helps in the conservation of environment.

Urban water systems need the supply of relevant amounts of energy for their operation. Considering the costs of sewer construction and operation, decentralized systems, the adoption of energy-recovery technologies like anaerobic digestion, will be increasingly interesting from an energy point of view.

REFERENCES

[1]. Pratima Singh[1], Cynthia Cariell-Marquet[2] and Arun Kansal[3], Department of Energy and Environment, TERI University, New Delhi[1], Department of Civil Engineering, University of Birmingham, Birmingham[2] and Department of Energy and Environment, TERI University, New Delhi[3] “Energy pattern analysis of a waste water treatment plant” 2012

[2]. Yongteng Sun[1], Ming Lu[1], Yongjun Sun[2], Zuguo Chen[1], Hao Duan[1] and Duan Liu[1], School of Information and Electrical Engineering, Hunan University of Science and Technology, Xiangtan, China[1] and College of Urban Construction, Nanjing Tech University, Nanjing, China[2] “Application and Evaluation of Energy Conservation Technologies in Wastewater Treatment Plants” 2019

[3]. Andrea G. Caoidaglio[1] and Gustaf Olsson[2], Department of Civil engineering and Architecture, University of Pavia, Pavia, Italy[1] and Department of Biomedical Engineering, Division of Industrial Electrical Engineering and Automation, Lund University, Lund, Sweden[2]“Energy issue in sustainable urban waste water management: use, demand reduction and recovery in the urban water cycle” 2020

[4]. Renan Barroso Soares[1], Marina Santos Memelli[2], Regiane Pereira Roque[1], Ricardo Franci Gonçalves[1], Departamento de Engenharia Ambiental. Universidade Federal do Espirito Santo, Vitoria, Brazil[1] and Centro Tecnologico, Universidade Federal do Espirito Santo, Vitoria, Brazil[2] “Comparative Analysis of the Energy Consumption of Different Wastewater Treatment Plants” 2017

[5]. NSW Government Office of Environment and Heritage “Energy Efficiency Opportunities in waste water treatment facilities” 2019

[6]. A-B Processes: Towards Energy Self-sufficient Municipal Wastewater Treatment by Meng Zhang and Yingqun Ma 2019

[7]. RungnaphaKhiewwijit, Wageningen University, Wageningen, NL “New waste water treatment concepts towards energy savings and resource recovery” 2016

[8]. Sam Azimi and Vincent Rocher, SIAPP- Direction Developpement et Prospective, Colombes, France “Energy Consumption reduction in a waste water treatment”2017

[9]. Joakim Rydh and Ann Akesson, Department of Industrial Electrical Engineering and Automation, LUND University “Energy consumption in wastewater treatment operation” 2007

[10]. Olumide Wesley Awe, Ranbin Liu, Yaqian Zhao, UCD Dooge Centre for Water Resources Research, School of Civil Engineering, University College Dublin, Newstead, Belfield, Dublin, Ireland “Analysis of Energy Consumption and Saving in Wastewater Treatment Plant: Case Study from Ireland” 2016

[11]. Mau Teng Au[1], Jagadeesh Pasupuleti[2], Kok Hua Chua[3], Power Engineering Centre[1], Centre for Power System Simulation[2], Institute of Energy Policy Research[3], Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, Kajang, Selangor, Malaysia “Strategies to improve energy efficiency in sewage treatment plants” 2013

[12]. Energy Conservation in Water and Wastewater Facilities Manual of Practice No. 32 By Water Environment Federation (WEF) 2009

[13]. Environmental Engineering (Vol. II) Sewage Disposal and Air Pollution Engineering by S.K. Garg

[14]. Environmental Engineering-II Wastewater Engineering by Dr. B.C. Punamia, Er. Ashok Kumar Jain and Dr. Arun K. Jain