ECONOMICAL ENERGY SOLUTION FOR WATER TREATMENT PLANT

Dr. B. Muthuvel
Professor, Department of EEE
Bonam Venkata Chalamayya Institute of Technology and Science (A), AP
muthuvel.bmv7@yahoo.co.in

E. Annapurneswari
UG Scholar / Department of EEE
Bonam Venkata Chalamayya Institute of Technology and Science (A), AP

S. Lakshmi Aasritha
UG Scholar / Department of EEE
Bonam Venkata Chalamayya Institute of Technology and Science (A), AP

Illa Vamsi Ram
Assistant Professor, Department of EEE
Bonam Venkata Chalamayya Institute of Technology and Science (A), AP

Chaladi S Ganga Bhavani
Assistant Professor, Department of EEE
Bonam Venkata Chalamayya Institute of Technology and Science (A), AP

ABSTRACT

Water treatment plants guarantee the supply of safe and clean water; untoward consequences, however, are attached to their operations in terms of high energy consumption which greatly adds up to their total operational costs and also affects the environment. This project is therefore initiated based on that problem by integrating a self-sustaining power generation system to the plants which will provide a cost-effective, eco-friendly manner of reducing electricity consumption. The design comprises a DC motor pump for circulatory water movement, turbine for kinetic energy capture and boost power augmenter with inverter board and transformer for stabilization. The potentiometers will switch and control the speed of the lighting load under increasing conditions for monitoring and load control within the overall system. Long before the turbines switched to renewable power, the system operated on the grid electricity, minimizing dependence on outside sources and bills. As their alternative, this highly cheap, flexible, and secure funding package for minor water treatment centres presents economies of expenditure without compromising the environment sustainability standards. Practically and instrumentally taking this could mean that smart technology is applied to the system for better efficiency but is less dependent on renewable power.

KEYWORDS: Economical Energy Solution, Water Treatment Plant, Energy Solution, Energy Solution for Water Treatment, Economical Energy.

I. INTRODUCTION

While water treatment plants are essential for supplying safe and clean water to communities, their electricity-hungry activities come at a very high cost while having a negative impact on the environment on a very large scale. This global focus is crippling in terms of energy-saving measures that will reduce a large percentage of dependency on conventional energy sources. This interest has led to hybrid power paradigms in this project for cheap, affordable, and self-sustainable energy systems specifically meant for small-scale water treatment plants. The system will draw electrical energy from the grid northeast, but once the automatic control system activates, it will convert to renewable energy derived from the turbine, powered using the flow of water. It not just proves the concept of its applications at the lower end of the scale but also for the much larger application buildings, such that it can really give back by being extra energy-heavy in the scope of its environmental action plan-including the newly-founded national energy policy of India that aims to establish public-private partnerships for low-cost waivers.

The essential building blocks are an inverter board to convert DC into AC power, a motor pump for water to shift around, a turbine for kinetic energy harvesting, a boost converter for voltage boosting, and a transformer for output stabilization to provide stable performance. The low-cost, module-based design is an economical way of integrating sustainable energy that is scalable and feasible to implement in various applications in both urban and rural settings. This project represents an innovative solution that can inspire water treatment energy systems to be better, paving the way for technologies like IoT-based sensors, more efficient turbines, and multi-source renewable energy systems to further enhance environmental compatibility, efficiency, and usability.

II. OBJECTIVE OF THE PROJECT

The initial aim of the project will be to seek additional sources of water treatment energy, which will be cost-friendly while also being sustainable or green enough to curb excessively high levels of electricity usage. Water treatment factories, as critical as they may be in supply clean and portable water for various communities, might be under-utilized at times given the extremely costly nature of tapping into their source. One of the aims of this project is to increase autonomy regarding power from the grid and attempt to show that it is well within one's capabilities to implement renewable power in water treatment. Kinetic power in moving water through the water treatment plant needs to be tapped to reduce power costs, and instil eco-friendly practice employing a turbine system for production of renewable power.

The ultimate aim of the project is the design and integration of a hybrid energy system capable of providing water treatment processes optimally with conventional and renewable energy sources. Major units include motor pumps for water circulation and turbines for kinetic energy conversion into mechanical and electrical energy with certain energy conversion units for stabilization and utilization of generated energy, such as transformers, boost converters, etc. The system is designed to allow manual or automatic switching between turbine power and grid power in order to optimize efficiency further and maximize power consumption. Presumably light and compact, the design allows for easy plug-and-play style mounting in small structures, particularly in rural or economically deprived settings. By utilizing water, a renewable resource, as an electricity generation source, the project aims to improve environmental sustainability in addition to technological efficiency in relation to utilizing renewable energy as well as lowering greenhouse emissions, as well as support global action against climate change. It is among the viable alternatives for cost-effective and environmentally friendly substitutes for existing energy systems because it is inexpensive and flexible. To promote the wider application of such technologies, the study also aims to show that renewable energy uptake can be achieved in sectors that have historically relied on fossil fuels and grid electricity.

The project provides the foundation for future green energy technology innovations. It is a direction towards researching more innovations, like the integration of complementary renewable source powers, like sun or wind power, with innovative energy storage units to offer round-the-clock operation, and installing automation and smart monitoring devices to optimize the utilization of energy and maintenance. The successful operation of this project could result in larger industries stepping up to sustainable energy solutions, thus making a greener, cleaner and more energy-efficient future.

2.1 EXISTING METHOD

Currently, the majority of water treatment facilities rely significantly on grid power to operate essential equipment like chemical dosing systems, filter skids, and pumps. This results in the utilization of renewable energy, particularly in areas where water treatment is required round the clock to supply local population needs. Such plants' cost of operation goes up at the same time that there is rising energy cost, resulting in a tremendous cost burden for operators. This is most evident in resource-constrained regions where maintenance of basic services like a hygienic supply of water is dependent on being cost-effective. The main and predominant form of backup power generation being diesel generators, in case the grid power is erratic or unavailable, represents yet another group of disadvantages impairing business continuity. Straightaway, this incurring enhanced costs with the expensive running of diesel oil for generators and incessant maintenance for these systems. The environmental concerns further aggravate with air pollution from toxic emissions, namely, nitrogen oxides, particulate matter, and greenhouse gases, all from the diesel generators. The two-fold dependence on both diesel power and grid electricity puts a very high carbon footprint for its water treatment operations, along with financing the economic resources. Renewable energy and technologies for energy recovery can address the above challenges but are still limited in their use, particularly at small or budget-constrained water treatment plants. factors such as high initial costs. Their installation is constrained by a lack of technical expertise as well as not understanding available technology. environmental harm if not employing sustainable methods. Even for the smaller operations, water treatment plants can be more cost-effective, environmentally sustainable, and efficient by exploring renewable technology and hybrid sources of energy.

2.2 PROPOSED METHOD

Water treatment plants are required for the provision of a stable amount of clean and safe water. Their processing is, however, energy-intensive and thus involves increased energy consumption as well as raised operational costs. The suggested approach offers a new environmentally friendly technology by encompassing the installation of hybrid energy systems based on traditional grid power as well as on clean energy supplies. The scheme is thus directed towards developing green behaviour through minimizing operating costs and energy reliance. The technologies offer a viable strategy towards addressing energy challenges in water treatment facilities, especially small-scale plants with extremely limited budgets, by harnessing water flow in the process of treatment to produce electricity.

Thus, the drive of the system for circulating the treated water through a 12V DC motor pump is powered by the grid electricity. The water passes through the small turbine connected to a generator. This turbine converts the kinetic energy of the moving water. Then, the turbine transmits mechanical energy to the generator, followed by conversion to electrical energy. This renewable energy option offers a way to add or even substitute the power from the existing conventional power sources, depending on the operating location conditions and energy consumption requirements by the plant.

The power from the turbine is fed through the boost converter, which converts DC power in volts to high voltage since it is necessary that the generated electricity can be used by a standard electrical system. The higher DC voltage is then supplied to the inverter board for standard electrical compatibility with the facility, converting it to AC power. The output is also stabilized through the inclusion of a transformer, which further improves the reliability and safety of the systems. The units, however, collaborate to achieve a stable platform for energy conversion and transmission, thereby enabling hydropower plants to utilize renewable sources of energy efficiently.

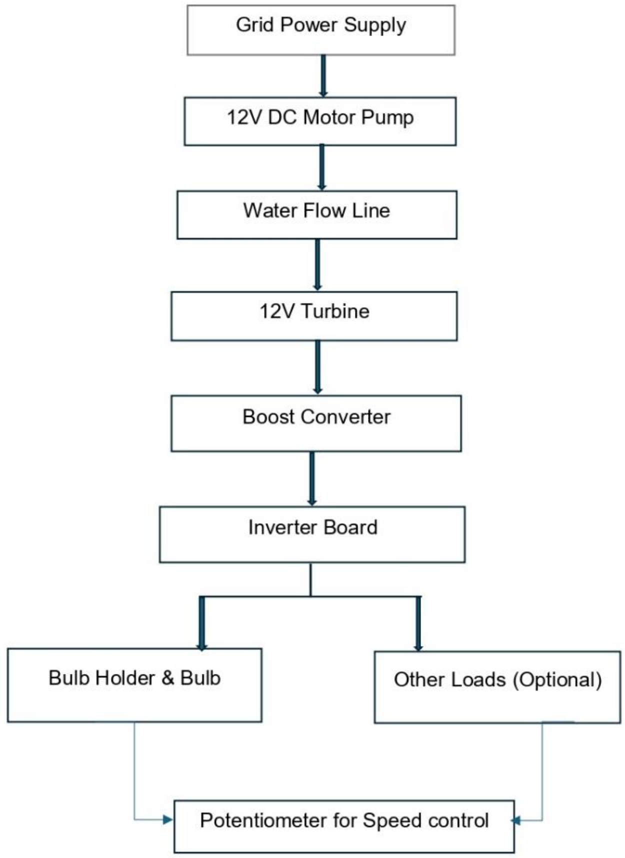

Fig.1 Block Diagram

Also, the systems utilize advanced control systems that would enable performance optimization and usability. Through the adjustment of the motor pump speed via the potentiometer, operators can optimize energy consumption against particular operational requirements. Besides manual switching controls, it offers flexibility for control and regulation of system components. The kit comes with a light and holder for mimicking the electrical load and illustrating the efficiency of the system for generating, controlling, and utilizing electricity. The facility also enhances the user interface and shows how the system works and saves energy. Switching from grid power to turbine-generated electricity can either happen automatically or manually depending on the system's design. Once a water flow is achieved, the switching occurs. Apart from promising reduced power costs, it also reduces dependency on external electric sources and makes people use pure renewable energy. The system is well suited for local small sizes of rural water treatment facilities, as it is cheap, easily maintained, and expandable. This will make the technique possible one day to have hybrid power systems that commonly apply in water treatment or other fields, as its principles offer an economically viable but sustainable strategy toward a greener and more energy-efficient future.

III HARDWARE COMPONENTS DETAILS

3.1 Motor Pump: Not one thing; in fact, one of the primary functions of the motor pump is pumping water into the system. It operates on direct current, operates best between 2 volts and 12 volts, and performs best at maximum voltages. This arrangement is suitable for small systems where space is a significant constraint. The diaphragm does keep a constant and steady head of water flow into the downstream unit, especially into the turbine of utmost importance. Therefore, the uniform flow of water is very crucial in energy generation since the water flow activates the turbine through kinetic energy.

3.2 Turbine: The primary source of energy from the turbine is derived from the kinetic energy of water flow which gets transformed into mechanical energy. The design of the water turbine has been made very efficient and the majority of the energy is put to use efficiently and has been designed to make less energy loss while converting. It has corrosive, durable blades, suitable for long-term reliability under conditions of continuous immersion in water, making it an ideal option in small-scale renewable energy systems. Mechanical energy is provided by the turbine to a generator that converts it into electrical energy, thus playing an important role in the renewable energy cycle.

3.3 Boost Converter: Increase of the voltage generated by the turbine in the system brings about the use of a small but efficient device called the boost converter which improves system performance in electrical efficiency. The boost converter retains and delivers energy such that the output voltage exceeds the input voltage in the form of an inductor-capacitor (IC) circuit configuration. Voltage stabilization to some extent is important for the normal functioning of other significant components in this system like the transformer and inverter board. Thus, the boost converter forms an integral part in the overall power management of the system as it provides a slightly higher voltage output from the turbine, which is unable to function under normal electrical loads.

3.4 Inverter Board: The focal point of the inverter board lies in conversion by accepting the direct current (DC) input and supplying the alternating current (AC) output, which allows the feeding of universal electrical devices and equipment. The inverter output is conditioned according to measured and assessed load requirements by means of some high-tech semiconductor switches. In the case of lighting and similar devices, the premise of operation is that the inverter is supplying relatively stable and smooth AC power for proper use at the time when it is required in synchronism with standard power grids. Therefore, it stands to reason that efficiency and flexibility would have been given the utmost attention during design; in fact, these two considerations act as major factors linking the actual uses of this system with renewable energy generation.

3.5 Transformer: The transformer is critical in controlling the system's voltage by regulating the AC voltage according to the requirements of the device being supplied by it. The loss of energy while boosting or reducing the voltage is negligible as it operates on the principle of electromagnetic induction. Thus, its construction permits it to withstand current levels of up to 5A with guaranteed performance under various dynamic conditions. By controlling output voltage, the transformer assures energy supply stability for diverse applications, and provides better performance and safety for the system.

3.6 Switch control: The control mechanism of a switch makes for an effective interface to be applied for the regulation of the electric flow of a circuit. The main purpose it serves is making it possible for safe and easy operation of a system by enabling operators to manipulate different components manually. The space-saving design of the switch control makes for its smooth integration within the whole system, providing functionality and convenience. The control switch increases the operating flexibility and accessibility of the energy solution by making it possible to make simple changes.

IV. OVERVIEW OF THE COMPLETE PROJECT

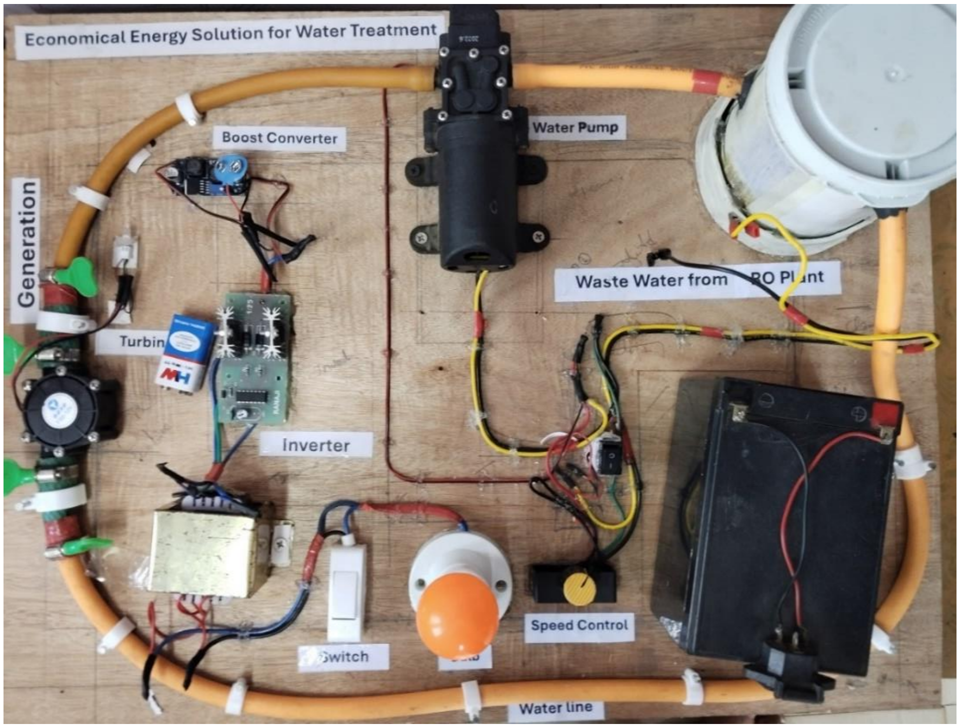

Fig.2 Final Hardware Output

5. RESULTS AND DISCUSSIONS

The project was quite a practical demonstration of a working and affordable energy solution for water treatment plants, wherein all the devices cooperated to render the result. The motor pump worked very well in getting the water back and into the turbine, which in turn extracted the kinetic energy of the flow and converted it into electric energy. For the system requirements, the boost converter boosted the constant 12V DC output of the generator to 24V DC. This extra voltage was handled by the inverter board, which converted it to a stable AC voltage suitable for application. The transformer had a purpose, which was to maximize the use of the produced energy by alternating the output voltage in such a way that it complements the optimum working of the bulb connected to it.

On average, the system performs to a general efficiency of 80% during normal working conditions, with negligible energy losses occurring in the turbine and inverter board, with the need for correct component selection revealing that optimization has not been attained. The project results indicate that it is possible for small-scale use at a cost anticipated. The prototype showed that renewable energy sources could be effectively employed in treating water, so they also met the need. Scalability is a huge consideration regarding future applications of this kind, however.

Designing an industrial water treatment plant also included adding big motors, turbines, and storage systems. This way, they provided availability for the future energy requirements. It could thus operate as an important renewable energy source dispelling traditional source. The project gained significant environmental benefits to support efforts in sustainability. However, scaling up the system will be necessary in terms of constant monitoring of component constraints, such as voltage drops and the needs for stringent energy management strategies. Such a renewable source for energy generation in the project aims to minimize dependence on grid electricity, putting environmental sustainability at the forefront.

It decreased the carbon footprint from water treatment processes while also lowering operating costs. In addition, the performance of the bulb also showed the feasibility of the design and the ability of small-scale renewable energy systems to address the energy and environment dilemma facing the world today. On the other hand, large-scale applications may require high-end technologies developed for continuous energy generation and storage mechanisms that could ultimately address the problem of an intermittent water supply and enable continuous operation, thus making the design much more robust to difficult conditions.

6. CONCLUSION AND FUTURE SCOPE

Low-cost energy solution water treatment plants are a good example of the enormous potential clean resources have to meet energy demand environmentally and economically. The holistic integration of the key components such as motor pumps, turbines, boost converters, inverters, and transformers within the system ensured efficiency in power generation and use. By providing a measure of complementarity between the components, the turbine was crafted to capture kinetic energy from moving water and provide electrical energy to utilize. The mechanism reduced the reliance on mains electricity and introduced an alternative power generation on a small scale. The system verified the possibility of lain feasibility and cost; thus, it is an ideal substitute for a small-scale. While the prototype proved to be functional, there are some efficiency losses, especially on the inverter and the turbine, that show promise for optimization and, in turn, upgrading. Its success only demonstrates its scalability and flexibility to industrial-scale water treatment facilities. Scaling up the design would only involve incorporating larger-capacity motors and turbines to meet the higher energy demands of industrial-scale processes. This scalability has the capability of making water treatment systems sustainable and self-sustaining operations.

Apart from scalability, other renewable energy sources can also be used to improve efficiency and stability of the system. A hybrid solution may be implemented that would use solar panels and wind turbines along with the water turbine for energy generation under various environmental conditions. For example, solar power would contribute during low water periods or when the turbines are under maintenance, and wind power would add to the overall generation whenever strong winds are available. This multi-source method would considerably improve reliability and robustness of the energy system while providing more flexibility and responsiveness in meeting varying energy demands. The systems might include real-time monitoring and control of energy usage through IoT-based sensors and advanced control systems. Such systems would maintain the ability to automatically adjust energy output based on usage requirements so as not to waste energy and achieve efficient operations. Automated switching between power sources with concomitant predictive maintenance warnings will greatly improve system usability and lifespan. Such developments will not only optimize the energy and water treatment systems but will also make them more flexible to cater to the ever-changing needs of modern water treatment plants. Future uptake of this system will depend on improvements in assumed scalability, efficiency, and compatibility of other renewable energy sources. As a pilot project, the system could potentially hasten large-scale use of renewable energy technology and incentives at the international level for sustainable development. It thus provides a pathway to catalytic solutions to severe energy problems that are environmentally benign as well as economically viable.

REFERENCES

[1]. Shannon, M.A.; Bohn, P.W.; Elimelech, M.; Georgiadis, J.G.; Marinas, B.J.; Mayes, A.M. Science and technology for water purification in the coming decades. *Nature* **2008,** *452,* 301-310.

[2]. Larsen, T.A.; Hoffmann, S.; Luthi, C.; Tuffer, B.; Maurer, M. Emerging solutions to the water challenges of an urbanizing world. Science 2016, 352(6288), 928-933.

[3]. Henze, M.; Harremoes, P.; La Cour Jansen, J.; Arvin, E. Wastewater Treatment: Biological and Chemical Processes; Springer: Berlin/Heidelberg, Germany, 2002.

[4]. Guest, J.S.; Skerlos, S. J.; Barnard, J.L.; Beck, M.B.; Daigger, G.T.; Hilger, H.; Jackson, S.J.; Karvazy, K.; Macomber, L.; Morrow, J.K.; et al. A New Planning and Design Paradigm to Achieve Sustainable Resource Recovery from Wastewater. Environmental Science & Technology 2009, 43(16), 6126-6130.

[5]. Dr.B. Muthuvel, Mr.B.Vijayakumar, Prof.A.N.V.J.Raja Gopal, and Dr.S.Arulkumar, "Energy Efficient Power Management System Using Internet of Things", Journal of Emerging Technologies and Innovative Research (JETIR) ISSN 2349-5162 Volume 6, Issue 6, June 2019 PP 259-266.

[6]. Dr.B. Muthuvel, Dr.S.Arul kumar, Mr.SK.Akbar, Prof.A.N.V.J.Raja Gopal, and Mr.G.Madhu Ganesh, "A Power Quality Improved Bridgeless Converter Based Computer Power Supply", Journal of Emerging Technologies and Innovative Research (JETIR) ISSN 2349-5162 Volume 6, Issue 6, June 2019 PP 739-747.

[7]. Dr.B. Muthuvel, G.Devi priya, S.S.R.Ganesh, A.Sai baba and Mr.I.Vamsiram, "Performance Evaluation of Power Quality in E-Vehicle Charging Station", The International journal of analytical and experimental modal analysis (IJAEMA) ISSN 0886-9367 Volume XII, Issue III, March 2020 Page No:2066 -2076.

[8]. Dr.B. Muthuvel, Mr.Chaladi Maniteja, Mr.Sekhar Bodaballa and I.Vamsiram, "Power Quality Improvement in E-Vehicle Charging Station", Journal of Interdisciplinary Cycle Research (JICR) ISSN 0022-1945 Volume XII, Issue IV, April 2020 Page No: 355-364.

[9]. Dr.B. Muthuvel, Dr.S.Arulkumar, Prof.A.N.V.J.Raja Gopal and Mr.Mohiddin Khan, "Simulation of 9 Level Output H-Bridge Multi Level Inverter", The International journal of analytical and experimental modal analysis (IJAEMA) ISSN 0886-9367 Volume XII, Issue IV, April 2020 Page No:1853 -1864.

[10]. Dr.B. Muthuvel, Dr.N.Muralikrishnan, Prof.A.N.V.J.Rajagopal and Dr.S.Arulkumar, "Simulation and Hardware Implementation of Z Source Buck Boost Converter Under Various Frequency Conditions", International Journal of Electrical Engineering and Technology (IJEET) ISSN Print: 0976-6545 and ISSN Online: 0976-6553 Volume 11, Issue 3, May-June 2020: PP 142-154.

[11]. Dr.B. Muthuvel, Dr.N.Arunkumar and Dr.B.Senthilkumar, "MMC controller and Controllable Capacitor based Reactive Power Control in HVDC Systems", Compliance Engineering Journal (CEJ) ISSN 0898-3577 Volume 12, Issue 2, February 2021 Page No: 29-38.

[12]. Dr. Muthuvel B, Dr. Rama Rao J V G, Chandra Prakasa Rao S, Vavilala Venkatesh, Sanaboina Amalodbhavi, "Tracking and Control of Power Oscillation Damping's in Transmission Lines using PV STATCOM", The Scientific Temper, E-ISSN 2231-6396, ISSN 0976-8653 Vol.14.3: July - September, 2023. PP 601-608.

[13]. [Dr. Muthuvel B, Dr. Rama Rao J V G, Ganga Bhavani C S, Adilakshmi Devi M, Durga Devi Kona, "A TLBO Algorithm-Based Optimal Sizing in a Standalone Hybrid Renewable Energy System", The Scientific Temper, E-ISSN 2231-6396, ISSN 0976-8653 Vol.14.3: July - September 2023. PP 629-636

[14]. Dr.B. Muthuvel, P.Jaya Krishna, K. Krishnaveni, P.K.N. Anvesh, and C. Yerraya Reddy, "Low-Cost Smart Vacuum Cleaner", Accepted and Presented for "International Conference on Integrating Recent Innovations in Science and Technology: Shaping the Future", (ICIRIST' 24) held on 1st and 2nd February 2024 organized by Dhanalakshmi Srinivasan Engineering College, Perambalur , Tamil Nadu, India.