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# Intelligent Controller and Adoption of Smart Grid for Sustainable Development and Smart Environment

**Indu Bhushan[1], and Nidhi Puri[2]**

[1]Department of Electrical and Electronics Engineering, Lloyd Institute of Engineering & Technology, Greater Noida, U.P, India
[2]Department of Applied Science and Humanities, Lloyd Institute of Engineering & Technology, Greater Noida, U.P, India

Correspondence should be addressed to Indu Bhushan; indu.bhushan@liet.in



**ABSTRACT-** Smart buildings are advanced concept for saving energy resource and related problems. The energy-guides represent different technologies that affect human working comfort. Energy management and control systems are combined in making a smart building. It is a challenging task where many technologies are to be kept under control. The objective of between those technologies is to find best solution to achieve building condition comfort. Therefore, intelligent system has been developed because of integrating of artificial intelligence to stochastic optimization using genetic algorithm (GA). This paper presents significant improvement in energy efficiency and building interior condition in smart buildings as well as various sustainable developed for various adaption of smart environment practices.

**KEYWORDS**- Intelligent Controller, Adoption of Smart Grid for Sustainable Development, Smart Environment.

## I. INTRODUCTION

There is an increased demand for energy and environmental comfort the requirement of in the interior of intelligent buildings and smart buildings. This requirement is an open multi- facet problem. The productivity, morale and satisfaction of human beings are largely affected various comforts in building. The buildings are annual consumers of the primary energy around forty five percent[1]. The utilization of more and more sustainable resources and reduction in fossil resources has increased the awareness among population to further reduce in consumption of energy and a move towards sustainability of resources. The management of Energy efficiency becoming more essential for intelligent buildings for meeting the requirement of reduced energy consumption and contributed towards further improvement in comfort index. The main important goals of optimised smart energy system are shown in Fig 1.
Optimise Energy Systems focussing on minimising the consumption of non-renewable resources, high efficiency, optimal use of new and existing energy and ICT infrastructure[2].

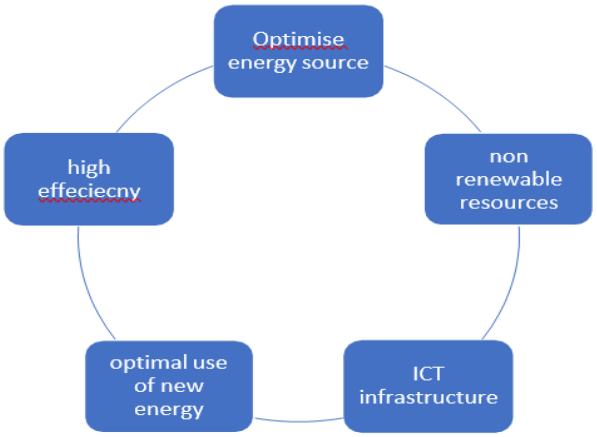


Figure 1: Goals of optimized smart energy system

The Energy sustainability and preservation of environment throughout the world is becoming the concern of industries and nations. Intelligent Smart Grid, the leading technology company seeks to bring technologically advanced solutions including distributed generation and microgrids to a global, consistent and sustainable power. Public awareness and adequate attention from potential researcher and policy makers with the technology is essential [3].
This paper presents an overview of Intelligent controller for effective sustainable energy management scheme and development. The Smart Grid intelligent controllers features and contribution in effective sustainable development will demonstrate how these technologies have shaped the modern electricity grid and continues to evolve and strengthen its role in the better alignment of energy demand and supply. Smart Grid implementation and practices in various locations of the world is also unveiled [4].

### *A. Smaít Gíid Initiatives in India*

The growing demand of electricity with the requirement of latest developments in the grids of power network proposes the need for the creation of smart grids. A smart grid is the integration of information and communication technology with the existing power network making the two-way communication possible in the generation, transmission & distribution sectors between the utilities and customers by employing the use of smart devices.

This paper presents a vision of smart grid development in India. The road map, highlights and development plans envisaged by the India Smart Grid Task Force for smart grid in India are discussed in the paper.Every power grid has three functional components generation, transmission & distribution. A smart grid should employ smart control centers, smart transmission network and smart distribution systems[5]. The paper discusses the chronological development in these functional areas. The development is based on the optimal use of natural resources, integration of grids, creating and enhancing smart infrastructure of generation,transmission & distribution technology. This work is an effort to investigate all the developments related to smart grid in reference to India. The developments for creating smart grid in India are multifactorial in nature but major concerns are to electrify rural sector of India which is yet deprived from electrification[6].

A total of 106,671 smart meters have been installed under the projects including 19,025 smart meters at CED in Subdivision 5, and 87,646 smart meters by JVVNL as shown in fig 2.

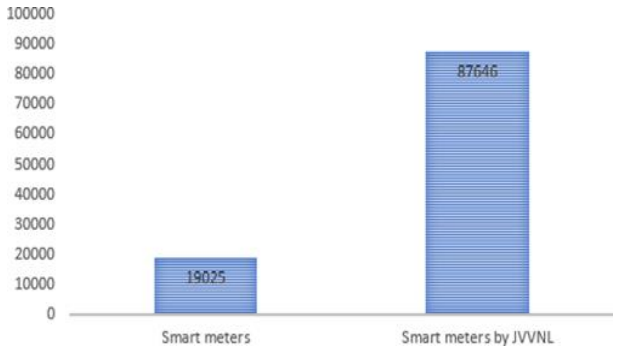


Figure 2: Smart meters

### *B. Main Features of Smart Grid*

It's a reliable solution for reliable, efficient, economical, possesses operational flexibility, which helps in integrating different types of power plants, and helps in managing of resources [7]. The main feature of smart grid is resiliency increase in the reliability of power supply to an area even if other areas suffer from power outage due to large disturbance, faults, blackouts etc.

Due to adoption of digitalization the smart grid provides a digital platform for controlling the operation in a much better way by using digital measuring devices, digital communication, and digital monitoring. Flexibility in smart grid helps in providing the

control scheme of power supply or in reference for increasing the power generating capacity. The smart grill intelligent operation by spreading the self-awareness and self- healing nature which is present in smart grid to operate in a better automatic control under any faulty condition[8]. The overall power network efficiency is sustained by deploying smart devices. The emphasis is on installation of renewable energy sources to a particular extent which doesn't deteriorate power system stability beyond certain limits. The liberalization of power market providing user friendly environment creating transparency in operations in the form of customization. The main features of Smart Grid are shown in Fig 3.

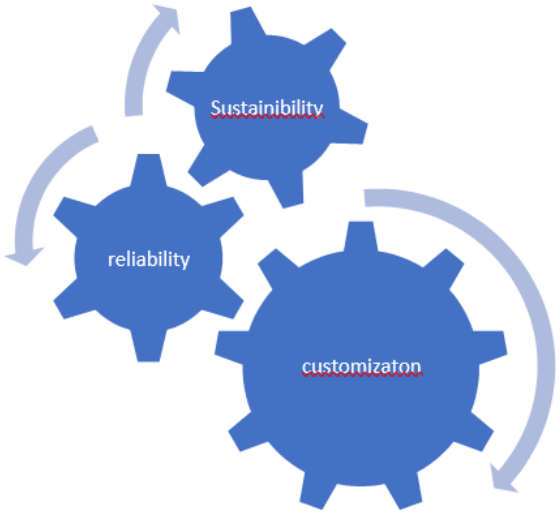


Figure 3: Features of Smart Grid

## II. LITERATURE SURVEY

The table 1 below summarize all scientific publications

Table 1: Below Summarize all Scientific Publication

| S. No | Author | Year | Description | Reference |
|---|---|---|---|---|
| **1** | ME El-Hawary | 2014 | This paper thinks about anElectric Power ExplorationFoundation definition withthat proposed by a reviewgathering of the International Electrotechnical Commission. | [9] |
| **2** | ZAHEERUDDIN and MUNISHMANAS | 2015 | This chapter examine themechanical base turn of events, improvement of special levy, and imperative administrative strategies that assistance in reasonabledevelopment of the savvy | [10] |
| | | | framework in the advancedpower area. | |
| **3** | G. M. Shafiullah*, Amanullah M. T. Oo, A. B. M. Shawkat Ali,Peter Wolfs | 2012 | This paper centers around the advantages and plausible organization issues ofbrilliant matrix innovationfor a supportable future both broadly and universally.Additionally examines the continuous significant | [11] |

| | | | | |
|---|---|---|---|---|
| | | | exploration programs inEurope, America and Australia for shrewd latticeand the related empowering advances. At long last, this study investigates thepossibilities and qualities of environmentally friendly power sources with conceivable organization combination issues to fostera spotless energy brilliant framework innovation for a keen power framework. | |
| **4** | Archana, RaviShankar, Shveta Singh | 2022 | This study attempts to uncover components that may be facilitators forIndia's brilliant latticeimprovement. To investigate the different parts of the brilliant matrix, poll studies, meetings, and studios weredirected with famous academicians, analysts, also, industry specialists workingin the power area. Anincorporated methodology of delicate frameworkprocedure (SSM), topical examination andfluffy mental planning havebeen utilized in this reviewto more readily appreciatethe multifaceted collaborations between partners. This explorationdiscoveries uncover thatspecialized improvement alongside buyer acknowledgment is a criticalelement for the solidexecution of shrewd framework. | [12] |
| **5** | Lamnatou, C.,Chemisana, D., | 2021 | This paper examine the savvy matrices/shrewd | [13] |
| | Cristofari, C. | | frameworks present many difficulties: private microgeneration, adaptability and dynamic support of the clients, advancement of environmentally friendly power frameworks (seaward wind power plants, building- incorporated nearby planet groups, and so on), energy progress, etc. | |
| **6** | Surender Reddy Salkuti | 2020 | This paper presents different difficulties of shrewd framework improvement including interoperability, network correspondences, request reaction, energy capacity what's more, dispersion lattice the executives. Aditionally surveys different issues related with the advancement of savvy lattice Nearby, territorial, public and worldwide open doors for the improvement of savvy lattice are likewise revealed in this paper. | [14] |
| **7** | Tuballa, M. L., & Abundo, M. L. | 2016 | This paper shows shows how advancements have formed the cutting edge power matrix and proceeded to develop and fortify its job in the better arrangement of energy interest and supply. Shrewd Network execution and practices in different areas are likewise revealed. Substantial energy arrangements work with Shrewd Framework drives around the world. Strangely, Shrewd Framework rehearses in various areas scarcely show contest yet rather an unbordered local area of comparable goals and shared examples. | [15] |

| | | | | |
|---|---|---|---|---|
| **8** | Sunil Luthraa, Sanjay Kumar, Ravinder Kharb, Md. Fahim Ansari, S.L.Shimmi | 2014 | This paper shows how organized model will assist with understanding interrelationshipsand interdependencies among the recognized hindrances to execute brilliant matrix advances. Various answers for dealing with these distinguished obstructions have additionally been recommended in the paper. Associations engaged with power age and dispersion might be helped by comprehension of these hindrances, their communications and recommended alleviation arrangements towards successful reception of brilliant network advancements. | [16] |
| **9** | Pallonetto, F., De Rosa, M., & Finn, D. P. | 2021 | This paper examine the information is used by different unique adaptability measurements inside the individual control calculations. Different season of purpose levies, in light of information from the Irish Commission for Energy Guideline and organized based on top, off-pinnacle and night time frames, are likewise utilized. Results show that energy cost decreases of up to 21% and 43% can be accomplished by the standard based and astute calculation, separately, without compromising the warm solace inside the structure. Additionally, complete moving and compelling adaptability capability of up to 34 and 54 kWh, individually, in view of the long stretch of January, can be accomplished by the reception of the astute control calculation. | [17] |
| **10** | Yan, Y., Qian, Y., Sharif, H., & Tipper, D. | 2012 | The buyers can limit their cost on energy by changing their insightful home machine activities to stay away from the pinnacle hours and use the environmentally friendly power all things considered. We further investigate the difficulties for a correspondence framework as the piece of a mind boggling shrewd network framework. Since a shrewd lattice framework could have north of millions of shoppers and gadgets, the interest of its dependability and security is very basic. Through a correspondence framework, a savvy network can further develop power dependability and quality to dispose of power outage. Security is a difficult issue since the on- going brilliant lattice frameworks confronting expanding weaknesses as increasingly more mechanization, remote observing/it are interconnected to control and oversight substances. | [18] |

## III. MULTI AGENT CONTROL SYSTEM

A multi agent-controlled system is an intelligent controlled system designed for smart interactions, managing and coordination between sustainable building operations. The below chain of control is added into the architecture has been established and employed to model

such an innovative system. In order to attain the maximum comfort, the central coordinated agent-controller manages the other local agent-controllers[19]. Fuzzy Logic controllers are implied at different levels of local based agents, which in turn provides a distinct level of comfort. The below given figure 4 shows the hierarchy of the Multi agent control system:

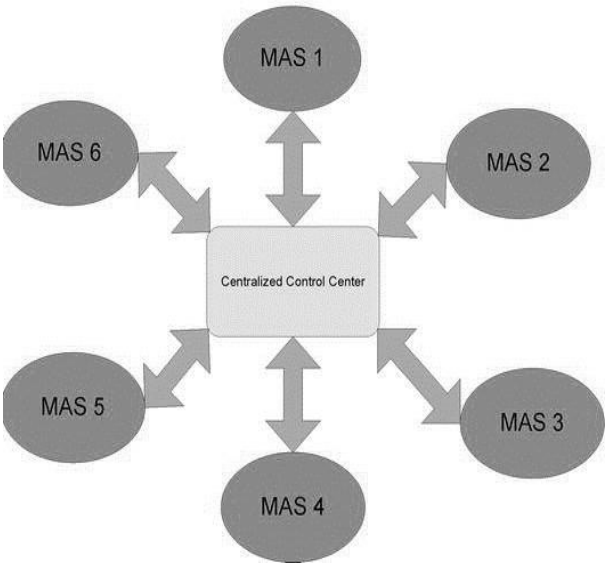


Figure 4: Multi agent control system

### *A. Internet of Things in Smart and Sustainable Environment*

The day to day breakneck technology enhancements in user's life have acted as a stimulus for the researchers to pervade up on adding new technologies which have become an integral part of our day to day work and no doubt has settled there for good. For instance, Internet of Things (IoT) and systems of intelligence. One such example of Internet of Things is "Intelligent Homes" which allows home owners to control the home appliances using Home Automation System (HAS).

Internet Of Things(Iot) can be used in numerous sectors-be it the Smart Retail, Smart Connected Homes, Connected Factories, Healthcare and Universities, Smart Farming and many more. Iot comprises of 2 terms: "Internet" and "Things"[20]. This "Connection and information exchange of Things" via "Internet" is termed as Internet of Things. This connection between different things, people, places, and almost everything that we see around, has made us more connected and makes the world a much smaller and a better place to be in. These continual rapid technological enhancements have not only connected us to distinct devices but have also equipped us with the ability to interact from anywhere and everywhere. Iot can be used to communicate and interact between multiple devices at once making it a revolutionary change in technology. One of the most popular domains of Iot is the "Smart Homes" which have made our houses more liveable. Today's home automation technology has become awfully addictive because of the convenience provided. The controlling of household appliances remotely sitting at any location via internet is something which everyone longs for. Intelligent homes are computerized systems [21] which are accessible through one central point which can be used to control and manage all the connected devices in a home. The machinery behind Iot that makes it go working is a long list of technologies like Radio Frequency Identification (RIFID), WIFI, Wireless Sensors (WSN), actuators, hardware, software and cloud[22]. Modern networks with switches and transmitters with the central axis are known as gateways. They constitute to the backbone of Iot which manages network connectivity by controlling/managing using smartphones or computers. This automation of multiple aspects of everyday routines have come up commercially and is divided into two broader categories:

- Managing the equipment's locally
- Managing the equipment's remotely.

The user can manage the equipment's locally without using the Internet cloud. Controlling and managing the devices locally, results in faster and better communication between the connected devices[23]. Whereas, managing the equipment's remotely has a benefit of controlling and managing the devices remotely by the comfort of sitting anywhere in the world. But as it is said that Technology doesn't come without the risk. It has its own pros and cons. When speaking about Iot the major drawback is "Not every size, fits all". Not all devices are compatible to interact with each other. Incompatibility and inoperability becomes a major drawback while setting up smart homes. Further these automated devices should have a suitable and safe communication range bypassing the security concerns. The below fig 5 shows role of IOT in sustainability.

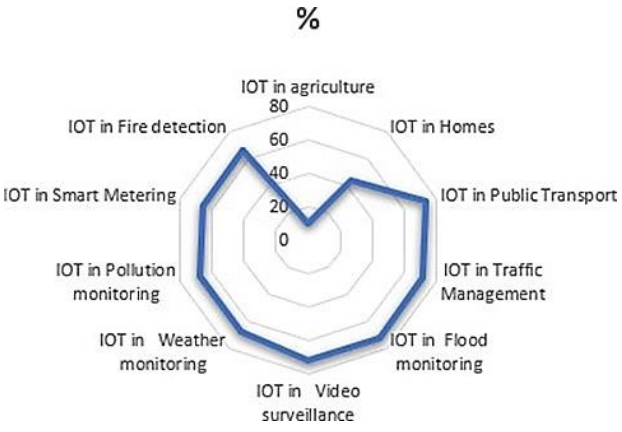


Figure 5: Role of IOT in sustainability

Table 2: Summary of the Smart Home Systems

| SH System | Controller | Indoor Control | Outdoor Control | Energy Manage- | Monitoring | Safety | Security | Smartphone | Real Implementa- | PC | Wireless Interface |
|---|---|---|---|---|---|---|---|---|---|---|---|
| David *et al.* [26] | Arduino Mega | Yes | Yes | Yes | Yes | Yes | | Yes | | Yes | Bluetooth/WiFi |
| Ozeer *et al.* [27] | Raspberry Pi | Yes | Yes | Yes | Yes | | | | Yes | Yes | Fog-IoT |
| Jabbar *et al.* [28] | Arduino Mega | Yes | | | Yes | | | Yes | | | WiFi |
| Davidovic and Labus [29] | Raspberry Pi | Yes | | | Yes | | | Yes | | | Bluetooth/WiFi |
| Kodali and Soratkal [30] | Node MCU | Yes | | | | | | Yes | | Yes | WiFi |
| Konidala *et al.* [31] | PC Server | | | | | | Yes | Yes | | | RFID |
| Badabaji and Nagaraju [32] | PC Server | | | | Yes | Yes | | | | Yes | GSM/WiFi |
| Ganesh [33] | 8051µc | Yes | Yes | | | | | | | Yes | GSM |
| Bhat *et al.* [34] | PC Server | | | Yes | | | Yes | | | | WiFi |
| Gupta and Chhabra [35] | Galileo board | Yes | Yes | Yes | Yes | | Yes | Yes | | Yes | Ethernet |
| Kaur *et al.* [36] | Arduino | Yes | | Yes | | | Yes | Yes | | | GSM |

## IV. PERVASIVE COMPUTING AND AMBIENT INTELLIGENCE IN SUSTAINABLE ENVIRONMENT

The study of ambient intelligence and pervasive computing has propelled smart environments to the forefront of many research labs. The goal of creating settings that behave like intelligent beings has come a long way, but there are still challenges that need to be resolved by academics due to the size of the issue. The use of multi-agent systems in intelligent environments is one such problem. In this article, we examine the function of multi-agent research in the context of intelligent settings and provide an overview of the field's most recent findings. Additionally, we present a number of difficulties that must be overcome in this dynamic and complicated field of research.

## V. METHODOLOGY SMART ENVIRONMENT

The breakneck advancements in the Smart Environment has been attracting researchers in a variety of realms, like Artificial Intelligence, Machine Learning, Cloud Computing, Robotics, Deep Learning, Neural Networks and many more. This in turn has seen a paradigm shift in the raise of smart projects. The rising increase in the popularity of the topic and demand for successful inhibition of these projects, we offer an updated look at the state of the art in smart environments.

Researchers gather extensive information to design smart environments which can gather all possible environment knowledge and provide an effective and comfortable user experience.

In accordance with the raise in numbers for refining Internet of Things (IoT) Security with Software-Defined Network (SDN) study, there will be more than 29 billion connected IoT devices by 2030[24]. The booming demand in Iot will result a growth of over 7.33 billion mobile users by 2023 and more than 1,105 million connected wearable devices users by 2022[25]. Thus, the Internet of Things is expected to accelerate into one of the smartest collective and collaborative systems in history. IOT usage is shown in Fig 6 below.

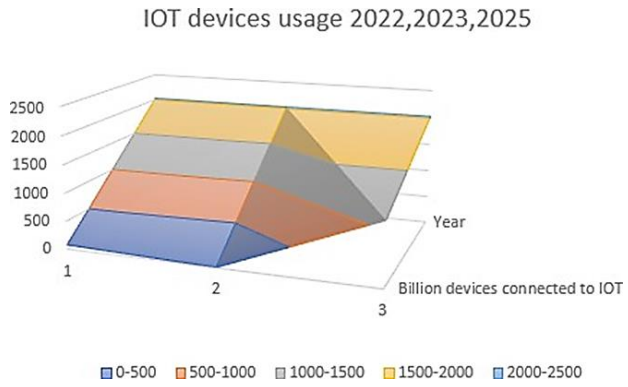


Figure 6: IOT device usage by 2025

### *A. Physical Components in Smart Environments*

Physical elements like sensors, controllers, and smart devices must be created and used properly because research on smart environments is conducted in actual, physical settings. This makes it possible for humans to watch, monitor, and interact with the physical world in real-time, allowing us to respond appropriately. A smart environment can be designed and built using this concept[26]. Without these physical elements, we end up with theoretical algorithms that have scant to no practical use.

Sensors collect and disseminate the data that smart environments require using (wireless) sensor networks made up of several distributed sensor nodes cooperating to carry out a task. To sense, acquire, analyse, and communicate data about the intended physical environments, such as temperature, humidity, motion, sound, and the like, wireless sensor networks are widely employed in place of conventional networks [27]. Contrarily, the end purpose of conventional networks is point to point (or point to many points) data forwarding.

To serve as a platform for ubiquitous/pervasive computing, sensor/actuator networks must, among other things, be quick, simple to set up and maintain, dependable, and self-organizing. The relatively limited system resources on sensor nodes, including as energy, communication, processing, and storage, which also exhibit high levels of

uncertainty in all other portions of the system, are one of the characteristics of such networks[28] As a result, there

are a number of areas that are unclear, including the sensing range, localization and synchronisation outcomes, wireless channel fluctuation and transmission, topology control and routing behaviour, security, and mobility [28].

### *B. Automation and Self-Adaptation*

In order to provide a platform for ubiquitous/pervasive computing, sensor/actuator networks must, among other things, be quick, simple to install and maintain, robust, and self-organizing. The relatively restricted system resources on sensor nodes, such as energy, communication, processing, and storage, are one of the characteristics of such networks, which also exhibit significant levels of uncertainty in all other aspects of the system. This causes uncertainty in a number of areas, including the sensing range, outcomes of localization and synchronisation, wireless channel fluctuation and transmission, topology control and routing behaviour, security, and mobility [29]. Thus, the effectiveness of a sensor network in overcoming these ingrained concerns and delivering desired trust in the functionality of diverse system components is what determines its success. Additionally, because there are many sensor nodes being deployed.

### *C. An Intelligent Controller for the Smart Grid*

The Consortium for Electric Reliability Technology Solutions estimates that power outages cost the US economy $80 billion annually (CERTS). With the use of computers and our electric power analysis capabilities[30] we can offer system operators or automatic control software sufficiently quick solution ideas to avoid domino consequences. It can accomplish this by either suggesting an action to the user or by applying the necessary control to the system without the need for human participation. Our suggested system will foresee the effects and decide the best course of action given the current circumstance.

For instance, the above-mentioned 2003 power outage cost $10 billion in lost utility revenue and commercial sales. A 60 GW loss of load and tens of millions of subscribers were affected by the outage. There was a two hour interval of the early phase of the cascade before any power generation was lost, even though it only took three minutes for the outage to spread from a single power plant to another 21 plants. It is possible to discover and fix the network during this early period, stopping the cascade and minimising effects on the system and customers. This has been described in Fig 7.

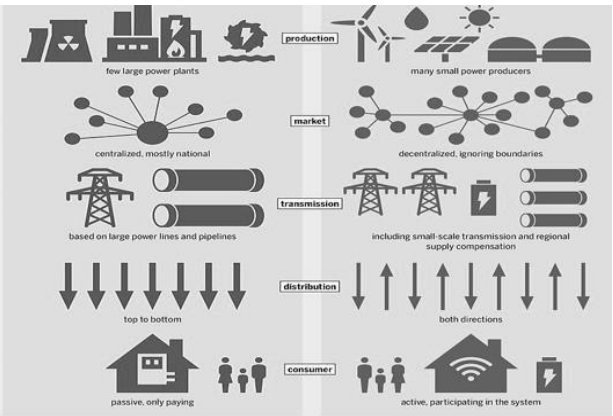


Figure 7: Smart Grid follows. Intelligent smart controller

## VI. CHALLENGES AND SOLUTION

In the past, agents have been used to act as representatives for people, devices, and programmes [31]. Agents can also be efficiently employed to provide transparent connections between various environmental components, increasing invisibility. As agents may overcome the constraints of thousands of resource-constrained devices, agent interaction and collaboration are essential components of pervasive (intelligent) ecosystems [32].

Systems for ubiquitous or intelligent computing must effectively support resource and service discovery, which is the act of locating software processes and agents, hardware components, and services [33]. Devices and the environment are given situational and device awareness through service discovery. Even so, a smart environment consists of innumerable inconspicuous objects, people, and all-pervasive services. A significant problem is the creation of efficient middleware technologies to hide the impacts of heterogeneous wireless devices and networks as well as mobility[34]. It is also crucial to offer consistent services wherever they are. This results in adaptive location-aware services that are best suited to the environment and the scenario at hand.

## VII. STOCHASTIC OPTIMIZED INTELLIGENT CONTROLLER FOR SMART ENERGY EFFICIENT BUILDINGS

Buildings are increasingly implementing emerging energy resource management concepts to cut down on energy use and waste. A range of technologies are included in the energy management and control system, which has an impact on worker comfort. Creating a comfortable interior building atmosphere while using a high level of energy efficiency is a difficult issue for the building control. In this paper, a multi-agent control system and a genetic algorithm for stochastic optimization have been devised (GA)[35]. The associated simulations of efficient energy management and customer comfort are shown. The designed control system significantly reduces energy usage and improves the comfort of the indoor environment in smart buildings.

For intelligent buildings to achieve the requirements of decreased energy consumption and better comfort index, energy efficiency and management have become crucial. Three fundamental comfort elements—thermal, visual, and air quality—determine how comfortable a space is for its occupants[36].The foregoing parameters are defined, in turn, by temperature, light levels, and CO2 concentration. Lighting fixtures, ventilation systems, and auxiliary heating and cooling systems are used as actuators for the physical environment control.

A decentralised control system has been devised in the current study to strike a balance between energy consumption and healthy interior environmental conditions. This control system aids in the development of the actuator system's energy consumption functions[37]. To provide the most comfort possible, it also develops the energy distribution plan. In order to improve the buildings' energy management, an evolutionary genetic algorithm has also been integrated into the control system. As a result, the control system initialises goals for both optimum interior comfort and low energy use[38].

## VIII. RESEARCH METHODS AND RESULTS DISCUSSION

This study was conducted in three stages, which depicted the review of various scientific publications published in Google scholar and various Microsoft academic research in Figure 8 and 9 and described as follows

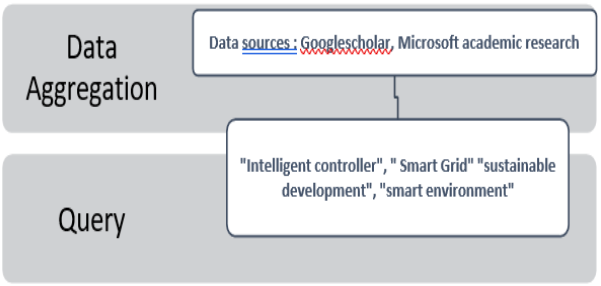


Figure 8: Research Method

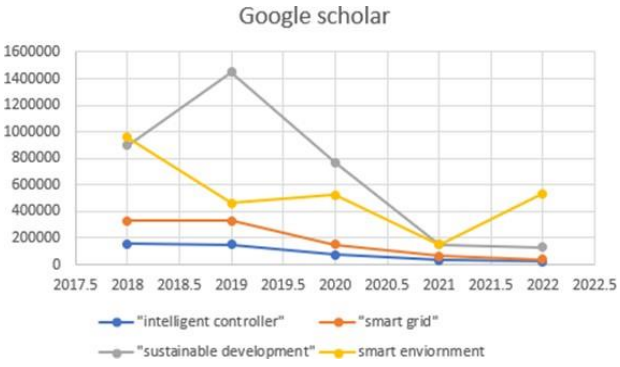


Figure 9: Scientific publication on "Intelligent controller", " Smart Grid" "sustainable development", "smart environment"

The below table 2 describe the Energy balance of electricity consumption as well as India and USA per capita as shown in Fig 10.

Table 3: Electricity consumption India and USA

| Electricity | Total | India per capita | USA per capita |
|---|---|---|---|
| Own consumption | 1,137.00 bn kWh | 815.98 kWh | 11,756.77 kWh |
| Production | 1,386.00 bn kWh | 994.68 kWh | 12,338.29 kWh |
| Import | 5.62 bn kWh | 4.03 kWh | 219.11 kWh |
| Export | 5.15 bn kWh | 3.70 kWh | 29 |

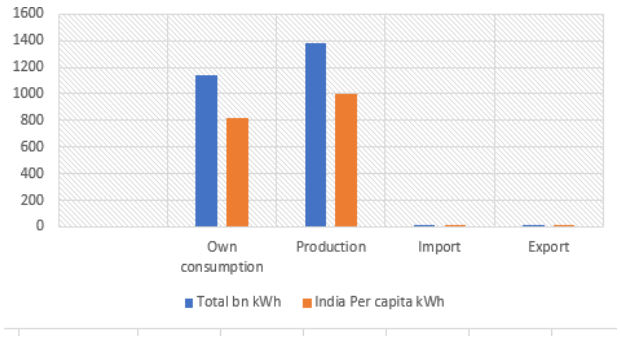


Figure 10: Electricity consumption

Table 4: Production and import of crude oil

| Crude Oil | Barrel/day | India per capita |
|---|---|---|
| Production | 709,000.00 bl | 0.001bl |
| Import | 4.06 m bbl | 0.003bl |

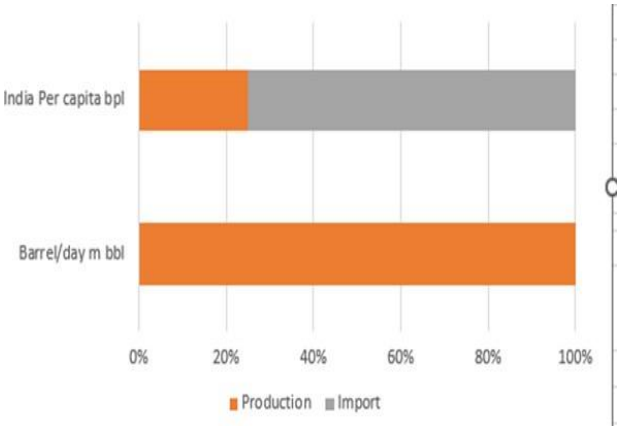


Figure 11: Production and import of crude oil Table 3: Production and import of Natural Gas

Table 5: Production of Natural Gas

| Natural Gas | Cubic meters | Indiaper capita |
|---|---|---|
| Own consumption | 55.43 bn m³ | 39.78 m³ |
| Production | 31.54 bn m³ | 22.64 m³ |
| Import | 23.96 bn m³ | 17.20 m³ |
| Export | 76.45 m m³ | 0.05 m³ |

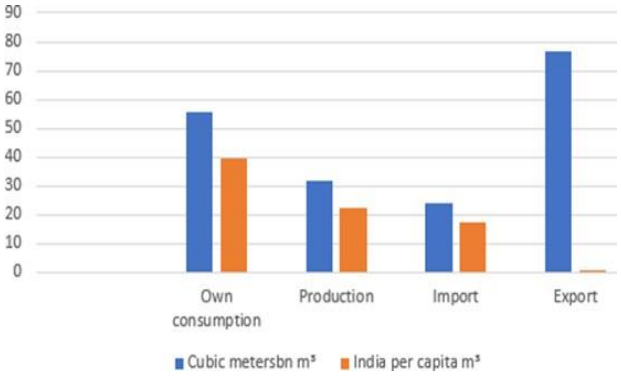


Figure 12: Production and import of Natural Gas

## IX. CONCLUSION

Intelligent Controller and the adoption of Smart Grid technology are critical components for sustainable development and a smart environment. The Intelligent Controller enables efficient and effective management of the energy grid, reducing waste and optimizing the use of renewable energy sources. The Smart Grid, on the other hand, helps in reducing carbon emissions, improving energy efficiency and reliability, and providing a more flexible and responsive energy system.

Furthermore, the integration of these technologies helps to ensure a more sustainable future by reducing our dependence on fossil fuels and promoting the use of renewable energy sources. The Intelligent Controller and Smart Grid also help to create a more resilient energy system, making it less vulnerable to failures and outages.

Overall, the Intelligent Controller and Smart Grid technology are essential tools in the transition towards a more sustainable and environmentally friendly energy system. The continued development and implementation of these technologies will play a crucial role in achieving a cleaner, greener, and more sustainable future for all.

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