3. EXAMINE THE ROLE AND CHALLENGES OF SCIENCE AND TECHNOLOGY IN ENERGY SECURITY IN INDIA?

APPROACH- Write about the significance of energy security followed by the role and challenges of science and technology in energy security in India. conclude the answer with a way forward.

INTODUCTION:

Energy security has been significant to the **economic transformation, global prosperity and well-being of the human kind** and it will continue to be detrimental to the existing life and much more crucial to the developing countries than the developed world. These resources are finite, and the **direct links between energy supply and economic growth have pushed the issue of energy security** at the core of the policy debate with a considerable impact on the geopolitics.India **imports 80 percent of its oil needs** and is the **third largest oil consumer** in the entire world.

Social and economic development in India both depend on **access to modern forms of energy.** Providing electricity to all while moving to **low carbon electricity generation is a social imperative**. Indian electricity supply and demand are projected to increase fivefold to sixfold between now and 2050. This development will require **massive investment and advanced technology.**

ROLE OF SCIENCE AND TECHNOLOGY IN ENERGY SECURITY:

Photovoltaic Solar:

- **The flat-plate PV modules** and the **concentration PV modules**, while, in concentrating solar system, efficiency can reach up to 30% or more. Nevertheless, concentration **PV module systems require water mainly for cooling** purposes in the steam cycle but also to **clean the vast mirror areas.**
- The knowledge of **PV electricity potential is useful to policy makers** for **reducing greenhouse gas emissions** from electric energy production.

Nuclear energy:

- Presently, **nuclear energy makes up around 3% of India's energy mix** and has the potential to become 20 to 25% of India's energy mix by 2050.
- The nuclear deal was aimed to help India to meet its looming energy crisis by enabling it to access to safeguarded **nuclear fuel, advanced light water reactors and civilian nuclear technology.**
- **India has 17 pressurised heavy water reactors (PHWRs) and two boiling water reactors (BWRs) inoperation.**

Hydraulic fracturing:

- India had decent amount of reserves of natural gas and oil and this would last even after the fossil fuels like petroleum and others were exhausted. Globally **hydrocarbon reserves** were enough to meet the demand for next four to five decades.
- The **highly energy dependent society** of today has increased the demand for hydrocarbons. Further, there is a **greater demand for clean energy**. Both have contributed to the increase in demand for unconventional.

Artificial intelligence:

- **AI has the potential to cut energy waste, lower energy costs, and facilitate and accelerate the use of clean renewable energy sources** in power grids worldwide.
- AI can also improve the **planning, operation, and control of power systems**. AI technologies are closely tied to **the ability to provide clean and cheap energy that is essential to development.**

Blockchain Technology:

- In the energy sector, blockchain is considered a promising tool **to record and facilitate transactions** between generators and consumers of energy.
- It includes various use cases, such as: **Peer-to-peer electricity trading, Management of renewable energy certificates, Grid management, and Electric vehicle charging and sharing**.

Biotechnology:

- the potential exists to employ biotechnology to **convert the residual hydrocarbons** in depleted oil wells and coal deposits **into methane** and recover a far greater percentage of the energy content in a reasonable time frame while **simultaneously reducing the amount of CO2** released to the atmosphere.
- **Biofuel, any fuel that is derived from biomass**, that is **plant or algae material or animal waste**. Since such feedstock material can be replenished readily, biofuel is considered to be a source of renewable energy.

IMPACT OF SCIENCE AND TECHNOLOGY IN ENERGY SECURITY:

- **Energy Efficiency**: Energy efficiency can play a crucial role in ensuring both long- and short-term **energy security in a cost-effective manner**. Energy efficiency also **reduces** the likelihood of **supply interruptions**; the only energy source that cannot be interrupted is the energy that is not used.
- **Advanced energy storage:** Wide array of technological approaches to managing our power supply in order to create a **more resilient energy infrastructure** and bring **cost savings to utilities** and consumers.
- **Batteries:** A range of **electrochemical storage solutions**, including **advanced chemical batteries, flow batteries, and capacitors.**
- **Thermal:** capturing heat and cold to create **energy on demand or offset energy** needs.
- **Mechanical Storage:** other innovative technologies to **harness kinetic or gravitational energy** to store electricity.
- **Hydrogen:excess electricitygeneration** can be converted into **hydrogen via electrolysis** and stored.
- **Pumped Hydropower:** creating **large-scale reservoirs of energy** with water. India has an installed hydro capacity of 36 GW, distributed over 256 projects with 761 dams in operation.
- **Offshore wind, solar and seaweed:Seaweed mainstream crop** in India can be used in production of **bio-plastics and biofuels**. The cultivation of seaweed in a **nature-inclusive way**, creating new habitats and creating biodiversity on the seabed.
- **Smart Metering:** the discrepancy between consumption and revenues, accounts for an annual loss of $23 billion in India alone. This discrepancy is mostly attributed to meter tampering. Rolling out smart meters would deliver precisely this result, as **smart meters can generate an additional 15-20% revenue per meter** relative to traditional meters. Utilities with smart metering infrastructure have also reported 95% billing efficiency in Q1-2020.
- India can also reduce the energy needed to support economic growth by promoting energy efficiency **technologies across buildings, lighting, appliances, water pumps, power plants, and transportation equipment**.

CHALLENGES OF SCIENCE AND TECHNOLOGY IN ENERGY SECURITY:

- **Exploration and production of unconventional resources** was **expensive**. wells have a shorter lifespan and newer ones need to be drilled soon.
- **Large concentrated solar power installations require large domains**. Finding suitable area for the project that also guarantees economic feasibility is a task.
- The **use of technology should avoid competition** between urbanization, environmental protection and cropland, on the one hand, and electricity production on the other.
- The **investments** to **fight meter tampering** and **non-technical losses** impact finances and reduce the capacity to invest in grid improvements and provide the quality service.
- **Inadequate research and development** fuels the challenges in energy security sector.
- **Seaweed production** involves **long underwater cords**, with seaweed growing at regular intervals along the cord which involves huge money and is time consuming.
- **Investment needed in high-resolution imaging, geo-mechanical studies, lean drilling and fracturing.**

GOVERNMENT INITIATIVES IN ENERGY SECURITY:

- **National offshore wind energy policy, 2015:** The project focused on the States of **Gujarat and Tamil Nadu** for identification of potential zones for development through **techno-commercial analysis and preliminary resource assessment.**
- **National wind solar hybrid policy,2018:** To provide a framework for promotion of **large grid connected wind-solar PV hybrid system** for optimal and efficient utilization of **wind and solar resources, transmission infrastructure and land.**
- **Jawaharlal Nehru national solar mission:** To establish India as a global leader in solar energy by creating the **policy conditions for its deployment** across the country. Each Phase is supported by differing key policies and targets.
- **PM KUSUM Scheme:** Scheme is aimed **at ensuring energy security for farmers** in India, along with honouring India's commitment to increase the share of installed capacity of electric power from **non-fossil-fuel sources to 40% by 2030 as part of Intended Nationally Determined Contributions (INDCs).**

- **National biofuels policy, 2018:** The Policy aims at mainstreaming of biofuels and bring about accelerated development and promotion of the **cultivation, production and use of biofuels to increasingly substitute petrol and diesel** for transport and be used in stationary and other applications.
- **Solar Parks:** The scheme aims encourage project **developers and investors, prompting** additional projects of similar nature, triggering economies of scale **for cost-reductions, technical improvements and achieving large scale reductions in greenhouse gas (GHG) emissions.**
- **Solar Cities:** The Solar City aims **at minimum 10% reduction in projected demand of conventional energy at the end of five years**, through a combination of enhancing supply from renewable energy sources in the city and energy efficiency measures.

CONCLUSION:

India, one of the **fastest growing major economies**, is also the **fastest growing energy consumer** in the world, is not well endowed with energy reserves. India has mammoth task of meeting its economic and social developmental goals, and lift its millions of people out of poverty. The country has no option but to strive for sustained growth rate of 8-10% to achieve this. The demand for energy in the coming years will accelerate further as India embarks on manufacturing through Government's much vaulted 'Make in India' programme, developmental projects and access to **electricity to all**.

Consequently, **energy security has emerged as one of the salient policy issues** over the past decade and a half, and the successive Indian governments have emphasised on addressing the impending energy crisis challenges.All of this will require a **national commitment** to developing **efficient energy technology ecosystems comprising innovation and research, technology services, local manufacturing and customer support for innovation.*(1400 words)***