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National Conference in association with CIGRE India and CIRED

Role of Distribution Systems and Distributed Energy Resources: Planning for 2030 and Beyond

New Delhi, Oct ‘25

Session Topic:

“Enhancing Distribution System Flexibility with Decentralization and Grid Intelligence"

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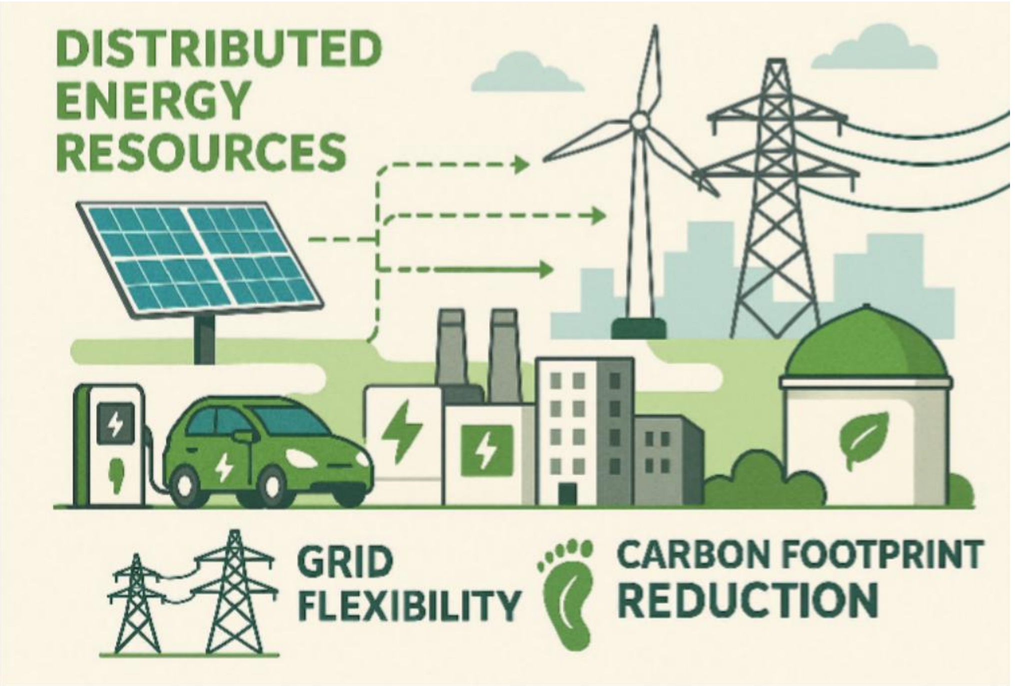
Role of DERs in Distributed Generation

Distributed Generation (DG) refers to DERs generating electricity closer to loads, rather than from remote, centralized power plants.

DERs are relatively smaller distributed energy sources operating independently with Microgrid, or in conjunction with the main grid.

Rise of DERs is a shift from a traditional "one- way" power flow (from large power plants) to a bidirectional or multi-directional flow.



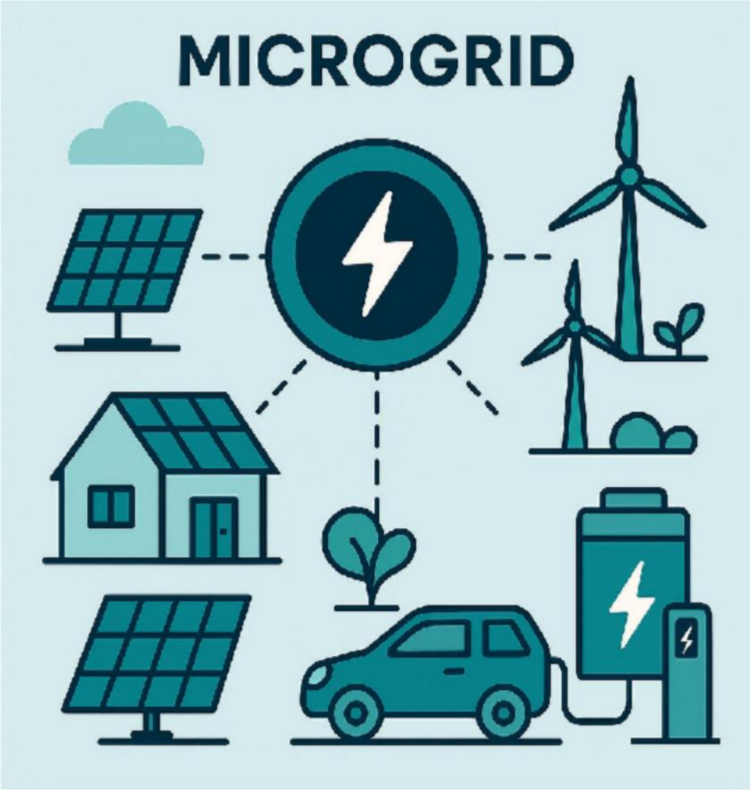
Distributed Generation & Microgrids

Distributed Generation (DG) units are located close to consumption points (e.g. rooftop solar, small wind turbine or biomass facility).

DG units are smaller in capacity compared to centralized power plants, often ranging from few KWs to tens of MWs.

They are modular, allowing scalable installations, ideal for Microgrids.

They can operate in grid-tied mode or in an islanded mode via Microgrid.



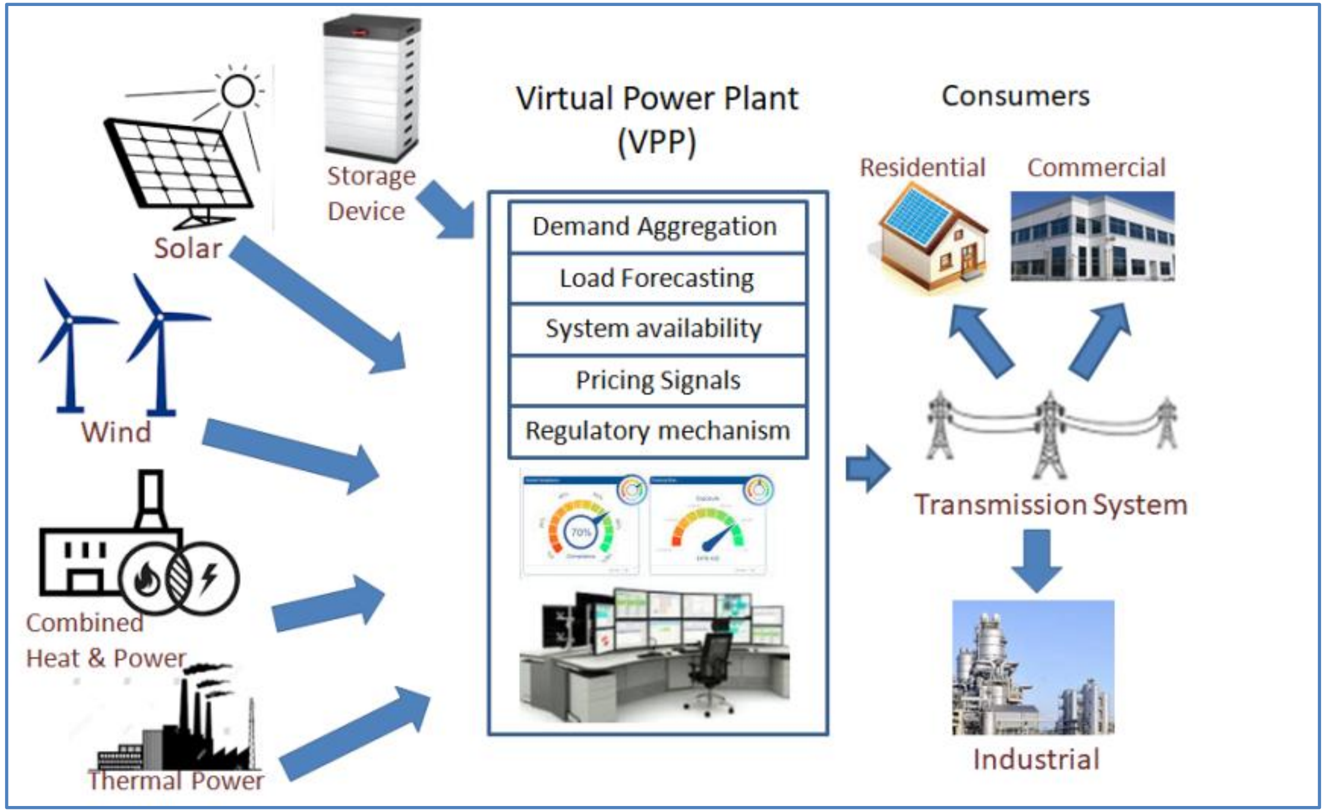
Virtual Power Plants

Characteristics of VPPs

- Aggregations of DERs (solar, wind, BESS, EVs)
- Coordinate via digital platforms to act like a single dispatchable power plant.
- They can trade in energy markets, provide ancillary services, and support local distribution networks.

Core Functions of VPPs

- Aggregates distributed generation (DG) assets into a dispatchable portfolio
- Bids into wholesale energy markets (capacity, ancillary services e.g. black start, grid support)
- Provides local grid support (voltage regulation, congestion management)
- Enables customer participation in flexibility programs (DR/ DSM)



Business Case of Distributed Generation

Technical Loss Reduction: Generating electricity closer to loads

Energy Security: Diversified energy mix reduces reliance on centralized power plants

Grid Resilience: Localized power is less susceptible to main grid failure

Consumer Participation: Consumers are encouraged to become Prosumers

Deferred CAPEX: Defer the need for expensive upgrades

Faster Deployment: DG projects are smaller and can be deployed faster

Peak Load Management: Dispatch during high demand, reducing grid stress

Waste Heat Recovery: Cogeneration captures waste heat, improving overall efficiency

Sustainability: Powered by RE (solar, wind, biomass, storage systems, etc.), Distributed Generation lowers carbon emissions and promotes sustainability

Challenges of DER Generation

Grid Integration: Connecting DERs to a grid designed for one-way power flow have technical complexities e.g. reverse power flow & protection coordination.

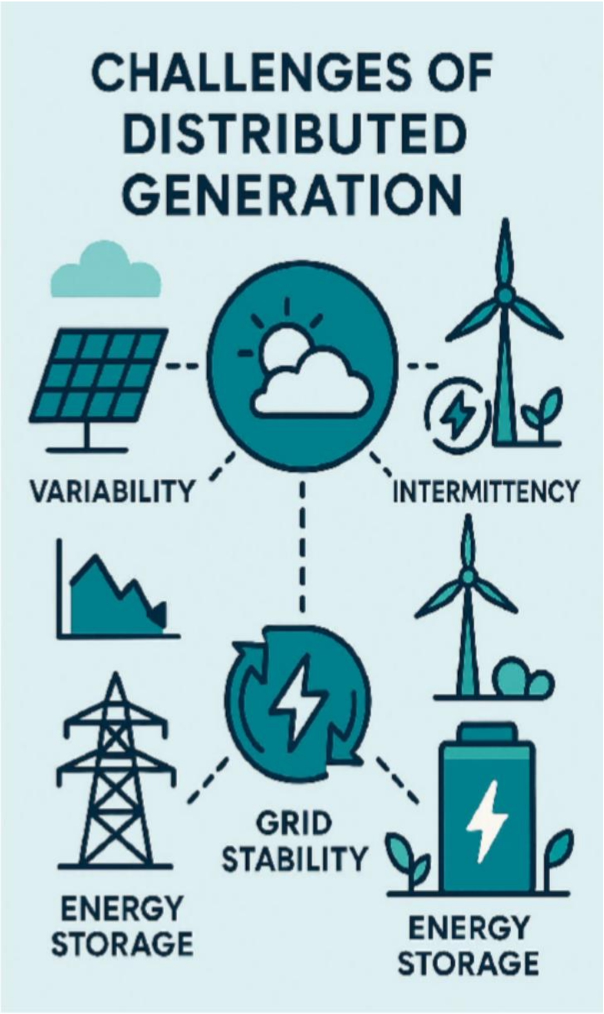
Intermittency: DERs are intermittent (weather-dependent), requiring forecasting of weather, energy demand, energy output and flexible backups.

Policy & Regulations: Regulations and market structures for DERs need to fully evolve.

Business Models: DERs can impact traditional revenue models of centralized generation.

Financing: Financing and approvals of DER projects are tedious.

Land Use: Installation of DERs often conflict with landscape aesthetics



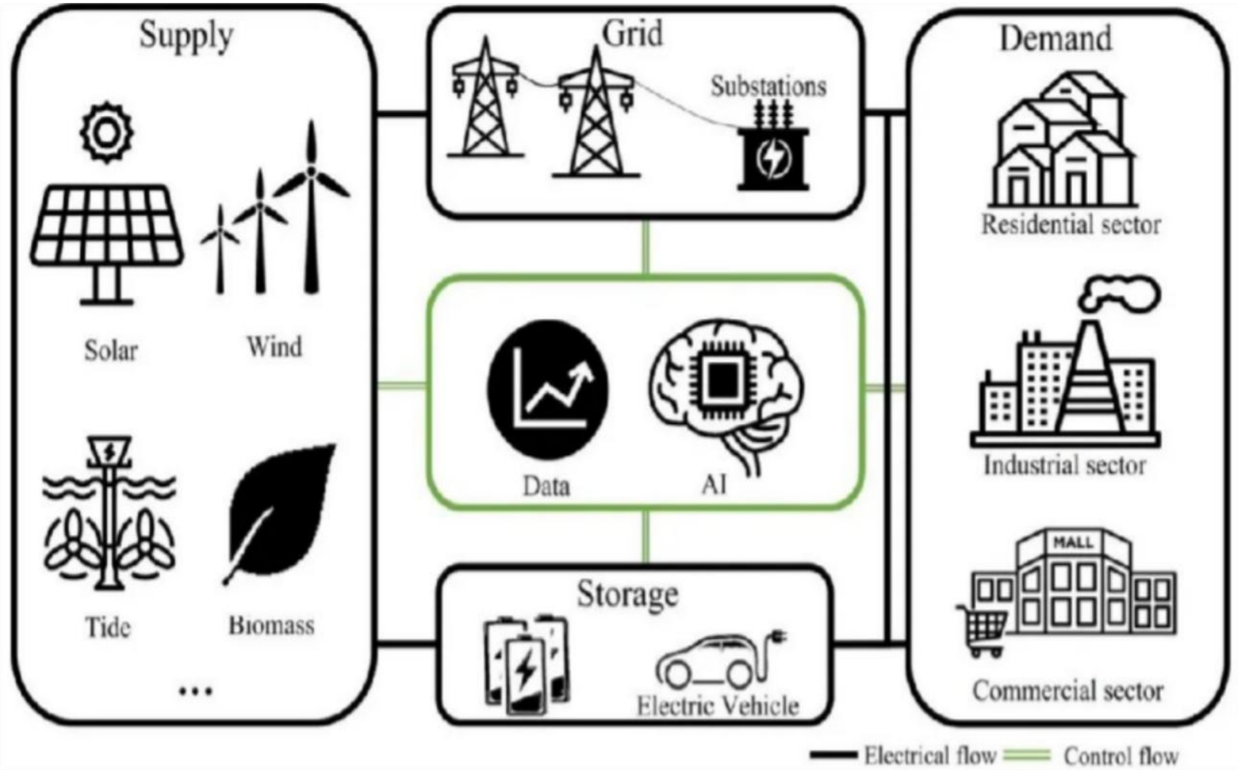
Improving Flexibility with Demand Forecasting

Demand Forecasting

- Optimize DER generation with accurate forecasting models
- Analyze historical consumption, demand/ behaviour, price trends and weather to improve modelling

Use Cases

- Use of AI/ ML tools to:
  - Improve predictions
  - Optimize generation
  - Shift peak loads with DSM



Technical Drivers of Flexibility

Advanced Metering:

- Ensure accurate billing, loss reduction, outage management and fault recovery

Data Management:

- Monitor and analyze network performance in real-time to generate demand response

Communication Standards:

- Enhance operational efficiency of network through improved data transfer & communications

Grid Modernization

- Plan & Design for compatibility in Substation/ Feeder automation, Transformer analytics, AMI/ MDMS, SCADA/ ADMS and EMS

Data-Driven Decisions

- Analyze CAPEX/ OPEX, failure rates, FLISR, environmental impact, etc.

Source: Ministry of Power

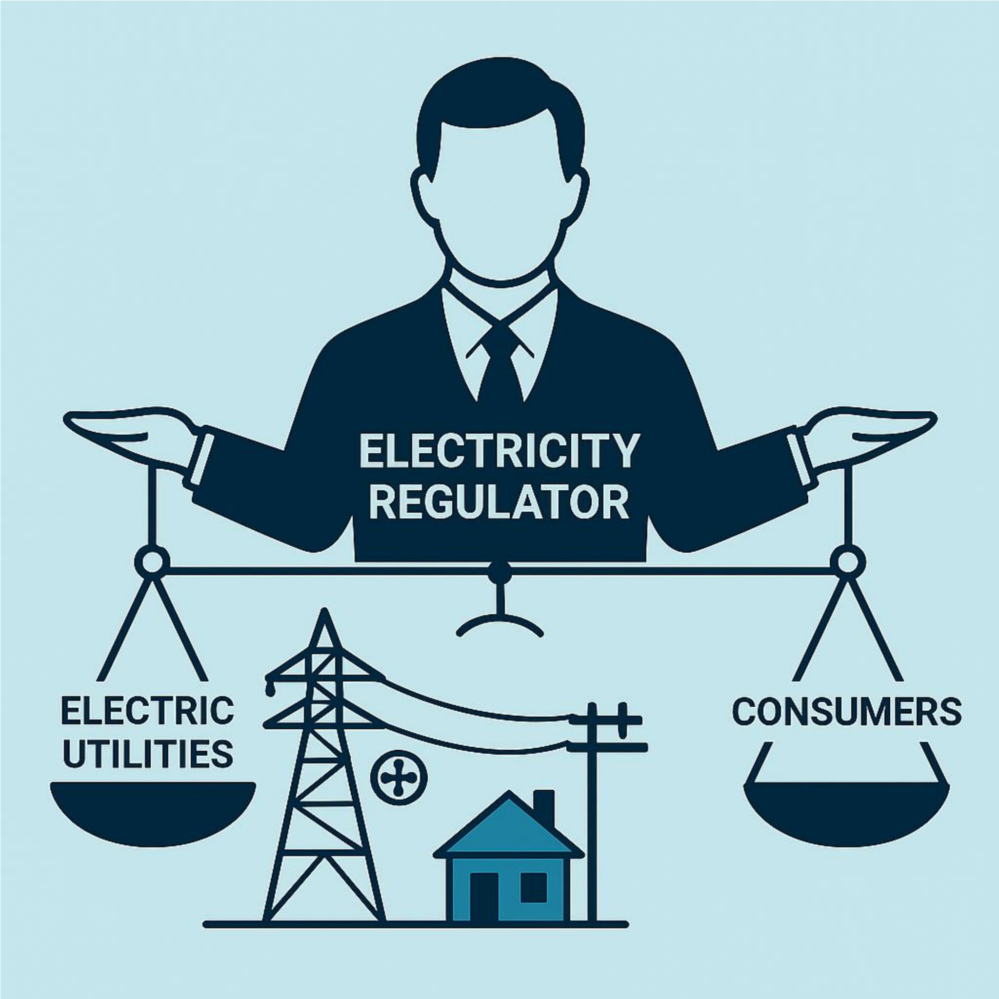
Regulatory drivers of Flexibility

Interoperability standards:

- Harmonize standards across generation, transmission, and distribution
- Ensure that all stakeholders work with the same set of rules, to bolster grid stability and transparency.

Data Integration:

- Data consolidation through digital dashboards and integrated platforms
- Provide real-time insights into system performance, enable proactive decision-making, capacity planning, early fault identification and rapid fault response.



Strategic levers of Flexibility Services

Standards and Interoperability

- Standardize specifications, installation practices, and safety protocols
- Interoperability between legacy systems and new technologies
- RE integration support & Grid enhancing technologies
- Power quality standards (IEEE 519, EN 50160, IEC 61000)

Regulatory Objectives

- Controlling CAPEX/ OPEX in grid upgrades and maintenance
- DER (mainly RE) integration and grid stability management
- Energy efficiency, DR/ DSM, Peak load management, price control

Cybersecurity in DER implementation

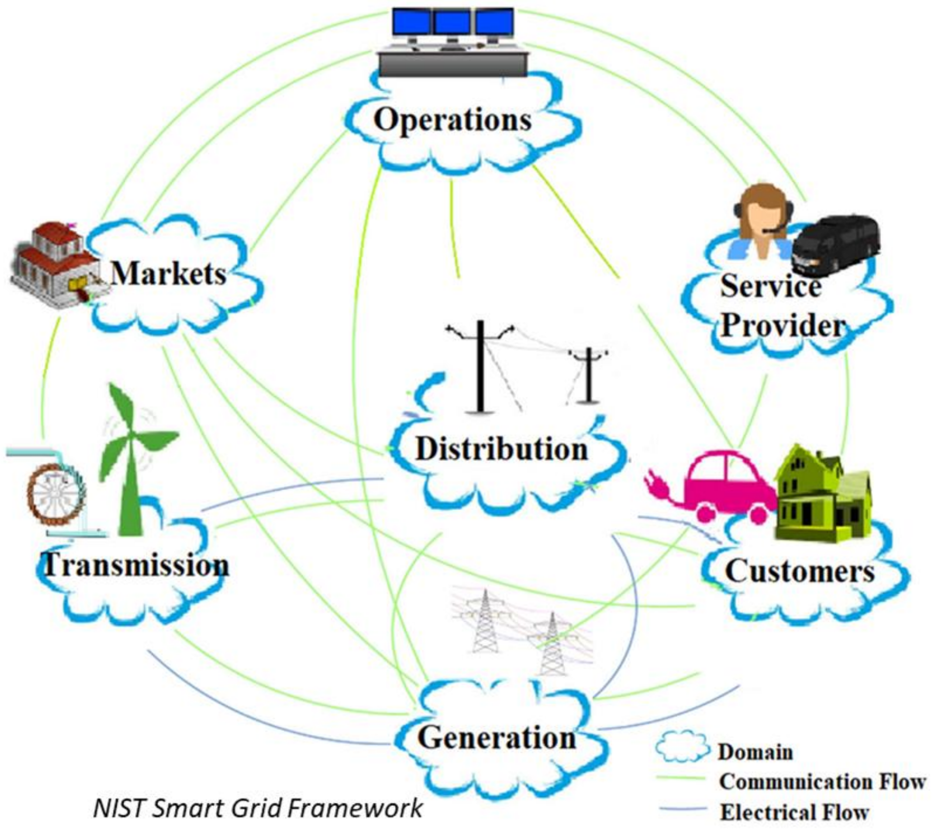
Robust cybersecurity for an increasingly digitalized, decentralized grid

Intrusion detection/ prevention, automated threat responses, and encryption to secure data flow in DER and grid operations.

Strong cybersecurity frameworks to prevent attacks that could compromise grid stability, safety and continuity.

Cybersecurity tools to monitor data integrity and system vulnerabilities, and safeguard infrastructure

Proactive measures to support a resilient infrastructure for threat management and recovery



NIST Smart Grid Framework

Future of Next Gen Utilities

Smart Grids and DERs

- AI is enabling smart grids that can dynamically balance supply and demand.
- DERs (solar and wind) is becoming more manageable with AI-driven predictive analytics

Predictive Maintenance

- AI/ ML used to predict equipment failures, reduce downtime and optimize maintenance

Energy Forecasting

- AI models are improving energy forecasting by analyzing weather data and consumption patterns, which is crucial for integrating renewable energy sources

Energy Efficiency and Sustainability

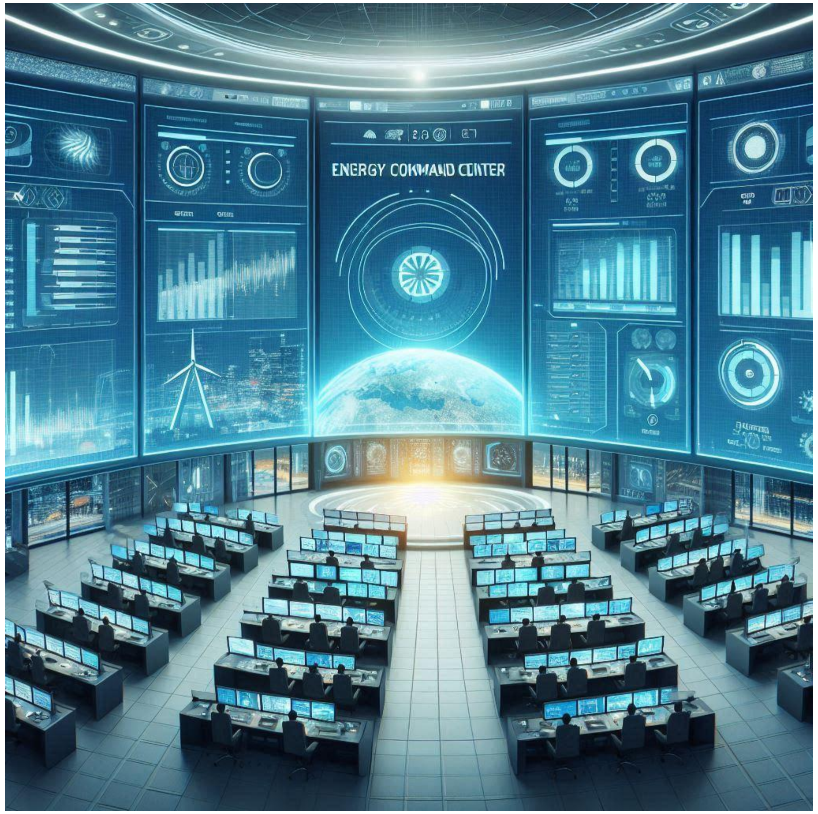
- AI-powered systems are optimizing energy usage, reducing waste, and promoting resource conservation and sustainability

Integration of Renewable Energy

- AI is addressing the challenges of intermittent renewable energy sources by analyzing massive amounts of data in real-time to optimize their integration into the grid

Consumer-Centric Solutions

- AI is enhancing the consumer experience by offering hyper-personalized energy solutions



Thank you!

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