1. Artificial Intelligence Evolution in Smart Buildings for Energy Efficiency

https://www.mdpi.com/2076-3417/11/2/763

Key Information:

1. **Objective**:
    - The paper aims to review and analyze the application of AI and AI-based approaches in smart buildings, particularly for improving energy efficiency.
    - It introduces an evaluation framework to assess recent research across major AI domains, including energy, comfort, design, and maintenance.
2. **AI in Smart Buildings**:
    - AI technologies are used in smart buildings to reduce energy consumption through better control, improved reliability, and automation.
    - Smart buildings integrate sensors, IoT, and big data to optimize energy use, comfort, and maintenance.
3. **Building Management Systems (BMS)**:
    - BMS is a key component of smart buildings, enabling the integration of cyber-physical systems (CPS) to optimize building performance and occupant comfort.
    - AI enhances BMS by enabling real-time monitoring, predictive maintenance, and energy optimization.
4. **Demand Response Programs (DRPs)**:
    - DRPs are used to manage energy demand in smart grids, reducing peak loads and stabilizing the grid.
    - AI plays a crucial role in automating DRPs, optimizing energy consumption, and reducing costs.
5. **AI-Based Modeling Approaches**:
    - The paper discusses various AI-based modeling approaches for predicting building energy use, including:
        - **Machine Learning (ML)**: Supervised, unsupervised, and reinforcement learning.
        - **Deep Learning (DL)**: Neural networks, convolutional neural networks (CNNs), and recurrent neural networks (RNNs).
        - **Hybrid Models**: Combining multiple AI techniques for improved accuracy.
6. **Applications of AI in Smart Buildings**:

- **Energy Efficiency**: AI optimizes HVAC systems, lighting, and other energy-consuming systems.
- **Comfort**: AI improves thermal comfort and indoor air quality.
- **Design**: AI assists in the design of energy-efficient buildings.
- **Maintenance**: AI enables predictive maintenance and fault detection.

7. **Challenges and Future Directions**:
    - The paper highlights challenges such as data privacy, security, and the need for globally accepted IoT standards.
    - Future research directions include integrating AI with renewable energy forecasting, improving energy accessibility, and developing robust AI systems.

Dataset Structure for IoT-Enabled Smart Buildings:

Building ID	**Timestamp**	**Energy Consumption (kWh)**	**Temperature (°C)**	Lighting Status	HVAC Status	enewable Energy Generation (kWh)	Weather condition
B001	2023-10-01 08:00:00	120.5	22.5	on	on	15.2	sunny
B001	2023-10-01 09:00:00	135.7	23.0	on	on	18.5	sunny
B002	2023-10-01 08:00:00	95.3	21.0	on	off	10.5	rainy
B002	2023-10-01 09:00:00	105.6	21.5	on	on	12.3	rainy
B002	2023-10-01 10:00:00	110.8	22.0	off	0n	14.7	cloudy

2. Investigating the Impact of AI/ML for Monitoring and Optimizing Energy Usage in Smart Home

https://ojs.wiserpub.com/index.php/AIE/article/view/6065

Key Information:

1. **Objective**:
   - To investigate how AI/ML techniques can be used to monitor and optimize energy usage in smart homes.
   - The study focuses on improving energy efficiency, reducing costs, and promoting sustainability in residential environments.
2. **AI/ML Techniques Discussed**:
   - **Supervised Learning**: Used for predicting energy consumption based on historical data, weather conditions, and user behavior.
     - Examples: Linear Regression, Decision Trees.
   - **Unsupervised Learning**: Used for clustering energy usage patterns to provide personalized energy-saving recommendations.
     - Example: K-Means Clustering.
   - **Reinforcement Learning**: Used for dynamic energy optimization by learning from real-time feedback.
     - Example: Deep Q-Networks (DQNs), Markov Decision Processes (MDPs).
   - **Deep Learning**: Used for handling complex datasets and improving prediction accuracy.
     - Examples: Long Short-Term Memory (LSTM), Convolutional Neural Networks (CNNs).
3. **Applications of AI/ML in Smart Homes**:
   - **Energy Consumption Prediction**: AI models predict future energy needs based on historical data, weather, and occupancy.
   - **Smart Thermostats**: AI-powered thermostats (e.g., Google Nest) adjust heating and cooling based on user behavior and environmental conditions.
   - **Home Automation**: AI systems control multiple appliances (e.g., lighting, HVAC) to optimize energy use.

    - **Demand Response**: AI adjusts energy usage during peak demand periods to reduce costs and improve grid stability.
4. **Challenges**:
    - **Data Privacy and Security**: Smart homes generate sensitive data, raising concerns about unauthorized access and data breaches.
    - **Scalability**: AI/ML models need to adapt to different home sizes, configurations, and changing user habits.
    - **Real-Time Decision Making**: AI systems must process large datasets quickly to optimize energy usage in real-time.
    - **Cost**: High implementation costs and the need for continuous updates to keep up with evolving technologies.
5. **Future Research Directions**:
    - **Federated Learning**: To address privacy concerns by training models on decentralized data.
    - **Integration of Renewable Energy**: AI/ML can optimize the use of solar and wind energy in smart homes.
    - **Cross-Domain Optimization**: Integrating energy management with other smart home functionalities like security and health monitoring.

Dataset Structure for Smart Home Energy Optimization:

Building ID	**Timestamp**	**Energy Consumption (kWh)**	**Temperature (°C)**	**Appliance Usage**	**Weather Condition**	**Renewable Energy Generation (kWh)**	**HVAC Status**	**Lighting Status**
B001	2023-10-01 08:00:00	120.5	22.5	on	sunny	15.2	on	on
B001	2023-10-01 09:00:	135.7	23.0	on	sunny	18.5	On	on

	00							
B001	2023-10-01 10:00:00	145.2	23.5	on	cloudy	20.1	on	off
B002	2023-10-01 08:00:00	95.3	21.0	off	rainy	10.5	off	on
B002	2023-10-01 10:00:00	110.8	22.0	on	cloudy	14.7	on	off