

AI in Energy

Group 7

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Challenges in the Energy Sector

- Problem Forecasting/Failure Prediction
- Resource Management
- Power Grids
- Outdated infrastructure and expertise
- Toxic waste



<http://www.pes.eu.com/wind/radical-innovation-the-challenges-facing-the-energy-industry/>

AI addressing challenges in the Energy Sector

- Smart Grids
- Intelligent Energy Sources
- Power trading
- Prevention of disaster



<https://www.whatech.com/artificial-intelligence/blog/642962-artificial-intelligence-in-the-energy-sector-opportunities-and-challenges>

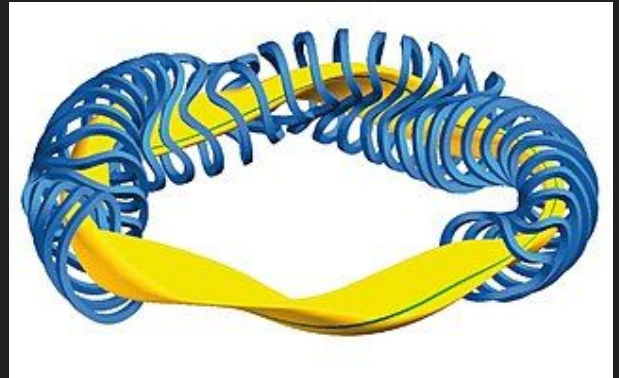
AI in Nuclear Energy is used to:

- Assist design process
- Assist operator decision making
- Detect and predict failures
- Increase operational efficiency
- Increase safety

AI can assist the design process of fusion plants

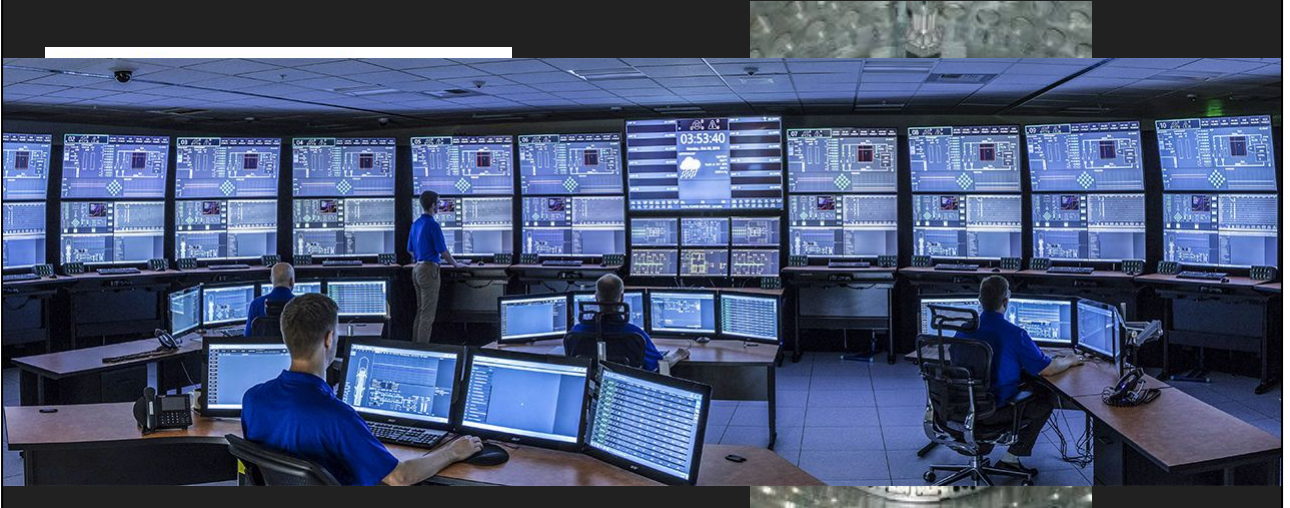


https://en.wikipedia.org/wiki/Wendelstein_7-X



- Trained on simulated and empirical data of fusion reactors, including stellarators
 - Not much empirical data
 - Simulated data does not produce equivalent results
- Trained to perform real-time control functions to maintain fusion reaction
 - Towards a heat controller: learned connections between physical concepts
 - Optimal policy for preventing fusion *disruptions*
- Can provide insight into fusion physics
- Methods
 - Reinforcement learning problem (producing optimal policy), used bayesian networks.
- Obstacles
 - Still computationally expensive (2 hours for 300ms)

AI can assist day-to-day plant operations



Suman, S. Artificial intelligence in nuclear industry: Chimera or solution? *Journal of Cleaner Production* **278**, 124022 (2021).
<https://www.nuclear-power.net/nuclear-power-plant/nuclear-fuel/>

- Complexity of plant: Analytical reasoning during abnormal events
 - Identification of *transient* reactor behavior from real-time data
 - Human-computer reasoning program
- Fuel management: large solution space, non-linear
 - Improves efficiency, peak power
- Detection of accident-causing faults
 - Visual hair-line fault detection in camera-only accessible places, like reactor core

AI Methods used in Nuclear Sector

- Neural networks
- Genetic algorithms
- Support vector machines
- Biologically inspired algorithms
 - Ant-colony
 - Bee-colony
- Simulated annealing
- Bayesian networks

Dangers of AI in Nuclear Energy



Alcorn, M. A. *et al.* Strike (with) a Pose: Neural Networks Are Easily Fooled by Strange Poses of Familiar Objects. *arXiv:1811.11553 [cs]* (2019).

- Uncertain how AI will perform on unseen tasks, especially NNs
- May not detect real emergency or may false alarm
- Vulnerable to hacking
- AI used to design reactors is safer, more dangerous in operational controllers/monitors

Problems with Renewable Energy in the Power Grid

- Installation of domestic renewable power systems has been increasing
- Current System are highly variable



Bauer, Josh. Lithium Iron Phosphate Battery from Blue Ion (2020). IEEE Spectrum



Sendry, Andrew. Are Solar Panels Worth it? (2017). PV Magazine

The last few years have seen a dramatic rise in the installation of domestic renewable power sources such as solar panels. Unfortunately, modern day solar panels offer highly variable power generation and cannot reliably meet the power demands of a house, thus most houses are still connected to the grid. This creates a unique problem on operators who are trying to manage power supply, demand and storage across the grid. Sometimes certain areas can be a power source, sometimes a power sink; requiring dynamic responses to the current distribution of power on an almost constant basis. This instability increases the risk of outages, overloads and general power wastage.

Autonomous Energy Grids (AEG)

- AI-controlled micro-grids that manage and optimize power usage for a renewable energy community
- Basalt Vista, Denver
- AEG connected smart devices allow for Intelligent predictions of demand

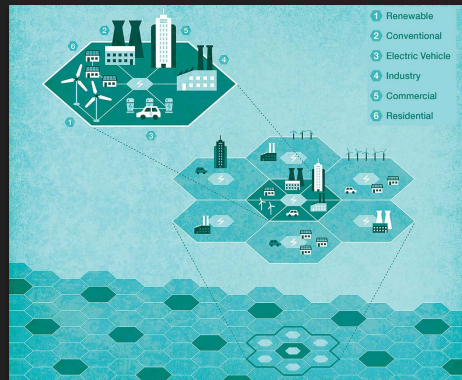


Randall, Scott. Basalt Vista (2020). IEEE Spectrum

A proposed solution to the issue of decentralized power generation is the introduction of AI-controlled micro-grids which manage power within a small community containing renewable power sources. The concept is currently being explored in Basalt Vista, Denver where the 27 homes in the neighborhood allow an autonomous system to manage their aggregate community power needs. By shifting the power management to encompass a small community rather than a single home, you increase general stability of the system by allowing neighbors who produce excesses of power to share with neighbors who do not produce enough for themselves. Furthermore, the AEG is connected primary power draws in each of the houses (i.e. heating, cooling etc.) and allows them all to communicate their power usage in the effort of optimizing the grid's efficiency.

AEG's On a National Scale

- In the future AEG's will be able cooperate in order to stabilize the national power grid
- AEG output predictions will further simplify gauging demands for regular power plants



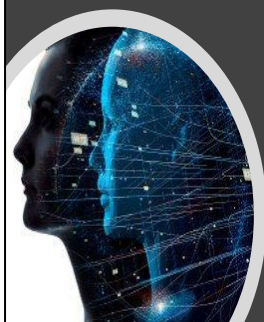
Buffum, Jude. The Distributed Grid (2020). IEEE Spectrum

AEG's can be pushed farther than just managing their micro-environment. In the future, AEG's will be able to communicate with each other in a hierarchical distributed system. Allowing AEG's that give energy back to the grid to automatically send their excess to AEG's which are generating below their usual load. Thus allowing distributed power generators to autonomously patch problems in the macro-grid.

Future of renewable energy

- One of the important issues that remains silent is the waste that energy sector produces
- The future of AI in identifying environment friendly materials and minimizing adverse environmental impacts is crucial with rising concerns on climate change.





How AI solves the problem

- Rationale design
- Data-Driven Screening tools
- Use big data tools to identify solvents and characterize chemicals

Sources

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