

Conflict Reduction and Deterrence in the Power Grid of the Future: A Cyber Security Perspective

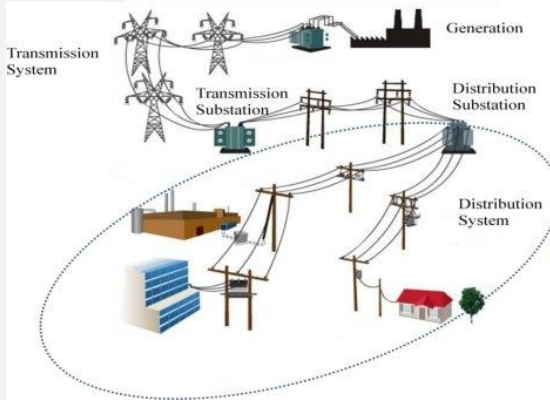
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Cyber Security for the U.S. Power Grid : National Security Perspective



- Research trends suggest an impending shift from a hierarchical to a modular grid architecture.
- Incorporation of renewables has led to distributed generation of power by consumers.
- AI is poised to play an important role in efficient functioning of a modular, decentralized grid.
- Disruptive technologies in power need to be evaluated for their potential strategic capabilities.
- Vulnerabilities in the future grid need to be identified and cultivated for asymmetric use.

Distributed Generation, Modular Grid: *So what? Who Cares?*



- Transformation to advanced energy systems:
 - Renewables are becoming more affordable.
 - Consumers are now more empowered.
 - Power generation capabilities are popping up everywhere.
 - Grid is becoming decentralized.
- Future advanced energy strategies already implemented by China, Russia, Japan and E.U.¹
- U.S. is yet to come up with a holistic national strategy on advanced energy.¹
- Advent of advanced energy systems could have a huge global impact¹:
 - Diversity of supply, more efficient grid leads to lesser reliance on traditional sources.
 - Decreased reliance on fossil fuel leads to tilting of geopolitical balance².
- Therefore, securing the future power grid becomes essential³

Advanced Energy is a question of “when”, not “if”!

1. Advanced Energy and U.S. National Security, CNA Military Advisory Board, June 2017.

2. Tatiana A. Mitrova. Review of the Global and Russian energy outlook up to 2040. Energy Research Institute of the Russian Academy of Sciences.

3. Cybersecurity in a Distributed Energy Future,, Advanced Energy Economy Institute, January 2018

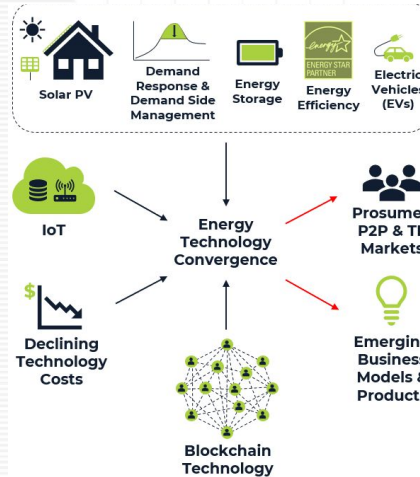
Advanced Energy : Key Research Questions

- Will the future power infrastructure witness a shift towards a modular and dynamic architecture?
- As AI becomes more prevalent in the grid, will data become a strategic capability or vulnerability?
- As the attack surface becomes more diffuse, would it make large scale attacks harder to orchestrate?
- How will this shift play a role in conflict reduction in the global energy dynamics of the future?

Advanced Energy: Disruptive Trends

Distributed Energy Resources

- Power generation devices at consumer level.
- Include Photovoltaics, Wind and storage devices.
- DERs more affordable due to storage costs reduction⁴.
- Largely rely on smart scheduling for maximum efficiency.



Microgrids

- Miniature grids that are self sustaining⁵.
- Driven by DERs, rely on IOT devices at the edge
- 1900 Microgrid projects planned in the US⁶.
- Aggregate smaller power systems, easier to manage⁶.

Electric Vehicles(EV)

- Battery powered automobiles.
- Potential to disrupt fossil fuel reliance.
- Charging places pressure on ageing grid⁷.
- AI provides consumers with Smart Incentives⁸
- Demand Response can combat grid failure.

Blockchain

- Touted to be the most disruptive for energy⁹.
- Capability to tie DERs together among consumers.
- Offers a decentralized distributed approach.
- Blockchain driven grid leads to p2p energy trading⁹.
- \$300 million in research investment in the Blockchain for energy by industry and government⁹.

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7. EV Clustered Charging Can Be Problematic For Electrical Utilities, <https://www.fleetcarma.com/ev-clustered-charging-can-be-problematic-electrical-utilities/>

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Artificial Intelligence (AI) in Energy



- AI refers to class of algorithms that are able to¹⁰:
 - learn from observed data to make more informed predictions.
 - perform complex tasks without human intervention.
 - improve prediction accuracy as more data is collected.
- AI algorithms are becoming more popular in Advanced Energy:
 - Smart Scheduling¹¹
 - Smart charging discharging of Electric Vehicles, storage devices.
 - Failure Avoidance and Preventive Maintenance¹²
 - Use streaming sensor data to predict failure of power system assets
 - Cyberattack detection¹³
 - Identifying False Data Injection (FDI) attacks with remarkable accuracy.
 - Requires huge amount of training data.

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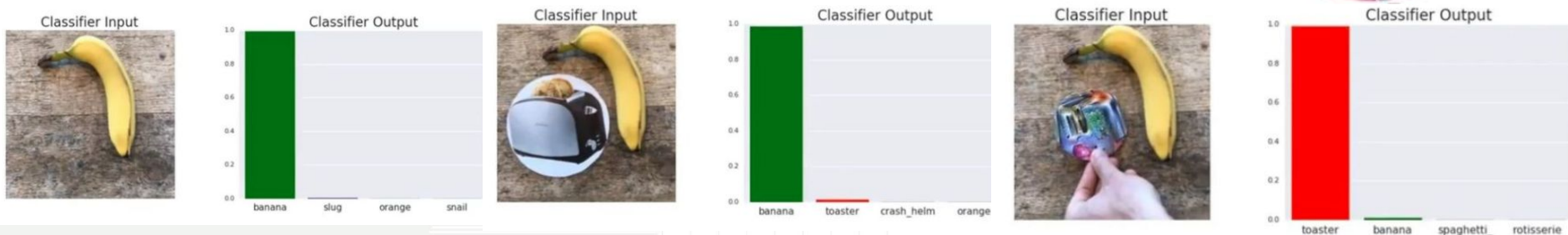
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Fooling AI: Data based manipulation

- Data manipulation by malicious actor may skew the ML algorithm¹⁴.
- Smarter malware can be potentially built with AI.
- AI could act and perform all actions like a human¹⁵.
- Detecting the real culprit might be difficult in AI driven systems.



Psychedelic Adversarial AI¹⁶



- Loopholes might exist in AI algorithms for power which might lead to backdoor vulnerabilities.
- Simulating training data alone is sufficient to guess behavior of power system equipment.
- Could be a huge step towards cultivating asymmetric AI based cyber capabilities.

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Distributed Energy: Boon or Bane?^{17,18,19}

Attack Characteristics	Decentralized Grid	Centralized Grid
Vulnerability	High due to ICS fragmentation	Low due to limited control devices
Orchestration	Difficult due to built in resilience	Easier, single point of failure
Impact	Harder for large scale impact	Easy to create any impact
Detection	Extremely Complicated	Straightforward
Recovery	Resilient, easy restoration	Time consuming, could take weeks

- Decentralized Grid architecture offers “islanding”, which allows for stand alone operations.
- A decentralized grid has largely been touted as a much more robust model by the research community.
- However, decentralized grid could be more vulnerable owing to heavy fragmentation of devices..

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Advanced Energy : Geopolitical Aspects



- Advent of Advanced Energy can transform the geopolitical landscape²⁰.
- Advanced Energy could contribute upto 50% of domestic demands in certain countries²⁰.
- Rise of EVs and smart energy storage might wean consumers away from fossil fuels.
- Russians have the most to lose from Advance Energy breakthroughs:
 - 70% of Russian exports, 16% of GDP and 52% of federal budget are fossil based²¹.
 - Russia faces an economic impact regarding EU shift to 27% renewable by 2030²².
 - Advanced energy advent could cause 1 percentage point erosion in Russian economy.²²
- Chinese have most to gain from Advance Energy:
 - Advanced Energy projects in China has led to 3.5 millions domestic jobs²³.
 - China is getting closer to E.U. renewable market to gain diplomatic and economic clout²⁴.
 - Since 2009, Chinese are racing to be the world leader in Advanced Energy²⁵.

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25. China and Renewable Energy in Africa: Opportunities for Norway? WWF-Norway, prepared by Pöyry Management Consulting (Norway) AS. 2011

Conclusion

- The conventional hierarchical grid is changing.
- Distributed Energy Resources are making the grid more decentralized.
- AI is playing a significant role in enabling the future grid.
 - However, AI algorithms pose unproven cyber security risks.
 - Cultivating AI by harnessing data driven simulation could lead to an effective deterrence mechanism.
- On the whole, decentralization makes grid more robust to cyber threats.
- Advent of Advanced Energy could have significant geopolitical impact:
 - Traditional fossil fuel based economies are threatened which might increase conflict.
 - Thriving renewables markets can play a major role in conflict reduction over energy.