NREL
Transforming ENERGY

Artificial Intelligence Applications in Renewable Energy

Grant Buster

AI in Energy: Advancing New Research Paradigms

August 17, 2020

NREL Science Drives Innovation

Renewable Power

Solar

Wind

Water

Geothermal

Sustainable Transportation

Bioenergy

Vehicle Technologies

Hydrogen

Energy Efficiency

Buildings

Advanced Manufacturing

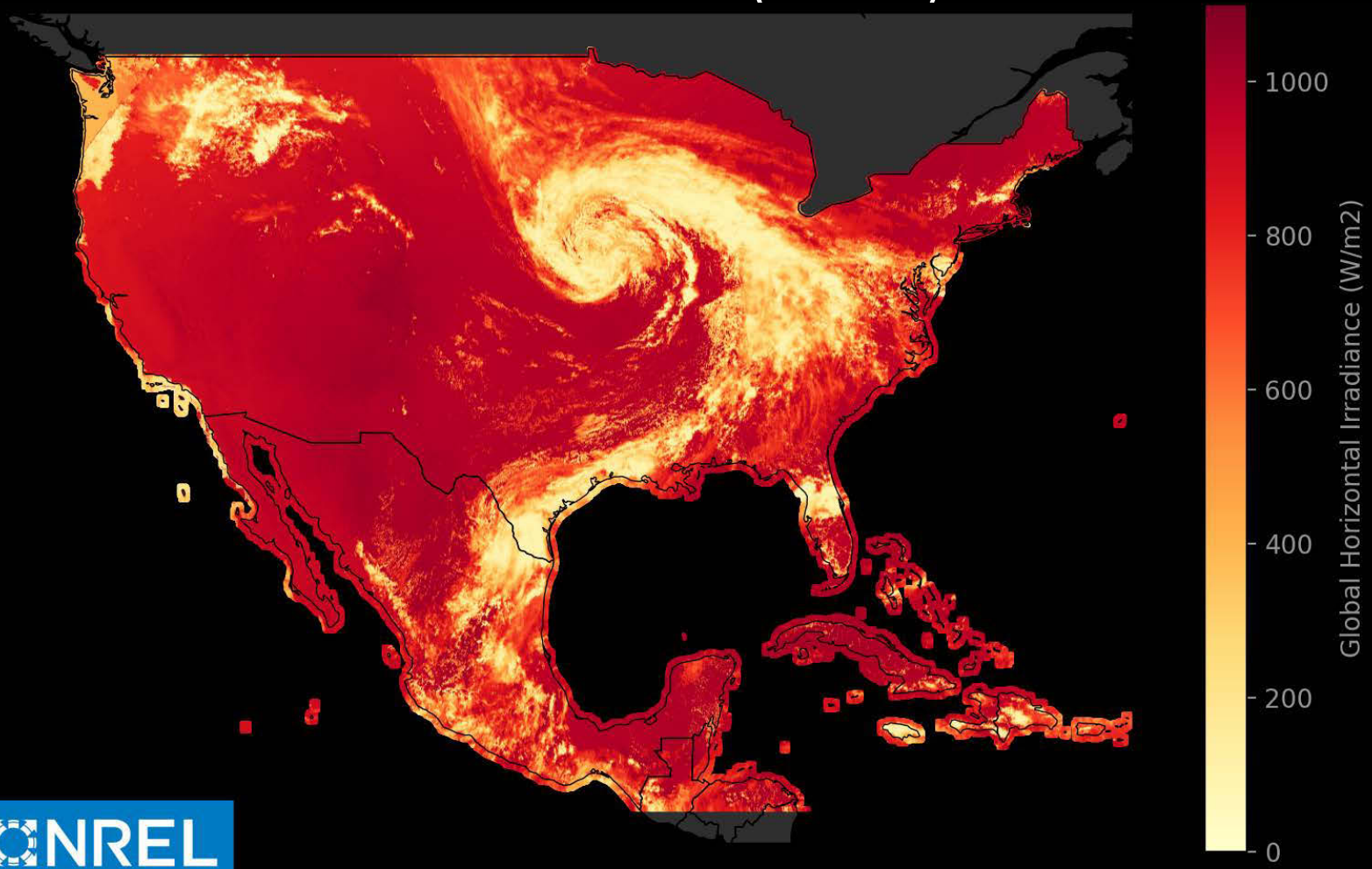
Government Energy Management

Energy Systems Integration

Grid Integration

Hybrid Systems

The National Solar Radiation Database (NSRDB)



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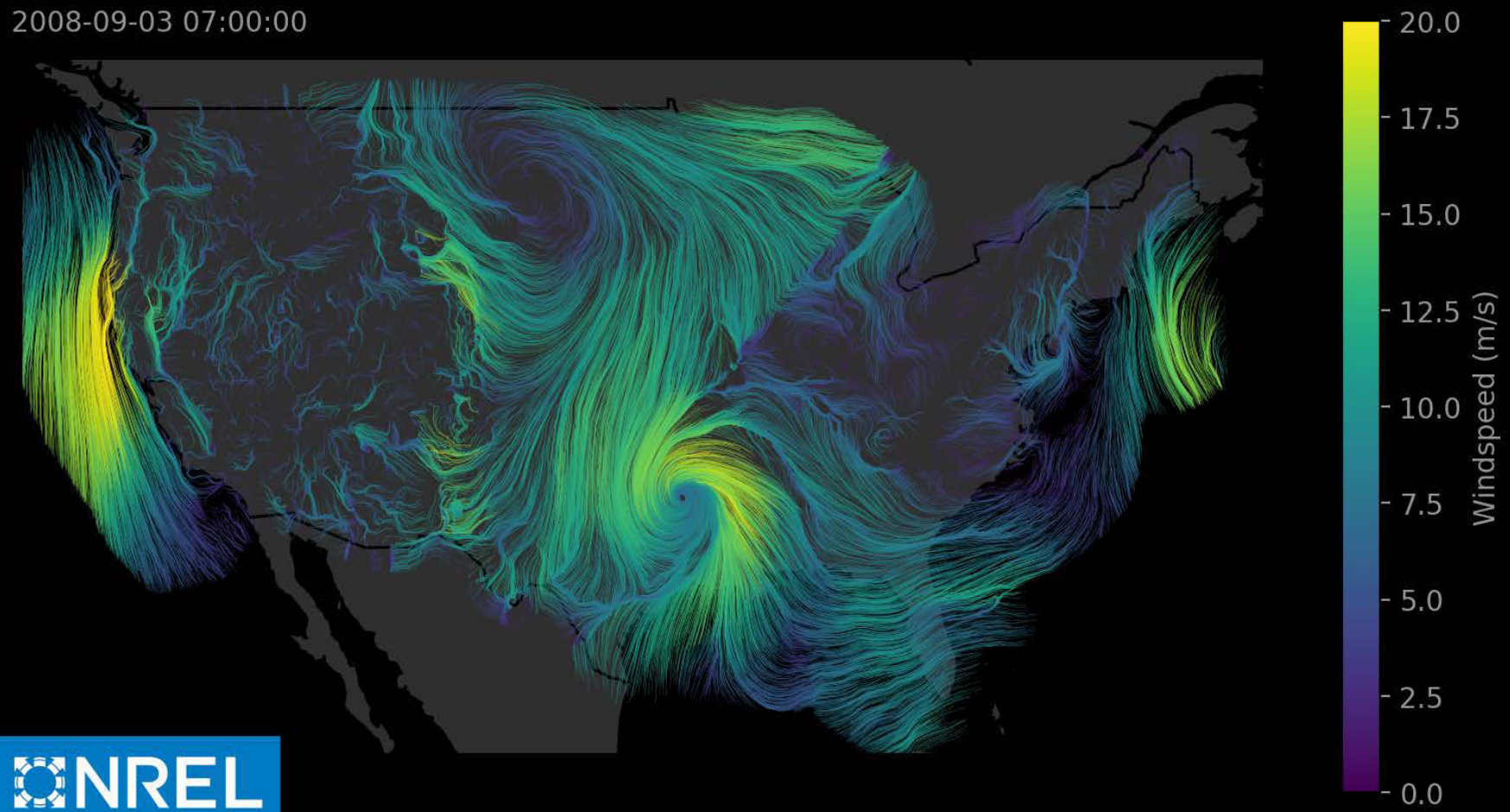
The Wind Integration National Dataset (WIND Toolkit)



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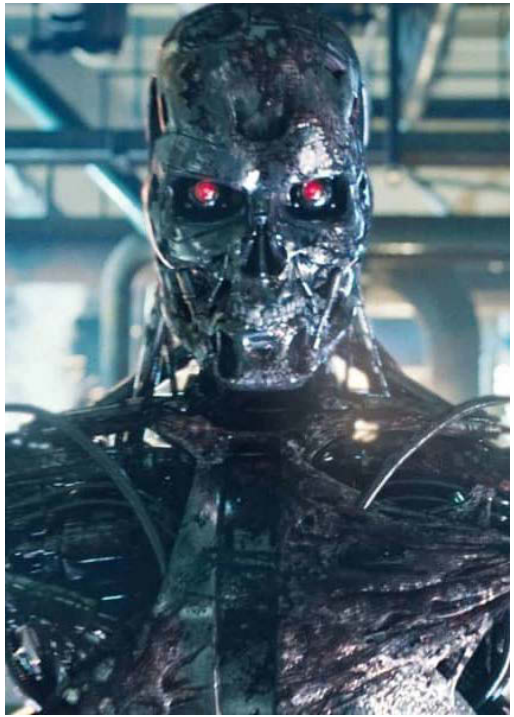
Artificial Intelligence (AI) Today

	A	B
1	Jan	January
2	Feb	February
3	Mar	Marruary
4	Apr	Aprruary
5	May	Mayruary
6	Jun	Junruary
7	Jul	Julruary
8	Aug	Augruary
9	Sep	Sepruary
10	Oct	Octruary
11	Nov	Novruary
12	Dec	Decruary

Where are we?



Google DeepMind's AlphaGo

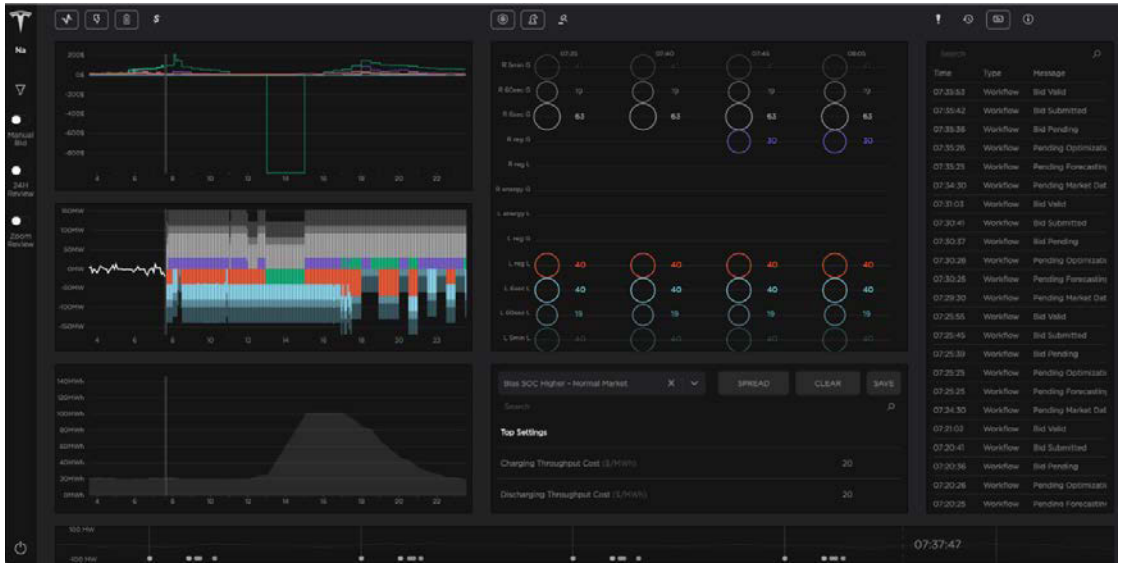
Game of Go:

361 possible moves

3^{361} unique board states

https://deepmind.com/research/case-studies/alphago-the-story-so-far
https://www.youtube.com/watch?v=WXuK6gekU1Y

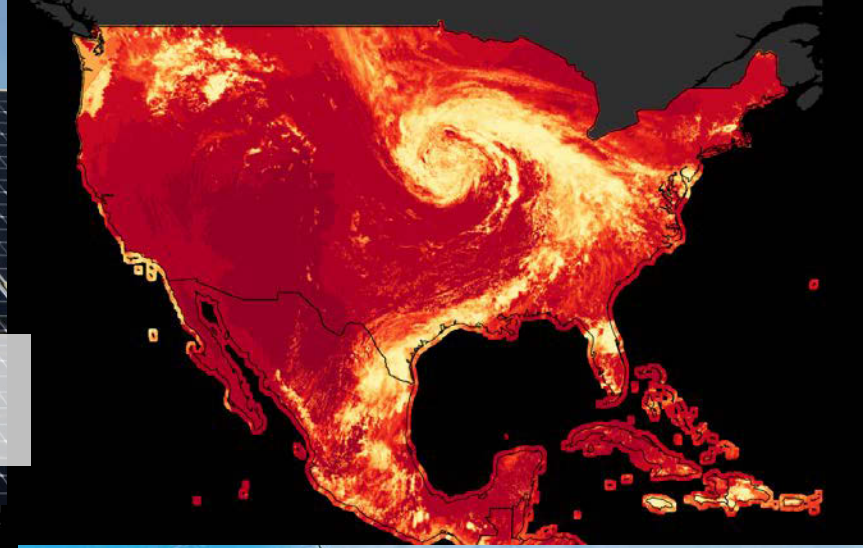
Tesla as a Utility: Autobidder

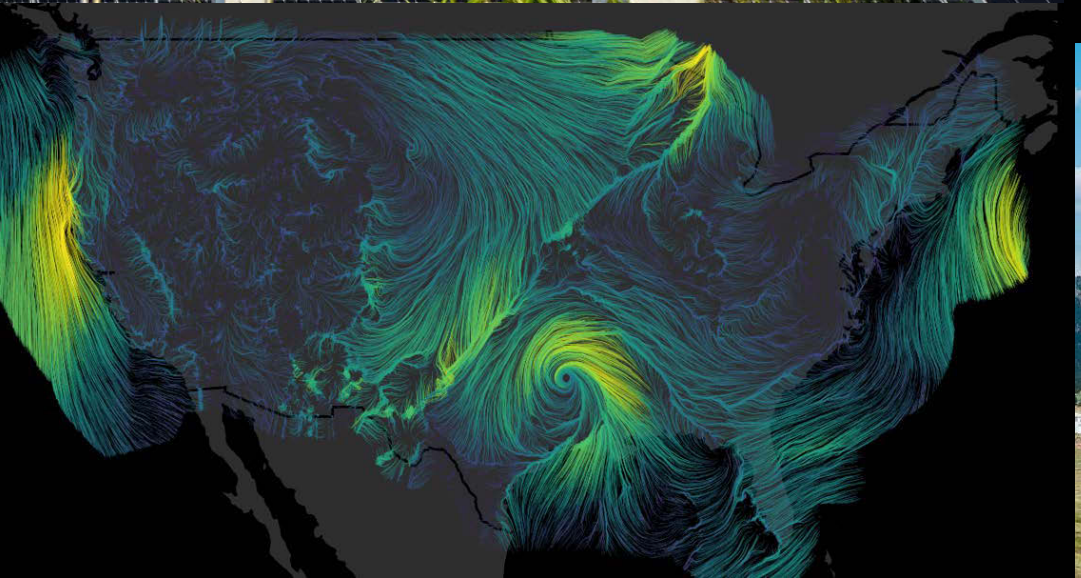


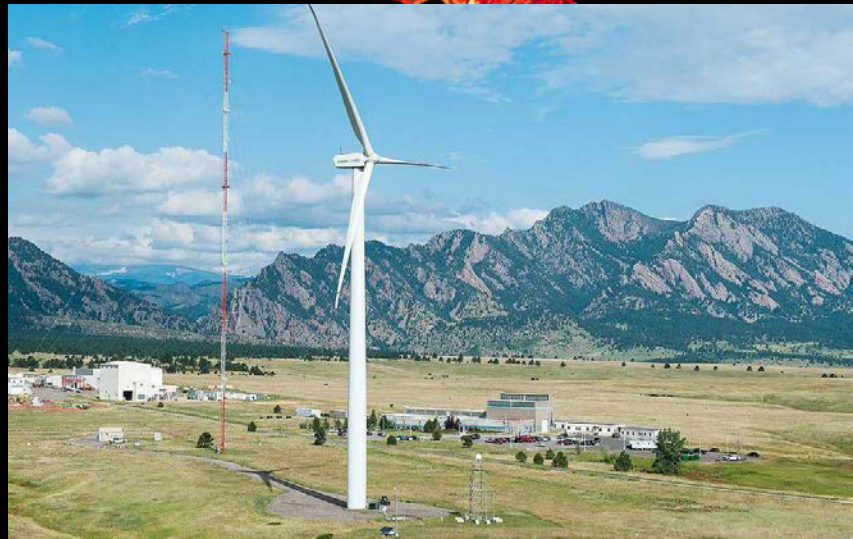
"Autobidder provides independent power producers … the ability to autonomously monetize battery assets"

https://electrek.co/2020/06/15/tesla-officially-approved-electric-utility-uk-why/
https://electrek.co/2020/05/03/tesla-autobidder-new-product-electric-utility/

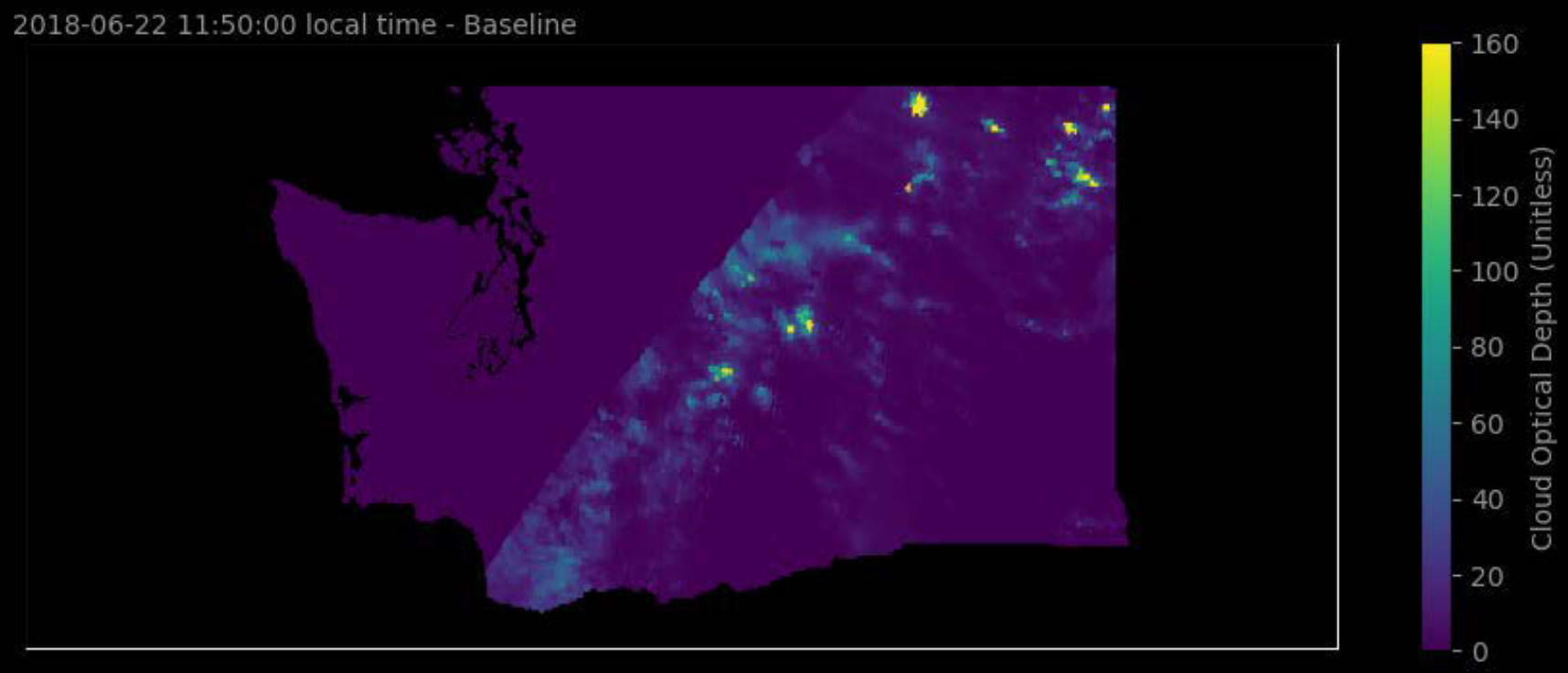
AI Applications at NREL







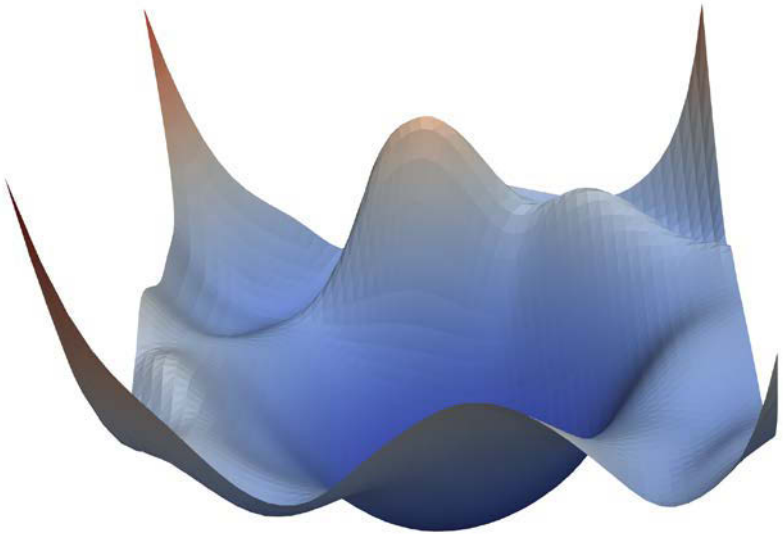
Limitations of Mechanistic Cloud Models:



Using Theory to Guide Learning:
Physics-Guided Neural Networks (phygnn)

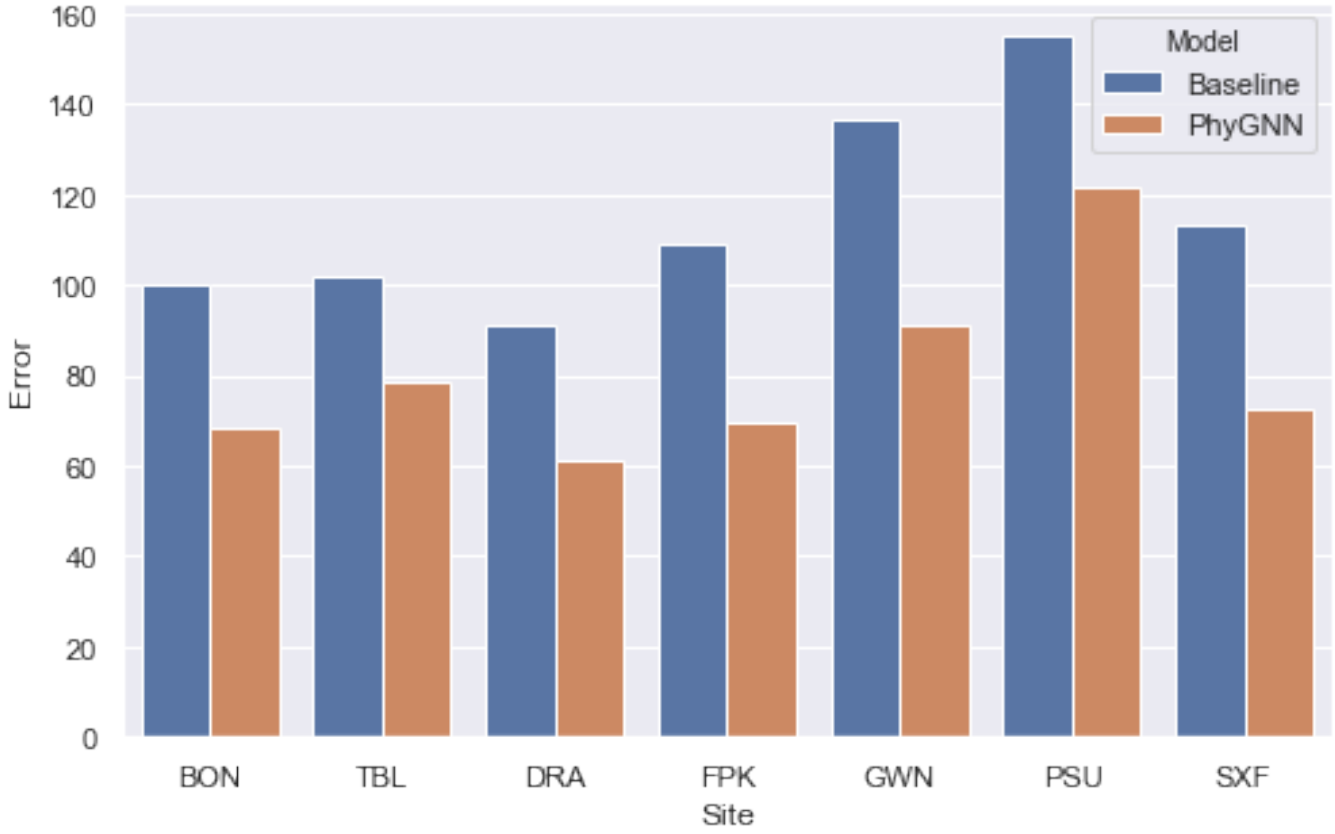
$$Loss = \lambda_0 Loss(\hat{Y}, Y) + \boxed{\lambda_p Loss_p(\hat{Y})}$$

Open source: https://github.com/NREL/phygnn

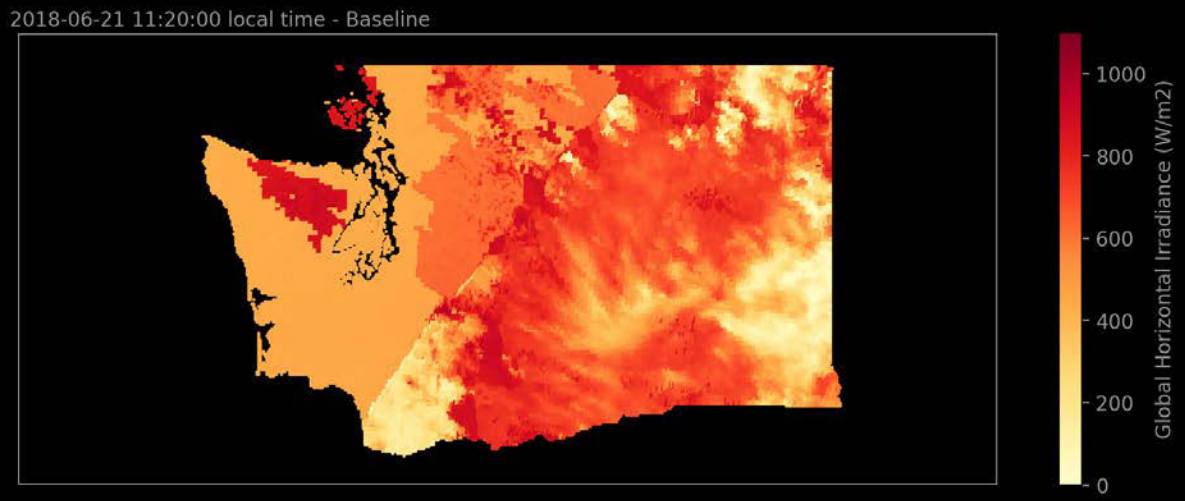


Example neural network loss surface
https://www.cs.umd.edu/~tomg/projects/landscapes/

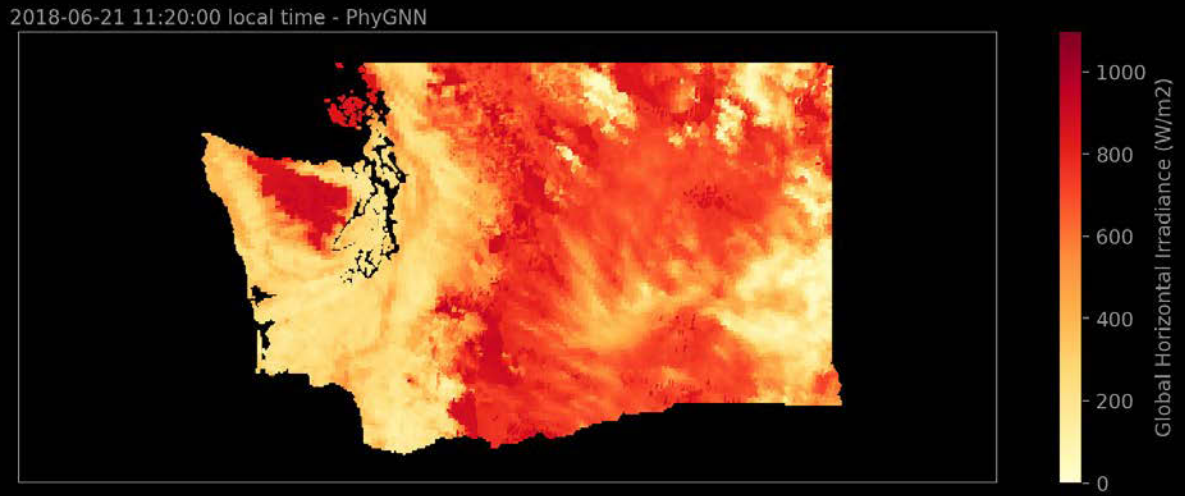
phygnn: reduces error, improves data product



Original Data



Improved Data



What about in the field?

gooml*

Geothermal Operational Optimization with Machine Learning

Partnership between:

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Upflow

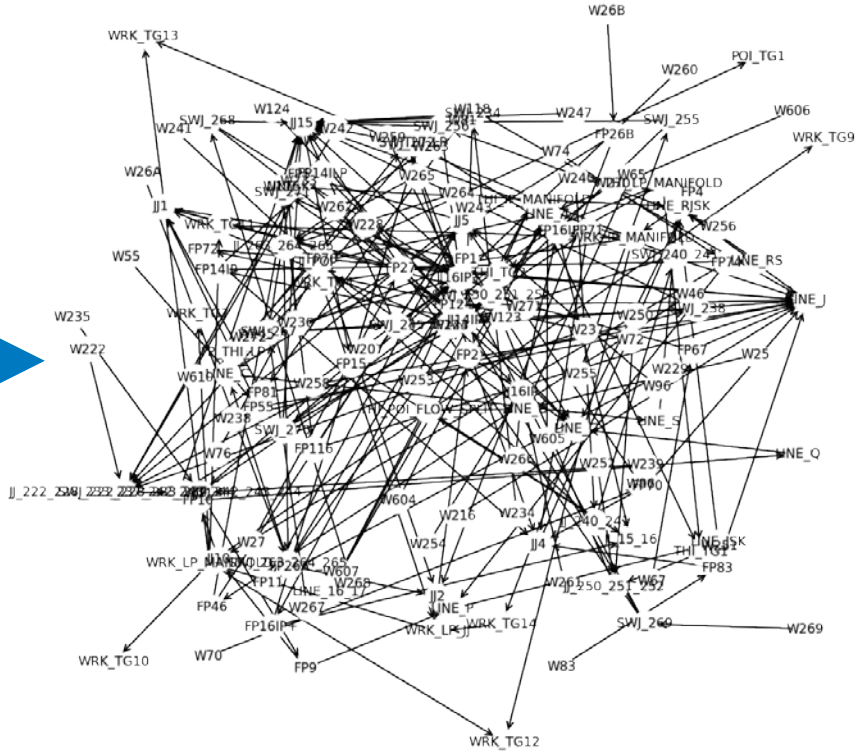
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Tuwharetoa mai Kawerau ki te Tai

contact

ORMAT

Step 1: Build a Digital Twin

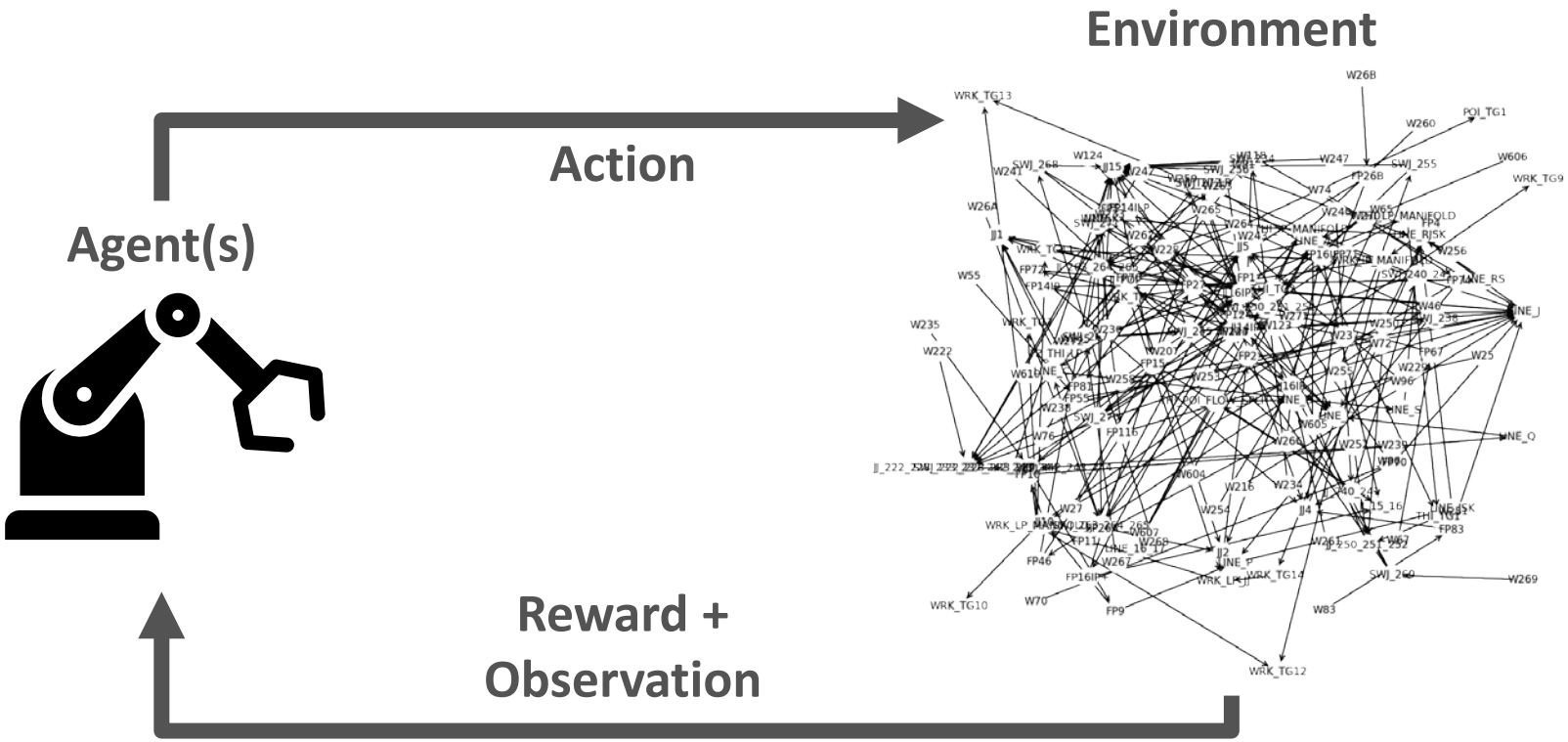


Step 2: Hindcast Validation

Steam Delivery

Power Generation

Step 3: Reinforcement Learning



Reinforcement Learning Experiment #1:

Agent controls:

- Line Pressures
- Wells

Lessons Learned

- Centering the reward at zero is an example of bad reward shaping (at least for this environment)

- The agent ***learned how to terminate the episode quickly*** to get the least amount of negative reward

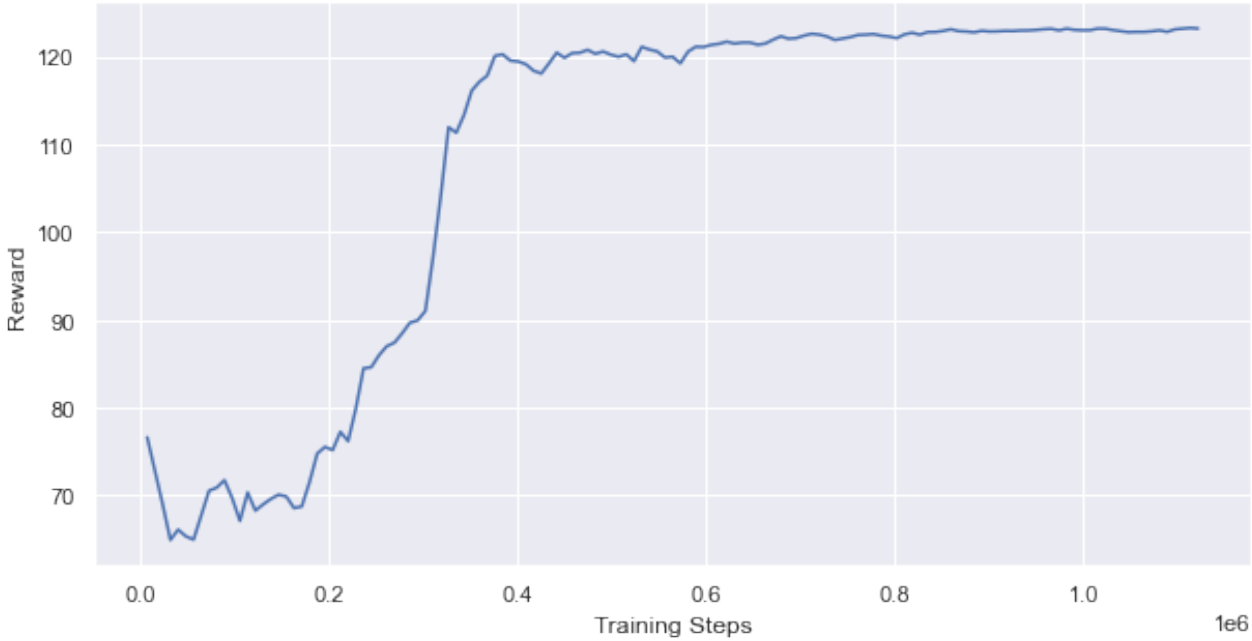
Lessons Learned

- Centering the reward at zero is an example of bad reward shaping (at least for this environment)
- The agent ***learned how to terminate the episode quickly*** to get the least amount of negative reward
- In other words, the negative reward shaping ***affected the agent's will to live***!

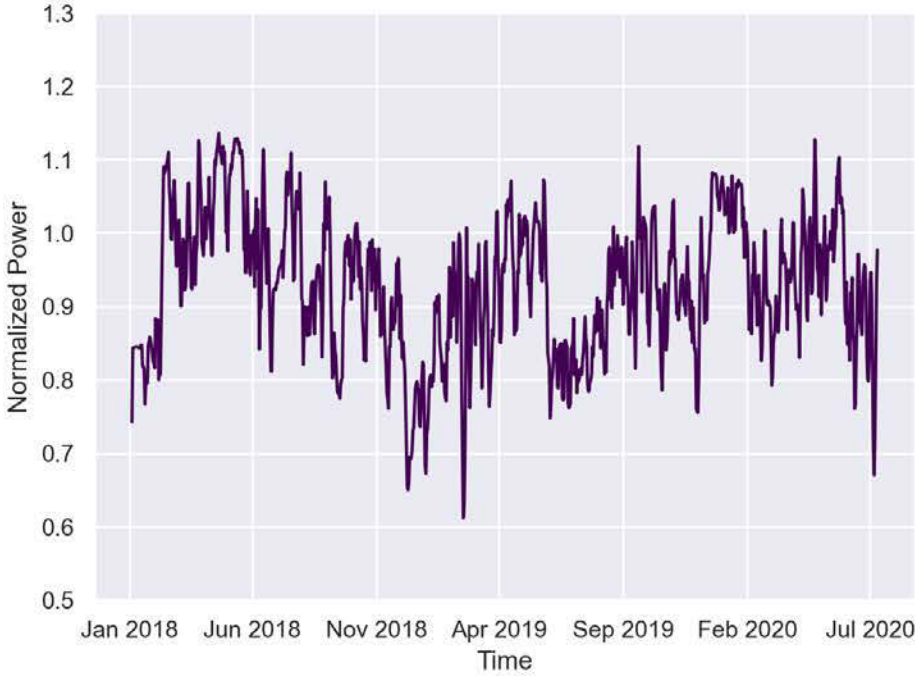
Reinforcement Learning Experiment #2

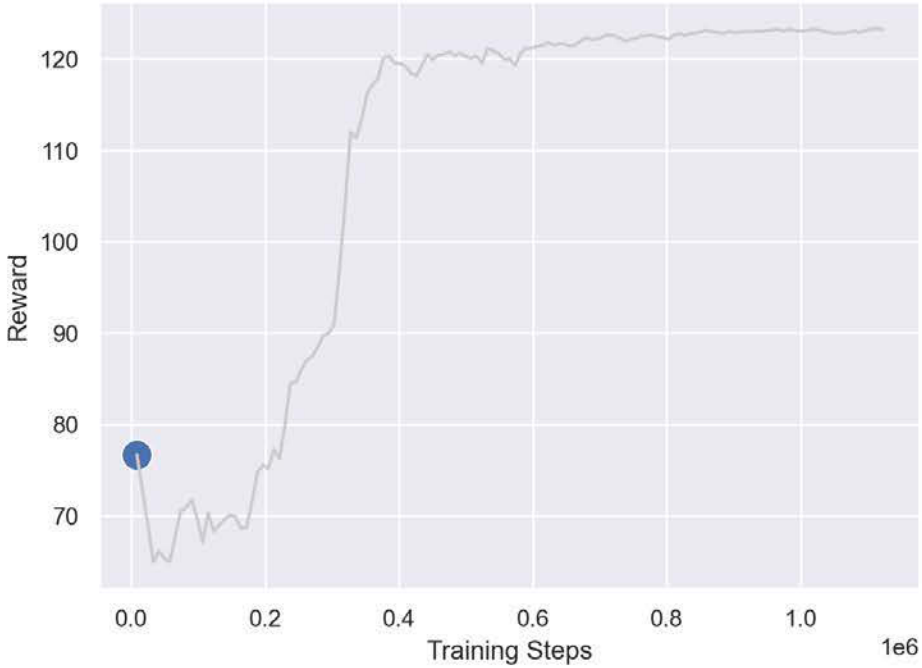
Agent controls:
- Line Pressures
- Wells

Improved:
- Rewards
- Termination conditions

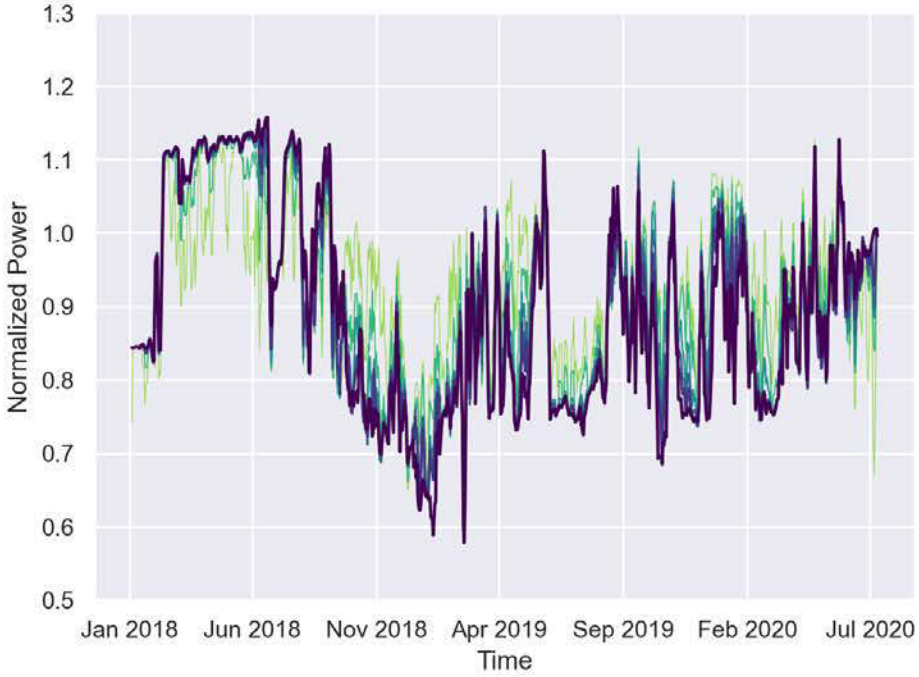


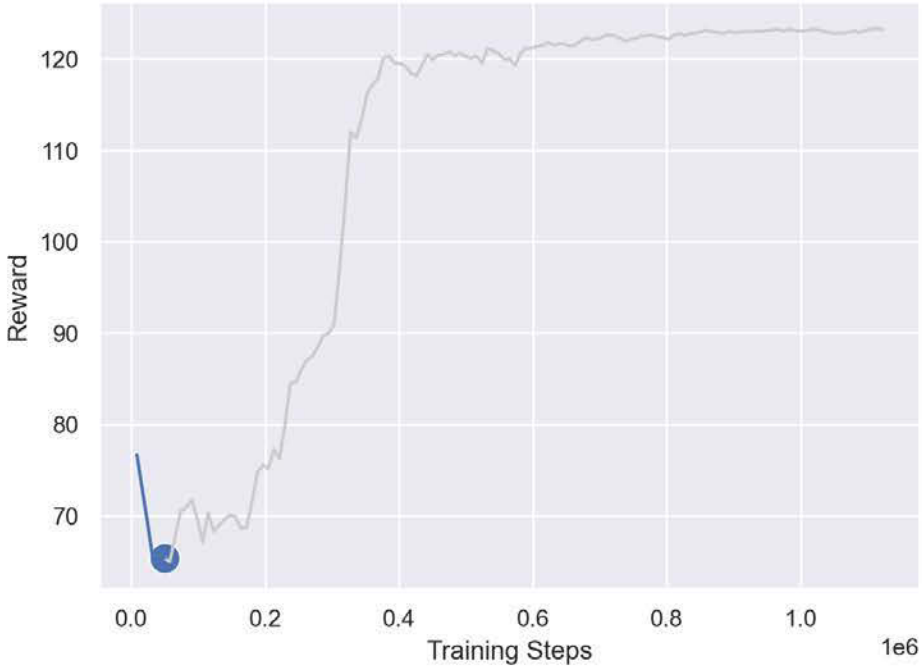
Agent Exploration in Action!





Agent Exploration in Action!





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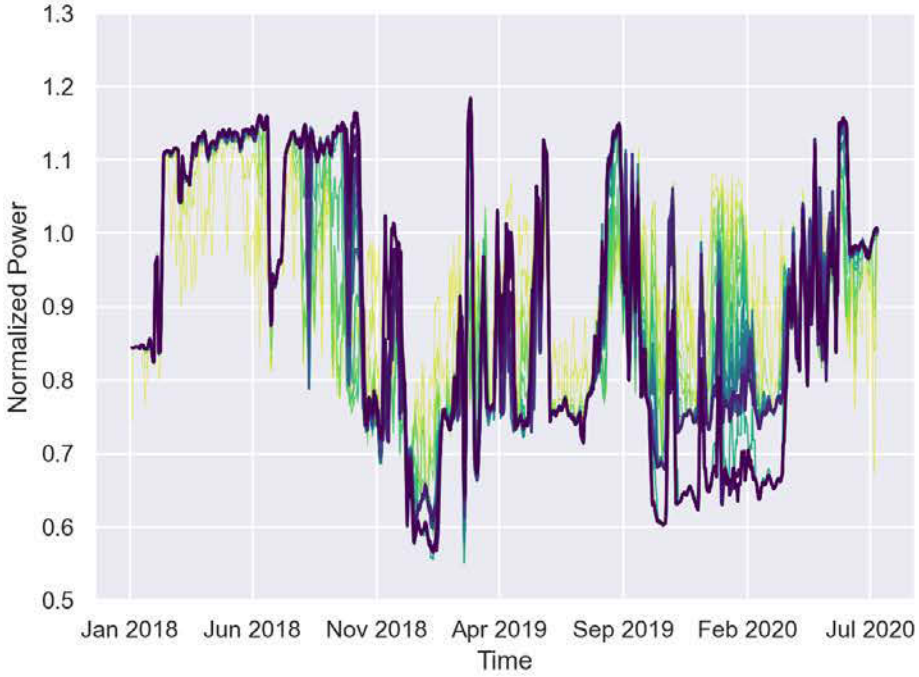

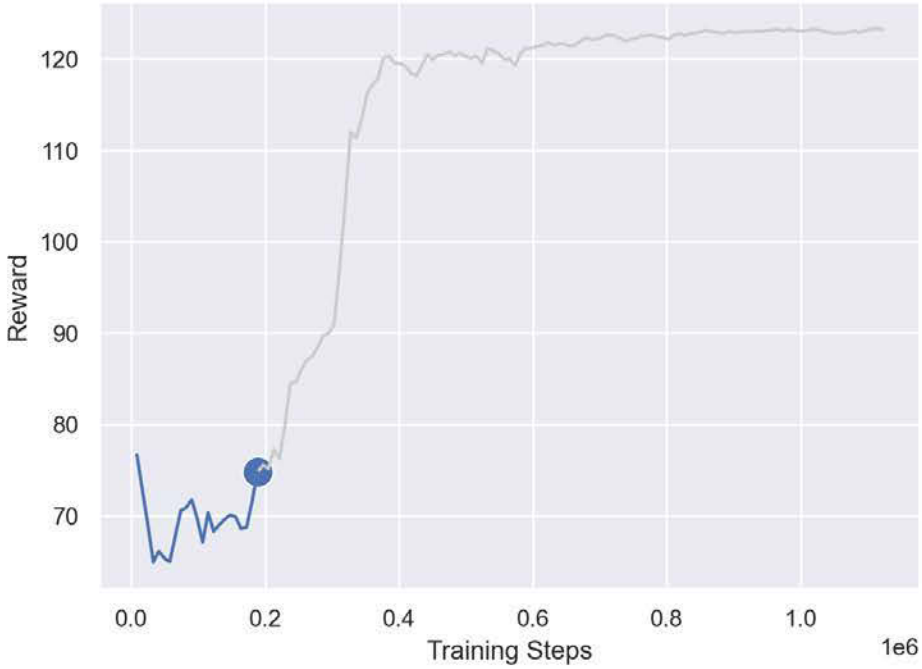

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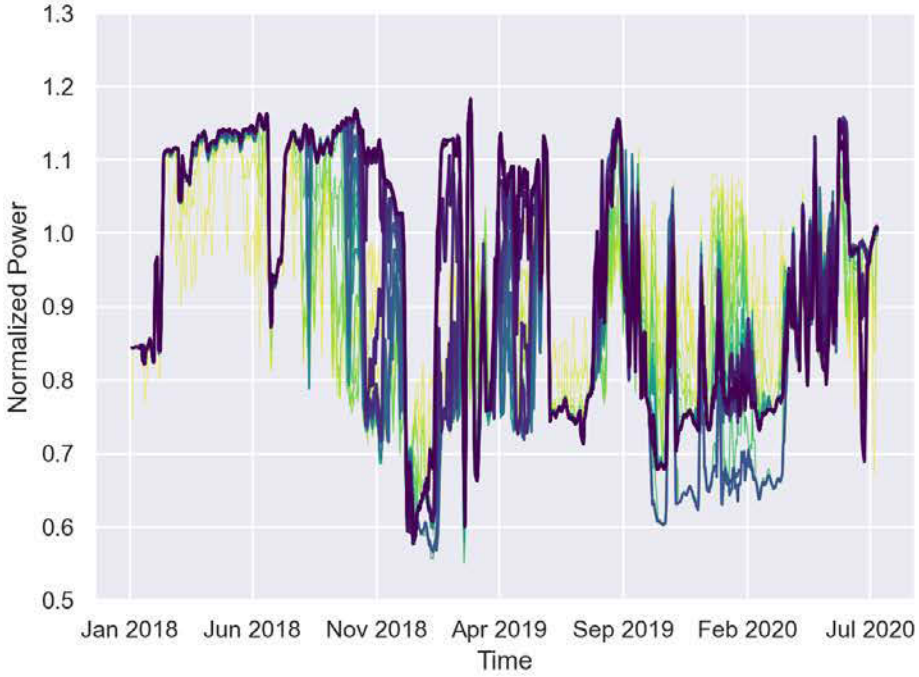

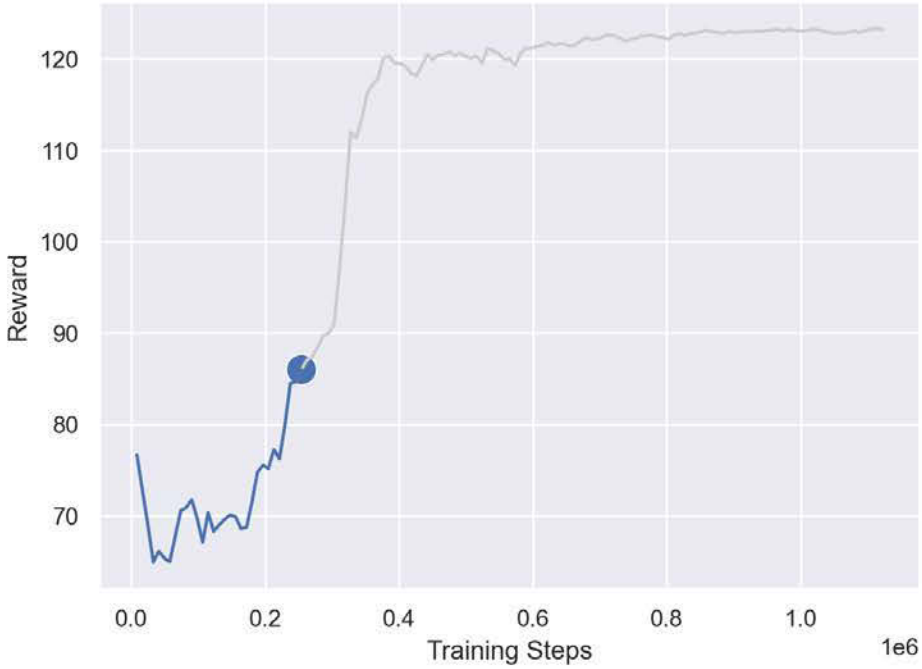

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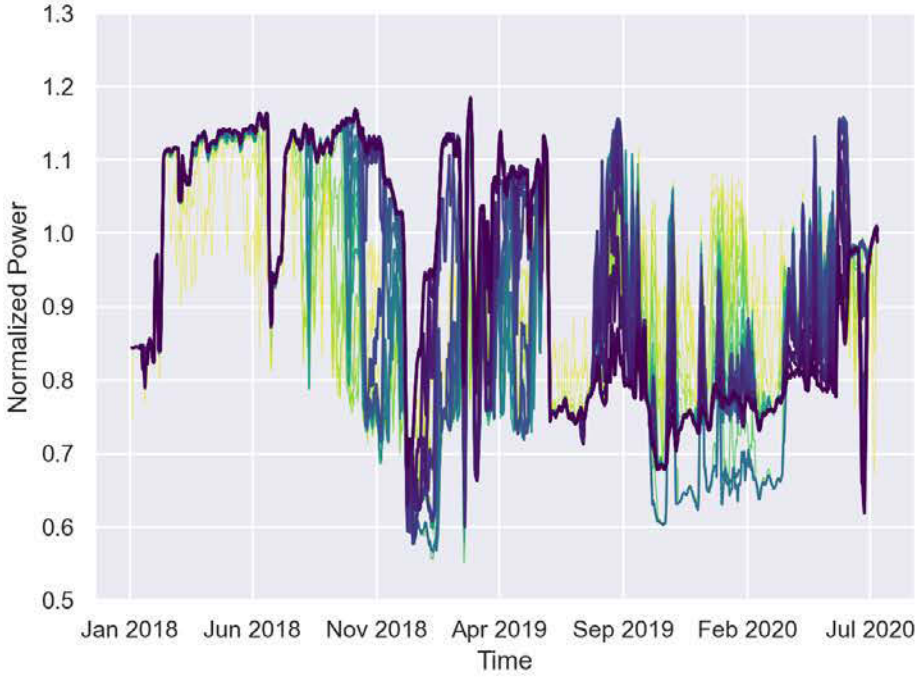
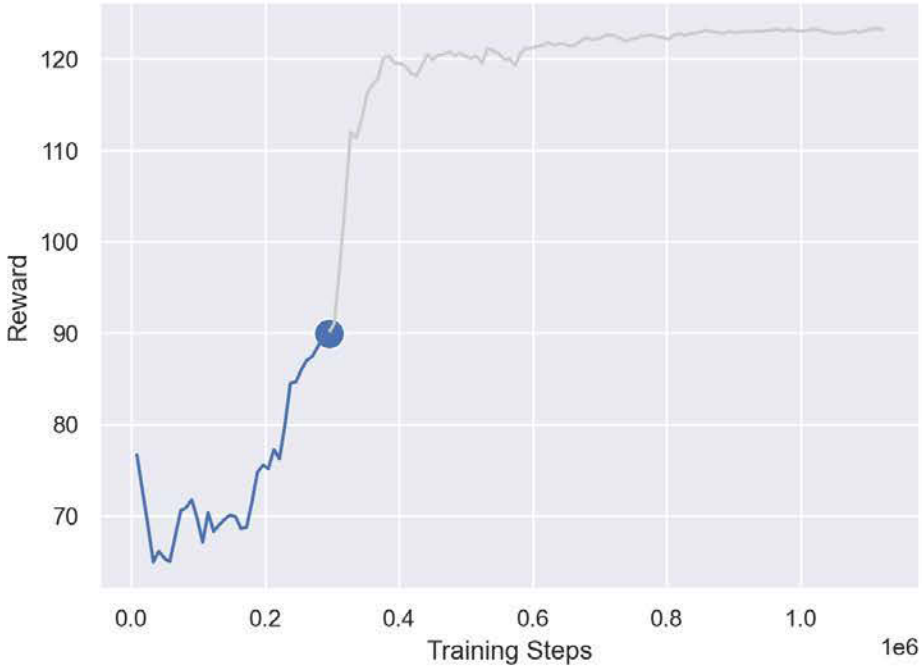
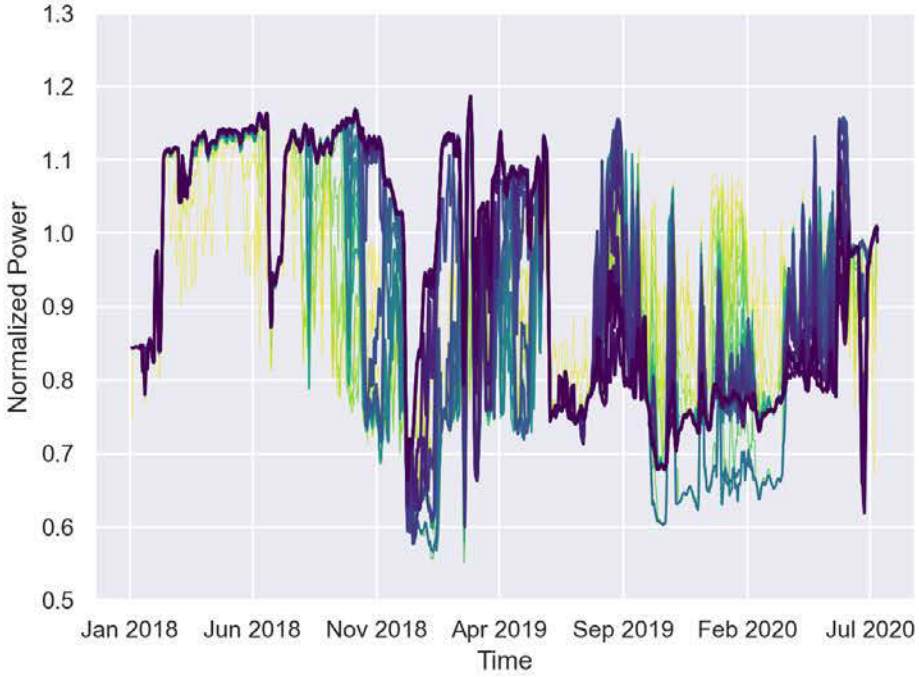
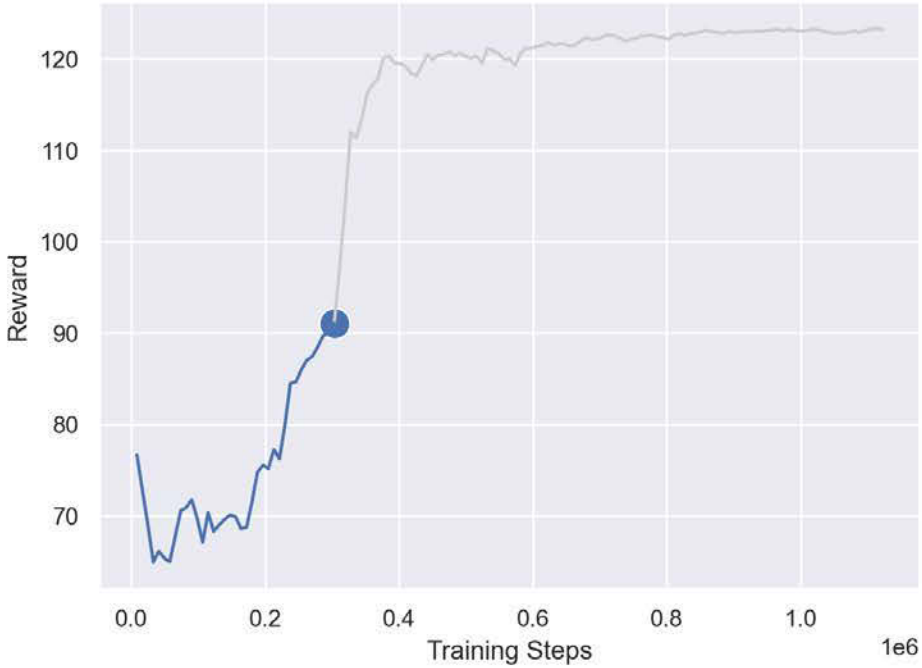




Agent Exploration in Action!





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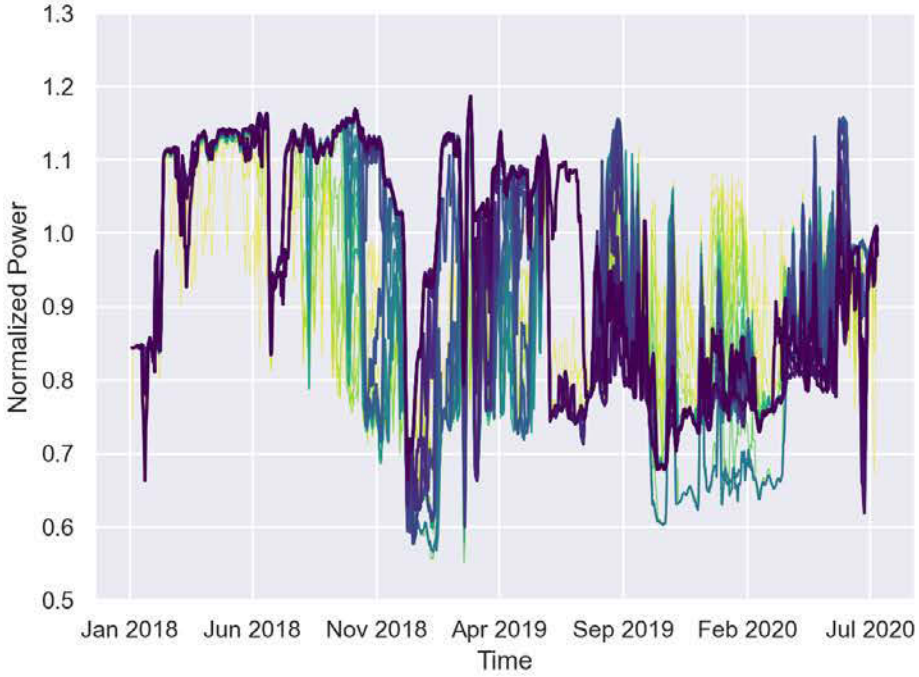
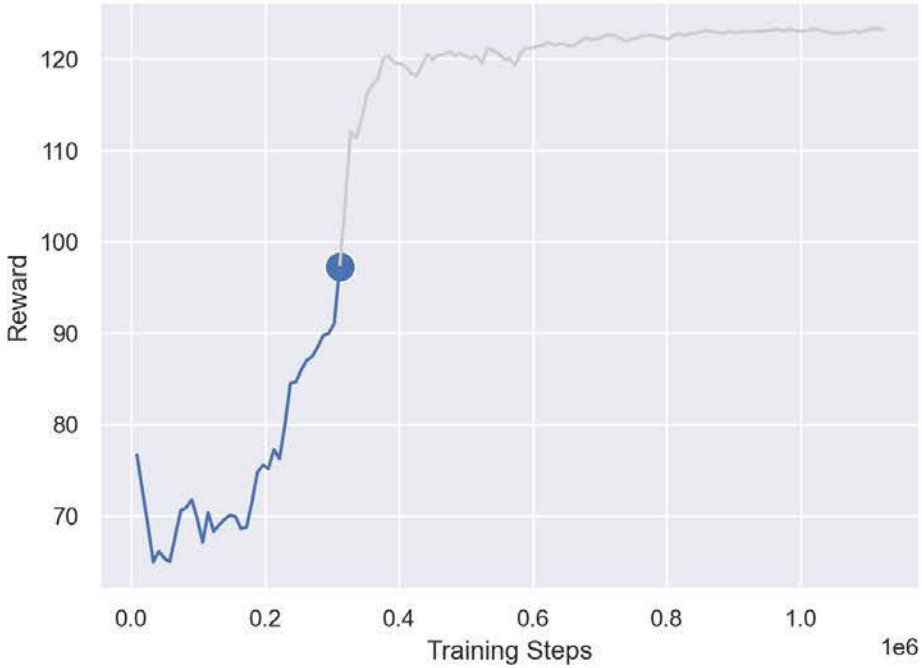
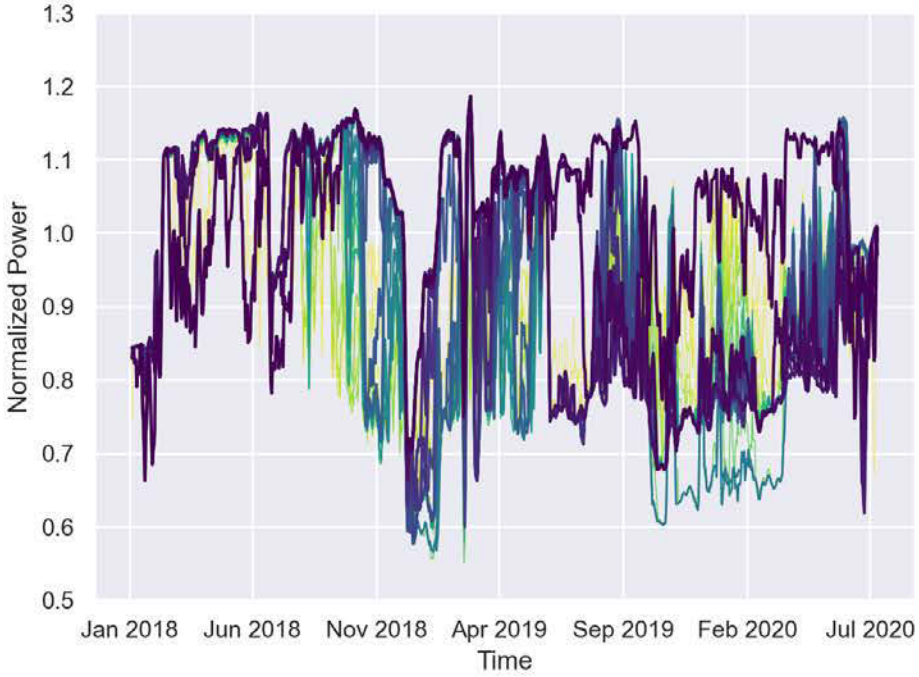
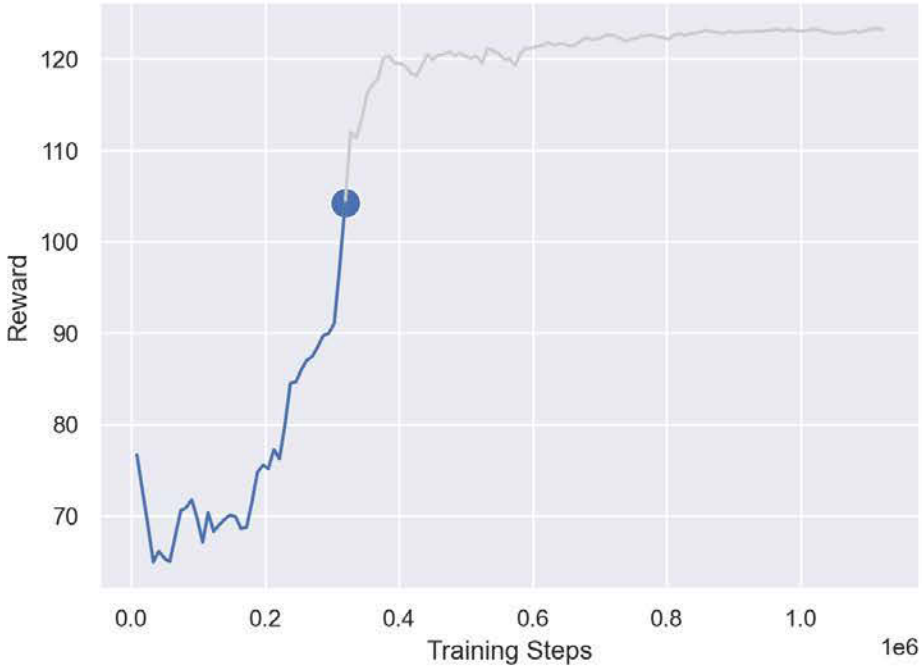


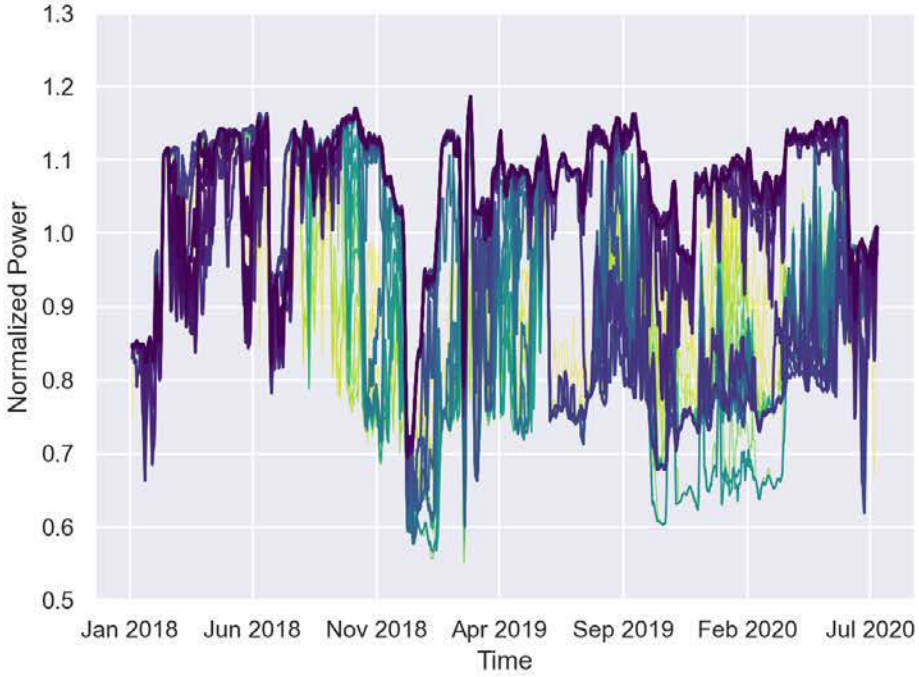


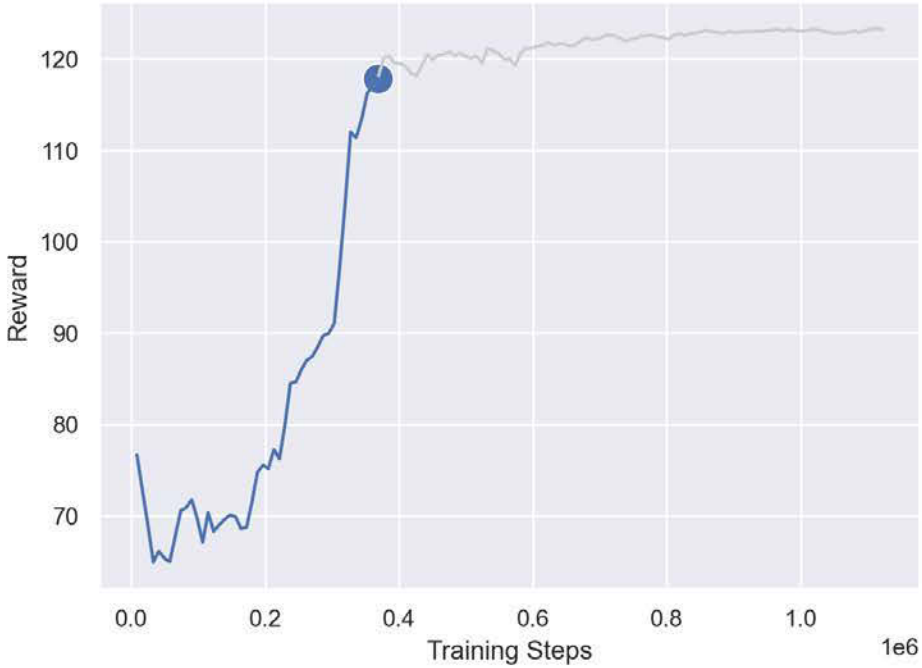
Agent Exploration in Action!





Agent Exploration in Action!





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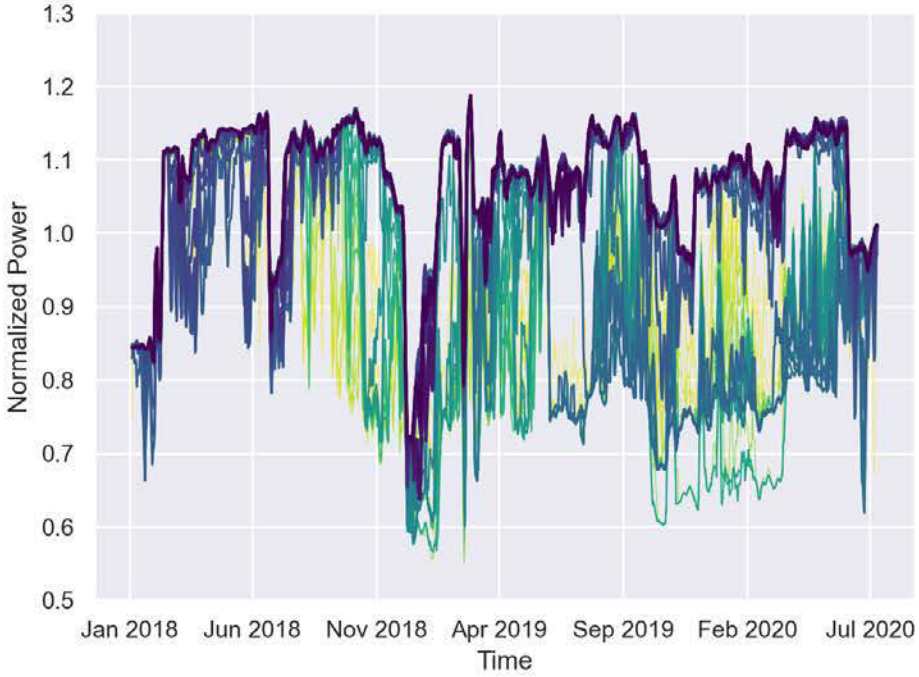

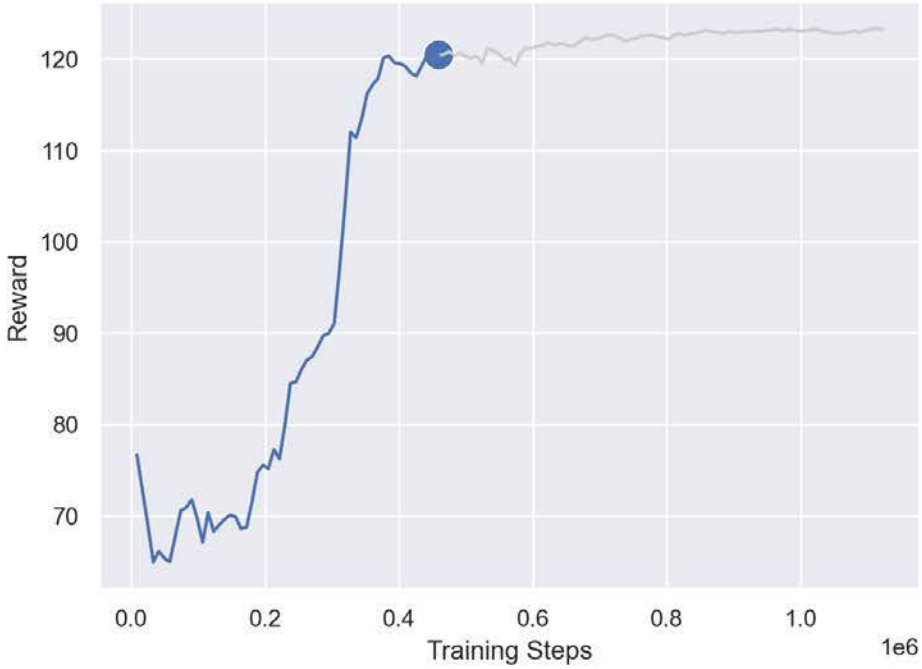

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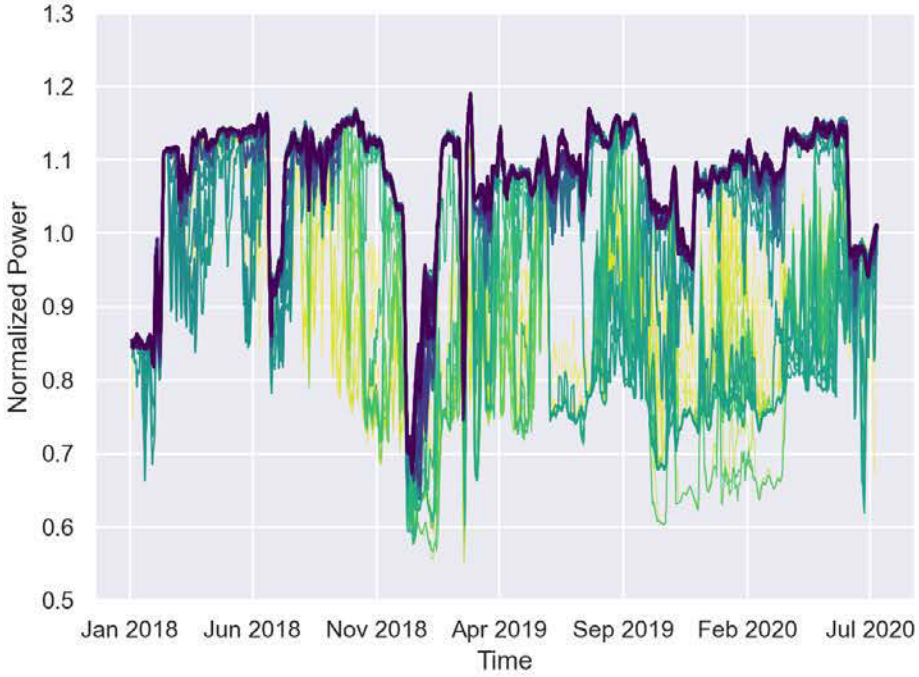

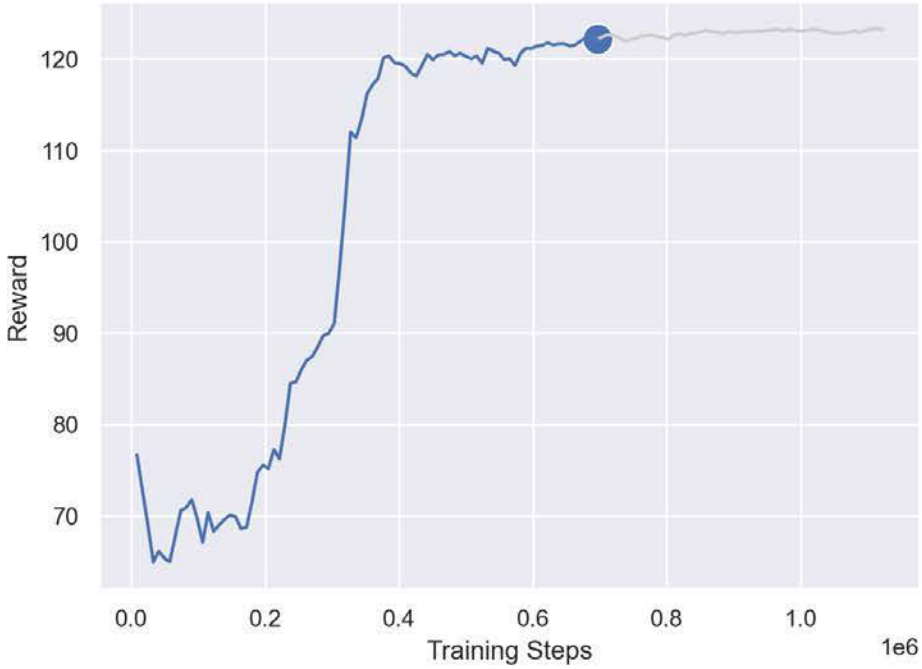

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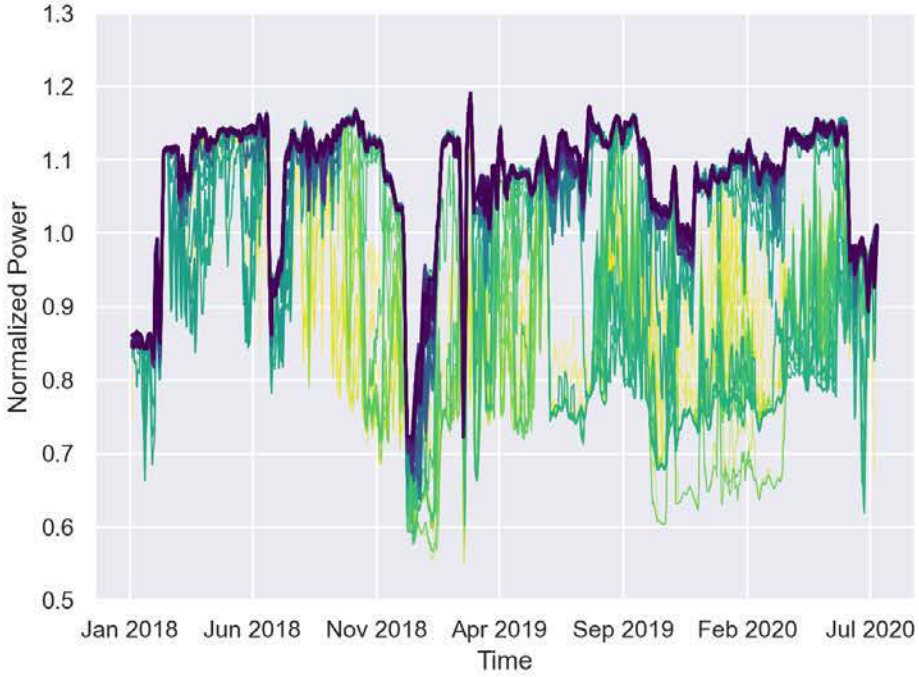

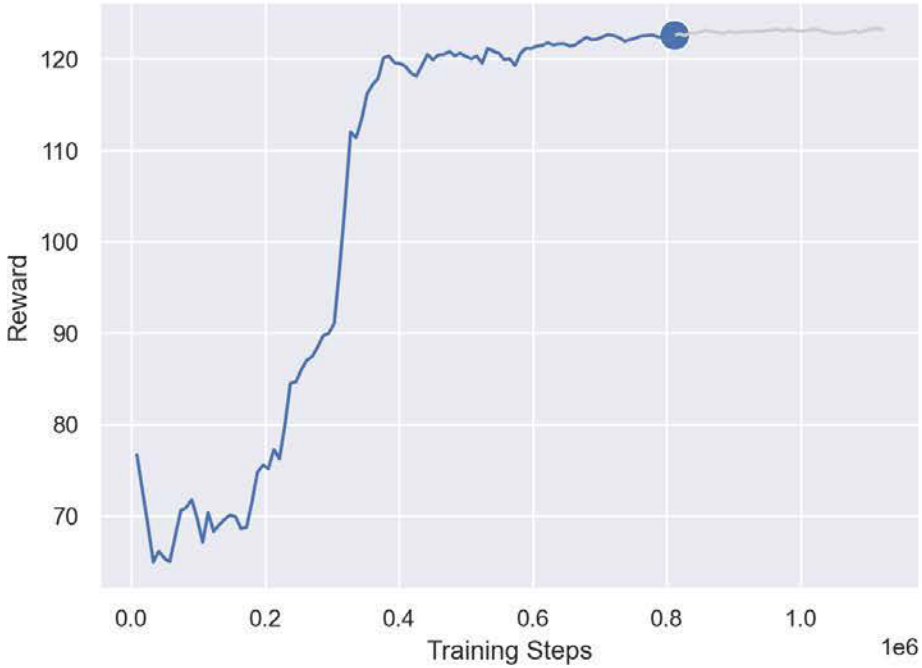

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Thank you

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NREL/PR-6A20-77593

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