Does Renewable energy and Battery storage, green the electric grid?

Carbon Footprint Analysis of Battery Storage Algorithms

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EARTH TALKS
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EARTH-TALKS.org

Rising Demand on Electricity Grid

one hour of streaming video in 2019 is 36 gCO2

0.3g CO2e spam email
4g CO2e regular email
50g CO2e photo email

- BBC

Data centres account for

~1%

of global electricity demand

- IEA

..Bitcoin currently consumes ~110 Terawatt hours per year

0.55% of global electricity production

- Harvard Business Review

Contents

1. Energy Usage Patterns

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   - Front of the Meter storage
   - Peak Prices

3. Behind the Meter storage

4. MinBills Optimization
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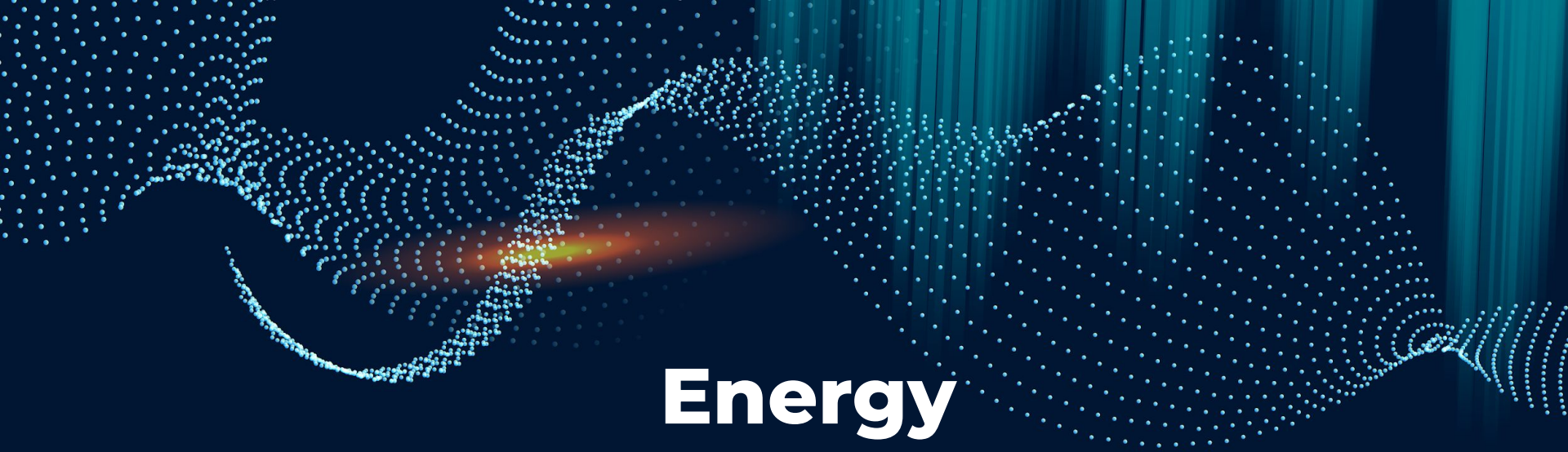
5. Carbon Footprint Analysis

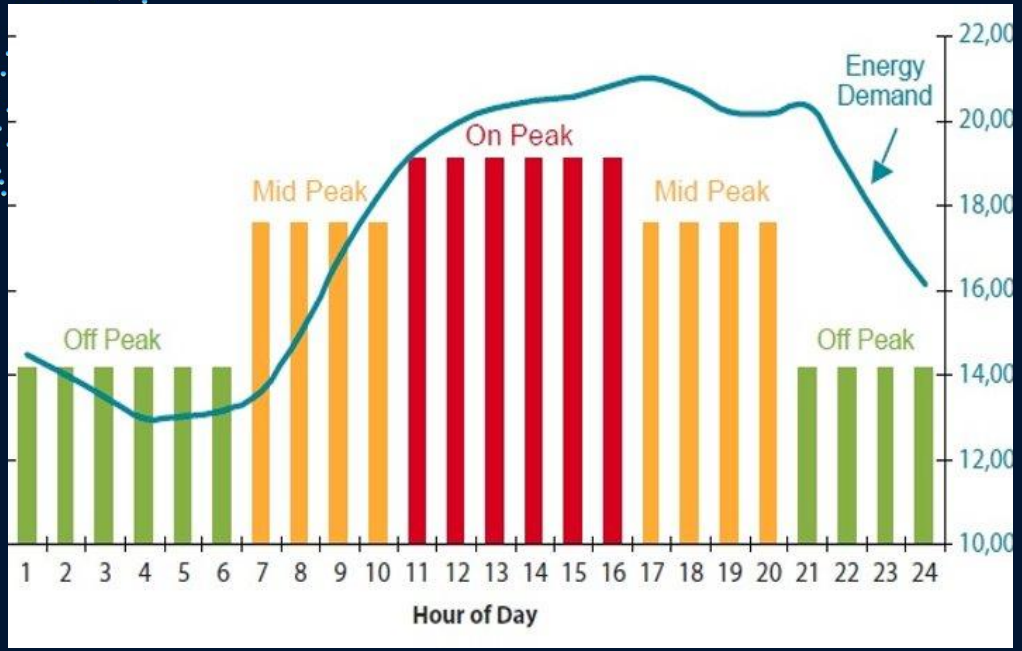


01 Energy Usage Patterns

Peaks and energy mix

1. Energy Usage Patterns

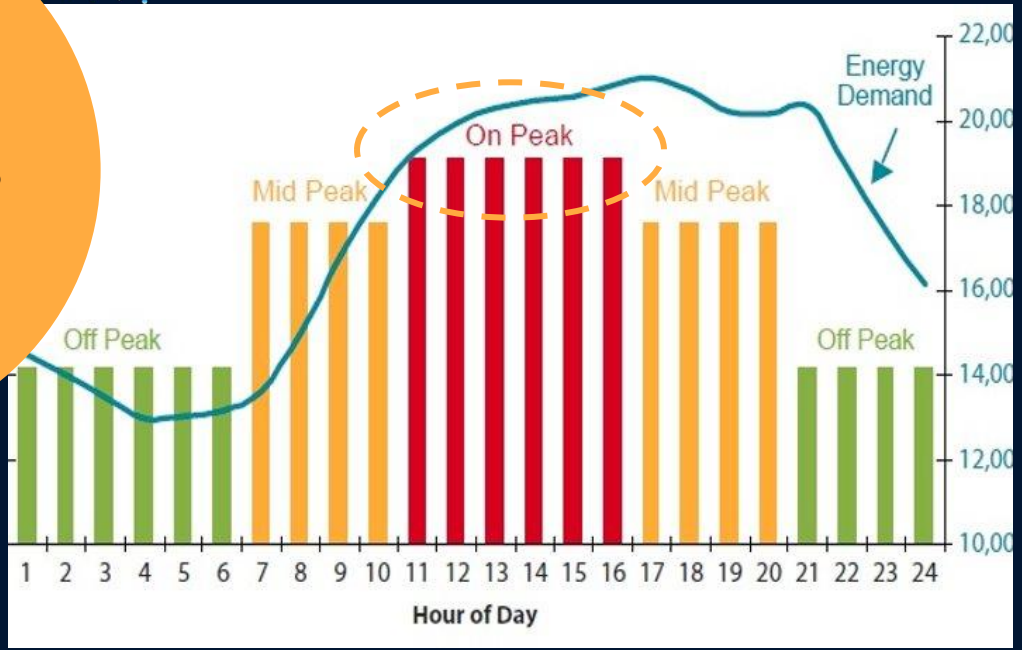
Daily Energy Peaks!



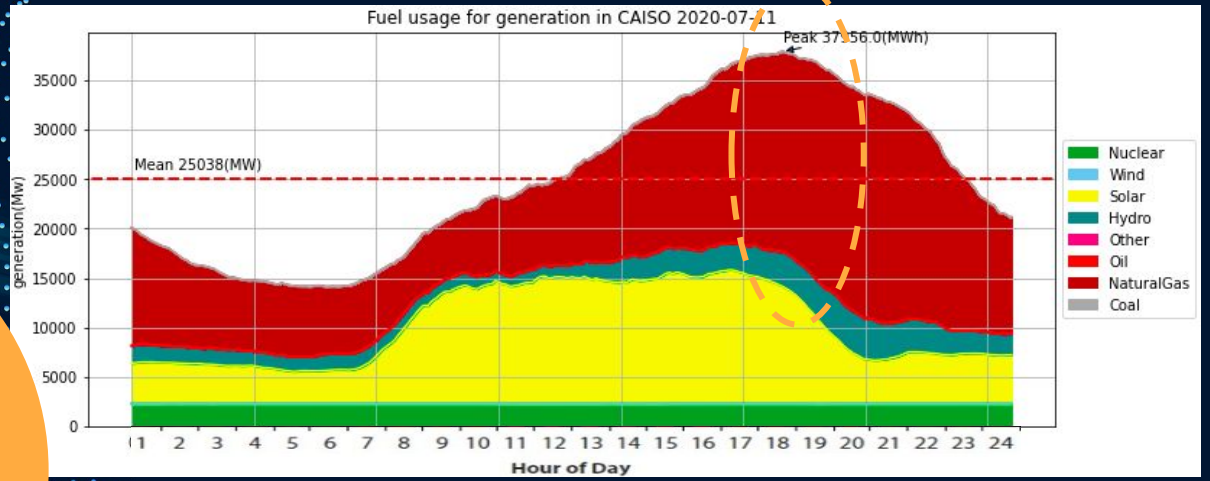
1. Energy Usage Patterns

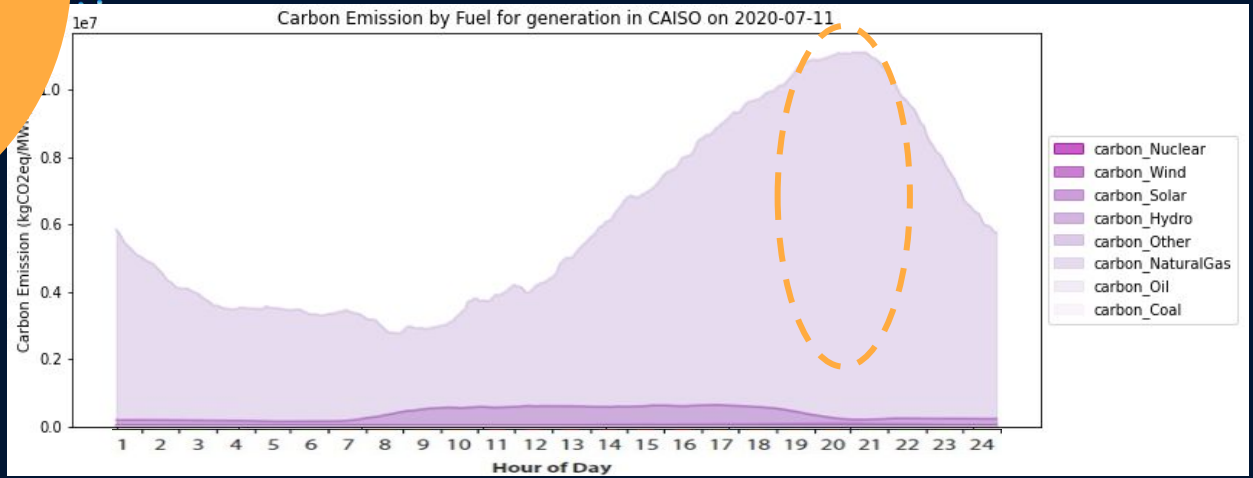
Daily Energy Peaks!

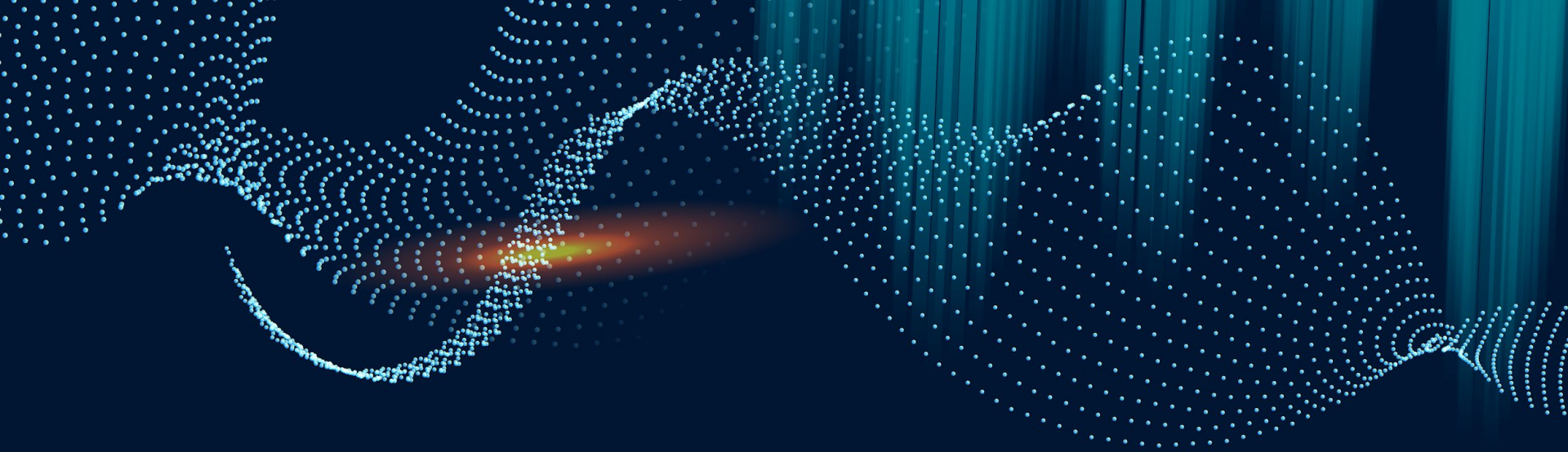
High Peaks in demand force **Electricity Grids** to generate more power.



Generators use more **Natural gas, coal** and **petroleum to** meet Peak demands hours







02 Electricity Grids

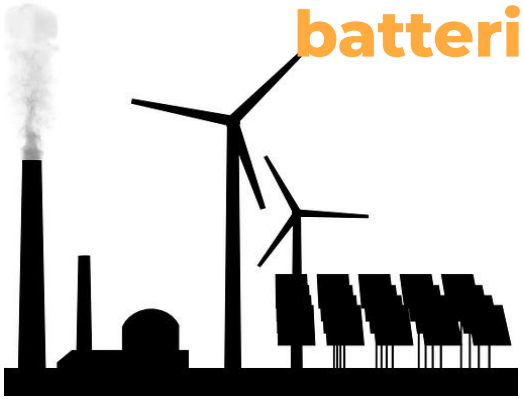
Front of the Meter storage
Peak Prices Grids

1. Burn carbon rich fossil fuel

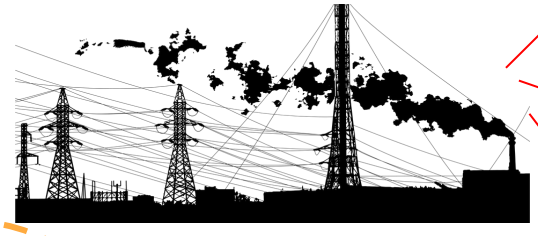
High carbon rich fuel sources (Petroleum , coal, natural gas so on) provide instantaneous electricity generation.

Thus often used to meet peak demand.

2. Grid Providers can use batteries to provide peak supply



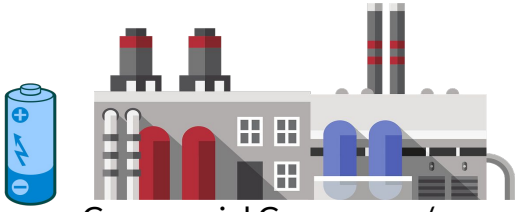
Power plants /
Energy generators



Power Grid
/ ISO or RTO or other Distributor

Front of the Meter Storage
Utility / grid Scale

Manufacturing plants



Commercial Consumers /
Data Centres

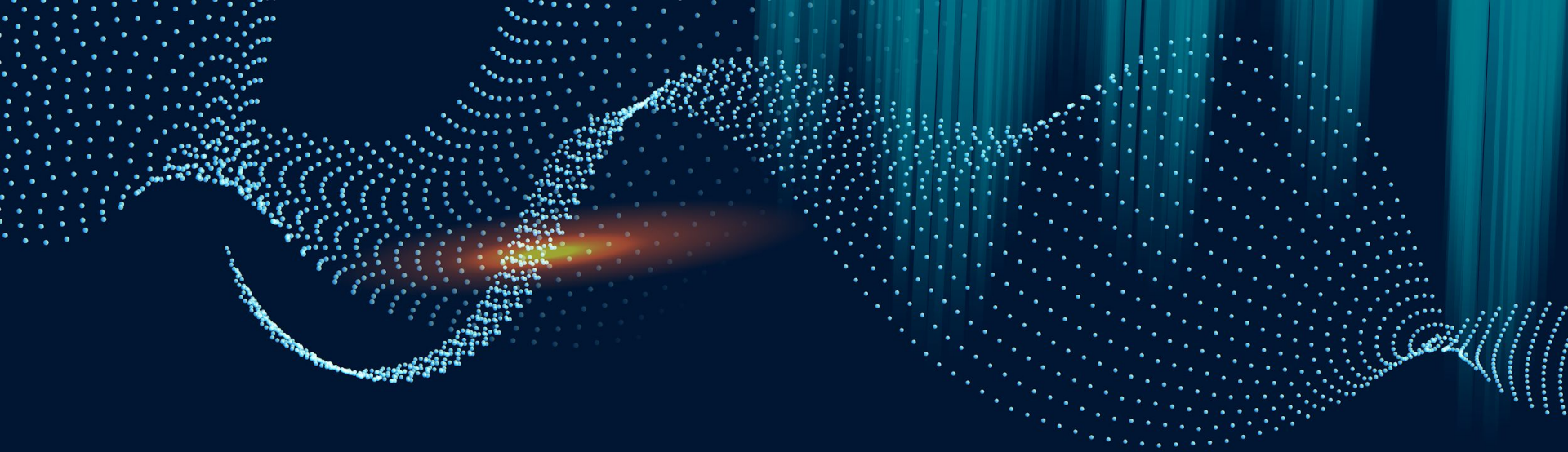
Residential Consumers

Behind the Meter Storage
Industrial / commercial scale

3. Time of Use and Flat Peak Pricing to Discourage Industries from creating peaks in demand

Seattle City Light implies demand charges according to TOU (Time of Use) and Peaks,

HG&E (Holyoke Gas & Electric) Department which implies charges according to Flat pricing on Energy and demand charges on highest Peaks.

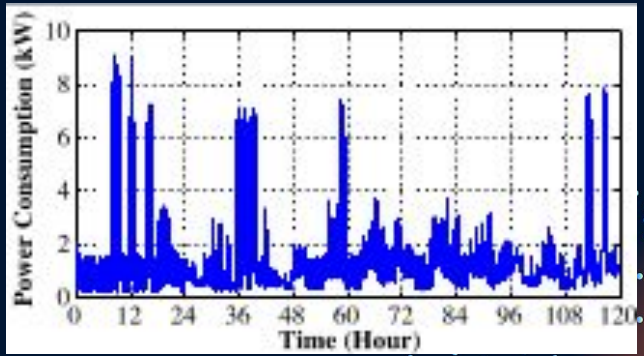


03

Behind the Meter storage

BTM Energy storage by industries and data centres

Peak Price and how companies avoid paying them



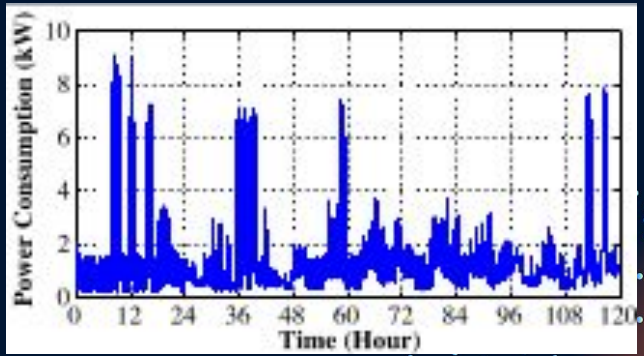
Reduce Peak consumption

Using solar panels in campus

Peak shaving using battery storage in off peak hours

Hybrid Oncampus Solar + Battery storage

Peak Price and how companies avoid paying them



~~Reduce Peak consumption~~

- Reduces profits

~~Using solar panels in campus~~

Too much upfront investment and real estate required

Peak shaving using battery storage in off peak hours

Low Investment, High Returns on Electricity Bill savings by avoiding peak prices

~~Hybrid Oncampus Solar + Battery storage~~

High investment and maintenance

Commercial energy storage solutions

Some commercial battery systems to help industries avoid peak pricing and perform demand charge reduction.

LG ESS Battery

Tesla Powerpack

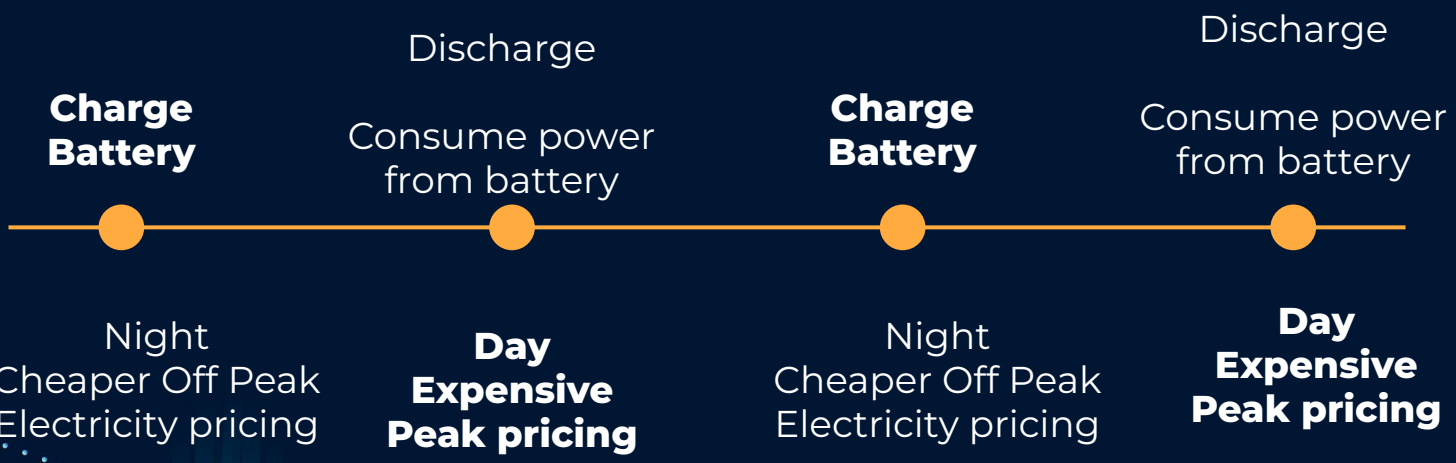
Voltpack from Northvolt

Tesla, Megapack

1] Grid/C&I/UPS Battery Introduction LG ESS Battery. https://www.lgessbattery.com/us/grid/intro.lg, 2021.
2] Northvolt unveils its own Tesla Power pack/Megapack competitor: Voltpack - Elec trek. https://electrek.co/2020/05/20/northvolt-voltpack-tesla-powerpack-megapack-competitor, 2020.
3] Wikipedia contributors. Tesla megapack
4] Image source : https://www.tesla.com/megapack

Industries uses Batteries to offset Peak Demand Charges

Greedy Battery Charging discharging to avoid peak pricing



Greedy Battery Charging discharging to avoid peak pricing

Can create demand peak in night

Battery is charged using power generated from **Carbon rich fuels**

Peak
ity pricing

Discharge

Consume power from battery

Day Expensive Peak pricing

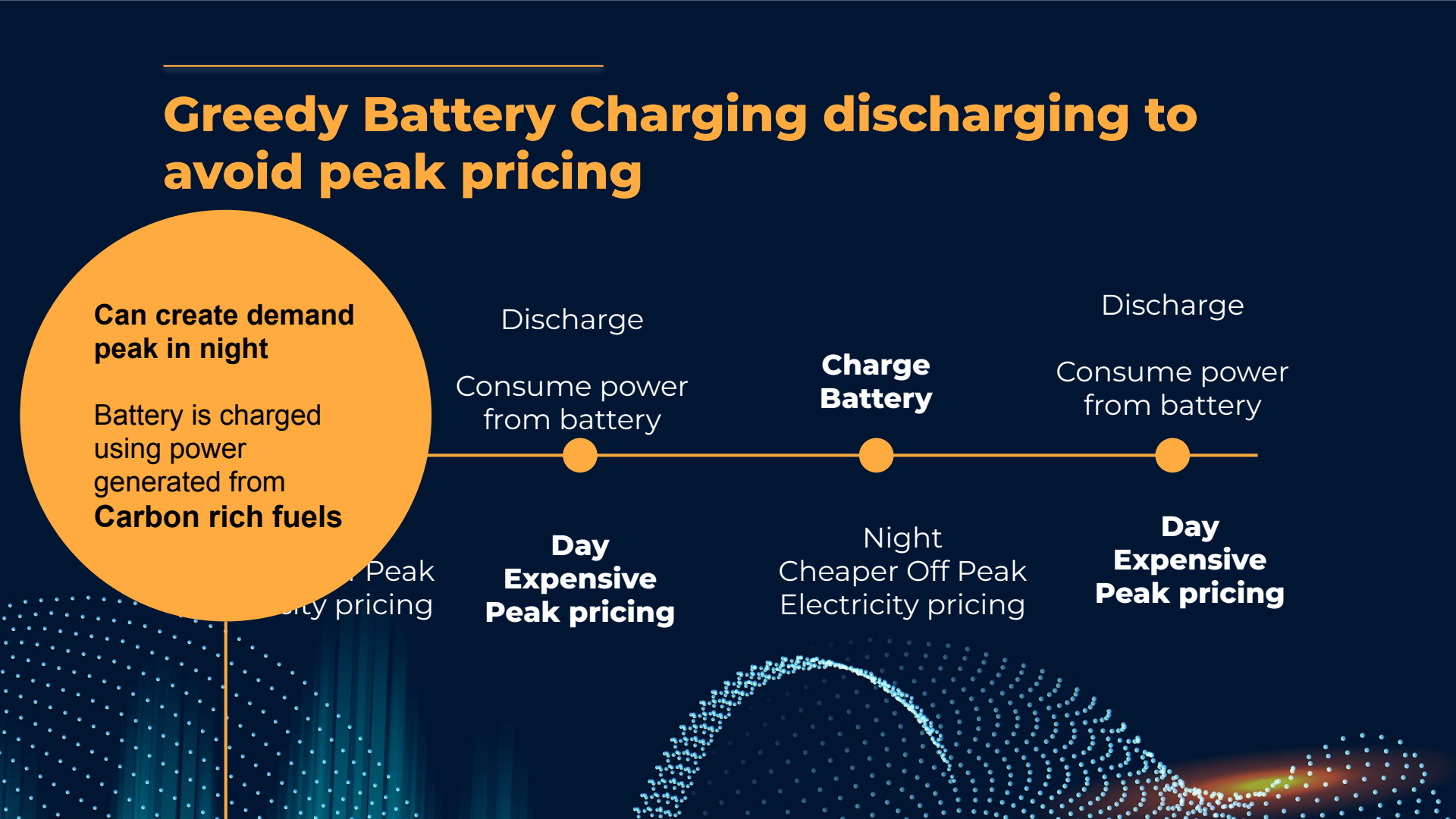
Charge Battery

Night
Cheaper Off Peak Electricity pricing

Discharge

Consume power from battery

Day Expensive Peak pricing



Analyze Commercial Battery Storage Algorithms

Lifecycle Emission

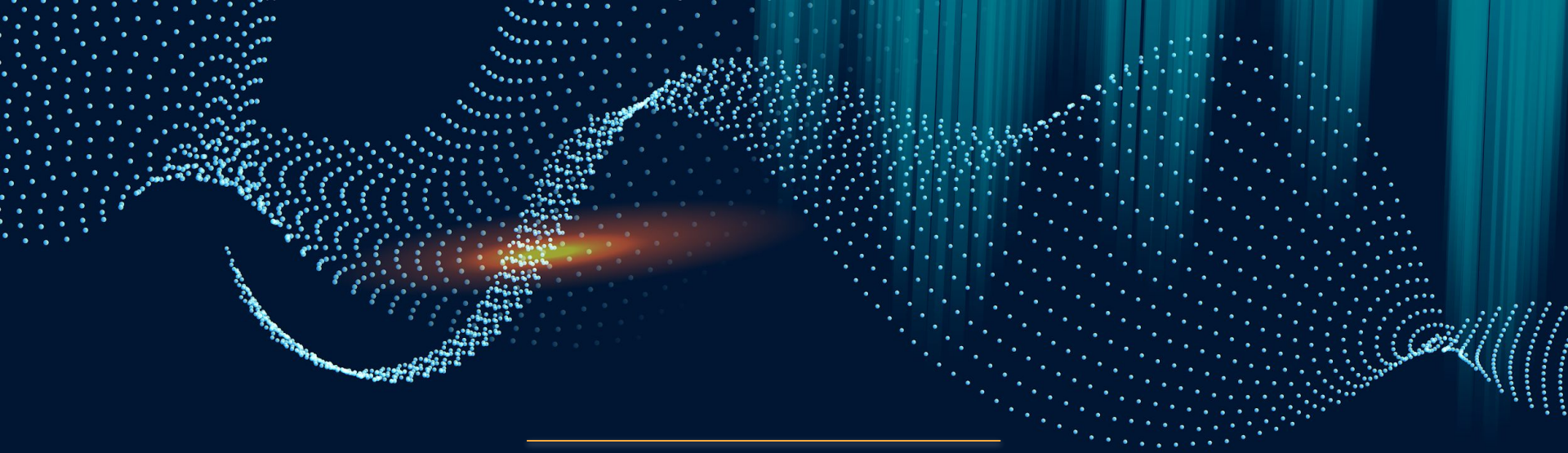
Lifetime CO2 footprint of ~100 kgCO2eq/kWh of battery capacity

Charge Discharge Efficiency

Round trip battery efficiency of 90%. so 10% of energy stored in battery is lost

Increase in Overall consumption

Total energy consumption increase after battery usage.



Current Battery storage leads to an increase in CO_2 footprint by millions of kg CO_2eq.

04

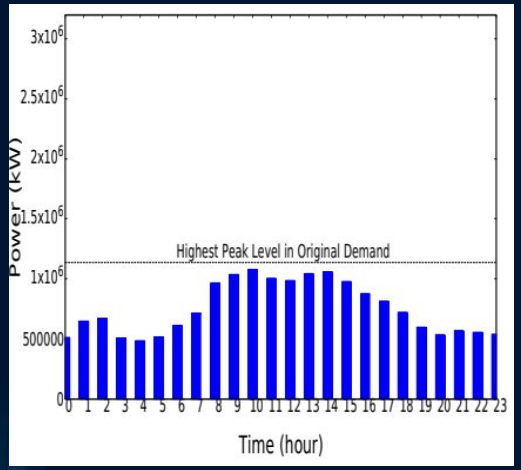
MinBills

Optimization framework

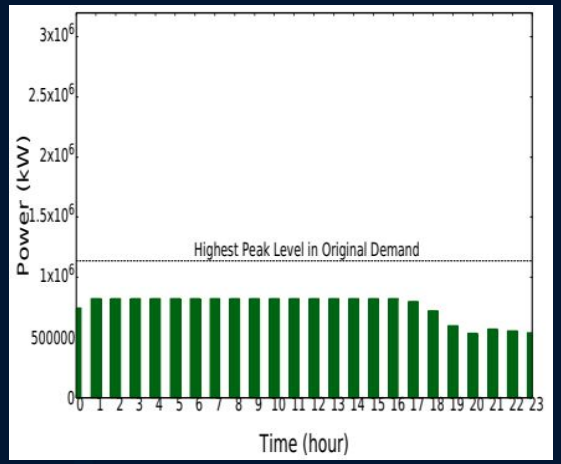
$$\text{Minimize } P^{T}_{i=1} m_i + L * c^{0}$$

- pi is the raw electricity demand on the grid
- mi is cost of electricity generation
- C^0 is Peak-based cost in $/kW
- L is maximum net power generated

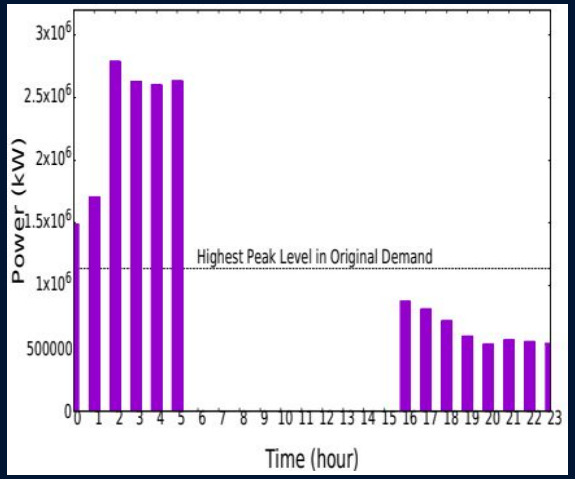
Experimental Evaluation



(a) Original consumption



(b) After MinBills with Flat + Peak Pricing

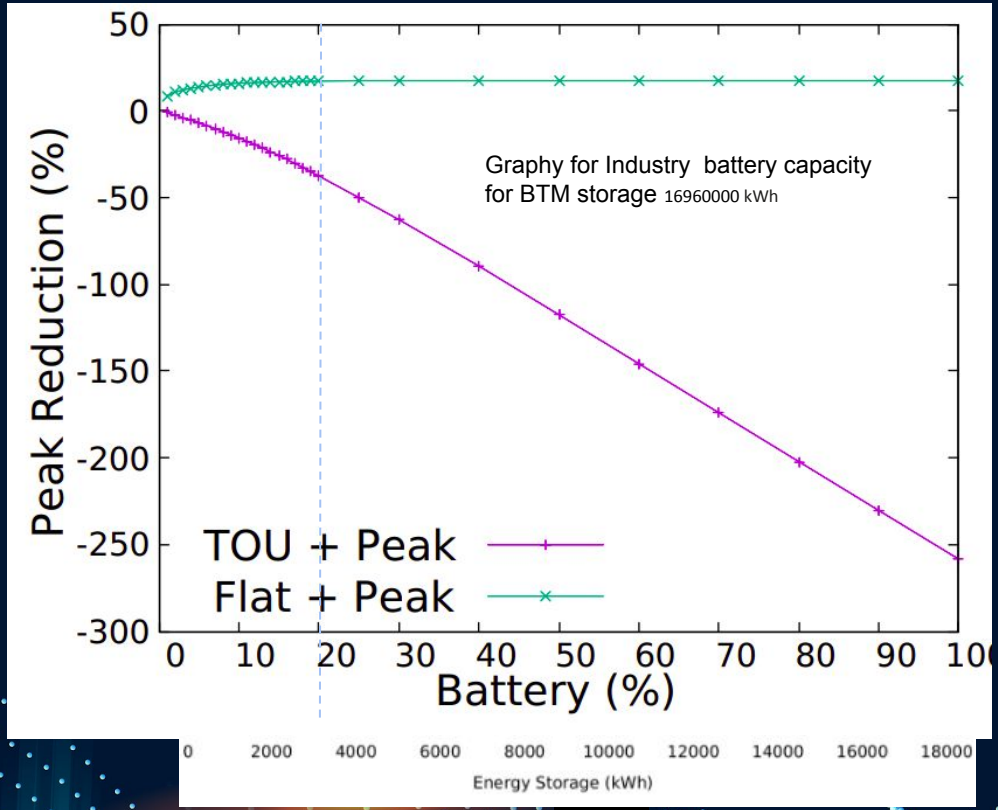


(c) After MinBills with Time of Use + Peak Pricing

Peak demand Reduction

Peak shaving for
- Flat Peak pricing
- Time of use based Peak pricing

MinBills can cuts peak demands up to **17.5%**



MinBills

save upto 6.25-28 %
on electricity bills
Economic Analysis

Gain on investment 55-56%
of storage system cost
Return on Investment (ROI)

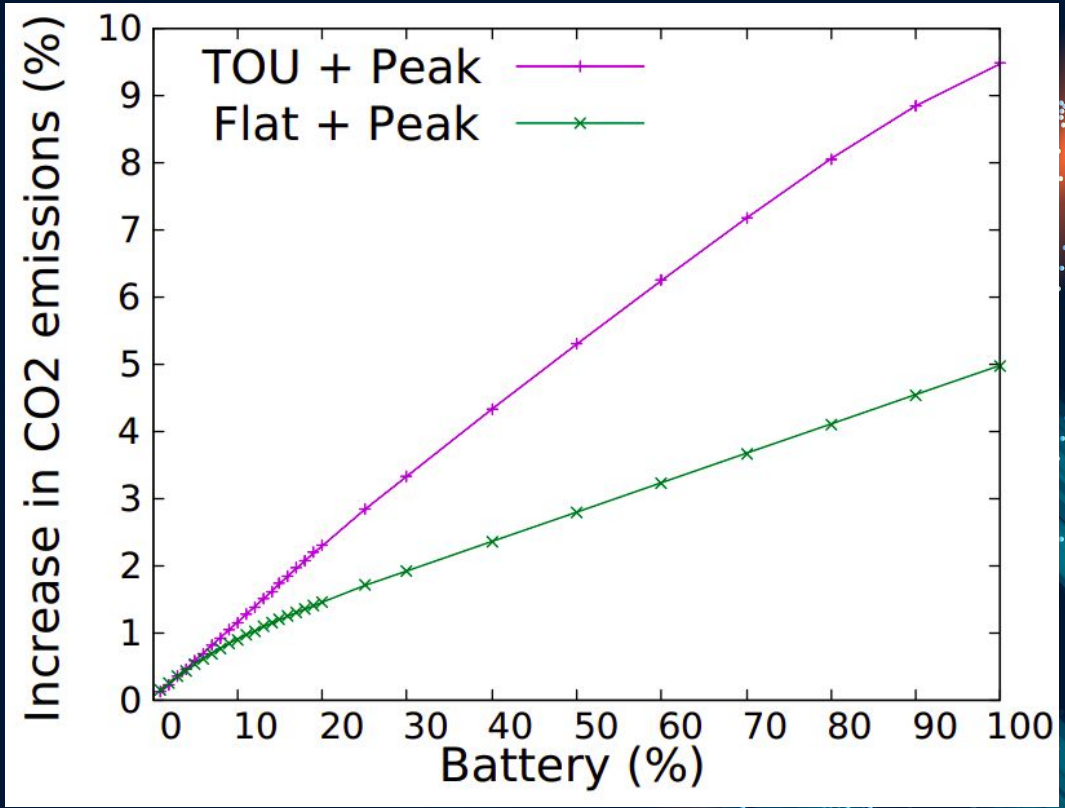
17.5 % cut in
peak demands
Peak shaving

05 Carbon Analysis

Unfortunately even MinBills Battery storage increases Carbon emission into the grid upto 9% .

Findings for some of the regions :

- 1-3% in the NorthWestern ISO region,
- 7% in New England ISO region and
- 6% in California ISO region.



Why isn't battery storage able to reduce carbon footprint by peak shaving ?

- Lithium battery’s heavy lifetime CO_2 footprint (100 kg CO_2-eq/kWh).
- Increased energy consumption due to battery inefficiencies.

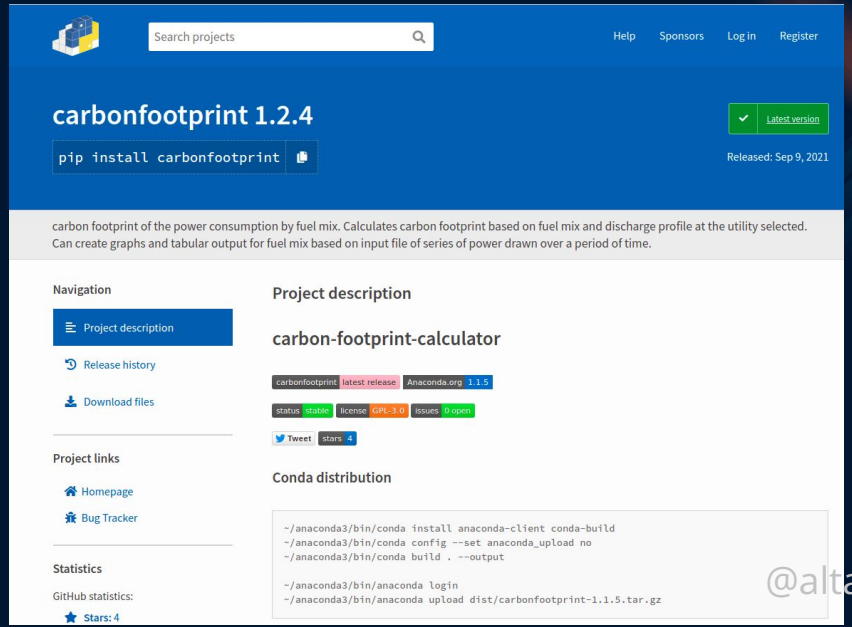
So to answer “Does Renewable energy and Battery storage green the electric grid?”

No, Not yet.

My research and findings

- Carbon footprint analysis from utility fuel mix
- Optimization for peak demand charges in electricity bill , Minbills (Research guided by Professor Aditya Mishra)
- Carbon footprint of BlockChain (Bitcoin) Networks
- Energy Efficiency and Carbon footprint of distributed VOIP communication networks

Open source Carbon Footprint Tracker for Regions

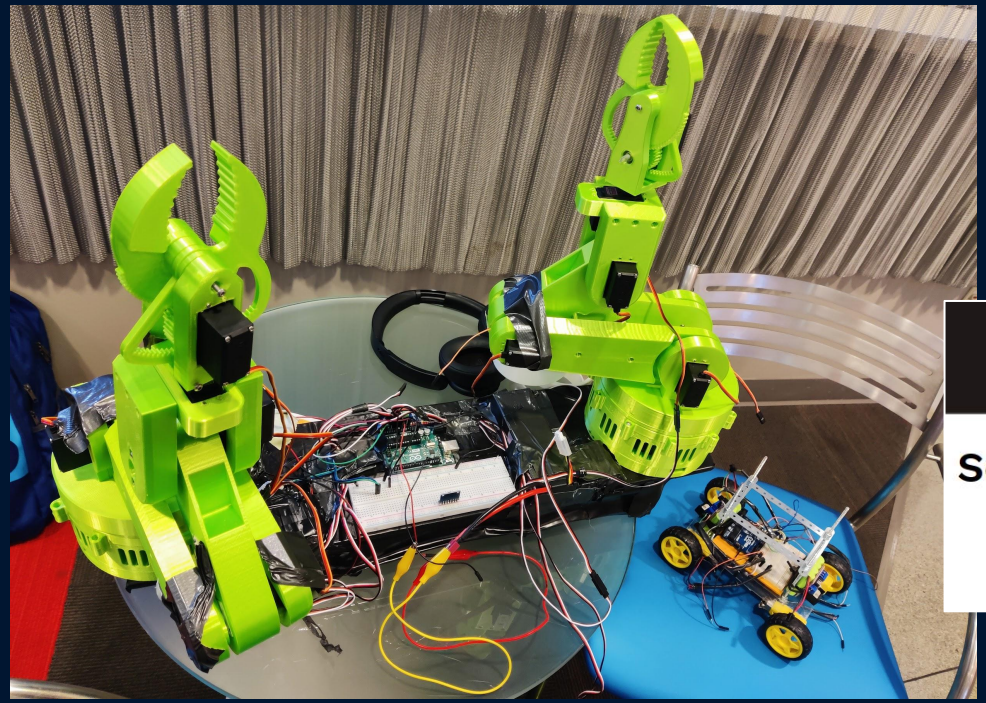


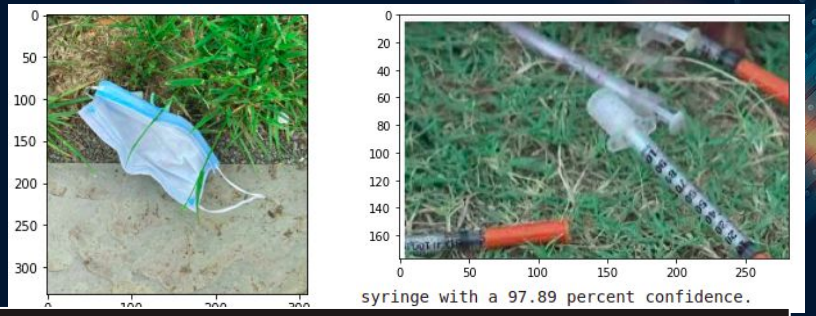
@altanai

https://pypi.org/project/carbonfootprint

RamudDroid

Garbage Picking Robot





the SPECTATOR

Seattle University's student newspaper since 1933.

Seattle U Graduate Students Are Building a Droid That Collects Trash

Andru Zodrow, Managing Editor | March 12, 2022

Thank you

@altanai

https://www.linkedin.com/in/altanai/

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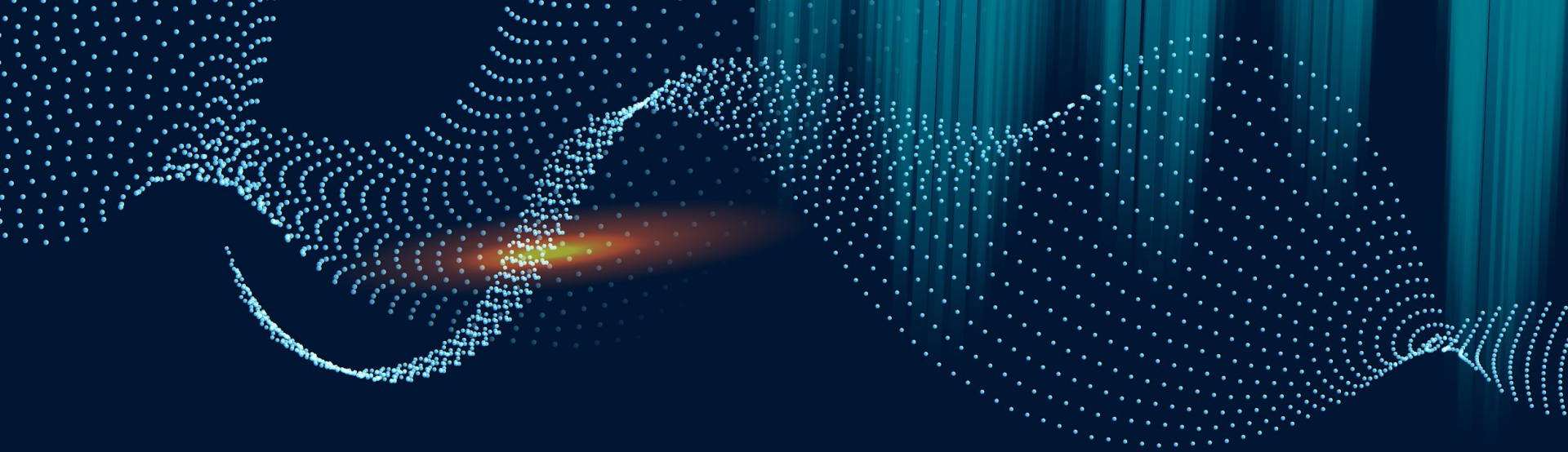


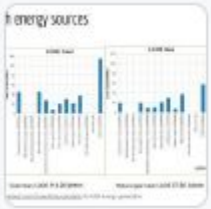
Extra Slides

More Links

More :

Seattle university Renewable energy research · GitHub

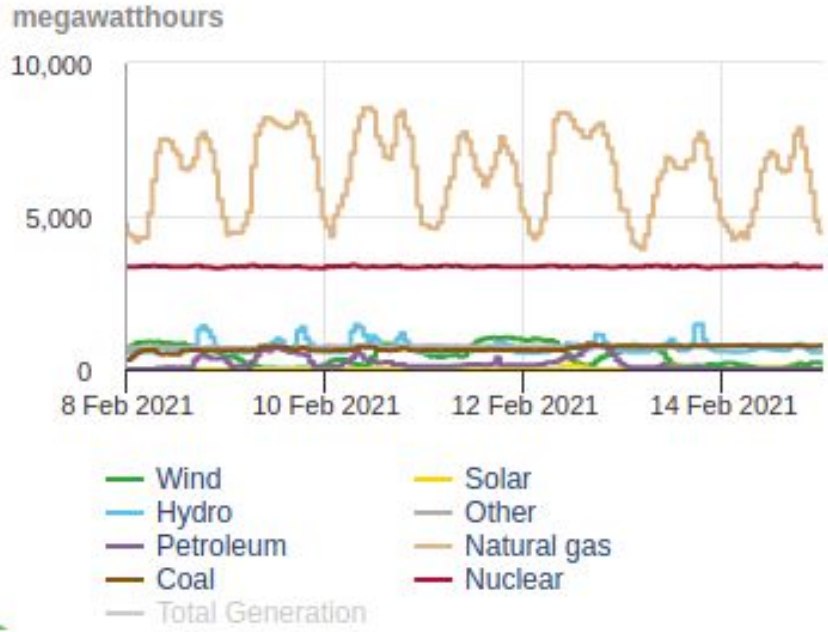
https://github.com/renewable-energy-experiments



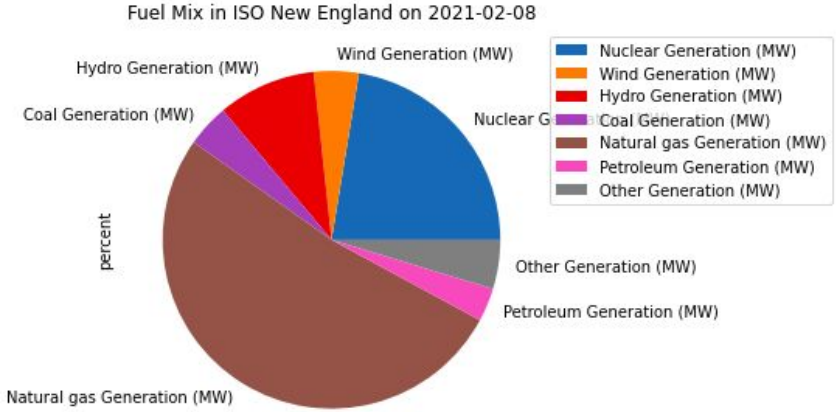
Seattle university Renewable energy research

Seattle https://altanairenewableenergy.wordp... @altanai tara181989@gmail.com

New England (NE) region electricity generation by energy source 2/8/2021 – 2/14/2021, Eastern Time



Source: U.S. Energy Information Administration

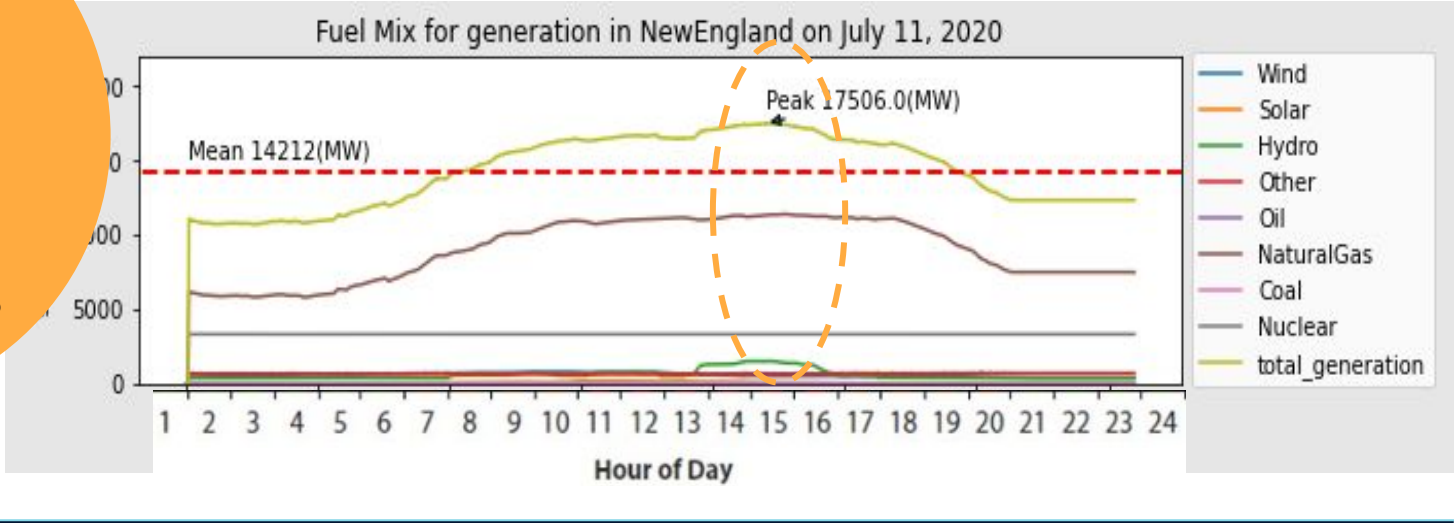


Peak Pricing(Demand Charges) in Electricity Bill

Given today's peak-based variable pricing and commercial battery storage systems, determine:

1. Can batteries shave peak demands?
2. Can batteries save enough on bills to result in a positive return-on-investment?
3. Can battery-based peak shaving solutions reduce the CO_2 footprint?

Generators pump more Natural gas, coal and petroleum to meet Peak demands hours



1. Energy Usage Patterns

Peaks and energy mix

Fuel Mixes and Demand Release Cycle

2. Front of the Meter storage

Electricity Grids

CAISO
North Western
NYISO

3. Behind the Meter storage

Commercial scale batteries

Data centres
Manufacturing Industries
Factories

MinBills

Optimized Battery Charging and Demand Charge Reduction Algorithm

Min bills applied energy storage with peak-based variable pricing

- Can cut peak demands
- Amount to significant cost savings over the system's lifetime
- But increase the customer's CO2 footprint