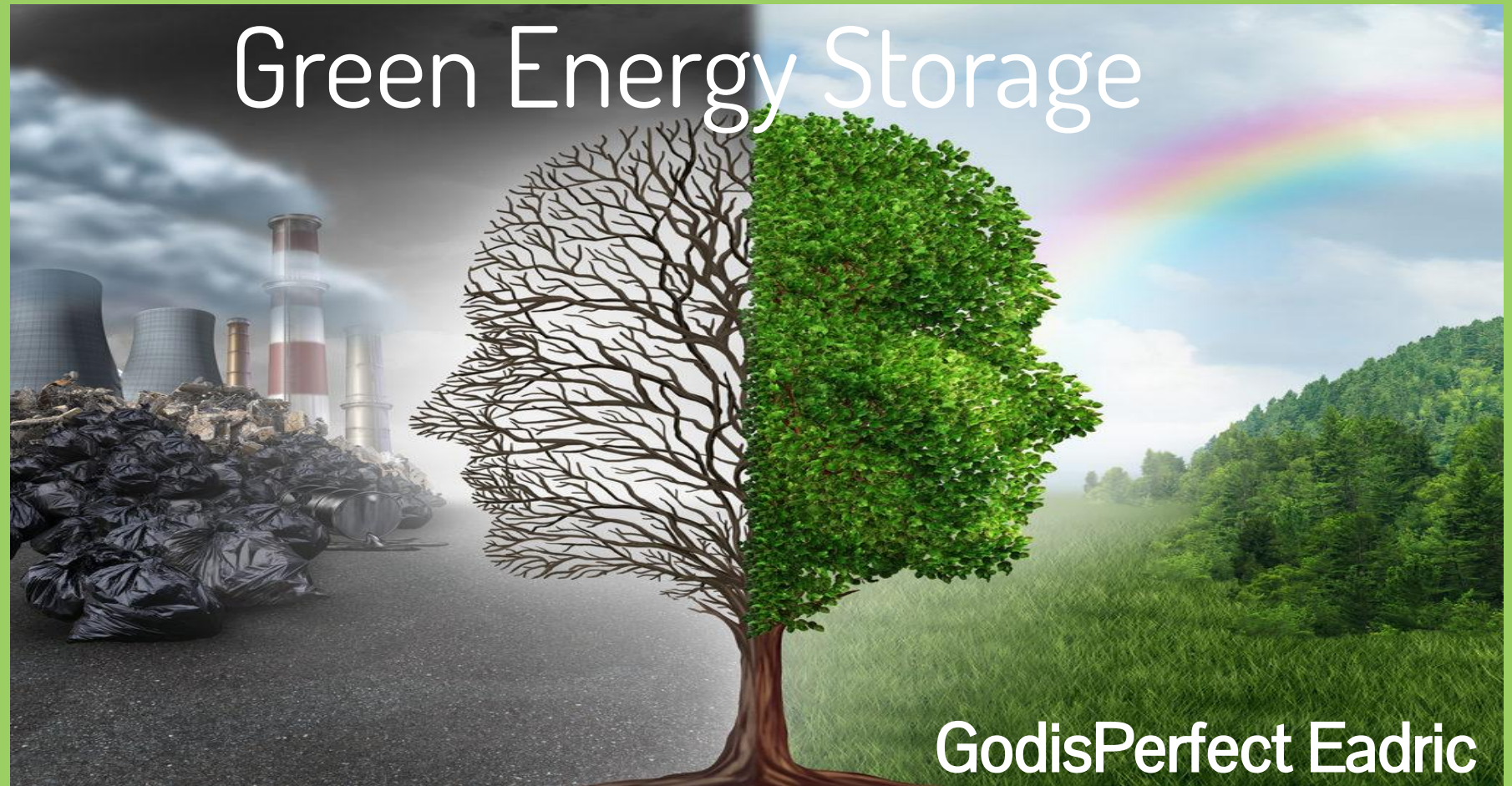


# Green Energy Storage



GodisPerfect Eadric



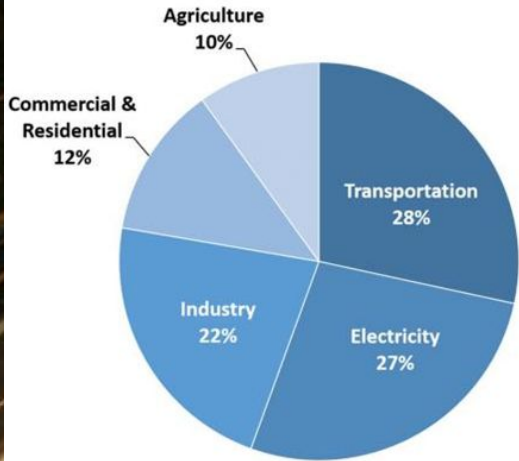
“

*The greatest threat to our planet is the belief that someone else will save it.*  
- Robert Swan



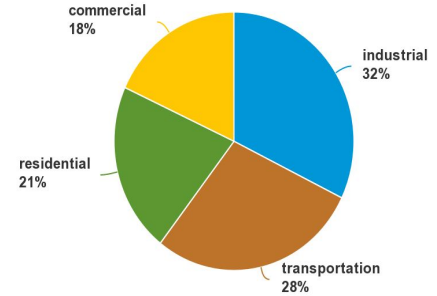
# Transportation

Total U.S. Greenhouse Gas Emissions by Economic Sector in 2018



Share of total U.S. energy consumption by end-use sectors, 2019

Total = 100.2 quadrillion British thermal units



Note: Sum of individual percentages may not equal 100 because of independent rounding.  
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 2.1, April 2020, preliminary data



- Large energy consumption
- Large Greenhouse Gas emissions





# Electric Vehicles

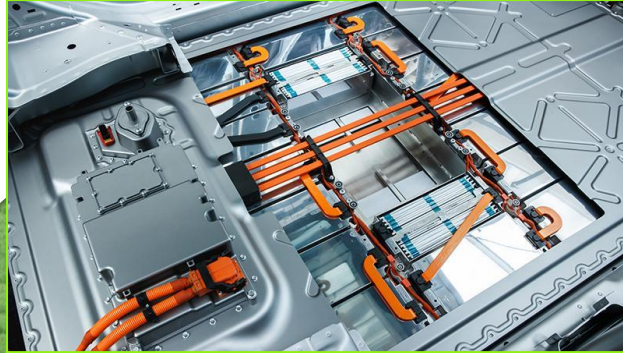
- ❑ Energy-Efficient
- ❑ Zero Greenhouse Gas Emissions

## Totally Green?

- ❑ Manufacturing
  - ❑ Li-ion batteries
- ❑ Charging
  - ❑ Power grid

# Litium Ion Batteries

“Without radical changes, the batteries which power green vehicles will continue to be tainted by human rights abuses ”



**- Kumi Naidoo, Amnesty International's Secretary General**

**AMNESTY  
INTERNATIONAL**



- Pros
  - High efficiency
  - Portable
  - Recyclable
- Cons
  - Cobalt Mining
  - Power Grid

# A Deeper Look...



## Cobalt Mining

- Lithium Cobalt Oxide Cathode - highly conductive without compromising stability
- Mining in the Democratic Republic of Congo - Ethical Concerns



## Power Grid

- Distributes power from electricity generation facilities to consumers
- 85% of electricity by nuclear power, coal, oil, and natural gas



# How many EVs are completely green?



**So do we  
give up on  
EVs?**

# Declining Renewable Costs Drive Focus on Energy Storage

Jan. 2, 2020







Over

# 446 Billion KWh

of energy were generated using renewables in 2019



# Common Methods of Energy Storage

## Batteries

- Li-ion, flow, lead-acid, sodium
- Potential - support of the Grid
- Compact compared to Energy Stored
- Portable or permanent

## Thermal

- Heating and Cooling
- Latent Heat Storage (LHS)
  - Physical transformation
- Sensible Heat Storage (SHS)
  - No physical transformation

## Mechanical

- Force for energy storage

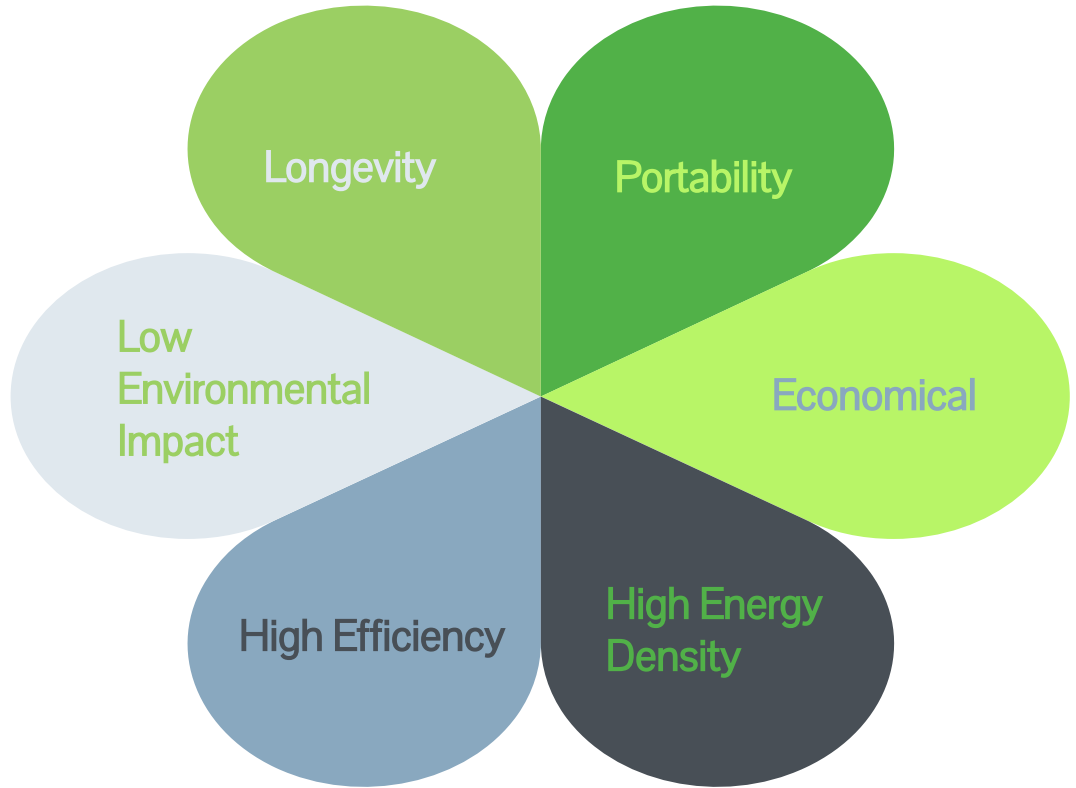
## Flywheels

- Mechanical Rotors
- High Power
- Short Duration

## Pumped Hydro Power

- 95% of energy storage
- Hold and Releasing Water
- Large Footprint

# Qualities of an ideal eco-friendly battery







Green energy  
needs green  
storage

A decorative graphic on the left side of the slide. It features a large, detailed green leaf in the center, with a smaller, stylized green leaf to its left. Two light blue circles are positioned in the background, one at the top and one at the bottom left.

This presentation was inspired by a design challenge I participated in during Summer 2020 titled “Mitigating Climate Change through Innovative Energy Storage Applications”

# Thanks!

ANY QUESTIONS?





# Sources

<https://www.bbc.com/news/world-africa-50812616#:~:text=DR%20Congo%20produces%2060%25%20of,human%20rights%20abuses%20and%20corruption>

<https://science.sciencemag.org/content/367/6481/979#:~:text=The%20use%20of%20cobalt%20in,structural%20stability%20throughout%20charge%20cycling.&text=For%20these%20reasons%2C%20cobalt%20was%20added%20as%20a%20stabilizer>

<https://www.nrel.gov/news/features/2020/declining-renewable-costs-drive-focus-on-energy-storage.html>

<https://www.epa.gov/energy/electric-power-grid-text-only-version>

<https://www.eia.gov/outlooks/steo/report/electricity.php>

<https://www.eia.gov/energyexplained/use-of-energy/>

<https://www.nyserda.ny.gov/All-Programs/Programs/Energy-Storage/Energy-Storage-for-Your-Business/Types-of-Energy-Storage>

<https://www-sciencedirect-com.ezproxy.cul.columbia.edu/science/article/pii/S1364032107000238?via%3Dihub>