Evaluating the Sustainability of Using Electric Vehicles

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BACKGROUND

- Fuel-based vehicles emit several types of air pollutants, such as nitrogen oxides (NO_x), carbon monoxide (CO), and particulate matter (PM).[1]
- Air pollution causes more than *three* million premature deaths yearly.[2]
- Electrification of passenger vehicles may result in carbon emissions reduction as well as decrease in criteria pollutant emissions, thus improving air quality.[3]
- Rising electric vehicles sales (Fig. 1) led to lower emissions due to their zero tailpipe emissions.[4]
- ***Sustainable Development***: Transitioning to EVs may ensure that we meet current needs while preserving resources for future generations.

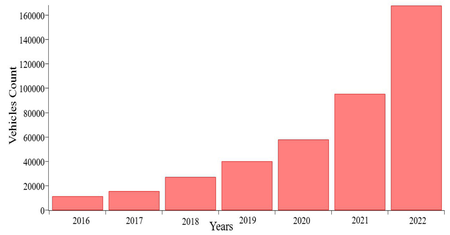


Fig. 1: Florida's registered EVs since 2016.[4]

OBJECTIVE

- The purpose of this study is to investigate the environmental, social, and economic impacts of the replacement of fossil fuels-based vehicles by EVs on air quality across different counties in the state of Florida, to evaluate the overall sustainability benefits of this replacement.

METHODOLOGIES

1. Choosing a Sustainability model.
   The ***Triple Top Line*** sustainability model (Fig. 2) is used because it creates positive environmental, social, and economical impact, hence promoting sustainability and resilience.
2. Conducting a ***Life cycle assessment (LCA)*** to assesses the environmental impact of the materials and components of EVs from their creation to their disposal, considering their influence on the climate.
3. Evaluating the ***United Nations Sustainable Development Goals (UN SDGs)*** that closely align with the transition from fuel-based vehicles to EVs .

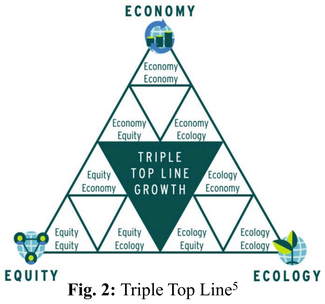


Fig. 2: Triple Top Line[5]

SUATAINABLE DEVELOPMENT GOALS

The transition from vehicles powered by fossil fuels to EVs is closely aligned with several of the ***UN SDGs :***

1. **SDG 3:** ***Good Health And Well-Being***
   - ***Targets 3.2 & 3.9*****:** Aim to end preventable child and newborn deaths by 2030.
     Indicators 3.2.1, 3.2.2 & 3.9.1: EVs contribute to reducing air pollution, a major cause of mortality.
2. **SDG 7:** ***Affordable And Clean Energy***
   - ***Target 7.1*****:** Attempt for affordable, reliable, modern energy for all by 2030.
     Indicator 7.1.2: EVs increase reliance on clean energy.
   - ***Target 7.2, Indicator 7.2.1*****:** Targets a higher share of renewable energy globally.
   - ***Target 7.a, Indicator 7.a.1*****:** Promotes investment in clean energy technologies.
3. **SDG 11:** ***Sustainable Cities And Communities***
   - ***Target 11.6*****:** Reduces environmental impact per capita in cities by 2030.
     Indicator 11.6.2: EVs improve air quality in urban areas
4. **SDG 13:** ***Climate Action***
   - ***Target 13.2*****:** Incorporates climate change measures in national agendas.
     Indicator 13.2.2: EVs reduces yearly greenhouse gas emissions

Fig. 3: Sustainable Development Goals aligned with this study.[6]

SUATAINABILITY MODEL

➢ ***Triple Top Line Model***:

1. ***Environmental pillar***:
   - Electrification resulted in 22.6% decrease in carbon footprint per vehicle in 2020.[7]
   - ***ANALYSIS USING EPA's MOVES:***
     - Over the five years (2018-2022), decreases in fuel-based vehicles led to a significant decrease in CO, NO_2, $PM_{2.5}$, and PM_{10} emissions by 20.87%, 43.81%, 43.12%, and 12.60%, respectively for passenger car.
     - ❖ EVs are heavier than the fuel vehicles so emits $PM_{2.5}$ and PM_{10} from non-exhaust source.
     - ❖ Greenhouse Gas (GHG) emissions associated with lithium-ion battery production.
     - ❖ EVs reduce emissions effectively only if the electricity production is clean.
2. ***Social pillar***:
   - Improved human heath due to better air quality.
   - Electrification adoption may avoid 150,000 early deaths in the US by 2050 by reducing air pollution.[8]
3. ***Economy pillar***:
   - EVs can save money on health and create new eco-friendly jobs.
   - Florida provides incentives, tax credits, and loans for renewable energy, with net metering and interconnection policies for home solar systems.[9]

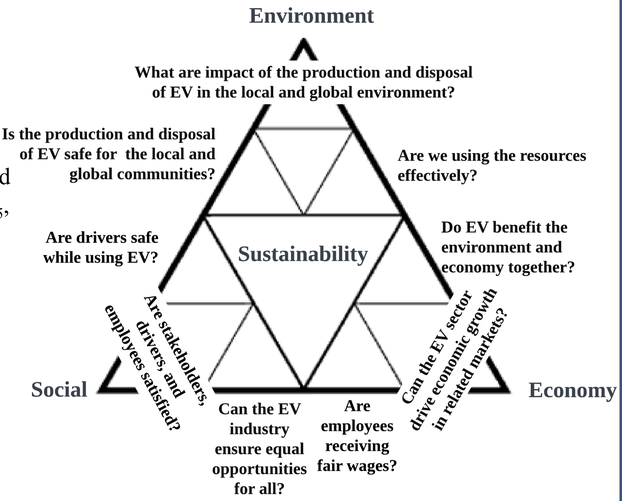
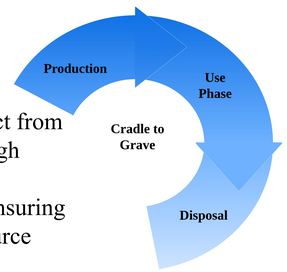


Fig. 4 : The Fractal Triangle for the framework to evaluate and improve the Sustainability of EVs, focusing on environmental, economic, and social dimensions.

➢ ***Life cycle analysis (LCA)***

- Cradle-to-grave: Focuses on minimizing environmental impact from production to disposal of EVs, aiming for sustainability through reduced waste and effective resource use.
- Using cradle-to-cradle model in manufacturing the EVs: by ensuring materials are continuously recycled, reducing waste and resource depletion, and supporting a sustainable, eco-friendly future.



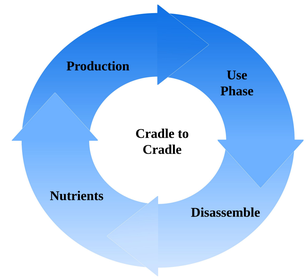


Fig. 5(a): Cradle-to-Grave life cycle model. **Fig. 5(b):** Cradle-to-Cradle life cycle model.

CONCLUSIONS & FUTURE WORK

- Transitioning to EVs addresses climate change and public health simultaneously.
- EVs are essential for a healthier, sustainable future - benefiting both the planet and its inhabitants.
- Implanting Cradle-to-Cradle analysis while manufacturing the EV's for sustainable environment.
- A stakeholder analysis will be conducted.

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