Analysis of Electrical Grid Capacity in Major U.S. Metropolitan Areas for Urban Air Mobility

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David Thipphavong

Caveats

This is an exploratory study with a top-level, first-order analysis that has the following caveats

- This study does not capture the dynamic behavior of electrical grids and users
- This study does not capture potential future developments in electrical grids and electrical devices
- Therefore, the results of this study are not to be used for investment decisions

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This presentation will hopefully spur our collective thinking and discussion on the electrical grid needs for UAM

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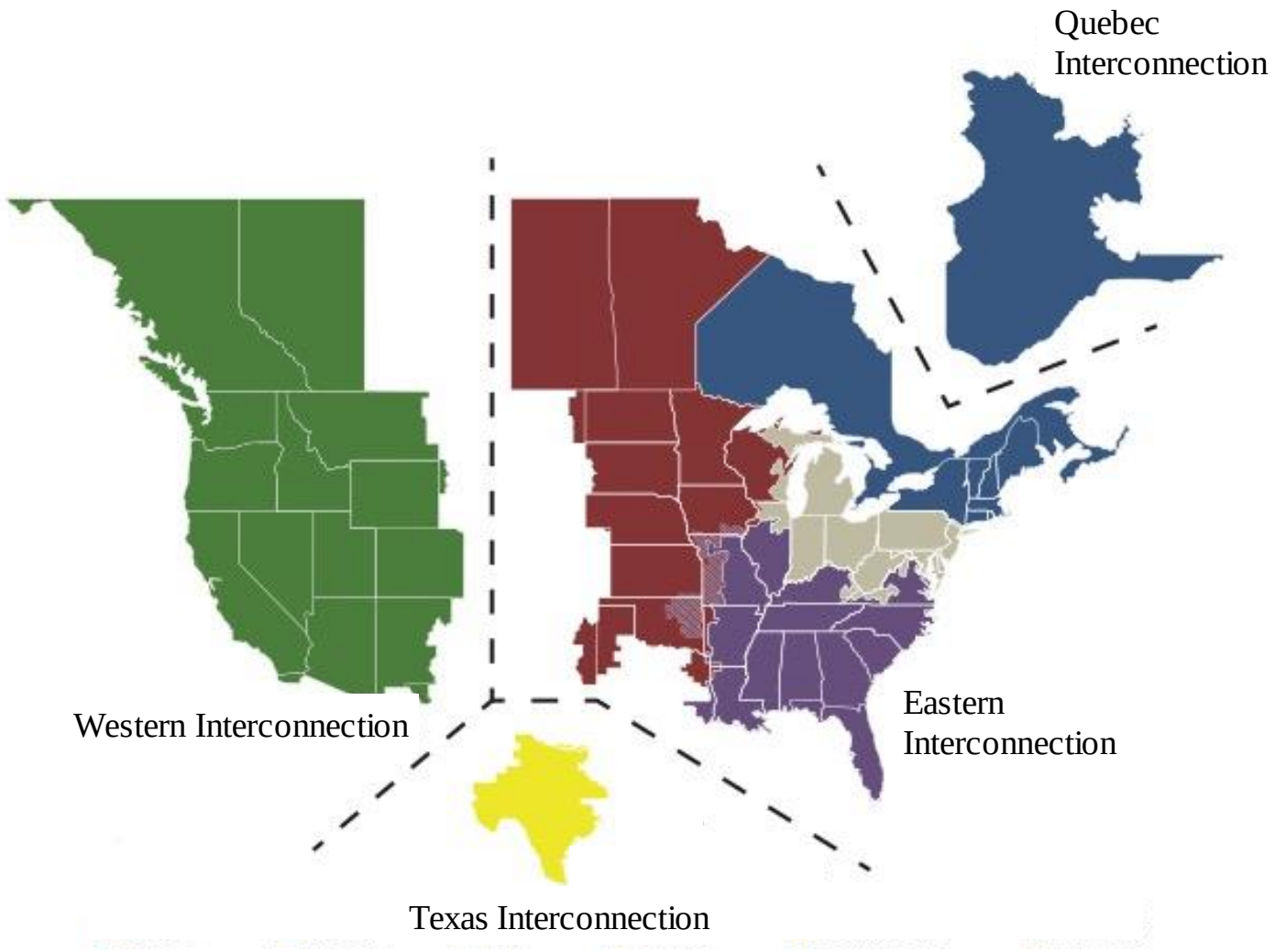
Introduction

Electrical Grids (aka Interconnections) in North America



Source: North American Electricity Reliability Corporation (NERC)
https://www.nerc.com/AboutNERC/keyplayers/PublishingImages/NERC%20Interconnections.pdf

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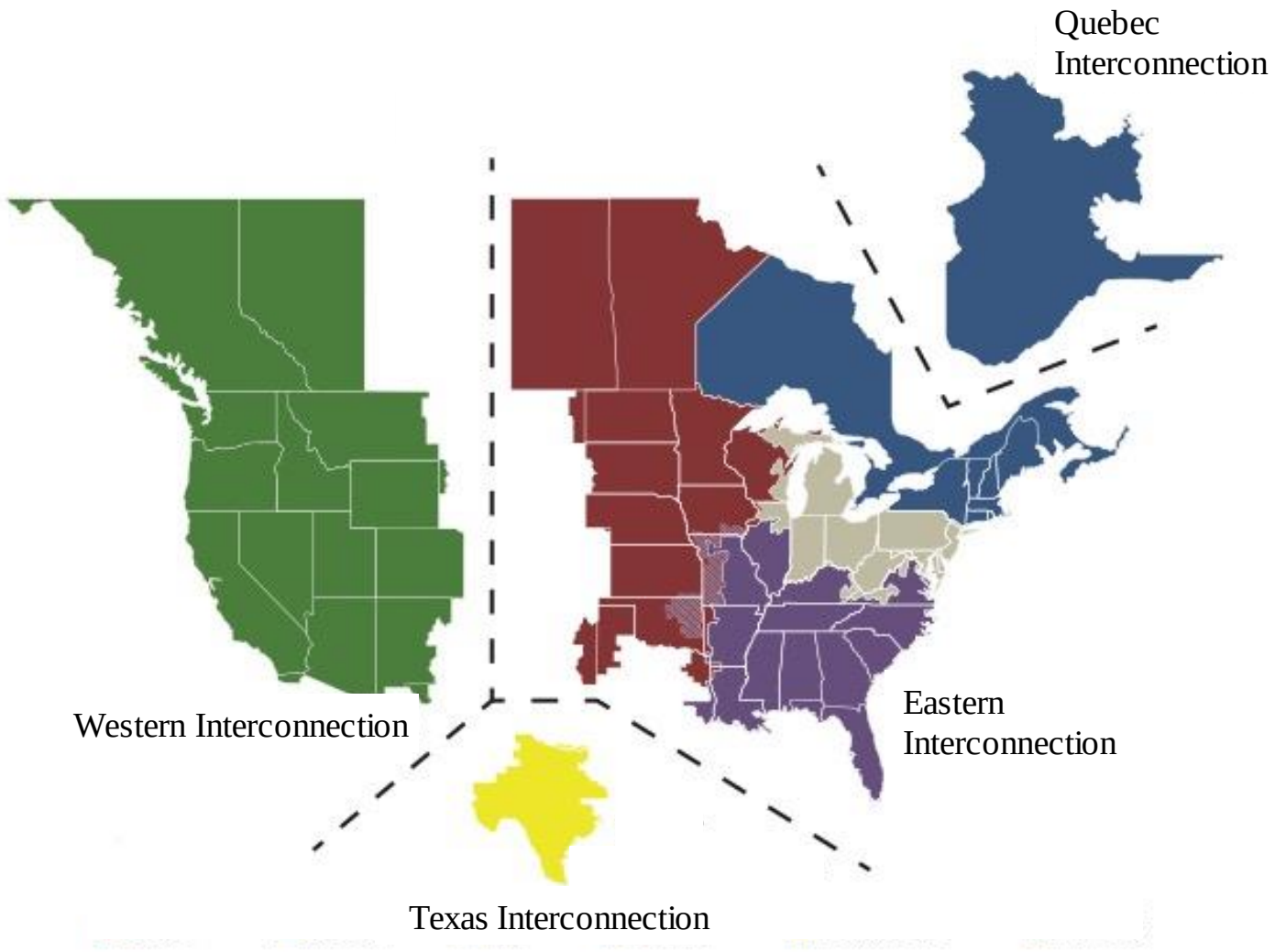

AIAA-2022-3316: "Analysis of Electrical Grid Capacity by Interconnection for Urban Air Mobility"

- Estimated the capacity for UAM operations on the three major electrical grids in the continental U.S. in the best-case scenario in which electricity can be transmitted and distributed within each as needed
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- Estimated the capacity for UAM operations on the three major electrical grids in the continental U.S. in the best-case scenario in which electricity can be transmitted and distributed within each as needed
- Results indicated that available electrical grid capacity could be a formidable constraint for UAM
- Present study is a follow-on analysis by metro area in the worst-case scenario in which each can only utilize the electricity generated within its own boundaries

Scope of Study

Present study focuses on the 25 most populous U.S. Metropolitan Statistical Areas (MSAs) that includes the target markets announced by prospective UAM operators and other U.S. MSAs with similar population sizes

- Joby Aviation: Announced plans to "focus initially on Los Angeles, Miami, and the New York and San Francisco Bay Area metropolitan areas"[1]
- Lilium Air Mobility: Announced plans to develop a network in Florida that is centered in Orlando[2]

U.S. Population Rank	Abridged MSA Name	U.S. Population Rank	Abridged MSA Name	U.S. Population Rank	Abridged MSA Name
1	New York	10	Boston	19	Denver
2	Los Angeles	11	Phoenix	20	Baltimore
3	Chicago	12	San Francisco	21	St. Louis
4	Dallas	13	Riverside	22	Orlando
5	Houston	14	Detroit	23	Charlotte
6	Washington, D.C.	15	Seattle	24	San Antonio
7	Philadelphia	16	Minneapolis	25	Portland
8	Miami	17	San Diego	-	-
9	Atlanta	18	Tampa	-	-

[1]https://www.jobyaviation.com/news/joby-aviation-announces-infrastructure-partnership/

[2]https://lilium.com/newsroom-detail/lilium-partners-with-tavistock-and-orlando

Methodology

Methodology (by Metro Area)

Step 1: Estimate available electrical grid power capacity

Data	Projections	Sources
Electric power plant nameplate capacity Electrical grid utilization	Generation capacity growth rate	eia Independent Statistics & Analysis U.S. Energy Information Administration FEDERAL RESERVE BANK of ST. LOUIS CENTRAL TO AMERICA'S ECONOMY

Methodology (by Metro Area)

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Step 1: Estimate available electrical grid power capacity	Electric power plant nameplate capacity Electrical grid utilization	Generation capacity growth rate	eia Independent Statistics & Analysis U.S. Energy Information Administration Federal Reserve Bank of St. Louis
Step 2: Estimate peak electrical power utilized for ground EV charging	Population Motor vehicle ownership	Population growth rate Ground EV growth, charging power, peak percentage charging	United States Census Bureau Department of Transportation U.S. Department of Energy USDRIVE Bloomberg New Energy Finance IHS Markit

Methodology (by Metro Area)

Step 1: Estimate available electrical grid power capacity

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Step 3: Estimate available grid power capacity for UAM by subtracting Step 2 from Step 1

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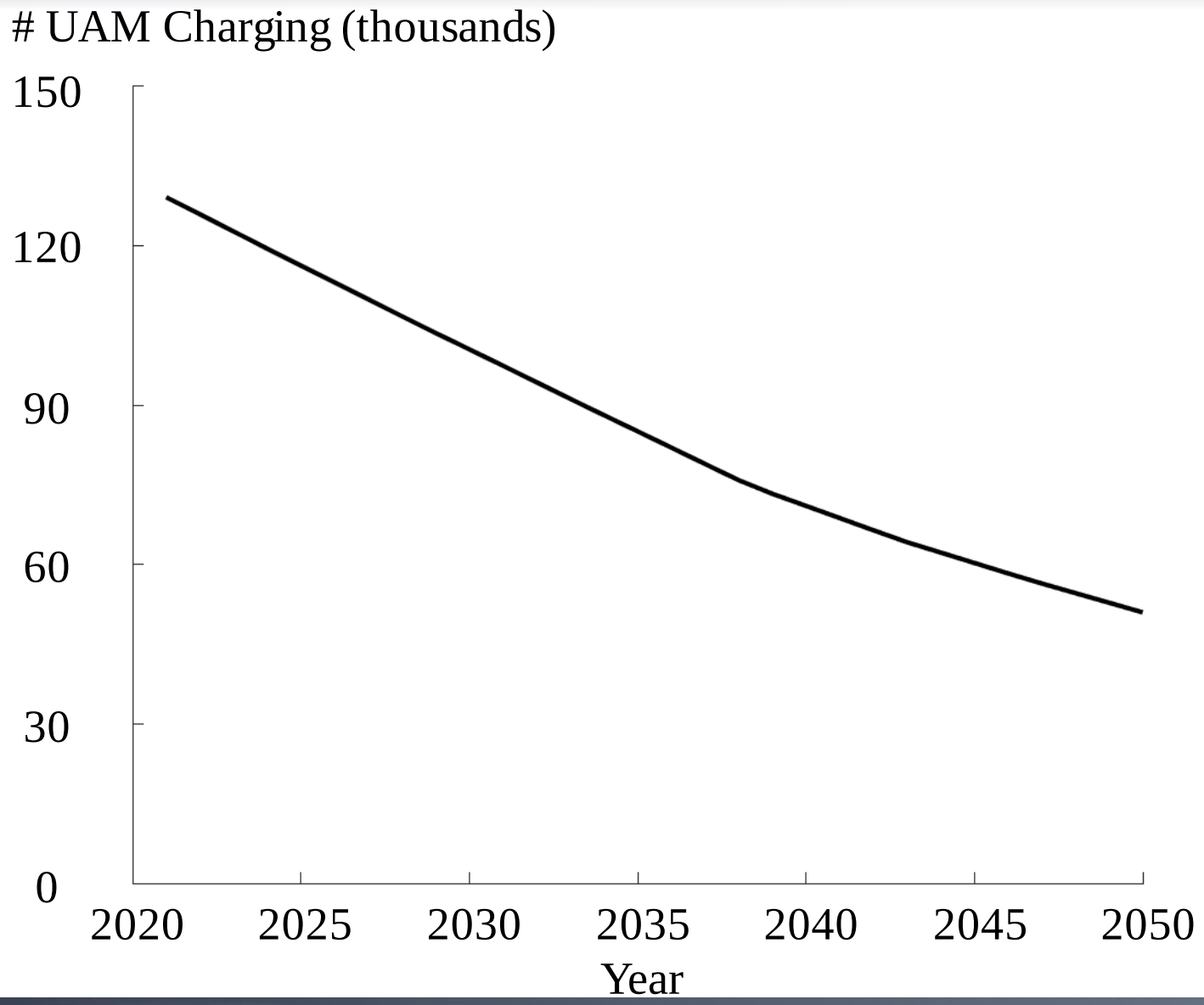
Step 4: Estimate maximum number of UAM by dividing Step 3 by UAM charging power	NASA UAM quadrotor eVTOL aircraft reference model	400 kW for 7-minute recharge after 20-nmi flight at 130 kts	NASA Black & Veatch

See paper for additional details!

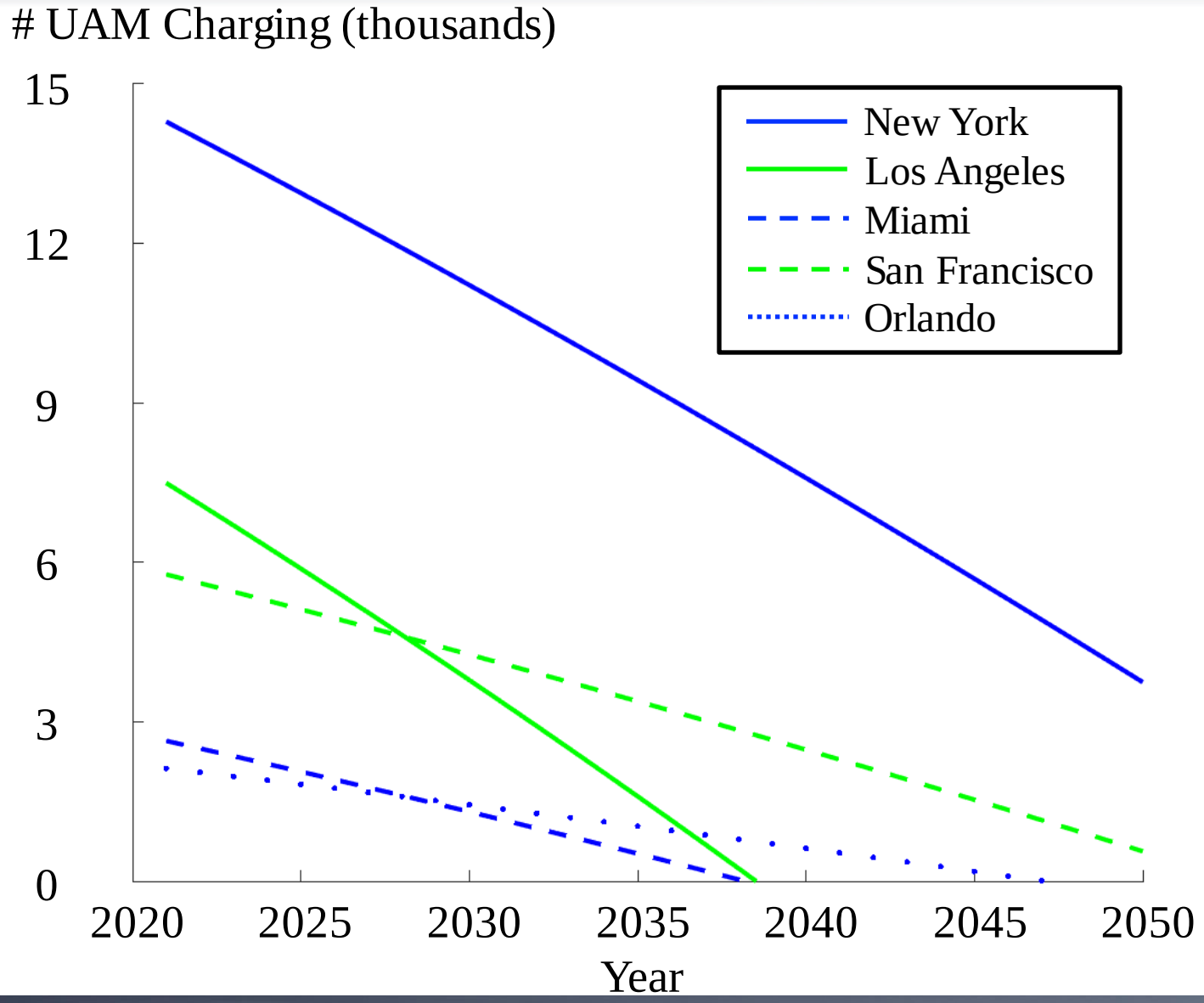
Results

Estimated Number of UAM Charging: 25 Most Populous U.S. Metro Areas



- Today
  - Ground EVs are only 0.5% of the ground fleet
  - Impact on the maximum number of UAM operations possible today is small
- 2050
  - Ground EVs are projected to proliferate to become 40% of the ground fleet
  - Estimated to reduce the maximum number of UAM charging and operations possible in the 25 most populous U.S. metro areas by 61%

Estimated Number of UAM Charging: U.S. Metro Areas Announced as Target Markets



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- 2050
  - Ground EVs are projected to proliferate to become 40% of the ground fleet
  - Estimated to reduce the maximum number of UAM charging and operations possible in the 25 most populous U.S. metro areas by 61%
  - Three MSAs—Los Angeles, Miami, and Orlando—announced as target markets by prospective UAM operators may lack any available electrical grid power capacity for UAM operations, unless electricity demand for other purposes is reduced
- Reminder: This is for the worst-case scenario in which each MSA can only use the electricity generated within its own boundaries

See paper for additional details and sensitivity analysis!

Summary and Future Work

Summary

- Many challenges must be overcome to conduct UAM operations with eVTOL aircraft at scale

- Success of UAM depends on the availability of electricity
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Future Work

- Extend the analysis to the other 359 U.S. Metropolitan Statistical Areas
- Analyze the potential impacts of increased ground EVs projected to occur as a result of the stricter emissions standards proposed by the U.S. Environmental Protection Agency that could exceed what is modeled in the present study
- Analyze the exacerbating impacts of electric utilities maintaining higher reserve margins during the summer when electricity demand and variation are highest
- Analyze the mitigating effects of increased distributed solar photovoltaic and battery storage systems

Questions, Comments, Feedback

david.p.thipphavong@nasa.gov