**Planning EV Charging Infrastructure in HOAs and Apartments**

**Introduction**  
As I reflect on the growing need for electric vehicle (EV) infrastructure, I realize how critical it is for communities, like HOAs and apartment complexes, to start planning for EV charging stations. This isn't just about adapting to the changing transportation landscape; it's about future-proofing our neighborhoods. The goal isn't to electrify every parking space immediately but to establish a scalable plan that balances practicality, cost, and the evolving demands of EV users.

**Understanding the Basics**  
I began by familiarizing myself with the different levels of EV chargers. For communities, Level 2 chargers, which operate at 240 volts, seem ideal. These chargers are common for overnight or short-duration charging and are far more cost-effective than fast chargers typically found on highways. Fast chargers, while impressive, are prohibitively expensive and unnecessary for most residential scenarios.

The realization hit me that not everyone in the community needs to charge simultaneously. I don’t need to electrify every parking space—just enough to cover the majority of charging needs, especially as EV adoption grows over the next 20 years.

**Modeling the Demand**  
To understand how many charging stations might be sufficient, I used a probability model. I likened the probability of a car needing a charge to rolling a one on a six-sided die. For instance, with 20 cars in a community and four charging stations, I calculated the likelihood of no more than four cars needing to charge at the same time. The approach helped me estimate how often cars would compete for charging spots and informed me that four stations could accommodate up to 56 cars with a 95% success rate.

The math showed me that charging demand is much lower than it might initially seem. A single EV in my scenario only has about a 3.57% chance of charging at any given time, much less frequent than rolling a one on a die.

**Scaling Infrastructure Gradually**  
I told myself to take a phased approach. Starting with just two or four stations buys a lot of time while EV adoption catches up. Expanding stations slowly over a 20-year period ensures costs remain manageable, and it prevents unnecessary overbuilding. For larger communities, I noted that the ratio eventually settles at one charging station per 20 cars, meaning only about 5% of parking spaces need to be converted.

This gradual buildout aligns with how technology and EV usage evolve. As battery capacities increase and workplace charging becomes more common, demand for community-based chargers may even decrease.

**Conclusion**  
Reflecting on this project, I recognize that the hardest part of implementing EV charging stations isn't the technical aspect but the planning and community alignment. Identifying which parking spaces to convert, navigating red tape, and getting residents onboard are the real challenges. Yet, starting small and scaling sensibly ensures the community remains adaptable to future needs without incurring unnecessary expenses or disruptions.

This journey has reinforced my belief that thoughtful planning and a step-by-step approach can effectively transition communities into the electric future.

import numpy as np

import matplotlib.pyplot as plt

from scipy.stats import binom

# Define the parameters

total\_cars = 20 # Number of cars in the community

charging\_probability = 0.0357 # Probability of a car needing to charge

max\_stations = 4 # Number of available charging stations

# Calculate probabilities

x = np.arange(0, total\_cars + 1) # Possible number of charging cars

probabilities = binom.pmf(x, total\_cars, charging\_probability)

# Calculate cumulative probability for fewer than max\_stations + 1

cumulative\_probability = np.sum(probabilities[:max\_stations + 1])

# Output results

print(f"Probability that no more than {max\_stations} cars need to charge: {cumulative\_probability:.2%}")

# Plot the distribution

plt.bar(x, probabilities, color='blue', alpha=0.7, label='Probability')

plt.axvline(max\_stations, color='red', linestyle='--', label=f'{max\_stations} Stations')

plt.title('Probability Distribution of Charging Demand')

plt.xlabel('Number of Cars Charging')

plt.ylabel('Probability')

plt.legend()

plt.grid(axis='y', linestyle='--', alpha=0.7)

plt.show()