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# Optimizing EV Charging Infrastructure in Boston

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15.C57 Optimization

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# Introduction

## Powering Boston's Sustainable Future

- **Boston's goal:**
  - Widespread adoption of zero-emission vehicles
- **Challenge:**
  - Ensuring equitable access to EV charging infrastructure
- **Focus:**
  - Dorchester as a test case
- **Objective:**
  - Develop optimization model for Level 2 charger placement

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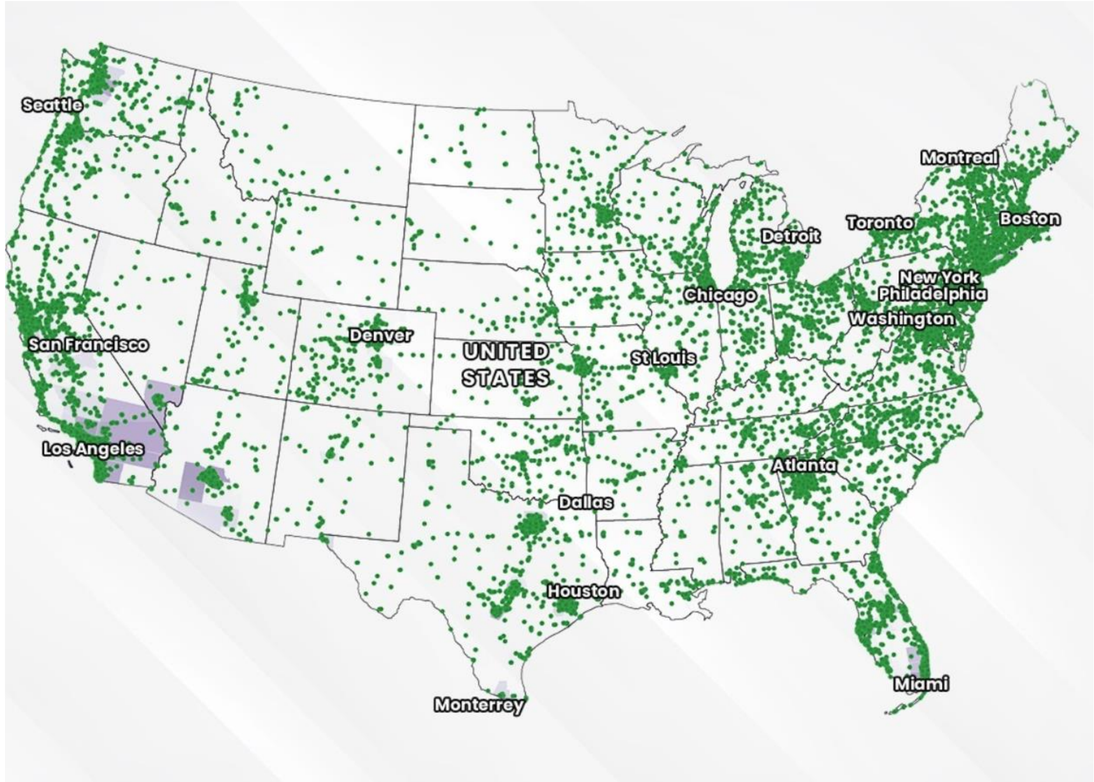
# Methodology - Data Sources

## Building a Comprehensive Dataset

- **Alternative Fuels Data Center (AFDC):**
  - Current EV station placements
- **ChargePoint:**
  - Charging station & charger costs
- **2020 U.S. Census:**
  - Residential units by neighborhood
- **Mass.gov:**
  - $15 million budget constraint



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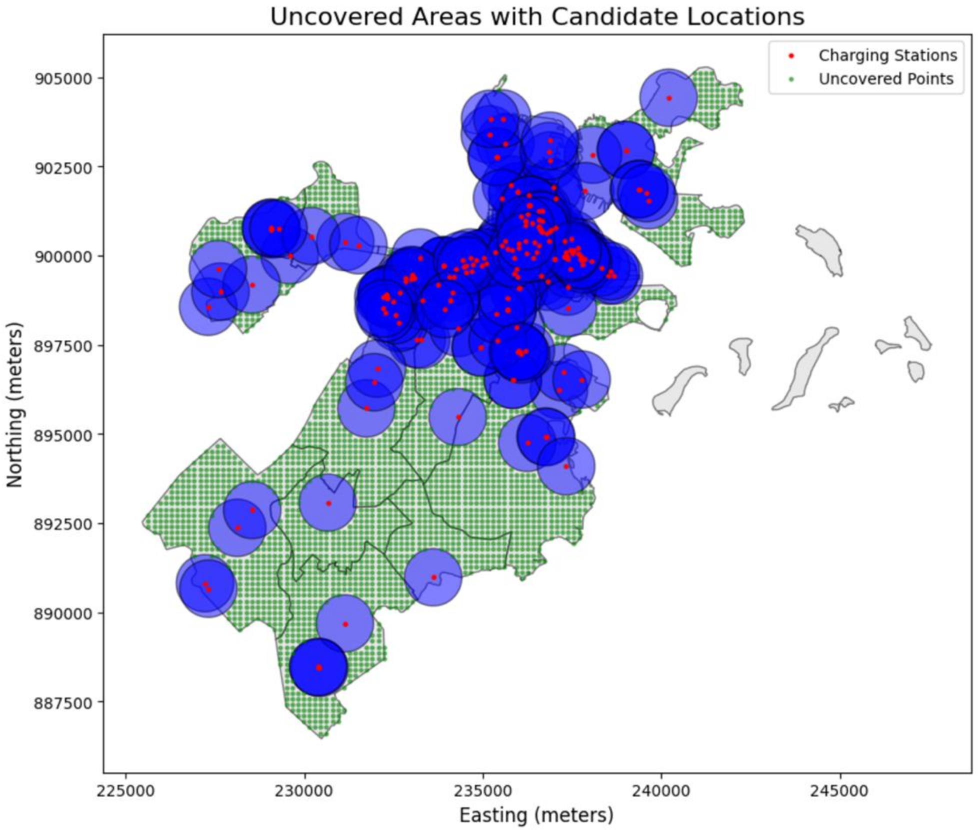
# Methodology - Data Preprocessing

- Generated grid of candidate locations (0.1-mile spacing)
- Identified uncovered areas beyond 0.5-mile buffer zones
- Simulated housing unit locations



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# Problem Formulation

- **Objective:**
  - Minimize total cost of building and operating EV charging stations
- **Coverage:**
  - Every housing unit within 0.5-mile radius of a station
- **Demand:**
  - Sufficient chargers to meet projected EV adoption
- **Budget:**
  - $15 million total (scaled to $2.85 million for Dorchester)

$$\min_{x,y,u,x',u'} \sum_{j \in F_k} \sum_{k \in N} (cx_{jk} + gu_{jk}) + \sum_{j \in F'_k} \sum_{k \in N} (cx'_{jk} + gu'_{jk})$$

$$\sum_{j \in \Omega_k} \sum_{k \in N} y_{ijk} \geq 1, \quad \forall i \in \Omega_k$$

$$2(u_{jk} + u'_{jk}) \geq \frac{1}{24} \alpha \cdot p \sum_{i \in H_k} y_{ijk}, \quad \forall j \in F_k, k \in N$$

$$\sum_{j \in F_k} \sum_{k \in N} (cx_{jk} + gu_{jk}) + \sum_{j \in F'_k} \sum_{k \in N} (cx'_{jk} + gu'_{jk}) \leq B$$

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# Optimization Model

- **Decision variables:**
  - Station locations, number of chargers, housing unit coverage
- **Constraints:**
  - Coverage, logical, charger limits, demand, budget
- **Assumptions:**
  - 62% EV adoption rate, 50% partial charging rate

$$
\begin{aligned}
\min_{x,y,u,x',u'} \quad & \sum_{j\in F_k}\sum_{k\in N}(cx_{jk}+gu_{jk})+\sum_{j\in F'_k}\sum_{k\in N}(cx'_{jk}+gu'_{jk}) \\
\text{subject to} \quad & \sum_{j\in \Omega_k}\sum_{k\in N} y_{ijk}\geq 1, \quad \forall i\in\Omega_k \\
& y_{ijk}=x_{jk}, \quad \forall (i,j)\in\Omega_k, k\in N \\
& u_{jk}\leq 12x_{jk}, \quad \forall j\in F_k, k\in N \\
& u_{jk}\geq x_{jk}, \quad \forall j\in F_k, k\in N \\
& 2(u_{jk}+u'_{jk})\geq \frac{1}{24}a\cdot p\sum_{i\in H_k} y_{ijk}, \quad \forall j\in F_k, j\in F'_k, k\in N \\
& u'_{jk}\leq 12x'_{jk}, \quad \forall j\in F'_k, k\in N \\
& \sum_{j\in F_k}\sum_{k\in N}(cx_{jk}+gu_{jk})+\sum_{j\in F'_k}\sum_{k\in N}(cx'_{jk}+gu'_{jk})\leq B, \quad \forall j\in F_k, j\in F'_k, k\in N \\
& y_{ijk}\geq 0, \quad \forall (i,j)\in\Omega_k, k\in N \\
& u_{jk}\in Z_{\geq 0} \\
& x_{jk}, x'_{jk}\in\{0,1\}, \quad \forall j\in F_k, j\in F'_k, k\in N
\end{aligned}
$$

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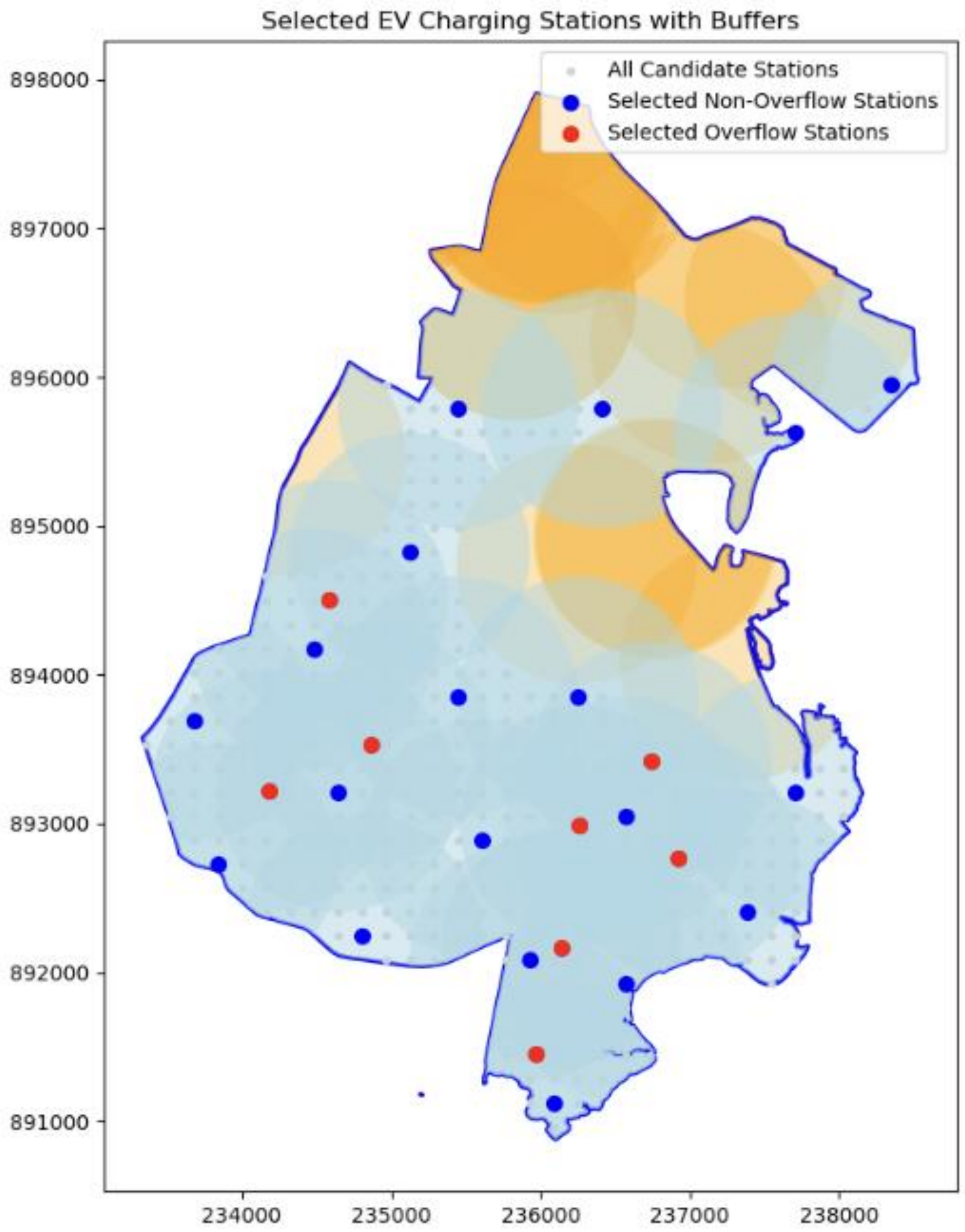
# Results for Dorchester

- 27 stations identified
- 213 total chargers
- Total cost: $1,936,800 (68% of allotted budget)
- Efficient coverage and demand satisfaction

| Station ID | Charger Count | Overflow Station ID | Charger Count |
|---|---|---|---|
| Station 124 | 4.00 | Station 124.1 | 12.00 |
| Station 132 | 8.00 | – | – |
| Station 162 | 3.00 | – | – |
| Station 166 | 12.00 | Station 166.1 | 2.00 |
| Station 173 | 11.00 | – | – |
| Station 251 | 12.00 | – | – |
| Station 292 | 12.00 | Station 292.1 | 5.00 |
| Station 302 | 8.00 | – | – |
| Station 307 | 12.00 | Station 307.1 | 7.00 |
| Station 315 | 6.00 | Station 315.1 | 12.00 |
| Station 342 | 12.00 | – | – |
| Station 362 | 5.00 | Station 362.1 | 12.00 |
| Station 363 | 6.00 | Station 363.1 | 12.00 |
| Station 373 | 10.00 | – | – |
| Station 376 | 12.00 | – | – |
| Station 433 | 3.00 | Station 433.1 | 12.00 |
| Station 470 | 2.00 | – | – |
| Station 507 | 10.00 | – | – |
| Station 509 | 2.00 | – | – |



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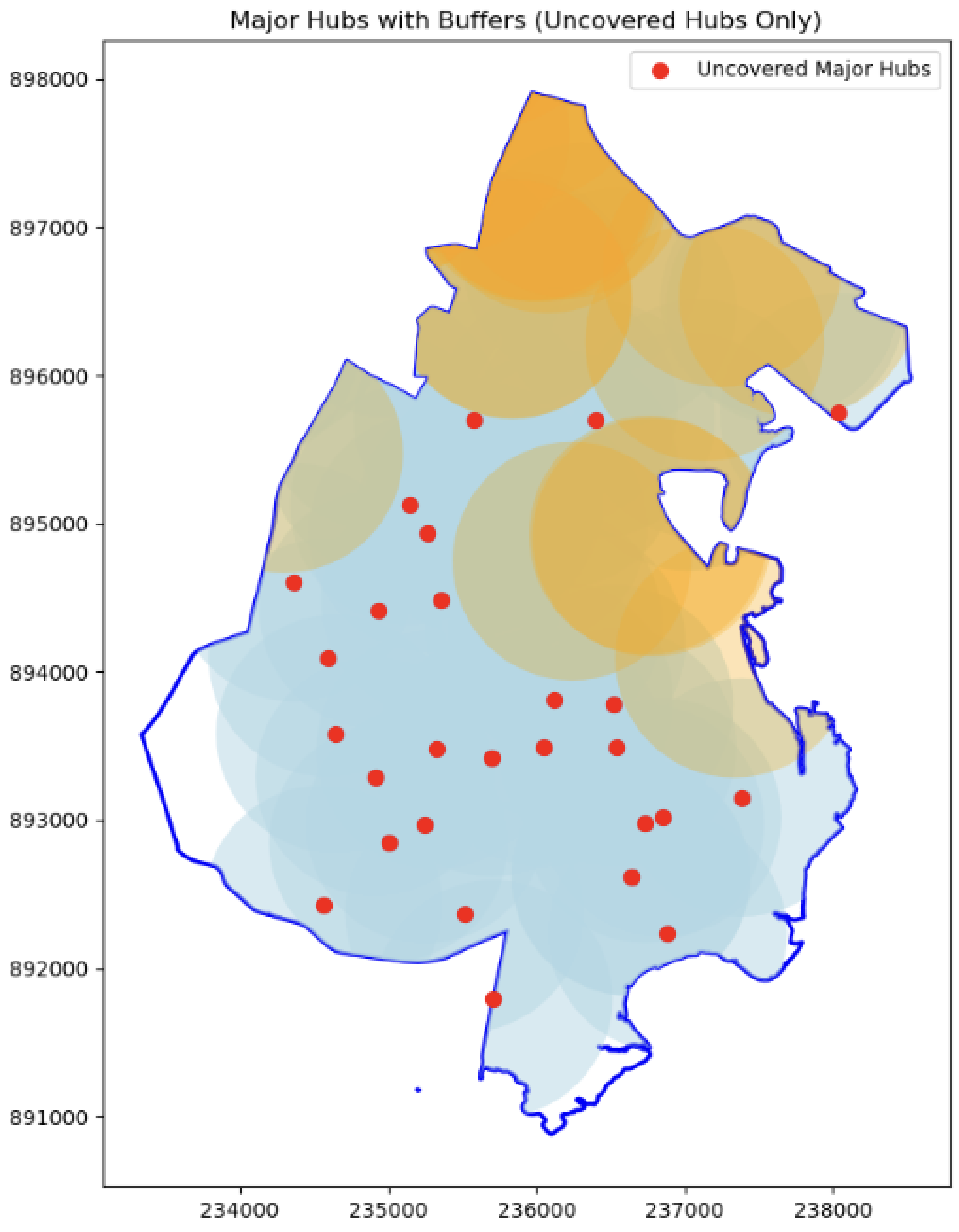
# Comparison with Heuristic Approach

- **Heuristic:**
  - Placing stations at community hubs (parks, libraries, schools)
- **Result:**
  - 28 stations required, still incomplete coverage
  - No information on how many chargers to allot to each station
- **Our model:**
  - Better coverage with fewer stations (27)
  - Detailed allocation of chargers for each station



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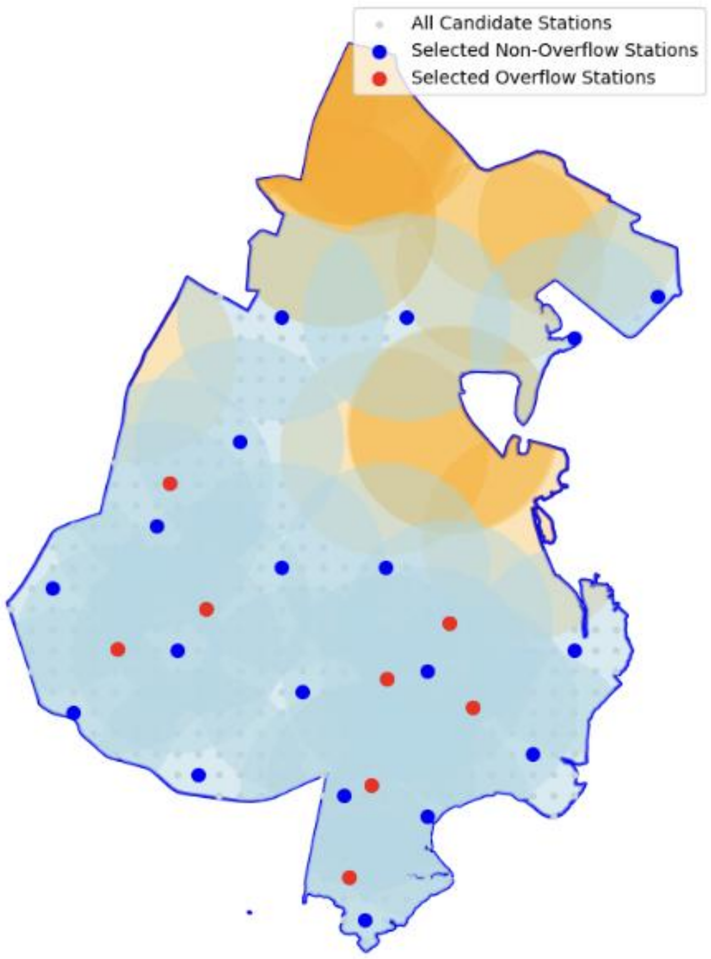


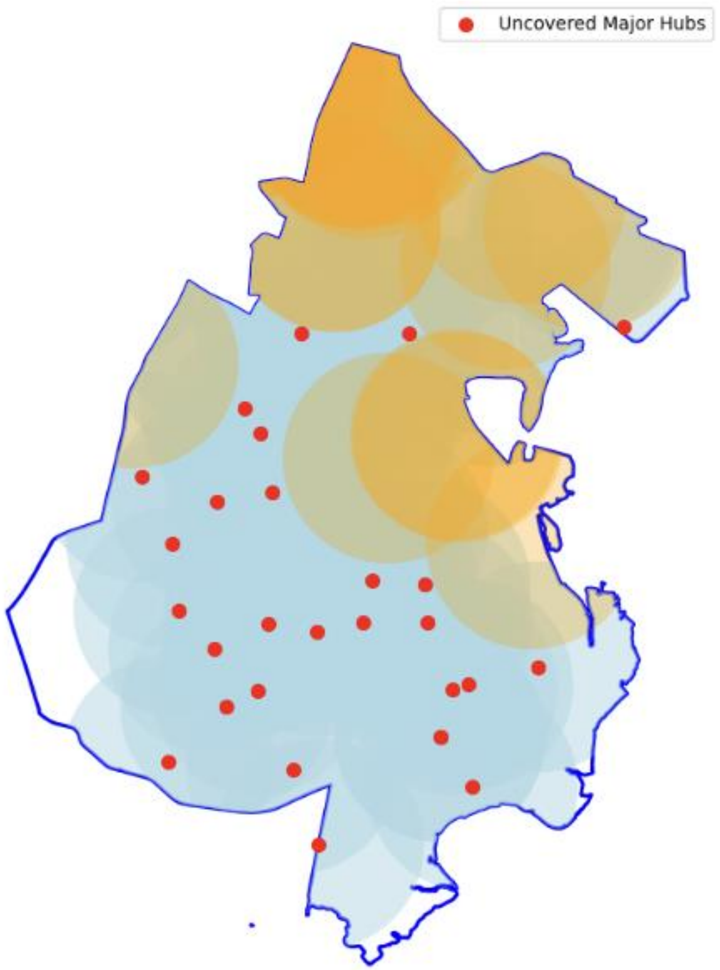


# Our Model

# Heuristic Approach

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# Discussion & Future Directions

- Model outperforms simpler heuristic methods

- Iterative scaling approach for citywide expansion

- **Future enhancements:**
  - Adaptive formulation for different EV adoption scenarios
  - Integration of real-time data on charging patterns and grid capacity

# “The future is in our hands. Let’s come together, raise our voices, and demand the sustainable and just world we deserve.”

**Helena Gualinga**