EQUITABLE ELECTRIC MOBILITY

Dr. Bruce Race, FAIA, FAICP
Gerald D. Hines College of Architecture and Design
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Interdisciplinary Approach

Skill Sets

• Community, environmental, and transportation planning
• Artificial Intelligence (AI) and scenario modeling
• Remote sensing and networks
• Community and market economics
• Technology integration and partnerships

Dr. Bruce Race
Environmental Planning

Dr. Aron Laszka
Computer Science

Dr. Driss Benhaddou
Computer Engineering Technology

Kimberly Williams, J.D.
METRO Innovation Officer

Dr. Vikram Maheshri
Economics

Dr. Ramanan Krishnamoorti
UH Energy
**Overall Objectives**

- This project will identify how the **deployment of smart technologies** can improve the reliability, comfort, and affordability of transit services.
- This project will apply **emerging data analytics, smart technologies, and machine learning** to tackle a national challenge of equitable access to EV ownership and electric mobility.
- Defines incentive programs reflecting:
  - National need to **stimulate equitable access** to EV ownership;
  - Regional policy impact demonstrating **collaborative partnerships** between cities, EV companies, fast charging developers, and ridesharing services; and
  - Research that opens up opportunities to use the data for **EV impacts on the energy grid** and future smart grid research and predicting **improvements to air quality**.

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**EQUITABLE ELECTRIC MOBILITY**

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Intelligent and Smart Transit Systems

- Coastal cities and regions (and university towns) with high percentage of knowledge employers and workers
- Progressive transportation (demand reduction) policies
- Markets full of early adopters and financial incentives for EV ownership
- HOWEVER. They are not focused on leveraging early adopter markets to support equitable access

Equitable Access

- Improving end-to-end travel experience
- System-wide access and affordability
- Universal access of transportation system facilities and vehicles
- Sharing economic and environmental upsides
**Pilot: West Bellfort METRO Park and Ride**

- Southwest Houston at intersection of I-69/59 and Beltway 8
- Serving SW Houston and Ft. Bend County - high educational attainment and income

**Market**

- Regional (Ft. Bend) market with high income, educational attainment working in the med center and downtown (early adopters can support access for local residents)
- Local market high percentage of low wage households, still driving to dispersed workplaces

**Equitable Electric Mobility**

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**Broad Community Access: Smart Mobility Hub Vision**

- **Seamless integrations of technology** - transit apps, pilot IoT (5G) and Bluetooth infrastructure corridor(s), operations and management, payment, and enforcement
- **Smart Shuttles** (Autonomous/EV) - routes, length, headway, span of service (hours/day), vehicles required, layout time (minutes)
- **Smart parking and charging** - real time data service, mobile payment app, license plate recognition, equipment/cameras, parking management integrator (flow of information)
- **Parking permit types** - monthly with bus pass, monthly parking only, daily on-line, daily pay by phone
- **Smart bus shelter technology** - location is critical, USB charging and hotspot
- **Smart trips** - personalizing transit trips
- **Ridesharing** - commercial carshare services, carpooling, and vanpooling
- **Private partners** - employer shuttle bus

**IMPLEMENTATION**

- **Marketing** - customer data, short term marketing, continuous outreach, technology-enabled marketing
- **Partner leadership** - agencies, jurisdictions, other stakeholders
- **Cost planning and sharing** - capital costs (infrastructure), operating costs, funding sources

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**Intermodal Transfer and Last Mile Connections**

- **RIDERSHIP**
- **METRO BUS**
- **INTER-REGIONAL BUS**
- **LOCAL-REGIONAL**
- **TRANSIT**
- **AUTO**
- **RIDESHARE**
- **OTHER FUTURE**
- **PED-BIKE**

**EQUITABLE ELECTRIC MOBILITY**  
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(Race, 2021)
**Issues and Opportunities:**

**Grid impact:**
As the number of EVs increases, so will the impact of EV charging on the power grid. To minimize the impact on the grid, we need to “smoothen” the load and avoid charging many EVs at the same time.

- Can we plan the charging schedules and locations of ridesharing EVs in a way that minimizes the impact on the grid while providing equitable mobility supply across Houston (i.e., do not charge all the vehicles at a time when lower-income areas need them)?
- How can we (or Uber) incentivize drivers to follow these planned charging schedules?

Charging schedules need to take into account the impact on the grid, the availability of charging stations, and mobility demand (maintaining or providing a seamless integration between different modes of transportation).

- Can we plan integrated charging schedules and locations for all ridesharing, personal, and transit EVs?
- Can we incentivize drivers to follow these schedules?

**Equitable distribution of charging hubs:**
Higher-income neighborhoods may have higher levels of EV adoption. Hence, to maximize the utilization of charging hubs, it would make sense to place them in higher-income neighborhoods and locations with high-income jobs. However, this would put low-income populations at a disadvantage. We need to consider the locations of residences, public services (schools, hospitals, etc.), and jobs.

- How can we balance maximizing utilization with providing equitable distribution?

**Park-and-charge-and-ride:**
- How can we integrate park-and-ride with EV charging for personal vehicles?
- Can we adapt public transit routes and schedules, so that it is easy to transfer from charging hubs to public transit?
- If a person’s preferred park-and-ride garage does not have the appropriate charging infrastructure, can we incentivize them to park elsewhere (e.g., by lower cost charging)?
- Can we integrate with BCycle to provide park-and-charge-and-bike service?
Issues and Opportunities:

Community outreach and incentives:
- What are the barriers to the adoption of EVs (besides higher up-front prices)?
- Do people subjectively prefer EVs or ICEVs? How do these preferences vary by socio-economic status and by neighborhoods?
- How can we incentivize people to use EVs as drivers and as riders?
- What concerns do people have about EVs (e.g., limited driving range, battery explosions)?

Post COVID-19 mobility:
- What will mobility look like in a post COVID-19 world?
- Which modes of transit will be more popular and which will be less popular?
- How will mobility demand change temporally and spatially?
- Can we plan the distribution of charging hubs anticipating long-term changes?

Privacy-preserving data collection:
To answer the above questions, we need data, which may include personal information, such as location traces and travel destinations.
- Can we collect and analyze data in a privacy preserving manner, which enables us to answer the above questions without storing or publishing any personally identifiable information?

Real-time data collection, processing, and distribution:
We need to collect real-time data from charging hubs and vehicles to plan (e.g., when to charge which ridesharing vehicle) and to inform drivers (e.g., about the availability of charging stations).
- How can we collect, process, and distribute this detailed data for a city as large as Houston?

Smart Charging and Parking Goal and Objectives

GOAL: To be able to provide seamless travel experience for EV charging, parking, and METRO pass system services - EQUITABLY

SMART SYSTEM OBJECTIVES:
- To be able to monitor the number of available spaces and chargers in park and ride lots
- To be able to provide available space information to requested by drivers to assist in decision-making for parking location and transit schedules
- To be able to provide available space information to METRO/parking operator
- To be able to provide available space information and bus schedules to traveler information applications
- To facilitate virtual METROpass, EV charging, and parking payments
Park and Ride Smart Parking Best Practice Schematic

Smart Transit Hub Concepts

- Integration of transit, energy, and IoT technologies
- Improved mobility access and performance
- Lower environmental impacts

Templet for smart transit hubs

https://local.iteris.com/arc-it/html/servicepackages/sp69.html#tab-3
(DOT, Architecture Reference for Cooperative and Intelligent Transportation, 2020)

Critical Questions Addressed

- Q1. What are the opportunities to increase the broader access to the electric mobility revolution?
- Q2. What are the barriers to EV ownership?
- Q3. What are the potential larger contributions to GHG and PM2.5 emission reductions?

(CeSAR, 2018)
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PATTERN OF LOW-WAGE EMPLOYMENT GROWTH

- West Belfort PnR

- Census Tracts within 2-Mile Radius
  - About 8 in 10 are minority households
  - As compared to the region:
    - Lower educational attainment
    - High percentage of low wage earners
    - Higher percentage poverty
    - Much higher percentage of renters
    - Have long commutes
    - Less likely to take public transit

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UNDERSTANDING BENEFITS AND INCENTIVES OF EV OWNERSHIP

- Missing out on benefits of EV ownership is an OPPORTUNITY COST to working families.
- **Tax Credits**
  - Small second hand market for EV
  - Up to $7,500 in tax credits for new cars (US EPA, 2021)
  - Access to Biden incentives for 500,000 new fast charging stations
- **Employee Benefits**
  - Incentives for “eco-commuters”
  - Knowledge-based employers more likely to provide incentives
- **Local Incentives**
  - Uber and City of Houston partnership for EV

MANY LOW INCOME HOUSEHOLDS ARE IN THE SECOND HAND CAR MARKET

- The INITIAL PURCHASE COST as a barrier to EV ownership. Until there is a second hand EV market, low wage earners will have a difficult time gaining access to affordable EVs.
- **Initial Purchase Price**
  - EVs cost more to purchase but save families money over the life of the car
- **Realizing Economic Benefits from Affordable Fueling and Maintenance**
  - Average auto maintenance costs are 40% lower for EVs compared to combustion engine vehicles (Office of Energy Efficiency & Renewable Energy, 2021).
  - A 2021 standard range Tesla 3 will save an owner $643 per year compared to an entry-level Camry (US DOE, 2021).
**Choices for Working Families**

- **A low-income family driving a used 2010 GMC SUV is spending $1,361 per year more than a basic Tesla. Over 15 years, the Tesla would cost over $20,000 less to own vs. keeping used SUVs on the road (US DOE, 2021).**

**2021 Tesla Model 3**
- $39,190 Starting Price
- 4.2 ★ Expert
- 4.8 ★ Consumer
- 141 MPGe Combined Fuel Economy

**2010 GMC Yukon**
- $12,800 Starting Price
- Expert (N/A)
- 4.5 ★ Consumer
- 21 MPG Combined Fuel Economy

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**Barriers to EV Ownership**

**There are fewer fast chargers located in low income communities**
- Many low wage households are renters in communities without fast charging options. These families pay a higher **cost of convenience** for access.
- **Lack of Local Fast Charging Infrastructure**
  - The lack of convenient and accessible charging for low wage families is a **household cost in time**
  - In 2018, fast charger to EV ratio in U.S. was 1:17.4 compared to 1:10 in the EU
- **Poor EV Charger Access of Low-Income Renters**
  - Low income rental housing does not have access to onsite EV charging
  - More dependent on off-site public fast charging
- **Cost of Installing Home Level 2 Charger**
  - Over 80% of EV charging happens at home (Energy Star, 2018)
  - Level 2 charger can cost up to $2,600 to install in a home
Equitable EV and Public Transit Mobility

Leveraging Early Adopters

Understanding indicators for early adoption:
- High educational attainment and income
- Single family home ownership
- Multi-car households
- Car-sharing
- Public charging
- Political party affiliation
Understand the market segmentation of early adopters - men in their 30s-50s, home owners, higher education attainment and income

Understanding equity indicators for access to electric mobility:
- Social Vulnerability Indicators (SVIs)
- EV affordability and diversity of EV fleet
- Innovation of EV access (car sharing, etc.)
- Awareness of incentives and benefits
EQUITABLE ELECTRIC MOBILITY

PM2.5 & Outliers

Top PM2.5 Sensors Readings
- PM2.5 Sensor
- 8 Counts
- 6 Counts
- 5 Counts
- 4 Counts
- 15 Counts
- 18 Counts

NEI PM2.5 Point Sources
- <6.37
- <32.96
- <74.77
- <154.10
- <285.54
- ≤943.89

ESCREEN PM2.5 Readings
- <10.5
- ≤25.0
- ≤37.5
- ≤50.0
- ≤62.5
- ≤75.0
- ≤87.5
- ≤100.0

Regional View

PM2.5 & Outliers

Top PM2.5 Sensors Readings
- PM2.5 Sensor
- 8 Counts
- 6 Counts
- 5 Counts
- 4 Counts
- 15 Counts
- 18 Counts

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Houston CAP-Baseline Emissions (2014)

GHG Emissions by Source

<table>
<thead>
<tr>
<th>Source</th>
<th>MTCO2e</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>STATIONARY ENERGY</td>
<td>16,454,686</td>
<td>49%</td>
</tr>
<tr>
<td>TRANSPORTATION</td>
<td>16,140,987</td>
<td>48%</td>
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<tr>
<td>WASTE</td>
<td>818,344</td>
<td>2%</td>
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<td>33,414,017</td>
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Transportation GHG

<table>
<thead>
<tr>
<th>Mode</th>
<th>MTCO2e</th>
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<tbody>
<tr>
<td>ON-ROAD</td>
<td>15,932,882</td>
</tr>
<tr>
<td>RAILWAYS</td>
<td>207,451</td>
</tr>
<tr>
<td>AVIATION</td>
<td>654</td>
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<tr>
<td></td>
<td>16,140,987</td>
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</tbody>
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**EQUITABLE ELECTRIC MOBILITY**

**Bruce Race, FAIA, FAICP, PhD**

**MTCO2e by On-Road Mode**

- Focus on passenger cars and small trucks (89% of MTCO2e)
- Short-haul trucks and commercial small trucks are important (8%)
- Long-haul trucks are a supply chain issue - national policy and regional partnerships are important (3%)
- Fleet vehicles - local policy (<1%)

**On-Road Transportation Goals with Policy Scenario 4**

<table>
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<tr>
<th>Year</th>
<th>Off-sets/Renewables</th>
<th>MTCO2e</th>
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<tbody>
<tr>
<td>2014 Baseline</td>
<td>0</td>
<td>15,932,883</td>
</tr>
<tr>
<td>2030</td>
<td>2,111,168</td>
<td>10,751,243</td>
</tr>
<tr>
<td>2040</td>
<td>3,951,327</td>
<td>6,673,363</td>
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<tr>
<td>2050</td>
<td>4,779,865</td>
<td>4,731,771</td>
</tr>
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</table>

**Baseline**

- 33% Below Baseline
- 58% Below Baseline
- 70% Below Baseline

**Demand-Side Goals**

- 14% Off-sets
- 25% Off-sets
- 30% Off-sets
Regional and Local Growth and EV Implementation

- Assumptions based on current 3,000 daily bus ridership

- **SCENARIO 1: Status Quo (Today - - Baseline)**
  - 70%-30% regional and local ridership
  - 20% reduction in VMT
  - 3,000 bus boardings
  - 23 MPGe (2014)

- **SCENARIO 2: Increased Regional Ridership and Growth in Ft. Bend County (Sprawl Model)**
  - 90%-10% regional and local ridership
  - 30% reduction in VMT
  - 5,000 bus boardings
  - 54 MPGe (Obama era CAFE standards)

- **SCENARIO 3: Redevelopment of I-69/Loop 8 (Infill Model)**
  - 60%-40% regional and local ridership
  - 40% reduction in VMT
  - 7,000 bus boardings
  - 112 MPGe Technical Limits

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Achievement Gap: Electrifying the Fleet

<table>
<thead>
<tr>
<th>Scenrio 1: 2025 CAFE and 2027 Truck Standards and 0% reduction in VMT</th>
<th>Scenario 2: 2025 CAFE and 2027 Truck Standards and 30% reduction in VMT</th>
<th>Scenario 3: &quot;Technical Limits&quot; and 40% reduction in VMT</th>
<th>Scenario 4: &quot;Technical Limits&quot; MPGe and 20% Reduction in VMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres of PV based on 2.8 gWh/acre</td>
<td>11,978</td>
<td>8,384</td>
<td>4,149</td>
</tr>
<tr>
<td>West Texas 2gWh wind turbines</td>
<td>16,769</td>
<td>11,738</td>
<td>5,809</td>
</tr>
<tr>
<td>6 to 20 SM of PV</td>
<td>Or, combination of distributed renewables from buildings, waste, and microgrids with diverse methods of bi-directional energy storage</td>
<td></td>
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</tr>
</tbody>
</table>

Solar and Wind Comparison

(Equate and Electric Mobility) (Race, 2021) Bruce Race, FAIA, FAICP, PhD
Reducing Commuter Emissions

- Assumptions based on current 3,000 daily bus ridership

**SCENARIO 1: Status Quo (Today - - Baseline)**
- 70%-30% regional and local ridership
- 20% reduction in VMT
- 3,000 bus boardings
- 24 MPGe (2014)

**SCENARIO 2: Increased Regional Ridership and Growth in Ft. Bend County (Sprawl Model)**
- 90%-10% regional and local ridership
- 30% reduction in VMT
- 5,000 bus boardings
- 54.5 MPGe (Obama era CAFE standards)

**SCENARIO 3: Redevelopment of I-69/Loop 8 (TOD Model)**
- 60%-40% regional and local ridership
- 40% reduction in VMT
- 7,000 bus boardings
- 112 MPGe EV Fleet

(CeSAR, 2021)

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Focusing on transit-oriented infill development and electrifying the fleet significantly decreases GHG emissions and PM2.5 for each of us - - what we drive and where we live

(EceSAR, 2021)

Equity is about ...

- Improved transit service
  - Smarter, more comfortable and safe, and reliable
  - Is an end-to-end experience
- Inclusive where the benefits of innovation are a shared experience
- Breaking barriers to EV ownership and sharing
- Recognizing early adopters can underwrite EV infrastructure
- There are co-benefits - - cleaner air, reduced climate impact, and a healthier
- AND - - new green energy, tech, and sales jobs

(Equitable Electric Mobility)
Engaging Community and Partner Process

Conclusions and Discussion

(Cesar, 2020)