Overview of The Texas A&M University System Electrified Mobility Mobility Collaborative Inaugural Workshop

June 2023

Prepared by: The Texas A&M Transportation Institute
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Executive Summary

In April 2023, The Texas A&M University System (A&M System) brought together researchers and representatives from the 11 A&M System Universities and eight A&M System State Agencies for a workshop on Electrified Mobility. Participants convened at the Texas A&M Transportation Institute (TTI) headquarters for an evening welcome reception and poster showcase, followed by a full-day interactive workshop. A facilitator led the participants through activities to get to know each other across institutions and disciplines, as well as to come together to ideate on how an A&M System Electrified Mobility Collaborative could bring value to participants and the System as a whole.

The workshop discussions and outputs stressed the importance of utilizing the A&M System’s broad range of deep expertise in overlapping issues related to mobility electrification, including aspects such as the energy grid, transportation modeling, and battery technology research, among other relevant topics. Participants acknowledged the advantages of interdisciplinary collaboration and sharing ideas and funding opportunities to build strong research teams for impactful outputs. Many themes and topic areas emerged for potential future research collaboration. In particular, broad areas identified included:

- Grid Expansion and Modernization
- Batter Technology Development
- Grid and Vehicle Interoperability
- Vehicle and Charger Accessibility and Availability

The A&M System, in conjunction with TTI, will continue to support and build the Electrified Mobility Collaborative following this initial event, using some of the ideas and feedback that emerged from the workshop. This document summarizes key elements of the workshop, synthesizes information that emerged from the discussion, and documents findings and next steps.
Acknowledgments

This workshop was supported by The Texas A&M University System Office of Research, led by the Vice Chancellor for Research, Dr. Joe Elabd, and the Texas A&M Transportation Institute.

This initiative was developed under the leadership of co-chairs Drs. Sharmila Pathikonda and Joe Zietsman. The success of the interactive collaboration was thanks to the Workshop Facilitator, Dr. Mary Léa McAnally. Thank you as well to the Workshop Planning Committee, organized by Dr. Tara Ramani, and consisting of Ben Ettelman, Brittnay Gick, Dr. Alice Grossman, Edgar Kraus, and Dr. Jacqueline Kuzio. The logistics and administrative support of Saundra Jackson, Anna Fildes, Mary Nevis, Karen Smith, Nancy Rowland, and Jordan Bertling was instrumental in planning, conducting, and reporting on the event. And of course, the workshop would not have been possible without all of the participants from across the Texas A&M University System who brought their expertise, ideas, open minds, and enthusiasm to the workshop. A full list of registered participants can be found in Appendix B.

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1.0 Introduction

Decarbonization is emerging as a national policy imperative in the United States and globally. The transportation sector is a leading source of greenhouse gas (i.e., carbon) emissions, and vehicle electrification is a major initiative seen as a viable pathway, coupled with an electric grid powered by renewables, to decarbonize the sector. The Texas A&M University System (A&M System) is well-positioned to lead research on the electrification of vehicles and other modes of transportation to support this national transition. As a transportation research institution with a strong background in the future of mobility and the intersection with vehicle electrification, system leadership tasked the Texas A&M Transportation Institute (TTI) with hosting and supporting the organization of the workshop. Comprising 11 Universities and eight State Agencies, the A&M System includes groups and individuals with expertise in the infrastructure of both transportation systems and the electric grid, as well as vehicle and battery knowledge. Many researchers at the A&M System are already impacting the planning and implementation of electrified mobility, and existing and new labs and test facilities are being developed to match growing needs. However, forming stronger connections and identifying opportunities for collaboration can accelerate and build upon existing efforts. Figure 1 shows the geography of the A&M System across Texas.

![Figure 1. A&M System Universities and State Agencies Mapped](image_url)

On April 11th and 12th, 2023, The A&M System and TTI held a workshop on Electrified Mobility at TTI headquarters at the RELLIS campus in Bryan/College Station, Texas. The event involved key participants from A&M System members and was framed as initiating an “Electrified Mobility Collaborative” within the A&M System. The workshop informed the member institutions about the rapidly evolving area of vehicle electrification and was a step in an ongoing coordination effort for
opportunities in Electrified Mobility. This document summarizes the workshop for the benefit of participants to understand the collaborative mission and next steps and to have a record of what was learned.

The goals of the workshop were to:

1. Develop an understanding of ongoing research and other activities across the System and the capabilities and interests of The Texas A&M University System members
2. Create awareness of future research and funding opportunities
3. Lay groundwork for information-sharing mechanisms to foster interdisciplinary collaboration – including individual and institutional capabilities, interest areas, and upcoming funding opportunities

The event brought together experts from the A&M System universities and agencies for an evening poster session and welcome, followed by a full-day interactive workshop. The agenda can be found in Appendix A, and the participant list can be found in Appendix B. The workshop included breakout group activities, reporting back, and full conversation among all participants in the room. Participants moved around throughout the day and met many people in the poster session welcome and interactive workshop.

The workshop and this document are a few first steps in establishing a “Community of Practice” to share information and know what others are doing within the A&M System. This can help make everyone’s research more impactful and help expand the opportunities for collaboration and research moving forward.

2.0 Workshop Emerging Themes

Conversations between participants at the workshop and the opening panel covered a broad spectrum of issues in the electrified mobility space. This section focuses on themes, ideas, and takeaways from the workshop identified throughout the event.

2.1 Themes from Expert Panel

The workshop started with a welcome from Mr. Gregory Winfree, Agency Director of TTI, and an opening address from Dr. Joe Elabd, Vice Chancellor for Research, The Texas A&M University System. Dr. Joe Zietsman, Deputy Agency Director of TTI, then facilitated an opening panel of the workshop to start the conversation about mobility electrification. The expert opening panel consisted of the following:

- **Ms. Onyinye Akujuo**, Chief Operating Officer and Deputy Executive Director, Houston-Galveston Area Council
- **Ms. Lori Clark**, North Central Texas Council of Governments/DFW Clean Cities Director
- **Mr. Jeff Davis**, Senior Fellow, Eno Center for Transportation
- **Dr. Joe Elabd**, Vice Chancellor for Research, The Texas A&M University System
• Dr. Thomas Overbye, Professor, Electrical & Computer Engineering and Director, Smart Grid Center, Texas A&M University

The opening panel (see Figure 2) served as a venue for participants to hear what is happening in the field from experts with on-the-ground experience. Slides from all the participants on the expert panel can be found in Appendix C.

![Figure 2. A&M System and TTI Leadership and Opening Expert Panel](image)

Before turning to the panelists, Dr. Elabd highlighted the opportunity for the A&M System to lead in e-mobility research, given the expertise and resources available across relevant disciplines and existing influence in transportation, energy, and related fields. He stressed the importance of this initiative, given the impact of moving towards electrifying around one billion cars worldwide. He also draws on his own expertise in polymers and electrochemistry as applied to batteries and their components and the importance of battery technology research and development to facilitate an efficient and effective transition to electrified mobility.

The panelists provided general overviews of national and regional EV plans and forecasts. Mr. Davis kicked off the panel with a “chicken and egg” analogy as it related to EV proliferation and EV charging infrastructure availability. Davis outlined federal actions to try to provide both incentives for EV sales and EV charging installation, as well as disincentives for continuing use of gasoline and diesel-powered vehicles. He reviewed funding opportunities and regulations/standards from the executive agencies.

Ms. Akujuo and Ms. Clark focused on their organizations’ Houston-Galveston and Dallas-Forth Worth regions, respectively. They showed current and project EV sales and fleet penetration and discussed planning and infrastructure needs. They also noted the important role of the Clean Cities Coalitions in planning and finding funding for EV charging infrastructure installation.
Dr. Overbye switched gears to the energy side, providing background on the electric grid. He discussed energy sources and the increase in the use of renewable and clean energy, which must be considered when evaluating the overall environmental impact of EVs. He also provided an overview of the different elements of the energy system to consider in terms of availability and capacity for vehicle charging, from generation to transmission to distribution to load, and the impacts of the ability to return energy to each level from vehicle batteries.

Themes for research and implementation needs were identified and reaffirmed by the expert panelists in their remarks, and the following facilitated question and answer session arose:

- **Charging infrastructure availability** – There is currently a lack of charger availability in many areas, especially rural (including along interstate corridors) and urban areas with multi-family homes that make home charging more complicated for users. Existing chargers also often go “down,” meaning they do not function due to connectivity or mechanical issues.
- **Electrical grid improvement** – The nation’s electrical grid will need to be expanded and updated for higher reliability and increased resiliency for drivers and fleet managers to depend on it for a transportation energy source. Technologies allowing energy transfer from the vehicle back to local loads or grids are one major element in this transition.
- **Workforce training** – The U.S. will need more electricians to support EV charger installation, upkeep, and maintenance workers for fleets transitioning to electric vehicles.
- **Vehicle accessibility and affordability** – There is a shortage of affordable personal passenger vehicles. There are also fewer freight and special-function heavy-duty vehicles on the market.
- **Coordination of grid supply and demand** – Strategies for managing and harmonizing grid supply and demand and transportation system supply and demand will become a major issue when larger portions of the fleet are electrified.

### 2.2 Existing Expertise

The workshop highlighted existing research and expertise at the A&M System related to Electrified Mobility. An opening evening poster session followed by the day-long workshop provided multiple opportunities for participants to hear detailed and broad descriptions of others’ work and knowledge areas.

The poster session highlighted ten posters from the A&M System universities and institutions attending the event. Some posters included multiple efforts related to electrified mobility within a research group or institution, and some focused on specific details of just one or two projects. The posters touch on new battery technology, alternative electro-hybrid biofuels, emissions modeling, and EV charging types and placement. Electronic copies of the posters are available by request to a-fildes@tti.tamu.edu.

In addition to the opening reception and expert panel, the remainder of the workshop involved interactive discussions and brainstorming exercises facilitated by Dr. Mary Léa McAnally, a
Professor at Mays Business School, Texas A&M University, and an expert organizational consultant and facilitator.

The workshop’s initial icebreaker activity had participants spend about five minutes at the location of their choice, with each location associated with a broad general theme. The themes available were: Electricity, Vehicles, Infrastructure, Economics, Policy, Environment, Health/Safety, and Equity/Accessibility. Participants were instructed to discuss why people chose the given topic and connect it to the expert panel and their research. This activity created opportunities for participants to begin to meet new people from other institutions and disciplines and see where their interests and expertise overlapped or complemented each other within the broad theme that brought them together.

Once the participants were seated back at breakout tables, the session started with paired conversations between three partners at each table. Partners learned about each other’s jobs, interests, and expertise related to electrified mobility and the A&M System. The table then came together as a group, and participants reported back about what they’d learned from their partners. The top ten most used terms in the notes taken reflecting self-identified relevant activities from this activity are shown in Table 1.

| Table 1. Frequent Terms Discussing Personal Activities |
|-------------------|------------------|
| **Word**          | **Frequency**    |
| EVs or EV          | 24               |
| cities or city or urban | 10           |
| Batteries or battery | 11              |
| electric           | 7                |
| systems            | 7                |
| testing            | 6                |
| emissions          | 5                |
| transportation     | 5                |
| chargers           | 5                |
| vehicles           | 5                |

This list shows the overlap between the energy and transportation sectors and their connection to emissions. The high usage of words associated with cities also shows a focus on Electrified Mobility activities related to urban settings. However, during other portions of the workshop, multiple participants also brought up rural considerations.

### 2.3 Research Future

The resources and expertise across the TAMU System in areas related to electrified mobility are clearly both broad and deep, which leads to opportunities and challenges for research within the System. One of the clear opportunities is the big issues that can be tackled with such a broad range of specialized knowledge. In the first breakout group session, groups worked to identify “particularly important/exciting” items and themes they had discussed with colleagues at the workshop. Each group created a slide to reflect the ideas generated at the table (see Appendix D). Key themes and subthemes for research and development identified across multiple groups emerged:

- **Battery Technology Development** – Battery technologies that do not require rare earth minerals are being explored and could increase the sustainability of supply chains. Recycling batteries and/or components of batteries could also support similar efforts. Lighter batteries would increase the energy efficiency of the vehicles while reducing loads on roads.
and pavement. Battery needs for heavy-duty vehicles have been researched less than light-duty ones, while growing demand for both is predicted.

- **EV Access for Disadvantaged Communities** – High prices for electric vehicles and a lack of charger availability have been identified as major barriers to EV adoption in disadvantaged communities. Breaking down these barriers will help achieve transportation and clean air equity goals.

- **Lifecycle Analysis** – More analysis of battery, vehicle, and infrastructure lifecycles is needed to assess the sustainability impacts of transitioning to EVs and support asset management planning and budgeting.

- **Multi-modal Considerations** – Buses, motorcycles, helicopters, and other types of vehicles beyond passenger cars and trucks are electrifying and must also be considered.

- **Right-Of-Way** – Right-of-way (ROW) is needed for charger installation, and design choices will impact accessibility and safety. Electric air transportation also introduces new ROW considerations.

- **Land Use** - Land use ties into transportation and charging/energy demand, ROW considerations, and equitable access to economic opportunity.

- **Energy Grid Distribution** – Energy generation, transmission, distribution, and load are all connected to EV charging demand and the potential for vehicles to add supply by transferring energy back into the System.

- **Safety and Security** – Safety and security concerns for users, fleet managers, and the general public include considerations at charging locations for personal safety and security, and cybersecurity. There are also emerging concerns about heavier vehicles leading to more fatal crashes and EV battery fires requiring excessive firefighter resources.

- **Social Science and Humanities** – Models and predictions of future adoption and use of electrified mobility depend on understanding human characteristics and behavior. Additional Social Science and Humanities expertise can help answer human-centered questions and plan more effectively.

The theme of collaboration among the A&M System researchers also reappeared across groups. In some cases, participants identified specific aspects of collaboration, such as multidisciplinary teams and collaboration along the supply chains and lifecycles. Groups also pointed out roles for researchers at various stages, from exploratory research to testing to pilot projects. One group suggested the formation of working groups and conducting strengths-weaknesses-opportunities-threats (SWOT) analyses to move forward with collaboration across institutes.

### 2.4 Ideas for the Collaborative

The second session of breakout groups asked participants to think about what they envisioned and wanted for the future of the collaborative. It facilitated the development of ideas for the directions that the collaboration could take moving forward (Figure 3).
The breakout session began with conversations between partners at the tables to get to know each other and each other’s work and then led to questions about collaborations (such as an electrified mobility collaborative) and organizations (such as the Texas A&M University System). In reporting to the breakout group, notes captured lists of factors participants identified as contributing to excellent collaborations and organizations.

Combining notes from all six groups showed emerging themes across conversations, agencies, and disciplines. The factors identified to “contribute to excellent collaborations” are shown in a word cloud in Figure 4a, and those identified to “contribute to excellent organizations” are in Figure 4b, with the most commonly named factors appearing in larger font sizes.

Many breakout groups focused on the importance of aspects of the people involved - such as diversity of disciplines, expertise, and ideas, as well as sharing and facilitating relationships and
connections within research and industry. This theme of the importance of the people also carried into conversations about excellent collaborations and organizations. For collaborations, participants also focused on the need for shared and clearly defined goals, timelines, roles, and work scopes in collaboration to reach success. Ideas around successful organizations included maintaining an agile organization, shown by a call for openness to new ideas and approaches, inclusion and transparency, and maintaining flexibility.

The last activity in the second breakout session brought together the previously discussed topics and themes. It asked groups to work together to think about how to design an “excellent electrified mobility collaborative” at the A&M System. Table 2 shows the factors identified in this activity and the associated actions and resources suggested by participants to reach those successes.

Table 2. Success Factors and Associated Actions and Resources Identified as Leading Towards “An Excellent Electrified Mobility Collaborative”

<table>
<thead>
<tr>
<th>Success Factor</th>
<th>Associated Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear Vision</td>
<td>• Define the vision, mission, goals, stakeholders</td>
</tr>
<tr>
<td></td>
<td>• Engage partners and stakeholders</td>
</tr>
<tr>
<td>Broad Expertise</td>
<td>• Identify and engage experts</td>
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<td></td>
<td>• Identify champions</td>
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<td></td>
<td>• Develop frameworks and roadmaps to direct research</td>
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<tr>
<td></td>
<td>• Collaborate across sectors and institutions</td>
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<tr>
<td></td>
<td>• Share information</td>
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<tr>
<td></td>
<td>• Create working groups</td>
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<tr>
<td>Focus and Specialization</td>
<td>• Identify challenges and opportunities</td>
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<tr>
<td></td>
<td>• Publish</td>
</tr>
<tr>
<td></td>
<td>• Create institutional memory</td>
</tr>
<tr>
<td></td>
<td>• Create continuous and iterative processes for research development and outputs</td>
</tr>
<tr>
<td>Productive Mindset</td>
<td>• Develop future workforce</td>
</tr>
<tr>
<td></td>
<td>• Evaluate continuously</td>
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<tr>
<td></td>
<td>• Think lean</td>
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<tr>
<td></td>
<td>• Think entrepreneurially</td>
</tr>
<tr>
<td></td>
<td>• Take risks</td>
</tr>
<tr>
<td></td>
<td>• Assess risks, biases, and uncertainties</td>
</tr>
<tr>
<td></td>
<td>• Reflect and adapt to current and upcoming needs</td>
</tr>
<tr>
<td></td>
<td>• Improve continuously</td>
</tr>
<tr>
<td>High Impact</td>
<td>• Adapt research findings for general and decision-making audiences</td>
</tr>
<tr>
<td></td>
<td>• Facilitate the adoption of electric mobility</td>
</tr>
<tr>
<td></td>
<td>• Create sandbox/testbed opportunities within the A&amp;M System</td>
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<tr>
<td></td>
<td>• Measure impacts</td>
</tr>
<tr>
<td>Organizational Effectiveness</td>
<td>• Develop bylaws</td>
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<td></td>
<td>• Encourage diversity and inclusion</td>
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<td></td>
<td>• Facilitate communication</td>
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</table>
Throughout the day, participants narrowed down the major needs moving forward in creating a successful electrified Mobility Collaborative as:

- Personnel time from experts and support staff
- Funds and facilities to support the work
- More social science/non-STEM participants
- Establish a means to keep in touch
- Central location to find people and their expertise
- Central location to find funding opportunities

3.0 Next Steps

Several key steps will be taken to ensure the sustainability of a research collaborative in electrified mobility. These steps include:

- **Expanding Interdisciplinary Collaboration**: The research collaborative should continue to connect with workshop participants from the A&M System, fostering collaboration among different disciplines and agencies. Efforts should be made to expand the range of disciplines involved, specifically focusing on areas of social science that were identified as underrepresented during the workshop. This expansion allows for a comprehensive and holistic approach to electrified mobility research.

- **Establishing Communication Avenues**: To maintain continuous support across the system, effective communication avenues should be established. Newsletters can be sent out regularly to keep participants updated on the latest developments, funding opportunities, and research findings in the field of electrified mobility. Information centers can be created to provide resources and expertise on funding opportunities and personal areas of interest and expertise. These communication channels help to foster collaboration and ensure a constant flow of information among researchers.

- **Leveraging Expertise**: The research collaborative can benefit from the expertise of individuals within the A&M System. For example, TTI's Dr. Tara Ramani has appeared on the TTI Thinking Transportation podcast series to discuss the goals and outcomes of the April workshop. By showcasing the expertise of researchers through various platforms, the collaborative can promote their work and attract further support and engagement.

- **Proposal Development**: To sustain research development, it is crucial to support researchers in developing strong research proposals. This involves identifying funding
opportunities and providing guidance on proposal writing. Facilitating interdisciplinary collaborations can also strengthen proposals by bringing together expertise from different disciplines. By securing funding for research projects, the collaborative ensures the continuity of research efforts.

- **Team Building**: Building a collaborative and inclusive research culture is essential for sustainability. Encouraging researchers from diverse disciplines to work together fosters interdisciplinary collaboration. Regular meetings, workshops, and conferences should be organized to facilitate knowledge exchange and idea sharing. These interactions contribute to team building and enhance the collective expertise of the collaborative.

- **Engaging Stakeholders**: Collaboration with stakeholders such as industry partners, government agencies, and non-profit organizations is vital. Engaging stakeholders facilitates knowledge transfer, helps identify research priorities aligned with real-world needs, and provides opportunities for technology transfer and implementation of research findings. Collaboration with stakeholders ensures the relevance and applicability of research outcomes.

- **Long-Term Planning**: Developing a long-term vision and strategic plan is crucial for sustained research development. This plan should identify research areas and objectives, considering emerging trends and challenges in electrified mobility. It should also account for scalability and adaptability to address evolving needs and technologies. Long-term planning provides a roadmap for sustained research efforts and ensures that the collaboration remains impactful over time.

- **Mentorship and Capacity Building**: Fostering mentorship programs and providing opportunities for early-career researchers and students helps build a sustainable research community. Training, workshops, and resources should be made available to develop the skills necessary for electrified mobility research. This approach enhances the expertise within the collaborative and ensures a pipeline of future researchers to sustain research efforts.

- **Knowledge Sharing and Dissemination**: Establishing effective channels for knowledge sharing and dissemination is essential. This can include publishing research findings in reputable journals, organizing conferences, symposiums, webinars, and utilizing digital platforms. Sharing knowledge and research outcomes contributes to the broader electrified mobility community, inspires further research, and facilitates technology adoption.

- **Continuous Funding**: Actively seeking funding opportunities from various sources such as government agencies, private foundations, and industry partners ensures continuous support for research activities. Developing relationships with funding organizations and exploring options for long-term funding commitments helps reduce dependence on a single funding stream and ensures continuity in research efforts.

By implementing these steps, a research collaborative can enhance its sustainability in electrified mobility research development. The collaborative will be better equipped to address challenges, foster innovation, and drive the adoption of electrified mobility technologies for a sustainable future.
Appendix A. Workshop Agenda
ELECTRIFIED MOBILITY COLLABORATIVE

Workshop
April 11th – 12th, 2023
Texas A&M Transportation Institute Building

Mission
To create The Texas A&M University System Electrified Mobility Collaborative, promoting collaborations and the pursuit of opportunities.

Goals
Develop an understanding of ongoing research and other activities across the system and the capabilities and interests of The Texas A&M University System members.

Create awareness of future research and funding opportunities.

Lay groundwork for information-sharing mechanisms to foster interdisciplinary collaboration – including individual and institutional capabilities, interest areas, and upcoming funding opportunities.

Address/Venue: RELLIS Campus
1111 RELLIS Parkway, Bryan, TX 77807
Contact: Saundra Jackson, s-jackson@tti.tamu.edu, (979) 317-2456
AGENDA

DAY 1 – TUESDAY, APRIL 11, 2023

5:30 pm  Welcome Remarks
Chancellor Sharp (TBC)

6:00 – 7:30 pm  Reception and Poster Session

DAY 2 – WEDNESDAY, APRIL 12, 2023

8:30 – 9:00 am  Continental Breakfast

9:00 – 9:05 am  Welcome
Greg D. Winfree
CEO/Agency Director
Texas A&M Transportation Institute

9:05 – 9:15 am  Opening Remarks
Dr. Joe Elabd
Vice Chancellor for Research
The Texas A&M University System

9:15 – 9:25 am  Workshop Introduction
Dr. Joe Zietsman
Deputy Agency Director
Texas A&M Transportation Institute

9:25 – 10:30 am  Panel Discussion “Roadmap for Electrified Mobility Implementation”
Moderator: Dr. Joe Zietsman
Speakers:

- Dr. Rachael Nealer, DOE/DOT Joint Office of Energy and Transportation (invited)
- Lori Clark, North Central Texas Council of Governments/DFW Clean Cities Director
- Jeff Davis, Senior Fellow, Eno Center for Transportation
- Dr. Thomas Overbye, Professor, Electrical & Computer Engineering and Director, Smart Grid Center, Texas A&M University

10:30 – 11:00 am  Break
11:00 – 11:05 am  Introduction to Breakout Discussions  
Dr. Tara Ramani  
Deputy Director, Center for Advancing Research in Transportation Emissions, Energy and Health (CARTEEH)  
Texas A&M Transportation Institute  

11:05 – 11:15 am  Icebreaker  
Dr. Mary Léa McAnally  
Executive Professor  
Mays Business School  
Texas A&M University  

11:15 am – 12:00 pm  Breakout Session Part 1  
Electrified Mobility Activities Across The Texas A&M University System  

12:00 – 12:30 pm  Report back from Breakout Part 1  

12:30 – 1:30 pm  Lunch  

1:30 – 1:45 pm  Introduction to Breakout Discussion Part 2  
Technology/Database Demo  

1:45 – 2:45 pm  Breakout Session Part 2  
Building our Electrified Mobility Collaborative  

2:45 – 3:15 pm  Break  

3:15 – 4:00 pm  Report Back from Breakout and Close
## Appendix B. Participant List

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<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Alice Grossman</td>
<td>Texas A&amp;M Transportation Institute</td>
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<tr>
<td>Amir Hessami</td>
<td>Texas A&amp;M University, Kingsville</td>
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<tr>
<td>Andrea Kishne</td>
<td>TAMU/TEES Smart Grid Center</td>
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<tr>
<td>Ben Ettelman</td>
<td>Texas A&amp;M Transportation Institute</td>
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<td>Bumsik Kim</td>
<td>Texas A&amp;M Transportation Institute</td>
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<td>Chuma Nnaji</td>
<td>Texas A&amp;M University</td>
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<td>Curtis Morgan</td>
<td>Texas A&amp;M Transportation Institute</td>
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<td>D Valle Rosales</td>
<td>Texas A&amp;M University, Kingsville</td>
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<td>Darrell Kuhn</td>
<td>TAMUS</td>
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<td>David Coatney</td>
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<td>David Ramirez</td>
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<td>David Salgado</td>
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<td>The Texas A&amp;M University System</td>
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<td>Debbie Lollar</td>
<td>TAMU Transportation Services</td>
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<td>Dorsa Talebi</td>
<td>TAMU/TEES Electrical Engineering</td>
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<td>Edgar Kraus</td>
<td>Texas A&amp;M Transportation Institute</td>
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<td>Heidi Taboada</td>
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<td>John Diem</td>
<td>TEES/Bush Combat Development Complex/Innovation Proving Ground</td>
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<td>Jose Espiritu</td>
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<td>Jung Kyo Jung</td>
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<td>Justin Tippy</td>
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<td>JV Rajendran</td>
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<td>Karen Butler-Purry</td>
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<td>Ken Tobin</td>
<td>Texas A&amp;M International University</td>
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<td>Le Xie</td>
<td>TAMU/TEES Electrical Engineering</td>
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<td>Lori Clark</td>
<td>North Central Texas Council of Governments</td>
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<td>Madeline Dillard</td>
<td>TAMU Transportation Services</td>
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<td>Martha Clements</td>
<td>TAMU Transportation Services</td>
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<tr>
<td>Matt Miller</td>
<td>Texas A&amp;M Transportation Institute</td>
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<td>Mohamed Chouikha</td>
<td>Prairie View A&amp;M University</td>
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<td>Mohammed Askariyeh</td>
<td>Texas A&amp;M Transportation Institute</td>
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<td>Nuri Yilmazer</td>
<td>Texas A&amp;M University, Kingsville</td>
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<td>Onyinye Akujuo</td>
<td>Houston Galveston Area Council</td>
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<td>Pete O'Neill</td>
<td>The Texas A&amp;M University System</td>
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<tr>
<td>R. Krish</td>
<td>Prairie View A&amp;M University</td>
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<td>Rayan El Helou</td>
<td>A&amp;M</td>
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<td>Rob Greer</td>
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<td>Robert Balog</td>
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<td>Sharmila Pathikonda</td>
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<tr>
<td>Siva Ranjani</td>
<td>Karen Wooley’s Group - TAMU Chemistry</td>
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<td>Stephen Cisneros</td>
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<td>Stratos Pistikopoulos</td>
<td>TAMU/TEES Chemical Engineering</td>
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<td>Suyash Oka</td>
<td>TAMU/TEES Chemical Engineering Jodi Lutkenhaus’s Group</td>
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<td>Thomas Overbye</td>
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<td>Tiffany Sill</td>
<td>Sarbjit Banerjee’s Group - TAMU Chemistry</td>
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<tr>
<td>Tony Crites</td>
<td>TEEX</td>
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<tr>
<td>Wei Li</td>
<td>TAMU Landscape Architecture &amp; Urban Planning</td>
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<tr>
<td>Xinyue Ye</td>
<td>TAMU Landscape Architecture &amp; Urban Planning</td>
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Appendix C. Expert Panel Slides
RoadMap for Electrified Mobility Implementation: Electric Grid Background

Tom Overbye
O’Donnell Foundation Chair III
Electrical and Computer Engineering, overbye@tamu.edu

Electrified Mobility Collaborative Workshop
April 11-12, 2023

A Bright Electric Future

• Our electric energy future could be quite bright!
• Electric grids worldwide are in a time of rapid transition, with many positive developments including the addition of large amounts of renewable generation, transportation electrification, smart grid controls, etc.
  – The grid of the future is likely to be quite different from the one of the recent past
• There are lots of good engineering challenges and it is a great time for students entering the field!!
Electric Grid Basics

More generation is moving into the distribution system;

Asynchronous Grids Have Slightly Different Frequencies (USA 2/13/22)

Frequency image from Prof. Mack Grady of Baylor University
Important Electric Grid Considerations

- Electricity cannot be economically stored
  - Generation must be continually adjusted to match changes in electric load and losses
- Electric power flows on high voltage transmission lines cannot usually be directly controlled
  - Control is mostly indirect, by changing generation
- Customers have been in control of their load
- Transmission system has finite limits; often operated close to its limit for economic reasons

Changing Sources of Generation

- In the US and worldwide the sources of electricity are rapidly changing

In Texas (ERCOT) we now (2022) have 33.7 GW of wind and 11.7 GW of solar (out of a total of about 125 GW)
Electricity and Transportation

- It is now quite certainly that the electrification of transportation is going to occur, and that most of the associated energy will be supplied by renewable sources of generation
  - Texas will likely be a leader in this change
- This new load will require at least some new generation, some new transmission, and perhaps significant changes to the lower voltage distribution system
- A key issue will be the degree to which vehicle charging can be shifted to times of low electricity prices (primarily at night)
- Vehicle-to-grid (V2G) could provide significant benefits, though some of the benefits require substantial enhancements to communication and control systems
Thank You!
Electrified Mobility in Houston
A Regional Planning Perspective

Onyinye Akujuo
Chief Operating Officer/Deputy Executive Director
Houston-Galveston Area Council

Houston-Galveston Region

- Region’s population is currently 5.9 million, and is expected to reach 10 million by 2040
- Metropolitan area covers almost 9,000 mi² (23,000 km²)
- Economy has a broad industrial base in the energy, aeronautics, medical, and technology industries
- Home to over 5,000 energy related firms
- Port of Houston is the 10th largest port in the world and ranks 1st in the U.S. in international commerce
## Houston EV Population

<table>
<thead>
<tr>
<th>County</th>
<th>All Vehicles</th>
<th>EV Count</th>
<th>EV to Total Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazoria</td>
<td>326,135</td>
<td>2,022</td>
<td>0.62%</td>
</tr>
<tr>
<td>Chambers</td>
<td>46,400</td>
<td>120</td>
<td>0.26%</td>
</tr>
<tr>
<td>Fort Bend</td>
<td>686,364</td>
<td>9,359</td>
<td>1.36%</td>
</tr>
<tr>
<td>Galveston</td>
<td>287,680</td>
<td>1,559</td>
<td>0.54%</td>
</tr>
<tr>
<td>Harris</td>
<td>3,539,801</td>
<td>25,401</td>
<td>0.72%</td>
</tr>
<tr>
<td>Liberty</td>
<td>86,675</td>
<td>90</td>
<td>0.10%</td>
</tr>
<tr>
<td>Montgomery</td>
<td>560,689</td>
<td>4,383</td>
<td>0.78%</td>
</tr>
<tr>
<td>Waller</td>
<td>51,504</td>
<td>273</td>
<td>0.53%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,585,248</strong></td>
<td><strong>43,207</strong></td>
<td><strong>4.92%</strong></td>
</tr>
</tbody>
</table>


## Houston EV Sales and Fleet Growth

![Graph showing EV sales and fleet growth](image-url)

Source: Evolve Houston
Regional Infrastructure Needs

- H-GAC will be developing a regional ZEV infrastructure plan in preparation for infrastructure funding:
  - National Electric Vehicle Infrastructure Program (NEVI)
  - Charging and Fueling Infrastructure Grants (CFI)
  - Congestion Mitigation and Air Quality (CMAQ)

- Anticipated Needs:
  - Deploying high speed charging along interstate corridors
  - Ensuring charging for residents of multi-family housing
  - Installing office charging
  - Municipal code updates
  - Electrical grid improvement and expansion
  - Workforce training

Three-Legged Stool Paradigm

EV charging must exist where EV drivers live, work, and play to convince the vast majority of drivers that electric mobility is viable.
Preparing the Electrical Grid

- Proactively prepare for higher loads
  - Fleet charging at one facility can use as much power as a small city
  - Time to install this infrastructure can take years

- Increase grid resilience
  - Start grid upgrades before they are necessary
  - Upgrade grid infrastructure to enable bi-directional power flow
  - Smart Grids, V2G, and virtual power plants can help stabilize the grid in the event of another Uri

Regional Focus On Logistics

- Much work done to accelerate turnover of on-road vehicles within Texas
  - On road mobile emits 25% ozone precursors in HGB

- Less funding available for off-road replacements
  - Off road mobile emits about 23% of ozone precursors
  - Vehicle Examples:
    - Forklifts
    - Yard Tractors
    - Truck/Container Refrigeration Units
    - Locomotives
    - Container Handling Equipment
    - Marine Vessels

- Still opportunities to make big emission reduction gains
The Fuel Future Is “All of the Above”

- There is a national focus is on EVs:
  - 14 states have goals to phase out the sale of emitting vehicles

- There are difficult issues to grapple with for fleets:
  - Different use cases have different needs to balance:
    - Range | Carrying Capacity | Fuel Availability | Charging Speed
  - Companies need to balance decarbonization vs operational goals
  - Infrastructure availability

- These issues can affect the decision-making for fleet managers
- May decide to choose other fuel options

One last thing!

- https://dai.ly/x8i80tj
Contact Us!

Onyinye F. Akujuo
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Andrew DeCandis
Manager, Houston-Galveston Clean Cities Co-Director
(832)681-2589
A Clean Cities Perspective on Electrified Mobility

Lori Clark, Program Manager & DFWCC Director

cleanities@nctcog.org www.dfwcleanities.org

April 12, 2023
Texas A&M University System Electrified Mobility Collaborative Workshop

National Network of Clean Cities Coalitions

More than 75 Clean Cities coalitions with thousands of stakeholders, representing ~80% of U.S. population

Designated by the Department of Energy
Clean Cities Technology Portfolio

- Light-, Medium-, and Heavy-Duty Vehicles
- Alternative and Renewable Fuels and Infrastructure
- Idle Reduction Measures and Fuel Economy Improvements
- New Mobility Choices and Emerging Transportation Technologies

DFW Clean Cities Key Focus Areas

Fleet/Driver Guidance and Planning
- Support Transition to Zero Emission Vehicle (ZEV) and Other Alternative Fuel Technologies
- Assist Deployment of Clean Vehicle Technologies by Identifying, Promoting, and Providing Funding

Infrastructure Planning & Readiness
- Increase Equitable Access to Electric Vehicle (EV) Charging Infrastructure
- Build Publicly-Accessible Infrastructure Network to Support ZEV Transition in Medium- and Heavy-Duty Sector
- Ensure Local Governments are Informed and Prepared to Support Local EV Adoption
- Reduce Barriers, Delay, and Cost in Local Infrastructure Development

Energy Integration
- Minimize Negative Electric Grid Impacts Associated with Transportation Electrification
- Increase Local Availability of Renewable Fuels (electricity, natural gas, hydrogen, biodiesel)
- Improve Resilience against Fuel/Energy Interruptions
Infrastructure Needs Beyond the Texas EV Charging Plan

NCTCOG Environmental Justice Index and Public EV Charging Stations

Level 2 Intra-Regional Charging (aka "Community Charging")

Medium- and Heavy-Duty Infrastructure

Photo source: Portland General Electric & Daimler Truck
FEDERAL FUNDS & ELECTRIC VEHICLES

THE E.V. CONUNDRUM

v.
THE E.V. CONUNDRUM

Where to prioritize federal financial support?
- Ensure that EV charging and alt-fuel filling resources are widely available, so people will buy the vehicles, or
- Induce demand for the vehicles and thus ensure use of the infrastructure.

100+ years ago, popularity of gasoline vehicles preceded vehicle-oriented gasoline distribution. But driving was all-local then.

CHARGING INFRASTRUCTURE – I.I.J.A.

The IIJA provided $7.5 billion for grants over 5 years to fund EV charging and alt-fueling infrastructure.
- $5 billion in formula grants to states for EV charging stations and installation along designated charging corridors. (Texas share: $408 million.)
- $2.5 billion in competitive grants (will be reduced by 10-15%) to any level of government for electric, hydrogen, propane or natgas charging/fueling infrastructure, on or off designated corridors (50-50 on-off).
E.V. PURCHASE INCENTIVES

▪ Purchaser point-of-sale tax credit of up to $7,500 per new EV, depending on domestic content %.
▪ Credit for purchased of used EVs of up to $4,000.
▪ New standards released last month indicate that many EVs from US manufactures won’t be eligible for full $7,500.
▪ To be eligible for credits, car max MSRP is $55,000 and light truck max MSRP is $80,000.
▪ Structure of tax incentives (and new, higher interest rates) encourage fleet sales and leasing.

THE CARROT: I.R.A. TAX INCENTIVES
THE STICK: INCREASED FUEL EFFICIENCY STANDARDS

Being announced this week by EPA and NHTSA. Increased emission standards so that EVs represent:

- 54-60% of all US new LDV sales in 2030, and
- 64-67% of all US new LDV sales by 2032.
- (Previous stated goal had been 50% by 2030.)

Difficult to achieve IRL, and subject to amendment or repeal by future Administrations.

Thank you!

Any questions?
You can find me at:
- @JDwithTW
- jdavis@enotrans.org
Appendix D. Breakout Group Slides on Important and Exciting Opportunities
IDEAS:

1. Polypeptide Batteries
2. Anticipate the needs of consumers
3. Emergency evacuations if all EVs - how to charge, congestion on roadways when they die
4. Battery composition and charging technology - how to do it best; energy problem; life-cycle
5. VTG - to balance the load/demand/conserve energy
6. Battery disposal
7. Planning, design, deployment, maintenance and operations
8. Procurement standards, decision-making tools; production;
9. Education to inform people of options, risks, issues
● Battery technology maturity not ready for wide scale commercial adoption
● Heavy duty battery tech and Electricity generation is not feasible, at this time
● Excitement for future battery technology advances… many waiting for advances in technology (specifically as it relates to the sustainability, both environmental and economic)
● Current EV charging infrastructure is inadequate
● Incentives do not align with market realities. Domestic production and tax rates (as opposed to rebates at dealership) disincentivize EV sales (especially for low-income families)

“I am interested in purchasing an EV, but I am not convinced by the current state of battery technology, so I am holding off”
Table 3

Intellectual Leads Physical
TAMUS can be intellectual leaders
Research to inform flexible policy

Alice Grossman
Taesic Kim
Joe Henry
Jason Foley
Reza Nekovei
Bala Balasubramanya

Overarching considerations:
- Human Factors
- Green Audits
- Lifecycle Analyses

- Transportation
  - Non SOV mode
  - Safety considerations
- Power Sources
  - Charging and fueling beyond the grid: hybrids/Biofuels and others
- Vehicle -grid connection
  - Cyber security concerns
  - Equity concerns
Feasibility: a lot of hickups to work at the scale we envision

Three dimensional problem

Autonomy, transportation will be autonomous

Thinking about equity
  - Multiple dimensions
  - Mining of raw materials

Supply chain problems at large scale, battery technology that uses materials that are easily available

Better batteries that don’t rely on strategic materials

Availability of materials that are used for battery production, reliance on strategic materials, or those that are not available in every country

Recycling of batteries to alleviate dependencies on raw materials

“I’m worried about availability of battery materials in light of global politics”
- Electric bus, fleet
- Green transportation, Smart cities, reliable grid
- Integration of renewable energy source
  - Many capital investigation will be required, but think about the long term goal
  - Parking space w/ embedded charger (wireless)
- Fast-charging structural batteries
1. Interdisciplinary and Holistic Approach
   a. None of the problems we face today are going to solved alone.
   b. Having the systems of systems perspective in order to combat the unknown questions that will arise.

1. Working Groups
   a. We need to have working groups tasked to produce white papers that covers unexpected consequences, including dissenting opinions.
   b. SWOT Analysis would help to lead the groups in the direction that the group needs to focus.
- Multidisciplinary approach.
- Cultural and technical challenges.
- So many perspectives and uses.
- Federal mandate needs to ensure the transition to sustainability.
- Plan in advance. Failing is allowed, but a small scale with sand boxes supported by early adopters.
- A&M can create perfect environments to test application in real world.
- After the test and pilots, we need to develop standards.

Sandbox to test and develop standards

Plan to reduce risk of failure
Table 9

Eun Lee, Jacob Eaton, Amir Hessami, Martha Clements, Karen Butler-Purry

- Developing a framework analysis identifying trade-offs between conventional and electrified mobility solutions considering environmental, social and economical aspects

- Integration of renewables in the power sector and EVs into the transportation sector, considering infrastructure requirements

- Identifying safety hazards for EV operation, including interactions with pedestrians and battery hazards

- Security implications

- Technology requirements for electrification of non-ground-based transportation (aviation sector)
Table 10

Faruque Hasan, Ken Tobin, Jorge Seminario, JV Rajendran, Tara Ramani

- Flexibility in evolution and adoption of technologies
- Energy efficiency
- Sustainability - across life cycle and supply chain - circular economy
- Avoiding unintended consequences
- Economics - affordability?
- Opportunities - workforce transition for energy transition
- Future proofing the systems

Technological Development Guided by Systems Thinking