2022 Macro-Energy Systems Workshop

POST-EVENT REPORT

October 14, 2022

Event Date – June 20-21, 2022 | Stanford University, Stanford, CA

Stanford | Bits & Watts
Precourt Institute for Energy

2022 Macro-Energy Systems Workshop Organizing Committee
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Executive Summary

Macro-Energy Systems (MES) is an emergent field and research community that focuses on large-scale, systems-level, long-term aspects of energy systems and their implications for other systems, including the environment, economy, and human wellbeing.

The 2022 MES Workshop brought together 62 people for sessions including lightning talks, two keynotes, ideation, and a community meeting. The workshop was very successful in its main goals of **building networks** among MES researchers, producing a list of **key research topics and needs**, and **identifying priorities** for future community-building activities.

Our **lightning talk format** was designed to engage researchers and encourage discussions. These were 5-minute presentations on research conducted by the MES Community, immediately followed by a poster session to stimulate discussions. Talks were selected beforehand by the workshop committee in a double-blind peer-review process.

In a first keynote, **"Modeling for a different future"**, Valentina Bosetti discussed major limitations and potential avenues for improvements of Integrated Assessment Models, including exploring sources of uncertainty and better utilizing model outputs. Our second keynote was **"The Open Energy Outlook: An open and collaborative modeling effort for US decarbonization"**, jointly presented by Paulina Jaramillo, Jeremiah Johnson, Aditya Sinha, Katie Jordan, Aranya Venkatesh.

Ideation sessions were organized to generate ideas for future work for the MES Community. Through these sessions, we identified and discussed the following questions:

- What are the physical, economic, and social barriers to deployment and use of technological, climate solutions, and how can they be overcome?
- How do we define model-able and actionable metrics for equity in energy transitions?
- How do we prioritize values in the energy transition? Where is there conflict? Where is there complement? How do we define our priorities for the energy transition?
- How should we combine methods to effectively model cross-disciplinary systems?
- How should uncertainty be integrated and communicated to promote trust and usability?
- How do we better incorporate human behavior at different stages of model development to drive the energy transition?
- How can MES research use community feedback to benefit stakeholders and provide human scale outcomes?

The final event of the workshop was a **Community Meeting**, in which the following six themes were discussed:

1. **Building and engaging with the MES community** — How would we like to identify, affiliate, and engage with the MES community?
2. **Workshops and conferences** — How should we plan to bring the MES community together at workshops and conferences?
3. **Speaker series topics** — What topics should we address in future panel discussions as part of the MES Speaker Series?
4. **Students and education** — What educational resources should we offer related to MES, and how can we best support students who are interested in the MES space?
5. **Funding for MES activities** — What additional activities could MES pursue if we raised more money, and what funding sources could we target?
6. **Open discussion** — What additional ideas do we have for activities that the MES community should pursue over the next 1-2 years?

Finally, **much remains to be done**. Establishing a new discipline is not easy. The 2022 MES Workshop Organizing Committee thanks the attendees for their enthusiastic participation in this event, the latest in a series of efforts to grow the MES community. We extend an open invitation to new participants to join us. Academics and researchers who believe that their work fits within the MES vision can identify their discipline as such and can champion MES to their peers. We also encourage everyone currently engaged with MES to continue taking steps to grow and promote our community, and to reach out to the MES Steering Committee with any proposals for new MES initiatives. Community members can keep up to date with upcoming MES programming, including new post-Workshop initiatives, via the website, email listserv, and official Twitter account.

Introduction

Macro Energy Systems

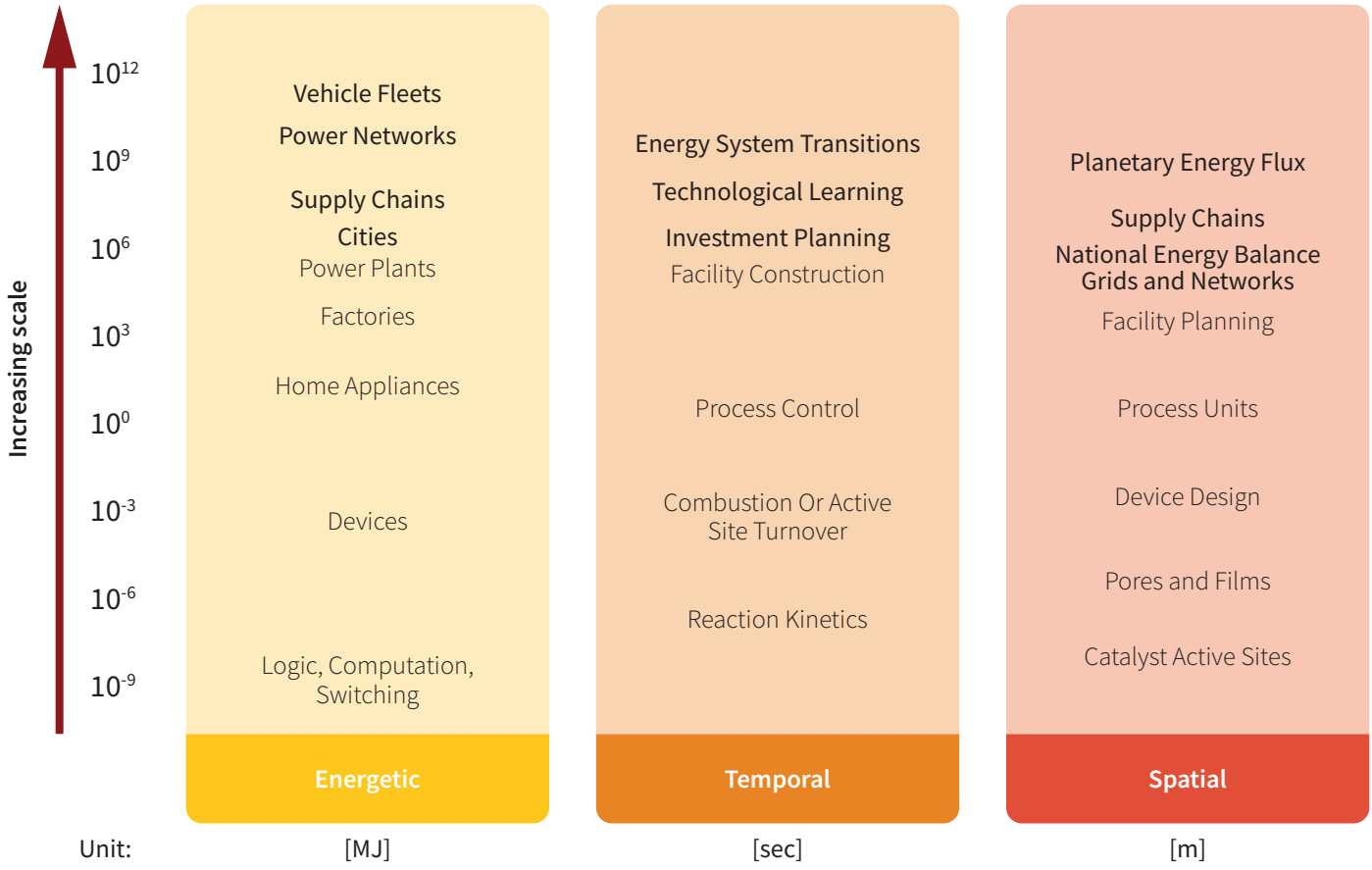
Macro-Energy Systems (MES) is an emergent field and research community that focuses on large-scale, systems-level, long-term aspects of energy systems and their implications for other systems, including the environment, economy, and human wellbeing (see Figure 1). Sustainability goals, equity and environmental justice concerns, and computational advances have all fueled a growing area of study with an increasingly rich set of tools and questions. Until now, this work has been scattered across many research communities. Macro-Energy Systems unites these efforts within a common field to foster better research, collaboration, education, and policy-making.

The MES Community aims to unite multidisciplinary research and action on the energy frontier. Connecting with the MES Community will enable researchers, students, academics, industry professionals, and policymakers to utilize and contribute to MES resources, including:

- Targeted journals and conferences supporting this research community;
- Credibility & visibility, to make it easier to find collaborators, determine faculty hires, and secure funding;
- Bright, interested students with a passion for energy systems;
- A strong professional community;
- Streamlined communication leads, to faster advances in our understanding and our methodologies;
- Stronger cross-disciplinary collaboration, to enable better understanding of linkages with human impacts, political institutions, and natural ecosystems.

Please see macroenergysystems.org for more information. Click here for a brief video overview of MES.

Figure 1: Relevant scales for MES research.



Credit: Levi et al. (2019). Macro-Energy Systems: Toward a New Discipline. Joule, 3, pp. 2282-2286.

Why have a workshop?

A key goal of the MES workshop was to continue to build community among MES researchers. The workshop included networking, research presentations, interactive ideation sessions, and a community meeting.

Innovative lightning sessions provided a forum for exchange of cutting edge research in MES. In these sessions, a mix of students and more experienced researchers provided brief overviews of their research, followed by in depth discussions in small groups.

In interactive working sessions participants banded together to ideate interdisciplinary, impactful projects and proposals in MES.

Finally, the community meeting helped set the course for future community activities, such as continuation of the remote panels, future workshops, possible structures for a formal organization, and other activities that further scholarship and application of MES.

Conference process overview

The 2-day Workshop included lightning sessions highlighting cutting edge research in MES from multiple disciplinary and topical perspectives; two keynote speakers; a highly interactive set of working sessions to develop a policy-relevant research agenda relevant to MES; and a community meeting to help set the agenda for the community in the coming years. It also included a reception and plenty of opportunities for networking.

The workshop was organized by the MES Workshop committee, which consisted of Erin Baker (chair); Aditya Keskar (intern), Alison Ong (intern), Ben Leibowicz, Elisabeth Graffy, Jacques de Chalendar, Jason Hirshey (intern), and Sauleh Siddiqui. We put out a call for submissions in January and received 55 submissions. The submissions were reviewed blindly for (1) the importance of the motivating question; (2) the fit to Macro-energy systems; and (3) the methods and results. Each submission was reviewed by two evaluators, with a total of four evaluators. Each evaluator gave a score for each criteria and an overall score. The complete list was then discussed by the four evaluators, and the final group of 40 presenters was chosen, with some attention to diversity, including demographic and organizational. With last minute cancellations, we had 36 lightning speakers.

Our goal was to keep the workshop to approximately 50 attendees to maximize the interaction and impact. Given the high quality of the abstract submissions and the interest from others, we increased the limit. Presenters were invited to register in March. Simultaneously, the MES steering committee was invited to register. Then, invitations were sent to people who had attended the original MES workshop in 2020. Finally, a few people who had directly expressed interest to workshop committee members were also invited. The final attendance total was 62.

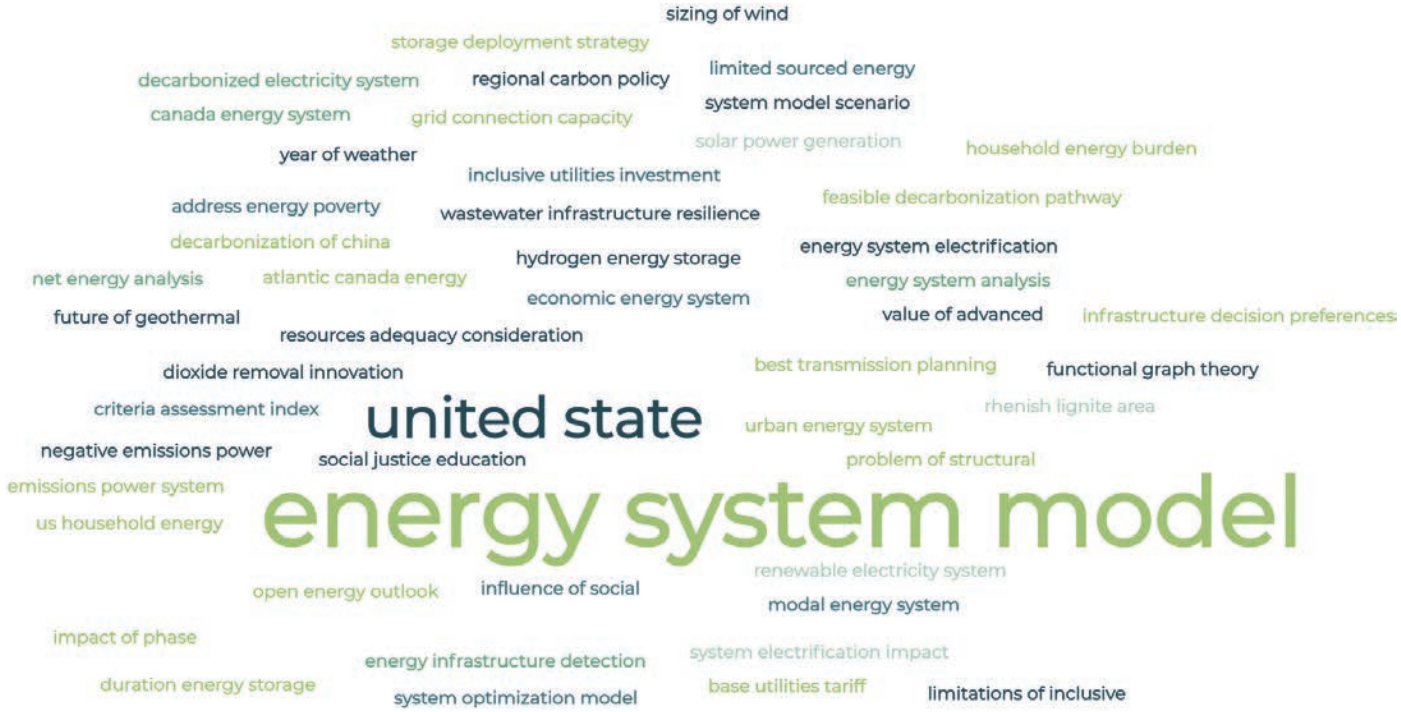
Lightning Talks and Poster Sessions

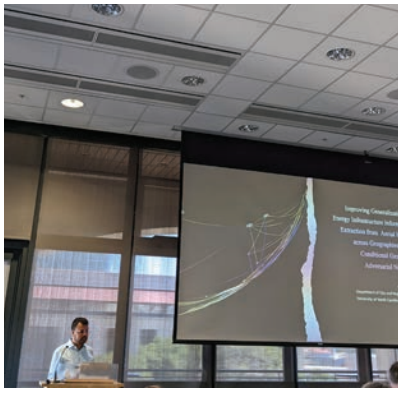
Lightning Talks are 5-minute presentations on research conducted by the MES Community, which are immediately followed by a poster session, where presenters had the opportunity for smaller group conversations with the MES community. Each talk and associated poster included motivation, with a focus on why this is an interesting and important problem, methods, and (possibly prospective) results.

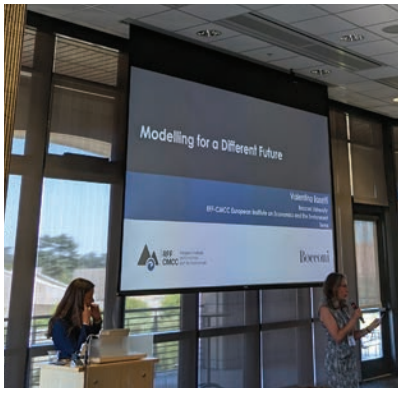
The lightning talks were chosen through a double-blind peer review of abstracts by the MES Workshop Committee. A rubric was used to score abstracts from a scale of 1-5. The rubric included a score for (1) motivation and impact; (2) fit to MES; (3) methods and results. In addition the reviewers scored the abstracts overall. This could be a specific mathematical formula from the three others, or a judgment based on combining these. The overall scores were used to identify an initial group; the individual scores were used to refine this group, with a goal toward demographic balance (students/nonstudents; academia/nonacademia; under represented minorities, women, qualitative as well as quantitative); and fill in up to a total of 40.

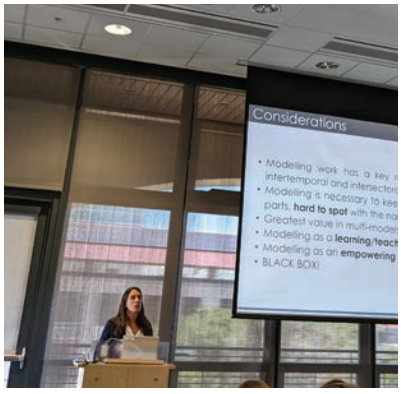
Figure 2 shows the prevalence of terms and phrases in the submitted titles of the talks and posters. Please see the Appendix for a table listing all speakers and topics.

Figure 2: Terms and phrases used in titles of submitted abstracts and posters, sized by frequency.









Plenary Talk Summaries

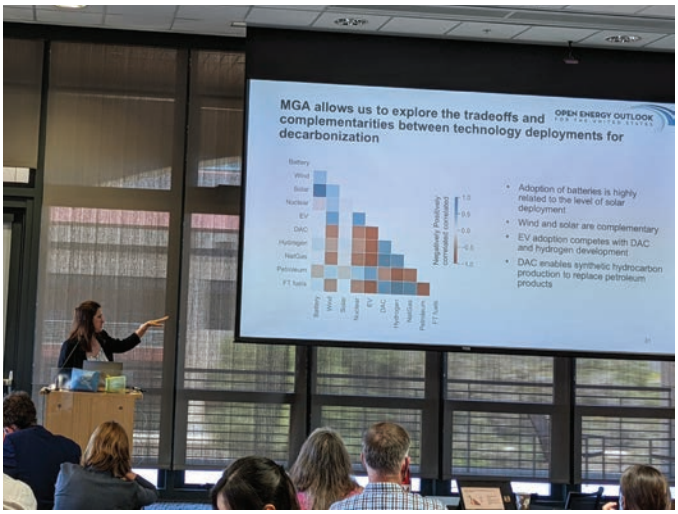
Each day had a Plenary talk or presentation. These were also live streamed in webinar style. We had 27 and 79 remote attendees for the two talks.

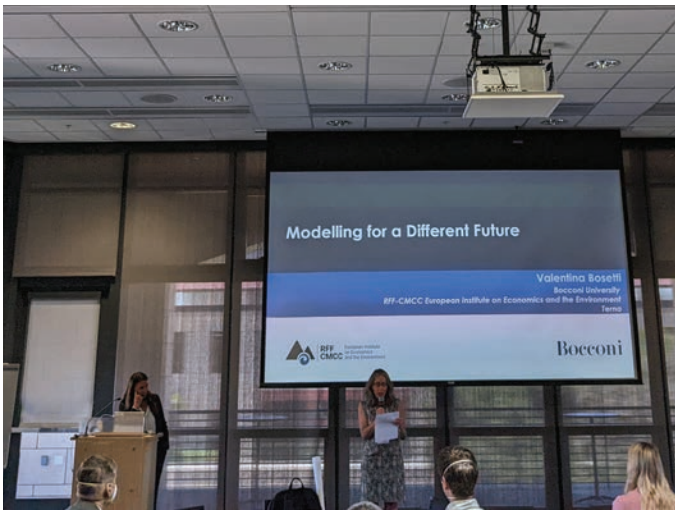
The first talk was presented by Valentina Bosetti. She is senior scientist at the European Institute on Economics and the Environment (EIEE), and full professor at the Economics Department of Bocconi University in Milan. She was a senior researcher at FEEM 2003-2018. She was a fellow at the Center for Advanced Studies in Behavioural Sciences at Stanford University in 2014-2015, and visiting fellow at Princeton University in 2009-10. She currently serves as Chairwoman of Terna S.p.A. She was a lead author of both the 5th and 6th IPCC Assessment Reports. She was the PI of two European Research Council (ERC) Starting Grants, one on Innovation and clean technologies (ICARUS) and another on Uncertainty and Climate Change (RISICO).

Her talk was entitled **Modeling for a Different Future**, and focused on Integrated Assessment Modeling as a tool to shape climate mitigation strategies and a major example of model-based science policymaking. She discussed the major limitations and potential avenues for improvements of IAMs, as well as key lessons learned over the past twenty years. One of the major challenges in studying and shaping the future is exploring major sources of uncertainties and finding ways to maximize the impact of the resulting information.

The second plenary was a special presentation introducing **The Open Energy Outlook: An open and collaborative modeling effort for US decarbonization**. This was a joint presentation, with participation from Paulina Jaramillo, Jeremiah Johnson, Aditya Sinha, Katie Jordan, Aranya Venkatesh.

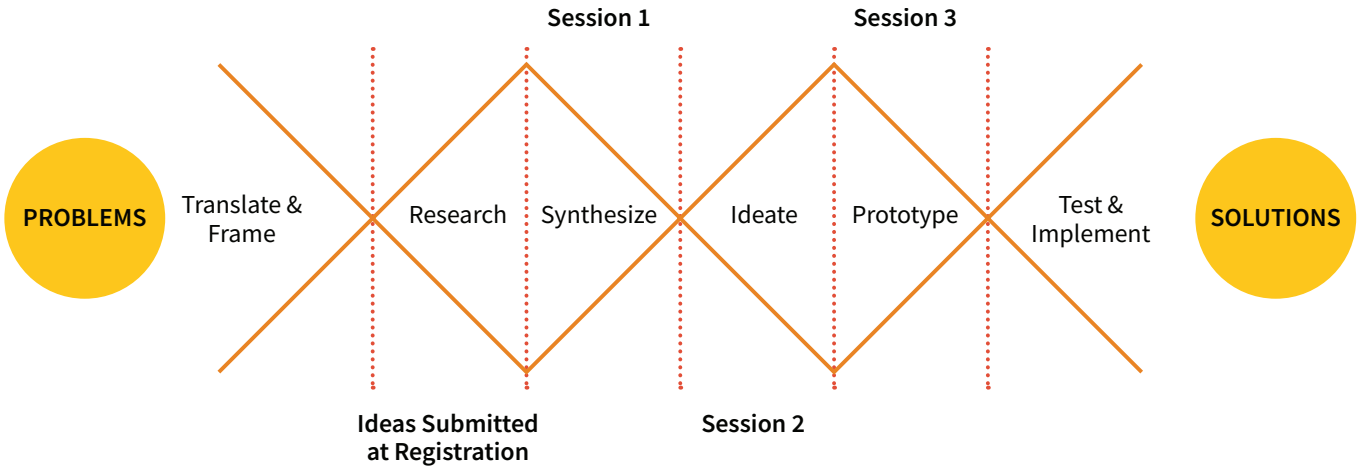
The Open Energy Outlook (OEO), an initiative of the Wilton E. Scott Institute for Energy Innovation at Carnegie Mellon University in partnership with NC State University, aims to examine U.S. energy futures to inform energy and climate policy efforts by applying the gold standards of policy-focused academic modeling, maximizing transparency, and building a networked community. Supported by the Alfred P. Sloan Foundation, this keynote marked the release of results from the first report by the OEO team. The presentation focused on the modeling approaches the team used, as well as model results and policy-relevant insights the project has gathered so far. Scenario and uncertainty analyses conducted by the team were also presented. The talk highlighted the robust engagement the team has conducted with energy stakeholders and experts.





Ideation Design and Execution

Figure 3: The Double Diamond Model of the UK Design Council Outlines our Ideation Methodology



The ideation sessions brought together a set of innovative approaches to generate ideas for future work for the MES Community. It was organized and conducted according to the principles of ***Participatory Design***, which integrates researchers collectively in the idea generation process. Direct involvement ensures that they are represented and invested in the process, which infuses the definition, approach, execution, and outcome of a research effort with diverse perspectives and priorities.[1,2]

The ideation session was organized and conducted around our version of the ***Double Diamond Model*** from the Design Council[3] (Figure 3). While most processes of creating agendas begin by brainstorming ideas (divergent thinking) and then narrowing the list (convergent thinking), they often stop there. The Double Diamond model highlights the need for this process to happen twice: first to solidify agreement on the challenges and only then to develop the approaches. Omitting the first step is a common error and can lead to generating the right answers to the wrong questions. In the case of the MES Community, which brings together participants with diverse expertise to address a set of challenges that connect differently to each of their work, the Double Diamond takes on even greater importance. The specifics of each stage are below:

Pre-Conference Survey

The registrants answered the following question: "Please write down some policy-relevant research questions that you think the MES community should be answering over the next five years. Feel free to refer to our panel discussion (link to recording) on this topic as you wish. Don't worry too much about precise phrasing or specificity, right now is the time to be broad and list as many ideas as you can."

The committee convened to categorize the questions into five broad themes: Transition/Energy Future, Technological Advancement, Methodology, Humans, and Equity and Justice.

1 Schuler, D., & Namioka, A. (Eds.). (1993). Participatory design: Principles and practices. CRC Press.

2 Boyer, B., Cook, J. W., & Steinberg, M. (2011). In Studio: Recipes for Systemic Change: Helsinki Design Lab. Sitra.

3 UK Design Council (2018) Retrieved From: https://www.designcouncil.org.uk/news-opinion/design-process-what-double-diamond

Day 1, Session 1 (2:30pm-3:30pm)
Wall of Questions (Define)

There were 5 large wall spaces with sticky notes for each theme proposed on the walls. Each wall had a broad suggested theme. The randomized groups were asked to look at all the questions and cluster them within their wall, seeing which of them fit in the broader theme of the wall. The groups then had a chance to redefine their wall-theme into broader research questions that encompassed most of the questions and clusters on their wall. Some research questions that might not fit into the broad theme were put to the side but still recorded. Each group then shared their broader theme in the form of overarching research questions which were combined and summarized by the workshop committee below:

- What are the physical, economic, and social barriers to deployment and use of technological, climate solutions, and how can they be overcome?
- How do we prioritize values in the energy transition? Where is there conflict? Where is there complement?
- How do we define metrics for equity that are model-able and actionable for the energy transition?
- How do we define our priorities for the energy transition?
- How do you combine methods to effectively model cross-disciplinary systems?
- How do you integrate and communicate uncertainty in a clear way to promote trust and usability?
- How do we better incorporate human behaviour at different stages of model development to drive the energy transition?
- How can MES research use community feedback to benefit stakeholders and provide human scale outcomes?

Day 1, Session 2 (3:45pm-5:00pm)
Carousels (Ideate)

We randomly split the attendants into 8 groups and had 8 stations around the room with a different research question. Each group started at a carousel to write down ideas on how our community would answer these questions. These included methods, data collection, engaging specific policymakers, and other ideas. After 5 minutes, the groups rotated to the next carousel. They observed what the group before them had written and added to that or edited. After 5 minutes, the groups rotated again. After 40 minutes, each group went to each question carousel and the last group summarized the discussion.

The committee then summarized the Broader Theme Research Questions (Session 1), Ideas to tackle them (Session 2), and any random ideas that didn't fit into these categories.

Day 2, Session 1 (2:30pm-3:30pm)
Roundtable Discussions (Prototype)

The committee presented the outcomes of the first two sessions and had a roundtable setup for each. Everyone then self-selected at least one and maximum two of these roundtables to participate. Each roundtable came up with concrete next steps for how the MES community can work on tackling these questions. These are summarized below:

What are the physical, economic, and social barriers to deployment and use of technological, climate solutions, and how can they be overcome?

- Prioritize research questions based on policy relevant decision making and community needs that need modeling/research assistance (identify questions through direct engagement)
- Map current tools (relative strengths and weakness) through a gap analysis
- Pursue scholarship and invite outside collaborators in an effort to fill gaps

How do we define metrics for equity that are model-able and actionable for the energy transition?

- Plan for next year:
  - Survey existing papers from EJ scholars
  - Identify community stakeholders that have ties to community needs
  - Synthesize what they said and produce a paper that describes what is model-able and actionable
- In future years:
  - Over the next few years, produce papers that use these metrics. A couple years down the road, have a paper that summarizes modeling results
  - Produce whitepaper to communicate findings publicly

How do we prioritize values in the energy transition? Where is there conflict? Where is there complement? How do we define our priorities for the energy transition?

- Survey researchers within and adjacent to MES, as well as decision makers and users, to learn (1) what factors and values they'd like to see considered in modeling exercises, (2) solicit information on standard models that are being used so that they can be easily compared.
- Create best practices/standards for factors to consider when creating a model for members of the MES community
- Create a best practice for documentation/communication of modeling ideas that collectively helps the group, a library with a consistent format documenting the models and published papers

How do you combine methods to effectively model cross-disciplinary systems?

- Better articulate the values and roles of broad vs. deep models and research initiatives
- Develop an online primer or commentary paper on effective cross-disciplinary collaboration

How do you integrate and communicate uncertainty in a clear way to promote trust and usability?

- To Do:
  - Create series of videos / TED style talks that communicate uncertainty
  - Develop common scenarios that could be used to generate ensemble of results in each model to understand structural uncertainty
  - Develop process to encourage community to think of outside of the box scenarios/edge cases that can help prepare for less expected outcomes
  - Use standardized libraries/tools to compile outputs that can help explore consensus across multiple models (See for example pyam https://pyam-iamc.readthedocs.io/)
  - Workshop to focus on how you pick metrics for comparison across models
- Plan for next year:
  - Use MES speaker series to focus on uncertainty and effective communication
  - Engage the decision making under deep uncertainty community to identify synergies and lessons for MES work
  - Model intercomparison (open data, open model, open results) effort underway for electricity capacity expansion models; develop common tool for exploring/compiling/exploring results across different models (e.g. Pyam)

How do we better incorporate human behavior at different stages of model development to drive the energy transition?

- To Do:
  - Special issue on interdisciplinary human behavior + MES modeling
- Plan for next year:
  - Workshop to build community
  - Weekly meeting sessions (Ph.d-students, post-docs and early career faculty) to develop a common ground of terminology and core ideas
  - Request for funding to incentivise interdisciplinary work/collaboration
  - Request for funding to add model complexity

How can MES research use community feedback to benefit stakeholders and provide human scale outcomes?

In the first round the idea of having MES research grounded in community preferences was prominent. This group discussed how this might be operationalized. The suggestions fell into X categories including (1) efficient data collection; (2) modeling; and (3) communication. Some key suggestions and ideas are listed here.

- Contingent valuation
- Apps on phones, for example to record blackouts, temperatures inside homes, etc.
- Smart meters combined with experiments, noted that often marginalized communities don't have smart meters.
- Sensors and instrumenting homes, again with an eye toward equity.
- Compulsory data from utilities
- Data collection designed in a way to get information that is useful for models, or useful for decision making.
- Attention to how data are aggregated before they go into models; what are the associated biases; what is being lost?
- Model at a granular level for use in communities; at the same time, determine when granular results are not needed or important.
- Multiple, modular models
- Linked models
- Downscale results to a power plant level, or a level relevant to regulatory action or decision scale
- Invite to the MES community people who think carefully about the human side, for example behavioral, epidemiological, social science, community representatives, meteorologists
- Outputs explained to communities in ways that are meaningful and useful for decision making
- Information that is communicated needs to go beyond costs, to other issues of importance to communities.
- Interactive tools, virtual reality, and art
- Use ideas from media that communities engage with, for example, weather reports
- Include diverse voices and perspectives when deciding what data to collect and how to use it. Modelers should ideally be from diverse backgrounds

MES Community Meeting

The final event of the workshop was the MES Community Meeting. Its purpose was to gather feedback from all of the workshop participants to help the MES Steering Committee prioritize future activities. We also invited enthusiastic participants to volunteer to organize MES activities that they feel particularly passionate about. The Community Meeting began with a brief summary of the activities that the Steering Committee has undertaken to date, to make sure that all workshop participants understood what we've already done and to provide a common foundation for thinking about possible future endeavors. Then, most of the Community Meeting was devoted to an open discussion in which participants were encouraged to suggest MES activities that they think would be valuable (and also identify activities that are not of interest). The discussion was divided into six themes, each with an overarching question that was posed to all participants. The sections below summarize some of the most notable feedback that participants provided for each one.

1. Building and engaging with the MES community — *How would you like to identify, affiliate, and engage with the MES community?*

- There is a need to establish mechanisms that allow people to identify as part of our MES research community, beyond the small Steering Committee and the group of workshop participants
- Expand the use of "macro-energy systems" as a Google Scholar keyword
- We could create a database of MES researchers where people self-identify and submit their information for approval, including keywords; make this database searchable on the MES website; could help MES scholars connect with each other
- There did not seem to be much enthusiasm for making MES a formal society with membership fees and so on
- While MES began as a U.S.-focused group, participants advocated for making it more global with international representation on the Steering Committee
- Note that a number of non-U.S. researchers participated in this workshop despite it being held in person at Stanford

2. Workshops and conferences — *How should we plan to bring the MES community together at workshops and conferences?*

- Participants expressed support for holding annual MES workshops but having them alternate between in-person and virtual formats
- Participants really liked the flash talk + poster session concept that we trialed at this workshop, and also liked having two keynote addresses
- In order to sustain our workshops moving forward, finding additional funding sources will be important; this one was able to take place as successfully as it did due to support from Stanford and others
- In terms of size, participants liked that this in-person workshop was small enough to encourage interesting discussions and allow people to get to know each other, but think that our virtual workshops should be larger to broaden participation
- There was enthusiasm for organizing MES side events (substantive and/or social) at major conferences that many of us attend, such as INFORMS and AGU
- We can also organize MES sessions - identified as such in the program - at these conferences, as some of us did at the 2021 INFORMS Annual Meeting

3. Speaker series topics — *What topics should we address in future panel discussions as part of the MES Speaker Series?*

- Economic principles that inform energy models
- Bring in experts from other relevant research and practice communities
  - Climate modeling
  - Urban planning
  - Finance
  - Behavioral science
  - Science communication
- Career paths in MES (especially useful for students)
- Modeling technological change and game-changing technologies

4. Students and education —
What educational resources should we offer related to MES, and how can we best support students who are interested in the MES space?

- Students suggested that it would be useful to put together a compilation of MES modeling tools and databases with supporting descriptions and tutorial videos; this could be hosted on the MES website and provide a template that users can fill out for each item, essentially crowd-sourcing the information
- The tutorial videos could be promoted as educational materials (e.g. on the MES YouTube channel) or even incorporated into a more formal MES introductory "course"
- MES should consider offering a summer short course
- An NSF REU program based on an MES research theme could be a terrific way to fund MES research and bring talented undergraduates into our research community
- Students expressed a desire for more information and advice on the full range of careers that are aligned with MES; a speaker series panel that showcases different MES career paths would be helpful

5. Funding for MES activities —
What additional activities could MES pursue if we raised more money, and what funding sources could we target?

- NSF and some foundations offer grants for workshops, so we could pursue them to help cover the costs of future workshops
- A summer short course (mentioned above) could also help us fund a workshop if the two events are organized back to back in the same location
- Participants expressed mixed feelings about seeking industry sponsors of MES; the funding could be valuable but we should maintain independence
- It would be helpful to have sufficiently steady funding to hire a secretariat, so that we can have consistent administrative support

6. Open discussion —
What additional ideas do you have for activities that the MES community should pursue over the next 1-2 years?

- In the open discussion there was ample support for the importance of MES providing platforms for researchers to share knowledge and tools - models, databases, tutorial videos and "how-to" documents, new publications, and so on

Follow-up Survey and Results

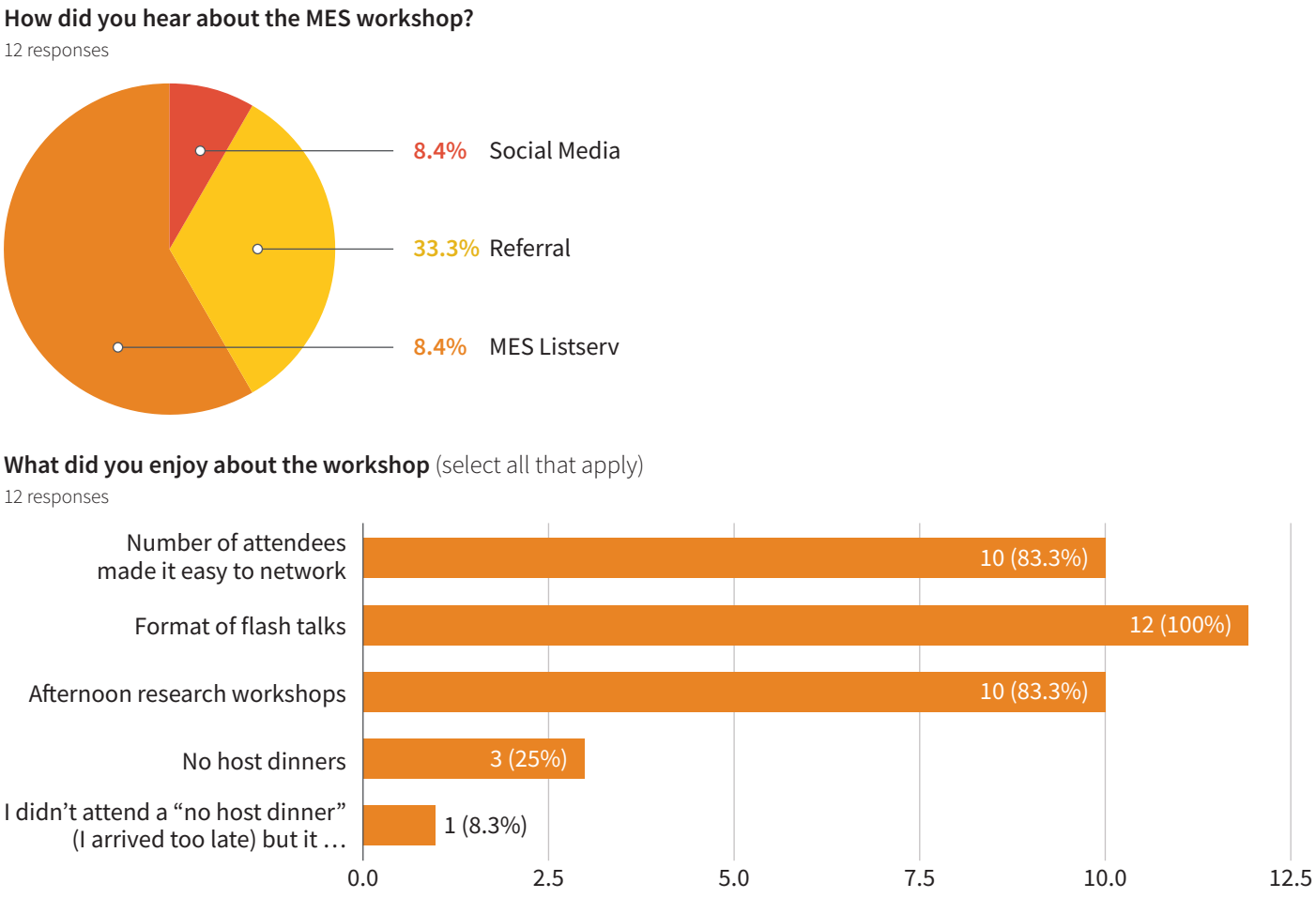
A follow-up survey was conducted after the workshop. We asked attendees what they enjoyed the most about the conference, any suggestions they had, and what conferences they regularly attend (for organizing potential MES track sessions in those conferences). Figure 4 shows where folks heard about the MES workshop and aspects of the workshop they most enjoyed. Important takeaways include:

a) The format of lightning talks, afternoon research workshops, and the number of attendees received a thumbs up from all respondents.

b) Suggestions included: more presentations from faculty/ senior people, more discussion on limitations of modeling with respect to decision making, polling dietary restrictions beforehand, and mixing up topics during sessions so the presenters can interact with other like-minded researchers during other sessions.

c) Conferences that respondents regularly attend are: INFORMS, IEEE PES GM, ISSST, AEESP, PSCC, AGU, Industrial Ecology Conference.

Figure 4: Summary of participant responses to the follow-up survey.



The Path Forward

The 2022 MES Workshop was an important part of the ongoing effort to grow the MES community and improve the quality and impact of MES research. We appreciate the attendance of a diverse group of researchers from academia, government, and the private sector, and were particularly encouraged by the strong interest and engagement from young researchers and students. The workshop was successful in promoting increased dialogue and community building among MES researchers, and the ideation sessions and community meeting have provided grounding and ideas for future research and community initiatives.

In the coming months we hope to build on the workshop's successes, engaging with community members to develop the proposed initiatives and encourage greater participation and cross-collaboration among current and new community members. We envision MES as an inclusive and community-driven project, and encourage those interested in promoting new ideas or initiatives to reach out to the Steering Committee or the community at large via the MES Discussions board. We hope that those currently engaged with MES will continue to help grow and promote our community, raising awareness of MES resources and inviting new researchers to work with us on the transition toward a low-carbon future.

Acknowledgements

We would like to acknowledge the Stanford Bits and Watts Initiative for providing funding for this workshop. We thank the MES Workshop Committee for their work allowing this workshop to happen. We thank the MES steering committee, in particular the Chair Patricia Levi, for providing the backbone of the MES community. We particularly thank Lizzy Kolar and Polly Yan for invaluable administrative support.

Appendix A – List of Presentations

NAME	LIGHTNING TALK TITLE
An Pham	The Value of Advanced Planning for a Negative Emissions Power System
Aneesha Manocha	Reducing transmission expansion by co-optimizing sizing of wind, solar, storage, and grid connection capacity
Anna Li	Is there space for a third storage technology in variable renewable electricity systems with long- and short-duration storage?
Cameron Wade	The ACES Project & temperature dependent efficiencies in capacity expansion models
Carey King	Is energy in your macroeconomics? … no, really?
Charalampos Avraam	Critical Infrastructures Resilience Against Compound Cyber-Physical Threats
Charles Van-Hein Sackey	Infrastructure Decision Preferences and the Influence of Social Justice Education
Dakota Thompson	The American Multi-Model Energy System Model
Enrico Antonini	The quantity-quality transition in the value of expanding wind and solar power generation
Eric Scheier	Measuring Household Net Energy Burdens
Erik Smith	Projected Changes in Wind and Solar Resources and Implications for Renewable Generation
Geoffrey Blanford	Achieving Economy-Wide Net-Zero Carbon Emissions in the U.S.
Natasha Reich Presented by Jacqueline Dowling	Technological levers and constraints of Power-to-Gas-to-Power (PGP): Hydrogen energy storage at scale
Jethro Ssengonzi	Assessment of renewable energy capacity credit at increasing regional grid penetration levels
Jill Ferguson	Enhancing Demand Side Macro-Energy System Model Scenarios
Kshitiz Khanal	Improving Generalization of Energy Infrastructure Information Extraction from Aerial Images across Geographies Using Conditional Generative Adversarial Networks
Lane Smith	Should Storage-Centric Tariffs be Extended to Commercial Flexible Demand?
Liqun Peng	Heterogeneous effects of battery storage deployment strategies on decarbonization of provincial power systems in China
Lyssa Freese	Nuclear and Coal Power Generation Phaseouts Redistribute U.S. Air Quality and Climate Related Mortality Risk
Miriam Athmer	Coal Phase-Out in Germany: The Wicked Problem of Structural Change in the Rhenish Lignite Area

NAME	LIGHTNING TALK TITLE
Morgan Edwards	Modeling uncertain adoption of carbon dioxide removal technologies using historical analogues
Noah Kittner	The need to address disparities associated with increased electrification
Paola Pimentel Furlanetto	Capturing Carbon But Not Its Co-Pollutants
Qian Luo	Diverse Pathways for Power Sector Decarbonization in Texas Yield Health Co-Benefits, but Fail to Alleviate Exposure Inequities
Qianru Zhu	Enhancing policy realism in energy system optimization models: Politically feasible decarbonization pathways for the United States
Rajon Bhuiyan	Assessing the need for power system flexibility on a global level: A multi-criteria assessment index
Ranjitha Shivaram	Modelling the impact of hybrid work on urban energy use
Ruaridh Macdonald	Co-Optimizing Heat and Electricity Generation in Macro-Energy System Models
Sam Penrose	Towards Better Units for Macro Energy Systems
Simon Öberg	The cost dynamics of hydrogen supply
Suman Saurabh	An Agent-Based Approach To Consumption, Inequality In Distribution And Sustainability Of A Limited Sourced Energy-Dependent Society
Teagan Goforth	Low-carbon energy transitions: a systematic approach to quantifying equity and sustainability trade-offs
Tyler Ruggles	How many years of data are enough?
Wilson Ricks	Operational Flexibility and the Future of Geothermal Power
Yinong Sun	Second-best Transmission Planning Under Regional Carbon Policy

Appendix B – Agenda Overview

TIME	EVENT	SPEAKER
7:45 – 8:30 am	Check-in	
8:30 – 10 am	Lightning Talks and Poster Session | Round 3	See Lightning Talk Speaker List
10 – 10:30 am	Break	See Lightning Talk Speaker List
10:30 – noon	Lightning Talks and Poster Session | Round 4	See Lightning Talk Speaker List
noon – 1 pm	Lunch	
1 – 2 pm	Keynote | Open Energy Outlook	Paulina Jaramillo Jeremiah Johnson Katie Jordan Aranya Venkatesh Aditya Sinha
2 – 2:30 pm	Break	
2:30 – 3:30 pm	Policy-Relevant MES Research Workshop: Prototype	Sauleh Siddiqui
3:30 – 3:45 pm	Break	
3:45 – 5 pm	MES Community Meeting	Ben Leibowicz
5 – 5:15 pm	Day 2 Wrap Up	Erin Baker

Appendix C – Attendee List

Enrico Antonini, Carnegie Science

Miriam Athmer, Ruhr-University Bochum

Charalampos Avraam, New York University

Erin Baker, University of Massachusetts Amherst

Rajon Bhuiyan, SnT – Interdisciplinary Centre for Security, Reliability and Trust; University of Luxembourg

Geoffrey Blanford, Electric Power Research Institute

Valentina Bosetti, Bocconi University

Jacques de Chalendar, Stanford University

Jacqueline Dowling, California Institute of Technology

Morgan Edwards, University of Wisconsin Madison

Aldís Elfarsdóttir, Stanford University

Jill Ferguson, Stanford University

Lyssa Freese, Massachusetts Institute of Technology

Isabella Gee, Alfred P. Sloan Foundation

Teagan Goforth, Carnegie Mellon University

Guido Guida, Terna SpA

Jason Hirschey, Georgia Institute of Technology

Bri-Mathias Hodge, University of Colorado

Paulina Jaramillo, Carnegie Mellon University

Jesse Jenkins, Princeton University

Jeremiah Johnson, North Carolina State University

Katherine Jordan, Carnegie Mellon University

Aditya Keskar, North Carolina State University

Kshitiz Khanal, University of North Carolina at Chapel Hill

Carey King, University of Texas at Austin

Noah Kittner, University of North Carolina at Chapel Hill

Benjamin Leibowicz, The University of Texas at Austin

Patricia Levi, Stanford University

Fran Li, University of Tennessee

Anna Li, California Institute of Technology

Qian Luo, North Carolina State University

Ruaridh Macdonald, Massachusetts Institute of Technology

Aneesha Manocha, Princeton University

Joan Nkiriki, Carnegie Mellon University

Destenie Nock, Carnegie Mellon University

Simon Öberg, Chalmers University of Technology

Alison Ong, Stanford University

Liqun Peng, Princeton University

Sam Penrose, Nextera Energy

An Pham, University of Michigan Ann Arbor

Paola Pimentel Furlanetto, University of Massachusetts Amherst

Natasha Reich, California Institute of Technology

Wilson Ricks, Princeton University

Tyler Ruggles, Carnegie Science

Suman Saurabh, The University of Texas at Austin

Eric Scheier, Department of Energy Solar Energy Innovators Program Fellow

Ranjitha Shivaram, Stanford University

Sauleh Siddiqui, American University

Aditya Sinha, North Carolina State University

Lane Smith, University of Washington

Erik Smith, Electric Power Research Institute

Jethro Ssengonzi, North Carolina State University

Yinong Sun, Johns Hopkins University

Dakota Thompson, Thayer School of Engineering at Dartmouth College

Camilo Toruño, Mascoma LLC

Charles Van-Hein Sackey, Carnegie Mellon University

Cameron Wade, Sutubra Research

Andrew Wadsworth, Cell Press

John Weyant, Stanford University

Qianru Zhu, Electric Power Research Institute

Micah Ziegler, Massachusetts Institute of Technology

MES Steering Committee

Inês Azevedo, Stanford University

Erin Baker, University of Massachusetts Amherst

Sally Benson, Stanford University

Jacques de Chalendar, Stanford University

Joseph DeCarolis, North Carolina State University

Elisabeth Graffy, Pacific Northwest National Laboratory

Emily Grubert, Georgia Tech

Jesse Jenkins, Princeton University

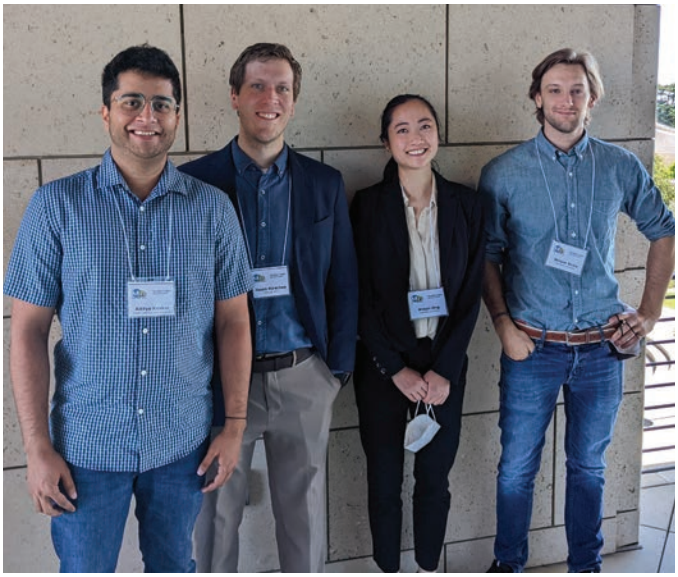
Ben Leibowicz, University of Texas at Austin

Patricia Levi, Stanford University

Sauleh Siddiqui, American University

Valerie Thomas, Georgia Tech

John Weyant, Stanford University



Macro-Energy Systems student fellows (2021-22): Aditya Keskar, Jason Hirschey, Alison Ong, Wilson Ricks.

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