The City College of New York
Office of Research

CRV: Community Energy Cells: An Interdisciplinary Approach to Climate Change, City Resiliency, and Energy Justice

Project Team:
Principal Investigator: Ahmed Mohamed
Department: Electrical Engineering, Grove School of Engineering, The City College of New York
Other Key Personnel: Jorge Gonzales (ME/GSOE); Shawn Rickenbacker (J. Max Bond Center, Architecture); Punit Arora (Economics/Business); Susanna Schaller (Urban Studies, Administration, and Planning/CWE); Michael Bobker (BPL-CIUS, Rangel Center); Mohamed Ali, (EE/GSOE); Michael Grossberg (CS); {Alexander Couzis, Sanjoy Banerjee, Robert Messinger, Elizabeth Biddinger} (ChE/GSOE)

Project Concept Description: (Maximum 2 pages)

Keywords: Community Energy Cells, Energy Justice, Global Warming, and Resiliency.

Objective: We propose to inaugurate a college-wide research focus on addressing climate change while promoting economic prosperity using a novel decentralized approach titled "Community Energy Cells." A *Community Energy Cell* (CE-Cell), in the context of this proposal, refers to *a group of distributed energy resources (DERs) and controllable loads (photovoltaic, batteries, electric vehicle chargers, smart buildings, etc.) in close geographic proximity, which can be collectively represented via a Cell Aggregator (CA) as a single controllable entity with respect to the main power grid*. CE-Cells can operate independently in a microgrid mode during service interruptions and provide backup power and telecommunications. CE-Cells form block-chain based peer-to-peer transactive grid markets where energy can be traded locally and/or among neighboring CE-Cells. The DERs within a CE-Cell can be owned by individual households, buildings, shared among community members, or a combination, with reliability and economic benefits shared among all participants. CE-Cells can be targeted to facilitate deployment of renewable energy sources in low-income communities, since they provide new revenue streams making renewable energy more affordable.

Approach: CE-Cells introduce a paradigm shift in the way energy is produced and delivered, with unprecedented levels of community involvement. Our central hypothesis is that decentralized deployment and operation of DERs, in the form of CE-Cells, is a key requisite to addressing climate change and resiliency while ensuring energy justice. To develop this vision, we will use the Harlem area as a case study to: (i) engage the community and collect data that gauge their interest and acceptance; and (ii) develop technical, economical, and regulatory framework proof of-concepts. The case study will be scalable and transferrable.

Research Question 1*: What are the set of design and functional requirements for CE-Cells that can lead to community acceptance?*

Work Package 1: Community Engagement/Acceptance (Schaller, Arora, Rickenbacker, Mohamed, Bobker, Grossberg)

- WP1-Task 1: to facilitate workshops at CCNY and create materials that translate technical concepts (i.e., the proposed vision) into language that is readily understood by lay people and can be effectively deployed in creating coherent messaging around the concept of the CE-Cell.
- WP1-Task 2: design activities focused on engaging the Harlem community and raising awareness around energy consumption. These activities shall involve interdisciplinary teams of students, faculty, and community members, facilitated by the existing strong ties with Harlem community boards.
- WP1- Task 3: examine and anticipate stakeholder resistance to adoption from a behavioral economics perspective. This task will involve analyzing surveys and interviews with various stakeholders.
- WP1- Task 4: compile the outcomes of Tasks 1-3 into a set of community requirements, which will inform CE-Cell design and operation.

Research Question 2*: Can technology support CE-Cell design that fulfils community requirements?*

Work Package 2: Technology Readiness (Mohamed, Gonzales, Bobker, Messinger, Biddinger, Gonzales, Banerjee, Ali, Couzis, Grossberg)

- WP2-Task 1: in collaboration with ConEdison, develop and simulate a framework for a realistic case when groups of buildings and facilities within Harlem are forming CE-Cells. Identify and address challenges related to interconnection, control, and protection.
- WP2-Task 2: advance safe low-cost DERs and energy storage for resilient CE-Cells, in coordination with designing grid-interactive building retrofits for carboncap compliance with NYC Local Law 97.
- WP2-Task 3: explore how advances in block-chain technology can be tailored to enable CE-Cells energy markets and integrate the outcomes to the proof-of-concept.

- WP2-Task 4: leverage recent advances in 5G technologies (e.g., network function virtualization and network slicing) to enable reliable massive machine type communications, and hence realizing our CE-Cell vision.
- WP2-Task 5: assess the resiliency benefits achieved by CE-Cells against short-duration outages, and advance their design to mitigate weather-induced long duration outages brought about by climate change.

Research Question 3*: How can CE-Cells be sustainable and economically viable?*

Work Package 3: Economic Viability and Marketing (Arora, Bobker, Rickenbacker, Mohamed)

- WP3-Task 1: develop marketing strategies to approach the general public as well as policy makers.
- WP3-Task 2: given current regulations and market design, evaluate potential revenue streams for CE-Cells, e.g., whether certain energy-related CE-Cell capabilities, such as distributed storage to provide capacity assurance and system stability, can be traded among CE-Cells and with the wholesale market.

Workplace Training and Student Education.

- Entrepreneurship and Innovation Competition: In collaboration with the Zahn Innovation Center, the team will support a college-wide student entrepreneurship competition centered around community-based energy systems, to develop and execute start-up ideas.
- A postdoc and three PhD students will be recruited and co-mentored by Co-PIs. The PhD students will tackle the various aspects while working very closely to gain interdisciplinary expertise.
- Some of the outcomes of this project will be fused into existing courses (e.g., EE G6910 Renewable Energy) or lead to development of new courses.

Outcomes: The work will result in a case study, based on real network/load data and community feedback, and engaging community members, power utility, and policy makers in co-developing CE-Cells. The work will help build a new area of focus for social science study at CCNY, complementing initial effort in the Colin Powell School Climate Fellows program along with community engagement and improved town-gown relationships; an earlier proposal effort for the US DOE Connected Communities program showed the potential for this to occur. The CRV funding will strengthen the team to further pursue external funding.

Expected Products: The team members have a track record of high-quality publications and funding proposals in areas related to the proposed topic.

- We plan to publish 3-5 articles per year in both engineering and social science journals.
- The team will aim at multiple proposal submissions, repeating application to the US DOE Connected Communities program and pursuing opportunities with NYSERDA and other state and federal agencies. The team will establish working relationship and organizational format for community engagement around CE-Cells, with participation from community organizations, political representatives and city agencies.

Merits: The proposed approach is expected to lead to: **(1)** combating global warming by enabling increased deployment of renewable energy; **(2)** improving city resiliency in response to low-frequency high-impact events by securing community-based back-up power and telecommunications; **(3)** ensuring environmental/energy justice by empowering low-income communities to access affordable and clean energy; and **(4)** introducing more green energy jobs to low-income communities.

Impact: The proposed project, if successful, will result in a tangible future-proof solution to combat global warming, increase city resiliency in the face of natural disasters and manmade threats, and assure energy justice by enabling low-income communities to access affordable renewable energy and be less prone to service interruptions. The outcomes of this project will directly impact and benefit NY. These outcomes will be scalable nationally and globally and transferrable to other locations.

Milestones:

Months 1-6: *Collect data and prepare tools; start community and stakeholder engagement; prepare case study.*

End of Year 1: *Annual report; discuss Year-1 results and Year-2 development plan; analyze low-income data; develop marketing strategy; prepare preliminary results from case study for proposal submission.*

End of Year 2: *Established community and stakeholder engagement; test marketing strategy; submit a proposal*

End of Year 3: *Complete the case study; disseminate the results; target a large proposal submission (e.g., NSF ERC).*

Budget (Maximum Budget $200K):

Post-doc ($66K), 3 PhD students ($108K)

OTPS Costs: Supplies ($26K) (field experiments to analyze community adoption practices resistance + entrepreneurship award money)