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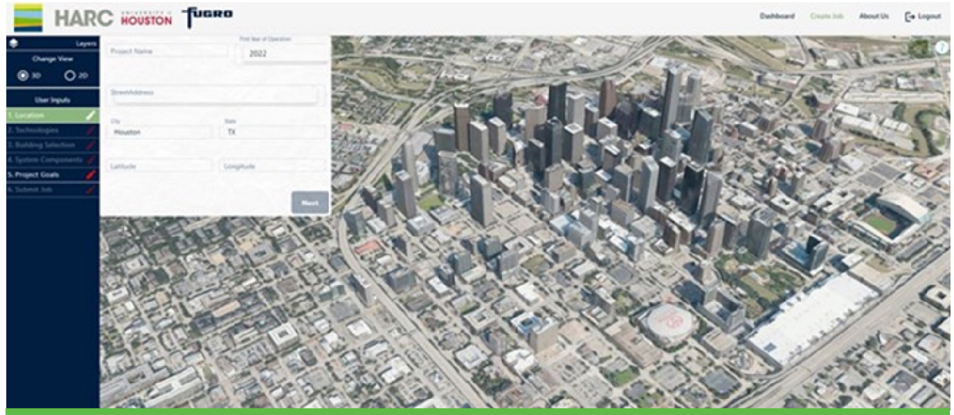

A screenshot of the feasibility analysis tool's graphical user interface (GUI). *Image courtesy of HARC, University of Houston, and Fugro.*

A Simplified Tool for Rapidly Deploying Feasibility Analytics for the Non-Technical User

District energy systems efficiently provide thermal energy to multiple buildings and facilities through a network of shared infrastructure. Frequently, district energy systems are centered around combined heat and power (CHP) plants that generate electricity, as well as heating and cooling, to the local buildings. By providing both electricity and thermal energy from a single fuel source and central location, these systems use less fuel, decrease energy and operational costs, and reduce the need for heating and cooling equipment in individual buildings.

District energy systems are found throughout the world in areas such as denser downtowns, college campuses, military bases, and hospital complexes. These systems range in capacity and can utilize different fuel types and technologies. While district energy has been around for more than a century, these systems are not as common in the United States as in many other countries.

District energy system adoption is complicated, in part, by the lack of accurate information available to key decision-makers (such as investors and government officials). Better decisions could be informed through feasibility analysis, an essential step in planning any energy system, as it allows project developers to assess the system's practicality. The evaluation includes identifying specific CHP technologies appropriate for a particular district energy system, projecting financial risk, locating technical resources, weighing budgetary considerations, and identifying potential options and solutions. However, conducting a feasibility analysis and interpreting the results requires a technical background that most decision-makers lack.

This project will develop an agile, user-friendly feasibility analysis tool for stakeholders with limited engineering knowledge to expedite the feasibility analyses of CHP-based district energy systems and microgrids. By integrating a geographic information system (GIS), the feasibility analysis tool will reduce the time needed to complete feasibility analyses. The tool will also include artificial intelligence (AI) technologies that will help eliminate decision-maker bias. Together, these built-in mechanisms will expand the number of district energy system/microgrid options that can be expeditiously assessed, ensuring that end users are provided with the optimal preliminary designs for their needs among the thousands of options available in every project. The project will also develop a user-friendly website to host the tool and provide access to training and educational materials.

Benefits for Our Industry and Our Nation

District energy systems and community microgrids benefit end users by improving energy efficiency and power supply reliability. However, inadequate analysis prevents decision-makers from identifying the most cost-effective, efficient, and resilient system with the greatest long-term benefits. The feasibility analysis tool will provide answers to "real-world" planning questions, enabling informed choices for users, including those without technical backgrounds. The democratization of a feasibility analysis tool is expected to result in increased implementation of district energy systems and microgrids by enabling system selections that are more likely to meet planners' economic and efficiency goals.

In addition, the tool will support the identification of the incentive policies required to raise interest and involvement among investors, increasing the likelihood that implementation initiatives will garner adequate interest and funding.

Applications in Our Nation's Industry

This project will advance the state-of-the-art of district energy system and microgrid planning. Not only will the feasibility analysis tool remove cost and technical barriers for non-technical users, it will also be capable of assessing the integration of CHP technologies, renewable energy sources, and battery and thermal storage for new and existing district energy systems/microgrids. Investors, policymakers, and market researchers will have the ability to independently determine business opportunities centered around district energy system/microgrid implementation.

In addition to analyzing multiple physics and engineering domains impacting CHP-based single- and multi-building district energy systems/microgrids, the tool will also provide advanced features for technical users. The features will include a detailed description of the technical solution, more accurate performance assessments, and defined probability of different economic results. With AI integration, the tool will bring an unprecedented level of breadth and objectivity to the feasibility analysis process by enabling the unbiased assessment of many more CHP-based district energy system/microgrid options. The feasibility analysis tool could be used to validate resilient designs and potential carbon-neutral scenarios in urban areas as well.

Project Description

The goal of this project is to develop a cloud-based, user-friendly, and agile feasibility analysis tool that will allow stakeholders, investors, government officials, and other non-technical users to participate in the feasibility analysis process of CHP-based district energy system and microgrid planning. Using downscaled future climate data and risk analysis techniques, the tool will provide detailed information about future economic performance, while cutting modeling time in half and costs to zero. The completed tool will be available to the public, free of charge, and fully operative for a 25-square-mile area in Downtown Houston.

Barriers

- Integration of the tool components, such as the incorporated GIS tool, downscaled climate data, and geospatial data
- Optimization of the tool's execution time, which may be hindered by the complexity of the employed algorithms and the high volumes of data to be managed

Pathways

This project will be divided into two phases, each 18 months in duration. At the end of the first phase, the GIS tool will be customized for feasibility analysis inputs and will be able to send the input to the computational engine in the correct format. At this point, the climate model and all the data will have been integrated into the GIS tool, and the computational engine will be able to identify an optimal microgrid system.

Adding a customized GIS tool to the system will expedite data collection. Other information that will need to be incorporated into the tool (e.g., pricing and technical information on CHP systems, renewable energy technologies and energy storage, and distribution systems) will be found online. Any updated average prices that are not publicly available will be obtained from engineering companies and vendors to provide the most accurate results possible.

The University of Houston, a project partner, will work to improve the existing algorithms, which will be compiled into a cloud-based computational engine hosted in the university's Research Computing Data Core (RCDC). Using this facility's high-performance computing resources, the project will optimize the feasibility analysis users' experience. The user will input variables through the GIS tool; the RCDC will execute calculations on a first-come, first-served basis and send an e-mail to the user with a link to the results.

At the end of the second phase, the website hosting the fully operative tool will be complete, as will training and promotional materials. Format results and their values will have been validated, and the tool will be able to perform feasibility analyses for district energy systems and microgrids.

Milestones

This three-year project began in late 2020:

- Preliminary design of the GUI, including a description of inputs and outputs prior to execution of the computational engine (2021)
- Testing of probability functions for sensitive variables integrated into the GIS tool (2021)
- Integration of downscaled climate data and geospatial data (2021)
- Testing of data exchange between the GIS tool and the computational engine in the required formats and confirmation of output accuracy (2021)
- Tool testing with non-technical users under guidance of the project team, followed by analysis and incorporation of user feedback (2021)
- Intensive tool testing, including development of four theoretical case studies showing positive and negative feasibility values (2022)
- Validation of results through the completion of at least 16 feasibility analyses on district energy systems/microgrids within the Downtown Houston demonstration area (2022)

Technology Transition

Upon project completion, the website will be launched, providing access to the fully operative tool. The website will include training materials and a user manual, including 10 video tutorials detailing the tool's capabilities and providing instructions for each function. The tool will be formally launched at a U.S. Department of Energy event before a national audience.

Project Partners

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