NREL Transforming ENERGY

2019 ASHRAE WINTER CONFERENCE
JANUARY 12–16 // AHR EXPO JANUARY 14–16

Seminar 14 - Multiscale Building Energy Modeling, Part 10

Modeling Zero Energy Communities

Daniel Macumber

National Renewable Energy Laboratory, Golden, CO

daniel.macumber@nrel.gov

Learning Objectives

- Introduce the EnergyPlus features to enable building energy models to explicitly consider thermal interactions between buildings and among buildings and the urban atmosphere
- Describe different Zero Energy definitions
- Understand design principles for Zero Energy Communities
- Understand the scalability and accuracy of current urban/multi-scale approaches

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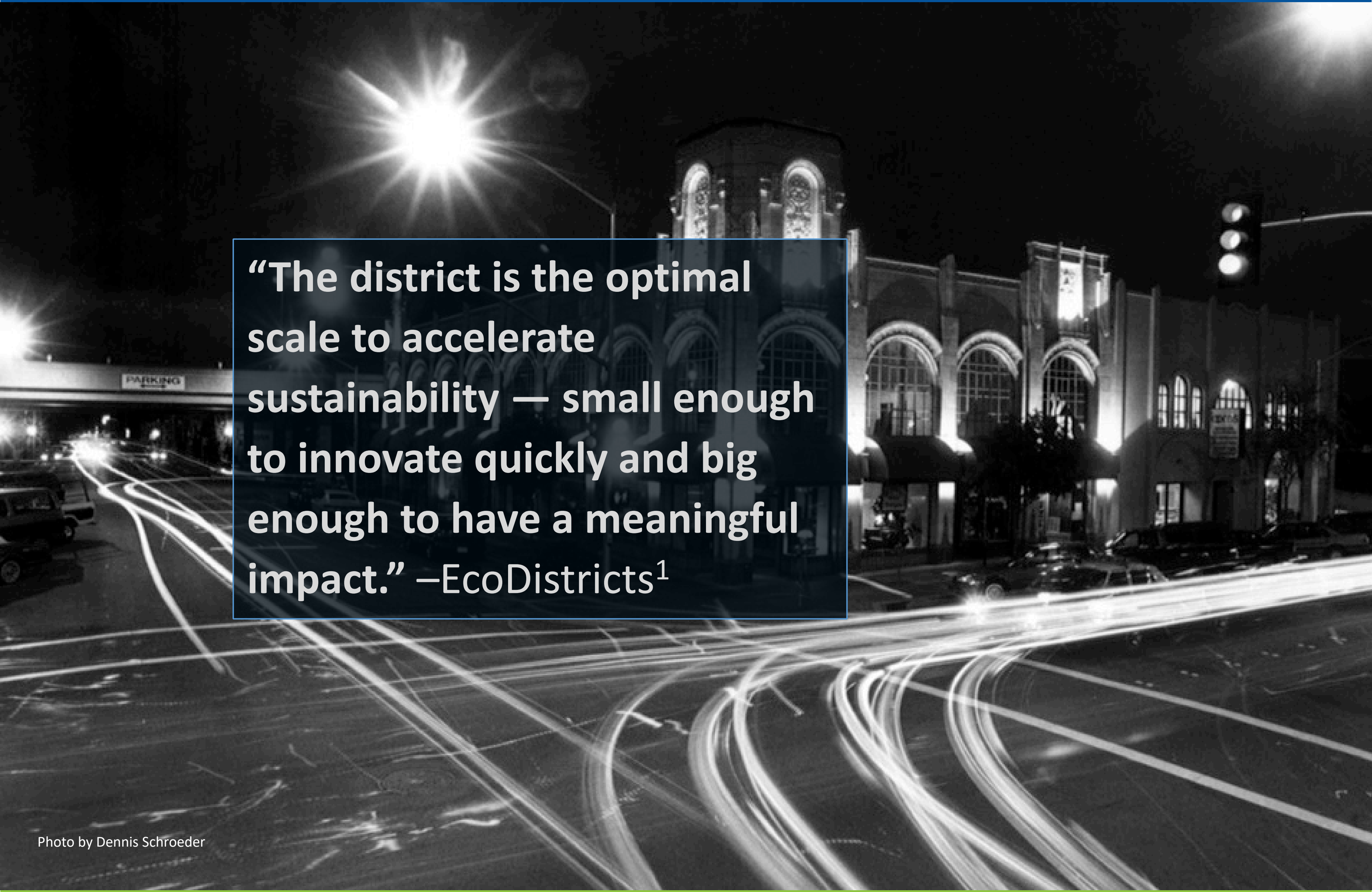
Acknowledgements

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided in part by U.S. Department of Energy Building Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

Outline/Agenda

- Why districts?
- What do districts need?
- Vision of a district energy analysis ecosystem

Why Districts?



"The district is the optimal scale to accelerate sustainability — small enough to innovate quickly and big enough to have a meaningful impact." –EcoDistricts[1]

Photo by Dennis Schroeder

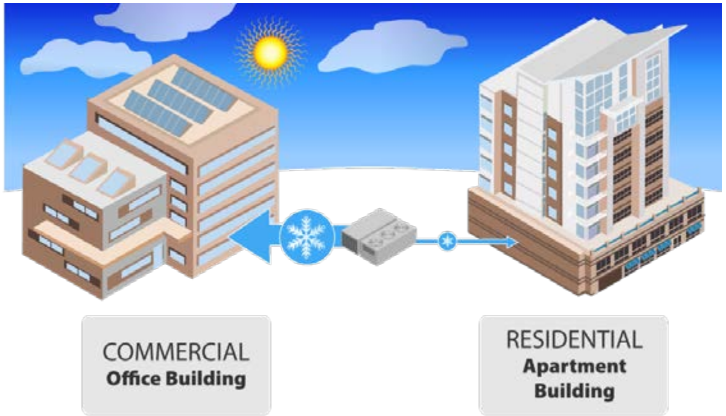
Why Districts?

Unlock new cost-effective energy savings through:

- Upfront planning
- Economies of scale
- Load diversity
- Waste heat capture

Testbeds for new:

- Technologies
- Utility programs



Zero Energy Definitions

Definitions [2]

In addition to establishing a definition for ZEB, shown below, it was clear that definitions were needed to accommodate the collections of buildings where renewable energy resources were shared. To meet this need, the team provided variations on the ZEB definition. The bold text represents key terms that are further addressed in the nomenclature and guidelines.

Zero Energy Building (ZEB)

An energy-efficient **building** where, on a **source energy** basis, the actual **annual delivered energy** is less than or equal to the on-site renewable **exported energy**.

Zero Energy Campus

An energy-efficient **campus** where, on a **source energy** basis, the actual **annual delivered energy** is less than or equal to the on-site renewable **exported energy**.

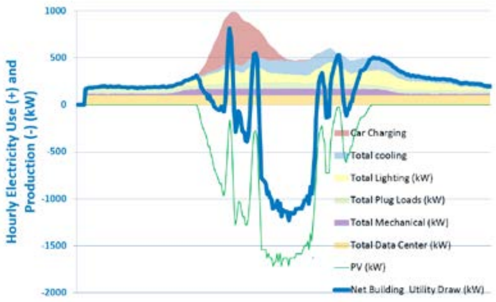
Zero Energy Portfolio

An energy-efficient **portfolio** where, on a **source energy** basis, the actual **annual delivered energy** is less than or equal to the on-site renewable **exported energy**.

Zero Energy Community

An energy-efficient **community** where, on a **source energy** basis, the actual **annual delivered energy** is less than or equal to the on-site renewable **exported energy**.

Zero Energy District Design Principles



Maximize Building Efficiency

Maximize Load Control

Maximize Solar Potential

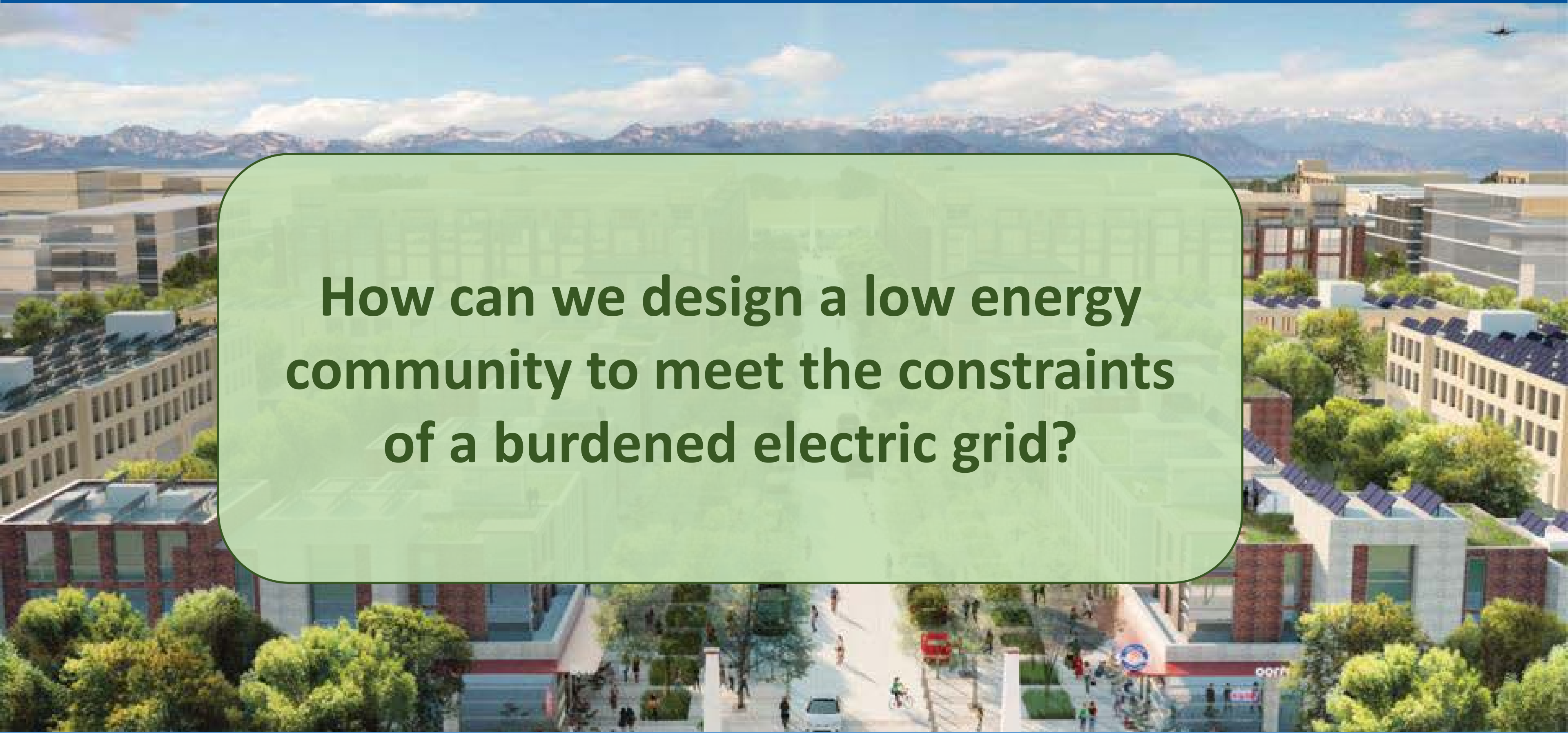
Maximize Renewable Thermal and Heat Recovery

Better Buildings Zero Energy District Accelerator

- **Six district partners across U.S.**
  - **Developing energy master plans with DOE/NREL/partner guidance**
  - **Identifying common barriers and innovative solutions**

- **National partners:**
  - **USGBC**
  - **EcoDistricts**
  - **Rocky Mountain Institute**
  - **Xcel Energy**

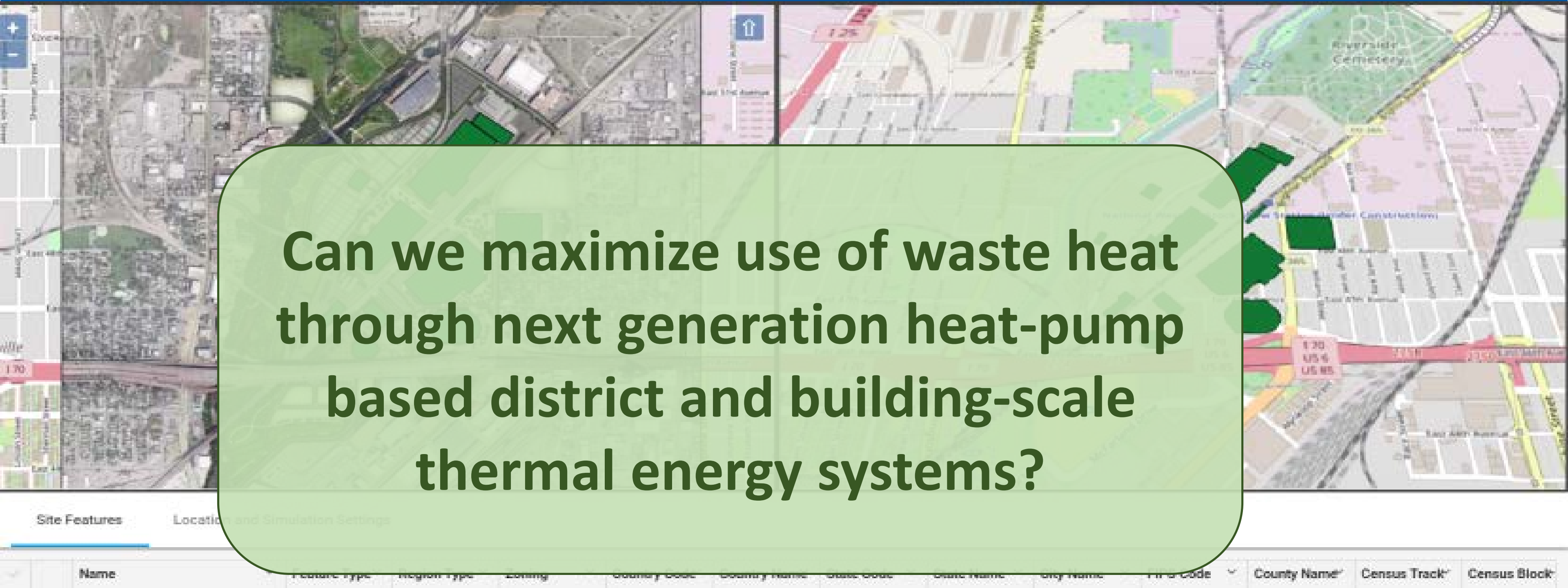
Peña Station Next, Denver, CO



How can we design a low energy community to meet the constraints of a burdened electric grid?

- DOE ESIF High Impact Project (FY17/18)
- Project Partners: Xcel Energy, Panasonic, L.C. Fulenwider Inc., City and County of Denver
- Building and distribution system modeling to assess “non-wired” solutions
- Evaluated 4 different scenarios with varying levels of energy efficiency and system types. Presented results to developers.

National Western Center, Denver, CO



Can we maximize use of waste heat through next generation heat-pump based district and building-scale thermal energy systems?


Rendering Provided by City and County of Denver

- DOE Accelerator District Partner
- City of Denver, Colorado State University, Xcel Energy, CH2M
- Modeling development/workflow validation through NREL LDRD project (FY16/FY17)
- Modeling helped set EUI targets

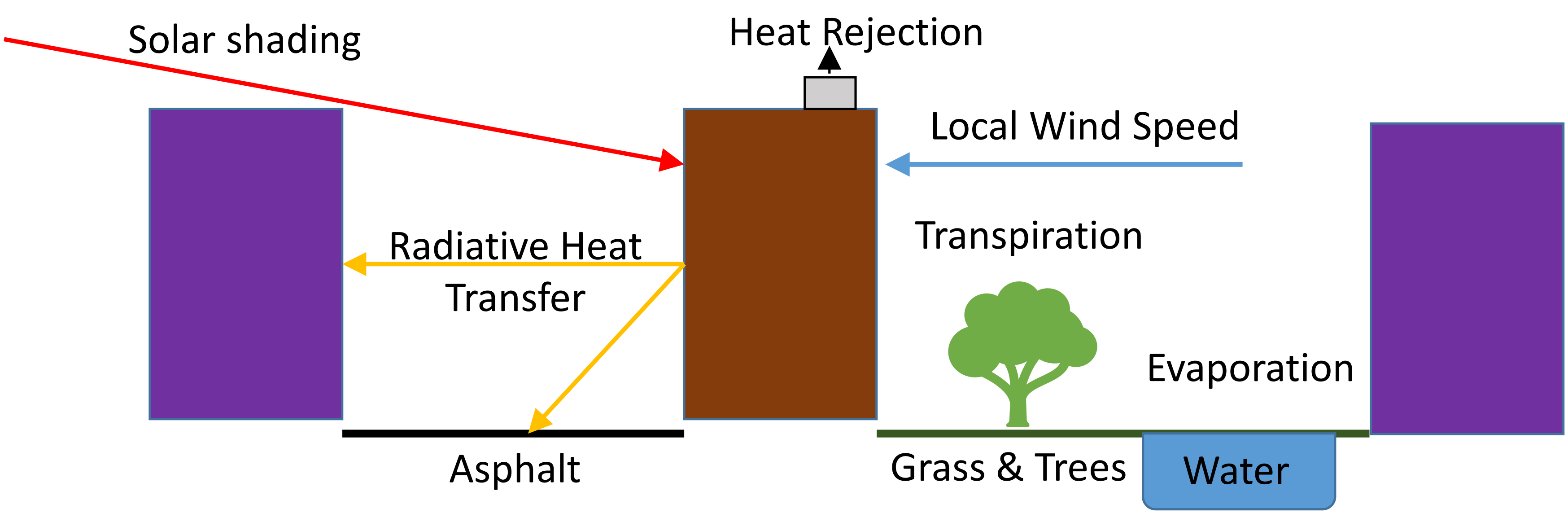
What Do Districts Need?

- Gather information on existing buildings and provide input or use smart defaults for new construction
- Energy Use Intensity (EUI) and generation targets/goals
- Understand the impact and interaction of the urban form with energy use and production
- Building load profiles for different program, efficiency, and equipment scenarios
- Sizing for solar, storage, and district energy systems
- Control strategies for storage and district energy systems
- Economic analyses of different scenarios

Interaction Of The Urban Form With Energy Use And Production

- The interaction between buildings and the urban environment is very complicated (partially shown below)
- Each project has different concerns and degrees of freedom

Macro effects: Geography, Urban Heat Island, Pollution, Climate



Tools For Urban Microclimate Modeling?

- Many urban microclimate models and tools are available

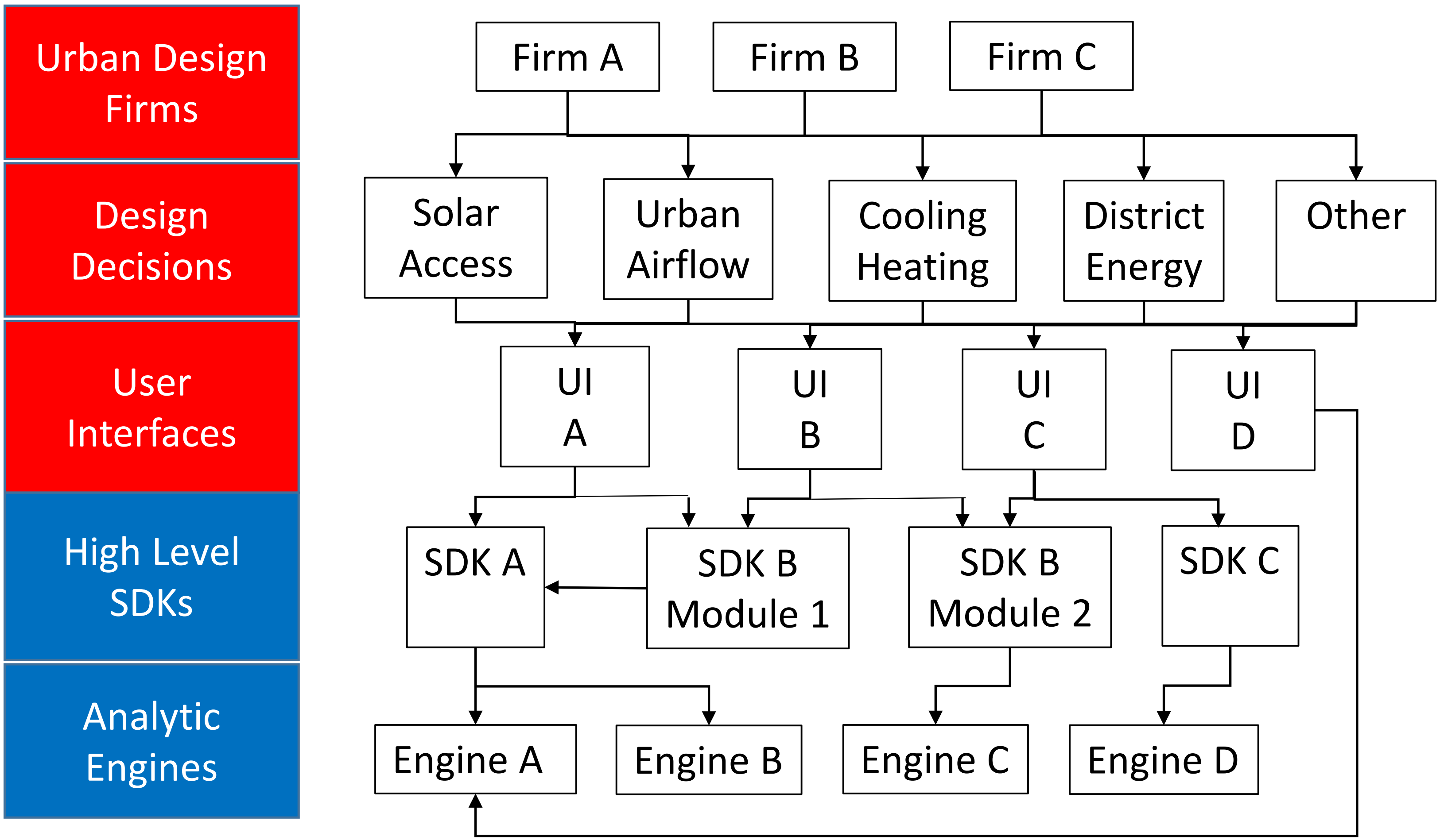
- Partial list of models and tools:
  - SOLENE-microclimate[3]
  - Urban Weather Generator[4]
  - WeatherShift[5]
  - ENVI-MET[6]
  - INDRA[7]
  - Urban Tree Inventory[8]
  - UMM[9]
  - ASHRAE Research Project 1561[10]
  - WRF[11]

- Each tool has different strengths; no one-size-fits-all approach

Potential Design Principles For A District Energy Analysis Ecosystem

- Components are developed as modules with clear inputs and outputs. Any component can be replaced by another with the same inputs and outputs.
- Components are developed in separate, single-purpose repositories with clear ownership, dependencies, licensing, documentation, and testing.
- Components may be written in a variety of software languages (Ruby, Python, C++, etc); interoperability via well-documented file formats is preferred to options that restrict language choices.
- Users (either end users or third-party applications) design and manage their overall workflow by combining tools; there is not one “right way” to do things.
- Open-source, transparent, and validated simulation engines, datasets, and frameworks form the analytical foundation. Third-party application developers build interfaces and provide support to end users.

Vision Of A District Energy Analysis Ecosystem



Benefits Of A District Energy Analysis Ecosystem

Collaborative environment with many roles to fill:

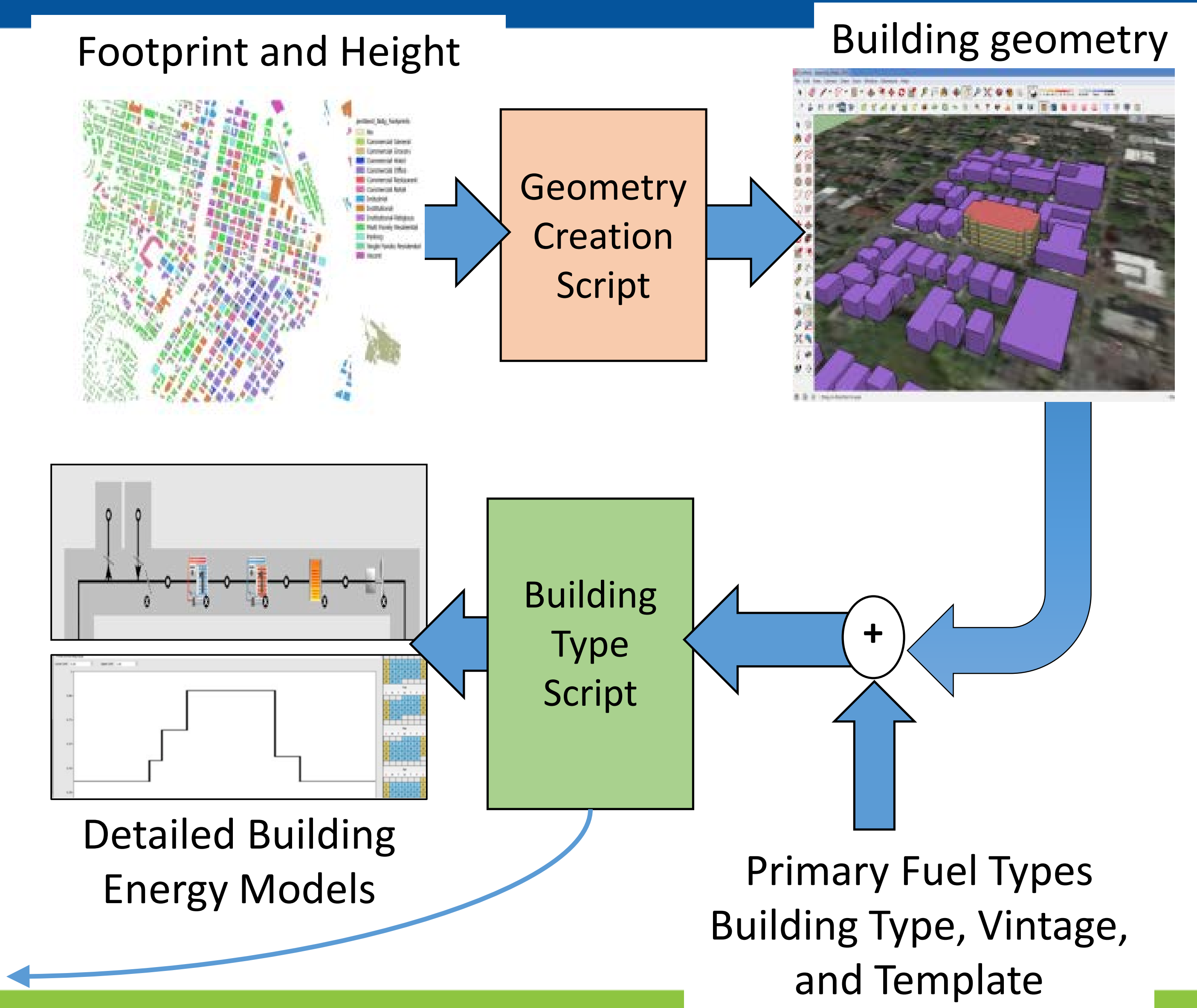
- Aggregation and transformation of urban data sets
- Integration between existing tools and analytic engines
  - Urban microclimate modeling
  - Building heat transfer with urban environment
  - Indoor/outdoor comfort and health
  - Walk score and real estate amenities
  - Electrical distribution system modeling
- Improved modeling techniques and data sets
  - Improved libraries of prototype buildings
  - Advanced district thermal system modeling
  - Stochastic influence of occupancy and other factors
  - Comparison/calibration with measured data to increase realism

Generate Building Load Profiles

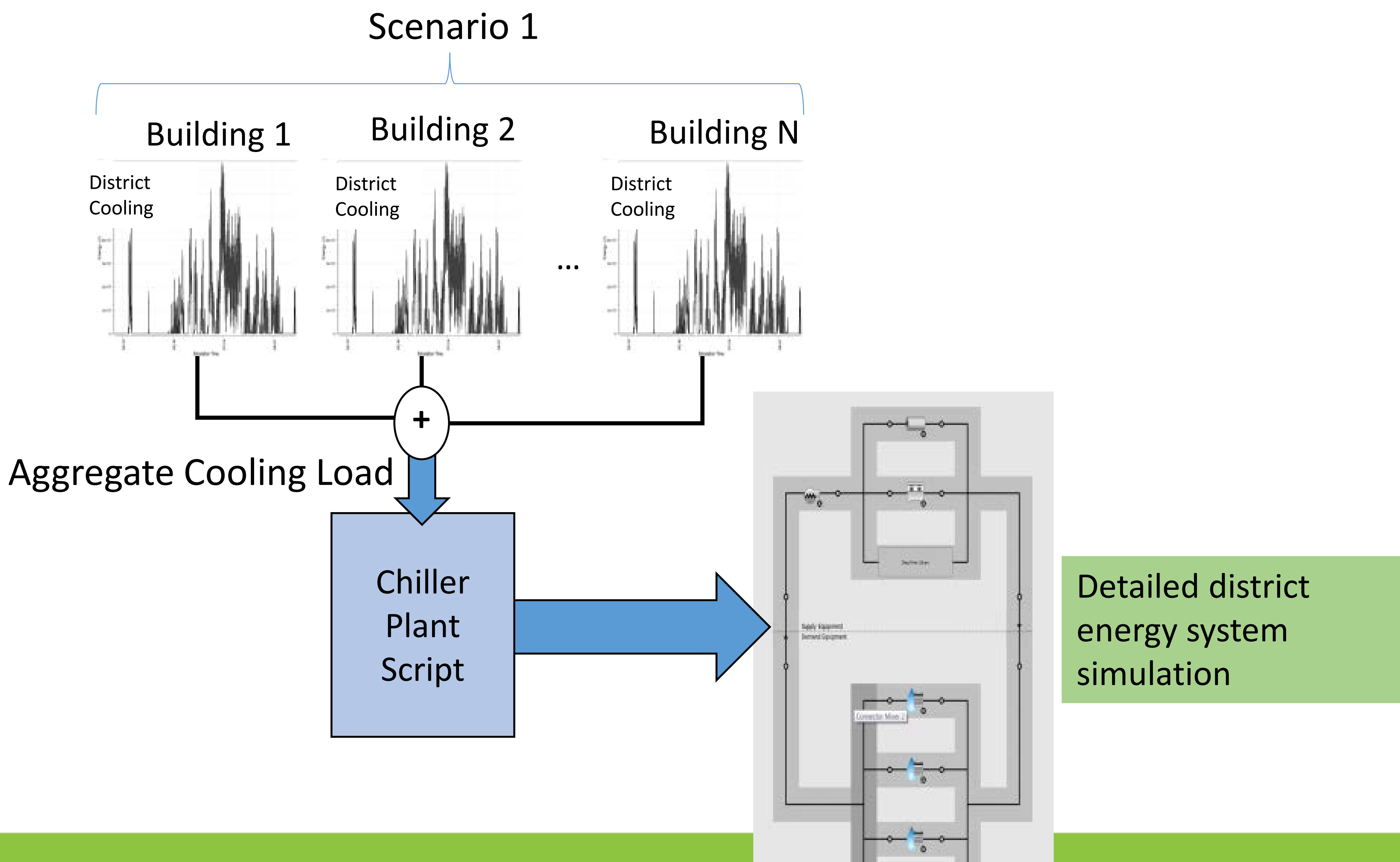
Automatically create code minimum baseline or zero energy ready

Apply prototypical values to create full model with minimal input

Collaborative project: NREL, LBNL, ORNL, PNNL, Canada NECB, India ECBC, HERS/ERI

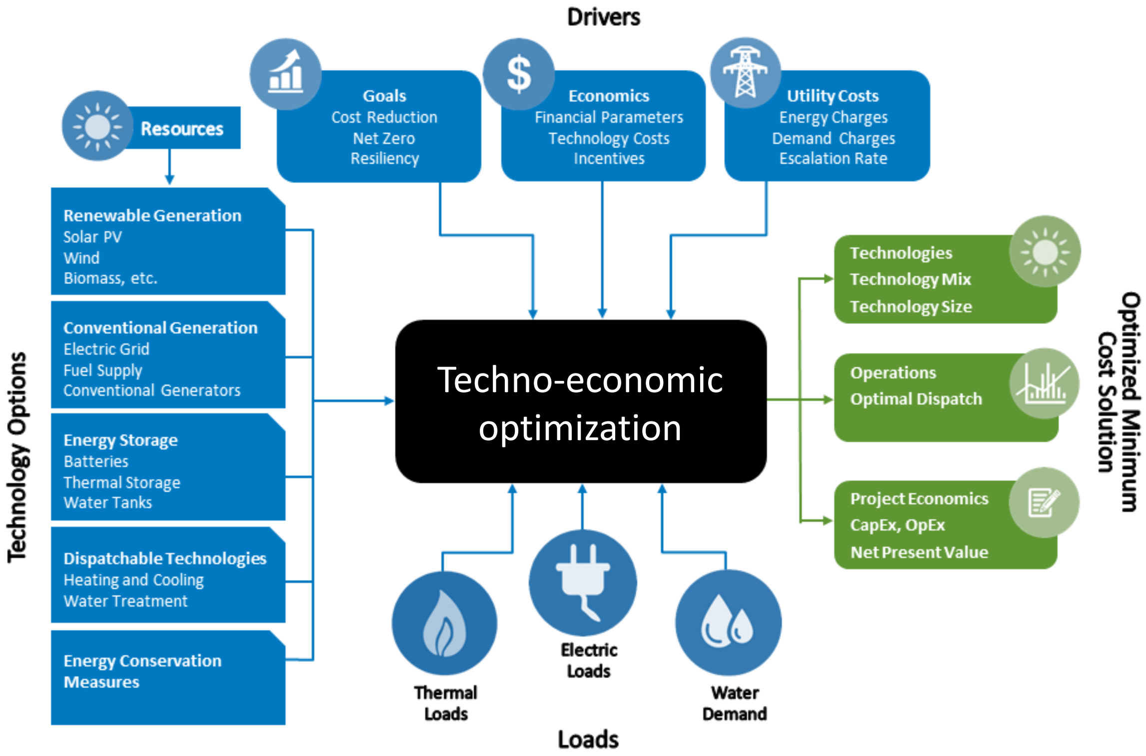


District System Modeling



Optimize On-site Generation And Storage

- Optimize PV, wind, and battery storage for given load profiles
- Optimize for financial savings or energy resilience



Conclusion

Many districts have desire to innovate and set energy goals but lack necessary analytical capabilities

An ecosystem consisting of many urban modeling tools and components is needed to provide these capabilities

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Questions?

Daniel Macumber

daniel.macumber@nrel.gov

Ben Polly

ben.polly@nrel.gov

Shanti Pless

shanti.pless@nrel.gov