Demo Abstract: A Virtual Testbed for Net Zero Energy Communities

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1. INTRODUCTION

Net zero energy communities (NZECs) are communities where the annual delivered energy from the grid is less than or equal to the on-site generated renewable energy on a source energy basis [1]. Due to its multidisciplinary nature, understanding on the characteristics of an NZEC, which is indispensable for NZEC design/operation, requires significant efforts.

System modeling is a commonly used method to study complex systems, such as NZEC. In previous studies, although system modeling was used to assist decision-makers in designing NZECs, some limitations exist. Firstly, the dynamic patterns and the interactions between different subsystems were usually ignored in order to accelerate the simulation, which may lead to inaccurate representation of real processes. Secondly, only limited system topologies were studied because only those topologies are supported by existing building modeling tools [2, 3]. This limits the application of system modeling in NZEC related studies.

In this demonstration, we will introduce how we create a virtual testbed of NZEC based on an existing NZEC. More specifically, we will demonstrate different system models: high fidelity physical models that provide more detailed information as well as the low-fidelity data-driven models that have less computational demand. The two kinds of models are inter-exchangeable and can constitute hybrid models for different application purposes.

2. HISTORIC GREEN VILLAGE

This study selects Historic Green Village (HGV) which is an existing NZEC located in Anna Maria Island, Florida. Consisting of five mixed-use commercial buildings (Figure 1), HGV has achieved the net zero energy goal in its past 36 months of operation.

In this community, there are three renewable energy subsystems to satisfy the energy demands of the community. They include an electric energy subsystem powered by PV panels, a water-source heat pump subsystem, and a solar thermal domestic hot water subsystem. Those systems are coupled with each other. For example, as shown in Figure 2, the solar thermal domestic hot water subsystem will recover the waste heat from the heat pump subsystem, which is powered by the electric generated by the PV panels.

BuildSys '16, November 16-17, 2016, Palo Alto, CA, USA
ACM 978-1-4503-4264-3/16/11.

DOI: http://dx.doi.org/10.1145/2993422.2996396

Figure 1 The layout of HGV

(Source:https://buildingdata.energy.gov/project/anna-maria-historic-green-village-multiple-bldgs-district)

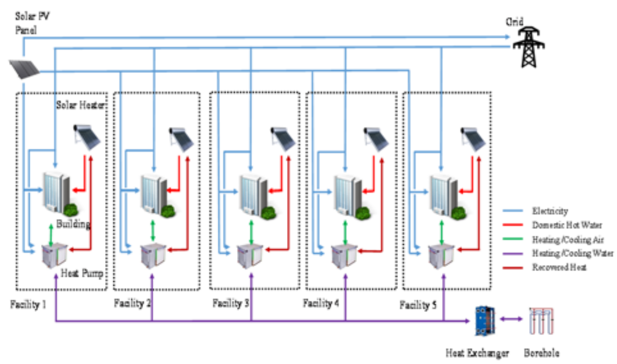

Figure 2 The schematic of the energy systems of HGV

3. SYSTEM MODELING

The energy system shown Figure 2 in is a typical multidiscipline dynamic system. The modeling and simulation of this system can be challenging for two reasons: First, the interactions between different subsystems complicate the structure of the community system models, which make it difficult to create and debug the models; second, the simulation tends to be computationally intensive since the system is a mixture of fast and slow dynamics.

To address the above challenges, we divide the community energy system into different groups according to their dynamic behavior, instead of physical locations. Figure 3 shows the model partition of the studied system to enable the exchange and interoperation of different model components. The models within the same subsystem are packaged into one group and the energy/mass/information connections between different groups are modeled with corresponding buses. By doing so, one can enjoy two benefits: first, the subsystem model is separated to enable unit test for quick bug detections; second, by splitting the system model into different groups, one can assign different solvers for the models: for subsystems with a fast dynamic, one can assign an explicit solver with a small time step; while for that with a relative slow dynamic, one can assign an implicit solver with a larger time step to save the computational time. Then, the connection between different solvers can be realized by co-simulation interfaces such as Functional Mock-up Interface.

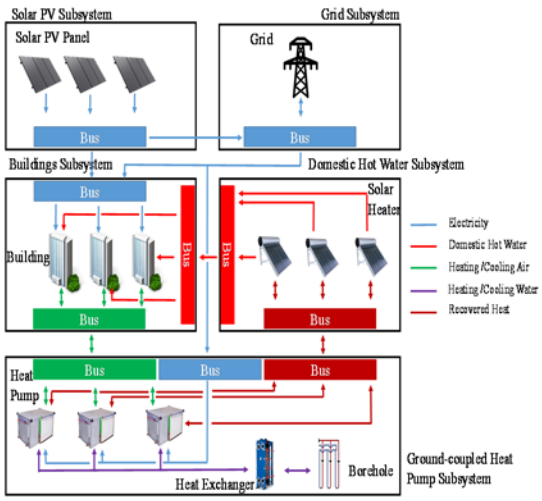

Figure 3 Block diagram for the exchange and communication of different subsystem models in NZEC

Based on the model configuration shown in Figure 3, we establish the system model for HGV energy system. Figure 4 shows the diagram of the top-level model, which is implemented in Modelica/Dymola environment. The diagram consists of five icons and each icon represents one subsystem model for one group. For example, the WSHP represents the water-source heat pump subsystem group [4]. All the subsystem models are built using Modelica *Buildings* library [5].

To further increase the simulation speed, we also explore the possibility of substituting the physics-based system model with purely data driven model, such as ANN model. As shown in Figure 5(a) both the physics-based model and the ANN model achieve good accuracy.

With the established system model for the HGV system, we predicted the electricity demand for the entire community shown in Figure 5(b). The system model can catch the trend of electricity demand change quite well.

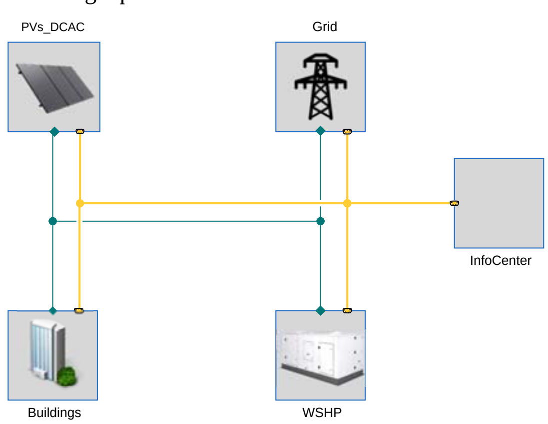

Figure 4 The top level system model of HGV system

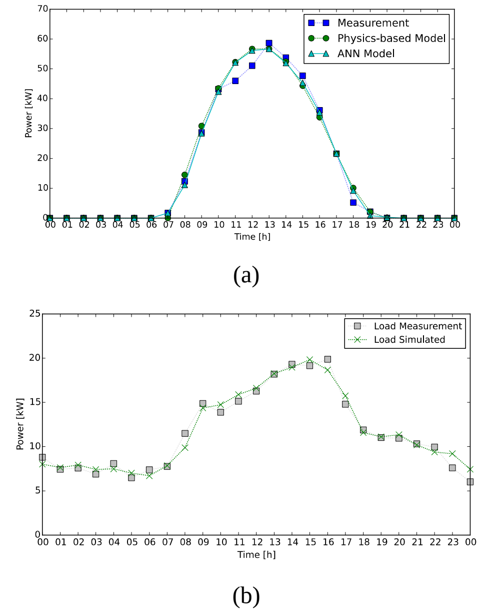

Figure 5(a) Comparison of the simulated PV power with the measurements (b) Comparison of the total predicted and real power of the energy loads in HGV. Both are on August 25, 2014

4. CONCLUSION

In this demonstration, we developed a virtual testbed model for a real NZEC system. The simulation results suggest good accuracy can be achieved using the developed model. The results also reveal ANN model can achieve almost the same accuracy with the physics-based model for a day. To better assess the virtual testbed, an evaluation with a longer period will be performed in the future.

5. REFERENCES

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