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ScienceDirect

Procedia Engineering 205 (2017) 2076–2083

Procedia Engineering

www.elsevier.com/locate/procedia

10th International Symposium on Heating, Ventilation and Air Conditioning, ISHVAC2017, 19-22 October 2017, Jinan, China

# Community energy system planning: a case study on technology selection and operation optimization

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**Abstract**

Community energy planning has attracted wide attention in China as the implementation of China's low-carbon city policies. Meanwhile the rapid development of energy science and technology has shifted buildings and communities from energy consumers to prosumers, which lead to more difficulties in configuring the energy technology portfolio. This study es-tablishes an optimal decision-making model for community energy planning and develops an online tool called District EnErgy Planning(DEEP). Based on DEEP, the impact of energy price and equipment cost on optimization results, and the corresponding operational strategies are discussed through case study and scenario analysis. The results show that, when natural gas price exceeds 2yuan/m$^3$, the gas-based solutions become economically uncompetitive. The technologies are propitious when equipment prices are reduced by 50%, 50%, 80% for CHP facilities, PV panels and electric battery, respectively.


Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.

*Keywords:* Community energy planning; Decision optimization; Renewable energy; Distributed energy system; Operational strategy

## 1. Introduction

In recent years, climate change has become one of the most pressing problems facing all countries all over the world. Inefficient use of fossil fuels is an important reason. Community energy planning(CEP) is a useful tool to improve energy efficiency and reduce building energy consumption in district scale. In China CEP is becoming increasingly a necessary part in area planning and construction of low carbon cities. However, the current decision-

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1877-7058 
Peer-review under responsibility of the scientific committee of the 10th International Symposium on Heating, Ventilation and Air Conditioning.
10.1016/j.proeng.2017.10.100

making process of the energy planning is generally lack of scientific basis. The planned scheme is usually difficult to implement and/or achieve the desired goals. The optimal analysis, as an important means to achieve efficient matching of energy supply side and demand side, is the key segment of CEP. It helps to find an efficient technology portfolio and economic operation mode for district energy system.

The energy system configuration and operational optimization issues, in fact, is a unit commitment problem, which refers to optimizing generation resources over a short time horizon to satisfy load demand at minimum operational cost while satisfying prevailing constraints[1]. There have been some discussions in the literature, but most of them are from the view of energy supply side, focusing on certain energy technologies like combined heat and power[2]. A few of them consider from the demand side to study the optimal technology portfolio to meet the energy needs, but relatively less technologies are involved[3]. It cannot meet the requirements of multi-energy complementary and low-carbon community without taking into account the distributed energy, renewable energy, energy storage, waste heat and/or absorption technologies as a whole. Most of these optimization studies have adopted a lower temporal resolution, but few of them discuss the impact of the time interval and the load handling approach on optimization results.

To make rational decisions in energy planning process, a District EnErgy Planning (DEEP) tool have been developed to provide support for the optimal selection of energy technologies and the determination of operation strategy. DEEP leverages a large-scale mixed integer linear programming method, using the minimized cost as objective to optimize the technology selection and operation strategy. The model is established based on predicted load data with full time resolution (8640 hourly data), and taking into account the combination of up to 16 kinds of energy technologies. DEEP also use carbon emission reduction objective and give carbon emission analysis by using carbon tax and carbon emission factors. Moreover, DEEP can con-sider the loss of pipe network for district energy plant. This paper validates DEEP's optimization ability through a case study. Different system configuration solutions and operation strategies are obtained and analyzed through changing the boundary conditions.

## 2. Mathematical models

### *2.1. Object and boundary*

DEEP is particularly suitable for a comparative analysis for a variety of energy technologies, which can be decentralized energy technologies on the customer side or a centralized energy technology, i.e. an energy plant. By considering the competitive relationship between the centralized technologies and decentralized technologies, DEEP can decide whether an energy plant is needed. Although centralized energy plant is not the focus of DEEP, the transmission loss for DHC utility is involved by considering a simplified method regarding pipeline net-work topology and a load-related thermal loss.

DEEP provides an abundant technology candidates library. Fig. 1 is the energy flow diagram showing the most complicated energy technology portfolio considered in the model. Electricity, gas, heat from the municipal network and/or waste heat on the spot are considered as primary energy input. The energy conversion technology candidates include: conventional energy technologies such as boilers and electric chillers; renewable energy technologies like solar thermal, PV and all kinds of heat pumps; combined cooling heating and power (CCHP) and energy storage technologies like electric battery and thermal tank. The DEEP model pro-vides an optimized multi-energy complementary solution on the basis of energy demand and price information.