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Development of a Bottom-up Technology Assessment Model for Assessing the Low Carbon Energy Scenarios in the Urban System

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Abstract

This paper explores an approach based on a systematic-integrated modeling framework which helps to investigate the optimal behavior of an urban energy system. The model allows us to: 1) analyze the impacts of various demographic scenarios, 2) test and evaluate different policy measures for deploying patterns of efficient use of energy resources and emissions mitigation in the system and 3) test technological and system level solutions such as centralized versus decentralized energy supply networks. A highly resolved optimization technique using mathematical programming is applied to identify the cost-effective measures for achieving specific energy and emissions reduction-targets. The model then is applied to identify the optimal energy flow from available energy resources (Fossil, Renewable and external sources) to the end-user level in selected cities of Asia.

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Keywords: Asian cities; energy systems; low carbon society, optimization model.

1. Introduction

Analysis of multi-dimensional interactions of flow of energy in the urban energy system is a complex task that necessitates the development and utilization of analytical tools. Development of analytical tools with high complexity is usually based on conclusions of many concepts and theories from different scientific disciplines. Technology assessment and efficiency evaluation of the urban energy system have been pursued with the help of

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analytical tools that have been developed and implemented in the last decades [1-4]. Many of the available analytical tools are based on the heuristics and experimental data. But there has been little effort on concluding the theoretical background of analysis and developing respective energy models according to the optimal behavior of the system.

In this paper, an urban energy system is supposed to be organized in the form of a firm and appears in the market that oriented towards establishing an effective energy system to improve its overall resource efficiency which may be identified as delivering a certain level of urban quality (i.e. Demand for transport activity, space heating, lighting, air conditioning, etc.) with minimum total cost of the system. To this end, an optimization model founded on the microeconomic principles has been developed using the technique of mathematical programming.

Nomenclature

Z	Total Cost
k	Capital
m	Operation cost
e	Externalities
t	time
u	level of utility (i.e. electricity, mobility, heating, etc.)

2. Conceptual design of the model

In this research, the microeconomic principles have been utilized to develop a model that would represent the behavior of an urban energy system in a market with a perfect competition [5]. The local government as a decision maker in this market strives for maximum satisfaction (or utility) of delivering certain energy service to the end-users such as providing required electricity at the end-user level. The utility or satisfaction is a function of a broad range of parameters such as quality of the service, comfort, accessibility, environment, costs and time. Maximizing utility is subject to certain constraints due to the availability of resources. The resources are time, capital for obtaining a quality service, availability of reliable system environment and income. The solution of such a mathematical model would be possible if the utility function could be identified and formulated explicitly based on both supplier (local government) and consumers (end-users) viewpoints (Fig. 1). An alternative methodology has been developed which may be categorized as a direct solution of the model. Although the solution of the model based on the maximization of the utility of delivering energy services would be hardly possible due to difficulty in obtaining an explicit formulation of the utility function, one may make an effort of solving the dual of the primary model. The dual formulation of the primary model would achieve the optimal utility with minimum total costs, which would direct capital and operation costs.

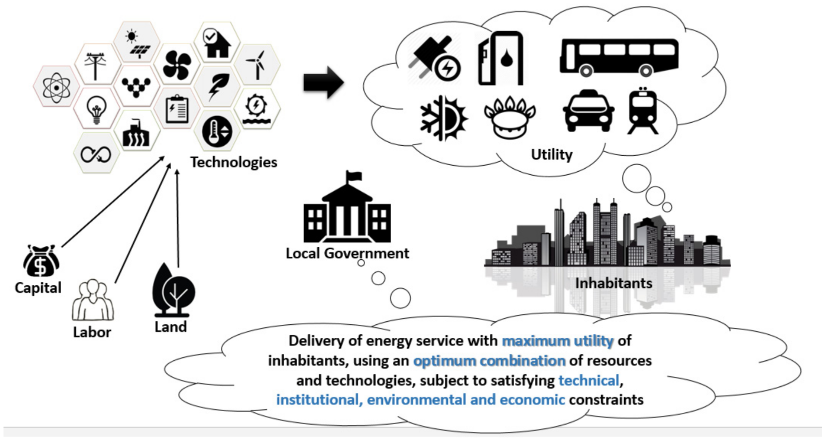

Fig. 1. Applying microeconomics principles to the urban energy ssystem