Energy and Buildings 48 (2012) 71–78

Contents lists available at SciVerse ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Financial analysis and optimal size and operation for a multicarrier energy system

A. Sheikhi*, A.M. Ranjbar, H. Oraee

Department of Electrical Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran

ARTICLE INFO

Article history:
Received 17 December 2011
Received in revised form 7 January 2012
Accepted 9 January 2012

Keywords:
Combined cooling heating and power (CCHP)
Energy hub
Optimal operation
Optimal size
Financial analysis

ABSTRACT

The interest on distributed generation has been increasing in recent years, mainly due to technical development on generation systems that meet environmental and energy policy concerns. One of the most important distributed energy technologies is combined cooling, heat and power (CCHP) systems. CCHP is a small and self-contained electric, heating and cooling generation plant that can provide power for household applications, commercial or industrial facilities. It can reduce power loss and enhance service reliability in distribution systems.

An important factor for the users is the capital cost of CCHP which is largely dependent on its type, capacity and efficiency. Therefore, among all existing commercial CCHP technologies, certain economic choices are to be taken into account. Cost and benefit analysis (CBA) is one of the most common approaches to maximize financial benefits.

In this paper, a model to find the optimal size and operation of CCHP, auxiliary boiler, heat and electrical storage unit for users is proposed by considering an integrated view of electricity and natural gas network using GAMS software. Then, as a case study, for a hotel in Tehran, this method is implemented. Finally, by applying COMFAR III software, useful financial parameters are calculated for the proposed multicarrier energy system with optimal elements.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

The electric power industry is under deregulation in response to changes in legislation, technology, market and competition. One of the main advantages of deregulation is that it can increase the efficiency of industrial and commercial sectors and reduce the cost of electrical energy for all customers [1].

Deregulation has evolved in all three sectors of the power system (i.e. generation, transmission, and distribution) from centralized to a decentralized status. One of the main concepts in deregulation is microgrids which are used at the distribution level [2]. Microgrid, with its decentralized electricity generation, combined with onsite production of heat, could provide reliable and electric power as well as heat and cooling to its consumers at an economic cost. Nowadays, following the expansion of natural gas networks and also benefits of this energy carrier such as lower emission level and prices, CCHP technologies have attained unprecedented level of popularity as one of the most important distributed energy resources [3].

One of the major factors for users to choose a CCHP system is the overall cost of CCHPs which is largely dependent on its size [4]. Hence finding the optimized size of a CCHP is economically important.

Generally, an optimized CCHP can be evaluated by analyzing two main factors: costs and benefits. Cost is one of the main components in nearly all DG financial analysis, but is inadequate for complete evaluations. Furthermore, reliability enhancements [5], power cost saving, power loss and emission reduction [6] are also key elements in deciding which CCHP should be installed.

The cost of generation of electricity, heat and cooling from a CCHP can be classified into capital investment cost, operation and maintenance (O&M) costs, fuel cost and depreciation cost. On the other hand, the benefits from the CCHP placement can be classified into power loss reduction and significantly decreasing the expected energy not supplied which is a favorable effect in a power system.

CHP can inject its power directly into distribution feeders and by alleviating transmission losses the benefits of power loss reduction become quite clear [6,7]. Moreover, reliability enhancement has received substantial attention as it reduces the costs of losses incurred by utility customers as a result of power failures [8].

All of these costs and benefits are calculated in terms of present value factor (PVF), accumulated over the economic life of the respective equipment. It is common practice for a decision maker to translate future cash flows into their present values.

From a number of recent publications [1–9], it can be seen that in a deregulated power system, each individual distribution company may wish to determine the costs and benefits of DG planning

* Corresponding author. Tel.: +98 912 6613840.
E-mail addresses: sheikhi@ee.sharif.edu, aras.sheikhi@yahoo.com (A. Sheikhi).

0378-7788/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.enbuild.2012.01.011

Nomenclature

List of symbols and abbreviations

N	time intervals of optimization
$L_e(N)$	electrical energy demand in the time interval (kWh)
$L_h(N)$	heating energy demand in the time interval (kWh)
$L_c(N)$	cooling energy demand in the time interval (kWh)
$e(N)$	electricity price $(kWh)
g	gas price $(kWh)
ir	interest rate
iff	inflation rate
EL	economic life of the equipment (year)
MC	maintenance cost $(kWh)
C_m	yearly maintenance cost $(year)
η_E	Effective efficiency of CHP
η_{ee}	transformer efficiency 20 kV/440 kV
η_{ge}	electrical efficiency of CHP
η_{gf}	auxiliary Boiler efficiency
η_{gh}	thermal efficiency of CHP
η_{ac}	absorption chiller efficiency
χ_e	emission factor for average power generation $(kWh)
χ_g	emission factor for gas power generation $(kWh)
$VOLL$	value of lost load $(kWh)
HHV	higher heating value

Variables

$P_e(N)$	purchased electricity (kWh)
$P_g(N)$	purchased natural gas (kWh)
P_{gM}	maximum purchased natural gas (kW)
P_{gm}	minimum purchased natural gas (kW)
P_{eM}	maximum purchased electricity (kW)
P_{em}	minimum purchased electricity (kW)
$\gamma(N)$	dispatched factor for natural gas inlet
$\alpha(N)$	dispatch factor for auxiliary boiler
$\beta(N)$	dispatch factor for CHP
$S_{inh}(N)$	the input rate of heat storage (kWh)
$S_{outh}(N)$	the output rate of heat storage (kWh)
S_M	nominal capacity of heat storage (kW)
$SE_{in}(N)$	the input rate of battery (kWh)
$SE_{out}(N)$	the output rate of battery (kWh)
SE_M	nominal capacity of battery (kW)
Benefitx	benefit of using x element ($)
Costx	cost of using element x ($)
Capx	capacity of element x (kW)
BMC	benefit minus cost ($)
KK(N)	exported electricity to the grid (kWh)
Z_1	heat transfer from CHP, heat storage and auxiliary boiler to the load $ (N)
Z_2	purchased electricity and gas ($) (N)
H(N)	heat exported
H_M	maximum heat exported (kWh)
$CC(N)$	cooling exported (kWh)
C_M	maximum cooling exported (kWh)
P_{SeM}	maximum exported electricity from CHP to the grid (kWh)
EENS	expected energy not supplied
P_k	the probability of having a capacity outage equal to O_k
O_k	outage capacity
A_k	the energy not supplied because of the capacity outage O_k
a_k	annual net cash flow
DCF	discounted cash flow
IRR	internal rate of return
DPP	dynamic payback period
NPV	net present value

under different circumstances. It is difficult to find a single planning method that satisfies all objectives simultaneously. In this paper, a value-based planning method for CCHP placement based on the energy hub concept is proposed. The proposed method takes the benefits and costs of CCHP placement into account and determines the optimal sizing for CCHP placement. Test results show that with proper size selection, CCHP placement can be used to improve service reliability, and reduce power loss and emission costs.

The survey of previous literature on DER (distributed energy resource) planning as well as optimal DER deployment in the radial (conventional) as well as meshed-type distribution systems indicates that a number of similar studies [9–16], encompassing sensitivity analysis to modern soft computing techniques, such as genetic algorithms (GAs), evolutionary programming (EP), DER-CAM, etc. Special mention can be made to [9,14]. Ref. [9] proposes a method for distributed generator planning based on GAs and considers customer interruption cost (CIC) as the benefit of distributed generators placement but the benefit of waste heat recovery is not considered. Ref. [10] finds the optimal option of distributed generation technologies for various commercial buildings

Refs. [11,12] gives a novel method to optimal dispatch of a multicarrier system equipped with CCHP by considering environmental and economical aspects. Hashemi in [13] developed an offline model for optimal operation of combined cooling, heating and power systems. Ref. [14] gives the economic analysis of the microgrid, which evolves from the existing low-voltage (LV) network, on the basis of cost and benefit of potential reliability improvements. Ref. [15] optimizes the gas engine size with the minimum running cost objective function for a complex building. Ref. [16] uses the evolutionary-algorithmic (EA) approach to optimize placement of DG in a meshed microgrid. Ref. [17] presents a discussion on the economic viability of the DG investment option and compares its traditional counterpart of the upgradation of the feeder and substation. The contents of this paper are organized into the following six sections.

The energy hub concept and a brief overview of energy hub modeling are presented in Section 2. Section 3 provides detail formulation of the main idea behind the article and financial parameters are defined in Section 4. In Section 5, case study is debated in detail and the best size, best operation of energy hub elements and also financial parameters are calculated. Finally, conclusions are drawn in Section 6.

2. Energy hub concept and modeling

Some conceptual approaches for an integrated view of transmission and distribution systems with distributed generation have been published. Besides “energy-services supply systems” [18], “basic units” [19], and “micro grids” [20], so-called “hybrid energy hubs”, are suggested, where the term “hybrid” implies the use of multiple energy carriers [21]. An energy hub is considered a unit where different energy carriers can be converted, conditioned, and maybe stored. It represents an interface between different energy infrastructures and/or loads. Fig. 1 demonstrates an example of an energy hub.

The CHP device couples the three energy systems at the same time that produces electricity, heat and cooling from natural gas. The absorption chiller converts wasted heat from CHP or produced one from boiler to cooling power.

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات