Energy 90 (2015) 89–94

Contents lists available at ScienceDirect

Energy

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

Area-wide energy saving program in a large industrial area

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ARTICLE INFO

Article history:
Received 18 December 2014
Received in revised form
12 May 2015
Accepted 16 May 2015

Keywords:
Area-wide approach
Energy saving
Program
Industrial area
Pinch technology

ABSTRACT

Map Ta Phut industrial area which is one of the biggest heavy chemical complexes in Thailand is located 190-km southeast from Bangkok and was founded in 1990s. This area is considered not to have potential for any further energy saving because their designs have been optimized for energy efficiency. However they need to improve further energy efficiency to increase their international competitiveness and prevent global warming. To achieve the further energy saving, the concept of "area-wide approach" was applied to this area to develop an area-wide energy saving program which was composed of a number of collaborative energy saving projects across sites. Area-wide approach used the methodology of area-wide pinch technology which had been applied to Japanese heavy chemical industrial areas and derived some area-wide energy saving projects practically. The area-wide energy saving program was the mid and long term plan for Map Ta Phut industrial area showing how to implement many collaborative energy saving projects in turn. A large amount of energy saving will be achieved by this program.

1. Introduction

Oil refineries, petrochemical and chemical plants that have been recently constructed in the heavy chemical complexes of South East Asia are considered not to have potential for any further energy saving because their designs have been optimized for energy efficiency. Map Ta Phut industrial area which is one of the biggest heavy chemical complexes in Thailand was founded in 1990s and are thought to be highly efficient. Map Ta Phut industrial area has been strongly interested in not only environmental protection but also energy efficiency improvement. This area needs to improve further energy efficiency by developing a new scenario to reduce the energy consumption in the whole of sites. However, their conventional thoughts for energy saving were based on the concept of a single site optimization ("single site approach"), which would optimize the energy efficiency only within the site itself. A heavy chemical plant consists of a process system and a utility system. The utility system provides heat and power for all the process systems. Klemes et al. [1] developed and applied the total site approach for energy saving studies in utility systems by using pinch technology. Alwi and Manan [2] introduced a STEP (Stream Temperature vs. Enthalpy Plot) method to simultaneously show the pinch points, energy targets and the maximum heat allocation. Alwi et al. [3] extended the STEP method to simultaneously target the multiple utilities and perform heat allocation between the utilities and the individual process streams. Sun et al. [4] extended the STEP method for cost targeting that considered different types of heat exchangers. Perry et al. [5] applied the design strategy of Total Site targeting from chemical process industry to large building complexes to reduce the carbon footprint by supplying hot water and low pressure level steam from a heavy chemical site. Application of this concept was still limited to a single site. It has often been thought that all possible energy saving measures in heavy chemical sites within complexes had already been studied and implemented. A fresh approach was therefore required to overcome this limitation and to achieve further improvement. This paper proposed a new concept of "area-wide approach" for further energy saving within a heavy chemical industrial area and developed an area-wide energy saving program which was composed of a number of collaborative energy saving projects across sites. Area-wide approach took care of multiple sites that would be considered together as if they were a single entity and many collaborative energy saving projects across sites could be developed. The aim of this approach was to develop the area-wide energy saving program which was the mid and long term plan for Map Ta Phut industrial area, and which showed how to implement many collaborative energy saving projects in an appropriate order.

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http://dx.doi.org/10.1016/j.energy.2015.05.058
0360-5442/

2. Methodology

Fig. 1 shows steps to achieve energy saving in a site. At first step, conceptual design, and then basic design, detail design and construction. Once construction is completed, operation starts to obtain energy saving. At final step, energy management can be used to maintain energy saving very well. It is important to develop a good conceptual design to achieve energy saving reliably and practically. For this reason, a systematic approach based on the thermodynamics is required to develop a good conceptual design for especially a collaborative energy saving project across sites because such project requires properly theoretical explanation to each site. Area-wide approach has to use a good methodology which satisfies the abovementioned requirement. In area-wide approach, there are two types of plan (conceptual design) for area-wide energy saving. One is "energy efficiency improvement" and the other is "heat sharing". It is considered that "area-wide pinch technology" is able to satisfy such requirement and is sufficiently able to develop a good conceptual design based on the experience (Matsuda et al. [6]) in Japan. Therefore area-wide approach uses the methodology of "area-wide pinch technology" which consists of two analyses (R-curve analysis and Total Site Profile analysis) and is able to analyze, develop and evaluate the abovementioned two types of plan for area-wide energy saving. R-curve analysis can manage energy efficiency improvement and TSP (Total Site Profile) analysis (Hackl and Harvey [7], Nemet et al. [8]) can manage heat sharing.

2.1. R-curve analysis

Kimura [9] developed a method for analysis and optimization of a utility systems based on the R-curve concept by Kenney [10] and top-level analysis by Makwana et al. [11]. Top-level analysis could be applied for existing total site utility systems to evaluate the current performance and the potential scope for improvement. Kimura and Zhu [12] further developed R-curve analysis method to determine the most economic modifications to existing utility systems. Karimkashi and Amidpour [13] studied the cost and emission value in the utility system based on the R-curve concept. Ghaebi et al. [14] investigated targeting of the cooling demand of the total site based on the R-curve concept. Manesh et al. [15] introduced the R-curve concept for optimal design of a LNG cogeneration plant. R-curve can be constructed based on the following two equations.

$$\text{Integrated Energy Efficiency} = (W + Q_{heat})/Q_{fuel} \quad (1)$$

$$\text{R} - \text{ratio (power} - \text{to} - \text{heat ratio)} = W/Q_{heat} \quad (2)$$

where,

Q_{heat}: Heat demand for the utility system.
W: Power demand for the utility system.
Q_{fuel}: The integrated energy consumption which is the summation of the consumed fuel oil/gas and the purchased power in the utility system.

Fig. 1. Steps to achieve energy saving.

2.2. TSP analysis

The utility system must be understood and optimized in the context of a total site that consists of a number of process plants. Dhole and Linnhoff [16] and Raissi [17] introduced a graphical method, so called site profiles. Klemes et al. [1] considerably extended this methodology to site-wide applications. Heat recovery data for individual processes are firstly converted to GCCs (grand composite curves) which are combined to form a site heat source profile and a site sink profile. These two profiles form TSP (total site profile) which is analogous to the composite curves for the individual processes. TSP shows the energy and heat utilization profile of the whole plant. TSP analysis can identify the opportunities for inter-process integration via the utility system and the appropriate integration idea. Sorin and Hammache [18] introduced the targeting model by extending the SGCC (site utility grand composite curve). Bandyopadhyay et al. [19] developed the methodology to estimate the cogeneration potential at the total site level, utilizing the concept of multiple utility targeting on the SGCC. Ghalami et al. [20] applied SGCC to demonstrate the potential of energy saving, cogeneration targets and promising modification in the retrofit cases. Chew et al. [21] investigated the issues of plant layout and operation that have influenced on total site heat integration solution. Hackl and Harvey [22] applied total site analysis and exergy analysis to target for energy savings potential in refrigeration operation within a chemical cluster. Hackl and Harvey [23] investigated to create a more integrated utility system within chemical clusters by total site approach.

3. Results

3.1. Map ta Phut industrial area

There are more than 160 sites in Map Ta Phut industrial area. This study focused on the center of the industrial area where the relatively earlier developed sites are located, and selected 15 sites from them, each within 5 km distance of each other in Fig. 2. 15 sites consisted of 2 refineries, 11 chemical plants, a gas separation facility, and a utility company. Data were collected from the sites about the utility system and 991 "process - utility heat exchangers"

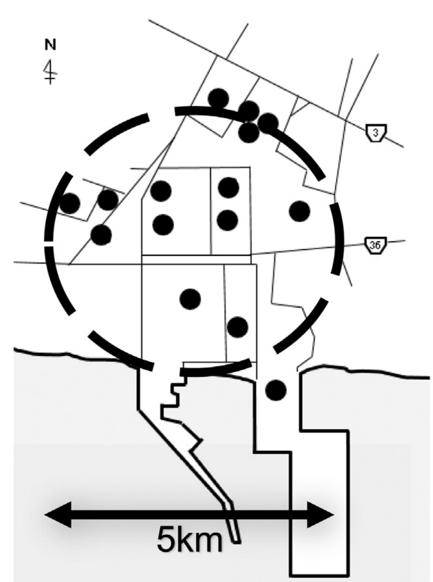

Fig. 2. Map Ta Phut industrial area.