Process oriented industrial classification for energypark

Classificação industrial orientada a processo para parque energético

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Abstract

In the US, manufacturing plants are classified by Standard Industrial Classification (SIC). Similar classifications are also used in many other countries. Energy use data for 300 manufacturing plants in Southern California are collected and analyzed by SIC code. The results showed that the classification is less than useful for energy categorization. The SIC is not a convenient tool to classify energy use. This paper suggests a process based classification which proved to be more convenient to sort manufacturing plants by their energy intensity. The method can be used to match plants for Combined Heat and Power (CHP) and also to create energyparks.

Keywords

Energy efficiency. SIC. Energypark. CHP. Cogeneration.

Resumo

Nos EUA, empresas de manufatura são classificadas pela Standard Industrial Classification (SIC). Classificações semelhantes são também utilizadas em vários outros países. Energia utiliza dados de 300 empresas de manufatura na Califórnia do Sul. Dados são coletados e analisados pelo código SIC. Os resultados mostraram que a classificação é menos que útil para categorização de energia. A SIC não é uma ferramenta conveniente para classificar o uso de energia. Este trabalho sugere uma classificação baseada em processos que se mostrou ser mais conveniente para classificar empresas de manufatura por sua intensidade energética. O método pode ser usado para comparar empresas por meio de calor e energia elétrica combinadas (CHP) e também para criar parques energéticos.

Palavras Chave

Eficiência energética. SIC. Parque energético. CHP. Cogeração.

Energypark

There are several ecoparks aimed at reducing and recycling material waste. Such parks encompass a wide range of layouts ranging from virtual parks to collocations of businesses endorsing green building technologies and promoting environmentally friendly processes including organic food supply. Energypark is suggested as a symbiosis designed specifically for energy efficiency (BEYENE, 2005). Waste reduction and material streamlining remain important factors of energypark, but secondary to energy efficiency.

Establishing an energypark requires the selection of manufacturing plants that share energy in the same way ecoparks share resources. Heat and power requirements are matched with "donor" and "receiver" plants. Two general options for plant selection exist: a grouping of similarly sized plants with different processes, or one base plant with a large amount of waste heat and several smaller parasitic plants [BEYENE, 2004]. Resource streams form the second level of screening for potential associate plants.

Matching of energypark affiliates for optimum energy usage requires in depth knowledge of their manufacturing processes. The Standard Industrial Classification (SIC, 2005) used to categorize manufacturing plants does not provide fair insight to energy usage. An alternative matching method is recommended below.

The concept of Ecopark capitalizes on the benefits of Combined Heat and Power (CHP) by selecting plants with appropriate thermal to electric ratios and varying degrees of thermal load quality. Single manufacturing plants often have varying Thermal to Electric (T/E) ratios during the manufacturing cycle. This requires bypassing and dumping excess outputs, diminishing efficiency of the system. However, a CHP system that supports energypark - several T/E matched plants, can operate at or near maximum efficiency at all times (BEYENE, 2004).

Process Oriented Matching

It is important to design a process by which affiliates of an energypark are selected and matched. In the US, the Standard Industrial Classification (SIC) code, now replaced by the North American Industrial Classification Standard (NAICS) code, is used to categorize manufacturing plants based on their main products. Neither SIC nor NAICS account for the manufacturing process or the energy profile of the plant including thermal electric ratio, energy intensity, and electric load factor. Categorizing manufacturing plants by their energy usage could lead to identification of partnerships, waste heat sources, energy efficiency opportunities, and demand management including peak shedding.

Data from 350 energy assessments by the Industrial Assessment Center (IAC) at San Diego State University (SDSU) was used to establish a pattern in energy usage among manufacturing plants in southern California. The 350 plants are small and medium sized, as defined by Department of Energy. The data collected at each of these sites provide an excellent overview of manufacturing plants and their energy usage profile.

The IAC data were used to determine energy use profiles from utility bills and major plant equipment. The T/E ratio was determined for each manufacturing plant. This ratio provides insight to the process and energy needs of the plant by comparing the thermal needs to the electric needs. Generally a value of 5 or higher indicates a good candidate for a cogeneration system [THUMANN; MEHTA, 2001]. This same value is also an indicator of waste heat recovery potential. The

Table 1 - Major SICs and Processes and Number of Assessments in Each Category

SIC	Description [24]
20	Food and kindred products
22	Textile mill products
23	Apparel and other textile products
24	Lumber and wood products
25	Furniture and fixtures
26	Paper and allied products
27	Printing and publishing
28	Chemicals and allied products
29	Petroleum and coal products
30	Rubber and misc. plastic products.
32	Stone, clay, and glass products
33	Primary metal industries
34	Fabricated metal products
35	Industrial machinery and equipment
36	Electronic & other electric equipment
37	Transportation equipment
38	Instruments and related products
39	Miscellaneous manufacturing industries

Process
Annealing
Assembly
Baking
Boiling
Bonding
Chilling
Curing
Cutting
Drying
Extrusion
Grinding
Heat Treating
Incineration
Injection Molding
Lamination
Machining
Melting
Mixing
Molding
Painting
Plating
Press
Press, punch
Printing
Sintering
Soldering
Welding

T/E ratio does not differentiate between high and low grade heat, and further investigation into the process is required to determine the heat quality. However, it can be an excellent first filter for determining waste heat recovery potentials.

To further categorize the manufacturing plants in a manner that would be convenient to compose an energypark, energy intensity was defined as the total energy use divided by the total annual sales, to serve as a guiding parameter. Another parameter was also defined as the total energy use per kg of product. With the T/E ratio and energy intensity determined for each plant, the plants were grouped by major SIC and by manufacturing process.

Once all reports were screened, similar processes were combined and 27 major processes were identified and ranked based on their energy intensity. Table 1 presents the major SIC and process categories. The top four most frequent SICs among the surveyed plants are 30, 34, 20, and 33 and the four most common processes are mixing, extrusion, press, and machining.

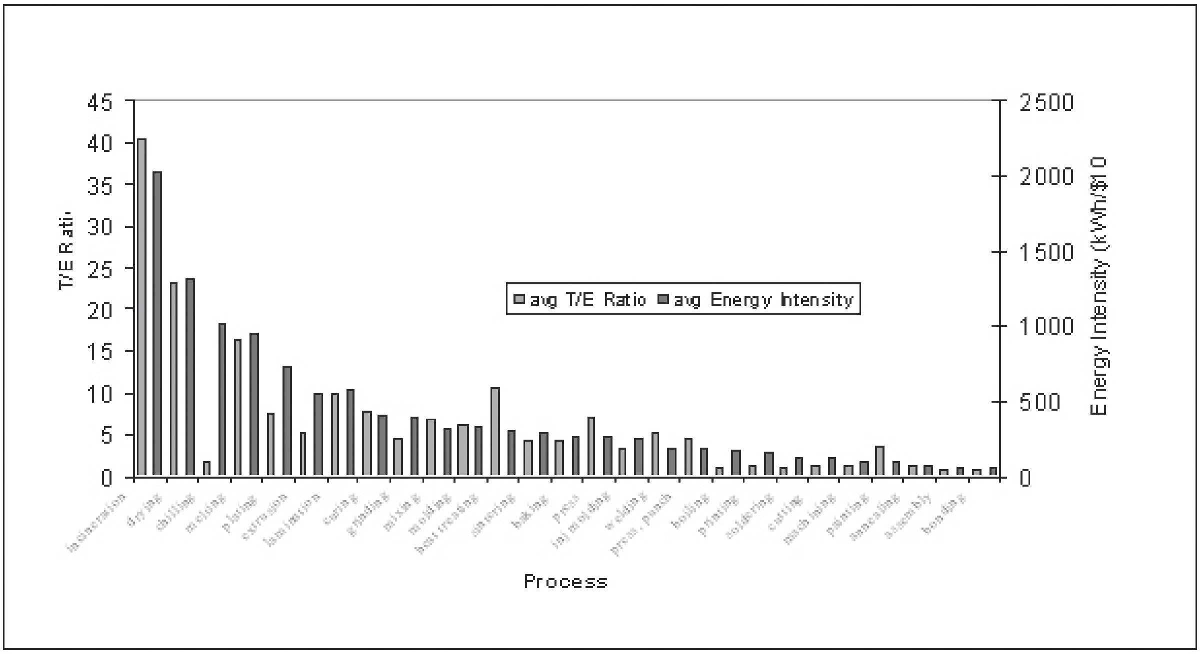

Figure 1 - Energy intensity and T/E ratio by major process

While the energy profiles within SIC categories varied significantly, a clear trend emerged across the process categories. Thus, although the purpose of the IAC assessments is different and the data are gathered with different objectives in mind, it can still serve as a useful data source for process based energy intensity classification. The analyses showed that the SIC code is a poor tool to predict energy usage.

Application

The results depicted above show that categorizing manufacturing plants by major manufacturing processes provides a clearer picture of the energy usage and intensity plants. The process description can lead to a first level screening of plants for waste heat recovery and/or cogeneration potential, and energy conservation opportunities. The benefits of energy efficiency improvements to a plant with a high T/E ratio are evident by the nearly linear increase in energy intensity; the greater the energy intensity the greater the economic benefit from any type of waste heat recovery.

With the SIC system, energy parameters like T/E ratio and energy intensity are not consistent even for plants manufacturing the same final product. Beyene (2005) conducted research on the same IAC data and compared other parameters, like energy usage per employee, electric rates, and energy conservation opportunities (types and savings), and found no consistency within SIC categories. His plots showed no uniformity or unique features that could be generalized by SIC.

Nine plants using processes in the top ten energy consuming categories identified in the analysis in the previous section were analyzed more closely for energy conservation opportunities. Chilling was not analyzed as the energy usage of that process was already determined to be unique. The plants were chosen randomly from within the categories with only an attempt to provide a typical view of a manufacturing plant using the process. The nine processes were curing, drying, extrusion, grinding, incineration, lamination, melting, mixing, and plating. The assessment data were used to tabulate waste heat recovery potential and demand reduction potential. The results were then

Table 2 - Energy Measure Potential by Process

Process	T/E	Energy Intensity (kWh/$1000)	ECOs	Waste Heat Recovery Potential (therms/yr)	Peak Demand (kW)	Demand Reduction (kW)	Percent Peak
Curing	14.79	1752	VFDs, Lighting, Economizer	464,544	6003	164.3	3%
Drying	11.25	3128	VFDs, Photocells	0	2078	992	48%
Extrusion	18.42	3294	VFDs, Economizer, Evaporative Cooling	10,080	3601	2057	57%
Grinding	10.58	1262	VFDs, High Efficiency Motors, Lighting	0	2976	310.9	10%
Incineration	41.43	3830	VFDs, Preheat Feedwater, Insulation, Lighting	167,731	1211	488.5	40%
Lamination	1.2	141	High Efficiency Motors, Lighting	0	5655	1000	18%
Melting	21.21	1392	VFDs, Economizer, Insulation	48,470	2563	1528.8	60%
Mixing	14.93	666	Economizer, Insulation, Lighting, Condensate Return	15,725	587	108.7	19%
Plating	6.93	733	VFDs, Economizer, Insulation, Lighting	4,693	1267	840.4	66%

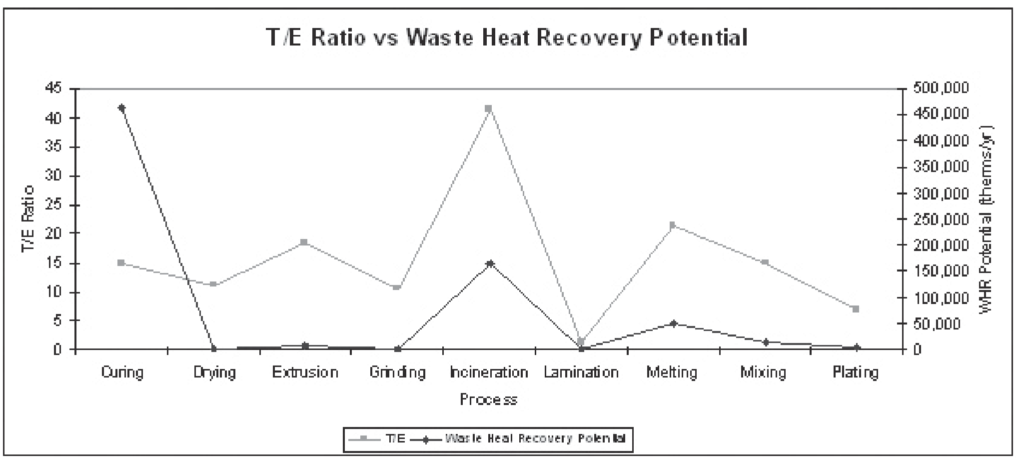

Figure 2 - T/E ratio versus waste heat recovery potential by process

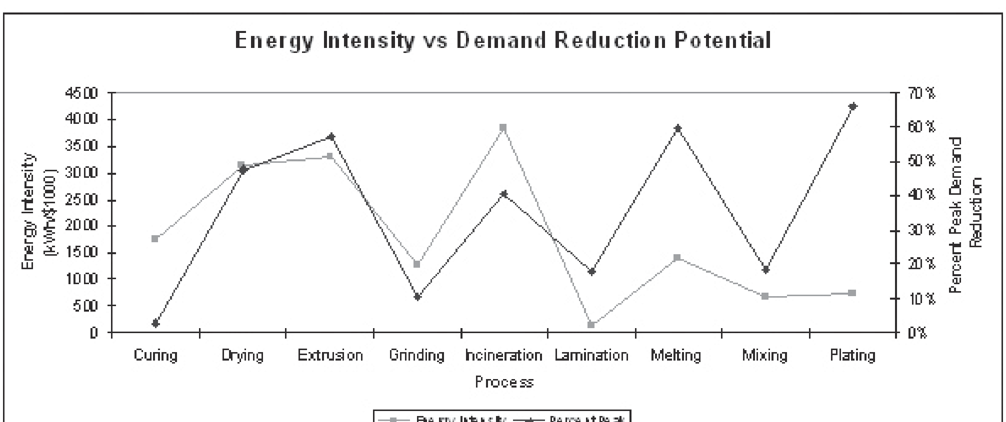

Figure 3 - Energy intensity versus demand reduction potential by process

plotted to see if the waste heat recovery potential corresponded to T/E ratio and if the demand reduction potential related to the energy intensity of the process. Figures 2 and 3 illustrate the waste heat recovery potential and the demand reduction potential respectively. The waste heat recovery potential generally followed the T/E ratio; in the case of the plant using a curing process, no waste heat recovery equipment was installed whereas at the other high thermal plants, incineration and melting, some waste heat recovery was already taking place. This accounts for the large waste heat recovery potential at the curing plant. The demand reduction potential generally follows the energy intensity although this data is not complete as the energy assessments do not look for demand reduction opportunities specifically. Further investigation into the demand reduction opportunity needs to be conducted to verify this relationship.

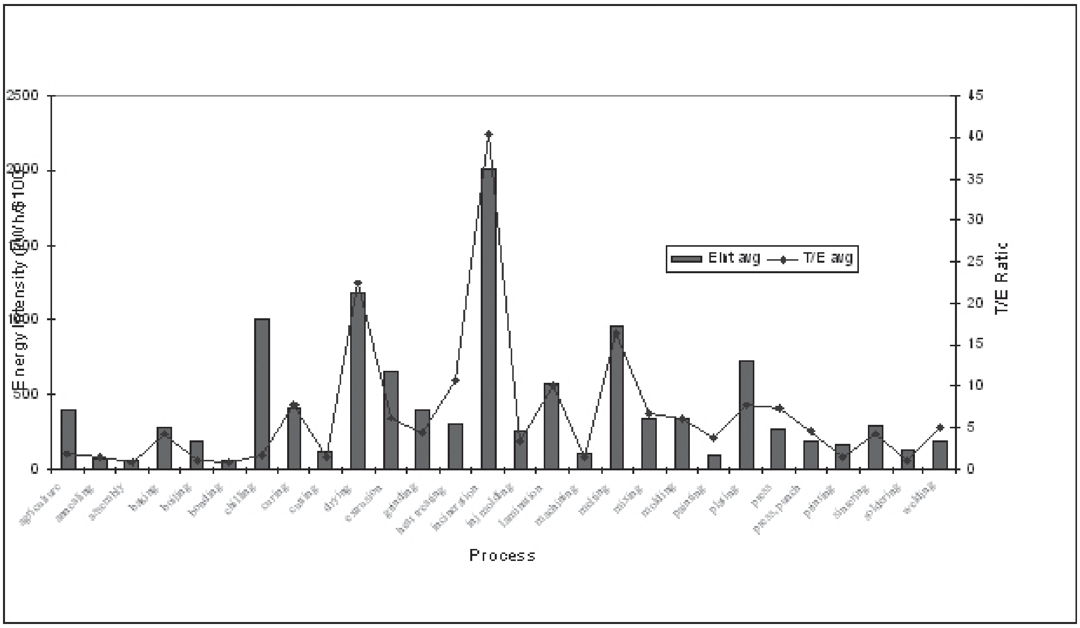

Figure 4 - Energy Intensity and T/E Ratio by Process

From the results of the above analysis, the potential benefits of process oriented classification can be seen. By determining the primary process in a plant, the potential for waste heat recovery and demand reduction can be identified. While the process classification will not provide exact information, it is a significant step towards identification of plants. The SIC classification system cannot provide this type of information.

Other applications

Two specific applications for the process oriented energy classification are demand management through peak shaving and matching plants for an energy park. The first, demand management, is crucial to the health of the country's energy distribution and generation systems. Demand management can be accomplished in several stages: permanent reductions, pre-determined short term reductions, and short notice response. Using the energy classification of manufacturing plants, utility and energy management personnel can target plants for each of the three stages. Energy intensity, electric load factor, and even waste heat recovery potential are all factors to be examined when determining peak shaving opportunities. Low electric load factors are indications of processes that surge at certain times; this can be a process like injection molding where the equipment cycles, or it can be a poorly designed system where all the equipment comes on at one time without regard for the demand. Waste heat recovery potential is usually associated with preheating combustion air, but it is also important for cogeneration applications which reduce demand on the electric grid. One specific energy conservation opportunity identified for six of the seven plants examined in detail is variable frequency drives (VFDs). VFDs ramp down the energy consumed when a motor is idling and can be applied in almost all manufacturing applications. In the six plants, VFDs could reduce demand by 1% to 54%. While not all energy usage is predictable with a VFD, it is in a process like injection molding, or grinding and some mixing, where the timing of the process does not vary. VFDs in these applications could lead to significant and reliable demand savings.

The second application is an energypark. A process classification allows an initial screening of manufacturing plants that meet the energy usage needs of the park design. For example, when using the donor/ receiver model, the base plant of the park should be one with a high T/E ratio and energy intensity to provide a source of waste heat for the other partner plants. Attempting to select this plant by SIC code would be nearly impossible. The same applies for the receiver plants; the receivers should have T/E ratios that indicate thermal usage (and electric in some cases) meeting the output of the donor plant. Receiver plants with a summed T/E ratio larger than that of the donor plant may not be the best match for the energy park. T/E ratio and energy intensity are not enough to select specific plants, further investigation must be conducted to determine the quality of the waste heat, specifically the temperature and composition (pollution levels) or other special considerations. But, the number of plants investigated in detail is significantly reduced when selected by a process based energy classification system. The next chapter will discuss plant selection for an energypark in detail.

In order to target manufacturing plants for energy conservation opportunities a core group of primary processes should be identified with a sub level added if further differentiation is necessary. This type of energy based classification will facilitate targeted energy efficiency programs and provide a clear starting point for any manufacturing sector energy projects.

This suggested "process oriented energy classification" (POEC) could consist of three numbers, the first addressing the T/E ratio, the second addressing the energy intensity involved in the process, and the third a load factor calculation. Some manufacturers may be hesitant to provide detailed information about their process to allow specific calculations, but with a detailed study of each type of process prior to implementation, categorizing plants with a 0-9 value in the three areas would be achievable. Unfortunately, a load factor comparison was not possible with the IAC data. Daily energy profiles, such as those available with a program like San Diego Gas and Electric's kWickview, would allow this type of analysis. Many plants have a real time metering capability and load factors, in percentages, could be determined and used to establish the third number in the classification.

With the POEC, manufacturing plants benefiting from comprehensive energy efficiency and demand management programs could be effectively targeted. With a process identified, the T/E ratio and energy intensity of the plant can be estimated with nearly 80% accuracy. With those values known, the waste heat recovery potential and demand reduction potential can be quantified. Clear trends in energy usage could be seen and compared locally and nationally to determine areas for improvement or geographically unique situations requiring attention. Development of an energy park or other cooperative scenario based on energy usage would be more easily accomplished. In summary, the POEC will provide an excellent tool for local and national agencies to improve energy efficiency and resource planning.

RESULTS AND CONCLUSIONS

This paper has presented a method for categorizing manufacturing plants by energy usage to facilitate the selection of plants for an energypark and the design and initial evaluation of an energy system. Further research could offer better prospects on detailed accounting to include project costs and thermoeconomic optimization of the system to select the best designed park system for the least cost. Extending the analysis further to determine the exergetic cost of grid power and the environmental impact would demonstrate the clear benefit of the suggested method.

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