Additional Information on the Proposed Methodology
"Introducing heat recovery heat pumps with natural refrigerants
for the food manufacturing industries"

Default efficiency values for the reference equipment

The proposed methodology is to introduce heat recovery heat pumps (HPs) using natural refrigerants to the food processing industries in Thailand. The HPs can generate hot and/or chilled water used for the food processing. For the purpose of calculating the reference emissions, this methodology introduces default efficiency values for the reference equipment that generates hot and chilled water.

1) Default efficiency values for the hot water supply equipment (boiler):

1.1 Survey on boilers in Thailand

According to the interviews with the major boiler suppliers Company A, B and C in Thailand, approximately, 70% of boilers installed in Thailand is fire tube type, 15% is water tube type (inclusive of once-through type), and the remaining 15% are other types such as thermal heat type or biomass type. It was conceived that the share of once-through boiler is still low in Thailand. It was also found out that installation of economizer is not commonly conducted since most customers prefer to have boilers without economizer considering initial high investment cost.

In general, oil, coal and natural gas are commonly used as a fuel of boilers in Thailand while the oil fuel boiler has the largest share among the fossil fuel boilers.

1.2 Reference boiler efficiency in Thailand

Oil and gas fire tube boiler is considered in setting the reference boiler efficiency. Coal fired boiler is excluded with a view to securing conservativeness.

According to two major manufactures which sell fire tube boilers in Thailand, the latest efficiency of the oil and gas fire tube boilers without economizer is 89% while the common boiler efficiency is 80－85%. Moreover, according to Training manual on senior energy practitioners in the field of heat set by DEDE (Department of Alternative Energy Development and Efficiency), the boiler efficiency in Thailand is stated as 85%.

Therefore, the reference boiler efficiency in Thailand is determined to be 89% taking the highest value among those figures.

2) Default efficiency values for the chilled water supply equipment (compressor):

2.1 Reason for a compressor being a reference equipment and not a chiller

Unlike other industries, the food manufacturing industries operate under a wide range of process temperatures (mostly within a temperature range of +120 degree Celsius to -50 degree

Celsius). For this reason, instead of installing a chiller, a custom-made 'refrigeration system' is usually designed specifically to meet the need of a factory's operation, by combining compressor units with condensers, evaporators and other relevant equipment.

The proposed methodology is for projects where a heat pump is introduced to reduce the inlet water temperature to a refrigeration system at a food manufacturing plant, thereby the compressor's cooling load is partially alleviated and its electricity consumption is reduced. Since the refrigeration system configuration remains the same as before and the most significantly affected by the project is the compressor's cooling load in the system, the reference equipment is identified as the compressor.

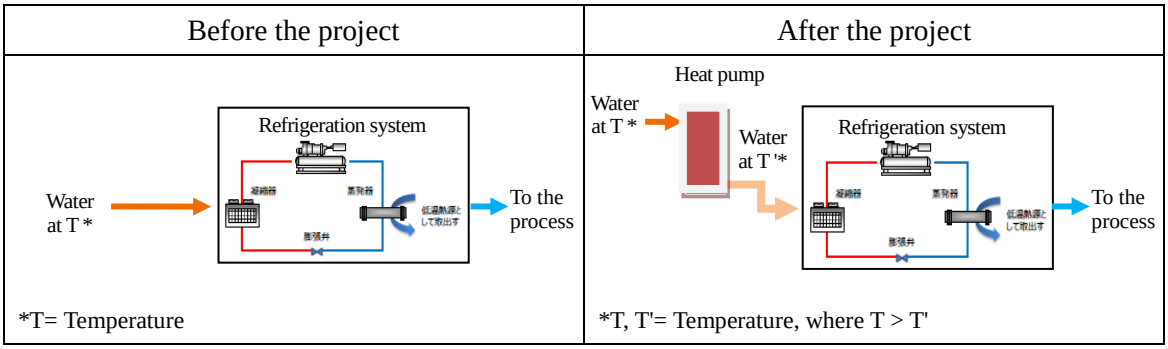

Figure 1: Heat pumps and refrigeration system

2.2 **Refrigerant compressor**

Refrigerant compressor is a device to compress refrigerant gas. The description of refrigerant compressor is shown in Table 1 below. There are mainly two different types: positive displacement type and dynamic type.

Table 1: Refrigerant compressor

	Refrigerant Compressor	
Feature	・Generates cold / hot heat by compressing the refrigerant with a compressor ・Closed circuit ・Possible for heating and cooling application	
Type	Positive displacement types	Dynamic type
	Reciprocating type, Rotary type (e.g. Screw and Scroll type)	Axial, Centrifugal type
Scope of application	Air coolers, chillers, refrigerators and others	

2.3 Choice of compressors for the reference equipment

As shown in the Table 1 and based on an interview, the positive displacement types—especially screw and reciprocating ones—are generally used in the food manufacturing plants in Thailand due to their high compression ratio and low initial costs.

Among the positive displacement types, the scroll type is not considered in this methodology as it is used for commercial application. Furthermore, Criterion 1 in the eligibility criteria of the methodology limits its application only to plants where the refrigeration system uses either screw or reciprocating compressors. Therefore, the default efficiencies suitable for those two types are developed in this methodology.

2.4 Default COPs for compressors

The food processing industries require a large quantity of cooling heat at a wide variety of outlet temperature for their process, which is quite different from cooling heat required for buildings for air conditioning application. Thai government establishes both MEPS and HEPS for chillers used for buildings[1]; however, there is no standard for the compressors used in the refrigeration system for food processing. Thus, a market survey is conducted to determine the default COPs for the compressors.

In Thailand, there are three dominant manufacturers selling screw and reciprocating compressors using different refrigerants to the food processing industries. After collecting manufacturers' specifications in July 2017, COPs for individual models are levelled out using the following conditions, and the results are summarized in Figure 2.

- Condensing temperature: 38 degree Celsius
- Evaporation temperature: -5 degree Celsius

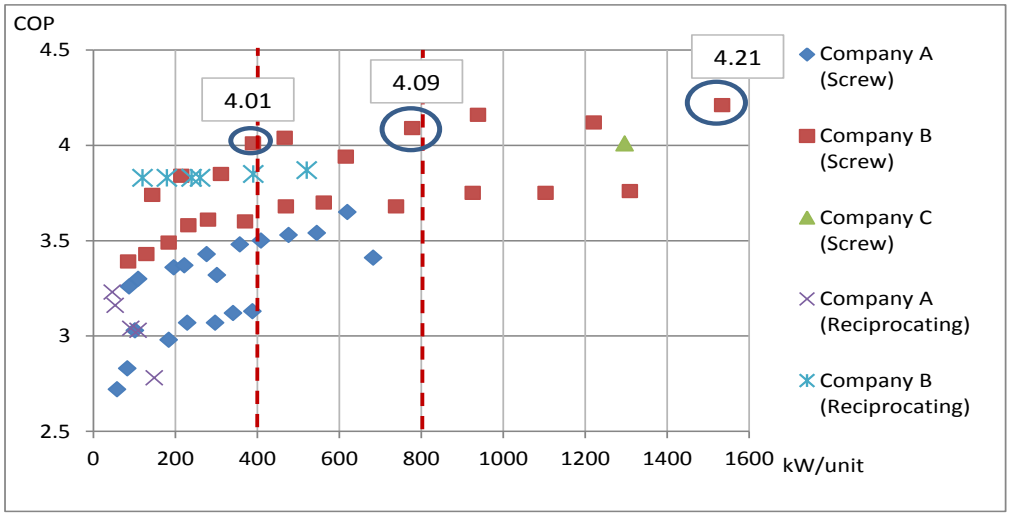

Figure 2: COPs for screw and reciprocating compressors

Based on the above information, the default COPs for the production process in the food processing industries in Thailand are set as follows:

Table 2: Default COPs for screw and reciprocating compressors

[1] MEPS and HEPS are for a chiller containing a compressor, condenser and evaporator all together to form a commercial product with manufacturer's specifications, and thus different from the refrigeration system explained for the food manufacturing industries in this methodology. For this reason, current MEPS and HEPS by Thai government is not considered in this methodology though MEPS and HEPS categorize the efficiency based on the types of the compressor used in a chiller.

Cooling Capacity /unit (kW)	**50≦x<400**	**400≦x<800**	**800≦x<1600**
COPs	4.01	4.09	4.21