

CHAPTER 5 CONCLUSIONS

The endeavor of this research is greatly to develop design and propose the strategies of integrated design for energy-efficient industrial buildings and human comfort which was one of a few researches in Thailand in terms of improving architectural design appropriate to tropical climate, according to the global warming, the climate change, and the 30% of end-use sector shares of total energy consumption [EIA, 2008]. A methodology of the research was conducted by acquiring data in field survey including 300 questionnaires and measurements of human comfort factors in 6 monitoring factories in 6 cities of Thailand: Bangkok, Pathumthani, Samutprakarn, Chachoengsao, Chonburi, and Rayong. Meanwhile the experimental building model was defined by the results of the data acquisition and hypothesizing of the integrated design strategies that was investigated by computing simulation tool in the last. The results of data acquisition indicated that the most concerned factor over human comfort affecting employee productivities is the temperature, afterwards lighting illuminance, noise level, and air velocity respectively. While IAQ (Indoor Air Quality) is the most discomfort condition that should be improved in the interviewees' attitude. In the implementation of design strategies ranked from managerial attitudes, it was found that the basic design strategies with less investment including orientation, green surroundings, daylighting and natural ventilation were preferable accordingly. Whilst the advanced design strategies with more investment including building envelope, fan assisted ventilation, green roof, and PV/ BIPV had been preferable accordingly. Regarding the potential of improving building performances to achieve maximized human comfort, air velocity inside the buildings should be increased by proper design, reducing mean radiant temperature of great impacts of roof and wall surfaces, reducing ambient noise level by specifying outperformed materials, and increasing ambient light level by using maximum daylight. Owing to the potential of achieving minimized energy use, air velocity inside the buildings optionally should be increased by fan assisted, increasing use of high effective machines and equipments, increasing opening for natural ventilation, and restraining task light zone by separating working area from common one in production area.

The design guideline of passive design in industrial buildings appropriate to tropical climate such as in Thailand was defined by decreasing mechanical methods and enhancing more natural methods whilst retaining human comfort is a way to encompass the integrated design strategies of energy-efficient and low-energy buildings. The basic idea of passive design is to allow in daylight, heat and airflow only when they are most beneficial, and to exclude them when they are not. General guideline of integrated design strategies in thermal comfort of industrial building in tropical climate had been proposed. Building orientation, the fundamental design at the first stage, should be planned correctly in direction of wind and sun, as well as shape of building should be related to face opening side into the breeze to achieve well cross-ventilation from the south for Thailand climate. Natural ventilation driven by the wind is simply method of practice for large buildings which particularly generated amount of heat by the machine

or process in their production areas. The effective daylighting and electric lighting design in high and opened planning as industrial buildings, provided ambient lights for common area such pass way and separately supply task lights for each work location solely, is a way to reduce energy losses in over supplied electricity. Building envelope and shading devices, using material specification to protect heat gain and sunlight accordingly, including insulation to reduce unwanted heat losses or heat gains through the roof, walls, doors, windows and floors. Moreover, integration with minimized active design of photovoltaic (PV) and building integrated photovoltaic (BIPV) as well as fan assisted ventilation are installed alternatively for outperformed building attributes.

In addition, the suggestion of ventilation design for roof monitor was stated. Flow heat under the roof from machine or process to the above roof due to the rule of thumb; the heat buoys to higher space and the cooler air blows instead. Providing indirect skylight area ratio 3% of roof area is proper to balance between lighting and thermal aspect enough for general working in daytime without electric lighting. The wall opening for ventilation with integrated design for industrial buildings had been proposed by setting-back VB wall and horizontal opening could increase effective ventilation area totally 75% compared with typical louver in same opening area, to protect splash rain and get shadow onto the wall to reduce direct heat. The other idea is increasing vertical opening for effective ventilation area totally 100% compared with typical louver in same opening area and getting shadow onto the lower wall. In case of rain, the operable opening could be closed to protect rain. However, evaluating the possibility of utilization in energy saving and thermal comfort of building comparing with the life cycle cost of materials and methods, is requisite to consider inclusively in future work or further research as well, in order to improve the quality of occupants' life in desirable environment for industrial buildings in Thailand.