CHAPTER I

INTRODUCTION

Petroleum products account for half of the total final energy consumption in Thailand. In 2009, almost all energy used by the transport sector comes from petroleum products which represent 72 percent of the total consumption of petroleum products in Thailand. Seventy-six percent of transport energy is consumed in the road sector with little fuel diversification, and with only a small amount of energy coming from renewable energy sources. Increasing use of petroleum products would not only increase oil import but also increase contribution to global warming from combustion of fossil fuels. Biomass has long been identified as a sustainable source of renewable energy. However, transportation using a solid fuel has had significant limitations with respect to materials handling requirements and efficient energy conversion. Converting biomass and agricultural residues into a liquid addresses these issues and makes possible the use of higher efficiency combined cycle systems for transportation.

Pyrolysis bio-oils are renewable liquid fuels, and are highly regarded as substitutes of petroleum fuels. However, as pyrolysis bio-oils are quite different from petroleum fuels, it is necessary to develop new technologies for the successful utilization of pyrolysis bio-oils, which requires adequate understanding of their overall fuel properties. Liquid pyrolysis bio-oil can be stored, pumped and transported in a similar way as petroleum based products and can be used as an alternative to fossil fuels in gas turbines, diesel engines and boilers. More importantly, because bio-oil is produced from biomass/agricultural residues or wastes, it is considered carbon neutral as CO_2 released can be readsorbed by biomass In addition, it does not produce SO_x (sulphur dioxide) emissions and significantly less NO_x (nitrogen oxide) emissions than diesel fuel during combustion. As a clean fuel, pyrolysis bio-oil has a number of environmental advantages over conventional fossil fuels as follows: 1) CO_2/greenhouse gas neutral: because pyrolysis bio-oil is derived from biomass (organic waste), it is considered to be greenhouse gas neutral and can also generate carbon dioxide credits. 2) No SO_x emissions: as biomass does not contain sulphur, bio-oil produces virtually no SO_x emissions and, therefore, would not be subjected to SO_x taxes. 3) Low NO_x: bio-oil fuels generate more than 50 per cent lower NO_x emissions than diesel oil in gas turbines. 4) Renewable and locally produced: bio-oil can be produced in countries where there are large volumes of organic waste.

Being one of the world leaders in agricultural production and export, Thailand has abundant biomass resources and agricultural residues. Among the total area of 520 million square kilometers, more than 65% is occupied by agriculture related activities. According to the assessment of the residue potential of ten main agriculture products in 2001, 22 million tons out of 66 million tons were used as fuel and a small amount for other purposes whereas about 44 million tons of agricultural residues, equivalent to 612.89 Pica Joule (PJ) of energy, were still unused. Therefore, Thailand has a high potential for energy production from agricultural residues. Pyrolysis bio oil can be derived from renewable biomass and residue such as rice straw and *leucaena leucocepphala*. However, in order to move towards sustainable use of pyrolysis bio-oil, LCA is needed to assess the environmental impacts of a product during its whole process in order to investigate and validate whether pyrolysis bio-oil is a green and sustainable fuel or not.

The propose of this research is to conduct the life-cycle energy and environmental assessment study on bio-oil production based on fast pyrolysis technology process using rice straw and *leucaena leucocepphala* in Thailand. The life cycle inventory analysis and impact assessment were carried out based on ISO 14040 series for all stages involved in the production of 1 ton oil equivalent (toe) of bio-oil from rice straw and *leucaena leucocepphala* which included raw material plantation and harvesting, transportation, pyrolysis, and upgrading process. Net energy ratio (NER) was used as an indicator to assess the energy efficiency of the bio-oil production. Comparison was systematically done between bio-oil, conventional fuels, and other biofuels. In addition, improvement options such as heat integration and heat recovery were applied to the upgrading process to enhance the environmental and energy performance of the bio-oil production.