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Water for bio-energy in Thailand

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Abstract: Thailand is one of the countries which positively promote bio-energy production by producing liquid biofuel from molasses of sugarcane, cassava, palm oil and coconut oil. However, bio-energy production may increase the water requirement as it requires more water per unit of energy than existing energy facilities. Therefore, this study aims to evaluate the water requirement for bio-energy in Thailand by a bottom-up approach. The results show that the water requirement for bio-energy production in Thailand is 2.4 billion m^3 for 2010, 52% of which is for bio-ethanol. Furthermore, it is estimated that the water requirement for bio-energy supply will increase to 3.9 billion m^3 of water in the future, 70% of which would be for bio-ethanol production. Finally we discuss the impact on water ecosystems through bio-energy production and the social and policy implications of bio-energy with respect to the water-energy nexus.

Keywords: water-energy nexus, liquid biofuel Thailand, bottom-up approach

INTRODUCTION

Thailand is one of the countries which positively promote bio-energy production. The bio-energy is closely connected with tropical and sub-tropical crops. Bio-ethanol, which is one of the main products for renewable energy strategy in Thailand, is made from sugarcane and cassava, and solid biomass such as paddy husk and bagasse of sugarcane is used as bio-energy. In addition, biodiesel, which is one of the liquid biofuels, is made from coconuts oil and palm oil. On the other hand, numerous studies have indicated that bio-energy production may increase water resource consumption as the water consumption per unit of bio-energy production (24-143 m^3/GJ) is higher than that for existing energy facilities (i.e. crude oil 1.1 m^3/GJ; hydro 22 m^3/GJ) [1, 2]. However, the practical impact on water resources by bio-energy production remains to be studied, therefore this study aims to evaluate the water requirement for bio-energy production in Thailand. First we explain the methodology used to analyze the water requirement for bio-energy, then we show the change of the water requirement for bio-energy over the last five years. Finally we summarize and draw conclusions.

MATERIALS AND METHODS

Situation of bio-energy in Thailand

The total bio-energy supply has been increasing and 22,002 ktoe of bio-energy (18% of total energy supply) was supplied in 2010 (Figure 1)[3]. The bio-energy in Thailand consists of solid biomass (wood, charcoal, paddy husk, bagasse, and agricultural waste), liquid biofuel (bioethanol and biodiesel), garbage and biogas and 96% of this bio-energy is produced from solid biomass while the other is liquid biofuel.

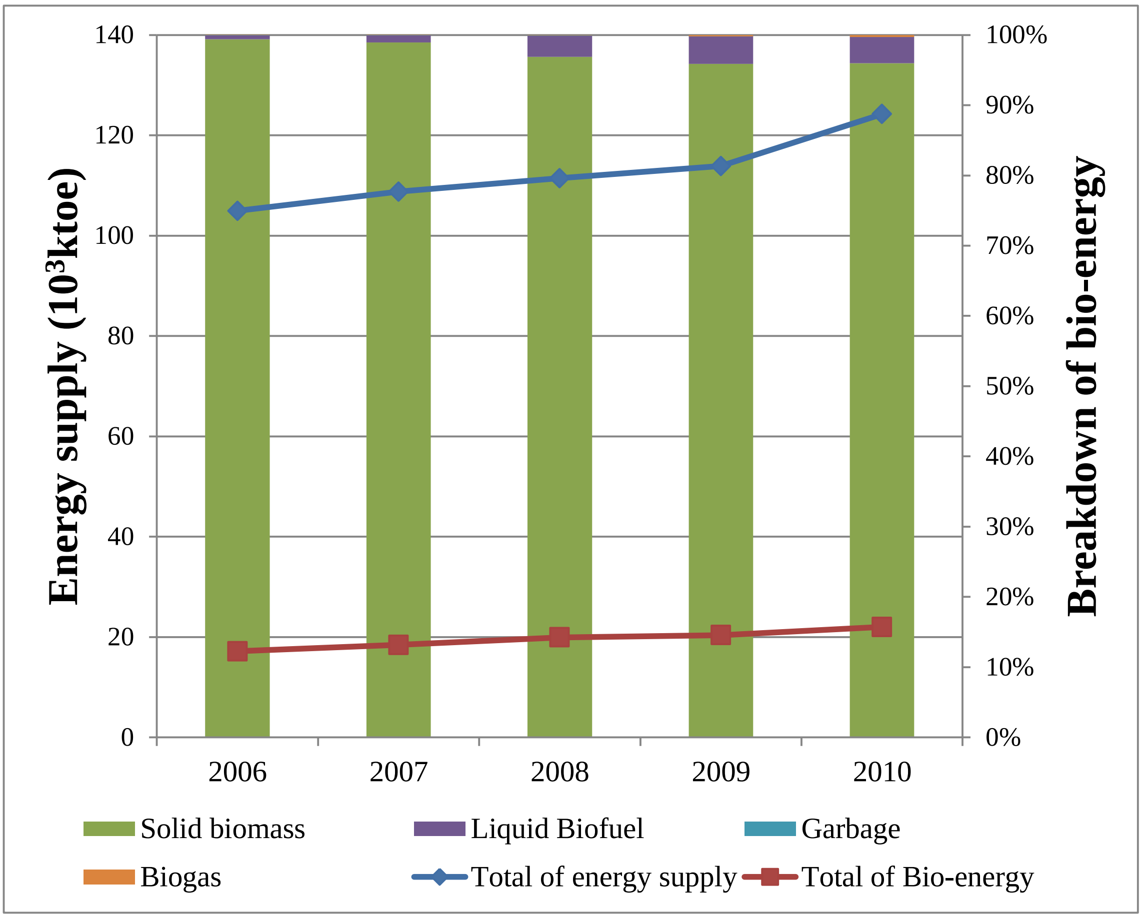

Figure 1 Situation of bio-energy supply in Thailand

Calculation of water for energy production

Numerous studies have investigated the water used in energy production (WEP) and they are mainly divided into two types. One is a bottom-up approach which defines WEP based on production process of not only energy production (direct water requirement) but also feedstock of biomass energy [1, 2, 4-7] or fuels [4, 5, 8] (indirect water requirement). The other takes into account energy consumption as well as energy production [9] and WEP is solved by a hybrid approach coupled with a bottom-up approach and LCA method based on environmental input-output analysis [10].

We adopted a bottom-up approach, for data accessibility of input-output tables. Thailand has published national input-output tables every five years from 1975, but the tables cannot be used for an analysis of bio-energy with hybrid approach, because they do not include bio-energy flows.

On the other hand, a bottom-up approach is a very simple method, which estimates WEP by energy production and water requirement content (WRC), so it is possible to apply to analyze bio-energy in Thailand.

By using national bio-energy statistics [3], we define domestic bio-energy production, such as solid biomass (fuel wood, charcoal, paddy husk, bagasse and agricultural waste), garbage, biogas, bioethanol and biodiesel, from 2006 to 2010. Furthermore, we estimate future WEP with bio-energy potential for 2010 in Thailand [3] .

Then we have referred to previous studies to set WRCs of the bio-energy products (Table 1). The system boundaries differ by research with some studies defining WRCs of bio-energy based on water consumption such as evapotranspiration of feedstock, thus water requirements here equal to water consumption. In addition, some studies evaluate water for bio-energy in Thailand [11, 12] based on bio-ethanol production processes, but we do not use the WRC because the system boundaries are different. For example, they distinguish sugarcane-based bioethanol among feedstock (bagasse and molasses), so we need data of the productions of the bagasse and molasses of sugarcane. However the energy statistics have the only aggregated bioethanol production made by sugarcane and cassava, so we define the WRC of bioethanol by average of WRCs of sugarcane and cassava of previous research. Furthermore, Furthermore, WRC of biogas production is negligible because the process requires small amount of water compared to the other bio-energy transformation [4]

Table 1 Water requirement content (WRC) of bio-energy

Bio-energy	WRC (m^3/GJ)	References
Solid biomass*	0.64	[8]
Garbage	n.a.	□
Bioethanol+	87.37	[2, 4-6, 13]
Biodiesel#	27.45	[4]
Biogas	0.00	[4]

Notes:
* represents Value of wood-fired generation.
+ represents Average of values of bioethanol of sugarcane and cassava.
# denotes value of palm oil production

RESULTS AND DISCUSSION

Water for bio-energy production and potential in Thailand

Water for bio-energy production increased to 2.4 billion m^3 in 2010 which is about three times that in 2006. In addition, the share of water for liquid biofuel production which comprises bioethanol and biodiesel has risen significantly to 76% of water for bio-energy in 2010 from 43% in 2006.

Furthermore, water for potential bio-energy production is estimated at 3.9 billion m^3 which is 1.7 times that in 2010 with 77% for liquid biofuel (70% by bio-ethanol).

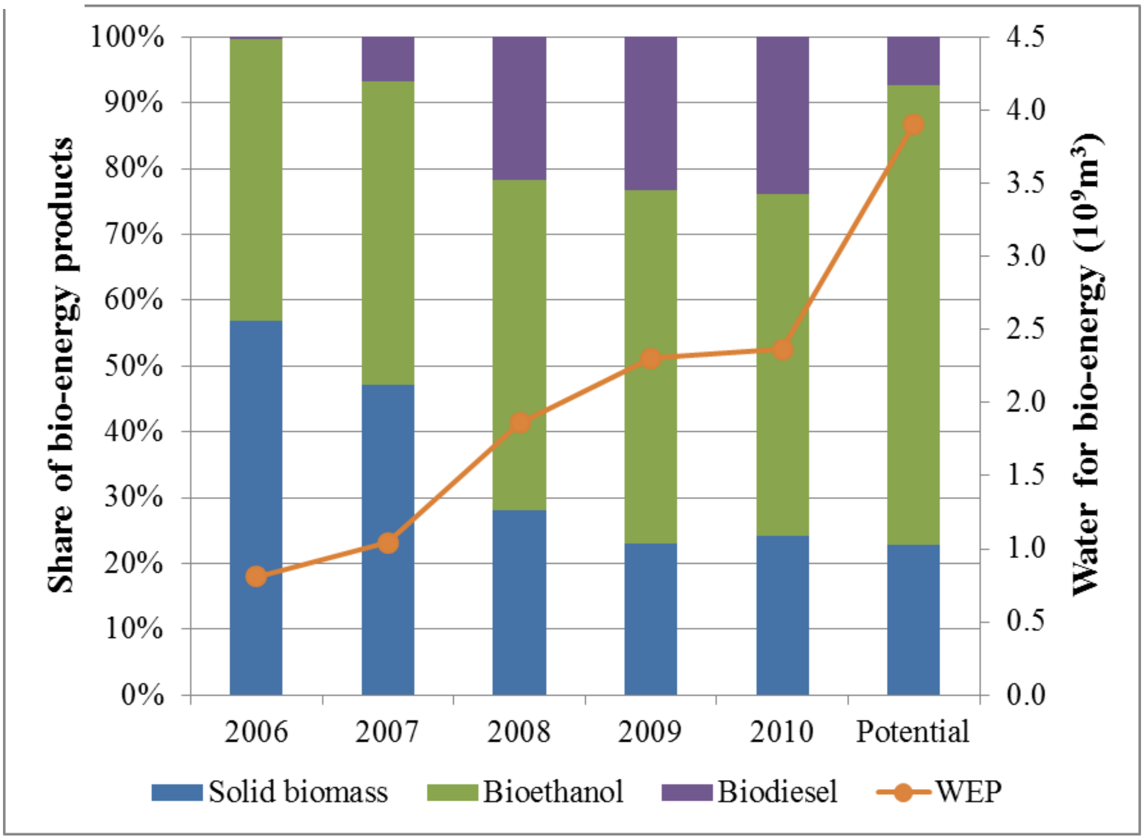

Figure 2 Water for bio-energy production and potential in Thailand

Notes:

Garbage and biogas are eliminated from Figure 1 since they are not available or zero respectively because of the WRCs.

Potential means bio-energy potential in 2010 based on the data of DEDE [1]

Impact on water ecosystems by bio-energy production in Thailand

Total renewable water resource in Thailand is estimated at 438.6 km^3 per year with 126 km^3 being exploitable, and dam capacities in 2010 were 76.8 km^3 [14]. Furthermore in 2007 57 km^3 was withdrawn for:- agriculture (51.8 km^3), industry (2.8 km^3) and households (2.7 km^3) [14].

Then we found that the water requirement for bio-energy production in 2007 corresponded to 1.8% of withdrawn water in Thailand. In addition, currently 74% of the water supply capacity is withdrawn for socio-economic activities but there is a potential for this to increase to 79% through future bio-energy production (Figure 3).

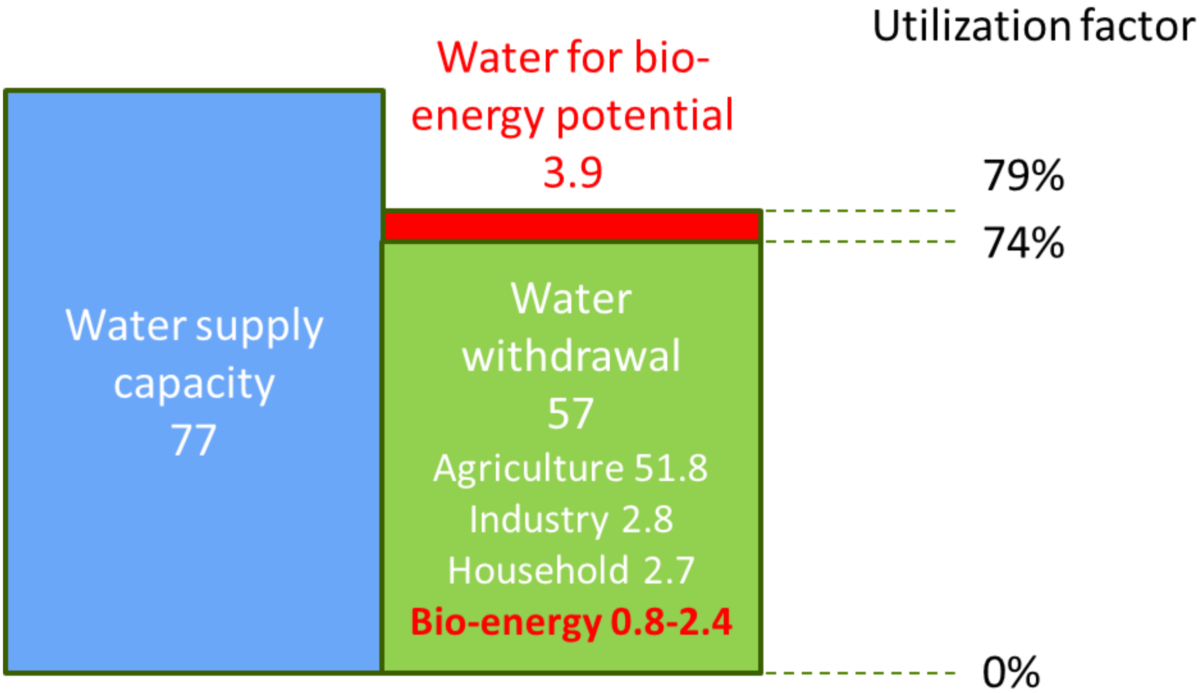

Figure 3 Impact to water resources by bio-energy production in Thailand in year 2007

Policy implication

Figure 4 shows that there is a high correlation between shares of bio-energy in total energy supply and ratios of water for bio-energy production to withdrawn water[1]. In addition, Table 2 shows the data about bio-ethanol production and water that is needed in that process. Then we found that bio-energy production tends to require more water in comparison with a contribution for energy supply in Thailand because the elasticity is higher. So from 2006 to 2009 the share of bio-energy in energy supply increased by 1.6%, nevertheless the ratio of water for bio-energy to water withdrawal increased by 2.6%.

On the basis of the results, Figure 3 and 4, water-saved bio-energy production systems are desirable for Thailand. Then it is probably effective to decrease water required to produce feedstock, because biomass production needs eleven times more of water compared to biomass refining [4]. Furthermore, cassava requires three times more of water compared to sugarcane [2], so it is considered that sugarcane is more desirable for water-saved bio-energy (ethanol) production in Thailand. Moreover if Thailand utilized sugarcane for ethanol production, sugarcane juice is more efficient in the aspect of water-saving [12]. However, we should take account of the conflict with sugar manufacturing.

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1 We fix water withdrawal as 57.3 km^3, which is the value in 2007 [12], since we cannot find the data for the other years in the period of 2006-2010.

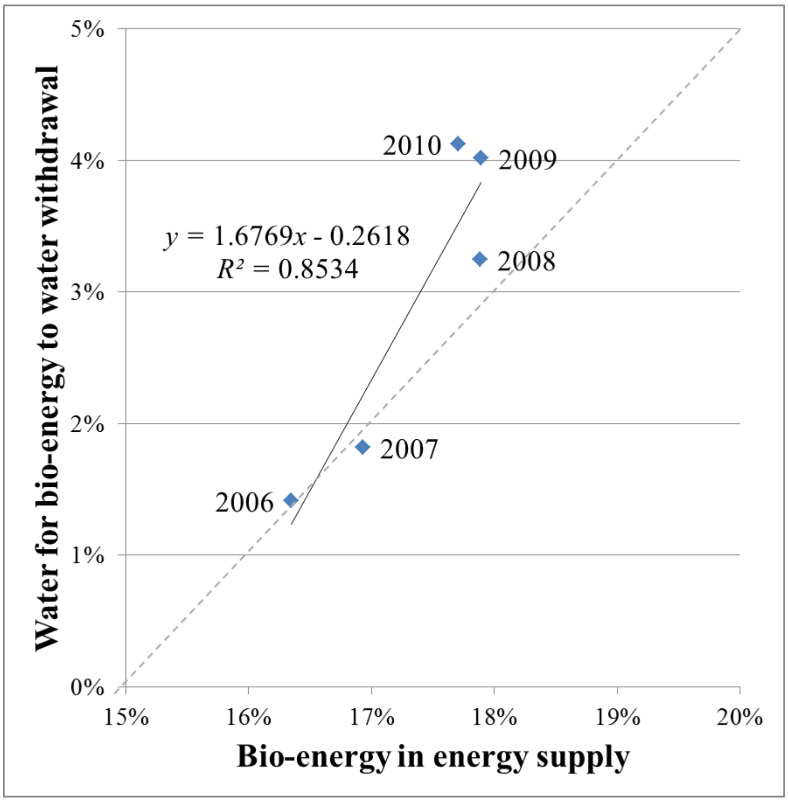

Figure 4 Water requirements and energy supply for bio-energy production in Thailand

Table 2 Water for bio-energy production (WEP) and bio-energy production

		2006	2007	2008	2009	2010
WEP	million m^3	809	1,041	1,860	2,301	2,364
Bio-energy	ktoe	17,154	18,417	19,932	20,376	22,002

CONCLUSION

This study has evaluated water requirement for bio-energy production for the present and future in Thailand. Our findings are that the water requirement for bio-energy production in Thailand is 2.4 billion m^3 for 2010, 52% of which is for bio-ethanol. Furthermore, it is estimated that the water requirement for bio-energy supply will increase to 3.9 billion m^3 of water in the future, 70% of which would be for bio-ethanol production. Finally we found that bio-energy production tends to require more water in comparison with a contribution for energy supply in Thailand, thus it is considered that water-saved bio-energy production systems are desirable for bio-energy policy in Thailand.

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