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ASSESSMENT OF THE CARBON EMITTED FROM THE LAYER AND YOUNG CHICKEN FARMING UNDER THE UNCERTAINTY

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ABSTRACT

Decision making under uncertainty could analyzed environmental problems from the energy using of the tender young chicken and layer farms in egg production. The analysis was based on pay of matrix principle by using all alternatives such as the energy sectors, situations of carbon emission from young chicken farms and layer farms. Then make the decision follow Pay off Matrix, Laplace Rule, Maximax Rules and Minimax Regret Rule on environmental problems. Life cycle inventory is a useful tool for estimating carbon mass of the food support eating. Layers were energy using animals that were raised for their egg, and produced emissions of green house gases such as CO_2 and CH_4. Therefore it was important to study and understand the relationship between the carbon emissions and carbon mass transfer for egg production. This case study of egg production was done to evaluate carbon emission on layer farms, to investigate the rate of carbon massflow from layer feed to layers and egg in farms and to study the carbon emission in energy patterns from electric energy and petrol used of the tender young chicken and layer farms in egg production. The study showed that total carbon emission per individual per year for production of layers was 0.030 tonC./ind./year. According to theories and rules applied in making the decision on environmental problems, they could be concluded that LPG and electricity were the best alternative but transportation energy for layer and egg production caused highest environmental problems among these three alternatives of the energy sectors. The study also showed that in both provinces, Nakhon Nayok and Khon Kaen, immature layers emitted carbon from the use of energy less than mature layers. The carbon emission from the using of transportation energy was quite high in terms of energy using but low in the using of electricity and LPG activities. Therefore, farmers should reduce emissions from energy consumption such as reduce distance for layer feed and layers transportation to farms. The using of fuel for transportation should be reduced because it creates the highest carbon emission.

Keywords: carbon, egg, layer, life cycle inventory, uncertainty.

INTRODUCTION

The food production system as a whole is recognized as one of the major contributors to environmental impacts since it is a great consumer of both energy and natural resources. The current consumption pattern has motivated an increasing interest to report the environmental performance of food products. In this sense, the food production, processing, transport and consumption account for a relevant portion of the environmental greenhouse gas (GHG) emissions. The emissions from food production have increase for two main reasons. First, a growing world population demands more food. Secondly, changes in dietary preferences towards higher-order foods can be increase GHG emissions, with trends towards more intensive of egg production. A growing demand for egg production requires the greater use of the demand for energy. It also induces changes in land use: a process that inevitably leads to CO_2 emissions into the atmosphere. Food production and food consumption are consequently of critical importance in the current and future development of GHG emissions. One of the environmental threats that our planet faces today is the long-term change in Earth's climate and temperature patterns due to global climate change, or the greenhouse effect. CO_2 and CH_4 from human activities are the most important greenhouse gases contributing to global climate change (IPCC, 1995) with CH_4 being 23 times more potent than CO_2 (IPCC, 1996). Chicken and layer are energy-using animals that are raised for their meat and egg, and produce emissions of both CO_2 and CH_4. Carbon is an important element for humans because it is the primary element of both plants and animals and it cycles through living and non-living components. The growth rates of human population drivers the demand of livestock production increase. Livestock animals meet a variety of food needs for people (Thornton *et al*., 2009). They are important nutrient sources of protein in the form of meat and egg (Lauhajinda, 2006). Livestock productions have emitted some greenhouse gases from fertilization, feed production, transportation, energy use in housing, respiration and digestion of livestock (Thanee *et al*., 2009a). The effects of livestock productions due to the utilization and changes of natural resources and environmental factors on the global should be considered (IPCC, 1996). The productive processes should release the least greenhouse gases to avoid such problems and save the Earth. Life cycle inventory (LCI) is an environmental assessment tool for evaluating the impacts that a product has on the environment over the entire period of its life from the raw materials extraction which it was made through the manufacturing, packaging processes, and the use, reuse and maintenance of the product and on to its eventual recycling or disposal as waste at the end of the useful life (Thu Lan and Shabbir, 2008). Layers are energy

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using animals that are raised for their meat and egg, and produce emissions of CO_2. The carbon emission is an alternative for consumers to select the products that release greenhouse gases emission into the environment (Thanee, Dankitikul and Keeratiurai, 2009b). The net carbon production is the rate at which carbon is fixed during growth and laying eggs, and can be used to explain the time averaged C stocks by carbon weight per time (van Noordwijk and Cerri, *et al*., 1997; van Noordwijk and Murdiyarso *et al*., 1998). Therefore, it is important to study the relevant factors concerning the entire production both physical and biotic environment (Thanee and Keeratiurai, 2010). This study deals with the assessment of the carbon emission for egg products which focused on carbon transferred to food chain and fixed in layer meat and eggs. In particular, the estimation of the rate of carbon massflow from animal feed to layer, and including the carbon emissions from electricity, petroleum, and LPG used during egg production were studied in Thailand.

MATERIALS AND METHODS

Study area

Khon Kaen and Nakhon Nayok provinces were selected which represent egg production of Thailand were based on the data of Agricultural Information Center, Office of Agricultural Economics (2004). These provinces have large areas and provide many layer farms and egg productions in these areas as shown in Figure-1 (Department of Livestock Development, 2009).

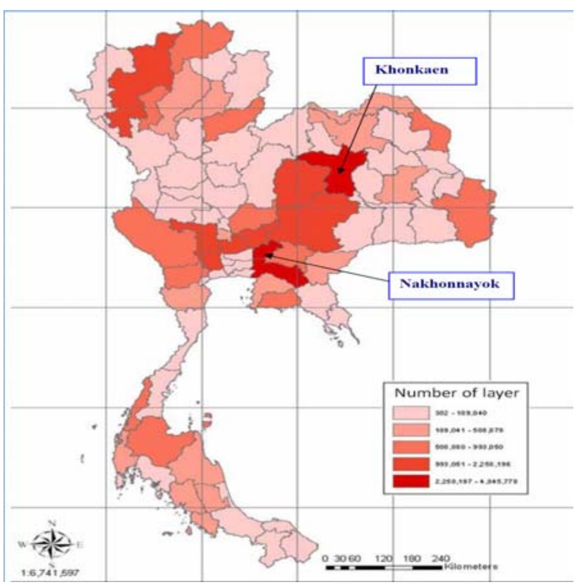

Figure-1. The study of the layer farming area in Khonkaen and Nakhonnayok provinces of Thailand. (From http://www.dld.go.th/index.html, department livestock development, 2009).

LCI methodology applied in this study

Life cycle inventory analysis involves data collection and calculation procedures to quantify the relevant input and outputs of a product system. These inputs and outputs may include the use of resources and releases pollutant to air, water and land associated with the system (Thu Lan, 2007). Life cycle study, data collection represented a time consuming task and it was important to obtain quantitative information concerning various processes in the product system. A significant part of data associated with life cycle of egg production was collected from chick and layer farms. Data for energy consumption, resources and material were obtained directly from farms. A useful instrument facilitating the estimation of gas emissions was the emission factor, which was a representative value attempts to link the associate with the system output. The process of impact assessment analyzes the environmental burdens associated with the material and energy flows determined in the inventory analysis phase though successive steps listed as follow classification, characterization, normalization and weighting (Curran, 1996). The study of life cycle inventory to evaluate the total carbon emission for the egg production in Khonkaen and Nakhonnayok, Thailand was shown in Figure-2.

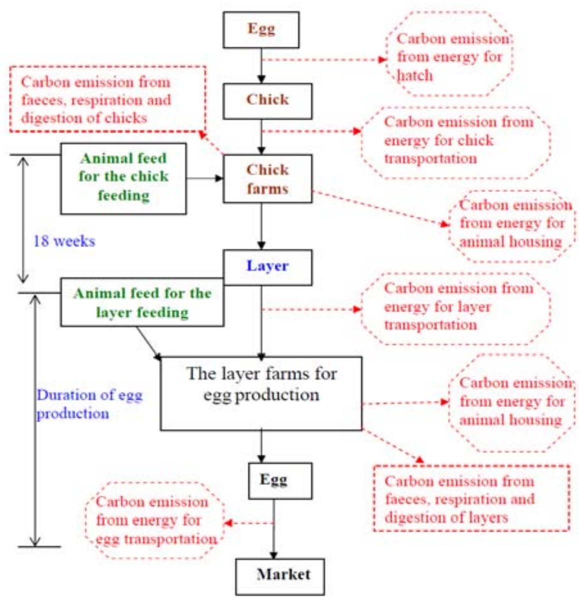

Figure-2. Scope of study on carbon emission from egg production.

Site sampling and analytical methods

The numbers of farms, young chickens, and layers in each district of selected provinces were calculated by determining the numbers of farms young chickens, and layers in the Khonkaen and Nakhonnayok provinces at 95% confidence level (Yamane, 1973; Cavana *et al*., 2001). (According to the population of the study, the totals of population study of the tender young chicken farms*, and layer farms were 2039*, and 1383 respectively.) Therefore, the sample groups were calculated by Taro Yamane's formula (Yamane, 1973) as follows:

$$n = \frac{N}{1 + Ne^2} \tag{1}$$

Where, n = Sample size
N = Population size
e = The error of sampling

So, the example of the sample size of young chicken farms for the study has been calculated according to the recommendation as follows:

$n = 2039 / \{1+2039*(0.05)^2\} = 335$ chick farms

With N = 2039, e = 5% (at 95% confidence level), hence the sample size is 335 respondents. The results showed that sample size were 335 young chicken farms, 400 young chickens and 311 layer farms, 400 layers calculated by *Taro Yamane formula.* Animal feed plus their egg and faeces were collected and transferred to the laboratory at Suranaree University of Technology for measurements. Carbon dioxide was measured from living layers at the farms. The evaluation of carbon emission from energy sectors in egg production was calculated with the software of Department of Livestock.

Development as shown in Figure-3 and the analytical methods are as follows:

a) Moisture contents were measured by weighing sample after oven drying at 103-105°C for 24 hours (APHA, AWWA and WEF., 1992).
b) Carbon contents were measured by CNS-2000 Elemental Analyzer (Manlay *et al*., 2004 b, and Keeratiurai and Thanee, 2013).
c) CO_2 was detected by Gas Analyzer (Kawashima, Terada and Shibata, 2000, and Keeratiurai and Thanee, 2013).
d) Volatile solids and ash were analyzed by weighing the known weight of the sample after burning at 550°C for 30 minutes (APHA, AWWA and WEF., 1992).
e) Weight of layer and egg by weighing (Vudhipanee *et al*., 2002, and Keeratiurai and Thanee, 2013).

Figure-3. The software was used to calculate the carbon emission in energy sectors of egg production.

RESULTS AND DISCUSSIONS

Analysis method for the decrease of carbon emission from egg productions and tendency of these egg productions in Thailand

CO_2 emitted from faeces and respiration of a layer was much higher than CH_4 shown in Table-1. This study also showed the ratio of carbon emitted to carbon input, and carbon fixation to carbon input for evolution of the environmental problems (Table-2). The carbon fixation in layer organs and eggs to the sum of carbon contents in layer feed and carbon contents from electric energy, petrol, and LPG used ($C_{fixation}/C_{input}$) was 0.210. The ratio of total carbon emitted per unit to total carbon contents per unit in layer feed and energy used ($C_{emitted}/C_{input}$) was 0.693. The ratio of total carbon emitted per day to carbon fixation per day in organs and eggs of a layer ($C_{emitted}/C_{fixation}$) was 3.308.

Total carbon emission from animal bodies in form of CO_2 and CH_4 from the wet faeces, respiration and digestion of layer as 0.00193 ± 0.00001 kg.C/ind./day including the carbon emission from energy used of farms in Thailand as 0.070 ± 0.03 kg.C/ind./day found that total carbon emission per individual per year for production of layers was 0.030 tonC./ind./year. Base on the Principle of Mass Conservation and the results of this study indicate the total carbon emission of eggs product shown in Formula 2 as follows:

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Total carbon emission from egg production

$$\text{C-emitted}_{\text{(animal+energy use)}} = (0.03) \text{ Layers} \quad (2)$$

Where

C-emitted $_{\text{(animal+energy use)}}$ = total carbon emission from layers and from energy use for egg production (ton C. / year).
Layers = Number of layers (individual)

Table-1. The average of CH_4 and CO_2 emission from layers on farms.

Animal	Living weight (kg/ head)	Average of gases (kg/head/ day)	CH_4 (kg/ head/ day)	CO_2 (kg/head/day)	Ratio CH_4:CO_2
Layer	1.91 ± 0.15	Faeces	0.000004 ± 0.000000	0.000080 ± 0.000027	0.049
		Respiration	0.000000	0.006954 ± 0.0000	0.000
		Total	0.000004	0.007034	0.00056867
		(CH_4 : CO_2)/living weight			2.977 x 10^{-4}

Table-2. Ratio of C_{input}, $C_{fixation}$, $C_{emitted}$ from feeding in egg production.

Kind of animal	C_{input}	$C_{fixation}$	$C_{emitted}$	The percentage of		
	(kg.C/living weight/day)×10^{-3}			$C_{fixation}$ /C_{input}	$C_{emitted}$ /C_{input}	$C_{emitted}$ /$C_{fixation}$
Layer	21.99	13.61	8.38	20.97	69.35	330.77

Decision making under uncertainty

The results of this study could analyze environmental problems from the energy using of layer and egg production. The analysis was based on pay of matrix principle by using all alternatives such as the energy sectors, carbon emission situation as shown in Table-3. Then make the decision follow theories and laws.

Table-3. The analysis under uncertainty was based on pay of matrix principle.

Alternative of the energy using	Situation of carbon emission from farms (kg.C/head/day)	
	Young chicken farms	Layer farms
Electricity	0.002 ± 0.00	0.002 ± 0.00
Transportation energy	0.044 ± 0.03	0.066 ± 0.03
LPG	0.003 ± 0.00	0.002 ± 0.00

The applied analysis using Laplace Rule to choose the alternative of the energy using which cause the highest environmental problems by setting the probability of the equal situations (n=2), results as in Table-4. According to the Laplace Rule, it could be advised that the best alternative of the energy using in layer and egg production of the transportation energy cause more environmental problems.

Table-4. Result from the application of Laplace rule.

Alternative of the energy using	(C emission from young chicken farms + layer farms)/2
Electricity	0.002 ± 0.00
Transportation energy*	0.055 ± 0.03
LPG	0.003 ± 0.00

Note: *Selected the alternative of the energy using which create maximum environmental problem

The Maximax Rules was applied to indicate the problems of the alternative of the energy using in layer and egg production by selection of situations (Table-3) which got the maximum result and then selected the maximum result from every alternative again. The results were shown in Table-5 which showed that the transportation energy of the layer and egg production was the worst alternative among these three alternatives of the energy sectors.

Table-5. Result from the application of the Maximax rules.

Alternative of the energy using	$\frac{\max \; Pij}{i(x)}$
Electricity	0.002 ± 0.00
Transportation energy*	0.066 ± 0.03
LPG	0.003 ± 0.00

Note: *Selected the alternative of the energy using which created maximum environmental problem

The Minimax Regret Rule was applied to avoid the regret that the decision was already made in taking the poor alternative. Consideration of the maximum result in each situation was set in the matrix as shown in Table-6. And select the maximum regret in each alternative. Each alternative was selected to find minimum value again. The results were in Table-7 which showed that the electricity and LPG energy for layer and egg production were recommended but transportation energy cause more environmental problems.

Table-6. Regret value of each alternative of the energy sectors.

Alternative of the energy using	Situation of carbon emission from farms (kg.C/head/day)	
	Young chicken farms	Layer farms
Electricity	0.042 ± 0.03	0.064 ± 0.03
Transportation energy	0.000 ± 0.03	0.000 ± 0.03
LPG	0.041 ± 0.03	0.064 ± 0.03

Table-7. Maximum regret value of each alternative of the energy using.

Alternative of the energy using	$\frac{\max Rij}{j}$
Electricity	0.064 ± 0.03
Transportation energy*	0.000 ± 0.03
LPG	0.064 ± 0.03

Note: *Selected the alternative of the energy using which created maximum environmental problem

According to theories and rules applied such as Pay off Matrix, Laplace Rule, Maximax Rules and Minimax Regret Rule in making the decision on environmental problems, it could be concluded that LPG and electricity were the best alternative but transportation energy for layer and egg production caused highest environmental problems among these three alternatives of the energy sectors.

Results of carbon transference and carbon emissions in layer production

The results showed that carbon input of immature layers in Nakhon Nayok province was 0.02 kilogram/individual/day which less than mature layers (C input = 0.042 kg/individual/day). Whereas carbon input in Khon Kaen province for immature layers and mature layers were 0.028 and 0.027 kilogram/individual/day, respectively as shown in Figure-4. Carbon input of both provinces had close values because the farm systems were the same. These values depended upon animal feed which organized by the employers.

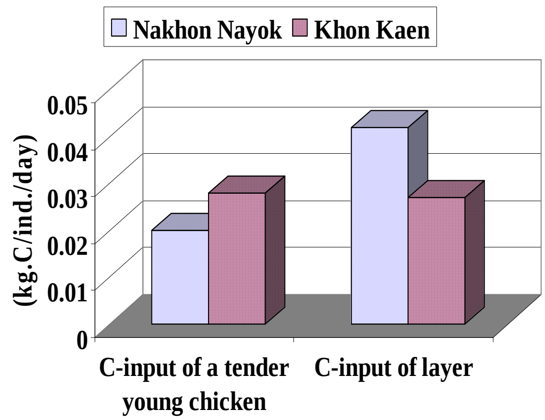

Figure-4. Carbon input of tender young chickens and layers in Nakhon Nayok and Khon Kaen provinces.

Carbon fixation of the both provinces from two types of layers were different which was higher in mature layers than immature layers due to sufficient food for living and egg laying. In Nakhon Nayok carbon fixation of immature layers and mature layers were 0.017 and 0.036 whist in Khon Kaen were 0.019 and 0.023 kilogram/individual/day, respectively. For mature layers, carbon fixation in Khon Kaen was lower than in Nakhon Nayok (0.023 < 0.036) as shown in Figure-5. This probably because of mature layers in Khon Kaen during data collection period were older (post mature layers) than in Nakhon Nayok. Post mature layers fix lower carbon than younger ones.

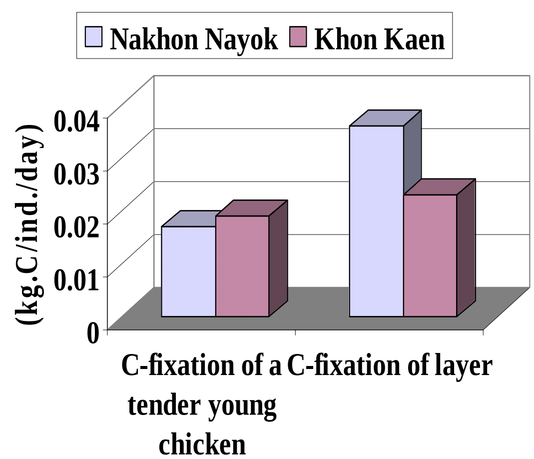

Figure-5. Carbon fixation of tender young chickens and layers in Nakhon Nayok and Khon Kaen provinces.

Carbon emission of both provinces was close value. Immature layers in Nakhon Nayok and Khon Kaen emitted carbon at 0.003 and 0.004 kilogram/individual/day and mature layers at 0.006 and 0.004 kilogram/individual/day, respectively as illustrated in Figure-6. Layer farms in Nakhon Nayok and Khon Kaen have managed farms as the same evap system and the

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same product transportation which were pooled in the centres and then distributed to the markets.

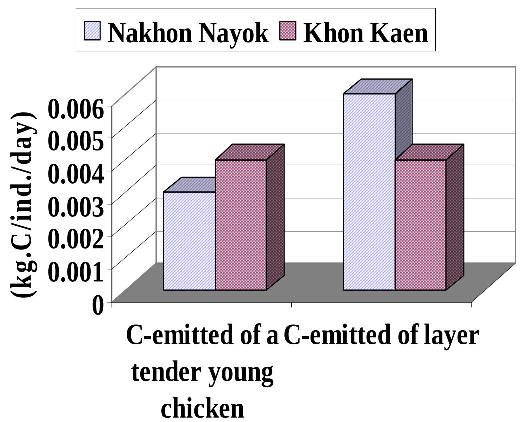

Figure-6. Carbon emitted of tender young chickens and layers in Nakhon Nayok and Khon Kaen provinces.

In both provinces, Nakhon Nayok and Khon Kaen, immature layers emitted carbon from the use of energy less than mature layers. Immature layers in Nakhon Nayok and Khon Kaen emitted carbon from energy use at 0.051 and 0.021 kilogram/individual/day whereas for mature layers at 160.071 and 240.484 kilogram/individual/day, respectively as shown in Figure-7. This duped on rearing durations. The rearing duration for immature layers was 14-16 weeks while for mature layers was 2-3 years. The comparison between these two provinces found that Nakhon Nayok had carbon emission from energy use lower than Khon Kaen. This may be because of transportation distance which Nakhon Nayok transported animal feed from shorter distance (Lopburi province) but Khon Kaen transported feed from longer distance (Nakhon Ratchasima).

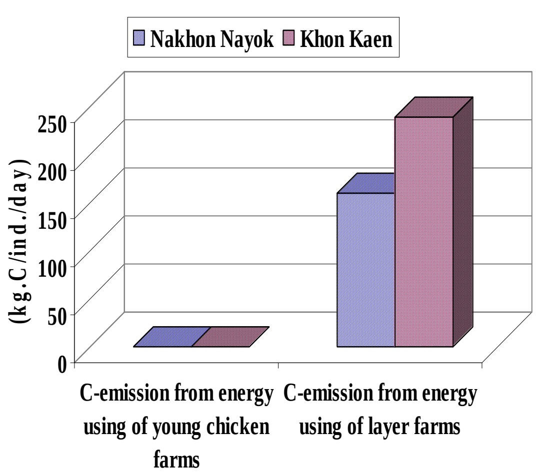

Figure-7. Carbon emission from energy use of layers in Nakhon Nayok and Khon Kaen provinces.

Forecasting trends of carbon emission from egg production

The future trend of carbon emitted from egg production in layer farms was shown in Figure-8. The graph predicts from carbon emitted for egg production to be 0.086 kg.C/head/day or 0.031 ton C/head/year, respectively. These values are based on layers statistics from 2001-2006. The results can be predicted by using the equation from simple linear regression analysis and least square method in net carbon emitted per year by using the following equation; C-emitted of egg production = 6549.5 (year) + 16661, (R^2 = 0.73) where; year is the year figure number from 2001-2011.

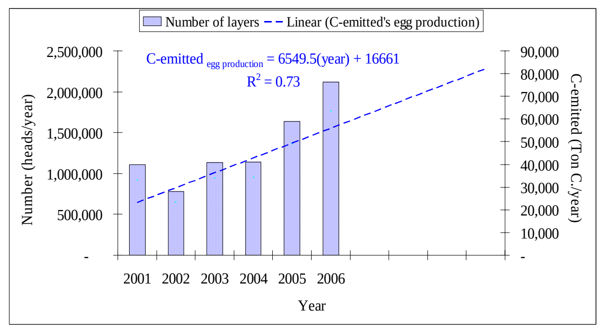

Figure-8. The future trend of carbon contents emitted from egg production.

CONCLUSIONS

The present work is the case study of egg production to evaluate carbon emission on layer farms, to investigate the rate of carbon massflow from layer feed to layers and egg in farms and to study the carbon emission in energy patterns from electric energy and petrol used of the tender young chicken and layer farms in egg production. The study showed that the ratio of total carbon emitted per unit to total carbon contents per unit in layer feed and energy used ($C_{emitted}/C_{input}$) was 0.693. The ratio of total carbon emitted per day to carbon fixation per day in organs and eggs of a layer ($C_{emitted}/C_{fixation}$) was 3.308. Total carbon emission from animal bodies in form of CO_2 and CH_4 from the wet faeces, respiration and digestion of layer as 0.00193 ± 0.00001 kg.C/ind./day including the carbon emission from energy used of farms in Thailand as 0.070 ± 0.03 kg.C/ind./day. Total carbon emission per individual per year for production of layers was 0.030 tonC./ind./year. According to theories and rules applied such as Pay off Matrix, Laplace Rule, Maximax Rules and Minimax Regret Rule in making the decision on environmental problems, they could be concluded that LPG and electricity were the best alternative but transportation energy for layer and egg production caused highest environmental problems among these three alternatives of the energy sectors. The study also showed that in both provinces, Nakhon Nayok and Khon Kaen, immature layers emitted carbon from the use of energy less than mature layers. The carbon emission from the using of transportation energy was quite high in terms of energy using but low in the using of electricity and LPG

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activities. Therefore, farmers should reduce emissions from energy consumption such as reduce distance for layer feed and layers transportation to farms. The using of fuel for transportation should be reduced because it creates the highest carbon emission.

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