An ex-ante evaluation of the economy-wide benefits of the Thai Energy Efficiency Action Plan

Felix Suerkemper, Wuppertal Institute for Climate, Environment, Energy, Wuppertal, Germany,
Johannes Thema, Wuppertal Institute for Climate, Environment, Energy, Wuppertal, Germany
Dr. Stefan Thomas, Wuppertal Institute for Climate, Environment, Energy, Wuppertal, Germany
Florian Dittus, indepecon Unternehmergesellschaft, Birkenfeld, Germany
Monthon Kumpaengseth, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bangkok, Thailand
Milou Beerepoot, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bangkok, Thailand

Abstract

The paper presents the results of an ex-ante evaluation of the economy-wide benefits that may be achieved through the implementation of the 20-year Energy Efficiency Action Plan (EEAP) in Thailand. The objective of the EEAP is to reduce energy intensity by 25% in 2030 compared to 2010. We specified an evaluation model for the calculation of the overall energy cost savings, energy import cost savings and reduced CO_2 emissions. Moreover, induced energy efficiency investments, employment effects and impacts on governmental budget have been calculated. The evaluation shows that an effective implementation of the plan would lead to a reduction in energy expenditure of €37.7 billion by 2030. EEAP-induced energy savings will significantly reduce the greenhouse gas emissions, Thailand's energy import costs and generate private investment in energy efficiency, in turn leading to additional employment. The size of the overall impact on Thailand's governmental budget is uncertain due to positive and negative effects, but a positive net effect can be expected.

Introduction

Over the last few decades, Thailand has experienced a transformation from an agricultural into a semi-industrialised economy (Phdungsilp, 2010). As a result of strong economic growth (average real GDP growth rates were at 4.2% between 2002 and 2012, BOT, 2013), the final energy consumption in Thailand has drastically increased and is expected to rise further in the future (Shrestha et al., 2007). Between 2011 and 2035, primary energy demand in Thailand is expected to grow at an average rate of 2.3% per year (IEA, 2013a). CO_2-emissions are expected to increase from 243 Mt CO_2 in 2011 to 460 Mt CO_2 in 2035 corresponding to an average growth rate of 2.7% (IEA, 2013a). Due to a limited availability of national energy resources, Thailand strongly depends on energy imports (AIT, 2010). The IEA (2013a) expects Thailand's net gas and oil import costs to rise from almost $30 billion in 2011 to around $100 billion in 2035. Energy supply security, a high dependency on energy imports, continuously increasing energy costs, as well as increasing pollution and greenhouse gas (GHG) emissions are therefore future key challenges for Thailand.

To address these challenges, the Energy Policy and Planning Office (EPPO) under the Ministry of Energy (MOEN) developed a 20-year Energy Efficiency Development Plan (2011 - 2030) (EEDP) to provide a national policy framework and guidelines on energy conservation implementation in the long term (GIZ, 2013). As an update of the EEDP, a more detailed Energy Efficiency Action Plan (EEAP) has been elaborated for Thailand in 2013 (Ministry of Energy, 2013). The overall aim of the EEAP is to reduce energy intensity in 2030 by 25% compared to 2010, which is equivalent to a reduction of final energy consumption by 20% or about 38,000 kilotonnes of crude oil equivalent (ktoe) relative to baseline projections in 2030 (Figure 1). Priority sectors for implementation of energy efficiency measures are transportation and industry (Ministry of Energy, 2013).

Figure 1. Thai EEAP energy efficiency targets. Source: Based on Ministry of Energy (2013).

In order to achieve the targets, several energy efficiency policy measures have been formulated in the two plans.[1] The implementation of the respective measures is expected to deliver numerous benefits for the Thai economy. The objective of this paper is to evaluate the economy-wide benefits that may result from a successful realisation of the EEAP energy savings. Our methodological approach allows for an ex-ante calculation of the energy cost savings, energy import cost savings and reduced CO_2 emissions. Moreover, induced energy efficiency investments, employment effects and effects on governmental budget have been calculated based on the best available data.
The paper is structured as follows: The next section gives a brief description of the methodological approach and the input data used. Then, the applied calculation approaches and the results of the evaluated EEDP benefits are presented separately for each indicator. After a brief summary of the results, the final section concludes and discusses further research needs and gives recommendations for future energy efficiency policy in Thailand.

Evaluation method

This section gives a description of the overall methodological approach of the evaluation. More detailed descriptions of the calculations and the data used are presented for each indicator in the following sections. A basic assessment approach is taken with a series of equations to calculate each indicator. The bases of all calculations and central input variable of the ex-ante analysis are the energy savings (as given in the EEAP) expected to result from the policies to be implemented within the EEAP framework stated in thermal energy savings $\Delta q_{ths}(t)$ as well as electricity savings $\Delta q_{els}(t)$ per sector s and year t. The EEAP energy savings are then combined with further input data collected from diverse sources in order to estimate the resulting benefits. Figure 2 gives an overview of the specified model. Five central benefits of interest have been quantified within this evaluation (dark shaded in Figure 2):

- Greenhouse gas savings (CO_2 equivalents)
- Energy cost savings (by sectors) and energy import cost savings (by carrier)
- Energy efficiency investments
- Employment effects
- Effects on the governmental budget

In order to increase the precision of calculations, total final energy demand (FED) has been disaggregated to the lowest level of available data for the respective calculations, i.e. the FED is split up into the final energy carriers (FEC) electricity, oil, gas, coal and renewables, with specific final energy products (FEP): For example, lignite is a FEP of the FEC coal.

[1] More details on the EEDP/EEAP measures can be found in Ministry of Energy (2011; 2013).

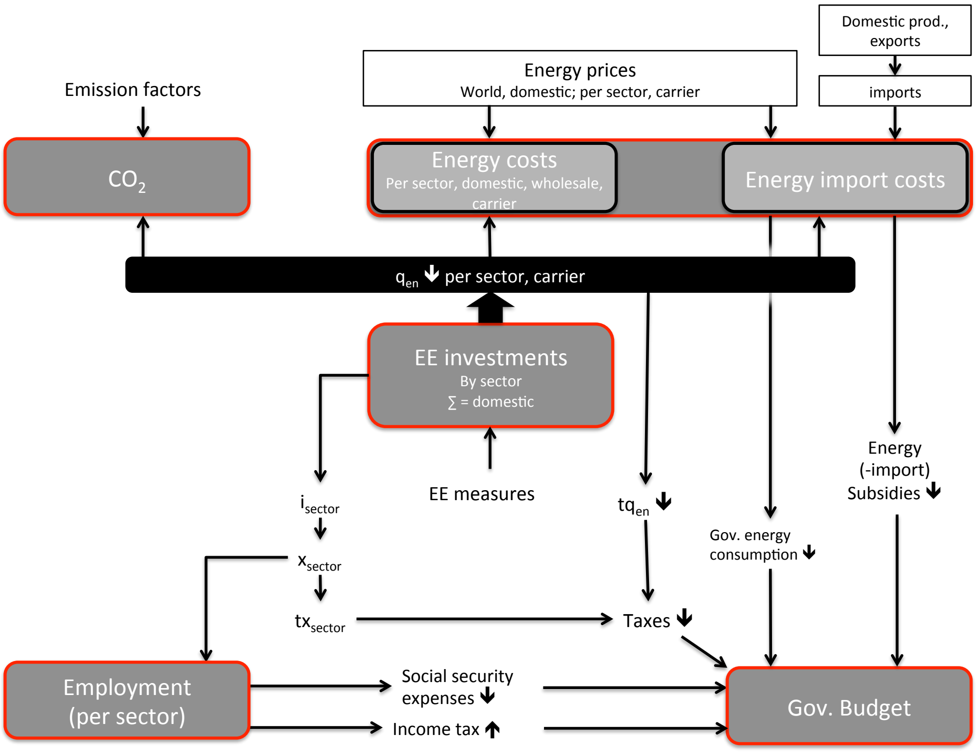

Figure 2. Schematic overview of the model. Source: Wuppertal Institute. Note: q_{en} = (energy) quantities, t = taxes, x = turnover.

Avoided greenhouse gas emissions (CO_{2eq})

In 2012, total CO_{2eq} emissions[2] in Thailand were at 239.59 Mt (EPPO, 2013). Due to the reduction of final energy consumption, GHG emissions will be reduced accordingly relative to the BAU scenario. To calculate the CO_{2eq} emission reduction induced by the EEAP, the respective energy savings of final energy products $\Delta q_{FEP}(t)$ were multiplied with the emission factors f_{FEP} shown in table 1 below.[3]

Table 1. Thai emission factors

Electricity/Fuel	unit	CO_2 emission factors (*f*) ($t\ CO_{2eq}$ per unit)	Source
Electricity	GWh	561	Ministry of Energy 2013
Natural Gas	ktoe	2,369	Ministry of Energy 2013
Coal	ktoe	3,996	Ministry of Energy 2013
LPG	kt	789	Ministry of Energy 2013
Bunker oil	million litre	839	Ministry of Energy 2013
Biomass charcoal	thousand ton	478	Ministry of Energy 2013
Benzene	ktoe	2,927	Ministry of Energy 2013
Diesel	ktoe	3,130	Ministry of Energy 2013
Jet fuel / kerosene	million litre	2,575	EPA 2011

Source: Ministry of Energy (2013, Appendix C, p.457) and EPA (2011).

[2] Emission estimations are based on CO_{2eq} emission factors from the EEAP and therefore include not only carbon dioxide but greenhouse gases as CO_2 equivalents.
[3] Traditional and modern renewable energies were not considered in this calculation, due to CO_{2eq} neutrality over the whole lifecycle of these energy carriers (assumption).

The overall amount is calculated by totalling the CO_{2eq} reductions of all n final energy products. Figure 3 shows an almost linear development of emission reductions until 2030 (resulting from the savings data from the EEAP). Absolute emissions in 2030 may be reduced from 509 Mt in the BAU case to 376 Mt CO_{2eq} (Wuppertal Institute 2013), a reduction of 133 Mt/year. Emission mitigation is mainly achieved by energy efficiency measures targeting electricity and oil consumption.

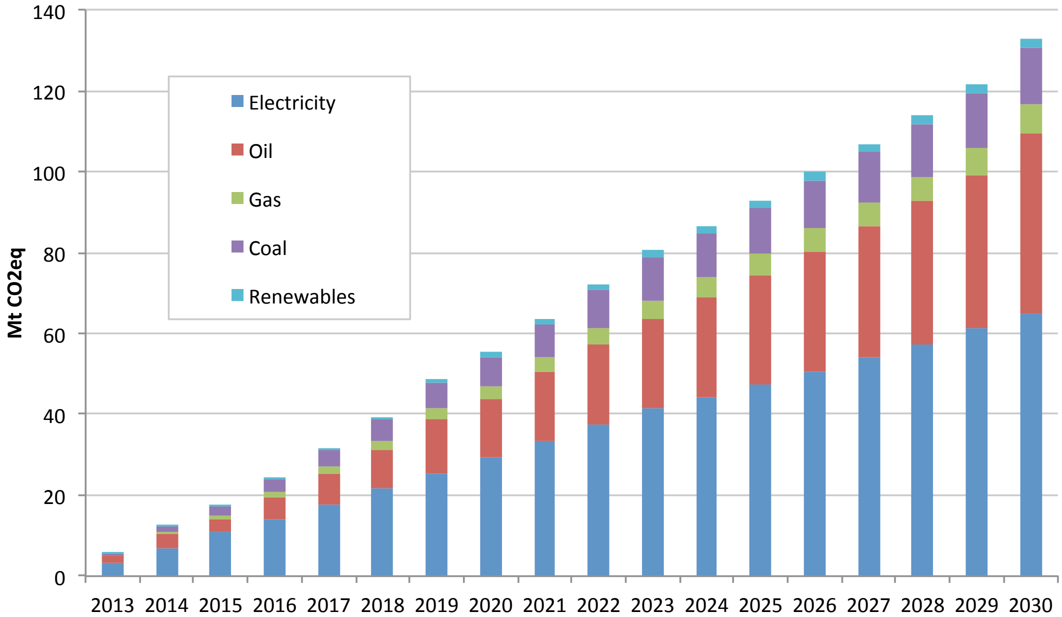

Figure 3. Avoided GHG emissions in CO_{2eq} per year and energy carrier (Mt CO_{2eq})

Energy cost savings

Energy cost savings resulting from the EEAP implementation are determined in this study for different sectors in the Thai economy. They are calculated as the product of sector-specific energy savings and sector-specific final energy prices. Since Thailand depends largely on energy imports, reduced energy import costs are calculated as well.

Sector-specific energy cost savings

The sector-specific energy cost reductions represent the benefits of the EEAP from a consumer perspective and are calculated by fuel type and for the following sectors: agriculture, transport, commercial, industry and residential. Final end-user prices (p_{FEPs}^{RT}) including taxes, levies and marketing margin are relevant. Based on reduced consumption of all n final energy products FEP (Δq_{FEPs}) and respective retail energy product prices (p_{FEPs}^{RT}), re-aggregated final energy carrier FEC cost reductions Δc_{FECs} FECs were assessed. Price rises have been oriented at the consumer price index (CPI). A conservative average nominal price growth rate of 2% i_p per year has been assumed in the forecasts. This value is oriented at the average consumer price index, which has increased in average of about 2.8% in the period 1998-2013 according to Bank of Thailand statistics (Bank of Thailand, 2013a).

$$\Delta c_{FECs}(t) = \sum_{FEP=1}^{n} (\Delta q_{FEPs}(t) \times p_{FEPs}^{RT}) \times {i_p}^{(t-2010)}$$

For each sector S, the final energy demand FED and cost savings Δc_{FEDs} are estimated by adding up all m relevant energy carrier cost reductions.

$$\Delta c_{FEDs}(t) = \sum_{FEC=1}^{m} \Delta c_{FECs}(t)$$

The energy savings and resulting cost reductions are highest in the industrial and transport sector. By 2030, the EEAP is expected to lead to a total consumer cost reduction of 1.5 trillion THB (€37.7 billion) (Figure 4).

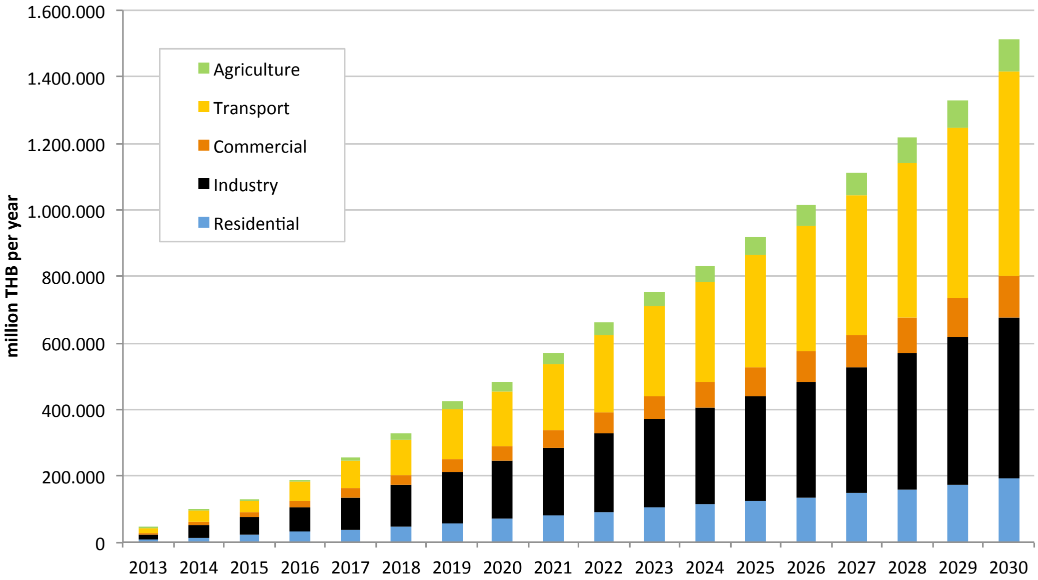

Figure 4. Energy cost savings per year and sector (million THB)

Expenditures on final energy are reduced especially for petroleum products and electricity. This is essentially a result of the high savings expected for these energy carriers.

Energy import cost savings

In 2013, Thai energy demand was, to a large extent, met by energy imports due to very limited domestic resources. Therefore, import cost savings resulting from EEAP measures are of interest and assessed in the following. As energy demand is expected to rise further due to economic growth, even with the EEAP implemented (see Ministry of Energy, 2011) and Thai production capacities limited, we assume that *all energy savings* triggered by the plan will directly lead to *reduced energy imports* (relative to the BAU scenario). The monetary import cost savings are consequently calculated as the product of energy savings (as laid down in the EEAP by sectors and energy carriers) and world/Asia import energy prices and adjusted for future import price developments (assumption: nominal price increase of 2% per year). A major share of the overall EEAP savings comes from electricity. Generation of electricity in turn needs primary energy inputs, end-use electricity savings were therefore converted to primary energy savings according to the Thai electricity generation mix.

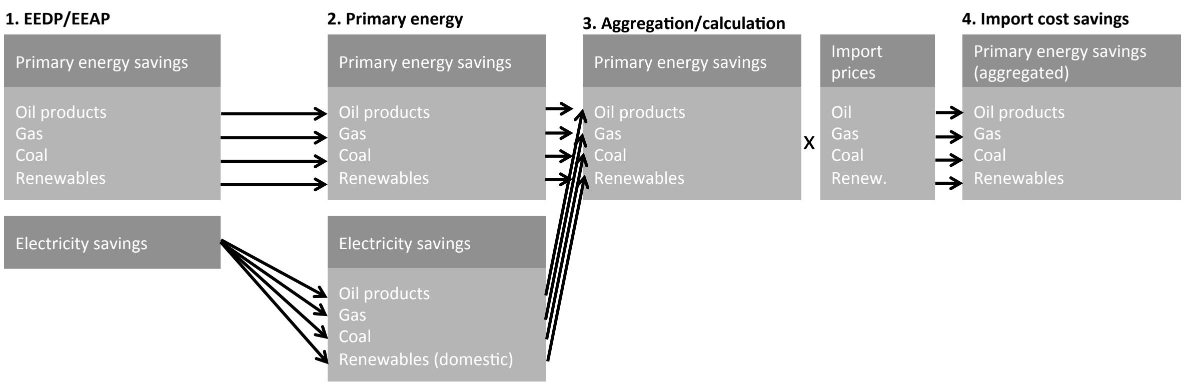

Figure 5. Calculation of import cost savings

To this end, the electricity generation capacity development as laid down in the Thai Power Development Plan (EPPO, 2012) has been used for the primary energy conversion.[4] The primary energy input shares of 2019 were used as a constant for the period 2020 to 2030 (Table 2).

Table 2. Primary energy input shares for electricity generation

Primary energy input	2013	2014	2015	2016	2017	2018	2019	2020-2030
hydro	9,0%	8,8%	8,9%	9,7%	10,3%	10,6%	11,1%	11,1%
natural gas/LNG	63,4%	62,0%	63,2%	59,0%	55,6%	57,1%	58,3%	58,3%
fuel oil								
diesel								
lignite	9,4%	8,8%	8,3%	7,8%	7,4%	7,0%	6,6%	6,6%
import. Coal	9,9%	11,2%	10,7%	15,0%	18,7%	17,6%	16,7%	16,7%
renewable	1,3%	1,4%	1,3%	1,3%	1,2%	1,1%	1,1%	1,1%
SPP	6,4%	7,0%	6,7%	6,3%	6,0%	5,7%	5,4%	5,4%
VSPP	0,3%	0,3%	0,4%	0,4%	0,4%	0,5%	0,5%	0,5%
EGAT TNB[a] (imports)	0,4%	0,5%	0,5%	0,4%	0,4%	0,4%	0,4%	0,4%

Source: EPPO (2012, 83). Note: Due to typical planning and realisation periods, generation from nuclear plants is expected not to take place within the period analysed.
[a] Note: Transnational connection with Malaysian Provider Tenaga Nasional Berhad (TNB).

Figure 6 shows saved energy import costs by energy carrier in million THB. In 2030, the largest share of energy import cost savings stems from oil and petroleum products (62%). Gas and coal import costs are also significantly reduced due to a large amount of electricity savings.

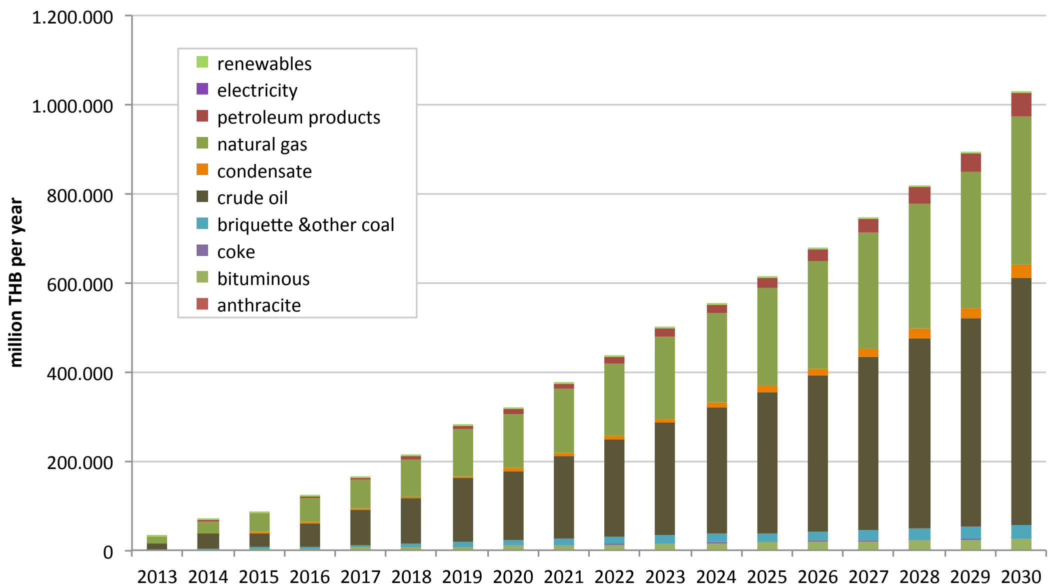

Figure 6. Energy import cost savings per year and energy carrier (million THB)

In 2012, total Thai energy import expenditures amounted to about 1,375 trillion Baht (€34.2bn) (EPPO, 2013). This means, 12% of GDP is already spent on energy imports. According to GDP extrapolations from the EEAP (Ministry of Energy, 2013) and BAU-energy import projections from Wuppertal Institute (2013), the share may rise to almost 20% of GDP.[5] The EEAP is expected to

[4] For the conversion of end-use electricity to primary energy, a conversion factor of 2.5 has been applied. This factor results from average Thai electricity generation efficiency of about 40% (Enerdata, 2014).
[5] This calculation is based on the assumption of average GDP growth of 4.3% (Ministry of Energy 2013) and a more complex energy import forecast from Wuppertal Institute (2013), that sees import expenses rise from 1.4 trillion THB in 2013 (EPPO, 2013) to more than 5 trillion THB in 2030. This estimate is close to the forecast of IEA (2013a).

limit rising energy demand and thus reduce import expenditure shares to about 16%. Hence, the import dependency decreases significantly relative to BAU. Realising the overall EEAP energy savings may save the Thai economy around 4% of its projected 2030 GDP due to saved energy import costs.

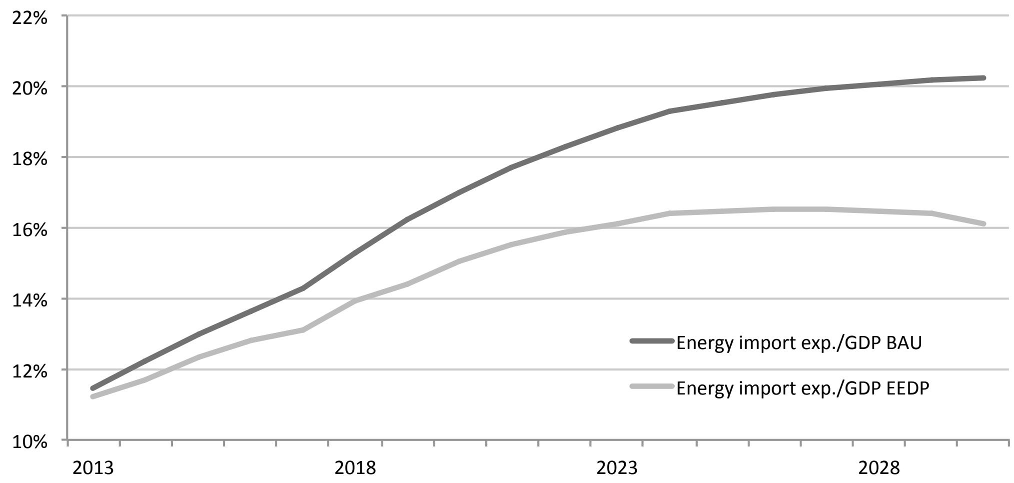

Figure 7. Energy import expenses as share of GDP

Energy efficiency investments

Energy efficiency gains and energy savings result from investments into more efficient technologies. As data for private sector investments into energy efficient technologies were not available for the Thai EEDP and EEAP, the investments had to be inferred from savings by backward induction, i.e. the investments necessary for realising the energy savings were derived from the (first-year) costs of saved energy (CSE^{1st}, see e.g. Molina, 2014, 7). These are defined as total discounted investment costs divided by first-year energy savings.

We have used the figures on cost of saved energy from the best available Thai data and the scientific literature, and estimated typical investment per unit energy saved and combined it with the energy savings as expected by the EEAP. Costs of first year saved energy were derived from the Thai DEDE 30% Subsidy Programme for the industrial sector, i.e. investment and savings data from actual implemented industrial measures in Thailand. This represents the most reliable data at hand.

The data was adjusted for other sectors than industry as follows: First-year savings for other sectors were calculated by adjusting the DEDE figures with typical sector-cost-relations taken from the international literature (DEDE, 2013; Arimura et al., 2009; Auffhammer et al., 2008; Friedrich et al., 2009; Gillingham et al., 2004; Nexant, 2003, 2012; UNU, 1991a, 1991b; Vongsoasup et al., 2004; WEC, 2013). The data from literature indicated lower costs of saved energy for thermal than for electricity measures, which is consistent with the generally found higher costs of electricity supply compared to fuel supply.[6] In order to allow a comparison with the Thai data, the CSE were adjusted for currency as well as inflation and in several cases converted to ktoe (CSE_{th}) and kWh (CSE_{el}).[7] Although all data was adjusted to 2011 values by consumer price indices, the derived CSE data should be regarded as only preliminary estimations for Thailand. Considering the available data, this approach was the most reliable way to assess energy efficiency investments in Thailand.

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[6] Furthermore, $CSE_{thtransportation}$ was found to be higher than other thermal costs. Residential $CSE_{thresidential}$ and commercial $CSE_{thcommercial}$ costs are expected to be between these values. Literature analyses indicated higher costs for saving electricity CSE_{el}. Costs of saved energy for commercial $CSE_{elcommercial}$ and industrial $CSE_{elindustry}$ measures were found to have lower costs compared to the residential sector $CSE_{elresidential}$.

[7] For currency adjustment, the following exchange rates were used: 1 U.S. Dollar = 31.218 THB; 1 EURO = 40.186 THB (July 06th, 2013 from Bankenverband (2013)). For energy unit conversion, conversion factors of Quasching (2013) were used.

Table 3. Cost of saved energy and calculated investments per first-year savings

sector	*Lifecycle* CSE based on literature	*Lifecycle* CSE based on DEDE 30% subsidy programme	Inferred investment costs per *first-year* savings Thailand
electricity	***THB/kWh (€/kWh)***	***THB/kWh (€/kWh)***	***THB/kWh (€/kWh)***
residential	3.18 *(0.08)*		**32.92** *(0.82)*
industry	0.57 *(0.01)*	1.05 *(0.03)*	**8.40** *(0.21)*
commercial	0.41 *(0.01)*		**6.11** *(0.15)*
thermal	***THB/ktoe (€/ktoe)***		***THB/ktoe (€/ktoe)***
industry	3,866,820 *(96,223)*		**24,456,675** *(608,587)*
transport	4,897,972 *(121,883)*		**30,978,454** *(770,877)*
residential			**26,605,331** *(662,055)*
commercial			**26,605,331** *(662,055)*

Source: own calculations, based on DEDE (2013), Arimura et al. (2009), Auffhammer et al. (2008), Friedrich et al. (2009), Gillingham et al. (2004), Nexant (2003, 2012), UNU (1991a, 1991b), Vongsoasup et al. (2004), WEC (2013).

Yearly investment figures per sector I_s were estimated by multiplying first-year costs of saved energy CSE^{1st} with respective savings from the EEAP: electricity savings (Δq_{els}) as well as thermal savings (Δq_{ths}) per sector and year. The induced investments[8] have been calculated for the two categories of electricity and thermal as follows:

$$I_s(t) = [CSE_{els}^{1st} \times \Delta q_{els}(t)] + [CSE_{ths}^{1st} \times \Delta q_{ths}(t)]$$

Due to the uncertainty associated with the CSE figures, three scenarios were considered in calculating the induced EEDP investments: an average, and a low/high scenario deviating by ±30% from the average scenario (representing the variance in CSE estimations from the literature). Figure 9 illustrates the expected annual investments resulting from the EEAP from 2011 to 2030.

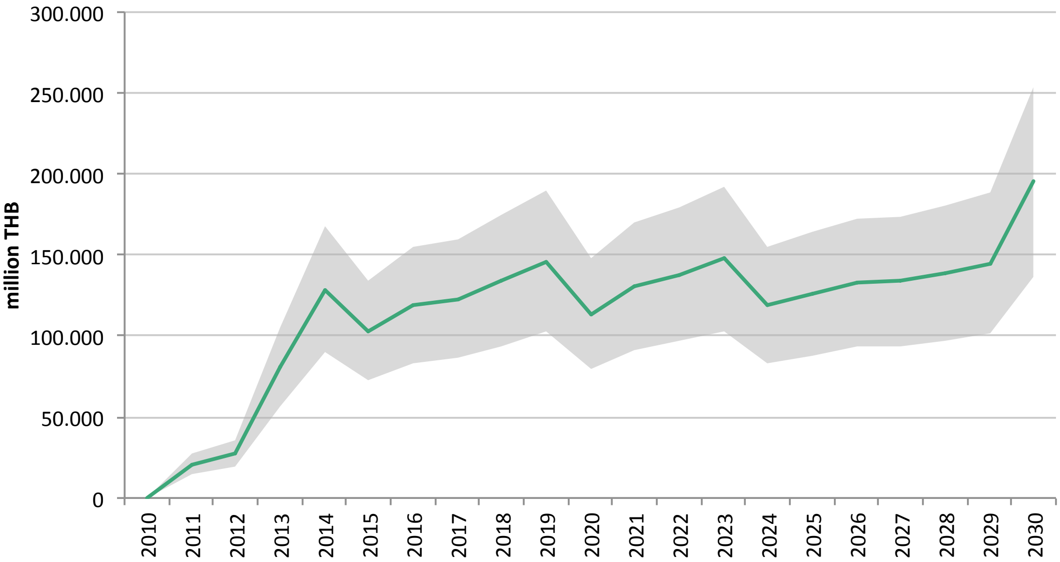

Figure 8. Induced energy efficiency investments per year (million THB). Note: The shaded area depicts an uncertainty corridor of ±30%

[8] Note: This approach calculates additional investments in energy efficiency, irrespective of the financing source. The investments may either come from other sectors, crowding-out alternative investments or be additional if funded e.g. by additional credit programmes.

The calculations yield energy efficiency investments of about 200 billion Baht (€4.86 billion) in 2030 in the average case (ranging from 136-253 billion THB). Investments from 2011 to 2030 total about 1.7 to 3.1 trillion THB. Estimated energy efficiency investments are at about 100 to 200 billion THB/year (€2.5 to 5 billion) from 2014 onwards. Investments are not estimated to be constant because they are calculated as a function of the oscillating input variable "energy savings", which is taken from the EEAP.

Employment effects

An estimation of direct employment effects as a consequence of EEAP-induced economic stimulus resulting from investments in the energy efficiency goods and services has been conducted using Thai statistics of sectoral turnover and employment (NESDB, 2013; Bank of Thailand, 2013b). For a general overview on labour market effects of energy efficiency investments see e.g. Bell (2011) and Schneck et al. (2010). The following description explains the approach followed here for a first assessment of direct employment effects as a result of the energy efficiency measures proposed. Due to the limited model complexity, the resulting employment figures should be interpreted as first rough estimations.[9]

As additional energy efficiency investments trigger turnover in the economic sectors providing energy efficiency goods and services, employment in these sectors will be stimulated. In order to derive employment effects from additional sectoral turnover, labour intensity by sector s in Thailand has been calculated first ($l_s = L_s/GDP_s$, see table 4). The data stems from Bank of Thailand (2013a, 2013b) (labour force survey) and NESDB (2011) (GDP).

Table 4. Employment, GDP and labour intensity per sector 2012

Sector	Employment (1000 pers.)	GDP (Mio THB)	% of labour force	% of GDP	Labour intensity (L_s/GDP_s)
residential	253.02	11,101	0.65%	0.10%	22.79
industry	8,121.62	4,955,509	20.86%	43.56%	1.64
commercial	10,368.84	3,144,833	26.63%	27.65%	3.30
transport	925.94	592,657	2.38%	5.21%	1.56
agriculture	15,433.58	1,395.743	39.63%	12.27%	11.06
public	2,914.77	1,021,346	7.49%	8.98%	2.85
total	**38,017.77**	**11,121,189**	**98%**	**98%**	

Source: Bank of Thailand (2013a, 2013b), NESDB (2013).

[9] More complex methods such as input-output-analysis or computable general equilibrium models (CGE) should be applied in the future in order to consider the following effects:

- Static effects: mostly bottom-up assessed effects resulting from additional turnover in sectors providing EE goods.
- Financing: source of additional investments. If private investments are taken from constant budgets, this may be simply a crowding-out effect. Net employment effects then depend on labour intensities of the sectors providing the alternative goods.
- Indirect impacts: second-round effects. Additional EE investments in one sector indirectly affect others positively and/or negatively. Mostly estimated by Input-Output-Models.
- Reduced energy demand leads to price effects, resulting reallocations and substitutions. These more complex effects mostly involve macroeconomic models like CGE.
- Monetary savings from energy cost savings are reinvested. They may be directed to a) consumption of other goods (increased production and consequent indirect rebound effects), b) increased energy consumption (e.g. higher comfort and consequent direct rebound) or c) monetary savings. At least effect a) and possibly b) and c) lead to further employment effects that should be evaluated.

Altogether, indirect effects are substantial and may even outweigh direct effects. For a more thorough estimation, they should therefore be accounted for in future evaluations.

If the investment data estimated in the previous section are an indicator of additional turnover, and if the target sectors of these investments and the labour intensities are known, their multiplication can be an indicator of employment effects. If energy efficient technology is imported and not produced within the country, then additional turnover (and employment) will be induced in the exterior.
However, as the domestic and foreign investment shares of the target sectors (α_s) are not known, Thai energy market experts of GIZ were interviewed. Based on these expert recommendations sectoral investment (I_s) allocation has been assumed: 40% to Thai industry, 30% into Thai commercial sector and 30% to foreign providers (the resulting foreign effect is not included in the following figures). These additional sector-wide investments were combined with sectoral labour intensities l_s. The labour intensity indicates the number of employees needed for generating turnover. Whereas the commercial sector requires 3.54 employees to generate one million THB, the industrial sector only needs 1.64 employees. The figures were derived from the Thai labour market and GDP statistics (employment per million THB of GDP) (Bank of Thailand, 2013a, 2013b; NESDB 2013) in order to yield additional yearly employment per sector L_s. The employment effect per sector is then

$$L_s = I\alpha_s l_s$$

and the total employment effect by year *t* across all sectors *S* is

$$L(t) = \sum_{s=1}^{S} I \times \alpha_s(t) \times l_s(t)$$

On the basis of estimated investments (including ±30% uncertainty, see previous section), assumptions and labour intensities, employment effects for the industrial and commercial sectors were calculated. In 2030, there will be an expected increase in employment in the range of approximately 230 to 430 thousand employees (Figure 9). Due to increasing energy efficiency investments from 2011 to 2030, the linear employment trend is positive.[10] As indirect effects (see footnote 9) has not been accounted for in the calculation, the resulting employment effect might be even more uncertain. It may be lower than depicted here due to e.g. potentially reduced employment in other sectors or higher e.g. due to economic stimulus effects..

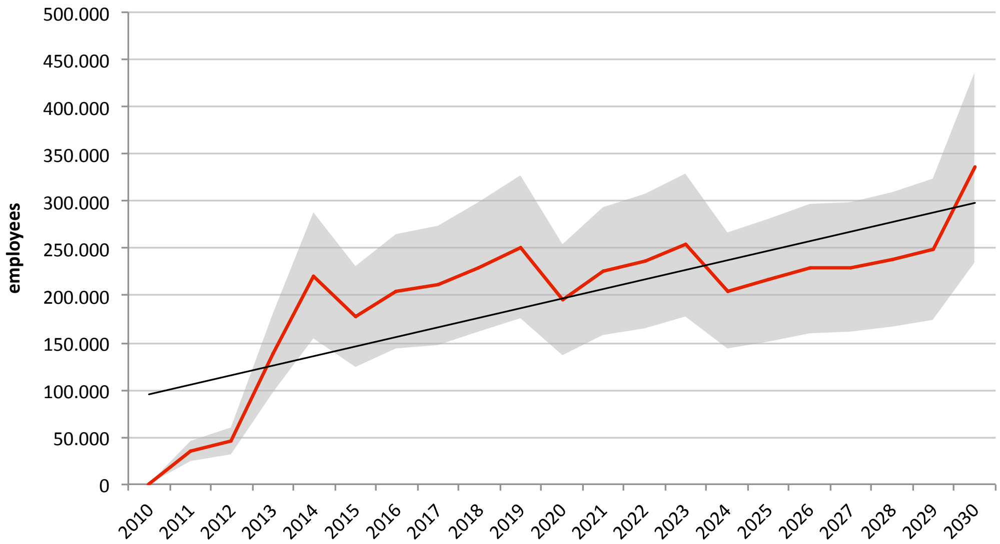

Figure 9. Induced labour market effect (persons/year)

Governmental budget

The public budget is affected through changing tax revenues and expenses. The total effect on the public budget is the sum of various positive and negative effects (see as well Figure 2). The following sections briefly describe the five effects estimated in this study.

[10] The linear trend is shown as a simple least-squares-fitted line of the average effect.

Corporate and value added tax revenues

Additional energy efficiency investments lead to increased turnover in the economy, which results in increasing corporate and value added tax (VAT) revenues (The Revenue Department, 2013a, 2014). The estimation of corporate tax effects builds on the estimation of additional energy efficiency investments and increased turnovers in the economy, which results in increasing corporate revenues that are being taxed. Thai corporate tax rates are 23% on net profits, but vary from 10% (for international banks, foreign company profit repatriation) to over 15% (small companies) to 25% for stock-listed companies. The VAT rate is at 7% (The Revenue Department, 2014).
Corporate tax rates are not average, but rates on net profits after deduction of depreciations and other allowances. For deriving additional tax revenues from additional turnover, either detailed statistics on the Thai business structure would be needed (which were not available) or average tax rates. Therefore, we chose a simple approach in order to estimate this expectedly positive revenue effect on governmental budget for this analysis: The average tax quota τ_{corp} was derived from the turnover of the industrial, commercial and transport sector (obtained from statistics of NESDB (2011)) and from corporate tax revenues from these sectors (obtained from The Revenue Department, 2013) with the most recent data available (2010-2012).

$$\tau_{corp}^{total} = \frac{1}{3}\sum_{t=2010}^{2012}\frac{T_{corp}(t)}{GDP(t)}$$

The average calculated Thai corporate tax quota for all sectors for the years 2010-2012 was 6.23% of total revenues. As a simplifying and conservative assumption we used an overall average rate for corporate taxes and VAT of $\tau_{corp+VAT} = 10\%$. Increasing tax revenues *T* due to the EEDP were thus estimated as the tax income on additional revenues (investment, *I*).

$$T_{corp+VAT}(t) = I(t)\times\bar{\tau}$$

The expected additional tax revenues *T* amount to 14-25 billion THB (€340-630 million) in 2030 (uncertainty due to uncertain additional investment/turnover).

Employment effect – income tax and social security expenses

Positive developments of employment figures affect the governmental budget twofold: by increasing personal income tax revenues and by decreasing government spending on unemployment schemes (decreased social security expenses) (The Revenue Department, 2013b). Both effects have been roughly evaluated. For the first effect (income tax), average income tax payments in the affected sectors were estimated. Figures on governmental income tax revenues T_{income} were obtained from the Ministry of Finance, employment figures (L) from the Bank of Thailand/National Statistical Office (labour force survey) for the years t = 2010-2013. From these figures, average income tax revenues per person were calculated.

$$i = \frac{1}{3}\sum_{t=2010}^{2012}\frac{T_{income}(t)}{L(t)}$$

This macroeconomic data yielded average income tax rates of 6,150-7,030 THB/year. We therefore applied average revenues of 6,600 THB (€164/year per person). For the total income tax effect per year, average income taxes *i* were multiplied with employment effects ΔL.

$$T_{income}(t) = \Delta L(t)\times i$$

For the second effect, contributions of the national government to social security schemes ("social protection", excl. health schemes; BOT, 2013a) were divided by the number of persons not in the labour force/potentially receiving payments (NESDB, 2011). Resulting average contributions per person were calculated at 37,590 THB/year (€935/year) and multiplied with the positive employment effect. The estimated positive outcome (higher income tax revenues and lower social security expenses) totals about 5.5 billion THB (€140 million) in 2030.

Governmental energy consumption

If public energy consumption decreases due to the EEAP measures implemented, energy expenses for the government are also directly reduced. EPPO (2013) states electricity consumption by tariff types. Our estimation uses the quantities stated in the MEA/PEA-tariff "Gov. & Non-profit" (EPPO, 2013). GIZ Thailand estimated the NGO consumption share within this tariff group to be 3%. We therefore assumed a power consumption share by governmental institutions of 97% of this tariff classification, as other data on governmental fuel consumption was not available. Governmental electricity expenditures are consequently expected to decrease by 10.2 billion THB (€250 million) per year in 2030. Since governmental expenditure for other fuels is not considered, this value represents a conservative estimate that may be higher in reality.

Energy subsidies

In the 2013 World Energy Outlook, the IEA (2013b) lists average energy subsidies in Thailand of 16.5% and total subsidy values by energy carriers (oil, gas, coal and electricity). From total energy costs calculated above and the IEA-figures we derived subsidy rates by carriers for the year 2012 and used them as initial values for the scenarios starting in 2013. We then calculated three scenarios: 1) a constant rate scenario assuming constant subsidy rates until 2030 (high scenario), 2) a phase-out scenario assuming a linear phase-out of subsidy rates until 2030 and 3) an average scenario with rates declining to half of the 2012-rates until 2030 (see table below). A complete phase-out of subsidies seems not likely due to strong public opposition. On the other hand, with rising energy demand over time, maintaining subsidies at current levels would continuously increase financial pressure on public budgets. A scenario between these two extremes seems therefore most realistic.

Table 5. Subsidy scenario overview

Energy carrier	2012	2030 scenarios		
		phase-out	average	constant rate
Oil	13.0%	0%	6.5%	13.0%
Gas	38.4%	0%	19.2%	38.4%
Coal	113.0%	0%	56.5%	113.0%
Electricity	16.6%	0%	8.3%	16.6%

Source: own calculations based on IEA (2013b).

The derived subsidy rates are multiplied with the above-calculated energy cost reductions in order to obtain the avoided total subsidy costs. Consequently, the three scenarios yield very different levels of avoided subsidies in the year 2030: 1) if subsidy rates remained at current levels, avoided subsidies would amount to 251 billion THB (€6.25 billion), 2) if subsidies were completely phased out until 2030, avoided subsidies would then accordingly be 0 (although, in previous years, when the phase-out is not yet complete, there would be subsidy savings) and 3) if rates were at intermediate levels, 2030-subsidy savings would be at 126 billion THB (€3.13 billion).

Energy taxes

Typically, foregone tax revenues are not included in evaluations. We took this approach here to provide an encompassing picture, which is however much less favourable than results from the usual evaluation approach.

Decreasing energy sales reduce energy tax revenues. Effects were estimated based on all available data on Thai energy price structures and respective energy taxes (DEDE, 2013; EPPO, 2013; APEC, 2012). Energy taxes contribute strongly to the public budget, thus their decrease due to reduced energy demand constitutes the most negative effect, with petroleum product savings having the largest effect. Overall foregone tax revenues (excise tax and municipality tax) are approximately 72 billion THB (€1.8 billion) in 2030.

Net effect on governmental budget

Due to the limited data availability, the absolute level of the total effect on governmental budget is not very reliable and should rather be regarded as a directional indicator in consideration of all assumptions. The equation below illustrates the calculation of the net effect on governmental budget by aggregating the individual effects.

Δc_{GB}	net effect on governmental budget
ΔT_{FED}	foregone energy tax revenue
Δc_{el}	cost reduction governmental energy consumption
Δs	subsidy cost reduction
T_{corp}	additional corporate tax and VAT revenue
T_{income}	additional income tax revenue and reduced social security expenses
t	Year

$$\Delta c_{GB}(t) = \Delta T_{FED}(t) + \Delta c_{el}(t) + \Delta s(t) + T_{corp}(t) + T_{income}(t)$$

The expected average net effect in 2030 on the governmental budget induced by the EEAP is (according to our calculation) on average highly positive (Figure 10). Taking into account major uncertainties, a wide range of -45 to +222 billion THB (€-1.11 to €6.25 billion) seems possible in 2030 (Figure 11). The large range of the results indicates the high uncertainty of the overall impact of the EEAP on the Thai governmental budget. However, as many effects are calculated conservatively in this study, and especially avoided subsidy costs may be very substantial, a positive net effect is very probable.

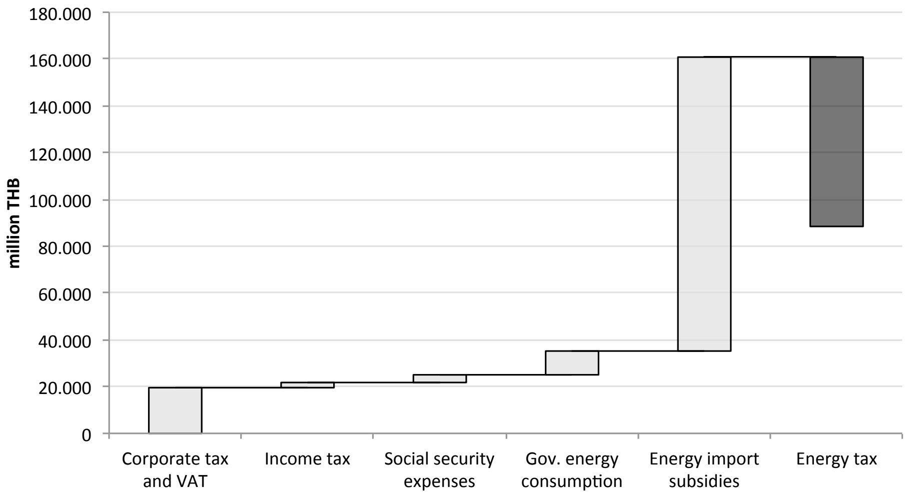

Figure 10. Composition of total effect on governmental budget in 2030 (average estimation, million THB)

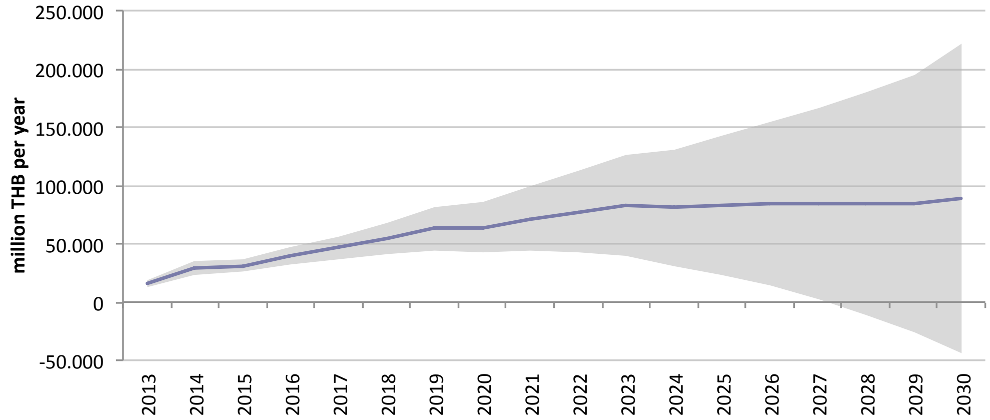

Figure 11. Effects on governmental budget (with uncertainty in investment and import subsidies)

Summary of results

The implementation of the EEAP has various effects on the Thai economy. The ex-ante quantified effects in this report are summarised in Table 6 including the low, average and high scenarios for the investment, employment and governmental budget effects.

Table 6. Summary of cumulated estimated EEAP effects in 2030

			Impact in 2030	
Effect	**unit**	**low**	**high**	**average**
Energy cost savings (consumer perspective)	**billion THB/yr** ***(billion €/yr)***			***total 1,515*** ***(37.70)***
Agriculture				100 *(2.49)*
Transport				612 *(15.22)*
Commercial				129 *(3.22)*
Industry				484 *(12.04)*
Residential				190 *(4.72)*
Savings on energy import costs	**billion THB/yr** ***(billion €/yr)***			**1,026** ***(25.53)***
Avoided CO_2 emissions	**Mt CO_2/yr**			**133**
Induced energy efficiency investments	**billion THB/yr** ***(billion €/yr)***	137[a] *(3.40)*	254[a] (6.32)	**195[a]** **(4.86)**
Employment effects (total)	**1000 employees**	**235**	**436**	**335**
Commercial		145	270	207
Industry		90	166	128
Governmental budget effect (total)	**billion THB/yr** ***(billion €/yr)***	**-44.7** ***(-1.11)***	**221.6** ***(5.51)***	**88.5** ***(2.20)***
Corporate tax		13.7 *(0.34)*	25.4 *(0.63)*	19.5 *(0.49)*
Energy taxes		-72.4 *(-1.80)*	-72.4 *(-1.80)*	-72.4 *(-1.80)*
Income tax		1.6 *(0.04)*	2.9 *(0.07)*	2.2 *(0.06)*
Social security expenses		2.3 *(0.06)*	4.3 *(0.11)*	3.3 *(0.08)*
Governmental energy consumption		10.2 *(0.25)*	10.2 *(0.25)*	10.2 *(0.25)*
Energy subsidies		0 *(0)*	251.3 *(6.25)*	125.6 *(3.13)*

[a] Note: investments are not cumulated, but additional investments per year.

By 2030, the plan is expected to lead to total energy cost reductions for consumers in Thailand of more than 1.5 trillion THB (€37.70 billion). Energy cost savings will be highest in the transport and industry sectors. Due to the high dependency on energy imports, the EEAP will also result in substantial energy import cost savings of more than one trillion THB. In 2030, the largest share of energy import cost savings stems from oil and petroleum products, but gas and coal import costs are also significantly reduced due to the large amount of electricity savings. Another important direct effect is the reduction of GHG emissions by 133 Mt/year in 2030, mainly achieved by energy efficiency measures targeting electricity and oil consumption. The investments in energy efficiency, which will be generated through the implementation of the EEAP, will create additional employment in the Thai economy of approximately 230 to 430 thousand employees in 2030. The overall impact of the plan on the Thai governmental budget through several positive and negative effects will be positive, if there are substantial energy subsidies. By the year 2030, if subsidies are at half of today's rates, the total budget effect is calculated around 88 billion THB (€2.2 billion).

Conclusions

This paper presents a first ex-ante evaluation of the effects that a successful implementation of the Thai EEAP would have for Thailand's economy. Starting from the 20% energy savings specified in the EEAP, we find that avoidable final energy expenditures are remarkable. The induced energy savings will significantly decrease the import dependency and reduce the energy import costs of Thailand in the future. Another important direct effect of the EEAP is a significant reduction of GHG emissions. In addition, private investment in energy efficiency will create additional employment in Thailand. There is some uncertainty as to the overall impact of the plan on the Thai governmental budget due to the different effects on corporate and income tax revenues, social security expenses, governmental energy consumption, expenses for energy import subsidies and energy tax income. As many of the positive effects on the governmental budget are calculated conservatively in this study, a highly positive net effect can be expected.

In summary, the evaluation results show that the key energy challenges for Thailand – energy supply security, a high dependency on energy imports, continuously increasing energy costs, as well as increasing pollution and GHG emissions – could be addressed effectively through the achievement of the forecasted energy savings.

This study has also thrown up several issues in need of further investigation and a number of limitations. The most important constraint is the limited availability of Thai data for the evaluation of several benefits. Therefore, we had to make respective assumptions or use data from international literature. In particular, more bottom-up cost data of energy efficiency technologies would help to calculate the induced energy efficiency investment and employment effects more accurately. Considerably more work is also due for the assessment of the EEAP-effect on employment. In order to also account for indirect effects on employment, more complex models such as input-output-analysis or computable general equilibrium models could be applied in the future.

Even if there are uncertainties in the evaluation results, the findings of this study have a number of important implications for future energy policy in Thailand. The key challenge for policy makers will be to actually realise the level of energy savings in the EEAP in order to achieve the full range of benefits for the economy and society. Therefore, all regulations and policies included in the EEAP should be implemented effectively and in the near future, which will require close collaboration between all relevant Thai governmental institutions. At the same time, the policy measures will need to be accurately and comprehensively evaluated and monitored to allow for corrections of undesirable developments. Therefore, the establishment of a monitoring and evaluation system for energy efficiency allowing an intermediate and ex-post evaluation of the EEAP is an important task that should be paid attention to in Thailand.

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