# EXECUTIVE SUMMARY

*"The study on determination of appropriate discount rates for evaluation of GHG mitigation measures"*

to

Thailand Greenhouse Gas Management Organization
(Public Organization)

by

Thammasat University Research and Consultancy Institute

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## A Research Team from Sirindhorn International Institute of Technology, Thammasat University


**Project leader**

Bundit Limmeechokchai

**Expert on Climate change modelling**

Pornphimol Winyuchakrit

**Research assistants**

Piti Pita

Pemika Misila

Sukanya Kanbua

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# EXECUTIVE SUMMARY

The provisions under the Paris Agreement in Article 4, Parties aim to reach global peaking of greenhouse gas emissions (GHGs) as soon as possible, so as to achieve the goal of limiting global temperature increase to well below 2 degrees Celsius and pursue efforts to limit the increase to 1.5 degrees above pre-industrial levels in 2100. The Paris Agreement requires all Parties to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts. There will be a global stocktake every 5 years to assess the collective progress towards achieving the purpose of the agreement and to inform further individual actions by the Parties.

Thailand is one of the Parties ratified the Paris Agreement on 21 September 2016 and put forward its best efforts through the NDCs. **Thailand intends to reduce its GHG emissions by 20 percent from the projected business-as-usual (BAU) level by 2030. The level of contribution could increase up to 25 percent, subject to adequate and enhanced access to technology development and transfer, financial resources and capacity building support** through a balanced and ambitious global agreement under the United Nations Framework Convention on Climate Change (UNFCCC).

The GHG emissions in the energy and transport sectors, including five sub-sectors, i.e. power generation, households, buildings, manufacturing industries, transportation, are expected to be reduced by 113.0 Million tonnes of carbon dioxide equivalent (Mt $CO_2$ eq). The energy conservation measures are different in each sub-sector. (see Table 1 and Figure 1) The mitigation measures in the Industrial Processes and Product Uses (IPPU), including clinker substitution in cement production process and replacement of new refrigerant in the cooling systems will reduce GHG emissions by 0.6 Mt $CO_2$ eq in 2030. In the waste sector, the waste and wastewater management will reduce GHG emissions by 2.0 Mt $CO_2$ eq in 2030.

Setting the framework of the long-term climate policy can help estimation of GHG emissions as well as the peak year. Moreover, the national focal point can move together with supporting agencies for the efficient policy integration. Therefore, the objective of this study is to propose the possible discount rate pattern that is appropriate to the national socio-economic situation concerning with the long-term period, for example 2031–2050, 2051–2080 and 2081–2100, which will be useful to support the national focal point as well as the supporting agencies for setting the long-term policies.

**Table 1** Thailand's NDC mitigation target

| Sector | Mitigation target (Mt $CO_2$ eq) |
|---|---|
| | 2030 |
| **Energy and Transportation** | **113.00** |
| Power generation | 24.00 |
| Households | 4.00 |
| Buildings | 1.00 |
| Manufacturing industries | 43.00 |
| Transportation | 41.00 |
| **Industrial Processes and Product Uses** | **0.60** |
| **Waste** | **2.00** |
| **Total** | **115.60** |

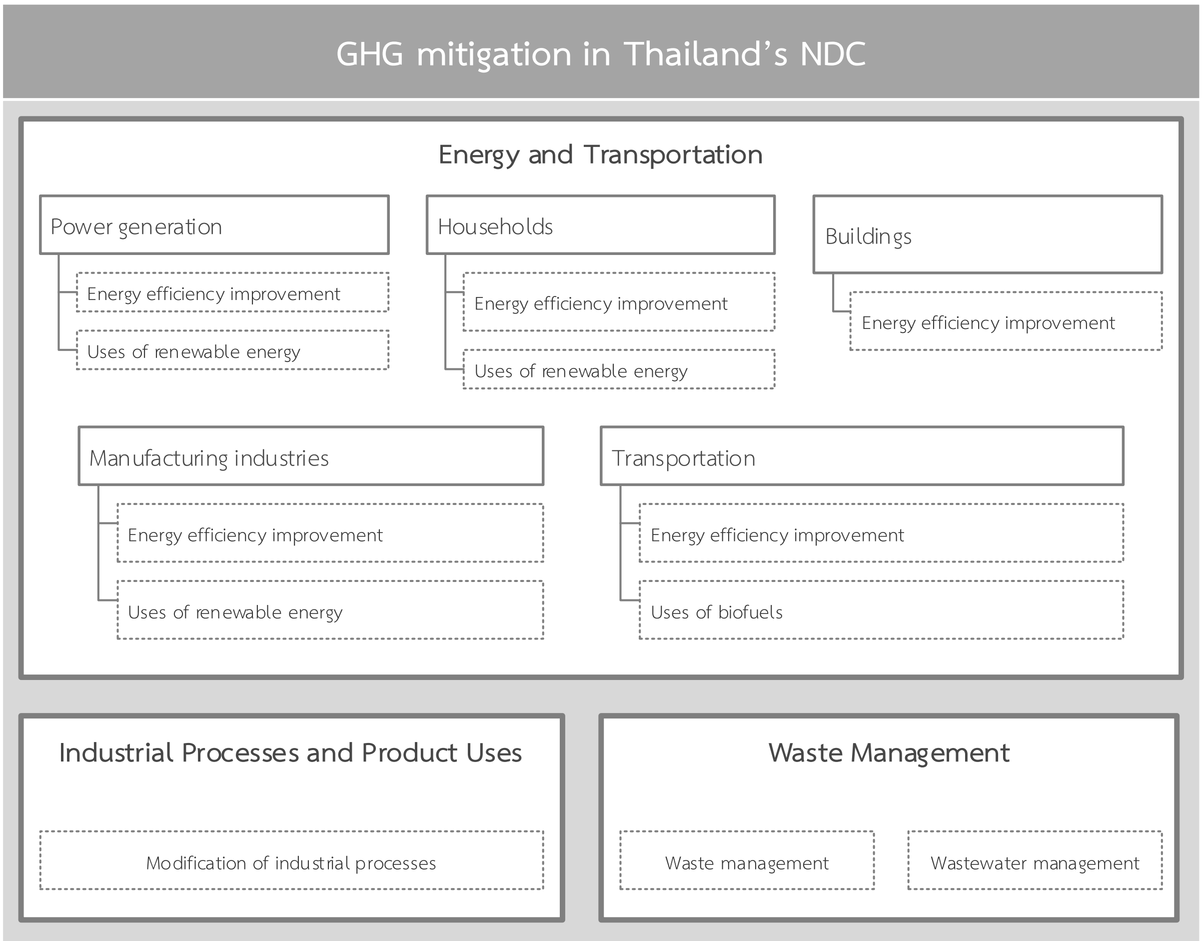


**Figure 1** Thailand's GHG mitigation measures

## Economics of climate change mitigation

Costs and benefits of GHG mitigation or climate policies can be estimated in many levels, including project, technology, sector or sub-sector, community, region, national and international levels. Factors influencing on costs and benefits include investment, economic, ecosystems and social costs. In economic analysis, cost-effectiveness analysis is the first step of an investment before commencing the projects. The "discount rate" is one of the important factors used to evaluate the initial investment as well as the future benefits of the climate change or mitigation projects in the long-term period. The developed countries have also applied the discount rate to evaluate the cost-benefit of the projects and used as a deciding factor in formulation of national climate change approaches or targets.

Costs of any projects can be divided into 2 main parts as follows:

- Private costs, including production costs, wages, land, fuel, equipment, interest rate, etc., are important for project appraisal. However, in the case that the project affects society or environment another cost, excluded in the aforementioned term, is considered as external costs.
- External costs are considered when the society or environment are affected from the operation of projects. In the case of global warming, the people are affected by climate changes. In such cases, financial bargain and negotiation mechanism are impossible due to the costs and benefits of climate change cannot be early evaluated.

In order to evaluate the costs and benefits of climate change projects, not only the private costs but also external costs should be included in the project appraisal. The consideration of both costs together in climate change project represents the **"Social cost of carbon (SCC)"**.

- Private costs are based on market price, which may vary according to the project components. For instance, a project with the investment cost of 5 Million Baht is evaluated from costs of land, labor and equipment. Therefore, this project considers only the private costs, but not social cost.
- Social cost is based on market price together with consideration of costs from rules/regulations/policies to reduce abuse of social or environment. These reflect the social or environment opportunity costs. It can be written as "Social cost = Private cost + External costs".

Costs and benefits have been studied for a long time and play an important role on implementation of climate change policies. Their impacts and benefits were studied before the United States of America and Russia signed and joined the Kyoto Protocol. For the projects concerning with GHG mitigation or climate targets, the social cost is evaluated by the impacts of carbon emissions and climate change in term of "**Social cost of carbon (SCC)**".

*Social cost of carbon for GHG mitigation targets*

The social cost of carbon is an important principle for understanding and promoting the climate policies. It is presented in the term of cost per a unit of carbon dioxide ($CO_2$) or carbon dioxide equivalent (in the case of other GHGs consideration, except $CO_2$). It is clearly implied that "**SCC indicates the social impacts of climate change in term of economic value**" in order that the policymakers can understand the economic impacts on formulated climate rules/regulations/policies. The SCC is the most important factor that can set the carbon price in setting climate rules/regulations/policies in many countries, including the United States of America and Canada. However, appropriate value of SCC applied to the cost and benefit analyses need to be considered seriously for decision making.

Figure 2 shows cost and benefit analyses when the SCC is applied to climate change policies. The costs and benefits of policies A and B were compared to the Baseline scenario. SCC value is 50 $/t-C. The costs and benefits of policies A and B were analyzed as follows:

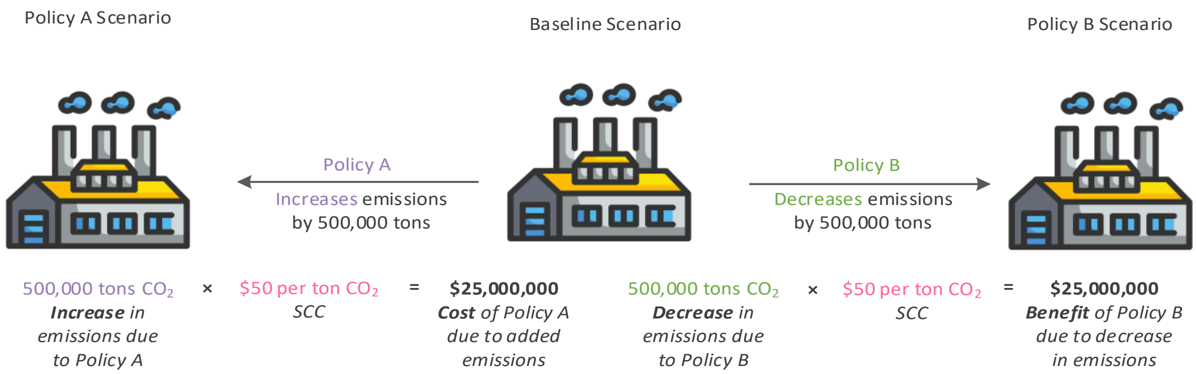


**Figure 2** Use of SCC in the evaluation of costs and benefits in climate change policies

- Policy A scenario: None of climate policies are implemented. Emissions therefore increase. Then, cost of emission reduction in the Policy A will be increased; determined from <u>increasing GHG emissions of</u> 500,000 tonnes multiplied by the SCC of 50 $/t-C. Therefore, the **cost of emission reduction** due to implementation of Policy A is 25,000,000 Million U.S. Dollars.
- Policy B scenario: Climate policies are implemented. Emissions therefore will decrease. Then, benefits of emission reduction from Policy B can be determined from <u>decreasing GHG emissions of</u> 500,000 tonnes multiplied by the SCC of 50 $/t-C. Therefore, the

**benefits of emission reduction** due to implementation of Policy B will be 25,000,000 Million U.S. Dollars.

Observations from the different SCC are as follows:

- If the SCC is high, it implies that the climate change projects/policies can reduce large amount of GHG emissions, but the cost of emission reduction is high.
- If the SCC is low, it implies that the climate change projects/policies are very strict. Even GHG emissions were reduced from low SCC, such policies may impede the progress of the projects.

Hence, the optimum SCC between costs and benefits of climate change projects/policies needs to be significantly determined. Currently, climate change projects operated in the developed countries consider not only the private cost, but also social cost in terms of GHG emissions and climate change impacts. It is considered in the form of "Carbon price", which reflects carbon content in the fossil fuels that will impact the environment and society. The price has been applied in different mechanisms, for instance, carbon tax, emission trading scheme, and carbon price floors, depending on the policies, as well as climate change mitigation targets of each country. For example, the International Monetary Fund (IMF) study simulated the impacts of different carbon tax rates on mitigation target of the countries under the achievement of the Paris Agreement in 2030. The IMF used three carbon tax rates: 25 $/t-C, 50 $/t-C and 75 $/t-C. The results indicated that the carbon tax rate at 75 $/t-C can help achieving the mitigation target of 1.5 degree Celsius while the rates between 25 $/t-C and 50 $/t-C cannot achieve neither 1.5 nor 2 degree Celsius. The carbon tax rate at 25 $/t-C and 50 $/t-C can help some countries to meet their mitigation targets, for example China, Germany, etc. but more policies still needed to be implemented to achieve their targets for Australia, Brazil, Canada, Korea, Mexico and Saudi Arabia (see Figure 3).

In 2019, Mexico and Japan set their carbon tax rate at 1–3 $/t-C, which was the lowest rate, compared with other countries while Swedish set at 127 $/t-C, which was the highest price (see Table 2). In contrast, the World Bank reported the average global carbon price at 2 $/t-C in 2019. In addition, the IMF published that in order to achieve the 2-degree target, the carbon price should be 75 $/t-C within 2030.

Besides carbon prices, the discount rate for climate change projects in the long run has been studied in the past decades. Therefore, the social cost of carbon should also be discounted.

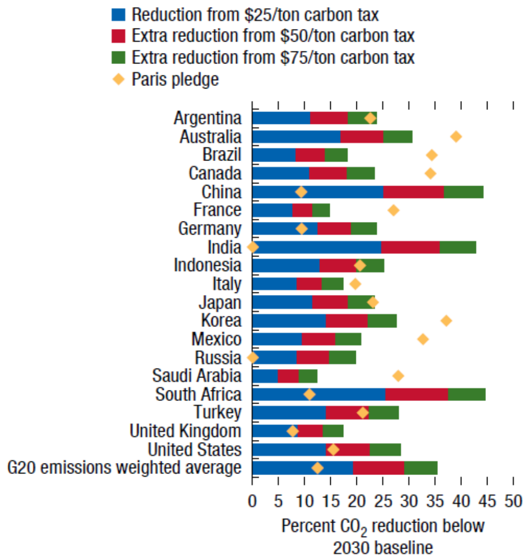


**Figure 3** $CO_2$ mitigation scenario from implementation of carbon tax in 2030.

**Table 2** Worldwide carbon prices

| Country/Region | Started year | Price at 2019 ($/t-C) |
|---|---|---|
| **Carbon taxes** | | |
| Chile | 2017 | 5 |
| Colombia | 2017 | 5 |
| Denmark | 1992 | 26 |
| Finland | 1990 | 65 |
| France | 2014 | 50 |
| Ireland | 2010 | 22 |
| Japan | 2012 | 3 |
| Mexico | 2014 | 1-3 |
| Norway | 1991 | 59 |
| Portugal | 2015 | 14 |
| South Africa | 2019 | 10 |
| Sweden | 1991 | 127 |
| Switzerland | 2008 | 96 |

| Country/Region | Started year | Price at 2019 ($/t-C) |
|---|---|---|
| **Emissions trading scheme** | | |
| California, USA. | 2012 | 16 |
| China | 2020 | N/A |
| EU | 2005 | 25 |
| Korea | 2015 | 22 |
| New Zealand | 2008 | 17 |
| 10 states in East USA | 2009 | 5 |
| **Carbon price floors** | | |
| Canada | 2016 | 15 |
| UK | 2013 | 24 |

**Note:** The Carbon Price Floor (CPF) is a UK Government policy implemented to support the EU Emissions Trading System (EU ETS). The CPF was introduced on 1 April 2013 to underpin the price of carbon at a level that drives low carbon investment, which the EU ETS has not achieved.

*Determination of discount rate for climate change action*

Discount rate is the rate used to determine the present value of future cash flows. Moreover, discount rate refers to the opportunity cost that the resources are used inefficiently or cannot be invested in other activities. In the climate policy study, the discount rate was used to compare the present and future values of money to evaluate the costs and benefits from the project/policy. In economic analysis, the net present worth is generally different when time changes. The net future worth is less than the present worth. Similarly, the future costs and benefits are also discounted. Therefore, the discount rate is an important factor in cost and benefit analysis of the projects. In general, discount rate depends on two important factors: real interest rate (RIR) and inflation rate (IR).

- Real interest rate is the rate of interest an investor, saver or lender receives when the inflation is included.
- Inflation rate is a quantitative measure of the rate at which the average price level of a basket of selected goods and services in an economy increases over the period of times.

High discount rate will lower the future value. Thus, net future worth of the project is discounted speedy with high discount rate. Therefore, the project is not cost effective in the long run. Thus, the use of high discount rate is not suitable for the climate change projects.

The Third Assessment Report (TAR) on Impacts, Adaptation, and Vulnerability and The Third Assessment Report on Mitigation of the IPCC supposed in the same direction that "***determining of discount rate to evaluate the cost and benefit significantly impacts on climate change projects***". Nevertheless, determination of discount rate has been discussed for long time without specific conclusion because it is changes in the future that has quite high uncertainty. Therefore, its determination cannot be done precisely. It was used as a fixed value in the analyses, although it is known that it changes in reality.

The discount rate can be considered in two approaches: *descriptive and prescriptive*.

- The *descriptive approach* to discounting matches discount rates to monetary interest rates observed in financial markets. The SAR proposed that the long-term low discount rate could be between 2 to 3 percent, and it could be increased to be at least 4 percent after tax.
- The *prescriptive* or ethical approach to discounting derives discount rates from fundamental ethical views, even if the resulting rates do not match market rates, called "**Social Discount Rate (SDR)**". Two supporting reasons using this approach are:
  - Firstly, the SDR refers to social rate of time preference. Therefore, future cost and benefit should be discounted by the SDR.

- Secondly, the SDR refers to social opportunity cost of social, which the resources cannot be used or invested in other activities or projects

Although the previous studies supposed the fixed discount rate indicating the cost and benefit of the significant project, in the recent years, few studies have proposed using of declining discount rate relating to time preference, which recognizes uncertainty in the future. However, IPCC noticed that "***using of declining discount rate for climate change projects is extremely challenge, though they are long period projects***".

### *Relationship between SCC and discount rate*

The fundamental of the SCC is to indicate the social damage cost from the project in terms of $/t-C. The SCC used to indicate how changes of current and future society be after implementation of climate change projects. Benefits from climate change projects will always arise over the long-term. Therefore, determination of SCC should involve discount rate into the consideration.

Discussion on the SCC related to the discount rate is an important issue containing mixed opinions. The social cost of carbon integrated assessment models (SCC-IAMs), including The Dynamic Integrated model of Climate and the Economy (DICE), The Climate Framework for Uncertainty, Negotiation and Distribution (FUND) and Policy analysis of the greenhouse effect (PAGE), have been widely applied to evaluate the SCC and the discount rate. Although, the SCC and the discount rate have been discussed in a large number, its determination cannot be done precisely because of high uncertainty. The benefits of climate change projects to the society will arise in the long term, therefore the **use of declining discount rate in the time preference, called "social declining discount rate" (SDDR)**, is recommended.

## Determination of appropriate discount rate for evaluation of GHG mitigation measures in Thailand

From the previous study of TGO, it was concluded that **Thailand's present socio-economic situation is under the SSP4 scenario**, considered as a situation that consistent with the Thailand's present socio-economic situation (see Figure 4). Based on the SSP analysis, Thailand's present socio-economic situation is under the SSP4 narrative or inequality situation.

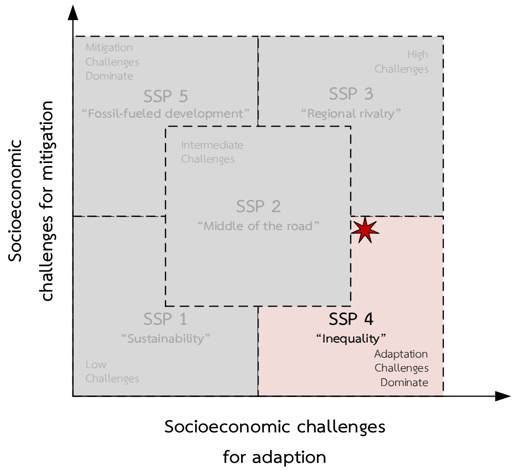


**Figure 4** Thailand's present socio-economic situation

Thailand is a developing country in the Non-Annex I Parties of the UNFCCC. There are two socio-economic scenarios comprising SSP2 and SSP1 that can bring Thailand to achieve low carbon society in both mitigation and adaptation targets. Details of each situation change are as follows:

- In the case of changes from **"SSP4 to SSP2"**, the country's socio-economic factors will change in the same direction and maintain as a developing country. The socio-economic national policies will focus on development of standard of living of the low- and medium-income households in order to reduce social inequality and improve climate change participation (see Figure 5).

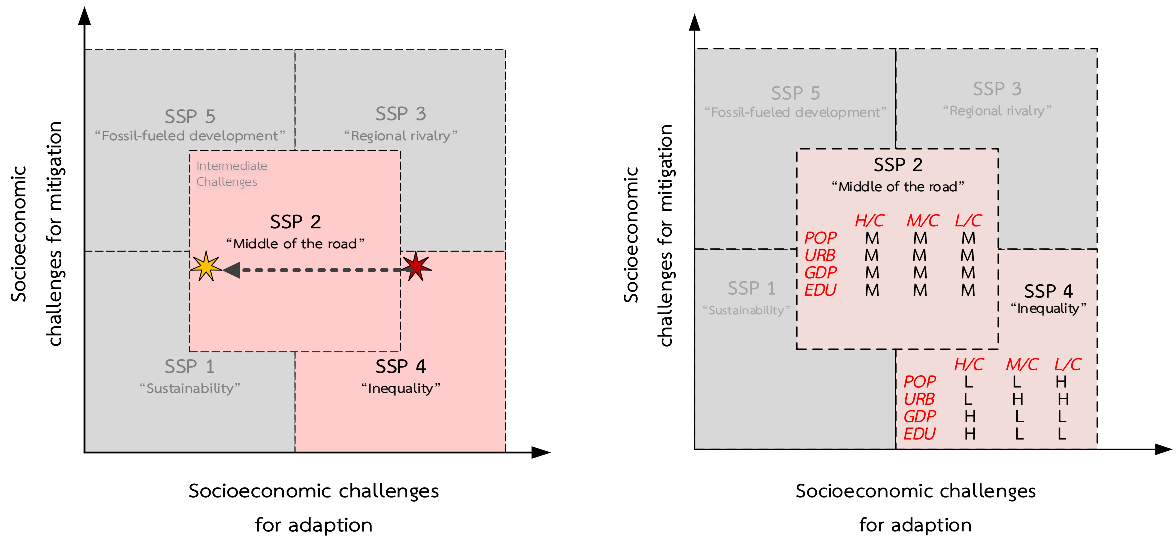


**Figure 5** Change from SSP4 to SSP2 for Thailand.

- In the case of changes from **"SSP4 to SSP1"**, the country's socio-economic factors will change towards low carbon society as a developed country. The national socio-economic policies will lead to sustainable development which can reduce social inequality and improve environment resulting in climate change participation of population (see Figure 6).

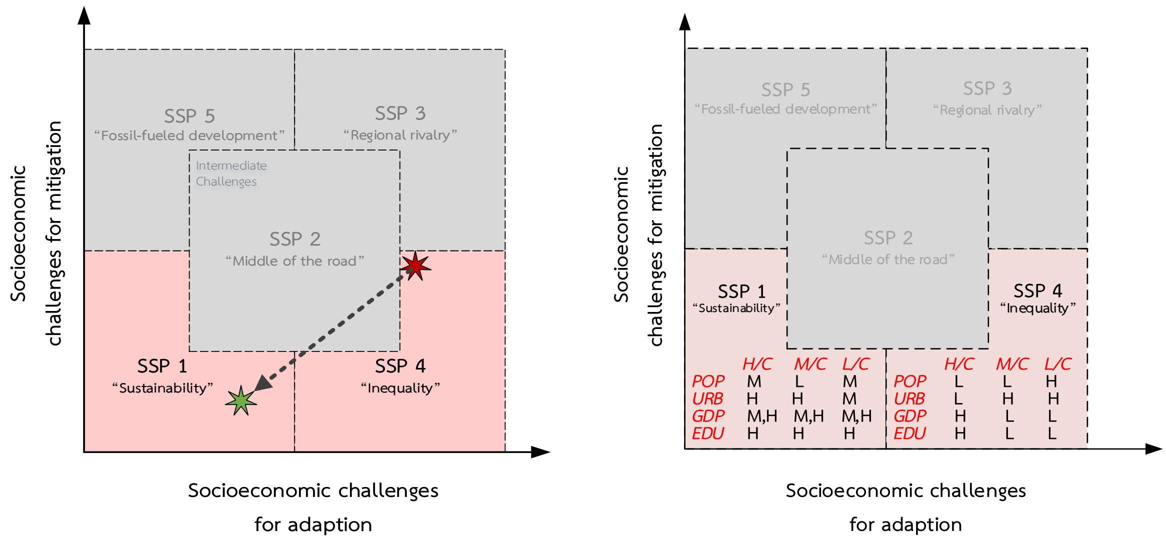


**Figure 6** Change from SSP4 to SSP1 for Thailand.

As explained above, the SCC in terms of economic cost per unit of carbon or carbon dioxide equivalent need to be considered. In addition, comparison of the present and future values of money through discount rate to evaluate the cost and benefit from the project/policy are required. Country should consider an appropriate discount rate related to the country's situation as well as time preference.

## *Guidelines of determination of appropriate discount rates for GHG mitigation in Thailand*

IPCC Working Group III suggested **"to use the discount rate at 10.0 – 12.0 percent for evaluating cost and benefit in *short-term* climate change projects"**. The values have been actually applied in many developing countries by international or world banks. On the other hand, lower discount rate at 4.0–6.0 percent has been used in developed countries. However, IPCC suggested that **"the discount rate should be lower than the current one and relate to time preference"** for long-term climate change projects.

Presently, the cost and benefit analysis of the projects in Thailand employs discount rates between at 10.0 and 12.0 percent. Therefore, regarding the IPCC recommendation, the lower discount rate should be employed for the climate change projects. According to socio-economic situations presented in the previous section, this study proposes three possible discount rate patterns in regard to the Weitzman 4-step discount rates when concerning the long duration. The first period is 2020 to 2030, referring to the present year and the end year of Thailand's NDC target. The second period is 2031 to 2050, referring to the first year after the Thailand's NDC target and a half of century as the IPCC target year to limit the global average temperature. The third period is 2051 to 2080, referring to the first year and middle of the second half of the century. Then, the last period is 2081 to 2100. Details of the proposed discount rate pattern are as follows.

- In the case of change from **"SSP4 to SSP2"**, Thailand will maintain as a developing country. The discount rate can be reduced by half from 10.0–12.0 to 5.0–7.0 percent for the short-term projects (< 5 years), 4.5–6.5 percent for the medium-term projects (6 to 10 years), 4.0–6.0 percent for the medium to long-term projects (11 to 30 years), 3.0–5.0 percent for the long-term projects (31 to 60 years), and 2.0–4.0 percent for the very long- term projects (over 60 years) (see Figure 7 and Table 3).

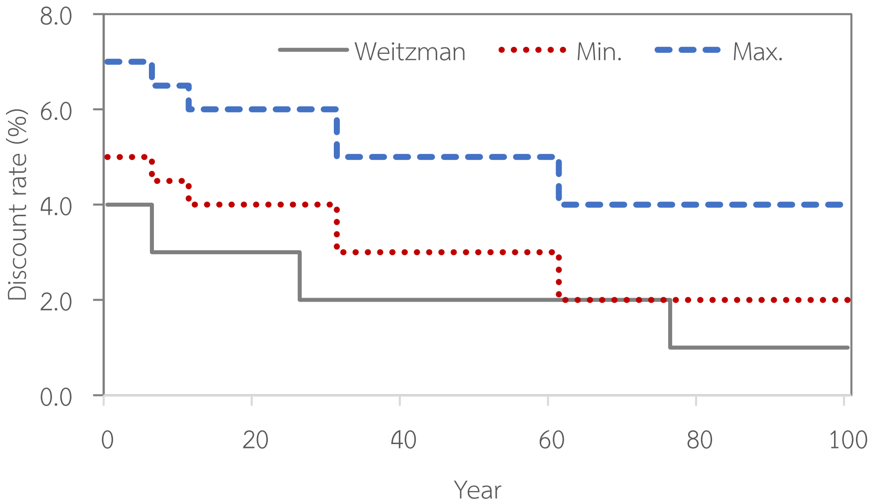


**Figure 7** Thailand's model of discount rates under the change of from SSP4 to SSP2.

- In the case of change from **"SSP4 to SSP1"**, Thailand will become a developed country. The IPCC suggested the use of the discount rate at 4.0–6.0 percent for developed countries. Therefore, the present discount rate is reduced from 10.0–12.0 to 4.0–6.0 percent for the short-term projects (< 5 years), 3.5–5.5 percent for the medium-term projects (6 to 10 years), 3.0–5.0 percent for the medium to long-term projects (11 to 30 years), 2.0–4.0 percent for the long-term projects (31 to 60 years), and 1.0–3.0 percent for the very long-term projects (over 60 years) (see Figure 8 and Table 3).

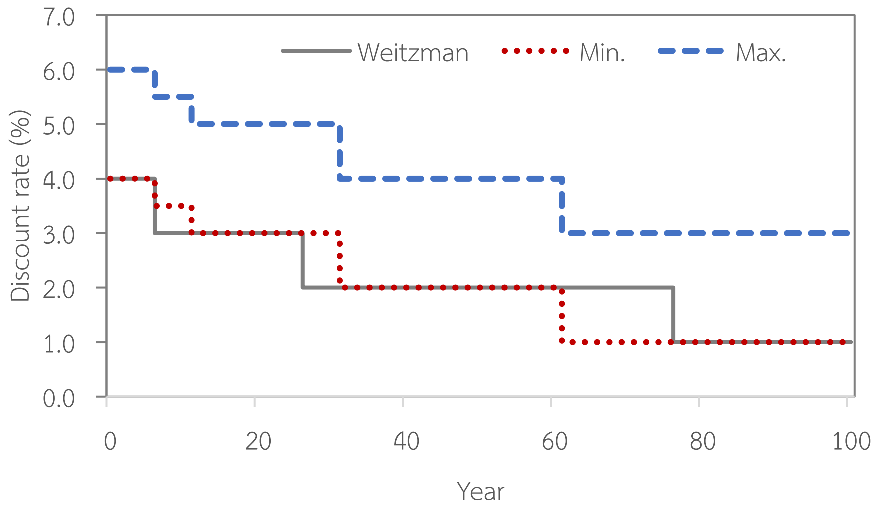


**Figure 8** Thailand's model of discount rates under the change of from SSP4 to SSP1.

**Table 3** Thailand's model of discount rates under the change of SSPs

| Timeframe of the project (Year) | Year | Discount rate (%) | | |
|---|---|---|---|---|
| | | SSP2 | SSP1 | Combined SSPs |
| **1–5** | 2020–2025 | 5.0–7.0 | 4.0–6.0 | **5.0–7.0** |
| **6–10** | 2026–2030 | 4.5–6.5 | 3.5–5.5 | **4.5–6.5** |
| **11–30** | 2031–2050 | 4.0–6.0 | 3.0–5.0 | **4.0–6.0** |
| **31–60** | 2051–2080 | 3.0–5.0 | 2.0–4.0 | **2.5–4.5** |
| **Over 60** | After 2080 | 2.0–4.0 | 1.0–3.0 | **1.5–3.5** |

- In the combine case or the change from "**SSP4 to SSP2 during 2020-2050 and to SSP1 during 2050-2100**", Thailand will be able to achieve the target of its 20-year National strategy (2018–2037), which will reduce social inequality and become sustainable low carbon development after 2050. Therefore, during the period 2020 to 2050, current discount rate is reduced by half from 10.0–12.0 to 5.0–7.0 percent for the short-term projects (< 5 years), 4.5–6.5 percent for the medium-term projects (6 to 10 years), and 4.0–6.0 percent for the medium to long-term projects (11 to 30 years). Then, after 2050, the discount rate should be 2.0–4.0 percent for the long-term projects (31 to 60 years), and 1.0–3.0 percent for the very long-term projects (over 60 years) (see Figure 9 and Table 3).

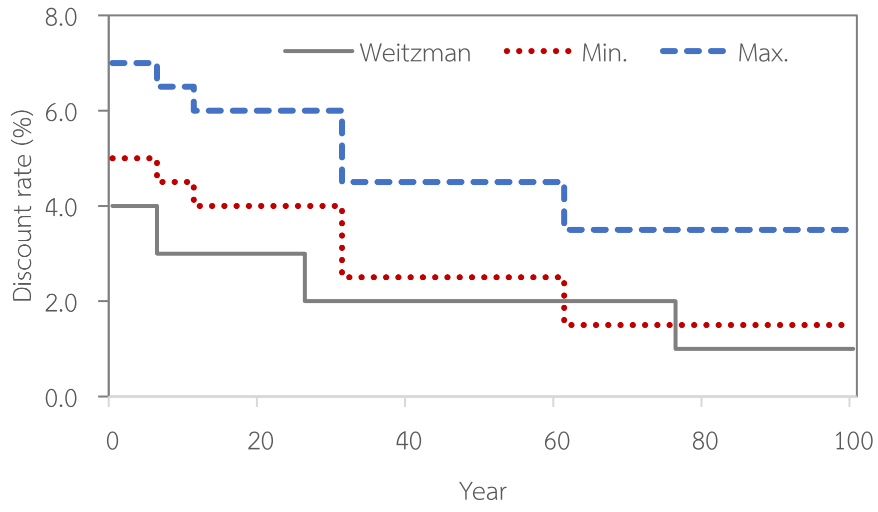


**Figure 9** Thailand's model of discount rates under the combined SSPs.

*Guideline of determination of appropriate discount rates for GHG mitigation measures in Thailand*

The "discount rate" is an important factor influencing the achievement of climate change mitigation measures. The high discount rate generally employs for evaluation of costs and benefits in conventional projects using fossil fuels because of its low investment cost; however, cost of fuels always fluctuates, and cost of maintenance is high. On the other hand, energy efficiency (EE) improvement and renewable energy (RE) projects mostly employ low discount rate because of its low operation cost; however, cost of investment is very high, especially for renewable energy/alternative energy projects.

In general, studies on energy and climate change policies allocate the mitigation measures in 3 periods: short-term, medium-term and long-term periods.

- Short-term measures, which the payback period is less than 5 years, are essential projects that can get results quickly. According to the Thailand's NDC roadmap 2030, short-term measures consist of energy efficiency improvement of electric devices such as LED lighting, high-efficient motors, high-efficient refrigerators, high-efficient air conditioners, etc. Therefore, the discount rates should be about 5.0–7.0 percent for the short-term projects (< 5 years) under the situation of a developing country for Thailand (see Table 4).
- Medium-term measures, which the payback period is less than 15 or 20 years, require supporting policies from the government to achieve the mitigation targets within the specified timeframe. According to the Thailand's NDC roadmap, medium-term measures

consist of the use of RE for electricity generation and fuel substitution in households and industries such as electricity generation from solar or wind, use of biogas from wastewater, etc. Therefore, the discount rates should be about 4.5–6.5 percent for the medium-term projects (6 to 10 years) and 4.0–6.0 percent for the medium to long-term projects (11 to 30 years) (see Table 4).

- Long-term measures, which the payback period is more than 20 years, require government's investment or allocation of concessions. In Thailand, the long-term projects such as electric trains were not considered in Thailand's NDC 2030. The discount rate should be about 3.0–5.0 percent for the long-term projects (31 to 60 years) and 2.0–4.0 percent for the very long-term projects (over 60 years) (see Table 4).

**Table 4** Thailand's model of appropriate discount rates for evaluation of GHG mitigation measures

| Timeframe of the project (Year) | Year | Discount rate (%) | Measures from Thailand's NDC |
|---|---|---|---|
| **1–5** | 2020–2025 | 5.0–7.0 | ● EE in power generation<br>● EE in households<br>● EE in buildings<br>● EE in industries<br>● EE in transportation<br>● Modification of industrial processes<br>● Waste management<br>● Wastewater management |
| **6–10** | 2026–2030 | 4.5–6.5 | ● RE power generation<br>● RE in households<br>● RE in industries<br>● biofuels in vehicles |
| **11–30** | 2031–2050 | 4.0–6.0 | |
| **31–60** | 2051–2080 | 3.0–5.0 | |
| **Over 60** | After 2080 | 2.0–4.0 | |

Based on the above theory, this study only suggests the appropriate discount rate patterns for evaluation of GHG mitigation measures in Thailand. The conventional flat discount rate over the periods should be revised and replaced by declining discount rates for the climate change projects in the long term. In order to apply this discount rate in cost-benefit analysis, further studies on the accurate discount rates, according to socio-economic information of Thailand, should be conducted.