Carbon Taxes to Cool Earth: Costs and Benefits to Thai Economy

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Abstract

In February 2011, the Minister of Finance (MOF), a chairman of the Commission on Environmental Tax Policy (CETP) of Thailand--an entity responsible for directing policies primarily derived from economic instruments especially environmental taxes--pondered relevant policy instruments for future measures including GHGs taxation or carbon tax schemes and emission trading schemes. More importantly, the Minister explored the situation of GHGs emissions in Thailand, considered whether or not Thailand should implement carbon taxation, analyzed the sectors that should be taxed, examined suitable carbon tax rates, and also paid attention to the possible impacts of carbon taxes on the Thai economy and the environment in order to recommend appropriate mitigation measures for those adverse effects.

Finally, the Minister reviewed the bottom line of the implementation of carbon tax schemes on both the quantitative and qualitative basis. In principle, carbon taxes could cool earth by reducing the amount of GHGs released into the atmosphere, but the Minister had to determine whether

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it would be practical and worthwhile for Thailand to do. Would the benefits outweigh the costs? With careful consideration, the Minister had to come up with an appropriate proposal for carbon tax schemes in Thailand.

Keywords: Climate Change, Global Warming, Carbon Tax, Costs-benefits, Thai Economy

ภาษีคาร์บอนเพื่อลดโลกร้อน: ต้นทุนและผลตอบแทนต่อเศรษฐกิจไทย

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บทคัดย่อ

ในเดือนกุมภาพันธ์ปี 2554 รัฐมนตรีว่าการกระทรวงการคลังในฐานะประธานคณะกรรมการกำกับนโยบายการใช้ภาษีสิ่งแวดล้อม (สนส.) แห่งประเทศไทย ซึ่งเป็นหน่วยงานรับผิดชอบการออกนโยบาย ด้านสิ่งแวดล้อมจากเครื่องมือทางเศรษฐศาสตร์ โดยเฉพาะอย่างยิ่งมาตรการทางภาษีสิ่งแวดล้อม กำลังพิจารณาไตร่ตรองนโยบายภาษีก๊าซเรือนกระจกหรือภาษีคาร์บอนและระบบการซื้อขายแลกเปลี่ยนสิทธิการปล่อยคาร์บอน

ในการนี้รัฐมนตรีฯ ได้ทำการตรวจสอบสถานการณ์การปล่อยก๊าซเรือนกระจกของประเทศไทยพิจารณาถึงความเหมาะสมว่าประเทศไทยควรจะมีการใช้ภาษีคาร์บอนหรือไม่ วิเคราะห์ว่าภาคส่วนใดที่ควรจะมีการจัดเก็บภาษีคาร์บอนบ้าง ประเมินอัตราภาษีคาร์บอนที่เหมาะสม และพิจารณาผลกระทบที่อาจจะเกิดขึ้นจากการใช้ภาษีคาร์บอนต่อระบบเศรษฐกิจและสิ่งแวดล้อมของประเทศไทย เพื่อหามาตรการลดผลกระทบทางลบที่อาจจะเกิดขึ้น

สุดท้ายรัฐมนตรีฯ ต้องประเมินผลกระทบทั้งเชิงคุณภาพและเชิงปริมาณถ้าหากมีการใช้ภาษีคาร์บอนในประเทศไทย โดยหลักการแม้ว่าระบบภาษีคาร์บอนจะช่วยลดภาวะโลกร้อนได้จาก

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กิตติกรรมประกาศ ผู้เขียนขอขอบคุณ คุณกฤติยาพร วงษา จากสถาบันศึกษานโยบายสาธารณะ มหาวิทยาลัยเชียงใหม่ ที่ช่วยวิเคราะห์และวิพากษ์วิจารณ์ประเด็นด้านการเปลี่ยนแปลงสภาพภูมิอากาศโลกและระบบภาษีคาร์บอนที่เป็นประโยชน์อย่างยิ่ง

การลดปริมาณการปล่อยก๊าซเรือนกระจกสู่ชั้นบรรยากาศ แต่รัฐมนตรีฯ ต้องประเมินว่าระบบภาษีคาร์บอนนี้จะมีความเป็นไปได้ในทางปฏิบัติและจะมีความคุ้มค่าสำหรับประเทศไทยหรือไม่ สรุปสั้น ๆ ก็คือ...ผลตอบแทนจะมีมูลค่าเกินกว่าต้นทุนหรือไม่นั่นเอง จากการพิจารณาไตร่ตรองอย่างรอบคอบ รัฐมนตรีฯ จำเป็นต้องได้ข้อเสนอที่เหมาะสมสำหรับการจัดเก็บภาษีคาร์บอนในประเทศไทย

คำสำคัญ: การเปลี่ยนแปลงสภาพภูมิอากาศ ภาวะโลกร้อน ภาษีคาร์บอน ต้นทุนและผลตอบแทน เศรษฐกิจไทย

It was the hottest day in February 2011. An old lady yelled in front of the Office of the Commission on Environmental Tax Policy (CETP) of Thailand, *"Surely, I will be the first to jump into the street to protest and burn the proposal if it suggests levying carbon taxes on NGV,"* while the Minister of Finance, a chairman of the CETP, was preparing a proposal for carbon tax schemes for the upcoming meeting.

Realizing that climate change was a global environmental problem that required the world community to act collectively and that Thailand had no commitment to reduce greenhouse gases (GHGs) emissions under the Kyoto Protocol, the Minister was in the process of examining a plethora of information relevant to the critical decision of whether the country should begin preparations for GHGs emissions control. Although he was partial toward carbon tax schemes as the way to effect reductions in GHGs, he had resolved that his proposal would be based on an in-depth review of several plausible policy instruments, including emission trading schemes, in addition to carbon taxes.

Further, in arriving at a recommendation as to whether Thailand should implement carbon taxation, the Minister knew that his proposal would have to be based on a thorough analysis of GHGs emissions in Thailand, as well as address carbon tax design and implementation issues and concerns. The proposal would need to include a careful analysis of the particular sectors that would fall under the tax, suitable carbon tax rates, an assessment of the potential impacts of such taxes on the Thai economy and environment, and a consideration of appropriate mitigation measures for any unfavorable impacts. The Minister was convinced that carbon tax schemes could, in principle, help cool the planet. But, he wondered whether it was something that would be both a practical and worthwhile initiative for Thailand to undertake. Would the benefits outweigh the costs?

Climate Change: A Global Environmental Problem

Climate change or global warming was a global environmental problem affecting all creatures around the world. Its causes and effects were widely known among climate scientists, although the efficiency and effectiveness of market-based mechanisms for GHGs emissions control and reduction were still subject to challenge and debate. Nonetheless, over the past two decades, the world community had been acting more and more collectively to avoid the potentially catastrophic threat posed by climate change. Various measures for controlling and reducing of GHGs emissions had been implemented – e.g., caps on GHGs emissions, efficient technologies, and incentives to reduce GHGs emissions.

Causes and Effects of Climate Change[1]

The main cause of climate change was human activities that eventually diffused certain gases--namely, greenhouse gases (GHGs)--into the atmosphere, inducing the greenhouse effect, a process in which that the atmospheric GHGs trapped thermal radiation emanating from Earth that would otherwise be absorbed into space. The consequence was a tendency toward a gradual warming of the surface of the Earth, i.e., global warming (see Exhibit 1). Greenhouse gases that contributed to the greenhouse effect included water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs) (see Exhibit 2).

Climate change or global warming, as it was commonly known, caused some regions to become warmer and some to remain unchanged, with the overall effect being a generally warmer Earth, on average. The Intergovernmental Panel on Climate Change (IPCC) forecasted that over the next century the average temperature would rise by 2.5-10 degrees Fahrenheit (1.4-5.5 degrees Celsius).[2] The warmer conditions would lead to more evaporation and precipitation overall, but some regions might become wetter and some dryer. Under a "worse case" scenario, the greenhouse effect would trigger more intense heat waves, warm the oceans, and partially melt glaciers and other ice. This would expand ocean water and contribute to rising sea levels. According to the IPCC, the effects on individual regions would vary over time with the ability of different societal and environmental systems to mitigate or adapt to change. In Exhibit 3 is contained the IPCC's synthesis and summary of the recent and future effects of climate change. Their prognosis of the regional effects of climate change is shown in Exhibit 4.

Worldwide Cooperation

The efforts of the IPCC eventually led to the negotiation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and the Kyoto Protocol (KP) in 1997. Specifically, Annex I countries (see Exhibit 5) committed to the UNFCCC to reduce their emission levels of GHGs below their 1990 benchmark levels by the year 2000. Under the

Kyoto Protocol, the Annex I countries were legally bound to their reduce GHGs emissions to reach a combined average of 5.2% below 1990 levels by A.D. 2008-2012. The mechanisms under KP that enabled Annex I countries to meet their emission targets through cost-effective means, which simultaneously stimulated green investments, were the “flexibility mechanisms.”

KP Flexibility Mechanisms[3]

Flexibility mechanisms under the Kyoto Protocol were comprised of three market-based instruments: (i) the Emission Trading Scheme, (ii) the Clean Development Mechanism, and (iii) Joint Implementation.

The Emissions Trading Scheme (ETS) simply considered “GHGs emission reductions or removals” as a new commodity called “emission permits”. Countries that could reduce GHGs emissions under their targets were considered as having extra or unused emission permits. Thus, these countries could sell their excess emission permits to countries that were over their targets. Since carbon dioxide (CO_2) is the principal GHG, people simply called ETS “carbon trading” or “carbon market.” Under ETS, carbon was then tracked and traded like any other commodity.

An emission permit that allowed the holder to emit one ton of carbon dioxide (CO_2) or to trade permits in the international market at their current market prices was defined as “carbon credit.”[4] Countries could accrue their emission permits or carbon credits. In addition to actual emission units (i.e., tons of carbon dioxide equivalence or tCO_2e), carbon credits were equivalently counted in various units -- i.e., a removal unit (RMU) on the basis of land use, land-use change and forestry activities such as reforestation; an emission reduction unit (ERU) generated by a joint implementation project (see below); and, a certified emission reduction unit (CER) generated from a clean development mechanism project activity (see below).

The Clean Development Mechanism (CDM) allowed a country with an emission-reduction or emission-limitation commitment to implement an emission-reduction project in developing countries. These projects then could earn certified emission reduction credits, each equivalent to one ton of carbon dioxide (tCO_2e), which could be traded or counted towards their targets. Examples of CDM projects included a rural electrification project using solar panels or the installation of more energy-efficient boilers. The major advantage of CDM was that it could stimulate sustainable development and emission reductions, while industrialized countries also gained some flexibility in how they met their emission reduction or limitation targets.

Joint Implementation (JI), resembling CDM, allowed a country with an emission-reduction or emission-limitation commitment to earn emission reduction units from an emission-reduction or emission-removal project in another Annex B country (see Exhibit 6), each equivalent to one ton of carbon dioxide (tCO_2e), which could be traded or counted towards their targets. The important advantage of JI was that it offered Annex I countries a flexible and cost-efficient means of fulfilling a part of their Kyoto commitments, while another Annex B country also benefited from foreign investment and technology transfer.

The above mechanisms had their own specific requirements, procedures, operating systems, and committees to administer, monitor, and evaluate as well as keep precise records of countries' actual emissions for trade in carbon market. Indeed, there were several other means for GHGs emissions control that were applied in various countries aiming for a low-carbon economy--an economy that released a minimal output of GHGs emissions, specifically carbon dioxide (CO_2), into the environment biosphere.

Pathways to Low-Carbon Economy

An economy could control GHGs emissions, specifically carbon dioxide (CO_2), through increasing carbon sinks and reducing carbon emissions. The former was a natural or artificial reservoir, such as reforestation, that accumulated and stored some carbon-containing chemical compound for an indefinite period.[5] The latter could be attained, for instance, by improving energy efficiency and by switching to low-carbon energy such as biomass. McKinsey and Company (2009) depicted several other techniques that could be used to increase carbon sinks and to reduce carbon emissions (see Exhibit 7).[6] Each technique had different abatement costs (euro per tCO_2e) and abatement potentials ($GtCO_2e$ per year).[7] Unless there were proper policy instruments, an economy would probably be reluctant to bring those techniques into practice.

There were three broad policy instruments to encourage an economy to put GHGs emissions control into action: (i) command-and-control, including mandated technology; (ii) moral suasion; and (iii) incentives. The first two instruments, widely used in the past, were found to be economically inefficient relative to the third one. Presently, there were three types of incentives for handling environmental problems. The first one was price-based incentives such as pollution taxes or abatement subsidies. The second one was quantity-based incentives such as tradable pollution permits or cap-and-trade. The third one was liability rules, originating from the polluter-pays-principle, in which the cost of pollution control, prevention, and remediation should be borne by the entity that profits from the process that caused the pollution.[8]

Quantity-based and Price-Based Incentives

Quantity-based incentives simply limited the maximum amount of GHGs emissions released into the atmosphere at a certain time and let the carbon market – i.e., demand for and supply of emissions -- determine prices of emission permits. The earlier-explained flexibility mechanisms under the Kyoto Protocol could thus be classified under the quantity-based incentive policy instrument. By contrast, price-based incentives specified prices of GHGs emissions released into the atmosphere and let market determine quantities of emissions. Many countries applied price-based incentives in a form of carbon tax on GHGs emissions although a carbon tax was not specified in the international climate agreement as were quantity-based incentives. Other examples of price-based incentives that were widely used included feed-in tariff and renewable energy subsidy.[9]

Some researchers opined that it was too difficult for governments to specify the correct amount of GHGs emissions since knowledge of polluters' production costs would be required. However, these production costs were normally not disclosed, as they were deemed proprietary. Thus, price-based incentives were thought of as perhaps being more accurate than quantity-based incentives.[10] Some researchers argued that because values of environmental damages normally increased at an exponential rate, price-based incentives specified at a constant rate might not sufficiently induce polluters to control their emissions appropriately. However, if abatement costs increased at a faster rate than values of environmental damages did, price-based incentives would be more effective than quantity-based incentives.[11] Currently, it was widely accepted that if values of environmental damages were uncertain, quantity-based incentives were more suitable. If values of environmental damages were known, price-based incentives were more accurate.[12]

Theoretically, in a perfectly competitive market with perfect information and without any other interventions or measures, both quantity-based and price-based incentives would reach the same results. However, in this complex world, human beings were usually sluggish to adjust. Were quantity-based and price-based incentives the sole instruments, the target might not be reached. The aforementioned policy instruments of command-and-control (mandated technology) and moral suasion were still important for solving climate change problems.

Carbon Tax Schemes

From an economic perspective, carbon tax internalized the negative externalities of climate changes not formerly taken into consideration by emitters as indispensable costs of their activities. Although tax schemes were not a part of international agreement on climate change, they were generally used as a tool to control and alleviate damages to natural resources and the environment. After UNFCCC described the detailed specification of greenhouse gases, units of GHGs emissions could be converted to equivalent units of carbon dioxide (CO_2e). From then on, carbon taxes were readily used as another policy instrument to tackle climate change in many countries. The rates of carbon taxes and the sectors on which they should be levied were typically varied, while the impacts, effectiveness and efficiency of carbon taxes were under debate.

In principle, in a perfectly competitive market, the real rate of carbon tax and the price of emission permits ought to be equal, reflecting the social cost of carbon (SCC)--the marginal cost of emitting one extra ton of carbon dioxide (tCO_2) at any point in time.[13] In reality, the estimation was uncertain and the market was not perfectly competitive, leaving the SCC with different estimated values. In 2009, the SCC ranged from a low of 0.47\$/tCO_2e (16Baht/tCO_2e) to a high of 680.70\$/tCO_2e (23,369Baht/tCO_2e) (see Exhibit 8). In addition, some countries might also consider carbon tax rates according to carbon credits accrued through emission reductions in the carbon market. In this respect, average values of carbon credits could be 23.61\$/tCO_2e or 803Baht/tCO_2e. Alternatively, actual carbon tax rates explicitly used in other countries (see Exhibit 9) as well as indirect carbon tax rates implicitly imposed on motor vehicles (see Exhibit 10), might be used as a benchmark for setting carbon tax rates.

There were also other conditions that should be taken into account when selecting carbon tax rates. A perception of the quality of lives of future generations with respect to the present generation, as well as the estimated risk and the degree and duration of the impacts –all of these together determined the appropriate value of carbon tax rates. However, a rate too high might significantly reduce overall production and economic growth, while a rate too low might be ineffective to induce polluters to change their behavior.

Thailand's Position: Cooling Down Global Warming

Thailand's Economic Growth

The Thai economy was a small, open, middle-income, semi-advanced, industrialized service economy depending largely on investments and exports, and least endowed with but mostly dependent on imported fossil-based energy. After recovery from 1997-Asian financial crisis, Thailand had enjoyed an average annual growth rate of over 4% during 2000-2008. Export industries (mainly electronic and computer components, jewelry, and agricultural products, as well as tourism services) -- collectively accounted for over two-thirds of GDP -- were the key engines driving the economy. Following the global financial crisis and oil price crisis during 2008-2009, the economy contracted by 2.3% in 2009. Thailand's fast revitalization led to an expansion of 7.6% in 2010 (see Exhibit 11). The economy was expected to experience at least moderate long-term growth, with high growth likely in the next few years.[14]

However, the strong economic growth of the past three decades had come at a cost of growing pollution and environmental problems. Since 1985, the year that the structure of Thai economy shifted from agrarian to industrial, Thailand had not only enjoyed fast economic growth but also experienced an extremely rapid increase in GHGs emissions, particularly carbon dioxide (CO_2) from energy sectors.

Thailand's GHGs Emissions[15]

In 1985, the energy sector emitted carbon dioxide (CO_2) in the amount of 40.5 MtCO_2e (0.8 tCO_2e per person), but by 2005 the amount had climbed to 233.0 MtCO_2e (3.5 tCO_2e per person)[16] -- equal to an annual increment of 9.15%, much higher than an average annual economic growth rate of 6.05% during the same period.[17] In addition, this rate of GHGs emissions was also higher than the world's average annual growth of GHGs emission (2.34%), Asia's (5.00%), and ASEAN's (7.06%) during the same period. The GHGs intensity of the economy also increased on the average of 2.44% per year, placing Thailand in the top spot among the leading 25 emitters of 2005. This was the combined result of an increase in energy intensity by 0.82% per year and an increase in carbon-intensive fuel mix by 1.62% per year. In 2005, Thailand emitted a total of 351.1 MtCO_2e (5.3 tCO_2e per person), accounting for 0.85% of the world total.[18] Overall, Thailand emitted three major GHGs -- i.e., carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) – that together accounted for 99.37% of the total GHGs emissions.

Thailand's GHGs emissions could be classified according to the main sectors that emitted them (see Exhibit 12). Notably, the energy sector, which mainly emitted carbon dioxide (CO_2), contributed the largest share of GHGs emissions in 2005. Within the energy sector, the electricity and heat sector, the manufacturing and construction sector, and the transportation sector had continuously generated the highest proportion of GHGs emissions. The next major GHGs emitter was the agricultural sector, which released mostly methane (CH_4) and nitrous oxide (N_2O). The industrial processes -- which mainly emitted carbon dioxide (CO_2), hydro-fluorocarbons (HFCs), per-fluorocarbon (PFCs), and sulfur hexafluoride (SF_6) -- were the third contributor of all GHGs emissions, followed by the waste sector, which primarily discharged methane (CH_4) and carbon dioxide (CO_2).

Thailand's Position: Cool or Warm

Although Thailand was a non-Annex I country and thus currently not legally bound to control GHGs emissions under the Kyoto Protocol, there were many reasons for the country to prepare for GHGs emissions control and reduction sooner or later. First, to fight global warming relying solely on Annex I countries to reduce GHGs emissions would not be sufficient to "stabilize GHGs concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".[19] Thus, it was anticipated that in the very near future, developing countries in non-Annex I such as Thailand, would be asked to commit to an emission-reduction or emission-limitation.

Second, as briefly mentioned earlier, the ongoing economic and social development and population growth in Thailand had resulted in an increasing rate of GHGs emissions over time. Thus, it was inevitable that Thailand would eventually be requested to design and implement a long-term plan for sustainable development with a better balance of economic growth and the environment preservation. Third, the growing number of non-tariff trade barriers erected by trade partners -- especially, the requirement of both producer and consumer environmentalists for goods with a low *carbon footprint*, i.e., total GHGs emissions from the entire production process and lifecycle of products -- made the development of such a plan a foregone conclusion. That is, the economy's heavy reliance on exports of goods and services – in addition to the trend of the world community toward low-carbon economy -- left Thailand little choice but to control its GHGs emissions.

Last, although Thailand had never imposed a carbon tax directly, it had imposed the tax indirectly as a part of fossil fuel fees on coal, gasoline, and natural gas with the main purposes of controlling smoke from combustions, economizing scarce energy resources, and inducing a development of clean technology. For instance, in September 2010, the average excise taxes, the oil funds taxes, and the energy conservation funds taxes were respectively 7.70, 7.50, and 0.25 Baht/L on premium gasoline; 7.70, 6.70, and 0.25 Baht/L on regular gasoline; 5.84, 0.65, 0.25 Baht/L on diesel; and 0.88, 0.06, 0.07 Baht/L on fuel oil. However, NGV was not only exempted from excise taxes but also subsidized by oil funds at the rate of 2 Baht/kg. Therefore, the question was not only whether Thailand was in a position to control and reduce GHGs emissions, but also whether Thailand was ready to do so and how to proceed. What would be the effects of GHGs emissions control and reduction in Thailand? What would be the costs and benefits of such controls?

Thailand's Carbon Taxes: Option for Consideration

The country's administrative and legislative foundations were also imperative factors that had to be taken into consideration regarding a decision on GHGs emissions control and appropriate policy instruments in Thailand. On an administrative basis, Thailand's Ministry of Natural Resources and Environment (MONRE) had prepared the "National Strategy on Climate Change, A.D. 2008-2012" as a prescriptive framework for government agencies which government agencies were to observe. The strategy was approved by the Cabinet on January 22, 2008. Additionally, MONRE also prepared the "National Master Plan on Climate Change, A.D. 2011-2020," as well as the corresponding "National Action Plan, A.D. 2011-2013," to cope with long-term challenges such as oil prices and the world food crisis. Both plans had been scheduled for Cabinet approval.[20]

On a legislative basis, Thailand's Ministry of Finance, in collaboration with the Asian Development Bank (ADB), prepared a draft "Act on Fiscal Measures for Environmental Management." The draft Act was approved by the Cabinet in October 2010 and was currently under review by the House of Representatives. The draft Act, if enacted, would act as an umbrella law legalizing the use of economic or financial instruments for environmental and natural resources management. In order for an instrument to obtain a legal status, a corresponding decree had to be prepared by the designated government agency and then be approved by the Cabinet.[21]

Thailand's Commission on Environmental Tax Policy (CETP)[22]

The Commission on Environmental Tax Policy (CETP) was responsible for directing policies primarily derived from economic instruments, especially environmental taxes that had to be approved and granted legal status prior to execution. The commission consisted of 15 committees as follows:

- Five under-secretaries from the Ministry of Industry, the Ministry of Natural Resources and Environment, the Ministry of Finance, the Ministry of Interior, and the Ministry of Public Health;
- Seven top representatives from the Federation of Thai Industries, the Thai Chamber of Commerce, the Tourism Council of Thailand, the Bangkok Metropolitan Administration, the Provincial Administration Organization Council, the National Municipal League of Thailand, and the Subdistrict (Tambon) Administrative Organization Council;
- An environmental economics specialist;
- The director of the Fiscal Policy Office, who served as secretary of the CETP; and,
- The Minister of Finance, who served as chairman of the CETP.

Prospective Sectors to be Levied

Levying carbon taxes might not always be suitable for all emitting sectors that might otherwise qualify (see list of qualifying sections in Exhibit 12). First, levying the tax on some sectors would have limited impact. For example, the waste sector released the least amount of GHGs, mostly during the waste handling processes. Levying carbon taxes on this sector might decrease the amount of waste disposal but barely alter the waste handling processes which were the actual source of GHGs emissions. Co-benefit policies addressing both climate change mitigation and development needs would be more effective. An example of co-benefit policies was the Reduce-Reuse-Recycle practice to which municipal and local governments had already been devoting full attention.[23] Another example would be waste-to-energy projects.[24]

Second, the GHGs output of some otherwise eligible sectors were so massive as to not be subject to mitigation through carbon tax schemes along. For example, industrial processes mainly released deadly GHGs in the form of chemical by-products--usually those with thousands of times the global warming potential of carbon dioxide (CO_2). To decrease such GHGs emissions, it was thought more sustainable in the long-run to reduce chemical by-products through technology changes. In this connection, "command-and-control approaches," along with subsidies and technology-capacity building, would be more desirable than carbon tax schemes to induce technology changes in this sector.

Third, the political dynamics attendant to activity in some sectors all but precluded the application of carbon tax schemes. For example, agriculture released GHGs mostly from rice fields, with amounts varying as a function of specific farming techniques. However, the nature of the agricultural sector in Thailand was such that one or more issues were always in dispute, which inevitably included a political dynamic. These disputes ranged from conflicts over land use, to food security, to poverty and inequality. Attempts to levy carbon taxes on this important sector would potentially become a political morass. Therefore, "command-and-control approaches," along with technology-capacity building, were thought to be more feasible and suitable mechanisms by which to induce farmers to apply low-carbon farming techniques.

Thus, among the major sectors producing GHGs, the energy appeared to be one of the principal candidate sectors where a carbon tax scheme could yield some appreciable results while also being politically feasible. Noteworthily, it was also a sector that had long been subjected to various types of taxes and subsidies, which made it an attractive sector on which to focus. Moreover, in coping with climate change, many OECD countries were already levying carbon taxes to either replace or supplement taxes on fossil fuels and motor vehicles.[25] This further accentuated its attractiveness as a sector on which to levy some form of carbon tax. The question was: Which energy products should be taxed?

Thailand's Energy Sectors and Fossil Fuels

In 2009, Thailand consumed a total 80.6 million tons oil equivalent (MTOE) of fossil fuels. Forty-two percent of this amount came from natural gases (1.4 trillion standard cubic feet (SCF)), 40% from oil (40 billion liters), and 18% from coal (33 million tons). These fossil fuels released 208 $MtCO_2e$ into the atmosphere – of which 38% came from oil (80 $MtCO_2e$), 32% came natural gases (66 $MtCO_2e$), and 30% from coal (62 $MtCO_2e$).[26]

Supplies of these fossil fuels were from various sources. Natural gases were mainly from domestic sources, with 21% imported from Myanmar. The proved reserves of natural gases would last for about 20 years from 2009. Three-fourths of total primary petroleum demand were imported, with the balancing coming from domestic proved reserves which would last for less than 10 years from 2009. Coal, mostly lignite, accounted for about a half of domestic consumption in 2009.[27] Alternative fuels, especially non-fossil fuels, accounted for less than 10% of energy consumption. Available renewable energy in Thailand included biogas, biodiesel, gasohol, and E85. Hydropower, windmills, and solar panels were the principal sources of alternative energy generation for the power sectors.

Demand for these fossil fuels was broad and diverse. In 2007, 75% of natural gases were used in power plants, 20% in industry, and the rest in motor vehicles. Two-thirds of oil fuels were used in the land transportation sector, while the rest was used in water and air transportation sectors. For coal, 46% was used in power plants, 37% in the cement and non-metal industry, and 11% in the iron and steel industry. Accounting for 15% of GDP, the top 15 energy-intensive industries with respect to energy cost shares included ice production at the top, followed by air and land transportations, hotel industry, and heavy industries (see Exhibit 13).

In more detail, the energy sectors and fossil fuel in Thailand could be classified as shown in Exhibit 14.[28] Since each fossil fuel had different emission coefficients (kgCO_2/unit), each would have different, corresponding carbon tax rates. For instance, the emission coefficient of coal and lignite were 1.5997 kgCO_2/kg (equivalent to 1.5997 tCO_2 per ton of coal), hence a carbon tax rate at 1 Baht/tCO_2 would lead to a cost of carbon taxes on coal and lignite of 1.5997 Baht/ton. In 2007, the total quantity of coal and lignite burned in Thailand was 32.41 million tons, which eventually released carbon dioxide (CO_2) in the overall amount of 51.8479 MtCO_2. The value of coal and lignite used in Thailand in 2007 was 27,576 MBaht thus, the carbon dioxide (CO_2) emission intensity was 1,880.18 tCO_2/MBaht (i.e., MtCO_2 divided by MBaht).

For a policy impact analysis, it was required to convert carbon tax rates from quantity-based taxes to value-based taxes, namely, *ad valorem* taxes. As a result, for a carbon tax rate at 1 Baht/tCO_2, an estimated *ad valorem* carbon tax rates on coal and lignite would be 0.188%. For the initial amount of 51.8479 MtCO_2 released from a combustion of coal and lignite, approximate carbon tax revenues from coal and lignite would be 51.8479 MBaht. *Ad valorem* carbon tax rates and carbon tax revenues for other fossil fuels could be derived likewise.

Potential Uses of Carbon Tax Revenues

Carbon tax revenues could be used for different objectives and in various means. First, to improve environmental conditions and solve environmental problems, the tax revenues could be collected and transferred into the Environmental Tax and Charge Fund, a pool of funds that could be dedicated for use in public and private abatement projects as well as in projects proposed by environmental NGOs.

Second, to relieve burdens on the production or supply side due to carbon tax schemes, the tax revenues could be used to reduce the rate of value added taxes (VAT) or corporate income taxes. The former might be thought of as a double-dividend phenomenon of which carbon tax schemes could reduce GHGs emissions and distortionary taxes at the same time. The latter might be thought of as a direct decrease in producers' tax burdens.

Third, to reduce poverty and improve income distribution, the tax revenues could be directly transferred in a lump-sum amount to specific households or used to cut the rate of personal income taxes.

The Ex-Ante Economy-Wide Impacts of Carbon Taxation

Carbon tax schemes had never been implemented in Thailand before; hence, schemes under consideration could be designed in various ways. The Minister of Finance was worried that levying certain carbon taxes would affect the whole economy, both production and consumption sides, and somehow alter the country's international competitiveness. With no other analytical options available, the Minister had to evaluate the ex-ante impacts of carbon taxes simulation techniques alone. Specifically, a key issue was that of what would happen if a wide range of carbon tax rates -- i.e., 10, 50, 100, 200, 500, 1000, 1200, 1500, and 2000 Baht/tCO_2 -- was uniformly imposed on various fossil fuels (i.e., coal and lignite, premium gasoline, regular gasoline, aviation fuel and kerosene, diesel, fuel oil, natural gas, and gas products), and if the corresponding government budget surplus was collected in the Environmental Tax and Charge Fund for the aforementioned purposes.

In general, the economy-wide effects of any given carbon tax rates initially started from a rise in energy prices due to carbon tax burdens (see Exhibit 15). Because energy was an important intermediate input for several sectors, especially energy-intensive sectors such as transportation, an increase in energy prices would lead to higher production costs in these sectors and in their downstream sectors as well (see Exhibit 16).

In response to the production-cost impacts, affected producers who were constrained by sluggish technology changes, fixed labor wage rates, and/or limited capital supplies would strive to maintain their profit maximization by adjusting the quantities or magnitudes of their employee base, capital, energy and other intermediate inputs. Specifically, producers might respond with a reduction in the number of their employees or man-hours through layoff or overtime reduction, with a re-allocation of capital from lower- to higher-return sectors, with a move to substitute cheaper energy inputs for more expensive ones, or with an adjustment to the mixture of intermediate and primary inputs according to the elasticity of substitution between inputs.

Any adjustments in the usage of primary inputs, i.e., labor and capital, would inevitably affect households' factor incomes since households were the main owners of these primary inputs. In general, a reduction in labor and capital uses would precipitate a fall in households' incomes. At the same time, households would also face higher prices of goods and services in the market. Consequently, given a fixed level of household savings, a decrease in household incomes and an increase in domestic prices would reduce household consumption and standard of living to a greater or lesser degree depending on the income and price elasticities of each household.

Higher domestic prices relative to fixed world prices would lead to an appreciation in the real exchange rate which would in turn negatively affect international competitiveness, especially in inbound tourism services and trade markets. Since government consumption and investment expenditure were relatively fixed in the short to medium-run, a reduction in household consumption, tourism consumption, and trade balance would eventually drive a negative change in real GDP from the demand or consumption side. Similarly, a drop in labor employment and capital uses would also make result in a decline in GDP from the supply or production side. However, carbon tax imposition would cause a reduction in energy uses (see Exhibit 17) and consequently a decrease in carbon dioxide (CO_2) emissions (see Exhibits 18-19).

In sum, there would be a trade-off between a decrease in real GDP and a reduction in carbon dioxide (CO_2) emissions (see Exhibit 15). More importantly, carbon tax schemes should at least lead to an improvement in energy efficiency. The government would obtain a budget surplus (see Exhibit 15) due to extra carbon tax revenues (see Exhibit 20) that would be collected in the Environmental Tax and Charge Fund, which if properly used, would help the country mitigate environmental problems and/or alleviate corresponding economic and social burdens.

The Minister's Final Thoughts Concerning the Proposal to Be Made to the CETP

The night before the CETP meeting found the Minister of Finance in deep thought as he reviewed the totality of qualitative and quantitative information on all facets of the proposal that he would have to make to the CETP on the following day. He knew that the Thai government was under intense international pressure to join in the effort to mitigate the effects of climate change. Hence, as shown in the schematic below, the first fundamental decision that he would have to propose to the CETP was whether Thailand should accede to such entreaties and become fully involved in the international climate agreement at the present time or postpone making commitments concerning GHG mitigation actions until some later point in time.

Choice A:	Delay the involvement.
Choice B:	Start the involvement with carbon tax schemes, while addressing additional issues such as: Who would pay the tax? How much should the tax be? How should the carbon tax revenues be used? How could the unfavorable effects of such a tax scheme be mitigated?

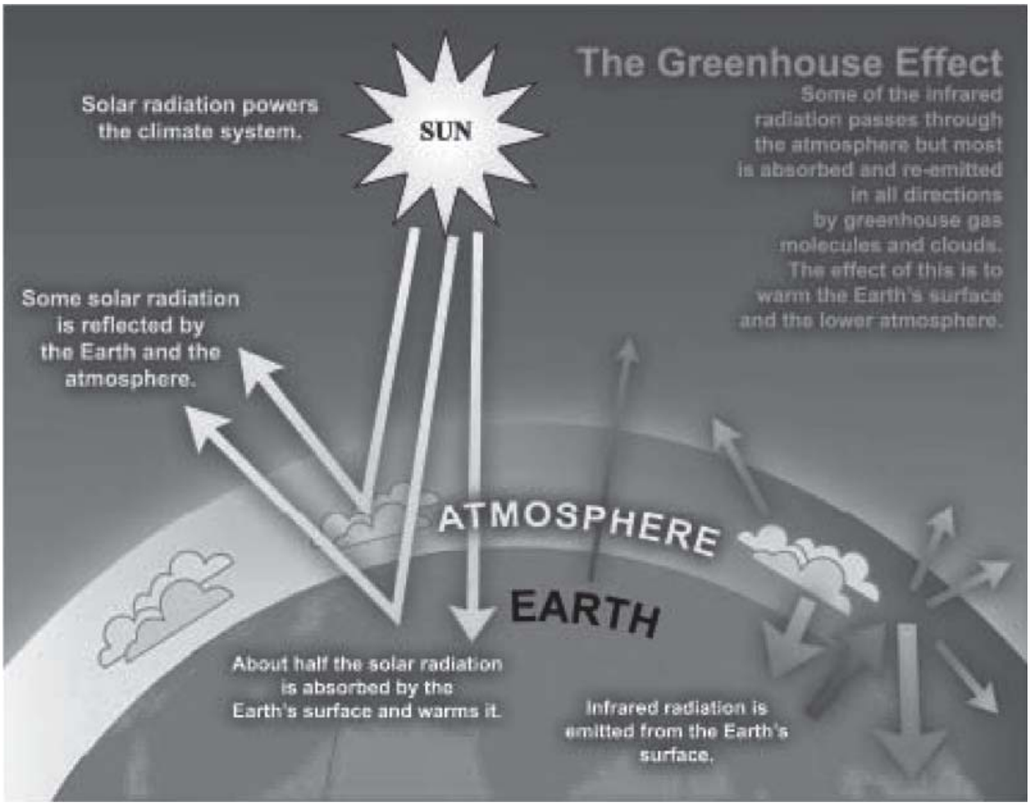
If he were to propose that Thailand delay joining in the international effort, the main follow-up action on the part of the Thai government might be nothing more onerous and politically risk than a mere commitment to study the matter further with the aim of taking decisive action at a later, more opportune, time. Recalling the threats of the elderly lady outside the CETP offices earlier in the day (specifically her cry that she would take to the street in protest and burn the proposal if a decision were taken to levy a carbon tax on NGVs), the Minister admitted to himself that *indecision can sometimes have its virtues – for example, no disgruntled citizens in the streets screaming their outrage over something the Minister did or did not do.* Alas, he knew that neither indecision nor procrastination was an option. The CETP was expecting him to come forward with a definitive and clear proposal concerning what Thailand's posture on GHGs mitigation should be.

With respect to the other decision option, if the Minister elected to propose a definitive course of near-term actions that would place Thailand among the nations actively working to slow or reduce GHGs emissions, he would have to take into account a multi-faceted set of critical issues that would require additional decision making. These largely concerned *how to mitigate GHGs* and *when* to begin the effort. In addressing these issues, a number of factors would have to be taken into account, including the advantages and disadvantages of carbon tax schemes relative to emission trading schemes, the administrative and legislative feasibility of carbon tax schemes, the possible carbon tax rates, the prospective emitting sectors to include in such a scheme, the alternative uses of carbon tax revenues, and the expected costs and benefits (that is, the expected net gains or net losses from carbon tax schemes).

From his analysis so far, the Minister had concluded that, although they involved entirely different mechanics and operation, emission trading and carbon tax schemes were similar in one major respect – i.e., both were aimed at holding GHGs emitters accountable for their polluting actions. That is, emission trading schemes directly signaled the quantities of emissions and let the carbon market indirectly determine the prices; but, both the carbon tax and emission trading schemes, by and large, involved a *"price to emit."* Thus, when price was a central concern (such as in the case of the ex-ante impact analysis), a consideration of carbon tax schemes would indirectly resemble a consideration of emission trading schemes as well.

Relative to carbon tax schemes, however, emission trading schemes had several serious drawbacks. Specifically, they would be efficient and effective only if there were enough sufficiently large industries participating in carbon trade markets; only if the target of emission reduction and distribution of emission permits were correctly identified; and, only if there were a properly organized operating mechanism for the emission trading schemes. For these reasons, as well as for reasons of the greater familiarity and simplicity of carbon tax schemes, the Minister of Finance, was partial toward carbon tax schemes, which he believed were likely to be more feasible than emission trading schemes. However, he was a few analyses away from feeling absolutely certain that some type of carbon tax scheme was the superior approach to imposing a "price to emit" on contributors to climate change. Among the uncertainties that gave him pause was his lack of confidence that anyone, himself included, could predict with any degree of assurance exactly what the expected benefits would be relative to the costs of the implementation of carbon tax schemes. Certainly, the Minister desired to select the choices that held the promise of yielding the greatest expected net gains and benefits.

Exhibit 1: Greenhouse Effects



Source: The Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report, "What is the Greenhouse Effect?" FAQ 1.3, Figure 1, An idealized model of the natural greenhouse effect
Retrieved: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-1-3.html

Exhibit 2: Major Greenhouse Gases (GHGs)

GHGs	**Sources**
Water vapor (H_2O)	• Evaporation of liquid water • Boiling of liquid water • Sublimation of ice
Carbon dioxide (CO_2)	• Respiration • Volcano eruptions • Deforestation • Land use changes • Burning fossil fuels
Methane (CH_4)	• Decomposition of wastes in landfills • Agriculture, especially, rice cultivation • Ruminant digestion • Manure management of domestic livestock
Nitrous oxide (N_2O)	• Soil cultivation practices • Commercial and organic fertilizers use • Fossil fuel combustion • Nitric acid production • Biomass burning
Chlorofluorocarbons (CFCs)[(i)]	• Refrigerants • Blowing agents • Propellants in medicinal applications • Degreasing solvents

Remark: (i) CFCs are now essentially regulated in production and release to the atmosphere by the Intergovernmental Panel on Climate Change (IPCC).

Source: The National Aeronautics and Space Administration (NASA): http://climate.nasa.gov/causes/#no1

Table by author

Exhibit 3: Recent and Future Effects of Climate Change

Recent Effects of Climate Change	Likelihood that Trend occurred in Late 20th Century
• Cold days, cold nights and frost less frequent over land areas	Very likely
• More frequent hot days and nights	Very likely
• Heat waves more frequent over most land areas	Likely
• Increased incidence of extreme high sea level(i)	Likely
• Global area affected by drought has increased (since 1970s)	Likely in some regions
• Increase in intense tropical cyclone activity in North Atlantic (since 1970)	Likely in some regions

Remark: (i) Excluding tsunamis which are not due to climate change.

Future Effects of Climate Change	Likelihood of Trend
• Contraction of snow cover areas, increased thaw in permafrost regions, decrease in sea ice extent	Virtually certain
• Increased frequency of hot extremes, heat waves and heavy precipitation	Very likely to occur
• Increase in tropical cyclone intensity	Likely to occur
• Precipitation increases in high latitudes	Very likely to occur
• Precipitation decreases in subtropical land regions	Very likely to occur
• Decreased water resources in many semi-arid areas, including western U.S. and Mediterranean basin	High confidence

Source: Summary for Policymakers, IPCC Synthesis Report, November 2007: http://www.ipcc.ch/
illustrated by the National Aeronautics and Space Administration (NASA): http://climate.nasa.gov/effects/

Exhibit 4: Regional Effects of Climate Change

Regions	Effects
North America	• Decreasing snowpack in the western mountains • 5-20 percent increase in yields of rain-fed agriculture in some regions • Increased frequency, intensity and duration of heat waves in cities that currently experience them
Latin America	• Gradual replacement of tropical forest by savannah in eastern Amazonia • Risk of significant biodiversity loss through species extinction in many tropical areas • Significant changes in water availability for human consumption, agriculture and energy generation
Europe	• Increased risk of inland flash floods • More frequent coastal flooding and increased erosion from storms and sea level rise • Glacial retreat in mountainous areas • Reduced snow cover and winter tourism • Extensive species losses • Reductions of crop productivity in southern Europe
Africa	• By 2020, between 75 and 250 million people are projected to be exposed to increased water stress • Yields from rain-fed agriculture could be reduced by up to 50 percent in some regions by 2020 • Agricultural production, including access to food, may be severely compromised
Asia	• Freshwater availability projected to decrease in Central, South, East and Southeast Asia by the 2050s • Coastal areas will be at risk due to increased flooding • Death rate from disease associated with floods and droughts expected to rise in some regions

Source: Ibid.

Exhibit 5: Annex I Countries Classified by UNFCCC. (41 Industrialized Countries and Economies in Transition)

Australia	Finland	Liechtenstein	Romania
Austria	France	Lithuania	Russian Federation
Belarus	Germany	Luxembourg	Slovakia
Belgium	Greece	Malta	Slovenia
Bulgaria	Hungary	Monaco	Spain
Canada	Iceland	Netherlands	Sweden
Croatia	Ireland	New Zealand	Switzerland
Czech Republic	Italy	Norway	Turkey
Denmark	Japan	Poland	Ukraine
Estonia	Latvia	Portugal	United Kingdom
			United States of America

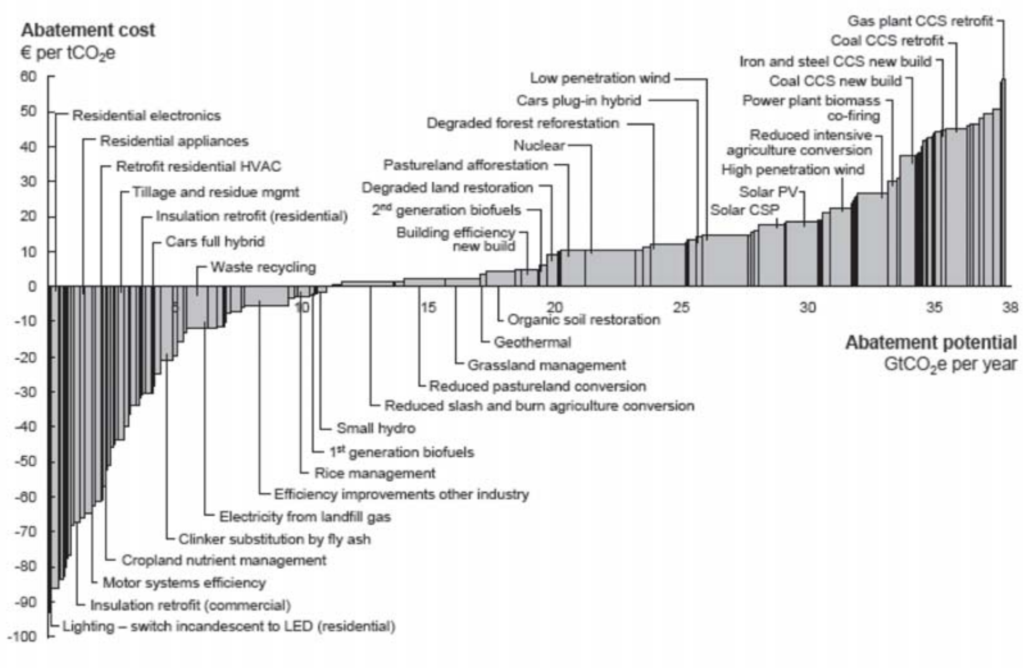
Source: United Nations Framework Convention on Climate Change (UNFCCC): http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php

Exhibit 6: Annex B Countries Classified by Kyoto Protocol

Country	Target (1990 -2008/2012)
EU-15, Bulgaria, Czech Republic, Estonia, Latvia, Liechtenstein, Lithuania, Monaco, Romania, Slovakia, Slovenia, Switzerland	-8%
United States of America	-7%
Canada, Hungary, Japan, Poland	-6%
Croatia	-5%
New Zealand, Russian Federation, Ukraine	0
Norway	+1%
Australia	+8%
Iceland	+10%

Source: United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol: http://unfccc.int/kyoto_protocol/items/3145.php

Exhibit 7: Abatement Costs and Potentials of Several Pathways to Low-carbon Economy



Remark: $GtCO_2e$ = Giga tons (10^9 tons) of carbon dioxide equivalent

Source: McKinsey & Company (2009), Pathway to a Low-Carbon Economy, Version 2 of the Global Greenhouse Gas Abatement Cost Curve: https://solutions.mckinsey.com/ClimateDesk/default.aspx

Exhibit 8: Social Cost of Carbon (SCC)

Researchers	Year	SCC ($/$tCO_2e$) in a Report	SCC ($/$tCO_2e$) in 2009(i)	SCC (Baht/tCO_2e) in 2009(ii)
Ayres and Walter	1991	32.48	49.78	1,709
Haradan	1992	1.99	2.98	102
Hohmeyer and Gaertner	1992	454.84	680.70	23,369
Peck and Teisberg	1993	2.73	3.99	137
Fankhauser	1994	5.54	7.91	271
Maddison	1995	4.50	6.27	215
Hohmeyer	1996	218.32	297.16	10,202
Cline	1997	24.02	31.93	1,096
Roughgarden and Schneider	1999	11.03	13.98	480
Tol and Downing	2000	14.50	17.95	616
Clarkson and Deyes	2002	27.70	32.70	1,123
Mendelson	2003	0.41	0.47	16
Cline	2004	34.93	39.33	1,350
Hope	2005	5.73	6.30	216
Downing et al.	2005	13.86	15.24	523
Stern et al.				
Business as usual	2006	85.00	91.27	3,133
450-550 ppm. CO_2	2006	28.00	30.06	1,032
IPCC	2006	11.73	12.59	432
Nordhaus	2007	7.64	8.01	275
Tol	2008	5.46	5.59	192

Remark: (i) IPCC suggested an increasing rate of SCC be 2.4% per year
(ii) Exchange rate: $1 = 34.33 Baht.

Source: Anan Wattanakuljarus and Kridtiyaporn Wongsa (2011), "Carbon Tax: CO_2 Emissions Control and the Impacts on the Thai Economy," Full report for Thai Universities for Healthy Public Policies, Thailand.

Exhibit 9: Actual Carbon Tax Rates directly used in Various Countries in 2009

Countries	Carbon Tax Rates	\$/ tCO_2e	\$PPP/ tCO_2e	Baht/ tCO_2e(iii)	BahtPPP/ tCO_2e
Finland	EUR20/tCO_2e	27.88	21.01	956.22	352.11
Sweden	SEK365/tCO_2e	48.03	38.99	1,645.84	653.43
Slovenia	EUR12/tCO_2e	16.73	18.93	573.73	317.25
USA.(i)	USD12.5/tCO_2e	12.50	12.50	429.09	209.49
Canada(ii)	CAD15/tCO_2e	13.20	12.57	452.45	210.66

Remark: (i) Boulder, USA.
(ii) British Columbia, Canada.
(iii) Exchange rate: \$1 = 34.33 Baht.

Source: Ibid.

Exhibit 10: Actual Carbon Tax Rates indirectly used on Motor Vehicles in 2009

Countries	Euro/ tCO_2e	\$PPP/ tCO_2e	Baht PPP/ tCO_2e
France			
Tax on vehicle registration	44.45	48.79	817.71
Regional tax on registration certificates	11.25-19.17	12.35-21.04	206.96-352.66
Company-owned vehicle possession tax	1,250.00	1,372.12	22,995.33
Germany	66.67	77.70	1,302.241
Ireland	437.50	468.42	7,850.17
Luxemburg			
Gasoline	133.33	132.32	2,335.06
Diesel	200.00	208.98	3,502.40
Norway	206.69	190.85	3,198.45
Portugal			
Excise tax on motor vehicle, hybrid	62.23	88.52	1,483.52
Excise tax on motor vehicle, gasoline	122.46	174.20	2,919.36
Excise tax on motor vehicle, diesel	333.06	473.77	7,939.90
Motor vehicle circulation tax	65.42	93.06	1,559.56
Sweden			
Alternative energy	58.88	66.76	1,118.79
Gasoline and diesel	80.55	91.33	1,530.54
United Kingdom			
First year	221.80	303.01	5,078.07
Following years	122.64	167.54	2,807.82

Remark: Driving distance: 12,000 km. per year Vehicle life time: 15 years

Source: Ibid.

Exhibit 11: Thailand's Key Economic Facts

Economic Indicators	Year	Amount	Rank[i]
Nominal GDP	2009	US$ 312.6 billion Industry (45.6%) Service (44%) Agriculture (10.4%)	-
Real GDP	2010	$PPP 580.3 billion[ii]	25
Real Growth	2010	7.6%	14
Labor Force	2009	38.7 million Industry (19.7%) Service (37.9%) Agriculture (42.4%)	-
Unemployment	2010	1.2%	7
GINI Index	2006	43%	50
Investment	2009	24.9%	45
Inflation Rate	2010	3.3%	97
Government Expenditures	2009	$35.40 billion	-
Private Expenditures	2009	$145.64 billion	-
Exports	2010	$191.3 billion	26
Imports	2010	$156.9 billion	27

Remark: (i) Ranking is from 227 countries.
(ii) $PPP, purchasing power parity, is a currency conversion rate that both convert to a common currency and equalize the purchasing power of different currencies, i.e., it eliminates the differences in price levels between countries in the process of conversion. (OECD Statistics Directorates)

Sources: US Central Intelligence Agency's The World Factbook 2010: https://www.cia.gov/library/publications/the-world-factbook/National Economic and Social Development Board (NESDB), National Income of Thailand 2009: http://www.nesdb.go.th/Default.aspx?tabid=94

Exhibit 12: GHGs Emissions in Thailand in 2005

Sector		$MtCO_2e$		Share (%)
Energy(i)		233.3		66.4
- Electricity and heat	*83.5*		*23.8*	
- Manufacturing and construction	*59.9*		*17.1*	
- Transportation	*55.9*		*15.9*	
- Other fuel combustion	*25.9*		*7.4*	
- Fugitive emissions(ii)	*8.1*		*2.3*	
Industrial Processes		21.1		6.0
Agriculture		88.8		25.3
Waste		7.9		2.2
Total(iii)		**351.1**		**100.0**

Remark: (i) Wood, charcoal, husk and the like were also the sources of CO_2 emission in Thailand, but the quantity used was very small and market transactions were not systematically accounted.

(ii) N_2O data is not available.

(iii) Emissions from the land use, land-use change and forestry activities were excluded since 2000 because the activities become a sink rather than a source of GHGs emissions in Thailand.

Source: World Resources Institute (2011), Climate Analysis Indicators Tool (CAIT) Version 8.0. Washington, DC. http://www.wri.org/project/cait

Exhibit 13: Top 15 Energy-intensive Industries in Thailand in 2007

Sector	Shares of Total Costs (%)
Ice	50.81
Air transport	33.54
Land transport	33.37
Hotels	32.89
Water transport	30.47
Basic chemicals	25.32
Water works and supply	25.30
Cement and non-metallic products	21.89
Ceramic and glass products	18.63
Spinning, weaving and bleaching	15.78
Iron, steel products	13.15
Plastic products	11.80
Fisheries	11.65
Monosodium glutamate	11.05
Non-metal ore	10.18

Source: Thailand social accounting matrix (SAM) 2007

Exhibit 14: Fossil Fuels, Emission Coefficients, Emission Intensities, and Equivalent *ad valorem* Tax Rates, in Thailand, in 2007

Fossil Fuels	CO_2 Emission Coefficient	Quantity-Based Carbon Tax Rate	Used Amount	CO_2 Emissions	Used Values	CO_2 Emission Intensity	*Ad valorem* Carbon Tax Rates	Carbon Tax Revenues
	$kgCO_2$/Unit	*1 Baht/tCO_2*	*Million Unit*	*$MtCO_2$*	*MBaht*	*tCO_2/MBaht*	*%*	*MBaht*
Coal and lignite	1.5997 $kgCO_2$/kg	0.0015997 Baht/kg	32,411 million kg	51.8479	27,576	1,880.18	0.188%	51.8479
Premium gasoline	2.1800 $kgCO_2$/L		2,625 million liter		42,408			
Regular gasoline	2.1800 $kgCO_2$/L		4,712 million liter		146,693			
Aviation fuel and kerosene	2.4630 $kgCO_2$/L		4,950 million liter		106,154			
Diesel	2.6956 $kgCO_2$/L		18,710 million liter		580,802			
Fuel oil	3.0747 $kgCO_2$/L		4,222 million liter		52,583			
Natural gas, raw	0.0572 $kgCO_2$/scf		524,561 million scf		489,633			
Natural gas products	0.0700 $kgCO_2$/scf		708,644 million scf		454,589			

Remark: scf = standard cubic foot The analyst must correctly fill in the remaining figures of other fossil fuels.

Source: Anan Wattanakuljarus and Kridtiyaporn Wongsa (2011), "Carbon Tax: CO2 Emissions Control and the Impacts on the Thai Economy," Full report for Thai Universities for Healthy Public Policies, Thailand.

Exhibit 15: Economy-wide Effects of Various Carbon Tax Rates in Thailand

Carbon Tax Rates (Baht/tCO_2e)		10	50	100	200	500	1,000	1,200	1,500	2,000
(1)	Real GDP (%)*	-0.010	-0.052	-0.104	-0.208	-0.516	-1.014	-1.209	-1.498	-1.914
(2)	Emission (%)*	-0.225	-1.073	-2.034	-3.710	-7.572	-12.138	-13.606	-15.555	-18.000
(3)	Emission (MtCO_2e)	-0.014	-0.068	-0.128	-0.234	-0.481	-0.778	-0.876	-1.007	-1.174
(4)	Efficiency (emission per GDP)(%)*	-0.215	-1.022	-1.932	-3.508	-7.093	-11.238	-12.549	-14.271	-16.402
(5)	Real GDP/Emission = (1)/(2)	0.046	0.049	0.051	0.056	0.068	0.084	0.089	0.096	0.106
(6)	Household consumption (%)*	-0.037	-0.181	-0.357	-0.697	-1.655	-3.120	-3.674	-4.476	-5.599
(7)	Export (%)*	-0.006	-0.032	-0.064	-0.128	-0.316	-0.622	-0.743	-0.923	-1.186
(8)	Import (%)*	-0.021	-0.101	-0.197	-0.381	-0.882	-1.623	-1.896	-2.288	-2.828
(9)	Tourism (%)*	0.000	-0.001	-0.002	-0.003	-0.008	-0.015	-0.018	-0.023	-0.030
(10)	Employment (%)*	-0.023	-0.113	-0.224	-0.438	-1.047	-1.989	-2.347	-2.868	-3.602
(11)	Capital return (%)*	-0.030	-0.148	-0.292	-0.571	-1.364	-2.586	-3.049	-3.722	-4.667
(12)	CPI (%)*	0.009	0.047	0.095	0.191	0.477	0.948	1.134	1.412	1.817
(13)	Tourism price index (%)*	0.013	0.063	0.127	0.258	0.654	1.318	1.582	1.976	2.548
(14)	Real exchange rate (%)*	-0.012	-0.061	-0.121	-0.242	-0.596	-1.171	-1.396	-1.733	-2.220
(15)	Budget surplus (billion Baht)	1.328	6.519	12.775	24.691	57.383	105.952	123.970	149.807	185.519
(16)	Carbon tax revenue (billion Baht)	2.106	10.353	20.328	39.420	92.236	171.481	201.058	243.622	302.721

* Deviations from baseline growth path.

Source: Simulation results

Exhibit 16: Price Effects of Various Carbon Tax Rates in Thailand (%)*

Carbon Tax Rates (Baht/tCO_2e)	10	50	100	200	500	1,000	1,200	1,500	2,000
Coal and lignite	2.006	9.840	19.253	37.044	84.666	152.681	177.373	212.495	260.646
Natural gas, raw	0.060	0.301	0.603	1.208	3.033	6.088	7.312	9.148	11.839
Premium gasoline	0.108	0.539	1.078	2.156	5.378	10.681	12.775	15.888	20.391
Regular gasoline	0.055	0.276	0.553	1.110	2.790	5.592	6.708	8.375	10.805
Aviation fuel and kerosene	0.088	0.442	0.884	1.768	4.407	8.742	10.450	12.985	16.645
Diesel	0.063	0.314	0.630	1.266	3.181	6.365	7.629	9.513	12.248
Fuel oil	0.180	0.901	1.800	3.588	8.868	17.379	20.689	25.560	32.514
Natural gas products	0.140	0.700	1.402	2.808	7.050	14.172	17.038	21.352	27.714

* Deviations from baseline growth path.

Source: Simulation results

Exhibit 17 Output Effects of Various Carbon Tax Rates in Thailand (%)*

Carbon Tax Rates (Baht/tCO_2e)	10	50	100	200	500	1,000	1,200	1,500	2,000
Coal and lignite	-0.999	-4.637	-8.526	-14.754	-26.749	-37.435	-40.161	-43.260	-46.387
Natural gas, raw	-0.074	-0.370	-0.736	-1.459	-3.550	-6.796	-8.019	-9.780	-12.216
Premium gasoline	-0.065	-0.323	-0.641	-1.262	-3.029	-5.705	-6.697	-8.109	-10.036
Regular gasoline	-0.040	-0.197	-0.392	-0.774	-1.876	-3.597	-4.252	-5.202	-6.531
Aviation fuel and kerosene	-0.048	-0.239	-0.473	-0.933	-2.244	-4.248	-4.996	-6.068	-7.542
Diesel	-0.042	-0.209	-0.414	-0.815	-1.959	-3.725	-4.391	-5.352	-6.686
Fuel oil	-0.999	-4.637	-8.526	-14.754	-26.749	-37.435	-40.161	-43.260	-46.387
Natural gas products	-0.074	-0.370	-0.736	-1.459	-3.550	-6.796	-8.019	-9.780	-12.216

* Deviations from baseline growth path.

Source: Simulation results

Exhibit 18: CO_2 Emissions Effects of Various Carbon Tax Rates in Thailand (%)*

Carbon Tax Rates (Baht/tCO_2e)	10	50	100	200	500	1,000	1,200	1,500	2,000
Coal and lignite	-0.999	-4.637	-8.526	-14.754	-26.749	-37.435	-40.161	-43.260	-46.387
Natural gas, raw	-0.071	-0.351	-0.698	-1.380	-3.339	-6.362	-7.497	-9.129	-11.380
Premium gasoline	-0.065	-0.324	-0.643	-1.266	-3.033	-5.707	-6.696	-8.105	-10.024
Regular gasoline	-0.040	-0.200	-0.396	-0.782	-1.893	-3.628	-4.287	-5.243	-6.580
Aviation fuel and kerosene	-0.049	-0.243	-0.483	-0.950	-2.283	-4.319	-5.078	-6.166	-7.660
Diesel	-0.043	-0.215	-0.426	-0.837	-2.010	-3.818	-4.499	-5.481	-6.843
Fuel oil	-0.106	-0.524	-1.039	-2.040	-4.839	-8.936	-10.410	-12.472	-15.218
Natural gas products	-0.085	-0.425	-0.844	-1.667	-4.025	-7.635	-8.981	-10.906	-13.545

* Deviations from baseline growth path.

Source: Simulation results

Exhibit 19: CO_2 Emissions Effects of Various Carbon Tax Rates in Thailand (MtCO_2e)

Carbon tax rates (Baht/tCO_2e)	10	50	100	200	500	1,000	1,200	1,500	2,000
Coal and lignite	-0.012	-0.055	-0.102	-0.183	-0.357	-0.539	-0.592	-0.659	-0.737
Natural gas, raw	-0.001	-0.003	-0.007	-0.014	-0.033	-0.064	-0.076	-0.094	-0.118
Premium gasoline	0.000	0.000	0.000	-0.001	-0.001	-0.002	-0.003	-0.003	-0.004
Regular gasoline	0.000	0.000	-0.001	-0.001	-0.003	-0.005	-0.006	-0.007	-0.009
Aviation fuel and kerosene	0.000	0.000	-0.001	-0.001	-0.004	-0.007	-0.008	-0.010	-0.012
Diesel	0.000	-0.001	-0.002	-0.004	-0.009	-0.018	-0.021	-0.026	-0.033
Fuel oil	0.000	-0.001	-0.003	-0.006	-0.013	-0.025	-0.030	-0.036	-0.045
Natural gas products	-0.001	-0.006	-0.013	-0.025	-0.061	-0.118	-0.139	-0.171	-0.215
Total	**-0.014**	**-0.066**	**-0.129**	**-0.235**	**-0.481**	**-0.778**	**-0.875**	**-1.006**	**-1.173**

Source: Simulation results

Exhibit 20: Carbon Tax Revenues from Various Carbon Tax Rates in Thailand (Billion Baht)

Carbon Tax Rates (Baht/tCO_2e)	**10**	**50**	**100**	**200**	**500**	**1,000**	**1,200**	**1,500**	**2,000**
Coal and lignite	0.548	2.591	4.862	8.717	17.115	26.232	28.990	32.527	36.782
Natural gas, raw	0.302	1.508	3.006	5.973	14.644	28.392	33.663	41.343	52.147
Premium gasoline	0.047	0.236	0.470	0.933	2.273	4.369	5.164	6.316	7.922
Regular gasoline	0.092	0.457	0.911	1.813	4.462	8.704	10.345	12.749	16.159
Aviation fuel and kerosene	0.103	0.512	1.020	2.025	4.953	9.571	11.336	13.902	17.504
Diesel	0.447	2.227	4.438	8.820	21.638	42.003	49.827	61.245	77.347
Fuel oil	0.104	0.519	1.029	2.026	4.845	9.051	10.589	12.763	15.700
Natural gas products	0.462	2.304	4.591	9.114	22.307	43.159	51.144	62.777	79.159
Total	**2.106**	**10.353**	**20.328**	**39.420**	**92.236**	**171.481**	**201.058**	**243.622**	**302.721**

Source: Simulation results

Endnotes

1 This subsection is compiled from:
The National Aeronautics and Space Administration (NASA):
http://climate.nasa.gov/causes/#no1
http://climate.nasa.gov/effects/
The Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report: Climate Change 2007: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-1-3.html

2 In 1988, the IPCC was formed by more than 1,300 scientists from the United States and other countries. Its aim was to assess the state of knowledge on the various aspects of climate change including science, environmental and socio-economic impacts and response strategies. (United Nations Environment Program(UNEP):
http://maps.grida.no/go/graphic/ipcc-and-unfccc-institutional-framework)

3 This subsection is compiled from:
The United Nations Framework Convention on Climate Change (UNFCCC),
Kyoto Protocol: http://unfccc.int/kyoto_protocol/items/2830.php
Emission trading: http://unfccc.int/kyoto_protocol/mechanisms/emissions_trading/items/2731.php
Clean development mechanism:
http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/items/2718.php
Joint implementation:
http://unfccc.int/kyoto_protocol/mechanisms/joint_implementation/items/1674.php

4 Carbon credit definition is from Investment Dictionary, Investopedia Inc.:
http://www.investopedia.com/terms/c/carbon_credit.asp#axzz1Waqc1n8l

5 Carbon sink: http://en.wikipedia.org/wiki/Carbon_sink

6 McKinsey & Company (2009), Pathway to a Low-Carbon Economy, Version 2 of the Global Greenhouse Gas Abatement Cost Curve:
https://solutions.mckinsey.com/ClimateDesk/default.aspx

7 tCO_2e = Ton of carbon dioxide equivalent;
$GtCO_2e$ = Giga tons (10^9 tons) of carbon dioxide equivalent

8 Polluter-pays principle definition is from Business Dictionary:
http://www.businessdictionary.com/definition/producer-pays-principle.html

9 A feed-in tariff (FIT) is a policy mechanism designed to accelerate investment in renewable energy technologies (http://en.wikipedia.org/wiki/Feed-in_tariff). It is the price per unit of electricity that a utility or supplier has to pay for renewable electricity from private generators. The government regulates the tariff rate (Environmental Terminology and Discovery Service (ETDS), http://glossary.eea.europa.eu/EEAGlossary/F/feed-in_tariff).

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14 National Economic and Social Development Board (NESDB), National Income of Thailand 2009: http://www.nesdb.go.th/Default.aspx?tabid=94

15 Anan Wattanakuljarus and Kridtiyaporn Wongsa (2011), "Carbon Tax and GHGs Emission Control: Options and Considerations for Thailand." 4th International Conference on Sustainable Energy and Environment (SEE 2011): A Paradigm Shift to Low Carbon Society, November 23-25, 2011, Bangkok, Thailand.

16 MtCO_2e = Million ton of carbon dioxide equivalent

17 World Resources Institute (2011), Climate Analysis Indicators Tool (CAIT) Version 8.0. Washington, DC.
http://www.wri.org/project/cait

18 Ibid.

19 The United Nations Framework Convention on Climate Change (UNFCCC), Article 2, Objective: http://unfccc.int/essential_background/convention/background/items/1353.php

20 Anan Wattanakuljarus and Kridtiyaporn Wongsa (2011), "Carbon Tax and GHGs Emission Control: Options and Considerations for Thailand." 4th International Conference on Sustainable Energy and Environment (SEE 2011): A Paradigm Shift to Low Carbon Society, November 23-25, 2011, Bangkok, Thailand.

21 Ibid.

22 Thai Universities for Healthy Public Policies (THUPP) (2010), "Q&A Environmental Tax: Concept, Principle, and Law," pp. 17-21:
http://www.tuhpp.net/files/B14.pdf

23 "*Reduce, Reuse, Recycle*" (3R's) are three ways to eliminate waste and protect the environment. "*Reduce*" is a way to make something smaller or use less, resulting in a smaller amount of waste. "*Reuse*" is a way to use materials again in their original form instead of throwing them away, or pass those materials on to others who could use them too. "*Recycle*" is a way to remake things into either the same kind of things or new products, resulting in a less consumption of energy and resources than making products from new materials. (The National Institute of Environmental Health Sciences (NIEHS), http://www.niehs.nih.gov/)

24 Waste-to-energy technology involves converting various elements of municipal solid waste such as paper, plastics, and woods to generate energy by either thermo-chemical or biochemical processes. (Energy Technology Bulletin, Naval Facilities Engineering Service Center, Port Hueneme, California, http://www.arch.hku.hk/research/beer/waste.pdf)

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[27] Thailand Energy Policy and Planning Office (2010), Energy Statistics: http://www.eppo.go.th/info/index.html

[28] The analyst is asked to correctly fill in the remaining figures of other fossil fuels in Exhibit 14.