Map Ta Phut Industrial Area

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Abstract

Map Ta Phut was the first industrial estate of the Eastern Seaboard development scheme run by the government's Industrial Estate of Thailand. Map Ta Phut industrial project had been successful in creating a large industrial development which had substantially contributed to the growth of GDP, reduction of import and creating a huge number of jobs for Thais. Yet, the communities living around the Map Ta Phut Industrial Area had been suffering from increasingly serious pollution such as air pollution, water pollution and hazardous waste. Worse, there had been several incidents that posed serious impact on localities including employees of the factories. With the continuous impact from industries, local people and NGOs both inside the area and from outside had voiced their opposition against the operations of factories periodically, particularly when there were serious incidents. However, the government had considered the expanding of this industrial estate as its location was one of the best. The Minister of Industry had to work out the future of Map Ta Phut Industrial area. On one hand, the area had created substantial benefit to the country. On the other hand, pressures from the local people, NGOs and academics were so strong that he could not overlook.

Keywords: Industrial Area, Environmental Impact, Pollution, Policy Decision Making

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พื้นที่อุตสาหกรรมมาบตาพุด

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บทคัดย่อ

นิคมอุตสาหกรรมมาบตาพุดเป็นนิคมอุตสาหกรรมแห่งแรกของโครงการพัฒนาอุตสาหกรรมในพื้นที่ชายฝั่งทะเลตะวันออก ดำเนินการโดยการนิคมอุตสาหกรรมแห่งประเทศไทย นิคมอุตสาหกรรมมาบตาพุดได้ช่วยพัฒนาอุตสาหกรรม ช่วยสร้างรายได้แก่ประเทศ ลดการนำเข้าและสร้างงานจำนวนมาก แต่ก็ได้ก่อให้เกิดผลกระทบต่อชุมชนที่อยู่รอบ ๆ เป็นอย่างมาก โดยเฉพาะอย่างยิ่งมลพิษทางอากาศ ทางน้ำ และขยะอันตราย ยิ่งกว่านั้นยังมีอุบัติเหตุอีกหลายครั้งที่รุนแรง กระทบต่อทั้งชุมชนและพนักงาน จากผลกระทบดังกล่าวทำให้เกิดการต่อต้านจากชุมชนและองค์กรพัฒนาเอกชนทั้งในพื้นที่และนอกพื้นที่ โดยเฉพาะอย่างยิ่งเมื่อเกิดเหตุการณ์ที่รุนแรง อย่างไรก็ตาม รัฐบาลก็พิจารณาที่จะขยายนิคมอุตสาหกรรมออกไปเนื่องจากที่ตั้งที่มีความเหมาะสม รัฐมนตรีว่าการกระทรวงอุตสาหกรรมจะต้องตัดสินใจอนาคตของพื้นที่อุตสาหกรรมมาบตาพุด ซึ่งในด้านหนึ่งพื้นที่นี้ก็ได้สร้างผลประโยชน์มหาศาลแก่ประเทศ แต่ในอีกด้านหนึ่งแรงกดดันจากชุมชน องค์กรพัฒนาเอกชน และนักวิชาการก็มีสูงไม่สามารถที่จะมองข้ามได้

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Introduction

On May 6, 2013, the headlines of all the major newspapers throughout the Kingdom of Thailand ran the same general headline:

> **"Again! Explosion at the ACB Chemical in Map Ta Phut: 12 dead and 14 injured"**

Although the Minister of Industry had already been informed of the explosion by way of an early morning telephone call from the director of the Map Ta Phut Industrial Estate, reading the headlines re-ignited the bad mood that the earlier phone call had brought upon him. Thrusting the newspaper aside, he decided to call the director of the Industrial Estate to find out whether there were any additional facts that he could obtain – facts that would be needed to answer questions that would doubtlessly arise both at forthcoming Cabinet meeting and at the time that journalists descended on his office to find out what had happened and what he intended to do about it. Wistfully, he recalled that not only was this the *third* incident of the current year, but also by far the most serious one to date.

The Minister was intimately familiar with the Map Ta Phut Industrial Area. As the largest and most productive estate in all of Thailand, it had contributed substantially to the GDP of the country and had been a major source of employment throughout its operating history. In fact, so successful had the Estate been that the government had been actively considering a proposal to expand the Area, as its location – close to the natural gas sites in the Gulf of Thailand and a large deep sea port --was one of the best in the nation and highly advantageous to the industrial companies operating therein. The factories in the area comprised natural gas and oil refinery, petrochemical production, chemical fertilizer, and other heavy industries that used natural gas or petrochemical products as their core raw material.

The Minister was only too aware that any obstacle to the operation and the expansion of the Map Ta Phut Industrial Area would not only damage the

nation's economic growth and employment but also the popularity of the government. Yet, this explosion – like the past incidents – was certain to trigger another series of strong and prolonged protests from the people living in close proximity to the Industrial Area, as well as from outraged NGOs from both inside and outside Map Ta Phut. It was a foregone conclusion, he mused, that their demands will be to stop any expansion of the Map Ta Phut estate and to close the factories that they believed to be dangerous to health, welfare, and safety of the local community. As the government's "point man" for matters of industrial policy and operations, the Minister knew that the prime minister, as well as the citizens as a whole, would expect him to come forward with actions to forestall any additional tragedies of this nature.

The Place: From First Industrial Estate to Province of Industries

Before the birth of Map Ta Phut Industrial estate, the communities in the area had earned their living from fishing and farming, growing crops such as cassava, sugar cane, and rice. Their considered lives to be in harmony with nature. As recently as 1978 there had been only about 8,400 people living in the area. By 2010, however, there were approximately 90,000 registered localities in 33 communities plus more than 100,000 unregistered ones, most of whose members worked for the industries located in or near the Map Ta Phut Estate. Thus, in just one generation, the overall population of the area mushroomed, and the main source of livelihood changed radically, from pastoral to industrial pursuits.

Map Ta Phut, the first industrial estate of the Eastern Seaboard development scheme run by the government's Industrial Estate of Thailand, had been the driving force behind this transformation. It was established in 1989by the Thai government after the discovery of a large natural gas reserve in Gulf of Thailand. Located in a coastal area of Rayong Province, about 200 km. southeast of Bangkok (see Figure 1), its initial area encompassed about 4,000 rai (650 ha.), but had expanded to its current size of about 10,000rai (1,600 ha.) – which when added to the surrounding four private industrial made for a total industrial area of about 19,000 rai (3,000 ha.). Currently, Map Ta Phut and its vicinity was the largest industrial area in Thailand.

It was the heart of the Eastern Seaboard Development scheme and was intended to be a petrochemical industry hub and a new gateway into Thailand for the world.

After only a little over two decades of development, the number of factories had substantially increased. Currently, there were about 60 heavy industries in the Map Ta Phut Industrial Estate, plus more than 80 industries in the surrounding private industrial estates. Collectively, they had expanded to fill the whole area of the Eastern Seaboard and beyond (see Figure 1). As such, the Map Ta Phut industrial project had successfully created a large industrial development which had substantially contributed to the growth of GDP, the reduction of imports and the creation of tens of thousands of jobs for Thais.

Figure 1: Location of Map Ta Phut, Rayong Province and Its Main Industrial Estates

Thus, Rayong Province -- once the land of agriculture, fishing and stunningly beautiful nature -- had become home to the largest petrochemical and heavy industrial constellation in Thailand. With petrochemical and related products as key industries in the area, the number and types of industries in Rayong Province had expanded rapidly. At present, there were about 1,700 factories in the Province with a total investment of about 27,170 million US dollars. Of these, there were 400 large factories located in eight industrial estates (see Figure 2). Rayong-based industries contributed nearly 14% of Thailand's GDP, thereby according Rayong province had the highest GDP per capita among all provinces in Thailand.[1]

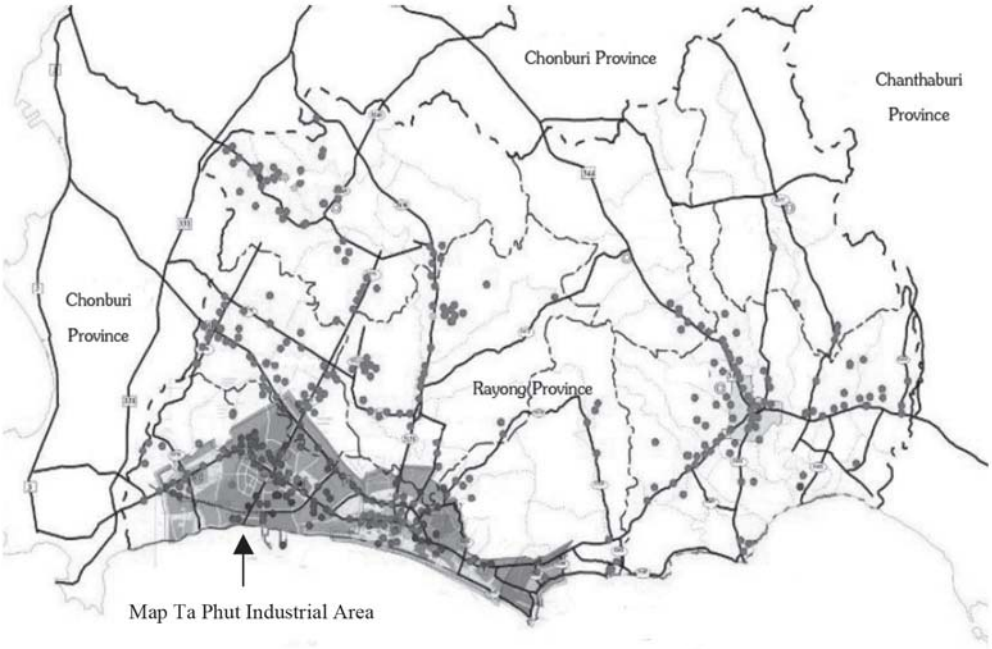

Figure 2: Factories in Rayong Province

The Problems: Pollution Galore!

Unfortunately, in line with Map Ta Phut's continuously increasing contributions to the Thai economy, the communities living around the Map Ta Phut Industrial Area had been suffering from increasingly serious pollution problems. Among the most concerning of the pollutions were those of air and water pollution, along with hazardous waste. A 2007 study by the Pollution Control Department contained statistics that revealed that communities in the vicinity of the Area suffered from respiratory diseases and cancer, at much higher level than the other areas. Serious impacts from air pollution had been experienced since 1993, and had not abated.[2]

Among the incidents chronicled in the aforementioned study was one that had posed such a serious health threat to students in Map Ta Phut Panpittayakarn School, a large secondary school located next to the area, that eventually the

school had to be moved to another area after a series of incidents that caused a number of students and teachers at the school to become physically ill from the air pollution. Some other examples of the severity of the pollution and related problems were:

- The 1997 hospitalization of approximately 40 Map Ta Phut students and teachers in consequence of their having succumbed to severe chemical odors from one or more of the adjacent plants. (The school had to be closed for several days.);
- A 1998 incident in which a number of local people living next to an industrial waste disposal site became ill from the emitted gas.
- The periodic and serious olfactory problems from petrochemical and refinery plants with which local communities had to contend during the period, 2000-2003; and,
- The 2005 serious shortage of water supply that had led to conflict between the factories and the local communities.

An interview with one community leader who goes by the name, Thanyapat, reaffirmed and underscored the locality's concerns about the severity of the pollution problems. She pointed out:

> *The most serious impact from Map Ta Phut industries is air pollution, especially the carcinogenic type of pollution. Sometimes we can't feel it, but it is always there. Bad smells is also another threat to us. We breathe it in everyday. We don't know when it exceeds our capacity.*

Other local leaders also expressed their concerns about the air pollution that they often smelled, as well as those that emanated from the occasional accidents, e.g., explosions. Their other concerns were about water pollution, noise pollution, waste, and traffic congestion.

The depiction of Map Ta Phut captured below in Figure 3 succinctly captured the views of the Estate and its neighbor industrial areas in the minds of local public.

Figure 3: Perception of Map Ta Phut in the Public's Mind

Types of Air Pollution in Rayong's Industrial Area

Given the large number of petrochemical factories concentrated in Rayong's industrial area, it was not surprising that the major air pollutants were "volatile organic compounds" (VOCs), sulfur dioxide (SO_2) and Nitrogen Dioxide (NO_2). Although VOCs were the most concerning type of air pollutant (of the more than 40 types of VOCs used or produced in the Area, 20 were known carcinogens), SO_2 and NO_2, as well as particulate matters were also believed to have serious health impacts on local people living close to the industrial area. Hence, the air pollution problem in Rayong had long been of great concern to local people, central government agencies, regional government offices and local authorities.

Pollution from Volatile Organic Compounds (VOCs). Results of the monitoring of VOCs from 9 stations around the Rayong industrial area from 2007-2010 showed that there were 3 types of VOCs -- benzene, 1,3 butadiene, and 1,2 dichloromethane, -- whose 1 year average volumes exceeded the Thai national standards. Another VOC of great concern was dichloromethane whose volume trend had steadily increased since 2010. The data also indicated that the stations where the VOCs volumes had exceeded the standards were mostly located close to the dense industrial areas of Map Ta Phut Industrial Estate and IRPC Industrial Estate. Figures 4 through 7 show the results of air quality monitoring at the 9 stations.[3]

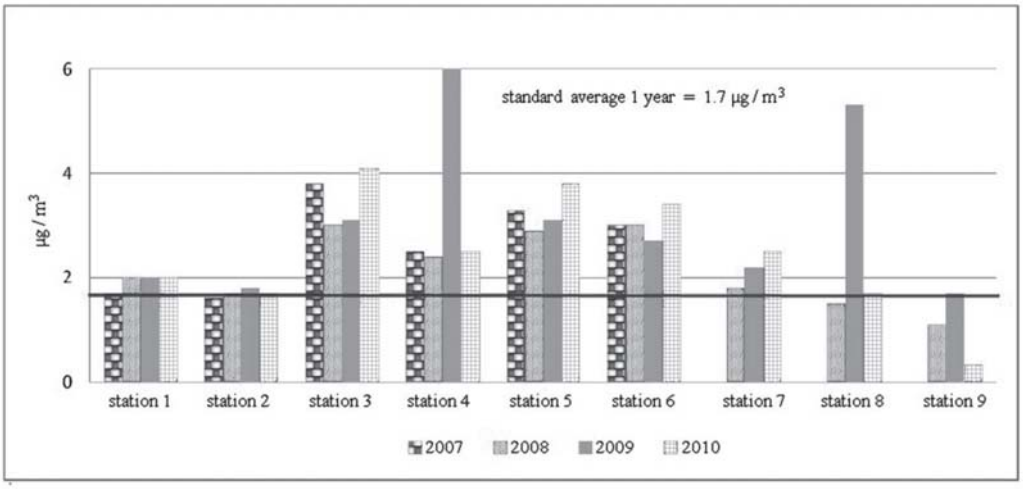

Figure 4: Benzene Volumes in Map Ta Phut Area, 2007-2010

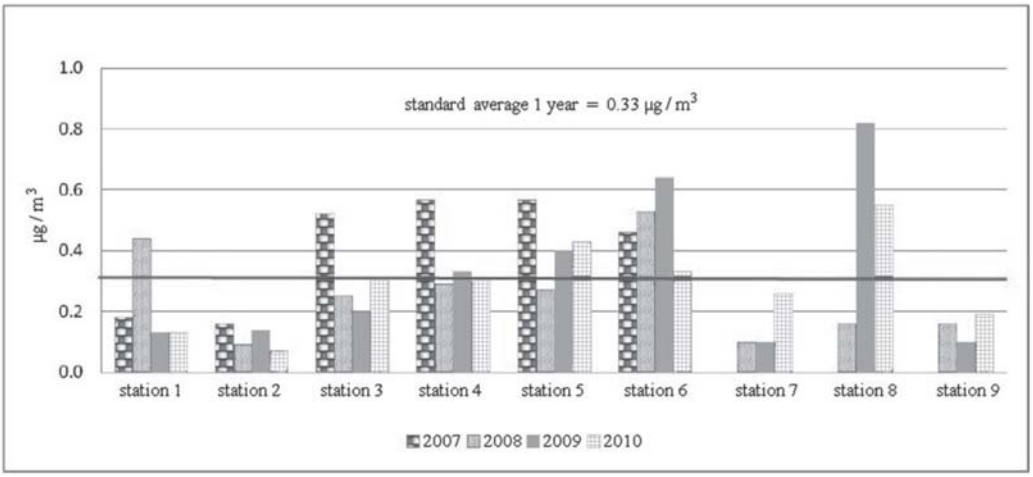

Figure 5: 1,3 Butadiene Volumes in Map Ta Phut Area, 2007-2010

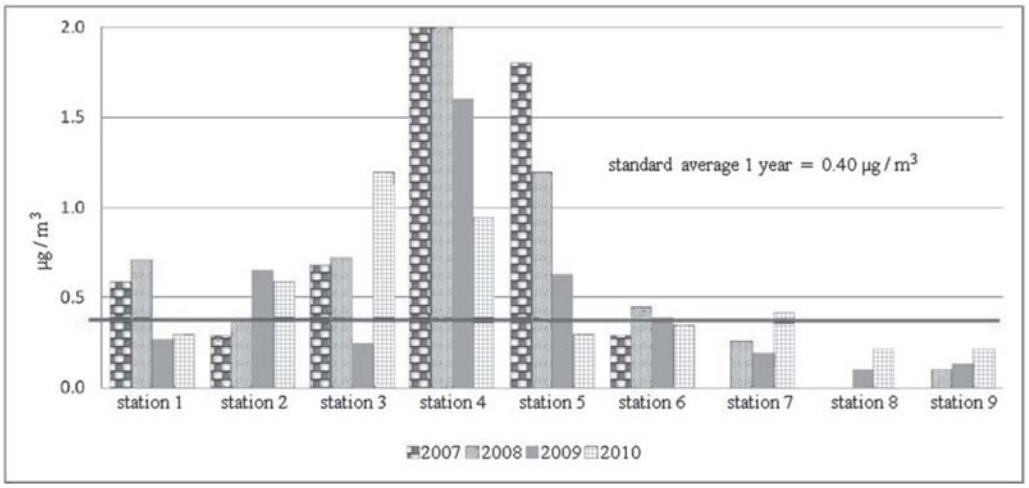

Figure 6: 1,2 Dichloroethene Volumes in Map Ta Phut Area, 2007-2010

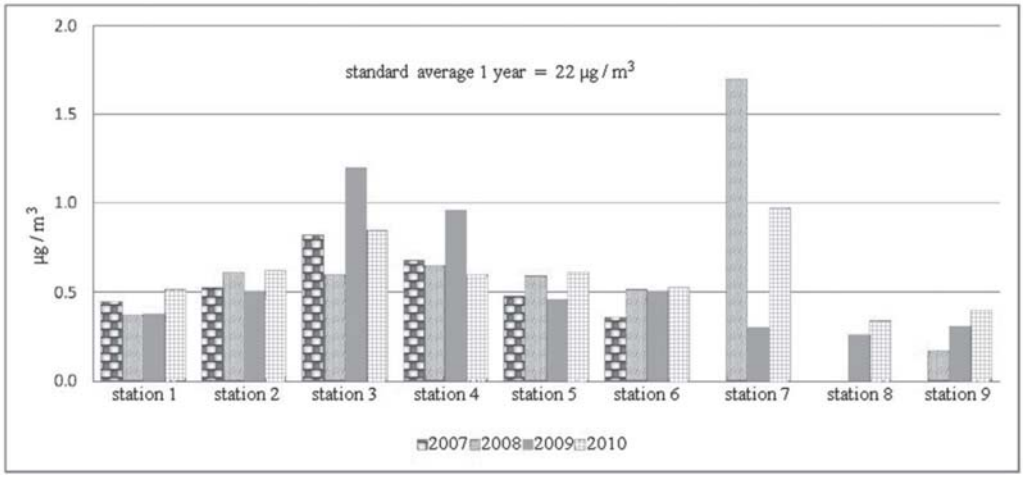

Figure 7: 1,3 Dichloromethane Volumes in Map Ta Phut Area, 2007-2010

As can be observed in the above-shown pollution monitoring results during the period 2007-2010, VOCs concentrations of carcinogenic air pollutions in the communities surrounding Map Ta Phut Industrial Area were consistently at a worrisome level. In some areas they were well above the standards. The levels were within the standards in the other areas, but barely so.

The Pollution from Other Sources –PM_{10}, Ozone, SO_2, NO_2, and CO.

Volatile organic compounds (VOCs) were by no means the only source of pollution in the Industrial Estate or in Rayong province as a whole. Air quality monitoring in the province's Pollution Control Area from 2004-2010, revealed that the 24-hour maximum volumes of PM_{10} (particulate matter that is smaller than 10 microns) exceeded the standards from 2004 to 2008. On the other hand, maximum volumes of ozone were within the Thai national standards from 2004 to 2006, but exceeded the standard from 2007 to 2010. Further, the maximum volumes of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and carbon monoxide (CO) were within the standards for these 7 years.

Impacts of Air Pollution and Safety Problems

Serious and steadily worsening environmental degradation in the Area was having impacts on local residents in at least two major ways. First, there were the immediate and out right *pollution* impacts on the health of those living or working

or attending school in the vicinity of the Industrial Estate; and, second were impacts of a safety nature.

Health Impacts. A continuum of health problems had come to be attributed to the poor air quality in the immediate vicinity of the Industrial Estate. At one end of the continuum were acute and chronic respiratory ailments, which had become an oft-encountered ailment of local people. In fact, the Pollution Control Department reported that the highest number of people visiting the external patient sections of hospitals and other healthcare service organizations came to get checked for respiratory diseases. In addition, it was reported that the ratio of people who suffered from respiratory diseases in Rayong was higher than that of the country as a whole. Worse, the trend in Rayong was accelerating, while the trend for the country as a whole was decreasing.

At the other end of the continuum of health issues and problems was the rising proportion of deaths that were attributed to cancer. It had come to pass that the ratio of the deaths from cancer, particularly lung cancer, in the Map Ta Phut industrial area was higher than the ratio pertaining to both Rayong Province and the country as a whole. However, notwithstanding the disproportionate incidences of such sicknesses and deaths in the Map Ta Phut industrial area, there was as yet no particular study confirming the relationship between these sicknesses and deaths and pollution in the Area. Thus, only an *association*, not *causality*, could be shown.

Safety Impacts. Since the establishment of Map Ta Phut Industrial Estate, there had been a series of serious incidents that had varying degrees of impact on workers and/or local people, ranging from injuries to loss of life. Unlike the health effects of air pollution, where causality was sometimes disputed and denied, the immediate cause of industrial accidents tended to be more indisputable. For example, culpability for the May 5, 2013 explosion at the BST Petrochemical Factory, one of the most severe accidents in the operating history of the Map Ta Phut Estate, could not be denied. The explosion wave strongly hit factories and buildings in 500-meter radius of the plant and could be heard as far away as 5 kms. (see Figure 8). Twelve workers lost their lives, and several others suffered injuries of varying degrees of seriousness.

Figure 8: The May 5, 2013 Explosion in Map Ta Phut Industrial Estate

Responses and Actions of the Factories, Government, and People

What to do about these health and safety issues had long been a matter of deliberation, debate, and action within each of the three most directly involved stakeholders of the Map Ta Phut Industrial Estate. These were expected to accelerate in line with the frequency and seriousness of the precipitating problems.

Factory Responses and Actions

Though their actions were not always visible to affected residents, the industrial plants themselves were active participants in the quest to improve the quality of life of residents in the vicinity of the Estates. In particular, factories in the Map Ta Phut area had attempted to alleviate major air pollution problems from their operations by establishing policy, making plans and projects, allocating budget, personnel, and equipment, and adopting modern technologies.[4] Some of the specific actions taken to control VOCs, SO_2 and NO_x were as shown in Table 1 below.

Table 1: Factory Actions Taken to Control VOCs,SO_2 and NO_x in Map Ta Phut

Actions	VOCs	SO_2 and NO_x
1. Establishment of policies	67%	64%
2. Development of plans and projects	83.9%	76%
3. Funding of sufficient budget to implement policies, plans and projects	90.3%	96%
4. Adequacy of personnel	80.6%	92%
5. Continuous monitoring of leak points /emissions	67.7%	96%
6. Adequacy of equipment	67.7%	n/a
7. Employment of modern technology	77.4%	80%
8. Continuously monitoring and evaluation of plans and projects	n/a	88%

VOCs. As shown in the Table above, the vast majority of factories in the Estate were tackling the problem of volatile organic compounds, with a plurality or greater purporting to have established policies, developed specific plans and projects, assured adequacy of budget and personnel with which to reduce VOCs emissions. In addition, slightly more than two-thirds of the industrial plants monitored VOCs emissions continuously and had enough equipment for VOCs monitoring; and, more than three-quarters purported to employ technology for monitoring and controlling VOCs leak points.

The principal technologies employed to prevent or minimize VOCs leaking were: dual mechanical seal pumps or seal-less pumps, a closed loop system in sampling connections, installing blinds, caps or plugs at open-ended pipes, using double rim seals for floating roof tank, installing incineration system, using activated carbon for VOCs absorbing, installing scrubber, etc. (see Appendix 3 for the examples of these technologies).

SO_2 and NO_x. Similarly, a near plurality of the factories reported having established policies for reduction of SO_2 and NO_x emissions, with a plurality or greater purporting to have plans and projects, along with budgetary sufficiency and personnel adequacy for this express purpose. Nearly all reported continuous

monitoring of SO_2 and NO_x emissions, and a plurality purported to employ modern technology for this purpose. Additionally, the vast majority represented that they continuously monitored and evaluated the progress of the plans and projects.

The technologies used were, for example: low NO_x burner, wet electrostatic precipitator, steam injection, steam de-NO_x, circulating fluidized bed boiler, bag filter single cyclone, sea water desulphurization, and, using alternative fuels (see Appendix 4 for the examples of these technologies).

Governmental Responses and Actions

The central government – through its Department of Industrial Works, the Industrial Estate of Thailand and the Pollution Control Department – had also been trying to mitigate the impact from air, and other, pollutions in the Map Ta Phut industrial area. One important measure was the implementation of the *2007-2011 Pollution Reduction in Rayong Province Action Plan* which was focused on the Map Ta Phut area. This action plan guided the activities of all concerned sectors – the factories, government agencies, local government and local people– with respect to tackling the pollution impacts from the industries. However, as could be seen from several subsequent pollution incidents and occasional protests by local residents and the NGOs, this action plan did not fully solve the problems. The weak point of the action plan was attributed to the inadequacy of concrete support to all actors, particularly in terms of financial resources. Hence, in large measure because of the very strong and continuing (2007) movement of local people and NGOs requesting the Map Ta Phut industrial area to be a pollution control zone, the government (by order of the Administrative Court) did precisely that in 2009 -- i.e., declared Map Ta Phut and its surrounding industrial area to be a pollution control zone.

Many observers had expected the action to lead to more effective measures to control and manage the pollution problem, as it required the relevant government agencies to pay more attention and provide more resources. However, the only concrete result of the declaration was the formulation of the Pollution Management Action Plan for the Pollution Control Zone which solicited the cooperation of all sectors, including local authorities and local people.

The latest initiative from the government was to develop Map Ta Phut Industrial Area into an "Eco-Industrial Park" or Eco-Industrial Town. The Industrial Estate Authority of Thailand had adopted the idea from European countries and Japan, where this approach had been working quite successfully in several industrial areas. The IEAT hired some consultants to study the feasibility and formulate a plan for Map Ta Phut. However, concrete implementation has yet to be seen.

The People's Responses and Actions

Due to the ongoing pollution impacts of the Map Ta Phut Industrial area, the local people had gradually become increasingly alarmed about the long-term health effects on themselves and their families. As this awareness and concern grew, residents had organized several protest demonstrations against the operation of the factories over the years – usually in the aftermath of yet another serious pollution incident. Among their perennial requests was that either the factories improve their operations in order to minimize the emissions – or, be closed. Sometimes the protests engaged in bold actions, such as blocking the entrance of the industrial estates and not allowing the workers to enter or leave (see Figure 9). The protesters had even trekked to Bangkok to demonstrate at the Ministry of Industry (see Figure 10).

Indeed, it was this kind of bold action by the local people, aided by the NGOs, that had precipitated the designation of Map Ta Phut as a pollution control zone. More specifically, when the local residents and their NGO supporters received no response to their April 2007 letter to the National Board of Environment demanding that the Board declare Map Ta Phut a pollution control zone, they had proceeded to file suit in the Administrative Court (October 2007), arguing that the board had shirked its duty. On March 3, 2009, the Court concurred and ordered the board to declare Map Ta Phut a pollution control zone.

Moreover, in that same year, the people filed a second suit with the Court seeking the indefinite suspension of 76 large new projects in the area on the grounds that they had not undergone the Health Impact Assessment as stipulated in the 2007 Constitution. The court responded with a ruling that ordered the suspension of 65 projects -- which resulted in a huge loss of investment in the area.

Figure 9: A Protest against Factories in Map Ta Phut

Figure 10: A Protest by a NGO at the Ministry of Industry against the operation of Map Ta Phut Industrial Area

Local community dissatisfaction with the performance of both the government and the factories was profound. Indeed, interviews with community leaders revealed that the majority of them were "dissatisfied" with the performances of the government agencies and the factories in solving the impacts of the industries on local communities. Pranee, a local activist, expressed her dissatisfaction towards the factories in these words:

> *The factories are not sincere in solving the problems. They don't come to talk to the people before launching projects. They don't inform people what exactly the projects are. When the problems occur, they always blame the other factories. If the incidents are clearly from their factories, they just say that they will try their best to prevent the next ones.*

Suthep, a community leader, concurred, pointing that "*the root cause of problems in Map Ta Phut Area is the factories do not conform to the laws due to their selfishness and lack of accountability"* and that *"corrupted government officers were an additional factor."*

Srisuwan, one of the leading NGOs who had been very active in ongoing efforts to have Map Ta Phut's pollution and safety problems adequately addressed, had a very strong opinion about the performances of the government and the factories

> *The government has absolutely failed to solve the problems. The relevant agencies fail to enforce the laws. They don't have good cooperation, so the control of pollution is ineffective. The factories don't observe the measures stipulated in their EIA (Environmental Impact Assessment) and HIA (Health Impact Assessment)."*

The Future of Map Ta Phut: Country Benefits vs. Local Sacrifices

"My only regret is that I have but one life to lose for my country."

. . . Final words of the American patriot Nathan Hale, who was hanged by the British for support of the American struggle for independence in the late-1770s.

The local residents in the vicinity of Map Ta Phut could be forgiven if they ever came to believe that they were being asked to sacrifice their health, if not their very *lives*, for the greater good of the nation as a whole. After all, despite the repeated attempts by all sectors – government, industry, and locals -- to solve the pollution and safety problems of Map Ta Phut, the crisis continued largely unabated. The number of people suffering from the still ubiquitous pollution continued to increase. The future of the Area was still unresolved, despite widespread discussion in several arenas by different interested groups with their own distinct views.

Local people and their NGOs allies were adamant about wanting Map Ta Phut to stop growing, and to undertake concrete improvement of the operation of the factories to minimize pollution. Moreover, they were insistent that the demonstrably dangerous factories be closed or moved out of the area. They demanded greater monitoring of the factories and stricter enforcement of laws concerning environmental issues. Srisuwan, who had joined the locals in filing a suit against the 76 new large projects, emphasized that:

> *For the better future of Map Ta Phut, the factories that cannot control the leakage or emissions of pollution must be closed. All factories must join the eco-industry process. Industry must adopt the real CSR (Corporate Social Responsibility) and implant this concept throughout their organizations, to all administrators and employees. Map Ta Phut must stop expansion definitely.*

Academicians also wanted the government to reconsider the development of the area, as it had already imposed too much of a burden on the environment and the local people. One of the academics who has been working with the issue for many years addressed what she considered the root cause of the problem:

> *There are too many factories in Map Ta Phut area. Although each factory emits pollution within the standards, the overall emissions are too much for the carrying capacity of Nature in the area. Hence, living things in the area cannot live their lives happily."*

Alas, it was an inescapable fact that the matter of Map Ta Phut was now, once again, in his hands, thought the Minister of Industry. The challenge of working out the future of Map Ta Phut Industrial area was now his as the incumbent Minister. On the one hand, not to be dismissed lightly was the fact that the area had created substantial economic benefit to the country – a contribution that was expected to increase in the future. But, on the other hand, the health of the local populace was a legitimate concern of government. In fairness, he wondered, how much sacrifice could the rest of society expect of the local people whose very lives were being placed at risk from the monumental pollution with which they were afflicted? Moreover, with pressures from the local people, NGOs and academics becoming steadily stronger with each successive incident such as the recent mishap, he could not overlook the possibility that the main opposition political party might capitalize on the growing dissatisfaction with the government's response and succeed in winning the election, which was scheduled to take place within the next year.

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Appendix 1: Information on Industries in Rayong Province

No.	Types of industry	Investment capital (baht)	Number	No. of employees
1	Chemical	253,433,385,885.23	131	15,545
2	Transport	182,617,410,764.13	154	28,116
3	Costume	11,616,000.00	2	291
4	Metal	72,300,181,000.00	29	5,168
5	Chemical and Products	59,125,900,000.00	15	2,078
6	Metal Products	33,582,214,104.40	193	13,538
7	Plastic	24,184,865,652.28	104	11,063
8	Non-metal Industrial	18,247,806,520.00	83	3,421
9	Machinery	15,003,494,458.43	94	7,609
10	Textiles	14,987,539,802.99	18	4,919
11	Electricity	14,793,778,567.65	50	9,861
12	Rubber	10,559,332,273.75	67	9,313
13	Paper and Paper Products	7,261,290,000.00	18	1,339
14	Cuisine	3,729,699,883.00	115	8,004
15	Wood and Wood Products	3,463,485,000.00	117	4,263
16	Agriculture	1,939,472,900.00	242	1,656
17	Furniture	1,710,095,000.00	40	6,214
18	Leather	838,950,000.00	5	823
19	Publications	576,540,000.00	14	884
20	Beverage	62,050,000.00	4	196
21	Other Industrials	96,832,224,673.48	236	9,805
Total		815,261,332,485.34	1,731	144,106

Note: 30 baht = 1 US$

Source: Rayong Provincial Industry Office, 2010

Appendix 2: Volumes of PM_{10}, SO_2, NO_x CO, and O_3 from 2004-2010 in Rayong's Pollution Control Area

Year	Fume < 10 Micron (PM_{10})			Sulphur Dioxide			Nitrogen Dioxide			Carbon Monoxide			Ozone		
	Average 24 hrs. (Microgram/1,000L)			Average 24 hrs. (Microgram/1,000L)			Average 1 hr. (Microgram/1,000L)			Average 1 hr. (Microgram/1,000L)			Average 1 hr. (Microgram/1,000L)		
	Max.	Min.	time>Std.	Max.	Min.	time>Std.	Max.	Min.	time>Std.	Max.	Min.	time>Std.	Max.	Min.	time>Std.
2004	162.0	10.31	11/333	65.0	0.0	0/7,721	76.0	0.0	0/8,137	2.9	0.0	0/8,204	96.0	0.0	0/8,167
2005	163.2	17.2	9/352	175.0	0.0	0/8,283	92.0	0.0	0/8,359	2.4	0.0	0/8,123	88.0	0.0	0/8,335
2006	137.0	13.4	3/355	73.0	0.0	0/8,197	64.0	0.0	0/8,249	2.3	0.0	0/8,345	98.0	0.0	0/8,335
2007	162.9	16.6	9/288	66.0	0.0	0/7,101	67.0	0.0	0/7,932	2.3	0.0	0/8,078	119.0	0.0	21/8,105
2008	121.3	14.4	1/330	70.0	0.0	0/8,023	74.0	0.0	0/8,101	3.3	0.0	0/8,039	114.0	0.0	12/8,107
2009	81.2	5.8	0/342	42.0	0.0	0/7,909	84.0	0.0	0/7,948	2.2	0.0	0/8,007	117.0	0.0	3/7,936
2010	63.3	7.3	0/316	25.0	0.0	0/7,515	62.0	0.0	0/7,400	2.1	0.0	0/7,576	141.0	0.0	9/7,571
Standard = 120				300			170			30			100		

Source: Pollution Control Department, 2007, 2008, 2009, 2010: website http://www.pcd.go.th/

Endnotes

[1] Rayong Provincial Industry Office. 2010. Information of Industry in Rayong Province.

[2] Pollution Control Department, 2009: website.

[3] Industrial Estate Authority of Thailand. 2011. *Final Report of Strategic Environmental Framework towards Eco-Industrial Town: A Case Study of Map Ta Phut Area.*

[4] Poboon, et al. 2012. "Air Pollution Management in Rayong's Industrial Area, Thailand." *WIT Transaction on Ecology and the Environment.* Vol. 157, 189-199.