Municipal Solid Waste Management in Thailand: Challenges and Strategic Solution

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1 Introduction

Thailand, covering an area of approximately 513,115 km^2, from North 5° 30′ to 21° and from East 97° 30′ to 105°, is the world's 50th largest country, while its population of approximately 64 million is ranked at the world's 20th most populous country. The GNP per capita was 153,952 Baht (5,047 US$) as of 2010 (Bank of Thailand 2012). The GDP was 373.3 billion US$ as of June 2012 and GDP per capita was 5,497.3 US$ (NESDB Economic Outlook 2012). Geographically, Thailand is located in the tropical zone and has a monsoonal climate with an average temperature 23.7–37.5 °C. It consists of 76 provinces, 926 districts (Amphoe)/minor districts (Ging-amphoe), 7,426 sub-districts (Tambon), and 74,944 villages. Some areas, including all the provincial capitals, are designated as municipalities. The capital is Bangkok with an area 1,568.737 km^2, a 6,710,883 registered population with the number of household being 2,263,680, and population density 4,160 persons/ km^2, while the average population density of the whole country is 133 persons/km^2, as of 2011 (Strategy and Evaluation Department 2012).

In general, the average generation rate of municipal solid waste (MSW) in Thailand is 0.64 kg/capita/day varying from 0.4 to 1.5 kg/capita/day based on the density of population. The moisture content of MSW ranges between 40 and 60 %. In 2008, around 41,064 tons MSW/day was produced, whereas the capacity of the sanitary disposal was approximately 38 % (Pollution Control Department 2008). The society has suffered from waste mismanagement as a result of insufficient know-how, a lack of realistically applicable technology that is suited circumstances and a weakness in the process of public participation, policy implementation and institutional support. Hence, the failure to optimize waste as a raw

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material in addition to reuse and recycling processes has occurred within and beyond administrative boundaries.

At present, a positive sign of change in the role of environmental management has recently taken place with the promulgation of a new constitution for the kingdom of Thailand in August 2007. The 2007 Constitution contains many more provisions affirming the rights and freedoms of the people in relation to their participation in the management of natural resources and environment. In addition, a draft master law for the promotion of waste reduction, reuse and recycling has been produced in order to control waste management from generation until final disposal. In this integrated solid waste management with resource conservation and recovery, the polluter pays principle, and public rights have been included to set up systematic and efficient waste management in Thailand (Pollution Control Department 2009). The drafted master law under the 2007 constitution provides the public right to be involved in waste management in term of the laws on waste reduction, separation, re-utilization as well in relation to information receiving and building up networks to co-ordinate activities. It is, therefore, necessary for Thailand to take this opportunity to strengthen the 3Rs in all respects under the current constitution and in the coming master law which promotes the 3Rs.

This paper attempts to tease out a sequence of perspectives and ideas of what should be the best research and development (R&D) opportunities for MSW management as the challenges and strategic solution in Thailand. Firstly, what MSW actually means by narrowing its related terminology, then waste composition and generation and how well it is collected and transported as well as the available techniques for treatment and disposal. Furthermore, information about the current situation of the 3Rs and an illustration of Thailand's experiences in MSW case studies to elucidate the tension between existing policies and practices are presented. Finally, ways of effectively accommodating a renewed national policy commitment to MSW management are proposed.

1.1 Definition of Municipal Solid Waste

Municipal solid waste (MSW) in Thai terms means waste generated in daily life from any activity within community. This includes organic waste and recyclable waste but by function of waste practices, MSW within the community includes infectious waste, hazardous waste, waste electrical and electronic equipment (WEEE) and packaging waste. Therefore, the definition of MSW in Thailand involves the meaning of the phrase and a pragmatic function. It can be concluded that municipal solid waste means unwanted materials and/or substances generated in a city or municipal area and the components of which generally include food/organic waste, infectious waste, hazardous waste, WEEE and packaging waste. Clear definitions in Thai law of waste, solid waste, hazardous substance, hazardous waste, infectious waste are as follows:

Waste means refuse, garbage, filth, dirt, wastewater, polluted air, polluting substance or any other hazardous substances which are discharged or originate from point sources of pollution, including residues, sediments or remainders of such matters, either in a solid, liquid or gas state [National Environmental Quality Act, B.E. 2535 (1992)].

Solid waste means used paper, worn out cloth, discarded food, waste commodities, used plastic bag and food container, soot, animal dung or carcasses, including other matters swept from roads, market places, animal farms or other places [Public Health Act, B.E. 2535 (1992)].

Hazardous substance means explosive substances, inflammable substances, oxidizing and peroxiding substances, toxic substances, pathogenic substances, radioactive substances, genetic transforming substances, corrosive substances, irritating substances or other substances, whether chemical or not, which may cause danger to human-beings, animals, plants, property or the environment. [National Environmental Quality Act, B.E. 2535 (1992)].

Hazardous waste means waste that contains or is contaminated with hazardous substances or exhibits hazardous characteristics including being flammable, corrosive, reactive, toxic or having specified constituents [The Notification of Ministry of Industry on Disposal of Waste or Unusable Materials B.E. 2548 (2005)].

Infectious Waste means body parts or carcasses of humans and animals from surgery, autopsies and research; sharps such as needles, blades, syringes, vials, glass ware; discarded materials contaminated with blood, blood components, body fluids from humans or animals, or discarded live and attenuated vaccines and items such as cotton, other cloths and syringes; waste from wards [Regulation of Ministry of Public Health B.E. 2545 (2002)].

1.2 Waste Classification

Waste in Thailand can be generally classified into 3 types as municipal waste, industrial waste and agricultural waste. Alternatively, waste can also be classified based on the source of waste generation, its physical appearance, its harmful tendencies, its utilization and disposal techniques.

Types of waste based on generation sources can be classified into household waste, municipal waste, kitchen waste, agricultural waste, construction waste/debris, institutional waste, industrial waste, hospital waste, laboratory waste, automotive station waste, etc. With the focus on utilization, waste can be classified as organic waste, recycled waste, general waste, and hazardous waste. In order to control solid waste disposal effectively and apply sanitation with technical principals, waste is classified into household hazardous waste, infectious waste and general waste. The difference in waste classification above due to specific functions of agencies involved in MSW management sometimes impedes capacities of management and collaboration.

2 Overview of Municipal Solid Waste

Waste generation is inextricably linked to socio-economic development, urbanization, population density and resource consumption. The greater the economic prosperity, the higher the population density and the greater the amount of waste produced. The composition of MSW is varied and diversified by external factors such as life style, economic conditions, culture, social activities, energy sources, weather, etc. Hoornweg and Thomas (1999) has estimated that in 2025 Thailand will generate waste 1.5 kg/capita/day with its urban population at 39.1 % of the total and a GNP per capita 6,650 Baht (1,995 US$) based on historical waste generation patterns, economic trends, population predictions, and per capita MSW generation. Health risks are associated with MSW due to the combination of hazardous waste and infectious waste within the community. Also, the high density of population in urban areas and improper management of the growth of settlement leads to problems of waste collection and, further, to waste treatment and disposal efficiency.

2.1 Waste Generation and Composition

Municipal solid waste in Thailand produced approximately 41,064 tons/day or 15.03 million tons/year in 2008. Between 1993 and 2008 (based on data from the Pollution Control Department 2004, 2007, 2008, 2009), the amount of MSW rapidly increased annually from 30,640 to 41,064 tons/day or in excess of 30 % and seems continuously to increase (Fig. 1). Although the disposal capacity has doubled (from approximately 7,047 to 15,540 tons/day) within 15 years, it still lags far behind the total waste generated, or in other words, there is not enough sanitary space for the waste collected. On average, the MSW generation rate in Thailand is 0.64 kg/capita/day, while in Bangkok, municipality areas including Pattaya and non-municipality areas have generated MSW at a rate of 1.5, 1.0 and 0.4 kg/capita/day respectively (Pollution Control Department 2009). While in 2001, Japan Bank for International Cooperation (JBIC) estimated that MSW generation rate in Bangkok is 1.3 kg/capita/day, and MSW generation (tons/day) in Bangkok will go from 11,138 in 2007 to 15,607 in 2019 with an increasing trend year by year (Department of Environment 2005, 2008).

The composition of the waste stream and the percentage contributed by each component is shown in Fig. 2 for MSW collected throughout the whole country and in Fig. 3 for MSW collected in the Bangkok metropolitan area.

The whole country's MSW data is dominated by organic waste (64 %), which are compostable organic substances with a high moisture content. Notably, the composition of the waste collected in the Bangkok metropolitan area shows how urbanization and rising income can change the MSW composition. Compared to the country data, Bangkok generates a smaller fraction of food/organic waste but a

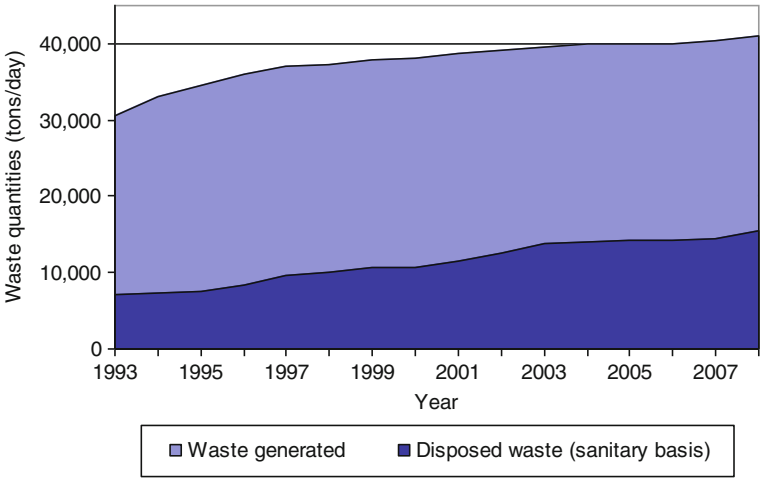

Fig. 1 Trends in municipal solid waste generation and management between 1993 and 2008. *Source* The graph has been prepared based on yearly data from the Pollution Control Department (2004, 2007, 2008, 2009)

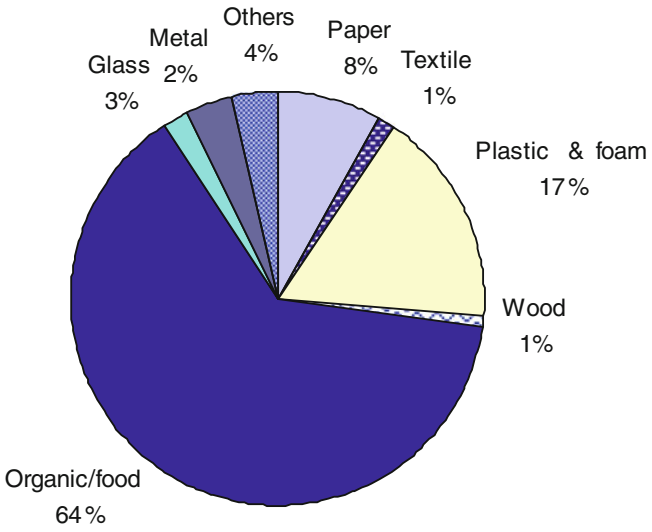

Fig. 2 Composition of municipal solid waste collected throughout the whole country. *Source* Adapted from data of the Pollution Control Department (2004)

larger fraction of packaging wastes like plastic and paper. This demonstrates modern society's demand for convenient purchasing and disposable products attributable in large part to a fast-paced lifestyle.

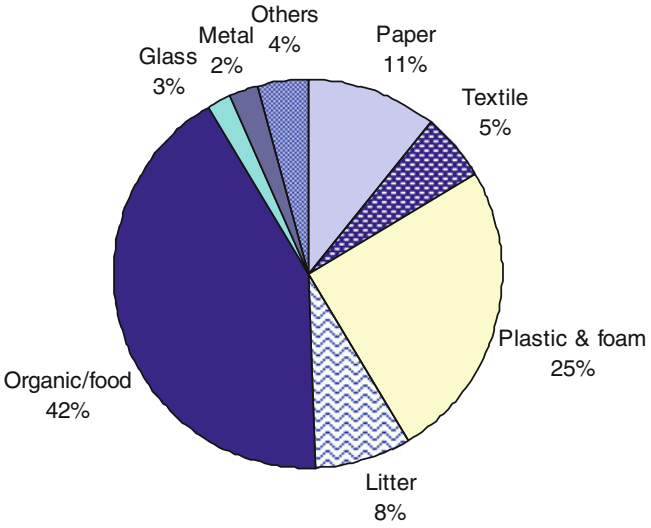

Fig. 3 Composition of municipal solid waste collected in Bangkok in 2008. *Source* The pie chart was prepared based on data from the Strategy and Evaluation Department, BMA (2009)

2.2 Method of Collection and Transportation

Waste is collected directly from households and indirectly via provided containers by truck at a frequency of 2 times/week up to everyday depending on the average waste quantity produced in each area. There are four types of dustbins and bags identified by color and symbol for separating waste e.g. **Green** for food waste, **Yellow** for recyclable waste, **Orange** for hazardous waste, **Blue** for general waste.

The collection and transportation of waste in urban areas is generally better resourced and more efficient than in rural areas. The Bangkok Metropolitan Administration (BMA) directly collects and transports waste generated in the Bangkok metropolis by truck and boat to three transfer stations namely Onnuch, Nong Kham and Saimai. The collection is carried out mainly at night and actual collection hours vary depending upon traffic conditions. Almost 100 % of MSW in Bangkok metropolis is collected. The BMA total expenditure for waste collection was 2,129 million Baht (1 US $\$\sim$34 Baht) in 2003 and almost double in 2007 (4,189 million Baht (Department of Environment 2008). However, collection services in rural areas are not comprehensive leading to improper treatment such as open dumping and burning of waste. At present, an integrated approach for collection, transportation and disposal has been set up as a cluster for local administrations based on waste generation rate, distance from the collection area and technology in order to support the proper segregation for recycling, composting, alternative energy etc. before final sanitary disposal.

2.3 Waste Treatment and Disposal

Waste treatment and disposal in Thailand are still viewed as serious problems due to improper segregation at source and insufficient sanitary landfills. Sanitary principles are lacking in practice during the segregation of waste at treatment and disposal facilities. It is very difficult to establish sanitary landfills because local people protest, even though the suitable landfill sites exist and disposal site selection requires initial environmental examination (IEE). Nevertheless, the technical skills of responsible staff and the maintenance budget for waste treatment and disposal systems are insufficient.

Based on the existing high percentage of its organic components and its moisture content, composting is a basically sound treatment for MSW. The BMA has subcontracted a private company to operate a composting plant situated at Onnuch transfer station with the capacity of 1,000 tons MSW/day and a production as compost 300 tons/day. However, the treatment affected by poor separation of biodegradable waste at source resulted in low-quality organic fertilizers (Department of Environment 2008). In the mean time, the BMA has introduced Takakura Home Composting Method to 33 districts to convert food waste into organic fertilizer. In addition, vermicomposing by earthworms has become a popular alternative for producing organic fertilizer from organic waste throughout the country.

Sanitary landfill is the preferable disposal method in Thailand compared with engineered landfill, controlled dumps, and open dumps. Of the 1,000 disposal sites nationwide, only 119 sites have been constructed to appropriate standards through national government funding. Disposal practices in provincial capitals are mainly engineered landfill (54 %), followed by open dumps (20 %), controlled dumps (17 %), and sanitary landfills (9 %). While sub-district (Tambon) municipalities appear to have open and controlled dumps of up to 92 % (Pollution Control Department 2008).

The incineration of MSW is a costly option that requires less space, saves money with regard to transport and produces neither leachates nor gas, when compared to landfill but there is increasing public health concern regarding the pollutants that are emitted from incomplete combustion. Thailand has had operational experience with a capacity of 140 tons/day and 250 tons/day on Samui Island (Surat Thani province) and Phuket province respectively.

In addition, Thailand through related government agencies and academic institutions, has been conducting the feasibility study of waste to energy technologies, such as **anaerobic digestion**, **gasification** and **refuse-derived fuel (RDF)**, to produce energy from MSW and to look for the possibility of further developing projects under the Clean Development Mechanism (CDM).

As of 2008, there are three waste-to-energy plants with their construction finished and their operating systems approved in Thailand. These are the incineration plant (1.5–2.5 MW) in Phuket province, the MSW landfill gas recovery project in Samutprakarn province (1 MW) and the energy and fertilizer plant (MSW

anaerobic digestion) in Rayong province (625 kW). The other three waste-to-energy plants that are undergoing operation systems tests include an incineration plant (70 kW) in Trat province, a MSW landfill (870 kW) in Nakornpathom province and a MSW elimination centre (950 kW) in Chonburi province. In addition, a RDF project (10 MW) in Chiang mai province is still under construction and a MSW gasification project (50 kW) is still at an experimental stage in Bangkok metropolitan area (DEDE 2009).

3 Reduce, Reuse and Recycle-3Rs

Problems found in waste management systems, among others, include limited areas for landfill, waste disposal costs, the emission of greenhouse gases and dioxins and concern over health and environmental quality, all of which can be solved more easily in combination rather than individually. In 2008, MSW 3.405 million tons (23 % of total) was utilized by recycling (89 %), as bio-fertilizer and biogas (7 %), and alternative energy for electrical generation (4 %) (Pollution Control Department 2009).

The 3Rs campaign was initiated to reduce the waste quantity and reuse plus recycle based on an increasing awareness of the linkage between waste generation and resource consumption. Activities for the 3Rs in Thailand are encouraged through cooperation among various stakeholders to implement effective waste management. The activities are, for example, a recycle-oriented society, community 3Rs activities, resources efficiency, recycled materials and products, source separation and re-utilization, providing incentives for the 3Rs operation, public participation in the 3Rs, in-house segregation, reuse and recycling activities (waste bank, waste donation etc.), safe composting, etc. The recycling business has been informally established in Thailand for decades. Local waste collectors or scavengers using a tricycle known as a "Saleng" roam around town to trade used materials from villager with money or used clothes. The Wongpanit Company is the leader with the concept waste is gold. The company has been operating recycling work since 1974 and has expanded throughout the country with 500 networks and franchise plus international franchises now.

Campaign 3Rs Activity has been promoted nationwide to enhance the effectiveness of MSW management leading to the awareness and participation of Thai people. Campaigns about integrated waste management systems for waste reduction, sorting, reuse and recycling have been constantly promoted through outreach (brochure, booklet, radio, TV spot, forum, conference etc.) towards municipal administrations, government organizations, communities, NGOs, universities and school networks. The examples for campaign activities that sustain the growth towards a sustainable Thai society are as follows:

Magic Eyes was the pioneer campaign in the early 1980s to reduce littering in Bangkok conducted by the Thai Environment and Community Development Association (TECDA). The famous quote is 'Ah! Ah! Don't litter!, The Magic

Eyes watch you!' had a big impact on environmental awareness and the responsibility of individuals to improve environmental quality. With community-based participation and a social marketing approach, this campaign was highly successful in making the corporate partners of government agencies, private companies, schools, the media, communities, and NGOs put their social responsibility into action, at its resulted in a long term effect of redefining behavior and the life style of Thai people.

Green label is an environmental certification awarded to specific products or services, excluding food, drink, and pharmaceuticals. The criteria to get label is that the products or services performed must have a minimum detrimental impact on the environment when compared with others serving the same function. Participation in the Thai green label scheme is on a voluntary basis. As of 2009, there are 231 products (under 18 groups of products) of 43 companies that have been awarded green label certification. The campaign was initiated by the Thailand Business Council for Sustainable Development, Thailand Environment Institute (TEI) since 1993.

Waste Bank is a campaign for handling waste by buying back waste in terms of a deposit like banking system resulting in efficiency in waste segregation. People are stimulated to use each product to its maximum benefit and realize the value of solid waste, so that it can benefit the community by not only providing a clean environment but also cash flow for extra saving. Moreover, students involved in the project have gained through the learning process and the knowledge repertory of waste management and the networks have exchanged both external and internal learning. Each bank is believed to have reduced the waste generated by 3–5 tons per month or a total of 18,000–30,000 tons/year from all banks together. The waste bank was initiated in 1999 in Phitsanulok province by the personnel of the Wongpanit Company who saw poor pupils are selling the recycled waste and depositing the earnings in the bank. In order to help the pupil, waste bank was set up as pilot project in school. Leaflets with a list of prices were distributed leading to the pupils progressively realizing the unexpected value of waste becoming eager to sort the waste and deposit it directly in the waste bank. At present, the waste bank is one of the most popular 3Rs activities in school, universities and the community nationwide.

Used Lead-acid Battery Recycling is a campaign programme to encourage recycling through tax incentives by taking into account the environmental and operational monitoring system. Up to now, 84 % of used lead-acid batteries have been recycling. The campaign initiated in 2000 by the Pollution Control Department.

Tod Pha Pa Recyclable Waste is a campaign to create a momentum for participation in the segregation of reusable solid waste for donation to monks as a Buddhist activities. People have been stimulated and now realize the handling problem of MSW. The activity was started in 2005 at Tesco Lotus in the Bangapi district, where 142 tons of recycled solid waste were donated. On June 4, 2005 alone, on the occasion of the Environmental Day, 164 tons of recycled solid waste were donated throughout all 50 districts in Bangkok Metropolitan Area. All of the

donated waste was sent on to be utilized as recycle products or raw materials for other products at Suan Kaew Temple where unemployed people are trained for careers and which serves as a recycling market. This is one of activities initiated by the Bangkok Metropolitan Administration (BMA) to achieve a 10 % reduction in MSW generation annually.

The outcome of these 3Rs campaigns can be viewed as an illustration of the philosophy of sufficiency economy (see detail in 6.1) and show how the least technically complex can be the most cost-effective solution when small communities participate in MSW management. At the heart of these 3Rs activities is the network established to involve people into the development process. Since the work requires not only coordination with central government and local government agencies but also planning processes jointly devised by meaningful participation of all stakeholders, all of these can certainly be lessons to be learnt by other communities.

4 Local Case Studies on Municipal Solid Waste: Incineration

Phuket and Samui islands are the most popular international tourist destination in the southern part of Thailand. The Phuket incineration plant was constructed in 1995 with a capacity designed to generate 2.5 MW of electricity from MSW 250 tons/day based on a heat value of 1,800–2,500 kcal/kg MSW. However, in reality, the incinerator is overwhelmed by 500 tons MSW/day and it can generate electricity at around 1.6 MW due to the decreasing of heat value down to 1,400–1,500 kcal/kg MSW (Vanapruk et al. 2007). The given reasons are the increased moisture in the waste with a high proportion of food waste and from the addition of rain water due to uncovered-waste bins and substandard collection trucks. The National Human Rights Commission has cited a survey by the Phuket Municipal Authority in 2007, which found that the level of dioxin measured at the province's garbage incineration was higher than it should be (Bangkok Post 2008).

The Samui incinerator was built in 1997 with a capacity of 140 tons MSW/day. At the beginning the island daily generates only about half of the full capacity, and the incinerator is left to rest with maintenance days while waiting for burning period (IPEN 2006). At present, the waste generation rate there already met the full capacity of the incinerator. The impact from the two MSW incineration plants became substantial, mainly because more than half of the waste is incombustible, which impedes the combustion process, and dioxin is generated because of this incomplete combustion. The situation was worsened by having no specific site to manage infectious and toxic waste, which is mixed with household waste.

In 2004, Greenpeace Southeast Asia, according to tests done by CUB Co. Ltd., found a very high concentration of dioxins, a complex mixture of non-chlorinated hydrocarbons and heavy metals (mercury, copper, and chromium) to have been

released from the Samui incinerator. The emission went far beyond the standard set by Ministry of Natural Resources and Environment (IPEN 2006). There were also concerns about the disposal of ash from incinerator which could contaminate ground water supplies.

The successful operation of incineration depends upon several factors other than selecting appropriate technology. To promote incineration as a benign waste management option, appropriate nitrogen dioxide and dioxin removal processes should firstly be provided. In addition, the separation of waste according to its heating value and moisture content and burning with suitable proportion should improve the combustion and reduce the use of fuel. Thus, a high-quality of MSW incinerator can facilitate the electricity production and can also be considered a complement to conventional power production.

5 Current Policies for Municipal Solid Waste Management

5.1 Legal Framework

The Constitution of the Kingdom of Thailand B.E. 2550 (2007**)** advanced environmental management and provisions affirming the public right to access information (Section 56) and to participate in the prevention and alleviation of public hazards, protecting and passing on the national conservation of natural resources and the environment (Section 73). For the planning of any project or policy that might cause a serious impact on the quality of the environment, on natural resources, and on the health of the people, comprehensive public hearings before implementation must be held before they are initiated (Section 67). The State shall promote and lend support to research and development and make use of alternative energy that is naturally acquired and advantageous to the environment (Section 86). Local governmental organizations have powers and duties in connection with the promotion and maintenance of the quality of the environment (Section 290) and must report its work to the people to enable them to participate in monitoring its administration and management (Section 287).

While the draft master law for the promotion of waste reduction, reuse and recycling is in the enactment process (Pollution Control Department 2009), MSW management in Thailand has been under the followings existing laws and regulations:

Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992) is the fundamental environmental law governing environmental standards, including planning, and monitoring environmental quality and establishing a system for environmental Impact Assessment (EIA).

The Public Health Act B.E. 2535 (1992) provides a legal role for local administration to manage MSW by issuing and setting ordinances or regulation to

control and protect environmental sanitation and covers collection, transportation and the disposal of waste. This is the most comprehensive law dealing with MSW.

The National Health Act B.E. 2550 (2007) specifies that state agencies have the duty promptly to reveal and provide data and information to the public, and individuals shall have the duty to cooperate with state agencies in creating a good environment.

The Hazardous Substance Act B.E. 2535 (1992) provides a legal basis to control the import, export, manufacturing, storage, transport and disposal of hazardous substances. The Act governs the methods of managing hazardous materials, hazardous waste and infectious waste.

In addition, other regulations which are partly related to solid waste management are the Public Cleansing Act B.E. 2535 (1992), Determining Plans and Process of Decentralization to Local Government Organization Act B.E. 2542 (1999), the Industrial Estate Authority of Thailand Act B.E. 2522 (1979), the Factory Act B.E. 2535 (1992), the Land Transportation Act B.E. 2522 (1979), the Industrial Products Standards B.E. 2511 (1968), the Petrol Act B.E. 2521 (1978), the Land Traffic Act B.E. 2535 (1992), the Highway Act B.E. 2535 (1992), the Building Control Act B.E. 2522 (1979) and B.E. 2535 (1992), and the Official Information Act B.E 2540 (1997).

5.2 National Policy

The national policy and plan of the Thai government regarding the waste aspect, will be to implement an environmental-friendly waste disposal system, enhance the waste disposal capacity of local administrative authorities, and promote the role of the private sector in research and development for recycling of raw materials and clean technology. Moreover, the government will not allow any area of Thailand to become an end receiver of waste, which has to bear the costs of waste and pollution. The National integrated waste management plan has been focused on the sustainable consumption of natural resources and the application of the 'cradle to cradle' concept, including control waste generation at source, increased waste segregation and the enhanced efficiency of waste utilization prior to final disposal. The target for waste minimization is 30 % of the total waste generated within 2009. The concept of the Polluter Pay Principle (PPP) is used to encourage responsibility in producers, importers, and consumers. The 3Rs is promoted as a vital tool for environmentally sound management. The life cycle approach is also integrated in waste management plan to minimize the large volume of packaging waste (Thongkaimook 2006).

The Pollution Prevention and Mitigation Policy 1997–2016 aimed to (1) reduce or control solid waste generation to a rate of not more than 1.0 kg/capita/day (2) have Bangkok and communities throughout the country utilize waste of not less than 15 % of the total solid waste generated (3) all solid waste left from collection in municipal districts was to be collected, and for outside municipal districts not

more than 10 % of total solid waste was to be left, and (4) ensure that each province has a master plan for sanitary solid waste disposal (Pollution Control Department 2009).

The Environmental Management Plan 2007–2011 was formulated to create a balance between the use for development and the need to preserve, conserve and rehabilitate natural and environmental resources at their optimum level, consistent with the carrying capacity of ecosystems and rising life standards of people. The goal is that people can participate and receive benefits from the sustainable maintenance of natural resources and the environment. This plan also promoted solid and hazardous waste management to attain Thailand as the Asian tourism hub as well as the world's kitchen (ONEP 2009).

The fast growing of MSW management seems to urge the private sector to provide services in collection, transportation and disposal at policy level. However, it should be noted that **privatization (public sector involvement) for MSW** management requires not only a proper legal framework according to the State Enterprise Capital Act B.E. 2542 (1999) and matched investment cost and capacity, but also the transparence of the central and local government sectors when employing private sector.

6 Future Development of Municipal Solid Waste Management

6.1 Philosophical Concept of Sustainable Development

His Majesty the King Bhumibol Adulyadej of Thailand graciously conferred the philosophy of **sufficiency economy** based on Buddhist principles of self-reliance, self-satisfaction and the middle path on the entire nation in 1997. (www.sufficiencyeconomy.org) The philosophy has been incorporated into the Thai National Economic and Social Development Plan since 2002 as it is trusted to lead the nation to balanced development in a more secure way and it will lead to a more resilient and sustainable economy, better able to meet the challenges arising from globalization and other changes, while preserving Thai national identity. The philosophy guides and conducts the livelihoods and behavior of people at all levels, from the family to the community and to the country, on matters concerning national development and governance. Well-being is focused upon rather than wealth based on understanding the requirement for basic human need and security, strengthening capability building to develop to is highest potential, providing effective self-immune mechanisms as safeguards for all changes, and including perseverance, wisdom, prudence, honesty and integrity in one's life style. The fundamental basis for sustainable development in the Thai context lies in the philosophy of sufficiency economy.

Being sufficient means that, whatever we produce, we must have enough for our own use. We do not have to borrow from other people. We can rely on ourselves, having enough and being satisfied with our situation. The characteristics of sufficiency included moderation, reasonableness and effective self-immunity. All plans and every step of implementation should be ensured by intelligence, attentiveness, knowledge, extreme care, the common interest, the public benefit and keep abreast of ethics and moral. The approach is to maintain balance and be ready to cope with surrounding rapid physical, social, and environmental changes. The concept is applicable to every person in every profession, living in both urban and rural areas, and thereby to the 3Rs campaign and the integrated management of municipal solid waste to meet the country sustainable development.

6.2 Research and Development Opportunities for Municipal Solid Waste Management

One of the most challenging issues is how to utilize waste as raw material while including the 3Rs properly and safely for the people, the environment and the quality control of manufacture. As a result the opportunities to involve the business community in 3Rs enterprises are growing following the increasing awareness and realizable the value of waste connected with natural resources and environmental quality. In addition, MSW management should also expand opportunity on CDM and waste to energy technology to serve climate change mitigation perspectives.

The next question is how to utilize management technology to ascertain sustainable development without knowing first what good for us. Many severe effects on human health and environmental quality have resulted from the mismanagement of MSW and the lack of source separation indicates that the implementations of the regulatory procedures (pollution control standards, waste collection fees, etc.) in Thailand have failed to bond MSW management with institutional functionality and have affected environment together.

To identify the most practicable technology for targeting communities from various sources of knowledge through the transfer of the proven technology, an investment should be made in R&D at an initial stage in order to assure the suitability for the country contexts, and this can be developed into cost-effectiveness, socially acceptance, and environmental sound business practice in the long-term perspective (Fig. 4). Consequently, to enable prompt action for the transferring of the proven technology to target communities, R&D study is also required at every stage when developing specific laws, regulations and guidelines, sanitary standards as well as applying the technology into pragmatic work of MSW management. This must be conducted based on the Thai environment, the carrying capacity of the target area, the knowledge base, local wisdom, behavior, attitude and life style in conjunction with culture and politics.

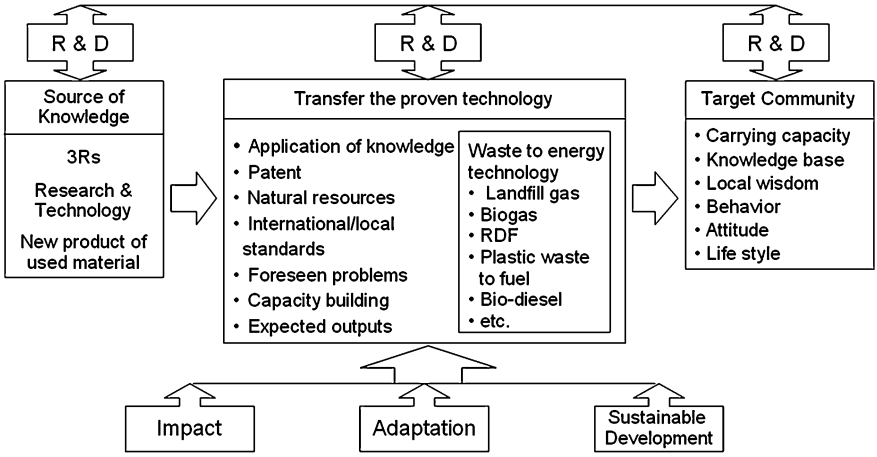

Fig. 4 Conceptual framework for R&D applied to municipal solid waste management (Siriratpiriya 2007)

The applying of the "**Polluter Pay Principle**" to make waste collection and disposal fees closer to waste generation rates is suggested at policy level **for both the public and government**. In this regard, further R&D study is required for setting up criteria to identify different stakeholders in order to resolve the disparity between residential and non-residential sources. The business community has great potential for direct user charges which will allow commercial, institutional and industrial waste for self-financing. The general community must also actively participate in the solutions by modifying their behavior. For instance, there is a need to exert discipline in separating waste and exercising environmentally friendly purchasing habits. However, proper waste services and capacity building to develop an attitude for proper MSW management and social values reinforcement are needed for communities that consist of the poor and minorities.

MSW management in Thailand is going in the direction of sustainable development through an integrated waste management system, including the minimization of the production of waste and the maximizing of the waste recycling and reuse. The things to overcome include efficiency of segregation at sources, excluding infectious waste and hazardous waste from general waste in addition to collection, transportation, treatment and disposal.

Prerequisite factors to be considered for R&D applied to MSW management are proposed in Fig. 5. These are a holistic approach suited to any process designed for production, transportation, segregation, collection and disposal of waste mainly including options for waste management and interaction with human heath and environmental risks, public education, technology, research and collaboration, etc. In addition, more locally suitable technologies are needed for recycling agricultural and household waste to bioenergy as well as for reducing greenhouse gas emissions from waste.

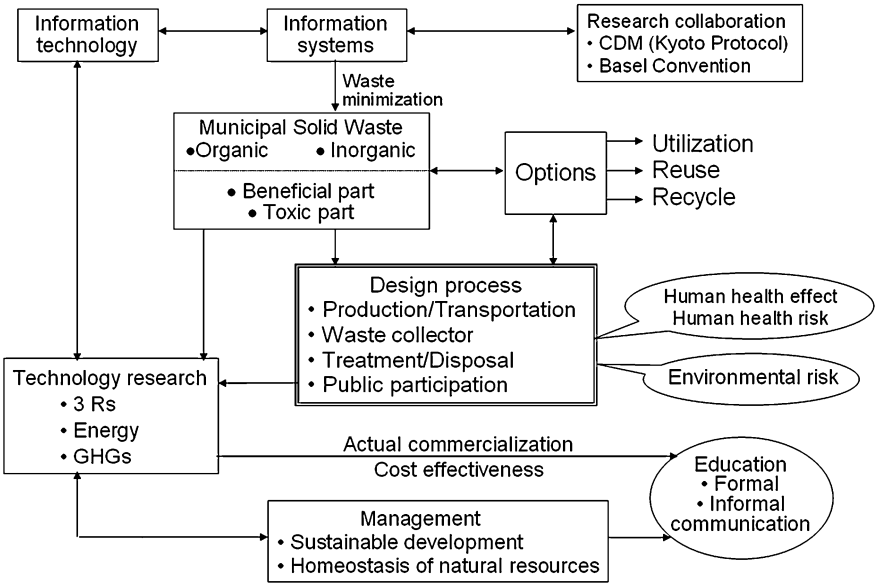

Fig. 5 Prerequisite considerations for research and development (R&D) applied to municipal solid waste management (adapted from Siriratpiriya 2005)

The **Pollution Prevention and Mitigation policy 1997–2016** reflected the **current status of MSW management in Thailand**, particularly waste segregation and household hazardous waste that obstruct the waste to be utilized downstream as well as solid waste disposal site under pollution control standards. This implied the urgent need to put strategies into practices for all types of waste beginning with urban community. In addition to specific policies and regulations as well as financing mechanisms, successful MSW management requires cooperation from local government and other levels of government, business and the general community because there is no strategy that will work if people do not feel it necessary to engage with one another on the follow-up activities.

Significantly, one prerequisite factor that is not yet clearly seen from the policy but should be seriously emphasized is the need to have **public participation in MSW management** in the real sense. Although the rights to public participation are already guaranteed by the current constitution, there is still a lack of clear measures to promote public participation towards the society. From the national assessment of environmental governance (Nicro and Vassanadumrongdee 2007), people are still unable to participate at the level of decision-making, operations, monitoring and implementation. It is crucial to note that most public hearings are held after some major decision has already been taken. In addition, there is no clear evidence to show that opinions and recommendations acquired from public hearings have been used in the decisions made by government and state agencies.

Public participation in MSW management related to policy and planning processes is still limited due to lack of skilful resources and tools to put it into effect. The meaningful inclusion of public participation needs more details of the significant stakeholders to be involved, employed knowledge, actual procedures, collaboration and coordination among government agencies, and the serious development of approaches for public relation (PR) to build up people's trust in the state administration of MSW management.

Last but not least, national policy must also target the **provinces to prepare suitable land for the long-term disposal of solid waste**. Constructing waste disposal facilities such as landfills and incinerators causes arguments about environmental and health impact and often generates most of public concern. Involving the community and following a technically sound and transparent site selection process are suggested to be the best way to minimize public opposition to new facilities (Hoornweg and Thomas 1999). However, this paradigm still contradicts what happens with public participation in reality. The general public is entitled to participate only at the information and the consultative levels, whereas only the authorized decision-makers of the representative from all the stakeholders participate at the partnership level. The barrier factors mainly include the culture of political and institutional dominance in decision making, the need for more specific legislation and guidelines for MSW related issues, clarifying procedures and the continuity of measures, and the pragmatic mechanism of effective management. Hence, to build up public trust, **public participation should be taken into account from the beginning of the project** and prior to decision-making on land use as well as into the monitoring programme of the disposal facility (interval time within 25 years of operation) to prevent the dispersion of pollution.

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