เอกสารแนบ 6

รายงานการวิจัยทางการตลาดแบบอิสระ เพื่อการเสนอขายหุ้นสามัญเพิ่มทุนต่อประชาชนเป็นครั้งแรก (IPO)

สำหรับบริษัทฯ โดย AWR Lloyd Limited

Independent Market Research Report for Initial Public Offering (IPO)

Prepared for TPI Polene Power Company Limited

Interim IMR, May 4, 2016

AWR Lloyd

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AWR Lloyd Limited
1403 West Tower
Shun Tak Center 14th Floor
168 Connaught Rd
Central Hong Kong
T: +66 2 685 383
F: +66 2 654 351
E: inquiries@awrlloyd.com
W: www.awrlloyd.com

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List of Acronyms

AEDP	Alternative Energy Development Plan
ASEAN	Association of Southeast Asian Nations
BMA	Bangkok Metropolitan Administration
CAGR	Compound Annual Growth Rate
CHP	Combined Heat and Power
COD	Commercial Operation Date
DEDE	Department of Alternative Energy Development and Efficiency
DIW	Department of Industrial Works
EEDP	Energy Efficiency Development Plan
EGAT	Electricity Generating Authority of Thailand
EPPO	Energy Policy and Planning Office
ERC	Energy Regulatory Commission
ESB	Enhanced Single Buyer
FIT	Feed-in Tariff
Ft	Fuel Adjustment Mechanism
GDP	Gross Domestic Product
IMF	International Monetary Fund
IPP	Independent Power Producer
LHV	Lower Heating Value
LNG	Liquefied Natural Gas
MEA	Metropolitan Electricity Authority
MoE	Ministry of Energy
MSW	Municipal Solid Waste
MT	Metric tonnes
NEPC	National Energy Policy Council
NESDB	National Economic and Social Development Board
OECD	Organisation for Economic Cooperation and Development
PAO	Provincial Administration Organization
PCD	Pollution Control Department
PDP	Power Development Plan
PEA	Provincial Electricity Authority
PPA	Power Purchase Agreement
RDF	Refuse Derived Fuel
RE	Renewable Energy
SPP	Small Power Producer
SWM	Solid Waste Management
TAO	Tambol Administration Organization
THB	Thai Baht
TPIPP	TPI Polene Power Co Ltd
VSPP	Very Small Power Producer
WB	World Bank
WHR	Waste Heat Recovery
WTE	Waste to Energy

Section 1. Introduction

AWR Lloyd was engaged by TPI Polene Power Company Limited (TPIPP) as market consultant to prepare an Independent Market Research Report to support the initial public offering (IPO) of TPIPP. This Report was prepared in an independent and objective manner to present a true and fair view of the electricity sectors and waste to energy (WTE) where TPIPP operates. The research was undertaken with a major focus on the electricity and WTE sectors in Thailand where TPIPP is most dominant, but also covers the main developments in related sectors.

This Report is structured as follows:

- Section 2 outlines the macroeconomic fundamentals in Thailand serving as a basis for the analysis of the Thai electricity demand growth.
- Section 3 provides an overview of the Thai electricity sector while examining its organization and structure in light of the recently updated Power Development Plan.
- Section 4 analyzes the main electricity consumption trends in Thailand, and presents an outlook for the development of electricity demand in Thailand to 2036.
- Section 5 focuses on Thailand's power supply, investigating installed capacity mix and power generation trends, and presents an outlook for the future generation mix.
- Section 6 examines the Small Power Producer (SPP) generation sector.
- Section 7 reviews the retail of petrol and gas in Thailand.
- Section 8 summarizes the development of the renewables sector in Thailand and addresses key issues concerning the growth of renewables, including regulatory framework and pricing structure, sector growth prospects and outlook.
- Section 9 outlines global issues and practices in solid waste management and discusses international developments in Waste to Energy (WTE) and Refuse Derived Fuel (RDF).
- Section 10 provides an overview of the Thai waste management sector, including collection and disposal, waste characteristics, and applicable policies and regulations.
- Section 11 analyzes development and trends of WTE and RDF in Thailand and discusses the main players in the sector.
- Section 12 presents an outlook of the Thai WTE sector and discusses opportunities and challenges for TPIPP.

Section 2. Thailand Macroeconomic Overview

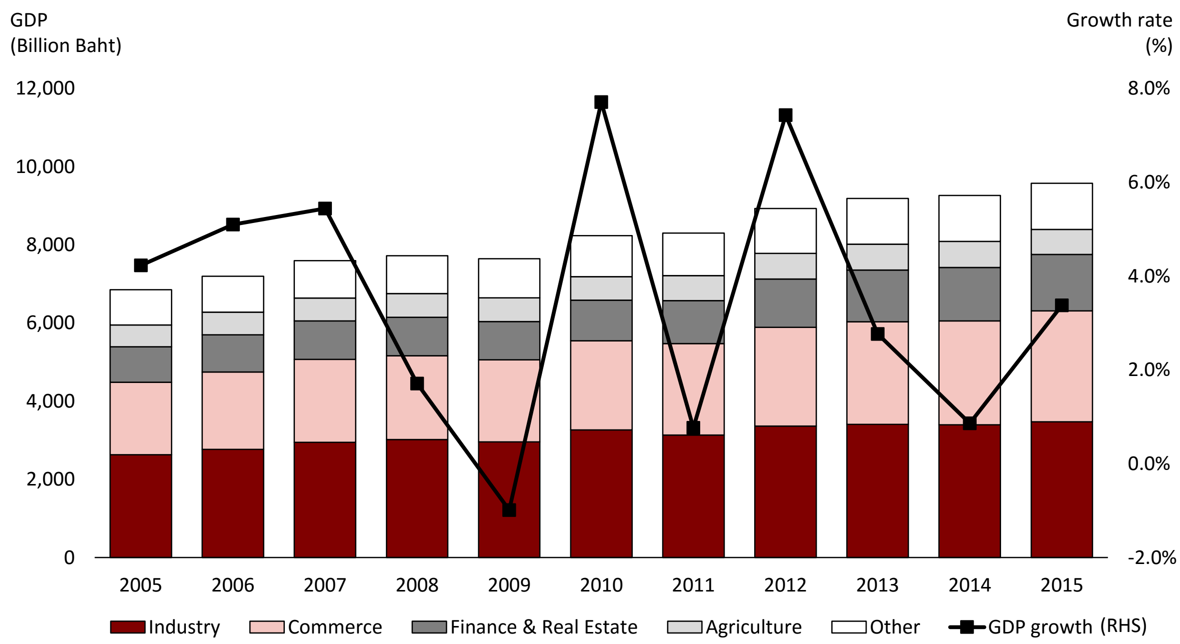
Thailand is the second largest economy in the Association of Southeast Asian Nations (ASEAN). Over the last four decades, Thailand has made significant progress in social and economic issues, experiencing sustained strong growth and impressive poverty reduction, particularly in the 1980s and early 90s. The country attained upper middle-income status according to the World Bank classification in 2011, and aspires to reach higher-income status within the next two decades.

The World Bank estimates that since the 1997 financial crisis, the economy has grown at a moderate rate of less than 4% annually. This moderate growth reflects a combination of some decline in export competitiveness as compared to newly emerging regional economies, a shortage of skilled labor and knowledge workers required for a modern knowledge economy, and political changes and uncertainty that have affected public and private investment. More recently, Thailand's economy expanded by a low 0.9 percent in 2014.

According to statistics from the National Economic and Social Development Board (NESDB), economic growth has largely been driven by industry and commerce. In 2015 these accounted for 36.3% and 29.7% of GDP respectively, while the finance and real estate contributed 15.1%. Agriculture had a minor contribution to the country's economy at 6.7% of total GDP. Remaining sectors, including public administration and defense accounted for 12.3%.

EXHIBIT 2-1

GDP by Sector and Growth Rate (2005-2015)



Source: NESDB

In its economic report from February 2016, NESDB forecasts 2.8-3.8% economic growth in 2016, driven by (i) the acceleration of government expenditure and public investment; (ii) contribution from economic stimulus measures rolled out during September 2015 – January 2016; (iii) depreciation of the Thai baht which will enhance income and liquidity for exporters and producers; (iv) low oil price which will accommodate economic recovery; and (v) the continued expansion of the tourism sector.

Nevertheless, the slowdown of the Chinese economy, the depreciation of the RMB and currencies of Thailand's main trading partners and competitors, as well as the impact of a prolonged drought in Thailand will remain as constraints and risks for economic recovery.

EXHIBIT 2-2

Asian Real GDP Growth Rates (2012-2016F)

(YoY percent change)	2012	2013	2014	2015F	2016F
Asia	5.7	5.8	5.6	5.4	5.4
China	7.7	7.7	7.3	6.8	6.3
India	5.1	6.9	7.3	7.3	7.5
Japan	1.7	1.6	-0.1	0.6	1.0
ASEAN	**6.0**	**5.2**	**4.6**	**4.6**	**5.0**
Indonesia	6.0	5.6	5.0	4.7	5.1
Malaysia	5.5	4.7	6.0	4.7	4.5
Myanmar	7.3	8.4	8.5	8.5	8.4
Philippines	6.7	7.1	6.1	6.0	6.3
Singapore	3.4	4.4	2.9	2.2	2.9
Thailand	**7.3**	**2.8**	**0.9**	**2.5**	**3.2**
Vietnam	5.2	5.4	6.0	6.5	6.4

Source: IMF

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Section 3. Thailand Power Generation Industry Overview

Thailand's power sector has long been regarded as secure and predictable. Relative to other developing countries in the region the sector is well regulated, has a strong regime for Power Purchase Agreements (PPA), and a proven ability to transact power assets. This is shown by the active participation of the private sector in power generation investment by both domestic and foreign investors. The country has a substantial track record of recent transactions, particularly in the renewable energy sector.

3.1 Value Chain and Segmentation

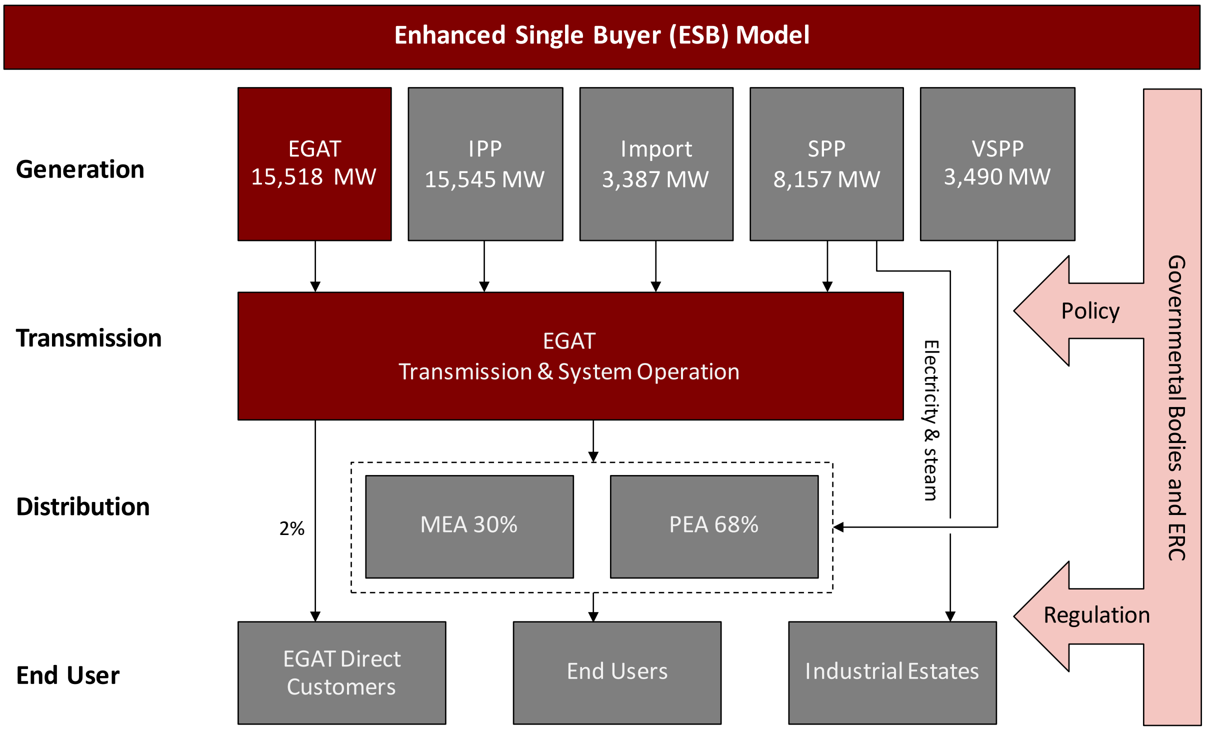
The Thai electricity sector is dominated regulated by the state-owned Electricity Generating Authority of Thailand (EGAT), responsible for power generation, transmission, and wholesale electricity sales. EGAT owns and operates power plants, mainly coal, natural gas and large hydro plants. Under the Enhanced Single Buyer (ESB) model, EGAT generates electricity from its own power plants and purchases bulk electricity from private power producers and neighboring countries. It sells wholesale electric energy to distribution utilities and a small number of direct industrial customers, as well as neighboring utilities.

Two state-owned utilities are responsible for the distribution of electricity to end-users. The Metropolitan Electricity Authority (MEA) services Bangkok and two neighboring provinces (Nonthaburi and Samut Prakan), while the Provincial Electricity Authority (PEA) serves the rest of the country.

The Energy Regulatory Commission (ERC) was established under the Energy Industry Act B.E. 2550 (2007) having the primary function and duties to oversee the regulations in relation to the electricity procurement and the issuance of Requests for Proposals for the purchase of electricity as well as monitor the selection procedures to ensure fairness for all parties, including provide opinions on the power development plan, the investment plan of the electricity industry, the natural gas procurement plan, and the energy network system expansion plan.

EXHIBIT 3-1

Thailand Electricity Industry Structure (March 2016)



Source: EGAT, Ministry of Energy

The Thai government has initiated private sector power programs to attract private capital to meet growth in demand for power generation and to enhance the efficiency of the electricity market. Since the early 1990s three programs have been introduced to allow for private sector participation within the power sector:

- Independent Power Producer (IPP): The IPP program was designed for large-scale power development, and was led off with a highly competitive public tender in 1994. There have been three IPP bidding rounds so far which collectively awarded 15.5 GW of generation capacity as of March 2016. IPPs run on natural gas or coal and sell their entire output to EGAT.
- Small Power Producer (SPP): Launched for smaller developments, the SPP program allows developers to propose projects with capacity sales up to 90 MW to EGAT. Any additional capacity can either be used "inside the fence" or sold to nearby industries. As of March 2016 8.2 GW of generation capacity has been installed under the program. SPP plants employ co-generation or renewable energy technologies (see Section 6).
- Very Small Power Producer (VSPP): Launched in 2002, the VSPP program allows small-scale renewable energy projects up to 10 MW to connect to the grid and sell electricity directly to MEA and PEA. The cap was initially set at 1 MW and was increased to 10 MW in 2006. To date, 3.5 GW of generation capacity, including the use of biomass, solar, wind, biogas and waste has been installed under the program.

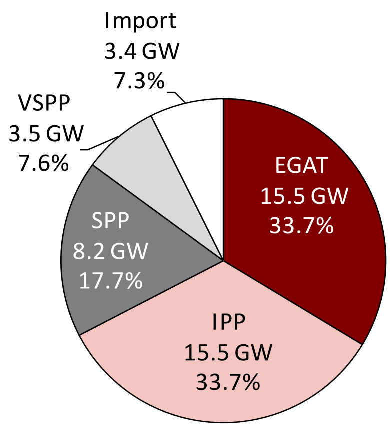
Despite the private sector programs EGAT continues to lead the generation sector, with a market share of 33.7%, followed by IPPs (33.7%), SPPs (17.7%), VSPPs (7.6%) and imports from neighboring countries (7.3%) in March 2016.

Both IPPs and SPPs have long-term PPAs with EGAT as the single buyer (typically 20 or 25 years). The PPAs allocate the risk of fuel prices to EGAT (and its captive ratepayers), leaving SPPs and IPPs to manage the operating risks. As direct steam sales by SPPs to their industrial customers do not have a price adjustment mechanism, the SPPs take on the fuel price risk.

Under government regulations, all power injected into the national transmission grid, whether by private power producers, other government agencies or producers in neighboring countries, must be sold to EGAT. The only exception is the VSPPs that can sell directly to the distribution utilities, but the sale is capped at 10 MW. EGAT thus is the primary entity that sells wholesale energy to the distribution sector. Onsite power generation where the power is used at industrial sites is not subject to this restriction.

EXHIBIT 3-2

Generating Capacity by Power Producer Type (March 2016)



Source: EGAT, ERC

Except for electricity distribution within industrial estates, private participation exists only in the generation of electricity while the Thai government retains ownership and control over rest of the value chain.

3.2 Regulatory Framework

Thailand's energy policies, including electric power and renewable energy policies, are drafted and proposed by the Ministry of Energy (MoE). The National Energy Policy Council (NEPC), chaired by the Prime Minister, has the final authority to review and approves the plans.

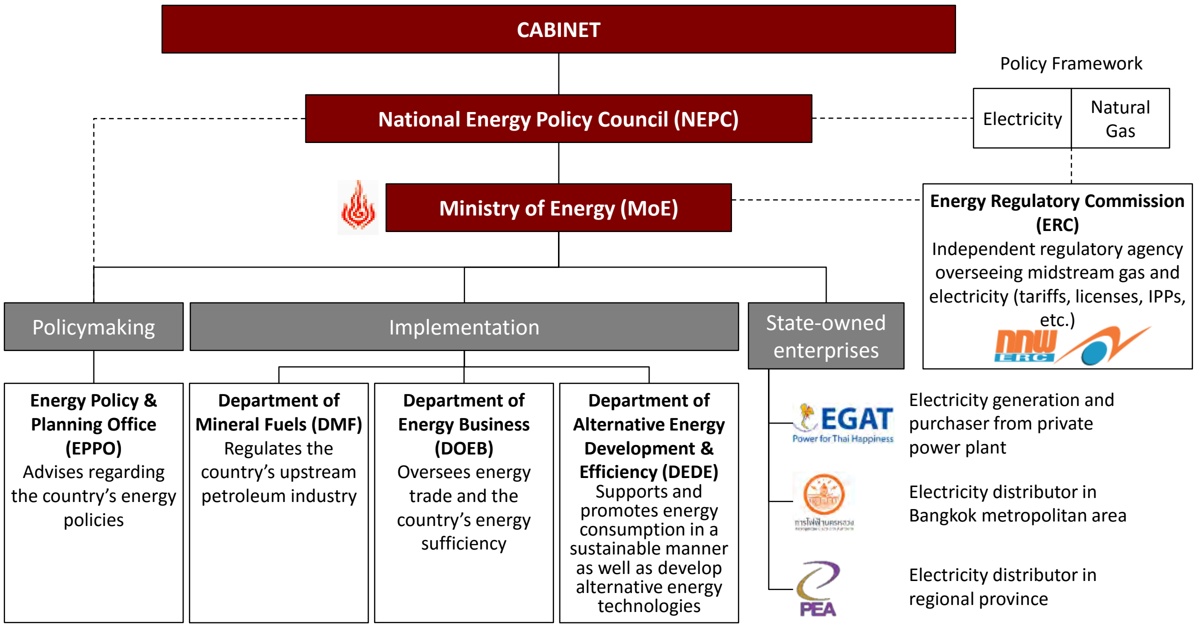
MoE is also responsible for the management of Thailand's Oil Fund, which regulates and, in effect, subsidizes retail and wholesale petroleum product prices. MoE oversees a number of agencies that are responsible for implementing energy policies and programs:

- Energy Policy and Planning Office (EPPO): implementation arm of the NEPC, is responsible for developing energy policies, measures, and plans for the oil, natural gas and power sectors.
- Department of Mineral Fuels (DMF): regulates the upstream sector of Thailand's hydrocarbons and is responsible for promoting oil and gas exploration and development including licensing rounds.
- Department of Energy Business (DOEB): monitors and supervises the trade, quality, industrial safety, environmental concerns and security of fuels.

- Department of Alternative Energy Development and Efficiency (DEDE): main implementing agency for compulsory and voluntary energy efficiency (EE) and renewable energy (RE) programs, including EE promotion, energy conservation regulation, development of alternative energy, and dissemination of energy technologies.

EXHIBIT 3-3

Institutional Framework of the Thai Energy Sector



Source: MoE

The following are the main laws governing the electricity sector:

- National Energy Policy Council Act (1992): established the National Energy Policy Council (NEPC) and its office (National Energy Policy Office or NEPO, subsequently renamed as Energy Policy and Planning Office or EPPO), with duties to prepare national energy plans and policies.
- Energy Industry Act (2007): established the Energy Regulatory Commission (ERC) and its office with duties to provide regulatory supervision on the operation of the electricity and natural gas industries, including related interconnection networks.
- Energy Conservation and Promotion Act (ENCON, 1992): instrumental in promoting energy efficiency and renewable energy measures, it obligates large factories and buildings to conduct energy audits and prepare energy conservation plans. The act also established the Energy Conservation Promotion Fund (ENCON Fund), which supports EE and RE programs.

3.3 Electricity Tariffs

Different tariff structures apply to different generator categories (IPP, SPP and VSPP). The type of contract (firm or non-firm) and energy source (conventional vs. renewable) determines the applicable tariff structure.

Thailand distinguishes between bulk (or wholesale) tariffs and retail end-user tariffs. Both are based on EGAT's marginal costs of generation and transmission and are regulated by ERC.

Although it does appear that the Thai government has considered differential FTs for different consumer classes, to date this has not been implemented and the actual charge has been identical.

3.3.1 Wholesale Tariff

The Bulk Supply Tariff Structure comprises generation and transmission costs. Voltage levels and time of consumption determine the applicable tariff structure. EGAT charges the bulk tariff to MEA and PEA and its direct customers.

EXHIBIT 3-4

Bulk Supply Tariff Structure (July 2011, November 2015)

Voltage Level	July 2011		November 2015	
	Peak THB/kWh	Off-Peak THB/kWh	Peak THB/kWh	Off-Peak THB/kWh
230 kV	3.0227	2.0173	3.3922	2.3316
69 – 115 kV	3.2504	2.0198	3.6199	2.3341
End of the line 69 – 115 kV	3.6781	2.0412	4.0476	2.3555
11 – 33 kV	3.8548	2.0424	4.2243	2.3567

Source: EGAT

3.3.2 Retail Tariffs

The Retail Tariff Structure comprises two parts:

- The Base Tariff reflects the marginal cost of the utilities to construct and operate power plants, transmission lines and distribution lines, including fuel costs. The distribution utilities charge different base tariffs for different consumer categories and consumption levels.
- The Fuel Adjustment Mechanism (Ft) is a mechanism for adjusting the power tariff so that it reflects the actual fuel cost for power generation at a given period of time. The Ft surcharge is revised every 4 months, to account for changes in EGAT's fuel costs, power purchase costs and the impact of policy measures set by the government, which include the Power Development Fund, and subsidies for renewable energy generation. In January 2016 ERC reduced the Ft surcharge for January-April 2016 by 0.0157 Baht/kWh to -0.048 Baht/kWh, due to a reduction in fuel prices.

EXHIBIT 3-5
Trend of Ft Charge (2011-2016)

Period	Ft (THB/kWh)
Jan – Apr 2016	-0.0480
Nov – Dec 2015	-0.0323
Sep – Oct 2015	0.4638
May – Aug 2015	0.4961
Jan – Apr 2015	0.5896
Oct – Dec 2014	0.6900
May – Aug 2014	0.6900
Jan – Apr 2014	0.5900
Sep – Dec 2013	0.5400
May – Aug 2013	0.4692
Jan – Apr 2013	0.5204
Sep – Dec 2012	0.4800
Jun – Aug 2012	0.3000
May 2012	0.0000
Jan – Apr 2012	0.0000
Sep – Dec 2011	-0.0600
Jul – Aug 2011	-0.0600

Source: ERC

The structure of retail electricity tariffs varies depending on end-user type, as well as consumption and capacity levels. Ft charges have been uniformly charged to all users with no variation. We do understand that the Thai government has made provisions for differential Ft charges for retail and wholesale consumers, but that this has never been applied. We do not see this changing in the near-term.

EXHIBIT 3-6
Electricity Consumer Categories

Consumer Category	Energy Consumption	Demand Consumption
(1) Residential	≤150 kWh >150 kWh	n/a
(2) Small general services	n/a	< 30 kW
(3) Medium general services	< 250,000 kWh/month	30-999 kW
(4) Large general services	> 250,000 kWh/month	> 1,000 kW
(5) Specific business service	n/a	> 30 kW
(6) Non-profit organization	< 250,000 kWh/month	< 1,000 kW
(7) Water pumping for agriculture	n/a	n/a

Source: ERC

3.4 Power Development Plan (PDP)

In June 2015, the Thai government approved a new Power Development Plan (PDP), called "Thailand Power Development Plan 2015-2036 (PDP2015)", with an outlook towards 2036. This is the first new PDP since 2010, incorporating the significant growth of renewables since 2005. Future plans for RE are detailed in the Alternative Energy Development Plan (AEDP), which is discussed in more detail in Section 8.

The PDP2015 is based on three pillars:

- Energy security: dealing with an increase in power demand taking into account fuel diversification in order to lessen dependency on one particular fuel
- Economy: maintaining an appropriate cost of power generation and implementing energy efficiency policies and measures
- Ecology: reducing environmental and social impacts by lessening carbon dioxide intensity of power generation

The PDP2015 emphasizes power system reliability by reducing dependence on natural gas power generation, increasing the share of coal power generation via clean coal technology, importing power from neighboring countries, and developing renewable energy. In addition, the plan targets transmission and distribution system development to support renewable energy development and ASEAN power grid integration.

More specifically, the PDP aims to achieve the following targets by 2036:

- Reduce dependence on natural gas for power generation, from 64% in 2014 to 30-40%
- Increase the share of RE in the total power mix from 8% in 2014 to 15-20%, with capacity reaching 20 GW
- Increase the share of coal and lignite from 20% to 20-25%, with an unspecified amount to be delivered as 'clean coal' by carbon capture and storage technology

- Increase the share of imported hydro power from neighboring countries from 7% to 15-20%
- Introduce nuclear power and achieve up to 5% market share

The PDP2015 does not specify new bidding rounds for IPPs and SPPs but remains committed to existing PPAs, and specifies criteria for the extension of PPAs with firm cogeneration SPPs that will expire during 2017-2025. Most new RE capacity is forecasted to be added under the VSPP program, with an average increase of 350 MW per year up to 2036.

EXHIBIT 3-7

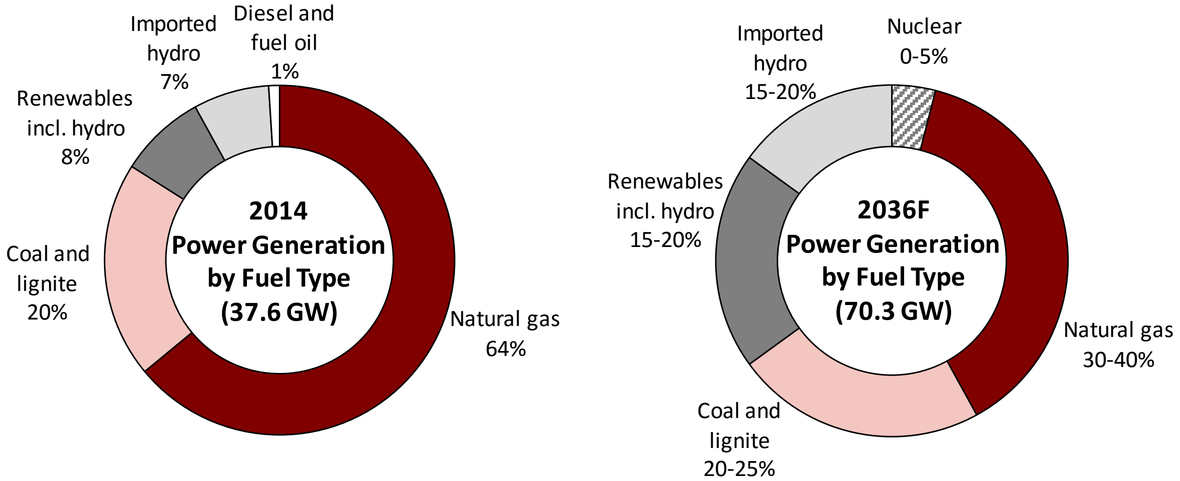
Target Share of Power Generation by Fuel Type

Fuel type	Share in 2014	Share in 2026	Share in 2036
Imported hydro power	7%	10-15%	15-20%
Clean coal including lignite	20%	20-25%	20-25%
Renewables including hydro power	8%	10-20%	15-20%
Natural gas	64%	45-50%	30-40%
Nuclear	-	-	0-5%
Diesel/Fuel oil	1%	-	-

Source: PDP2015

EXHIBIT 3-8

Power Generation by Fuel Type (2014 actual and 2036 forecast)



Source: PDP2015

3.5 Coal Demand and Outlook

Coal and lignite is used in Thailand for power generation and industrial processes. According to EPPO statistics, in 2014 total consumption was 17,897 ktoe, consisting of domestic lignite (27.2%) and imported hard coal (72.8%), which refers to sub-bituminous coal, bituminous coal and anthracite. Lignite is a form of low-grade coal coming from two major sources - mines belonging to EGAT and mines belonging to private producers. Of the total lignite consumption, 87% was used for power generation by EGAT and the remaining 13% in the industrial sector, particularly cement manufacturing.

The share of imported hard coal has increased steadily over the last 20 years, largely because of the expiration of lignite mining concessions and the depletion of local reserves. Most of imported coal used in Thailand is of sub-bituminous and bituminous categories. Coal-fired power generation by private sector IPPs and SPPs only uses imported hard coal. This accounts for an increasing share of imported coal use, up from zero in 1995 to 41% in 2014. This trend is expected to continue, as the PDP foresees the addition of 7,390 MW of new capacity fueled by coal and lignite during 2015-2036.

Total installed capacity of coal-fired power plants owned and operated by the private sector currently is 3,088 MW of which 2,452 MW is contracted for sales to the grid (see Exhibit 3-9).

EXHIBIT 3-9

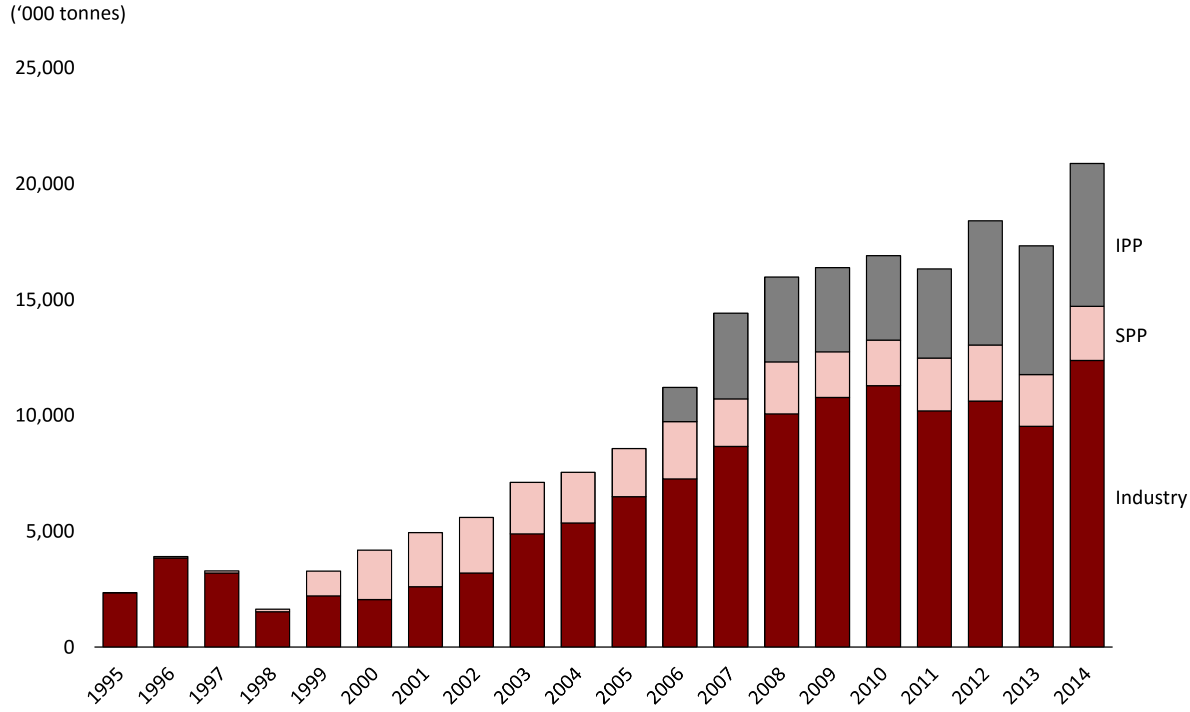
Coal-Fired Power Plants under IPP and SPP (March 2016)

Type	Company	Location	Installed Capacity (MW)	Contracted Capacity (MW)	Start of Operation
SPP	IRPC	Rayong	108	45	1994
SPP	Panchaphol Pulp Industry	Ayutthaya	40	8	1995
SPP	TPT Petrochemicals	Rayong	55	10	1997
SPP	Glow Energy (1)	Rayong	160	90	1999
SPP	National Power Supply (1)	Prachin Buri	164	90	1999
SPP	National Power Supply (2)	Prachin Buri	164	90	1999
SPP	Glow Energy (2)	Rayong	160	90	2000
IPP	BLCP Power	Rayong	1,436	1,347	2006
VSPP	Inter Pacific Paper	Prachin Buri	10	3	2007
VSPP	United Paper	Prachin Buri	10	3	2008
VSPP	Elite Kraft Paper	Sakaeo	10	3	2010
IPP	GHECO-one	Rayong	660	660	2012
VSPP	Siam Kraft Industry	Kanchanaburi	85	10	2016
VSPP	Thai Acrylic Fiber	Saraburi	27	4	n/a

Source: ERC

EXHIBIT 3-10

Coal Use by Industries and Private Sector Power Generation (1995-2014)



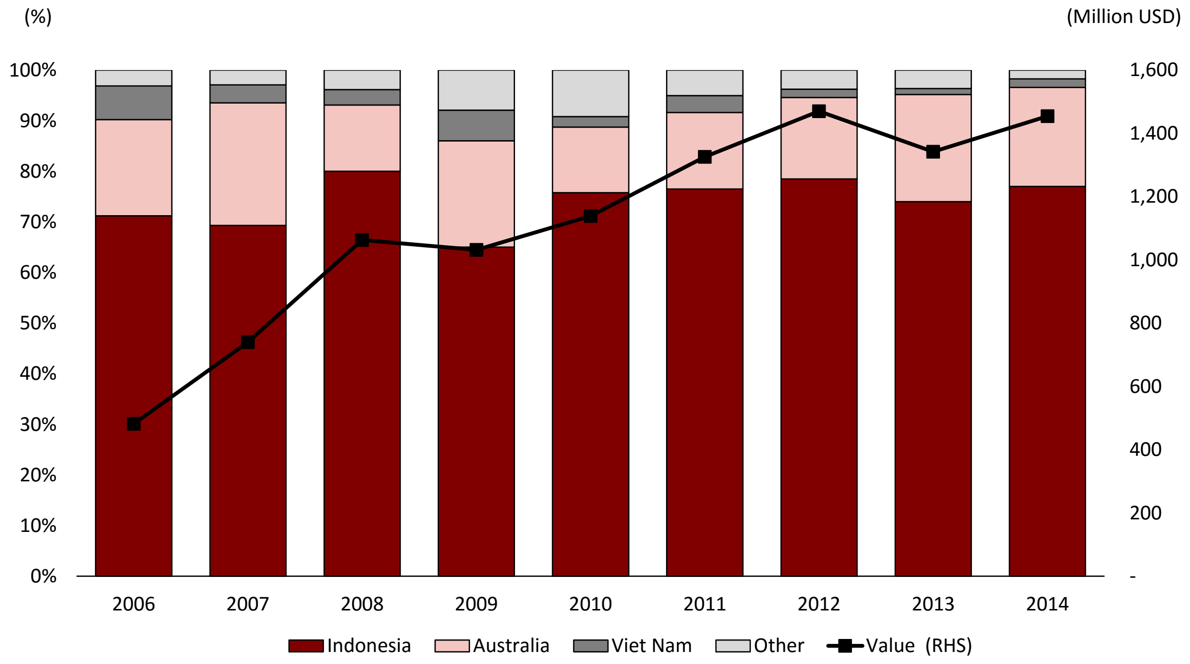
Source: EPPO

3.5.1 Supply and Sourcing

The vast majority of coal imports originate from Indonesia, averaging 74% between 2006 and 2014. Since 2006, Thailand also imports considerable amounts of coal from Australia, averaging 18% during the same period. Coal is easily sourced in Southeast Asia, with Indonesia being the largest producer within the region. According to a 2014 study by the Federal Institute for Geosciences and Natural Resources, Asia Pacific has the largest remaining potential of hard coal, with 7,516 Gigatonnes (41% of world total). The region also dominates the global hard coal market, with Indonesia and Australia accounting for 31.5% and 26.6% respectively in 2013.

EXHIBIT 3-11

Source and Value of Coal Imports (2006-2014)



Source: UN Comtrade

3.5.2 Coal Pricing

In early 2016, coal prices reached their lowest since the global financial crisis. Since the beginning of 2011, coal prices have fallen by more than 60%, because of chronic oversupply and falling imports into China and India. Europe and United States continue to shun coal amidst a global drive towards cleaner energy, collapsing gas prices, and increasing power efficiency. Furthermore, global coal supplies continue to increase aided by falling costs and depreciating producer currencies.

Coal prices are expected to decline somewhat further in 2016, on continued weak demand and oversupply. In its Commodity Markets Outlook, the World Bank forecast a gradual increase in prices for Australian coal, from a low USD 50/tonne in 2016 to USD 70/tonne in 2025 (see Exhibit 3-12).

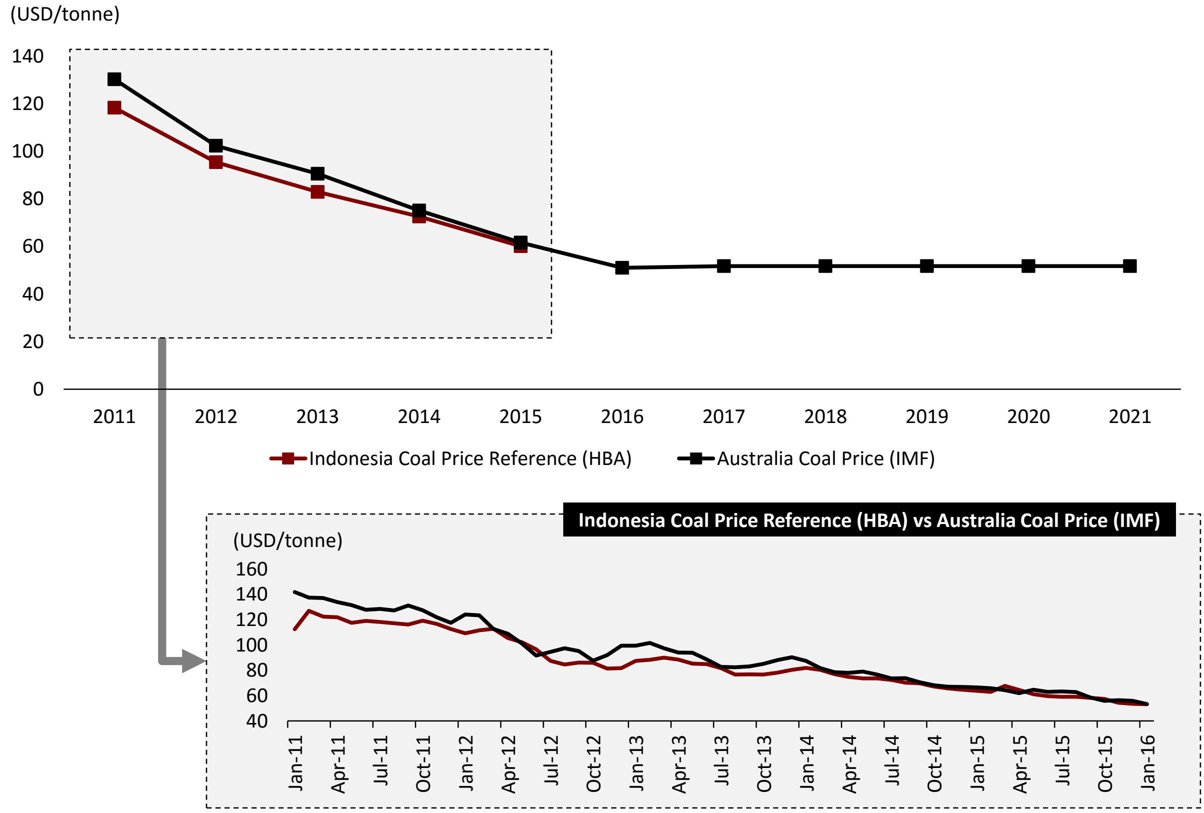
The coal industry faces difficult market conditions, as cheap natural gas and RE policies challenge coal's position in the power sector. Import demand in China is expected to continue falling, and will only partly be offset by rising demand in India and other emerging markets. However, the ASEAN region remains a center of significant coal growth, with the addition of significant coal-fired power generation. The International Energy Agency (IEA) expects that coal demand will grow to 5,814 million tonnes through 2020, growing with an average 0.8% per year. Coal use in the ASEAN region will grow by 79 million tonnes over the 5-year period.

Persistent low prices make coal very attractive for power generation. The current 1,900 GW of installed coal capacity globally is expected to increase as capacity under development in Asia exceeds the likely retirements in Europe and the United States.

As shown above, Thailand relies primarily on coal imports from Indonesia with Australia providing the second largest share. However, price forecasts for Indonesian coal are not publicly available. In the chart below we reference the World Bank forecast for Australian coal to provide an indication of price trends. Prices for Australian coal are typically slightly higher than for Indonesian coal, due to the higher heating value of the former, but prices are highly correlated. The chart also compares Australian coal prices with the Harga Batubara Acuan (HBA), a monthly historical benchmark of Indonesian thermal coal price for the previous month produced by the country's Ministry of Energy and Mineral Resources.

EXHIBIT 3-12

Price Forecast for Australian Coal (2013-2025F)



Source: Ministry of Energy and Mineral Resources of Indonesia, IMF and World Bank

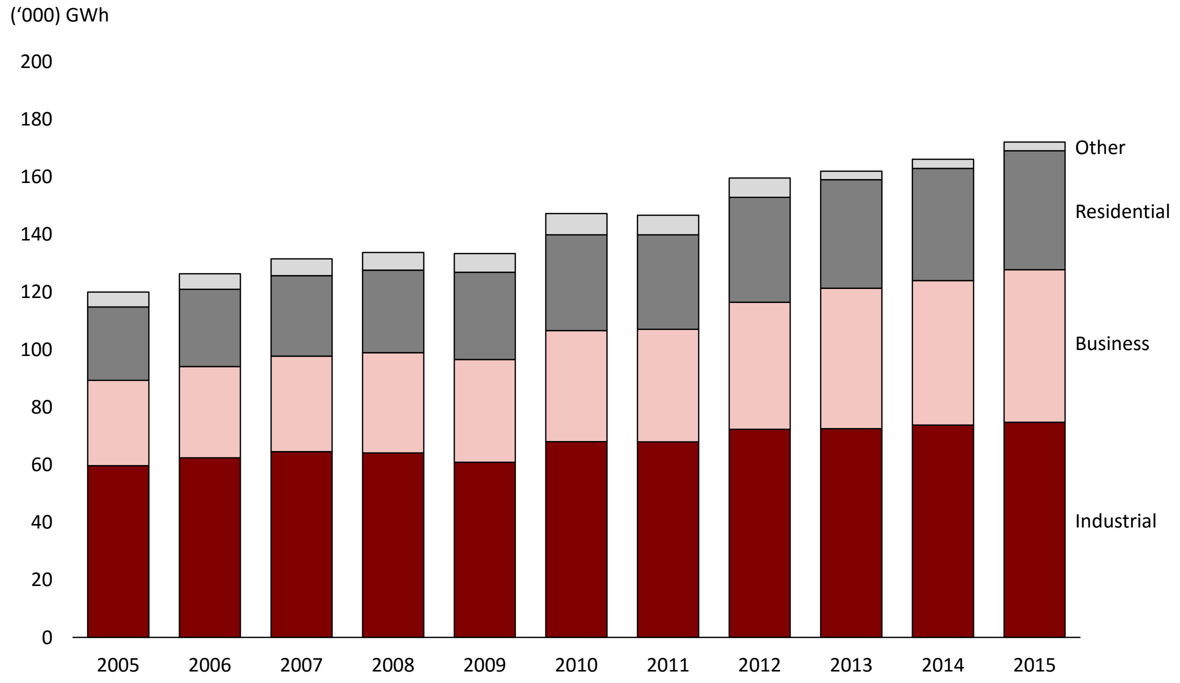
Section 4. Thailand Electricity Demand

4.1 Electricity Consumption Trends

Electricity consumption has grown at an average of 3.7% per annum over the last decade, reaching 172,090 GWh in 2015. The industrial sector is the largest power consumer, accounting for an average of 47% of total demand since 2005, but decreasing slightly from 50% in 2005 to 43% in 2015. Business and residential consumption have averaged 27% and 22% respectively over the same period, with the share of business consumption increasing from 25% to 31%.

EXHIBIT 4-1

Sectoral Electricity Demand in Thailand (2005-2015)

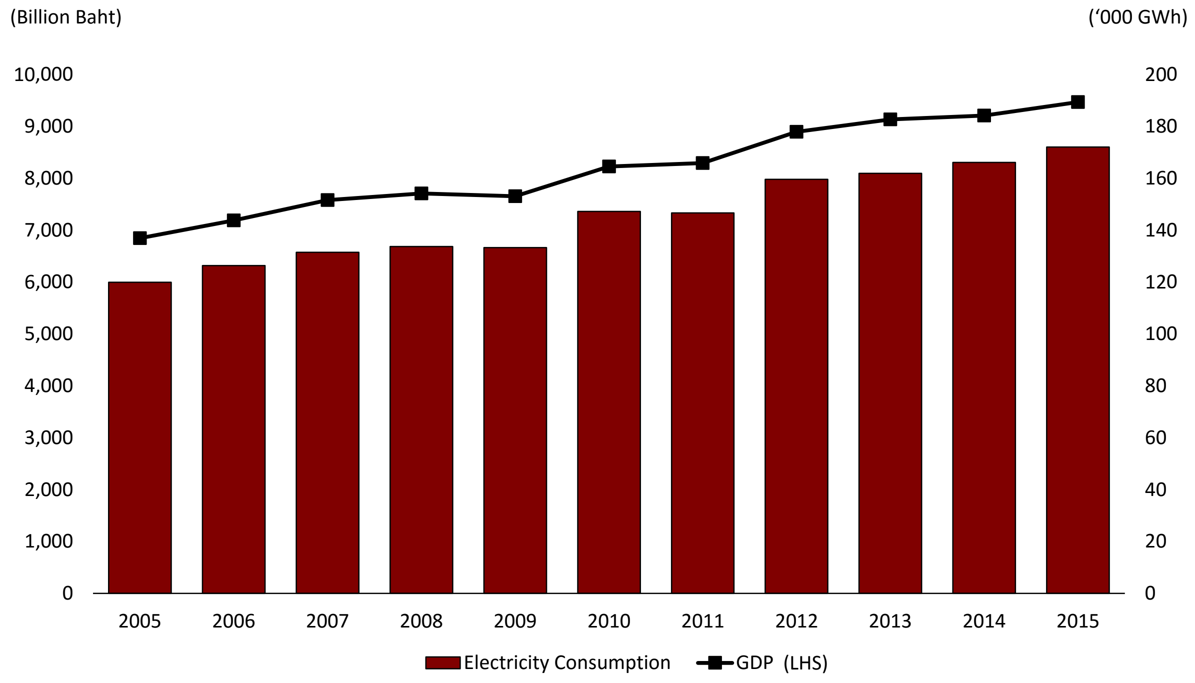


Source: EPPO

As shown in Exhibit 4-2 below, Thailand's electricity demand has historically followed its GDP closely, matching high economic growth until 2007, a slowdown in 2009 and 2011, and a recovery thereafter.

EXHIBIT 4-2

GDP vs Electricity Consumption (2005-2015)

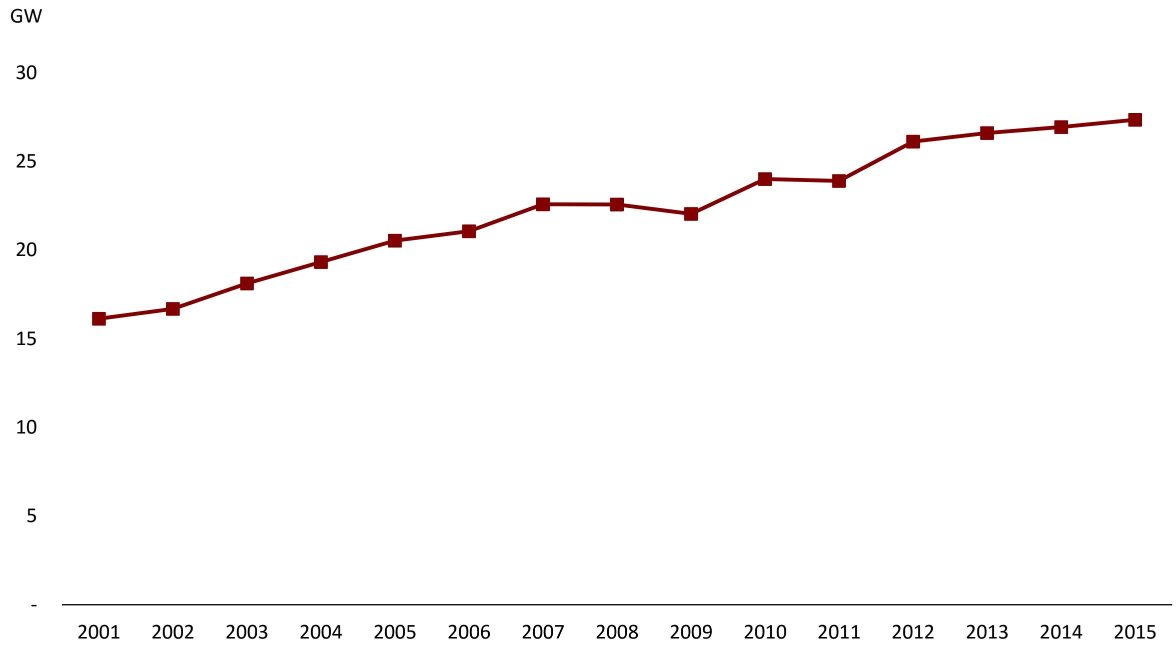


Source: NESDB, EPPO

Peak power demand on EGAT's system reached 27.7 GW in 2015. In the last 15 years peak demand has grown on average by 4.1% per year, following the same pattern as annual electricity consumption (see Exhibit 4-3 below). The demand peak typically occurs in April or May, which is the hottest period of the year.

EXHIBIT 4-3

Peak Power Demand of EGAT System (2001-2015)



Source: EPPO

EXHIBIT 4-4

Electricity Indicators by Country (2012)

Country	Electricity consumption per capita (MWh/year)	Access to electricity (% of population)
Thailand	2.47	100.0%
Singapore	8.69	100.0%
Philippines	0.67	87.5%
Vietnam	1.27	99.0%
Indonesia	0.73	96.0%
China	3.48	100.0%
India	0.74	78.7%
Japan	7.75	100.0%
USA	12.95	100.0%

Source: World Bank Development Indicators

4.2 Electricity Demand Outlook

The PDP2015 presents a revised electricity demand forecast formulated in line with economic growth, changes in economic structure, infrastructure development projects, and the potential and targets for renewables and energy efficiency. In addition, population growth, urbanization, and growth rate of electricity customers by economic sectors were also considered.

The demand forecast is based on an annual average long-term GDP growth of 3.94% and annual average population growth of 0.03% during 2014-2036, as estimated by NESDB. The PDP also integrates the Energy Efficiency Development Plan (EEDP), which projects a reduction of 89,672 GWh in annual electricity consumption by 2036 compared to only 27,282 GWh under the Business-As-Usual scenario (BAU).

Under Thailand's new power demand forecast, electricity consumption is expected to grow at an average of 2.67 % annually from 2014 to 2036. In 2036, the expected energy and power demand are 326,119 GWh and 49,655 MW respectively.

EXHIBIT 4-5

Peak Power and Electricity Demand Forecast

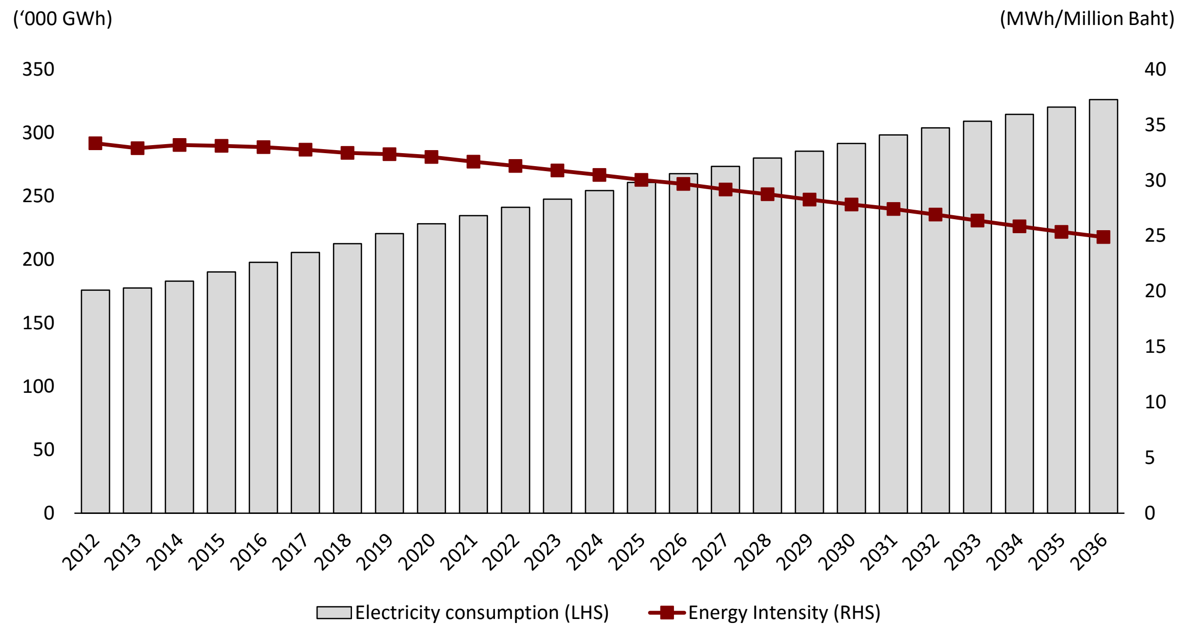
Year	Peak (MW)	Energy (GWh)
2016	30,218	197,891
2026	40,791	267,629
2030	44,424	291,519
2036	49,655	326,119

Source: PDP2015

Energy intensity, expressed as MWh per Million Baht of GDP, is projected to drop to 24.9 in 2036 from 33.2 in 2014. Measures to achieve these targets include building energy codes, energy performance standards, financial incentives, and the promotion of LED lighting.

EXHIBIT 4-6

Project Electricity Use and Energy Intensity (2012-2036)



Source: PDP2015

4.3 Demand Growth Uncertainty

Demand forecast in the PDP2015 has been revised downward from the previous PDP, by as much as 16% for 2030. This follows a trend of previous revisions of demand forecasts in earlier PDPs, reflecting the fact that forecasts have typically been higher than actual demand growth.

EXHIBIT 4-7

Power Demand Forecast

	Peak Demand (MW)			Energy (GWh)		
	PDP2010*	PDP2015	Change	PDP2010*	PDP2015	Change
2016	31,809	30,218	-5.0%	210,619	197,891	-6.0%
2026	46,003	40,791	-11.3%	304,548	267,629	-12.1%
2030	52,256	44,424	-15.0%	346,767	291,519	-15.9%
2036	n/a	49,655	n/a	n/a	326,119	n/a

Note: PDP2010 refers to the third revision of the PDP2010 issued in June 2012

Source: PDP2015

The downward revisions in the demand forecasts affect the implementation of the PDP, possibly leading to revisions in the timing of capacity additions and delays in new bidding rounds for IPPs and SPPs. This would favor projects that already have signed PPAs with EGAT.

Section 5. Thailand Electricity Supply

5.1 Installed Capacity

As of March 2016, Thailand's total installed capacity, which includes EGAT's power plants, IPPs, SPPs, VSPPs and imports from neighboring countries (see Exhibit 5-1) stood at 46,096 MW. Besides these grid-connected power plants, several industries use captive power plants for onsite generation and use 'within the fence'. No comprehensive data are available for the installed capacity and generation for captive power.

EXHIBIT 5-1

Installed Capacity by Type (March 2016)

Type of Power Plant	MW	Share
EGAT	**15,518**	**33.7%**
- Thermal	3,647	7.9%
- Combined cycle	8,382	18.2%
- Hydropower	3,418	7.4%
- Diesel	30	0.1%
- Renewable energy	40	0.1%
Independent Power Producers	**15,545**	**33.7%**
- Coal	2,096	4.5%
- Natural gas	13,449	29.2%
Small Power Producers	**8,157**	**17.7%**
- Firm	5,942	12.9%
- Non-firm	2,215	4.8%
Very Small Power Producers	**3,490**	**7.6%**
- Non-firm	**3,490**	7.6%
Neighboring Countries	**3,387**	**7.3%**
- Laos	3,087	6.7%
- Malaysia	300	0.7%
Grand Total	**46,096**	**100.0%**

Source: EGAT, ERC

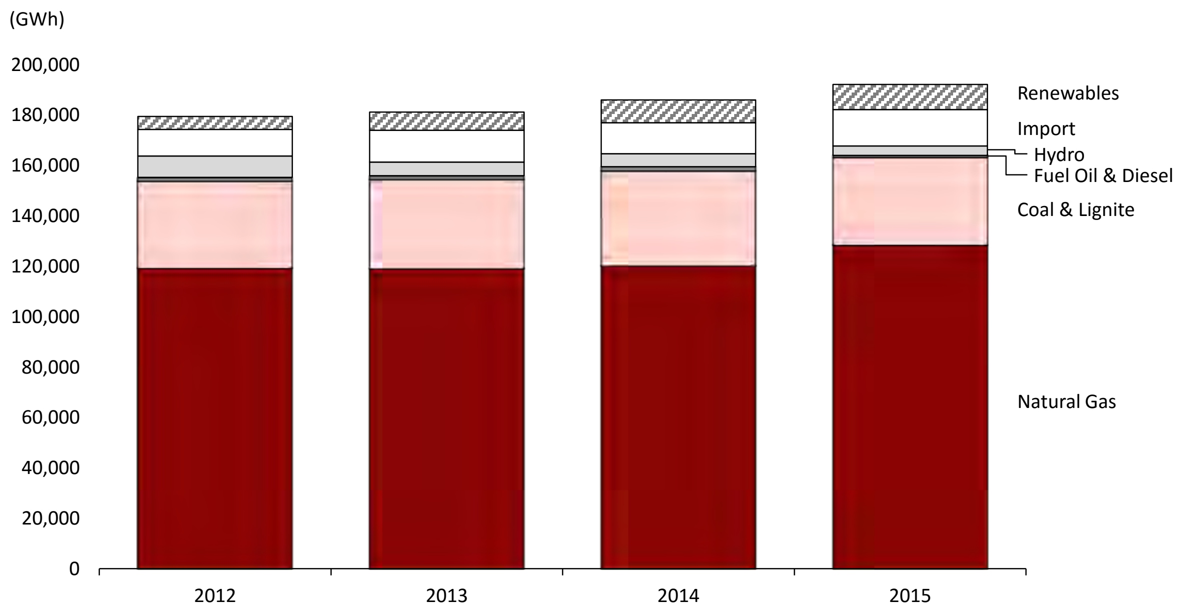
5.2 Electricity Supply Trends

Electricity generation in Thailand is highly dependent on natural gas. Over 60% of Thai electricity generation is produced from natural gas that is sourced from the Gulf of Thailand, Myanmar and Liquefied Natural Gas (LNG) imports, as shown in Exhibit 5-2.

As discussed in more detail in Section 8, the share of renewables (not including large hydro) has increased significantly over the last decade, contributing approximately 9% of the total electricity generation in 2015.

EXHIBIT 5-2

Electricity Production by Fuel Type (2012-2015)



Source: EPPO

5.3 Electricity Supply Outlook

According to PDP2015, in 2036 the total capacity is projected to be 70,335 MW, consisting of existing capacity (46,096 MW in March 2016) and new capacity (48,975 MW), less the retired capacity during 2016-2036 (24,736 MW), as shown below:

EXHIBIT 5-3

Installed Capacity 2016 – 2036

	Peak (MW)
Existing capacity as of March 2016	46,096 MW
New capacity during 2016-2036	48,975 MW
Retired capacity during 2016-2036	-24,736 MW
Total capacity in 2036	**70,335 MW**

Source: EGAT, ERC, PDP2015

Natural gas will remain the dominant fuel in the coming years, but this is projected to drop from the current 64% to 30-40% by 2036. To achieve this target, more power will be sourced from renewables, imported hydro, coal, and (towards the end of the PDP planning period) nuclear.

EXHIBIT 5-4

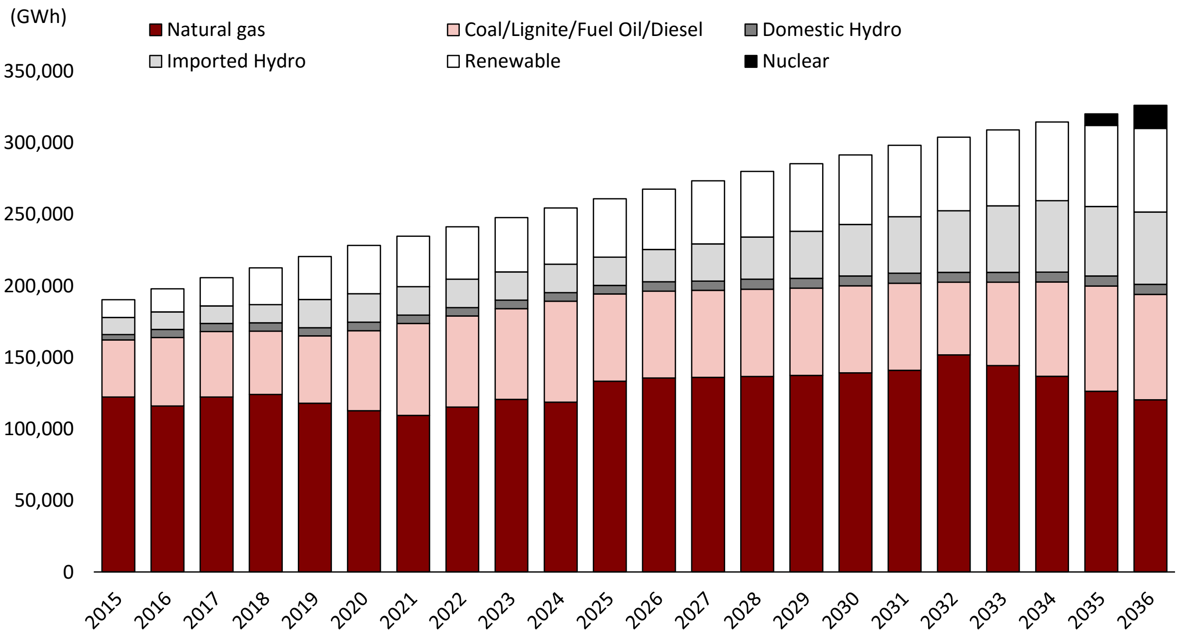
New Capacity to Be Added During 2015 – 2036

Type of Power Plant	Capacity Additions (MW)
Renewable power plant	21,648
- Domestic	12,105
- Power purchase from neighboring countries	9,543
Pump-storage hydro power plant	2,101
Cogeneration power plant	4,119
Combined cycle power plant	17,478
Thermal power plant	12,113
- Coal/Lignite power plant	7,390
- Nuclear power plant	2,000
- Gas turbine power plant	1,250
- Power purchase from neighboring countries	1,473
Total	**57,459**

Source: PDP2015

EXHIBIT 5-5

Projected Electricity Generation by Fuel Type (2015-2036)



Source: PDP2015

5.4 Reserve Margin History and Projections

Over the last fifteen years, Thailand has maintained a consistently high reserve margin - the amount of capacity available above peak demand - in its power system, well above the minimum standard of 15% as specified by the PDP2015. There have been active public discussions in which some analysts have commented that Thailand is currently planning too much additional generating capacity. In fact, MoE suggested in the PDP 2015 that the plant reserve margin could rise significantly from a historical 15-20% range to almost 40% in the next 10 years. This could be due to the following factors:

1) Slower demand growth given lower GDP growth—the new PDP assumes lower average GDP growth of 3.94% per year (compared to 4.49% previously)
2) Improved energy efficiency, with nearly 90 GWh savings per annum by 2036
3) New projects under construction or approved and waiting to be built
4) Additions of intermittent renewable energy supply such as wind and solar, which raise capacity figures, but may produce at a lower utilization rate and are not dispatchable

These conditions could lead to the construction of unnecessary power plants, or delays and cancellations of planned projects. However, existing IPPs and SPPs are mostly shielded as they are covered by PPAs.

5.5 Uncertainty to Supply Outlook

Under PDP2015, MoE is planning to increase contributions from coal, imported hydro and nuclear power to reduce dependency on natural gas imports for electricity generation.

Historically, Thailand has experienced opposition to coal-fired plants, illustrated by the fact that some IPPs have switched from coal to natural gas. EGAT currently also faces strong opposition to its planned 800 MW coal-fired plant in Krabi, which may mean that this plant as well as others under development may not come online as planned.

Similarly, the development of nuclear power has long faced strong objections from civil society. Despite plans for nuclear power being part of the previous PDPs, each subsequent PDP has postponed the online date for nuclear plants. Furthermore, given the long lead times for developing large hydro plants in Laos and Myanmar, prospects for additional imported power from these sources could be uncertain.

Therefore, the PDP projections for coal-fired, imported hydro and nuclear power may be overly optimistic. This means that Thailand's dependence on natural gas is likely to remain at levels higher than currently envisioned by the government.

5.6 Barriers to Entry

Private sector participation in the Thai power sector is restricted to the IPP, SPP and VSPP programs. The PDP does not foresee new rounds of IPP and SPP bidding in the near future. EGAT buys all of IPPs' output and most of SPPs' output, so there is very limited scope to build a large power plant without a PPA. VSPPs can sell directly to the distribution utilities but their capacity is capped at 10 MW.

Onsite power generation where the power is used at industrial sites is an exception to the above restriction, but since industrial sites are not allowed to export excess power without a PPA, it is a less attractive option for investors looking to enter the market. A handful of power plants do not have a PPA with EGAT and sell only to industrial off-takers, but they are uncommon in Thailand. The active M&A market over the last few years shows that another main option for market entry is the acquisition of stakes in existing power plants.

In principle the current regulations place no restrictions on companies that wish to enter the power market, but in practice the lack of new bidding rounds presents a significant barrier.

Section 6. Thailand SPP Sector Overview

6.1 Background

The Small Power Producer (SPP) program was initiated in the 1990s in response to power shortages, a desire to involve the private sector in power generation, a push towards energy efficiency and the utilization of alternative energy sources such as renewable energy and waste heat.

SPPs sell up to 90 MW of electricity to EGAT under a long-term PPA. They can sell any excess capacity directly to industries located within industrial estates. There are approximately 50 industrial estates in Thailand. These are promoted by the government and are overseen by the Industrial Estate Authority of Thailand.

With EGAT as the main off-taker for "firm" power, SPP projects are generally bankable. Non-EGAT power and steam are typically sold to reputable and large industrial customers located within industrial estates. Most SPPs are gas-fired and are located within industrial estates (which typically helps to minimize permitting and fuel issues).

EXHIBIT 6-1

SPP Installed and Contracted Capacity by Contract Type (March 2016)

Contract Type	Installed Capacity (MW)	Contracted to EGAT (MW)
Firm	5,942	3,990
Non-firm	2,215	1,237
Total	**8,157**	**5,227**

Source: ERC

6.2 Regulatory Framework

SPP plants are required to utilize:

- Renewable or alternative sources such as wind, biomass, solar, mini-hydro, as well as waste or by-products from agricultural and industrial activities; or
- Co-generation using natural gas or petroleum products under a number of conditions (e.g., efficiency > 45% and steam output > 10%).

For renewable projects, conventional fossil fuels can be used to complement renewable sources but the amount of thermal energy derived from the renewable source must be at least 75% of the total thermal energy used for power generation in any particular year. For cogeneration plants, system efficiency must be 45% or higher, and at least 10% of the energy output must be used for thermal applications in order to receive the full Fuel Saving (FS) payment.

EGAT has defined two types of purchasing rates for buying SPP power, firm and non-firm power. Firm power means the SPPs guarantee availability of electricity supply during the system peak months. Firm fossil fuel-fired SPPs must operate for at least 7,008 hours per year and they must generate power during the months of March, April, May, June, September and October.

Firm conventional energy SPPs receive an unbundled base tariff, which comprises a capacity payment, an energy payment and a fuel savings payment. Renewable energy SPPs with a firm PPA receive the same base tariff plus two additional components: a fixed one, called the renewable energy promotion, and one that is specified for each type of renewable energy, called 'adder'.

EXHIBIT 6-2
Tariff Structure for Firm SPPs

SPP Firm Tariff:	CP + EP + FS + REP + Adder
CP =	Capacity Payment (Baht/kW/month)
EP =	Energy Payment (Baht/kWh)
FS =	Fuel Saving (Baht/kWh)
REP =	Renewable Energy Promotion (Baht/kWh)
Adder =	Adder for Renewables (Baht/kWh)

Source: ERC

Non-firm power refers to power for which availability is not guaranteed and that is sold whenever it is available (solar, wind, some biomass, etc.). The non-firm tariffs are generally lower than those for firm power.

Non-firm conventional cogeneration SPPs receive the Energy Payment, based on EGAT's avoided energy costs, whereas non-firm renewable energy SPPs get the Time of Use (TOU) rate, adjusted for peak and off-peak hours, plus the Ft charge and an adder that depends on the type of renewable.

EXHIBIT 6-3
Tariff Structure for Non-Firm Renewable SPPs

Renewable SPP Non-Firm Tariff:	Wholesale rate + Ft + Adder
Wholesale rate	Wholesale tariff for 11-33 kV connection (Baht/kWh)
Ft =	Fuel Adjustment Mechanism, adjusted every 4 months (Baht/kWh)
Adder =	Adder for Renewables (Baht/kWh)

Source: ERC

ERC has the authority to regulate all sales of power, including sales within industrial sites. In practice, the sales of electricity by SPPs to industrial customers is not regulated by ERC but faces competition from sales by MEA and PEA, which are regulated by ERC.

6.3 Breakdown of Installed Generation Capacity by Type

SPP projects are dominated by natural gas cogeneration plants, which accounts for more than half of the total installed capacity (see Exhibit 6-4). All waste-based plants under the SPP are owned and operated by TPI Polene Power (TPIPP).

EXHIBIT 6-4

SPP Installed and Contracted Capacity by Fuel Type (March 2016)

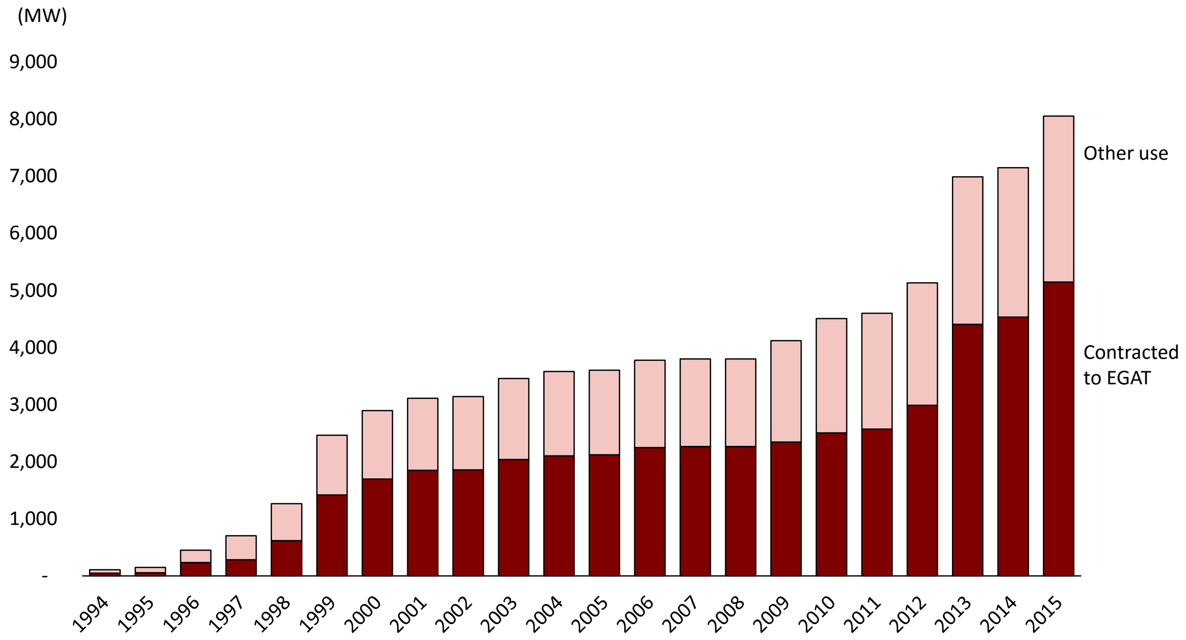
Fuel/Resource	Installed Capacity (MW)	Contracted to EGAT (MW)
Biomass	878	593
Bunker Oil	10	5
Coal	851	423
Hydro	23	12
Natural Gas	5,632	3,582
Other	21	14
Solar	455	346
Waste	80	73
Wind	207	180
Total	**8,157**	**5,227**

Source: ERC

Exhibit 6-5 shows the increase in SPP capacity since 1994, distinguishing total capacity from capacity contracted to EGAT. This shows a sharp increase in capacity during 2013-2015, following more moderate growth in the previous years.

EXHIBIT 6-5

Contracted and Total Installed SPP Capacity (1994-2015)



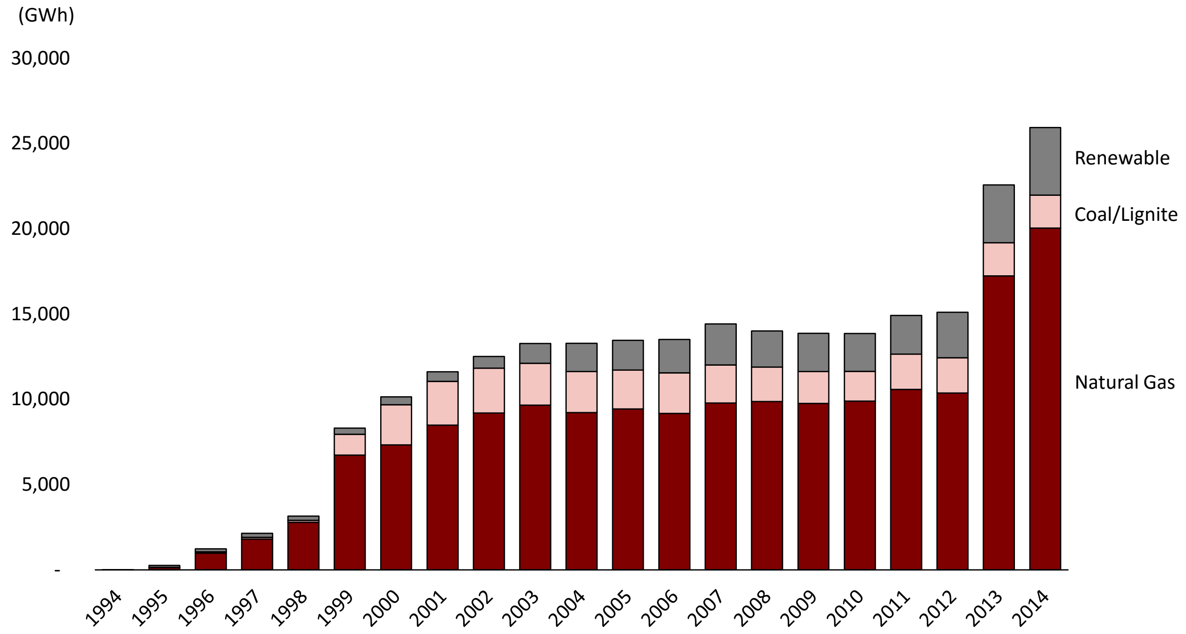
Note: 'Other use' refers to own use by industries and direct sales to industries in industrial estates

Source: ERC, AWR Lloyd research

As with SPP capacity, electricity purchases from SPPs by EGAT have increased significantly in recent years, as shown in Exhibit 6-6.

EXHIBIT 6-6

Electricity Purchase from SPPs by EGAT (1994-2014)



Source: EPPO

Section 7. Thai Petrol and Gas Retail Sector

The Thai retail petrol station business segment features a huge number of operators from stock market listed giants such as PTT down to small holders with single pumps. As of Q4 2015, Thailand had over 25,000 retail stations with the top 10 companies accounting for over 6,500 stations or 26%. In terms of the number of stations, PTT has the largest share with 6.8%, followed by PTG at 4.5% and Bangchak at 4.2%.

It should be noted that market share of fuel sales in volume terms differs considerably from station terms. A far smaller number of large operators account for large volume sales. PTT alone sells 37% of all fuel in Thailand with Esso, Bangchak, Shell and Chevron each contributing between 8-15%. Small players Susco and PTG each sell about 1%.

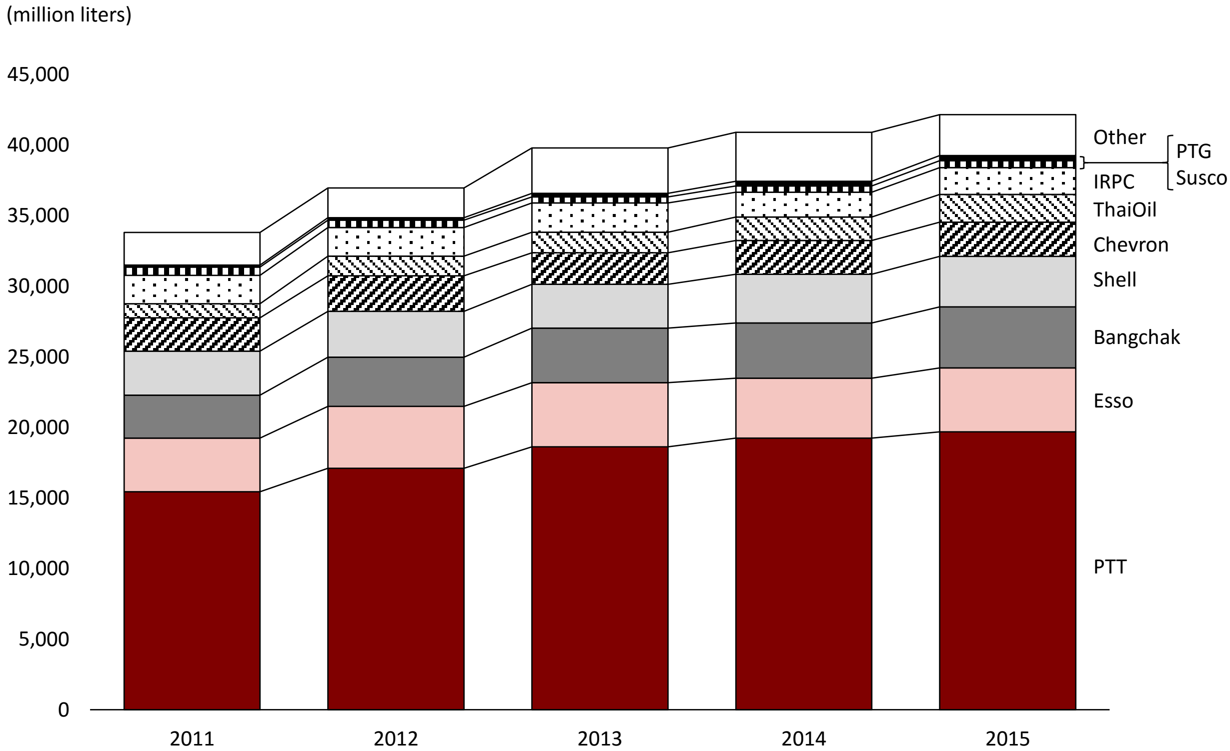
However, even at the station level, the number of stations is not the only key metric. Stations can range from large multi-pump units with sophisticated retail operations and other non-fuel businesses to tiny rural stations with barrels and manual pumps. Non-fuel operations in general have much higher margins. Sector leaders like Bangchak and PTT have both developed in-house brands to capture additional value. Large players also typically have larger stations and a greater concentration in the more lucrative areas of Bangkok and its surroundings. Stations located in urban areas may also include substantial property value.

Margins on petrol sales have ranged between 2-6% over the last decade with recent lower fuel prices pushing this to the higher end. We expect the NGV margins are slightly higher, to compensate for lower volume and slower throughput, although reliable data is not available. Non-fuel businesses can generate 30-40% margins although they remain in most cases a small portion of overall sales. PTT's non-fuel business contributed over 20% of profits in 2014.

Thailand also has 487 stations supplying natural gas to NGV vehicles, either as NGV only stations or in combination with other fuels. These either operate as conventional stations, which source gas directly from the natural gas pipeline, or mother daughter stations in which a central hub supplies compressed gas to a number of subordinate stations.

EXHIBIT 7-1

Retail Fuel Sales Volume by Retailer (2011-2015)



Note: Sum of benzene, diesel, LPG and NGV

Source: DOEB

EXHIBIT 7-2

Number of Retail Fuel Stations (2011-2015)

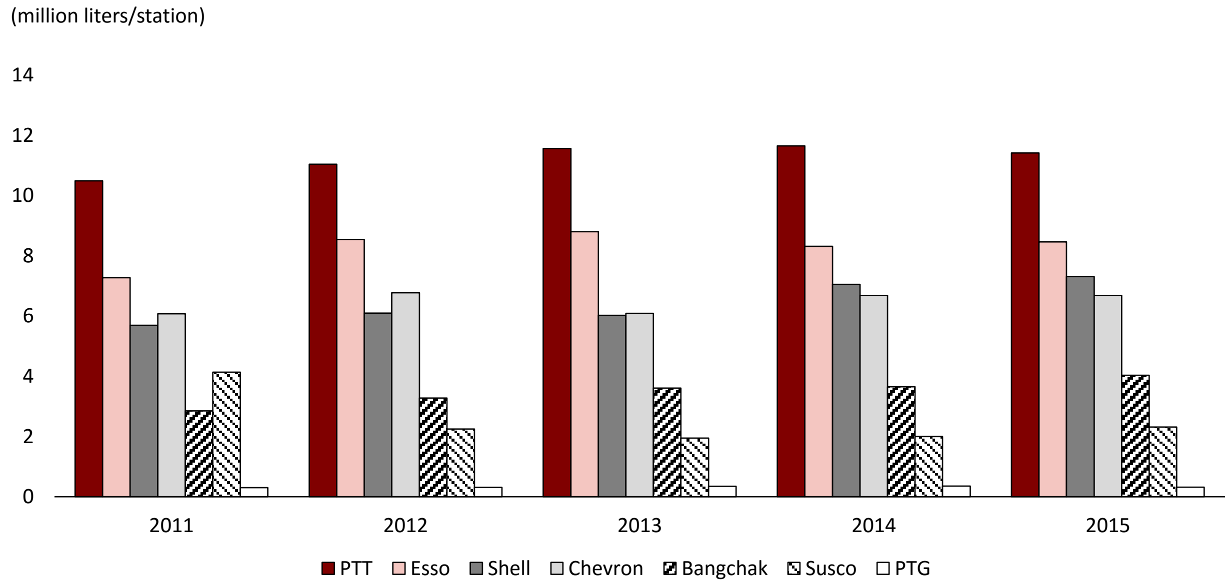
Retailer	2011		2012		2013		2014		2015	
	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)	(#)	(%)
PTT	1,472	7.3	1,550	7.2	1,610	7.0	1,652	6.8	1,725	6.8
PTG	438	2.2	577	2.7	743	3.2	951	3.9	1,150	4.5
Bangchak	1,068	5.3	1,067	5.0	1,074	4.7	1,070	4.4	1,072	4.2
Esso	523	2.6	512	2.4	516	2.2	511	2.1	534	2.1
Shell	547	2.7	533	2.5	515	2.2	489	2.0	491	1.9
WP	197	1.0	286	1.3	340	1.5	369	1.5	445	1.8
Siam Gas	329	1.6	363	1.7	418	1.8	405	1.7	431	1.7
Chevron	390	1.9	371	1.7	366	1.6	359	1.5	362	1.4
Susco	145	0.7	233	1.1	220	1.0	218	0.9	217	0.9
Unique	152	0.8	110	0.5	114	0.5	125	0.5	130	0.5
Other	14,991	74.0	15,804	73.8	17,088	74.3	18,064	74.6	18,786	74.1
Total	**20,252**	**100**	**21,406**	**100**	**23,004**	**100**	**24,213**	**100**	**25,343**	**100**

Note: Sum of benzene, diesel, LPG and NGV

Source: DOEB

EXHIBIT 7-3

Throughput per Station of Key Retailers (2011-2015)



Note: Sum of benzene, diesel, LPG and NGV

Source: DOEB

Section 8. Thailand Renewable Sector Overview

The development of the renewable energy sector is a cornerstone of Thailand's Power Development Plan and a core component of the country's goal of lowering dependence on imported energy. MoE also has a target to decrease CO_2 emissions by 2036 largely through the increased production of renewables-based power and energy conservation initiatives in four target groups: industry, business, residences and the public sector. This section addresses key issues concerning the development of renewable energy in Thailand, including the regulatory framework and pricing structure, sector growth prospects and outlook, as well as an analysis of the competitive landscape for renewables in the future generation mix.

8.1 Segment Organization and Value Chain Structure

Renewable-based installed capacity has reached significant scale in recent years with 5 GW of capacity on line as of March 2016. Biomass power is the leading technology with 2.4 GW installed, and accounts for nearly 8 % of total electricity produced domestically. A successful first stage of project development for solar power has already led to the installation of 1.8 GW, and ongoing developments are expected to bring the total to nearly 3.0 GW by the end of 2016, accounting for about 5 % of capacity and over 1 % of supply. Wind is also on track to reach GW-scale in the next few years, although as of March 2016 just over 200 MW is in operation. Biogas, waste-to-energy and other technologies contribute a similar amount. It should be noted that capacity utilization differs greatly across technologies and that biomass typically provides much greater load factors than solar or wind.

The new PDP2015 (see Section 3.4) also integrated the Alternative Energy Development Plan (AEDP) for the first time. The AEDP was previously developed independently. Targets detailed in the AEDP are the culmination of a long-standing Thai government commitment to alternative energy, supported by a strong regulatory framework and commitment within the PDP to provide a solid platform for future rounds of renewable energy development.

The key points of the 2015 AEDP include:

- Prioritization of power generation from waste, biomass and biogas in the near-term
- Local specification of renewable energy targets to match local grid capacity
- New solar and wind programs at a later stage, "as soon as they become competitive to LNG"
- Competitive bidding structured as a reverse auction in which the bid is submitted as a discount to the Feed-In Tariff (FIT) – instead of awarding of PPAs on a first-come first-served basis

Prepared by the Department of Alternative Energy Development and Efficiency (DEDE), the AEDP promotes the use of alternative energy to achieve the target of RE contributing 25% of total energy consumption by 2021 and ultimately with the view to reduce dependency on natural gas and energy imports. The new AEDP sets national targets of increasing RE capacity from 4.9 GW as of early 2016 to 16.4 GW by 2036, excluding large hydro power.

Specifically, the AEDP proposes a variety of policies, including, among others:

- *Solar power*: Target of 6 GW by 2036. Dedicated 25-year FIT for rooftop solar at households (up to 10 kW) and businesses (up to 1 MW), government sector and agricultural cooperatives (up to 5.0 MW) and, in the longer-term, additional solar farms (up to 90 MW).

- *Wind power*: Target of 3 GW by 2036. Construction of wind farms in areas with moderate wind speeds and classified as unprotected. As with solar, large-scale wind development will be incentivized further at a later stage.
- *Biomass and biogas*: Aggregate target of 6.2 GW by 2036, nearly tripling the current installed capacity. To be promoted as initial priority under the AEDP, especially projects with a capacity of less than 3 MW. Additionally, promotion of direct heat generation and fossil fuel substitution by industries.
- *Waste power generation*: Target of 500 MW by 2036 for power generation from Municipal Solid Waste (MSW) and other non-hazardous waste. As with biomass/biogas, promoted as initial priority and targeted for fossil fuel substitution.
- *Small hydro*: promote hydro power generation in mountainous and border areas not connected to the national grid;
- For all RE types, incentives will be provided by using competitive bidding with FITs as ceilings, and by zoning of available grid capacity and RE potential.

Considering Thailand's limited domestic conventional energy resources, renewable energy has the potential to provide an increasingly large portion of Thailand's energy supply in the future. With relatively good solar irradiation and large domestic biomass resources, as well as high potentials for decentralized power production, there are still various opportunities for the country to achieve its renewable energy targets. The high number of applications for solar power projects under the VSPP program shows considerable investor interest.

Renewables currently account for close to 10% of all power produced in Thailand and are crucial for ensuring energy security and reducing dependence on foreign energy resources. Growing energy security concerns, depleting gas reserves, difficulty of siting coal-fired power, and improving RE economics make this a trend likely to continue.

Solar: The annual average daily solar radiation in Thailand is about 5.0 to 5.3 kWh/m^2/day, corresponding to 18-19 MJ/m^2/day. High values, of about 20-24 MJ/m^2/day, are recorded during April and May. The Northeastern and Northern regions receive roughly 2,200 to 2,900 hours of sunshine per year (equivalent to 6-8 sunshine-hours per day). Thailand currently uses photovoltaic solar cells for electricity generation and, to a limited extent, solar thermal units for thermal applications such as hot water and steam.

Wind: There is considerable potential for wind energy on a larger scale in Thailand, especially in the Northeast and in the Southern regions of the country. Total potential for power generation is estimated at 14 GW. The wind current in Thailand is relatively light and unsteady, thus it has been frequently overlooked. Compared to wind turbines commonly manufactured for the European and U.S. markets, the country needs low-speed wind turbines to accommodate local conditions. The two major obstacles in using such turbines are the cost per unit of electricity generation and the lack of investment in Thailand for the low speed turbines. However, Thailand forecasts a large increase in wind energy use in the longer-term future as these issues are being solved progressively.

Biomass: Solid biomass has played a strong role as an energy source in Thailand and comprises roughly 16% of energy consumption. Most biomass feedstock is from rice husk, bagasse, wood waste, and oil palm residue and is used in residential and manufacturing sectors. Thailand has promoted biomass for heat and electricity. Biomass power generation has increased rapidly over the last decade but growth has slowed more recently.

Biogas: Anaerobic digestion of agro-industrial waste streams has been proven as a cost-effective treatment of agro-industrial waste water. Biogas technology has become a mainstream technical option, particularly for cassava-based starch mills and palm oil mills, which generates large volumes of organic waste water. Nearly 200 biogas projects have been implemented, either for onsite energy generation or electricity sales under the VSPP.

Waste: There are increasing opportunities for Waste-to-Energy (WTE). Total installed capacity selling to the grid has increased from 26 MW in 2010 to 132 MW in early 2016 and is projected to increase considerably in the near future. In addition, waste is increasingly used as fuel by cement factories and other industries. The country is faced with a growing waste disposal problem and the government has developed a roadmap for MSW management including the promotion of WTE.

Hydro: The government has been sponsoring development projects of small hydro power plants for additional capacity of 350 MW. DEDE and PEA are the main institutions involved with mini- and micro-hydro power plants. DEDE has also installed many village-level hydropower plants, and there is considerable potential for village-scale small hydro in Eastern and Central Thailand.

Amongst existing solar, wind and biomass generation capability, biomass is the only fuel source that contributes to the country's SPP firm power supply. Wind, as intermittent generation, accounts mainly for SPP non-firm supply. Most solar power is sold by VSPPs (up to 10 MW), with several large projects consisting of bundled VSPP PPAs. The segregation of existing capacity by fuel type and generation ownership type is presented in Exhibit 8-1 below.

EXHIBIT 8-1

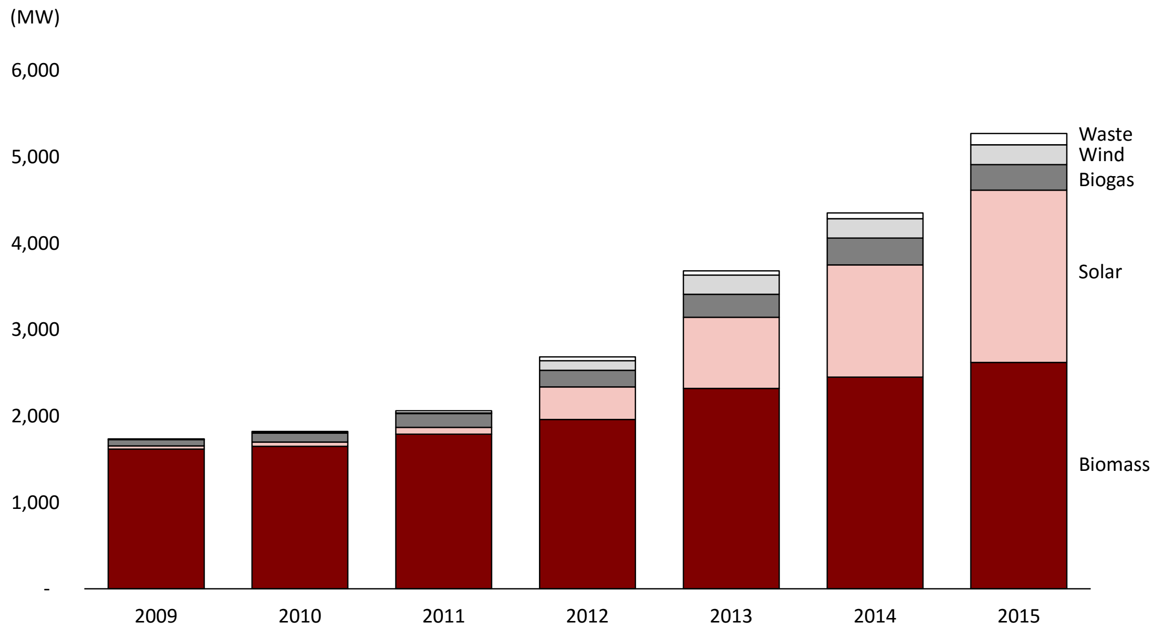
Installed Renewable Capacity by Generation Ownership Type (March 2016)

MW	Generation Type					
	Wind	Solar	Biomass	Biogas	Waste	Total
EGAT	3	2	-	-	-	**5**
SPP (Firm)	-	-	476	-	-	**476**
SPP (Non-Firm)	207	455	410	-	80	**1,152**
VSPP	20	1,391	1,556	304	52	**3,323**
Total	**230**	**1,848**	**2,442**	**304**	**132**	**4,956**
Share	**5%**	**37%**	**49%**	**6%**	**3%**	**100%**

Source: EGAT, ERC

EXHIBIT 8-2

Trend of Renewable Energy Installed Capacity (2009-2015)



Source: DEDE, ERC

8.2 Regulatory Framework and Pricing Structure

Renewable-focused projects sell their exported power either to EGAT or one of the distribution utilities through the SPP or VSPP programs, both of which provide for own use of power as well as sales to the grid. The distributing utilities (PEA and MEA) are obliged to purchase electricity generated, at the same tariff that they purchase electricity from EGAT. As much as 25% of the country's biomass and biogas may be used internally for power, steam or process heat.

The VSPP program was created in 2002, initially with a capacity limit of 1 MW and easy access to the grid through an administrative process, but offered limited additional incentives. During this time, pioneer small to medium scale biomass projects were developed. In 2006, the VSPP program was expanded to include projects up to 10 MW and an incentive system using price adders was adopted.

The cost of the adder, which is paid in addition to the base tariff for a period of seven years, is financed by a pass-through mechanism to all electric power customers (as is the new FIT). The value of the adder is determined by the type of renewable energy. Renewable projects under the SPP program also receive the adder on top of the base tariff.

In October 2014, the NEPC approved in principle that the promoted measure for power generation from renewable energy shall be changed from the adder system to the Feed-in Tariff (FIT) system. The new FIT rate has three components:

- FIT (F): set per type of technology and fixed throughout the PPA duration;
- FIT (V): a portion that is adjusted periodically depending largely on the inflation rate;
- Premiums for the use of certain fuels or projects located in the three most southern provinces (for the PPA duration of 20 years). Bio-energy projects (i.e. biomass, biogas and waste) receive premiums for the first 8 year of operation.

This FIT was applied retroactively, on a voluntary basis, for solar PV projects remaining in the queue from the previous application window, which had closed in 2010. These projects were to be completed in December 2015, and more than 400 MW has reached COD since the beginning of 2015. Projects that were operational or had a signed PPA before the FIT announcement receive the adder as per the previous mechanism.

The first new program under the FIT is the 800 MW solar program for government agencies and agricultural cooperatives. In August 2015 the ERC provided specific regulations for the program and opened up the application process. These ground-mounted projects have a capacity limit of 5 MW per project and will receive a fixed FIT of 5.66 Baht per kWh for 25 years. The application process closed in November 2015 and the ERC was expected to announce the awarded bids in December 2015, but at the end of January 2016 this was postponed for the second time until further notice.

Following an initial announcement in mid-2015, a competitive bidding program for biomass and biogas from agricultural waste and energy crops was postponed. Subsequently, in January 2016 ERC announced the first phase of bidding rounds for biogas (up to 10 MW) and biomass (up to 36 MW). This initial bidding is restricted to the three southernmost provinces (and 4 districts in Songkla province). The biogas bidding is expected to be completed by the end of April, to be followed by a bidding process for biomass. The capacity available for biomass will be assessed after the closing of the 800 MW solar program for government agencies and agricultural cooperatives. As of yet, there have been no announcements for waste-based projects.

For these technologies, bidding will occur by region to match the demand and capacity of the grid in each region, the so-called 'RE-zoning'. Available capacity will be announced for each bidding round. Under the competitive bidding for new VSPPs, the announced FITs only serve as a ceiling, and developers are expected to specify a discount on the base FIT in a reverse auction structure.

While the signing of new PPAs for renewables has slowed down in the last 2-3 years, it is expected that this will pick up again with announcement of more bidding rounds. The target to reduce the dependence on natural gas will require an aggressive campaign to add more renewables to the power system. While the first competitive bidding rounds are relatively small, more frequent bidding rounds and larger biddable capacity are foreseen in 2016 and beyond.

8.2.1 Pricing

As indicated in Section 3.3, different tariff structures apply for different generator categories (i.e. IPP, SPP and VSPP). These tariff structures depend on whether the generating asset is considered 'firm' or 'non-firm' and whether or not the energy source is a renewable-based technology. Firm renewable energy SPPs receive the same base tariff, plus two adders: one fixed, called the 'Renewable Energy Promotion' (REP) and one that varies depending on the type of renewable energy, the so-called 'Adder'. Non-firm renewable energy SPPs receive the Time of Use (TOU) rate, adjusted for peak and off-peak hours, plus the Ft charge and an adder, which depends on the type of renewable energy source.

The tables below show comparative pricing under the previous adder and new FIT programs. The FIT applies to VSPPs and as of yet ERC has not made announcements for FITs under the SPP program.

EXHIBIT 8-3

Adder Rates for Renewable Energy Projects

	Initial Adder (2006)	Revised Adder (from July 2009)	Additional for Diesel Substitution	Additional for projects in the 3 most southern provinces	Period
	(Baht/kWh)	(Baht/kWh)	(Baht/kWh)	(Baht/kWh)	(Years)
1. Biomass					
Installed cap. <= 1 MW	0.3	0.5	1.0	1.0	7
Installed cap. > 1 MW	0.3	0.3	1.0	1.0	7
2. Biogas (all sources)					
Installed cap. <= 1 MW	0.3	0.5	1.0	1.0	7
Installed cap. > 1 MW	0.3	0.3	1.0	1.0	7
3. Waste (MSW and non-hazardous industrial waste)					
Fertilizer/landfill	2.5	2.5	1.0	1.0	7
Thermal process	2.5	3.5	1.0	1.0	7
4. Wind					
Installed cap. <= 50 kW	3.5	4.5	1.5	1.5	10
Installed cap. > 50 kW	3.5	3.5	1.5	1.5	10
5. Hydro (mini/micro hydro)					
Installed cap. <= 50 kW	0.8	1.5	1.0	1.0	7
Installed cap. 50-200 kW	0.4	0.8	1.0	1.0	7
6. Solar	8.0	6.5	1.5	1.5	10

Source: ERC

EXHIBIT 8-4

Feed-in Tariffs for VSPP Renewable Energy Projects

	FIT (F)	FIT (V 2017)	Total calculated FIT	Period of support	FIT premium	
					For bio-energy (8 years)	Southern provinces (project lifetime)
	(Baht/kWh)	(Baht/kWh)	(Baht/kWh)	(Years)	(Baht/kWh)	(Baht/kWh)
Waste (e.g. incineration, gasification)						
Capacity <= 1 MW	3.13	3.21	6.34	20	0.7	0.5
Capacity > 1 up to 3 MW	2.61	3.21	5.82	20	0.7	0.5
Capacity > 3 MW	2.39	2.69	5.08	20	0.7	0.5
Waste (landfill gas)	5.60	-	5.60	10	-	0.5
Biomass						
Capacity <= 1 MW	3.13	2.21	5.34	20	0.5	0.5
Capacity > 1 up to 3 MW	2.61	2.21	4.82	20	0.4	0.5
Capacity > 3 MW	2.39	1.85	4.24	20	0.3	0.5
Biogas						
From wastewater/waste products	3.76	-	3.76	20	0.5	0.5
From energy crops	2.79	2.55	5.34	20	0.5	0.5
Hydro power						
Capacity <= 200 kW	4.90	-	4.90	20	-	0.5
Wind power	6.06	-	6.06	20	-	0.5
Solar*	5.66	-	-	25	-	-

Note: Solar program for government agencies and agricultural cooperatives

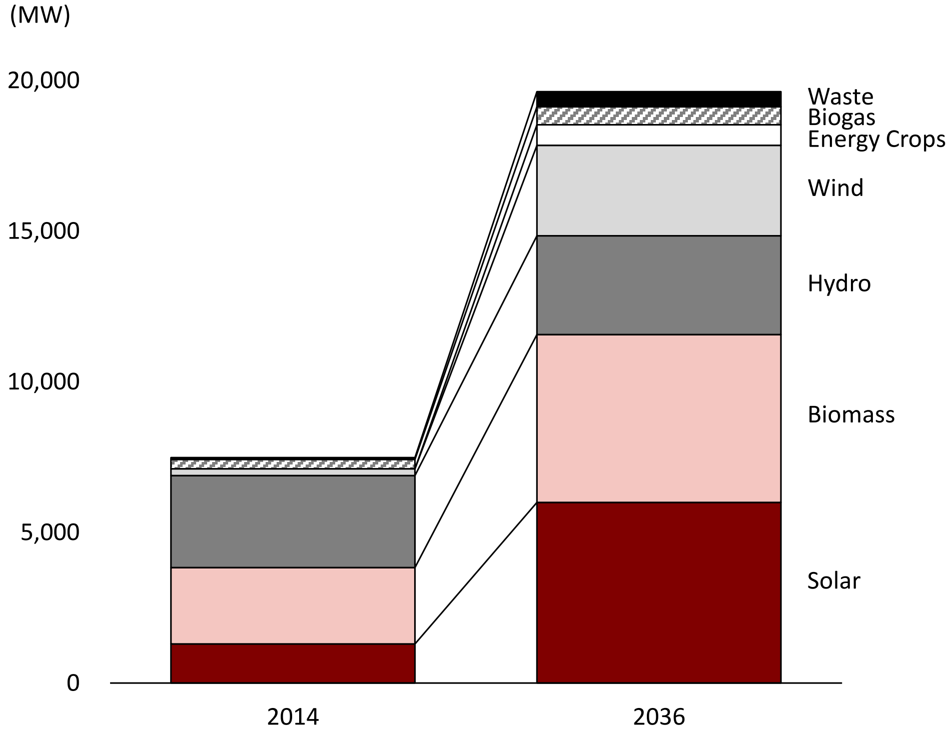
Source: ERC

8.3 Sector Growth Prospects and Outlook

As outlined earlier in this report, Thailand is expected to remain dependent upon natural gas for a significant proportion of its generation mix for the foreseeable future. Additional power is expected to be produced through more renewables, but also through hydropower, nuclear and coal. According to PDP2015, added capacities are expected to come mainly from biomass, solar, clean coal, nuclear and imports. It is expected that the share of renewable generation in the power mix will increase from 7% (in 2015) to 15-20% by 2036.

EXHIBIT 8-5

Current and Targeted Installed RE Capacity



Source: PDP2015

As noted above, significant additions in renewable energy capacity in the period from 2014 to 2036 are stipulated by the AEDP, most notably for biomass, wind and solar. By 2036, MOE expects that solar power will account for 31% renewable capacity additions, while wind is expected to account for 15 %. Biomass will also be dominant in capacity additions, with 28 % of the total share. Projected renewable capacity additions are illustrated in Exhibit 8-6 below.

EXHIBIT 8-6

Installed and Targeted RE Capacity

	March 2016		2036 Target	
	Capacity (MW)	Share	Capacity (MW)	Share
Solar	1,848	22%	6,000	31%
Biomass	2,442	29%	5,570	28%
Hydro	3,443	41%	3,282	17%
Wind	230	3%	3,002	15%
Energy crops	-	-%	680	3%
Biogas	304	4%	600	3%
Waste	132	2%	500	3%
Total	**8,399**	**100%**	**19,634**	**100%**

Source: PDP2015, ERC

8.4 Key Drivers and Challenges

A key challenge in the continued development of renewable-energy based generation, and achieving goals stipulated in the AEDP, is the transmission system constraints. After significant renewable capacity additions in the last ten years, the Thai utilities (EGAT and PEA in particular) now see transmission as a major constraint to the expansion of RE capacity.

The PDP2015 foresees the expansion of the transmission capacity to accommodate the connection of additional renewable capacity. This will facilitate the development of more large-scale RE plants, including wind and solar farms. In the short-term, new renewable energy applications need to match the capacity specified per substation.

Transmission constraints refer primarily to solar power, and to a lesser degree, to wind power. In the case of solar power, the problem has been exacerbated by a policy that enabled project development to take place in areas with cheap land and strong sun, not where the grid needs power. This is being addressed through programs that will zone new solar power. Wind resources in Thailand are primarily in remote areas, some of which are reserved for agricultural or preservation purposes. For biomass power and WTE the primary problem is fuel supply and particularly in the case of WTE, public opposition.

Although much has been said about the costs of renewable energy subsidies, according to AWR Lloyd analysis, the impact on ratepayers has been, and is expected to continue to be, very modest. Biomass power receives an adder in the range of 15% of the base rate and is cheaper than marginal new supply for power from LNG. Until recently, while solar PV under the adder scheme did have a significant subsidy that in effect up to tripled the solar tariff, the penetration of solar didn't exceed 3% of capacity or 1% of production at any point in time. This has never resulted in an increase in the average retail rate of more than over 3%. Prior to the fall in oil prices, new FITS for solar and waste were considered to be competitive as compared with costs of imported LNG-based power and offered risk mitigation benefits through diversifying the energy supply base. Although this argument may be weaker in the current lower gas price environment, it appears that given the relative cost and improving economics of renewable energy, renewable energy will remain an attractive source of energy in the future.

8.5 Competitive Landscape

From a competitive perspective the Thai renewables market remains immature with no dominant players or entities able to outcompete others in originating projects. While biomass is the largest sector, opportunities are dominated by agricultural companies, predominantly sugar mills, with captive fuels. The remainder of the industry is small and disaggregated.

Recently, several groups have begun to bundle groups of power plants. However, growth is constrained by competition for fuel in the biomass segment and limitations on the availability of new PPAs more broadly. Exhibit 8-7 lists the major Thai RE companies.

Wind Energy Holding (WEH) currently dominates the wind power sector as their first mover advantage has allowed them to achieve a market share higher than 90% and a competitive advantage by being the only firm to have developed a large project. However, Ratchaburi Electricity Generating Holding (RATCH), Gunkul and Energy Absolute also have wind projects that are in operation or under development. Several Thai companies also have significant international renewable energy portfolios.

In the last few years, there has been significant consolidation of operating assets and it is estimated that as much as 70% of RE capacity is owned by companies listed on the Stock Exchange of Thailand (SET). However, a successful listing has not proven to be a recipe for rapid growth. Solar giants SPCG and Energy Absolute have not managed to significantly grow their asset base despite successful listings. Bangchak Petroleum plans to list its 118 MW solar farm, but that was developed in 2010-2012 and its only large development since then was a recent acquisition in Japan. Bangchak is thought to be among the larger participants in the government and agricultural cooperatives solar program.

EXHIBIT 8-7

Major Thai Renewable Energy Companies (March 2016)

Company	Solar (MW)	Wind (MW)	Biomass (MW)	Comments
SPCG	181	-	-	- Total solar farm contracted capacity 206 MW (181 equity MW) - Solar rooftop of 30 MW expected COD in Q1 2017 - Japanese solar projects total contracted capacity 130 MW (51 MW equity MW) expected COD in Q1 2017 and Q1 2018
Energy Absolute	278	126	-	- Current three solar farms total 278 MW, and additional 90 MW expected COD by 2016 - Wind farms total 126 MW expected COD by 2016
Gunkul Engineering	88	12		- Solar farms (145 MW) and solar rooftop (5.3 MW) - First two wind projects in operation (12.5 MW), with an additional 160 MW under development - Two solar farms under construction in Japan (total 65 MW)
Thai Solar Energy	87.5	-	-	- Solar thermal 4.5 MW, solar PV farm 80 MW, and solar commercial rooftop 5 MW (co-invest with PTT-subsidiary GPSC) - Projects in pipeline include solar commercial rooftop 9 MW, Japanese solar farm 36.5 MW, three 8 MW biomass power plants
Bangchak Petroleum	118	-	-	- In January acquired 158 MW of operating and pipeline projects in Japan, considering IPO of RE subsidiary in 2016
Wind Energy Holding	-	207	-	- Over 92% of Thai wind capacity, deepest wind pipeline, acquired by KPN in June 2015
Mitr Phol Sugar Group	-	-	300	- Produced by five cogeneration plants fueled primarily by sugar cane, but supplemented by other agricultural waste. Power produced is used internally and exported.
Khon Kaen Sugar	-	-	160	- 35 MW more in planning process, most power consumed internally,
Total	**752.5**	**345**	**460**	

Note: Data for solar, wind and biomass refer to equity equivalent stake, data under comments include total installed capacity in which companies have a stake.

Source: ERC

Section 9. International Experience in Waste to Energy and Refuse Derived Fuel

9.1 Global Waste Management Practice

9.1.1 Major sources of waste

Solid waste originates from a broad range of sources, including residential, commercial and industrial sources (see Exhibit 9-1). A recent UNEP study estimates the global total of solid waste generation at 7-10 billion tonnes per year (Global Waste Management Outlook 2015).

EXHIBIT 9-1

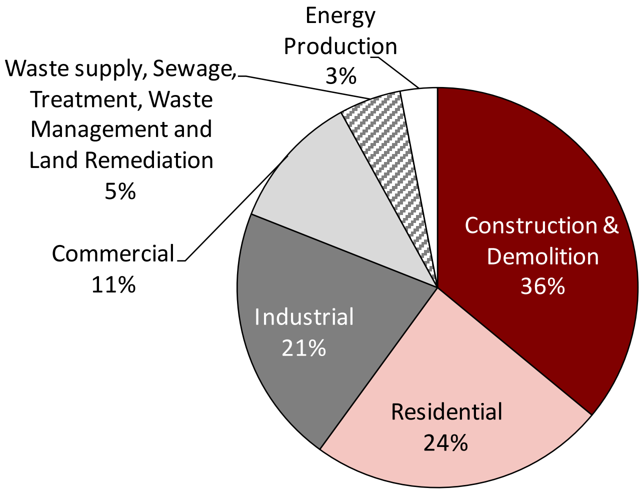
Sources and Types of Solid Waste

Source	Typical Waste Generators	Types of Solid Wastes
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, household hazardous wastes, e-wastes
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes, e-wastes
Institutional	Schools, hospitals (non-medical waste), prisons, government buildings, airports	Same as commercial
Construction and Demolition (C&D)	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, bricks, tiles
Municipal Services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas, sludge

Source: Adapted from What a Waste, a Global Review of Solid Waste Management, World Bank, 2012

EXHIBIT 9-2

Share of Global Solid Waste by Source in OECD Countries (2015)



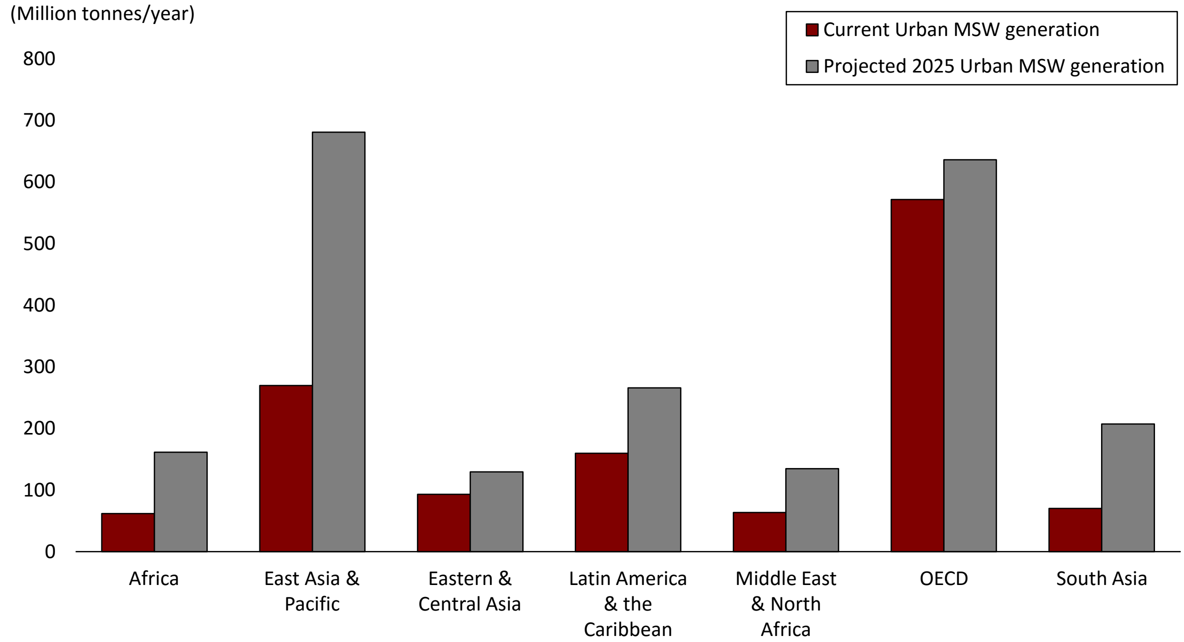
Source: UNEP

There is no formal definition of Municipal Solid Waste (MSW), but typically it refers to solid waste generated in population centers, originating from households, commerce and trade, office buildings, institutions and small businesses, yards and gardens, street sweepings and litter containers. It does not include waste from industries, construction and demolition or municipal sewage treatment.

Most MSW is generated in urban areas. Currently, more than 50% of the world's population lives in cities, and the rates of urbanization are increasing quickly. According to a global waste study by the World Bank (What a Waste, 2012), in 2002 there were 2.9 billion urban residents who generated about 0.64 kg of MSW per person per day (0.7 billion tonnes per year). By 2012 this had increased to about 3 billion residents generating 1.2 kg of MSW per person per day (1.3 billion tonnes per year). By 2025 this will likely increase to 4.3 billion urban residents generating about 1.42 kg per person per day of MSW (2.2 billion tonnes per year). The largest increases will occur in Asia, with China, India, Indonesia, Pakistan and the Philippines among the 10 countries in the world with the largest increases in projected urban MSW volumes by 2025.

EXHIBIT 9-3

Current and Projected 2025 Urban MSW Generation



Note: Organization for Economic Cooperation and Development (OECD)

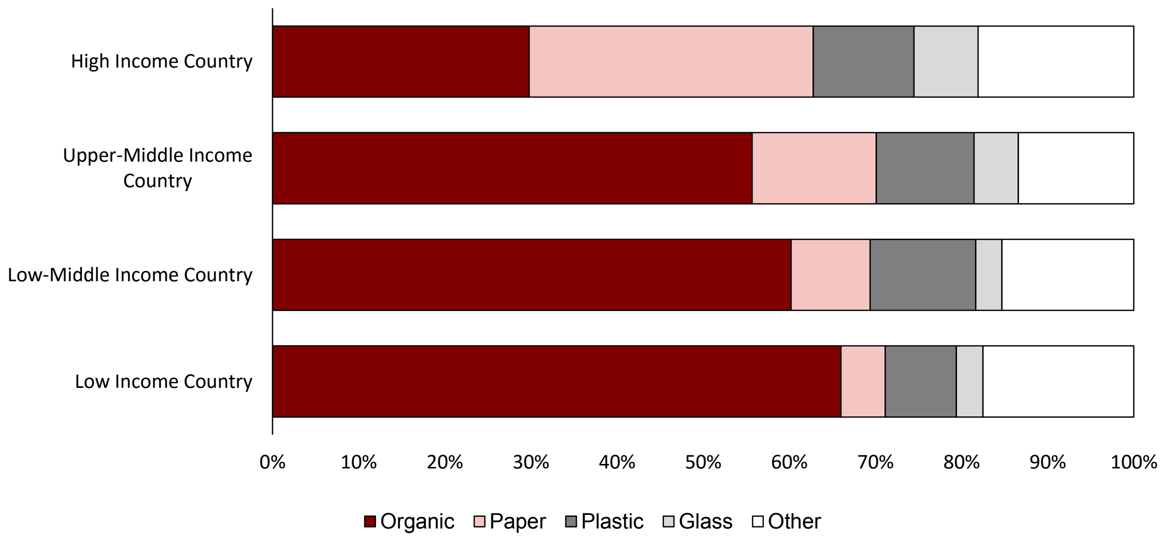
Source: Global Analysis of the Waste-to-Energy Field, EU Coolsweep Programme, 2013

9.1.2 MSW Composition

There are considerable differences in MSW generation rates across countries, between cities, and even within cities. Furthermore, there are significant variations in MSW composition for countries with different income levels, as shown in Exhibit 9-4. According to World Bank classification, Thailand attained upper middle-income status in 2011.

EXHIBIT 9-4

Waste Composition by Country Income Level



Source: World Bank (2013)

MSW composition significantly affects options for Solid Waste Management (SWM) and the choice of technology for collection, recycling and reusing. Over the last 50 years, the content of paper, plastics and other packaging materials has increased in high-income countries, significantly increasing the calorific value, making both recycling and Waste-to-Energy (WTE) more attractive. In contrast, the higher levels of organic content in lower-income countries means that the MSW is wetter, denser and has a lower calorific value, so additional drying and processing may be required for WTE.

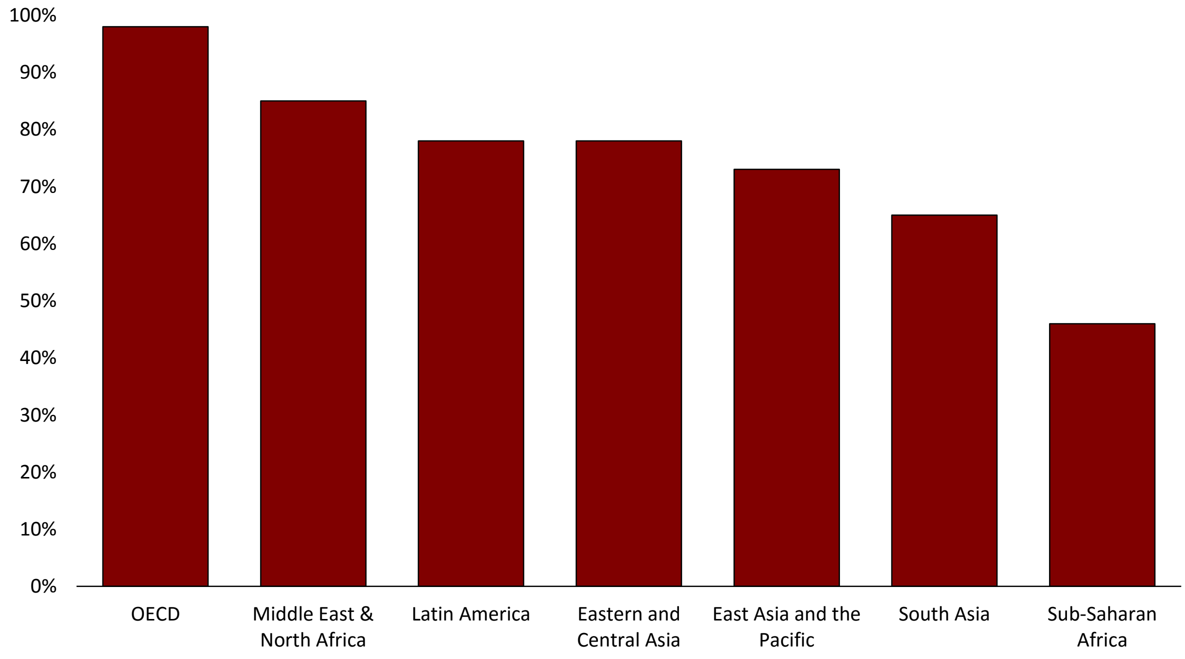
9.1.3 MSW Collection

Waste collection refers to the collection of MSW from point of production (residential, commercial, and institutional) to the point of treatment or disposal. MSW collection services come in a wide variety of shapes and forms. Services may be delivered by the formal sector, through either public- or private-sector operators, or by the community or 'informal' sector, through for example community-based organizations, non-governmental organizations (NGOs) or micro- and small enterprises.

The share of MSW collected varies widely by national income and by region. In low-income countries, collection services make up the bulk of a municipality's SWM budget (as high as 80% to 90% in many cases), yet collection rates tend to be much lower, due to lower collection frequency and efficiency. In high-income countries, although collection costs can represent less than 10% of a municipality's budget, collection rates are usually higher than 90% on average and collection methods tend to be mechanized, efficient, and frequent.

EXHIBIT 9-5

MSW Collection Rates by Region



Source: World Bank (2013)

9.1.4 Impacts of Improper Disposal

Improper MSW disposal can have severe impacts on public health and the environment, both locally and globally.

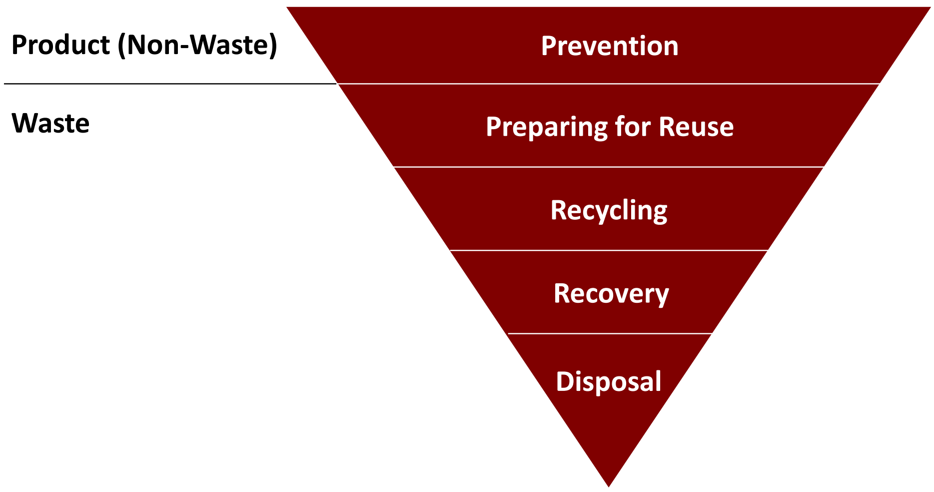
- Public Health: The uncontrolled burning of MSW releases particulate and persistent organic pollutants that are highly damaging. Accumulated waste and blocked drains are major contributing factors to flooding. In addition, they encourage vectors to breed, resulting in the spread of cholera, dengue fever and other infectious diseases. Uncontrolled dumpsites, and in particular the mixing of hazardous and other wastes, can cause diseases in neighboring settlements as well as among waste workers.
- Local Environment: In low- and middle-income countries, MSW is often dumped in low-lying areas and land adjacent to slums, rivers or seas. This leads to the contamination of groundwater and surface water by leachate, as well as air pollution from burning of waste that is not properly collected and disposed. Lack of enforcement of waste regulations means that potentially infectious medical and hazardous waste may be mixed with MSW, which is harmful to waste pickers and the environment.
- Global Environment: Poorly managed dumpsites located near the coast may pollute the coastal environment, leading to economic losses from decreased tourism and damage to fisheries. Coastal dumpsite erosion is also a source of marine litter. Decomposition of MSW is a large source of methane, a powerful greenhouse gas (GHG). It has been estimated that a 10 to 15% reduction in global GHG emissions could be achieved through landfill mitigation and diversion, WTE, recycling, and other types of improved SWM.

While it is difficult to estimate the amount of improperly disposed waste and associated costs, it usually results in down-stream costs being higher than what it would have cost to manage the waste properly in the first place. Research suggests that in a low- or middle-income city, the direct and indirect costs to society and the economy may be 5-10 times higher than the costs of proper waste management.

9.1.5 Waste Management Solutions

Solutions for the management of solid waste are often ranked in a hierarchy of preferred options. For example, the European waste policy is organized around a five-step waste hierarchy that EU member states are obligated to implement in their own legislation in order to move waste management up the hierarchy.

EXHIBIT 9-6
EU Waste Hierarchy



Source: EU Waste Framework Directive

EXHIBIT 9-7

Levels in the EU Waste Hierarchy

Prevention	Covers measures taken before a substance or product has become waste that reduces the quantity of waste and its adverse impacts on the environment and human health. Prevention is not seen as a waste management operation as it deals with objects before they can be defined as waste.
Preparing for Re-Use	Any operation by which products or components that are not waste are used again for the same purpose for which they were conceived.
Recycling	Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. Includes reprocessing of organic material but not energy recovery or the reprocessing into materials as fuels or for backfilling operations. Activities are classified as recycling if they include any physical, chemical or biological treatment leading to a material which is no longer classified as waste.
Recovery	Waste being used or prepared to replace materials that would otherwise have been used for a particular function. Incineration is only classified as a recovery if the waste is principally used as fuel or other means of generating energy.
Disposal	Any operation which is not recovery even where the operation includes secondary reclamation of substances or energy. Disposal includes landfilling, backfilling and (co-)incineration with low energy recovery.

Source: Adapted from Drivers for Waste-To-Energy in Europe, EU Coolsweep Programme, 2013

According to World Bank's report 'What a Waste' published in 2013, the total costs of SWM globally are estimated at USD 205 billion per year, and are expected to increase to about USD 376 billion by 2025. For low and lower-middle income countries waste management costs are projected to increase by more than four-fold during the same period.

EXHIBIT 9-8

Estimated Solid Waste Management Cost by Disposal Method

	Low Income Countries	Lower Middle Income Countries	Upper Middle Income Countries	High Income Countries
Gross National Income per capita (USD)	< 876	876 - 3,465	3,466 - 10,725	> 10,725
Waste Generation (tonnes/capita/yr)	0.22	0.29	0.42	0.78
Collection Efficiency (share collected)	43%	68%	85%	98%
Cost of Collection and Disposal (USD/tonne)				
Collection[1]	20-50	30-75	40-90	85-250
Sanitary Landfill	10-30	15-40	25-65	40-100
Open Dumping	2-8	3-10	n/a	n/a
Composting[2]	5-30	10-40	20-75	35-90
Waste Incineration[3]	n/a	40-100	60-150	70-200
Anaerobic Digestion[4]	n/a	20-80	50-100	65-150

Note: 1) *Collection includes pick up, transfer and transport to final disposal site for residential and non-residential waste*

2) *Composting excludes sale of finished compost (which ranges from USD 0 to USD 100/ton)*

3) *Waste Incineration includes sale of any net energy; excludes disposal costs of bottom and fly ash*

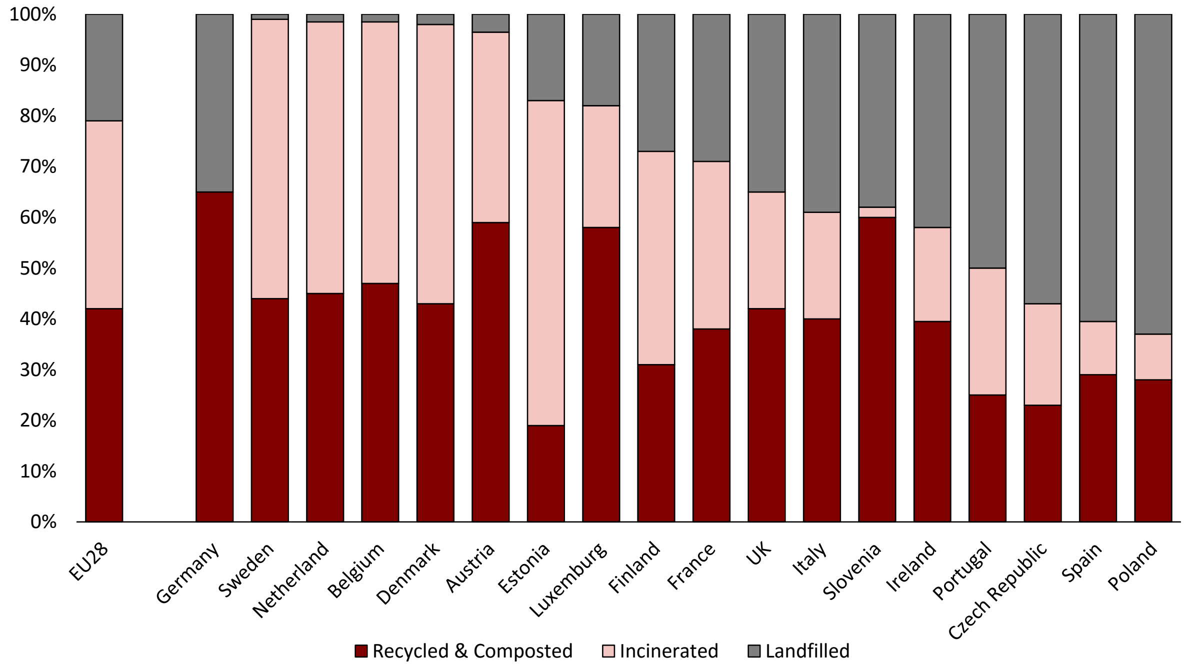
4) *Anaerobic Digestion includes sale of energy from methane and excludes cost of residue sale and disposal*

Source: *World Bank*

While critics often argue that large-scale WTE plants tend to discourage recycling and lead to greater amounts of waste, in fact countries with the highest rates of garbage incineration also tend to have high rates of recycling and composting of organic materials and food waste. Recycling allows for more effective waste separation and sorting, leading to a more efficient fuel for incineration.

EXHIBIT 9-9

MSW Treatment in Europe (2013)



Source: Confederation of European Waste-to-Energy Plants (CEWEP)

9.2 Waste-to-Energy Industry

While there is no standard definition of Waste-to-Energy (WTE), it typically refers to the generation of energy from MSW. Modern WTE facilities are considered a safe, technologically advanced and economically viable means of waste disposal while also generating energy, reducing GHG emissions and supporting recycling through the recovery of metals and other non-combustibles.

9.2.1 Global WTE Industry Overview

A 2015 WTE market study by ecoprog estimated that in 2015 there were more than 2,200 WTE plants active worldwide, with a total disposal capacity of approximately 280 million tonnes of waste per year. Technologies employed include incineration, alternative thermal treatment technologies such gasification, anaerobic digestion and landfill gas recovery, with incineration as the dominant technology. Between 2010 and 2014 more than 250 thermal treatment plants with an annual capacity of nearly 60 million tonnes were constructed, and almost 550 additional plants with an annual capacity of about 150 million tonnes will be constructed by 2024.

In a 2015 WTE study, Grand View Research estimated the value of the global WTE market at USD 25.3 billion in 2013, projected to reach USD 37.6 billion in 202o, growing at a CAGR of 5.9% between 2014 and 2020. Europe has traditionally been the largest regional WTE market, accounting for 47.6% of total market revenue in 2013. Increasing solid waste coupled with EU waste legislation are the major factors that drive the market.

According to the same study, Asia is expected to register the highest growth rate at an estimated CAGR of 7.5% from 2014 to 2020. This is largely due to increasing WTE technology penetration in Japan. Furthermore, increasing volumes of solid waste in China and India coupled with government initiatives to promote sustainable energy generation is expected to drive these markets. Both China and India have been developing low-cost WTE technology which is expected to reduce the investment costs of WTE plants.

WTE is mature in several European markets and in Japan. China's WTE industry has grown rapidly and seems poised to continue expanding for some time. Other countries are following suit. WTE plants in operation include 520 plants in the EU, 86 in the US, 328 in Japan and 200 in China. India also appears on track to develop the WTE market with 6 new projects with a total capacity of 74 MW of projects expected to launch in 2016, adding to the 154 MW of existing capacity.

EXHIBIT 9-10
WTE in Major Markets

Country	# WTE Plants	Waste Processed (Million tonnes/year)	Share of Waste Processed
Europe	520	95	26%
USA	86	31	12%
Japan	328	38	62%
China	200	4	15%

Source: AWR Lloyd research

Worldwide, there are multiple examples of companies building substantial businesses that profitably operate WTE plants at industrial scale. German company Energy from Waste (EEW) has a fleet of 18 projects that jointly process 4.7 million tonnes of waste per year. In February 2016 EEW was acquired by China's Beijing Enterprises for 1.44 billion Euros. According to the Financial Times, the purpose of the acquisition was to strengthen Beijing Enterprises' ability to compete in the growing Chinese WTE market. Hong Kong-listed Chinese renewables company China Everbright International currently operates 16 WTE plants across China, with a total annual capacity of 6.8 million tonnes. The company is planning a further 8 plants that will handle an additional 3.4 million tonnes.

EXHIBIT 9-11
Examples of Major WTE Companies

Company	Country	No. of Plants	Electricity	Waste Processing Capacity (million tonnes/year)
EEW	Germany	18	2,400 GWh	4.7
China Everbright	China	16	1,655 GWh	6.8
Covanta	USA/Canada	41	1,405 MW	54.0

Source: AWR Lloyd research

9.2.2 WTE in Southeast Asia

Southeast Asia's WTE markets are beginning to develop, with projects operating and under development in several countries:

- Singapore had the largest installed WTE capacity in the region, with 168 MW as of March 2016. This consists of four facilities that process all solid waste that remains after recycling. Any remaining ash and other non-combustible materials are disposed at Singapore's only landfill. All four WTE plants employ direction combustion and steam turbine technology. Three of the plants are owned by the National Environment Agency (NEA), one of which is operated by the company Keppel Seghers. The fourth plant (22 MW) was developed by the same company under a Design, Build, Own and Operate model, with a 25-year concession starting in 2009. The plant uses air-cooled tumbling grates and a flue gas treatment system. Keppels Seghers operates a total WTE capacity of 58 MW in Singapore.

- Thailand has the highest private sector involvement in WTE in the region. In Thailand, as of March 2016, there were 23 WTE power plants selling electricity to the grid with a total capacity of 132 MW. TPI Polene Power (TPIPP) is the largest WTE company in Southeast Asia with a total capacity of 80 MW from RDF-fired power plants in operation. TPIPP also operates 70 MW WHR power plants (30 and 40 MW). Another 70 MW of RDF capacity is under construction, as well as a 70 MW RDF/coal plant that will serve as the company's backup. Besides grid-connected WTE plants, industries use solid waste to co-fire with coal in boilers and kilns, in particular at cement factories (see Section 11 for more details).
- In Indonesia five landfill gas projects were built with the intention to sell carbon credits under the Clean Development Mechanisms. Three of these projects have been discontinued since the sharp decrease in the price of carbon credits. Two projects remain in operation with a total capacity of 8 MW, operated by the company Navigat Organic. Central and local government have recognized the potential of WTE for waste management, and have initiated programs with international donors and the private sectors to stimulate its development. Like for other renewables, the government has set FIT tariffs for waste combustion and landfill gas recovery, varying by voltage level and location, but these are significantly lower than FITs for WTE in Thailand.
- In the Philippines the only WTE facilities in operation are four methane recovery projects at landfill sites, with a combined capacity of 25 MW. There is not separate target or FIT for WTE, but WTE projects are eligible for a general biomass FIT of PHP 6.63 per kWh, which is comparable to the FIT for waste in Thailand. The Clean Air Act of 1999 bans all forms of mass incineration of waste. This means that WTE developers have to use more advanced (and possibly costlier) technology such as gasification and pyrolysis.

EXHIBIT 9-12

WTE in Southeast Asia (March 2016)

Country	# WTE Plants	Installed Capacity (MW)	Waste Processed (Million tonnes/year)	Share of Waste Generated
Thailand	23	132	n/a	n/a
Singapore	4	168	2.7	38%
Philippines	4	25	n/a	n/a
Indonesia	2	8	n/a	n/a

Note: Projects in Thailand either use direct combustion (6) or other technologies (17); All projects in Singapore are combustion-type plants; All projects in Indonesia and the Philippines are landfill gas.

Source: AWR Lloyd research

9.2.3 WTE Technologies

A wide variety of WTE technologies has been developed, mostly in high-income countries. These technologies are able to meet high environmental standards when properly operated, albeit at high investment and operating costs. To achieve high efficiencies, combined heat and power, or heat recovery, is often applied. Waste can be used directly, or after basic pre-processing to prepare Refuse Derived Fuel (RDF).

Combustion, also referred to as incineration in the waste sector, is a thermal process that burns the waste in a furnace or boiler to generate heat or steam, which can subsequently drive a turbine for power generation. Mass-burn combustion, in which solid waste is burned in a grate combustion system with little or no pre-sorting of the waste material, is by far the most common WTE technology. Many incineration plants are combined heat and power (CHP) plants, in which the heat or steam is recovered from the boiler or turbine to be re-used for heat applications, greatly increasing the system's overall efficiency.

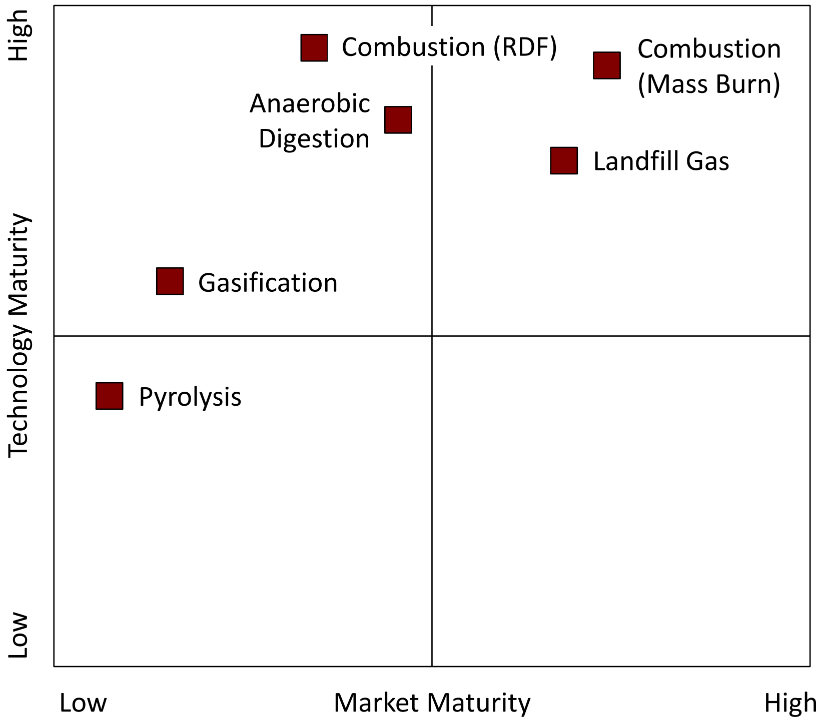
Gasification is defined as the thermal conversion of organic materials at temperature of 540 to 1,540 °C, with a limited supply of air or oxygen. This creates a low to medium calorific gas, called producer or syn-gas, which can be used to produce heat or power. Although more mature than some other processes, it requires complex systems, particularly for gas filtration and purification.

Pyrolysis is the thermo-chemical decomposition of organic material. The process involves the simultaneous change of chemical composition and physical phase that is irreversible. Pyrolysis occurs at temperatures above 400°C in a complete lack of oxygen atmosphere. The syn-gas produced is generally converted to liquid hydrocarbons, such as biodiesel.

Anaerobic Digestion converts the organic portion of waste into a combustible biogas. In this biological process, microorganisms are used to break down organic waste in the absence of oxygen in an enclosed vessel. The resulting biogas consists of 60%-70% methane, 30%-40% carbon dioxide, and other trace chemicals. It can be used to power gas engines or turbines, or purified and compressed to be used as vehicle fuel.

Landfill Gas (LFG) technology is a form of anaerobic digestion that captures the combustible gas released through the decomposition of solid waste at landfills. LFG contains roughly 50-55% methane and 45-50% carbon dioxide, with less than 1% as other organic compounds and trace amounts of inorganic compounds. Most (more than 70 %) of the LFG projects that generate electricity use internal combustion engines.

EXHIBIT 9-13
Market vs. Technology Maturity of WTE Technologies



Source: Pike Research

The output of a WTE plant is highly dependent on the characteristics of the waste, plant efficiency, and technology. In Germany, a WTE typically generates 600 kWh per ton of waste. Available data for WTE plants in Asia shows that 1 tonne of waste approximately generates 300-400 kWh. To a large extent, the difference is due to the difference in waste composition and heating value, since MSW in high-income countries typically has lower moisture content and higher content of combustible component, particularly paper.

Regardless of technology employed, a properly operated WTE facility typically comprises the following main elements:

1. Delivery and storage of the waste
2. Transfer of waste to process chamber to generate heat, steam or combustible gas
3. Electricity generation through a steam turbine or internal combustion engine
4. Electricity distributed to the local or national grid
5. Collection and processing of ash to extract metal for recycling and prepare for disposal or reuse
6. Collection of all gases, to be filtered and cleaned before being emitted into the atmosphere
7. Monitoring and control of emissions, pollutants and operating parameters to ensure compliance with permit conditions and environmental standards.

9.2.4 Regulatory Framework

To explore the full potential of WTE, a consistent and supportive regulatory framework is required. Government policies can play a major role in creating incentives for WTE. In Europe a number of national and EU policies have been introduced to help move Europe away from dependency on fossil fuels, and which have encouraged an increase in WTE capacity.

The European case exemplifies how regulations can drive the deployment of WTE. To a large extent, the European WTE market has been driven by the EU Landfill Directive of 1999, which specified a higher standard for landfill sites. Because many existing sites were not able to meet these standards, it led to the closure of thousands of older landfills and dumpsites all over Europe. In addition, the Directive stipulated a time schedule for reducing the amount of biodegradable waste being sent to landfills for each EU member state. Overall, the Directive bans the landfilling of 'untreated' MSW and several countries have reduced or even banned the landfilling of MSW. This became a very strong market driver for both recycling and energy generation from waste.

Individual EU member states have chosen different strategies to implement the directive, leading to cross-country market dynamics. Among others, these include favorable power tariffs, tax on carbon emissions, high landfill fees, and bans on landfilling. Countries like Austria, Germany and the Netherlands were the first to implement the new standards and are currently facing an overcapacity of WTE. On the other hand, the current lack of waste treatment facilities in the UK has led to an export boom, which grew to 2.4 million tonnes in 2014. This has led to the situation that Northern European plants were able to run at full capacity at the end of 2015.

In contrast, in the US only three WTE facilities have been installed since 1996. At federal level there is currently no national landfill tax or fee, although some fees exist at local or state level. Large variations exist between regions, with the Northeastern states having the highest number of WTE facilities, due to limited land availability and higher landfill costs.

9.2.5 WTE Business Models and Economics

The economic feasibility of WTE plants depends on three main factors:

1. Investment costs: covers land, design & engineering, equipment, as well as project development and management costs. Capital costs can vary widely between countries and markets. While capital cost for WTE in the U.S. is approximately USD 600-750 per annual metric ton of capacity, in China it is approximately USD 200, largely due to lower labor and equipment costs.
2. Revenue: to a large extent dependent on the business model chosen. Depending on the market, a WTE plant can pursue the following revenue streams:
    a. Tipping fees
    b. Sales of electricity and heat
    c. Sales of RE certificates to utilities
    d. Sales of carbon credits
    e. Sales of recycled materials
3. Operational costs: includes salaries, sourcing of feedstock and financing costs

9.3 Refuse Derived Fuel (RDF)

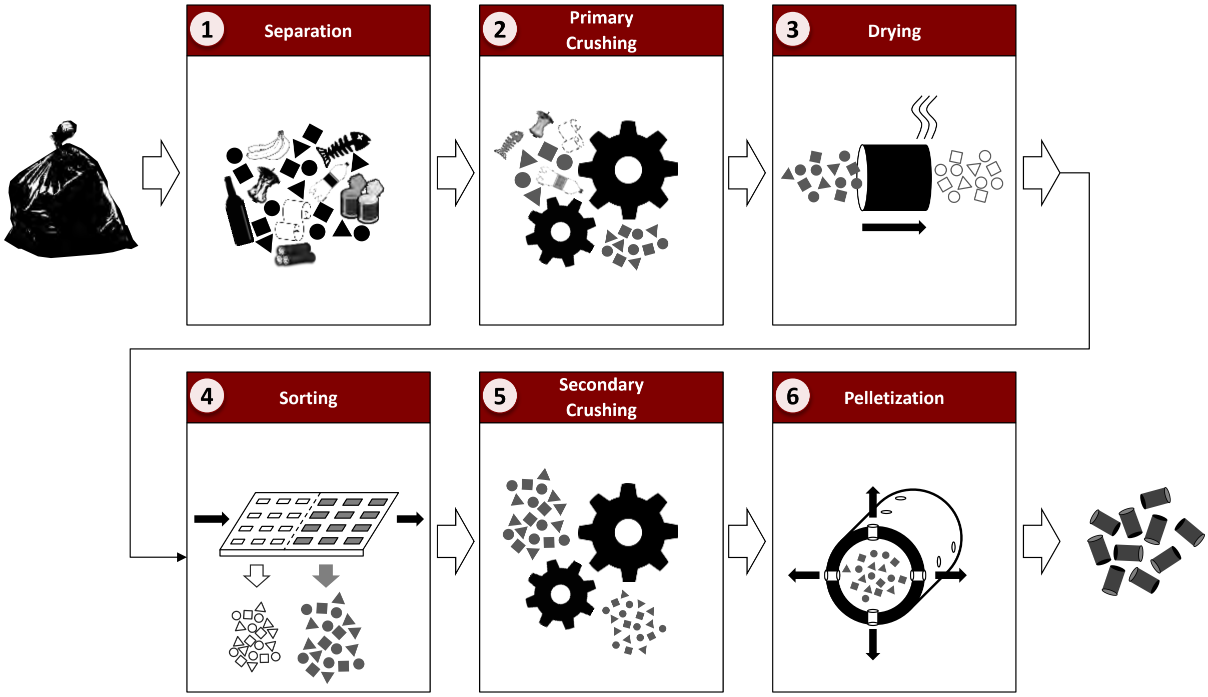
RDF is a fuel that is produced from solid waste, consisting largely of combustible components such as plastics and biodegradable waste. The waste can come from households, industry and commerce and is processed specifically for energy extraction. It can be used in WTE facilities and to offset standard fuels (e.g. coal) in cement kilns and power plants.

Waste materials which are generally reusable as RDF include tires, rubber, paper, textiles, exhausted oils, wood, and plastics. RDF is produced by removing the recyclable and noncombustible components of the waste and by shredding, drying and pelletizing the remaining waste into homogenous fuel. The quality of the fuel depends on the waste and the production process.

RDF is typically produced through multi-level processing in several stages (see Exhibit 9-14).

EXHIBIT 9-14

RDF Processing Process



Source: AWR Lloyd research

9.3.1 Benefits and Challenges

One of the most appealing aspects of RDF is that it can be employed as a supplementary fuel in conventional boilers, (partially) substituting for fossil fuels, which leads to:

- Reduction in GHG emissions
- Avoidance of landfilling
- Increased production of energy from renewable energy sources
- Reduced dependency on the import of energy, enhancing security of energy supply

RDF provides several advantages over untreated MSW, including:

- Longer storage periods before decomposing
- Higher bulk density allowing for easier handling and transportation
- Higher calorific value per tonne of fuel
- More homogenous fuel composition resulting in a more efficient combustion process

RDF is successfully burned in stoker boilers as well as in bubbling and circulating fluidized bed combustion technology boilers. It needs lower excess air than unprocessed waste and is hence a more efficient fuel. Removal of non-combustible material reduces the size of both the fuel and ash handling systems, resulting in a lower-cost boiler system compared to a mass-burn system.

Waste used for RFD production is often a heterogeneous mixture of materials. This is particularly true for MSW, whereas industrial waste is often less heterogeneous. Therefore, it is often a challenging task for RDF producers to reduce heterogeneities by technology and adapted processing.

9.3.2 Common RDF Applications

RDF is used as substitute fuel in cement kilns, coal-fired power plants, lime kilns, industrial boilers and CHP plants delivering energy to industry and/or municipalities. RDF is widely used by the European cement industry to offset the use of fossil fuels and reduce GHG emissions.

District heating plants and the power industry are other sectors that use RDF for co-firing in coal-fired plants. They mainly co-combust non-hazardous secondary fuels such as waste wood, straw and dried sewage sludge. The paper industry also co-incinerates large quantities of waste mainly originating from its production processes (i.e. bark, paper sludge, spent liquor).

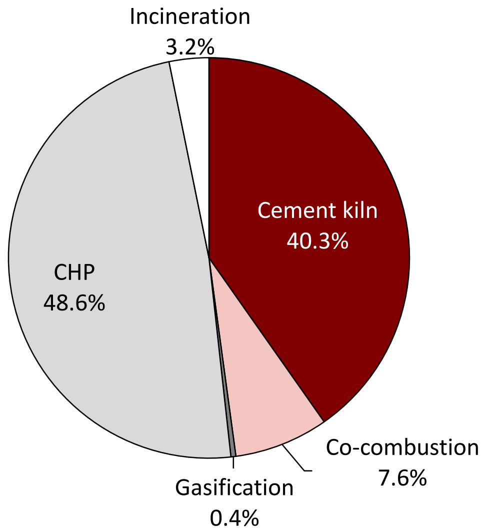
9.4 International Case Studies

9.4.1 RDF in the European Cement Industry

- Cement companies typically burn coal, petroleum coke and other fossil fuels in cement kilns.
- Partly in response to obligations under the Emissions Trading Scheme (ETS), the European cement industry has widely adopted co-firing RDF in cement kilns to displace fossil fuels. In some EU member states, the potential of co-firing RDF is even close to saturation.
- In 2012, the European cement industry used 9.6 million tonnes of RDF, corresponding to a substitution rate of fossil fuels of about 37% (around 3 million tonnes of coal). The cement industry accounts for over 40% of RDF use in Europe.
- To minimize emissions, legal restrictions on the use of waste in EU cement industry require the waste fuel to be burnt at a temperature of over 850 °C with a minimum retention time of 2 seconds. This prevents the generation of dioxins because of long stay at a high temperature in a cement kiln.

EXHIBIT 9-15

Use of Solid Recovered Fuels (SRF) in Europe (2012)

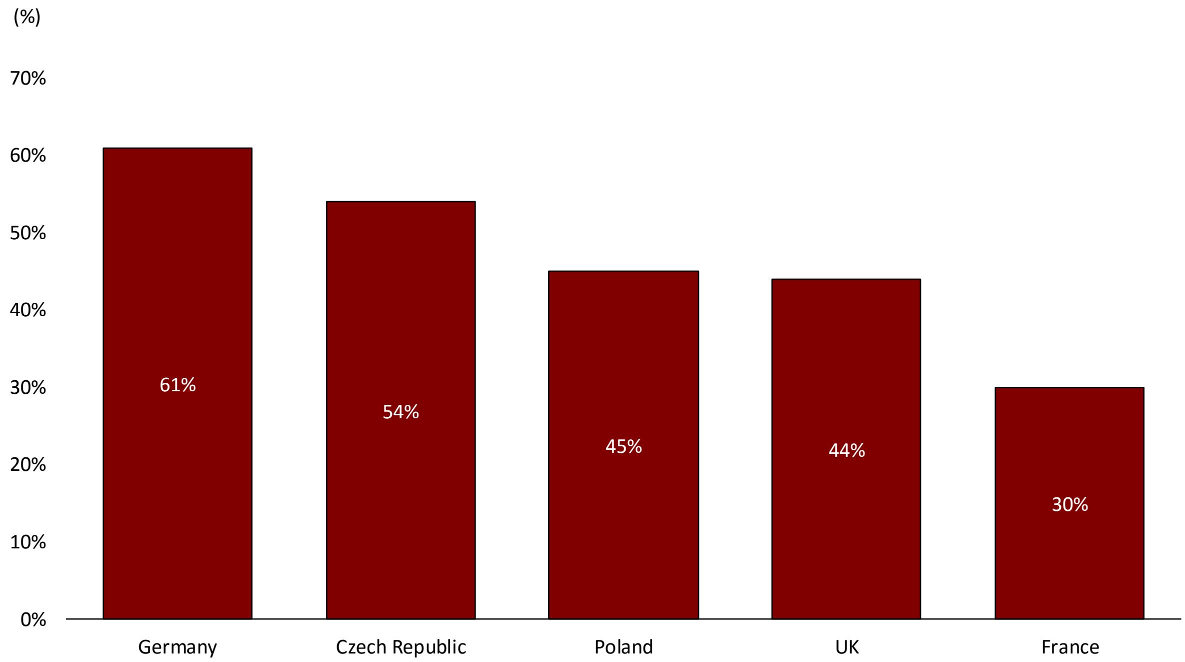


Note: SRF is a type of RDF that meets the classification and specification requirements laid down in EN15359 (Standard from the European Standardisation Committee).

Source: European Recovered Fuel Organisation (ERFO)

EXHIBIT 9-16

Fossil Fuel Substitution by RDF in European Cement Industry (2010)

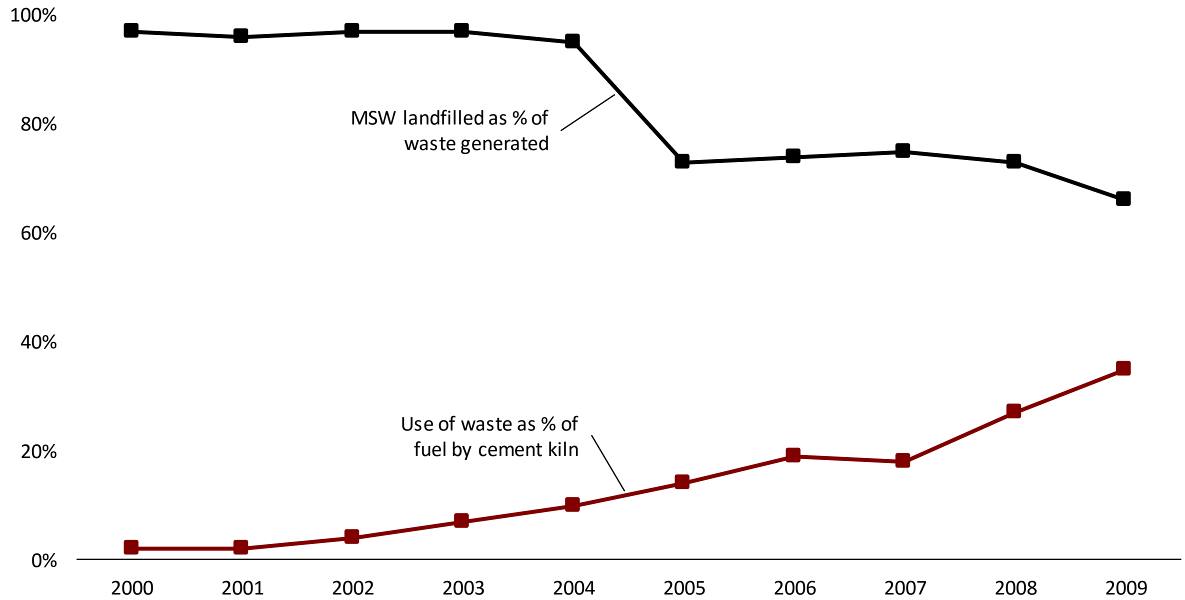


Source: Ricerca Sistema Energetico

Co-firing of RDF in cement kilns has been conducive in kick-starting landfill diversion in markets where WTE was initially too expensive, e.g. in Poland in the 2000s (see Exhibit 9-17). With a substantial cement industry, Thai cement factories provide a similar entry to the market for RDF, with several cement companies in Thailand already using RDF for operating their kilns.

EXHIBIT 9-17

Waste Use by Cement Industry and MSW Landfilling in Poland (2000-2009)



Source: World Business Council for Sustainable Development

9.4.2 WTE in Chinese Cities

- With increasing urbanization, MSW generation in China's major cities is growing rapidly, with more than 180 MT/yr collected. While landfilling is still the main method of urban waste management, cities are increasingly looking to WTE as a waste management strategy.
- More than 30 large and medium-sized cities operate, or are building, WTE plants. Total processing capacity in major cities has grown to more than 10 million tonnes of MSW per year and over 500 MW.
- Beijing currently has the largest WTE plant in China, processing 1,300 tonnes per day and generating 136 GWh/yr. The city is planning to invest more than USD 0.3 billion in four additional plants.
- Shenzhen has recently begun the construction of three large incinerators to handle the increasing amount of waste generated in the city. In 2015 waste generation stood at 15,000 tons per day and this has been growing by 6.1% annually. One of the new plants will be the world's largest waste-to-energy plant when it opens in 2018, with a capacity of 5,000 tonnes of waste per day.
- The build-operate-transfer model is the preferred model for financing and operating WTE plants in urban China. Under the model, a private operator receives a 20-30 year concession to finance, construct and operate the facility, earning revenue from gate fees and electricity sales. Gate fees vary widely between cities, from as low as 4 USD/MT, up to 39 USD/MT. WTE plants receive a subsidized tariff for electricity sales of 0.10 USD/kWh.
- Economic analysis shows that a plant with an annual processing capacity of 383,000 tonnes/yr requires an investment of USD 74 million, excluding land costs. To be feasible such a plant requires a minimum gate fee of USD 20 per tonne of MSW.

- While WTE has emerged as a cost-effective solution for urban areas, the public has opposed to the construction of WTE plants in some cities, due to inappropriate siting near residences and drinking water sources, the lack of public participation in decision-making, and incomplete disclosure of emission data.

EXHIBIT 9-18

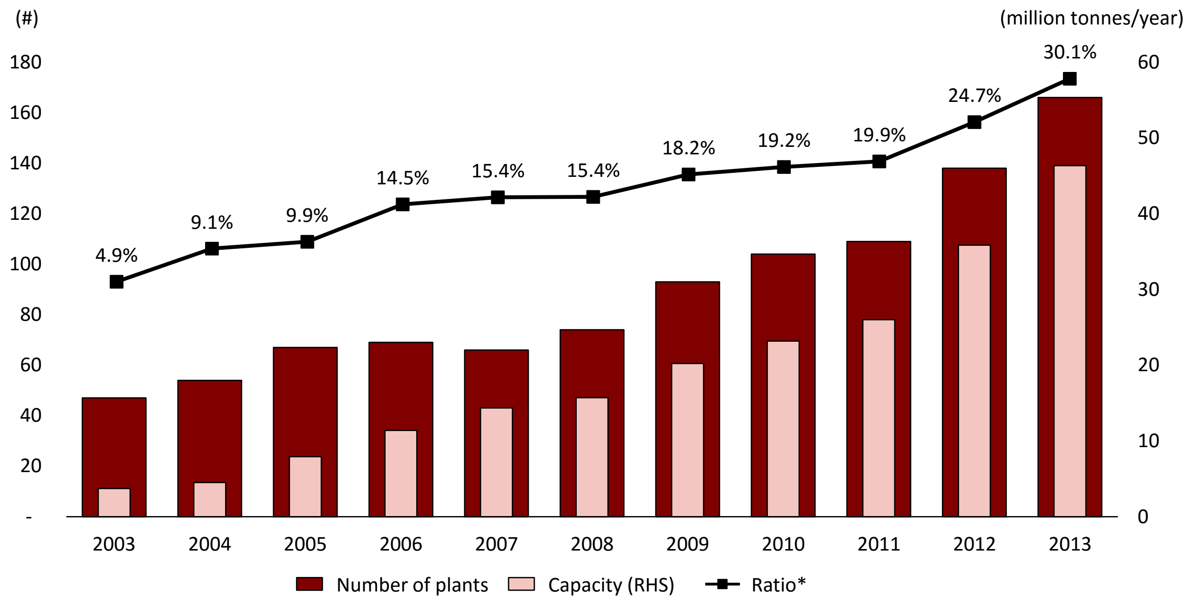
WTE Capacity in Major Cities in China

	MSW Generation (million tonnes/year)	MSW to WTE	WTE Capacity (tonnes/year)	Installed Capacity (MW)
Beijing	6.3	10.5%	528,000	30
Guangzhou	6.5	8.3%	990,000	55
Shanghai	7.3	14.8%	841,000	41

Source: Ling Qiu, Analysis of the Economics of Waste-To-Energy Plants in China (2012)

EXHIBIT 9-19

WTE Development in China (2003-2013)



Note: Ratio = Share of WTE capacity in overall waste management capacity

Source: Dongliang Zhang et al., Waste-to-Energy in China: Key Challenges and Opportunities (2015)

Section 10. Waste Management in Thailand

Compared to developed countries, waste management practices in Thailand are relatively underdeveloped. Similar to most developing countries, Thailand is faced with increasing amounts of waste each year while waste collection and treatment practices are still inadequate. Nevertheless, waste management is improving. The government has recently put the issue of solid waste management on the national agenda. Local governments nationwide have come under increasing pressure to better manage open dump sites. The related government agencies have started to collect more extensive data and revise assessment methodologies.

It should be noted that data on waste volumes, characteristics and management in Thailand can be incomplete and are often out of date. The data presented in this section are the best available at the time of research. While it would be preferable to have more recent data available for an analysis of the Thai waste sector, the information below provides a comprehensive overview of waste management practices and trends. In particular, Thailand's PCD did its most comprehensive study of the composition of Thai waste at a local level in 2003, so this report draws on it for some data. This information is presented for purposes of demonstrating differences between various municipalities, which are significant. More recent data, presented in this report, should be used for other purposes.

10.1 Industrial Waste and MSW in Thailand

Waste in Thailand can be broadly grouped into two main categories: industrial waste and Municipal Solid Waste (MSW), referred to in Thailand as community waste.

10.1.1 Industrial Waste

In 2014, industrial waste accounted for 34% of total waste generation. The Department of Industrial Works (DIW) is responsible for the registration of industrial waste that is reported by factories. In 2007, 18 million tonnes of waste from factories was registered across the country. The Eastern region generated the most, accounting for 30% of the total. Of the total 18 million tonnes, 16 million tonnes was non-hazardous and 2 million tonnes was hazardous. The top 10 provinces accounted for 74% of the total amount with Rayong, Lampang and Chonburi ranked as the top three provinces.

As shown in Exhibit 10-1, DIW reported that of the 18 million tonnes of industrial waste generated in 2007, 30% was recycled, 15% burned as fuel or WTE, 13% was sorted for resale, 13% went to disposal or treatment, 8% was reused or recovered and 22% was used for animal food, fertilizer, land reclamation or exported.

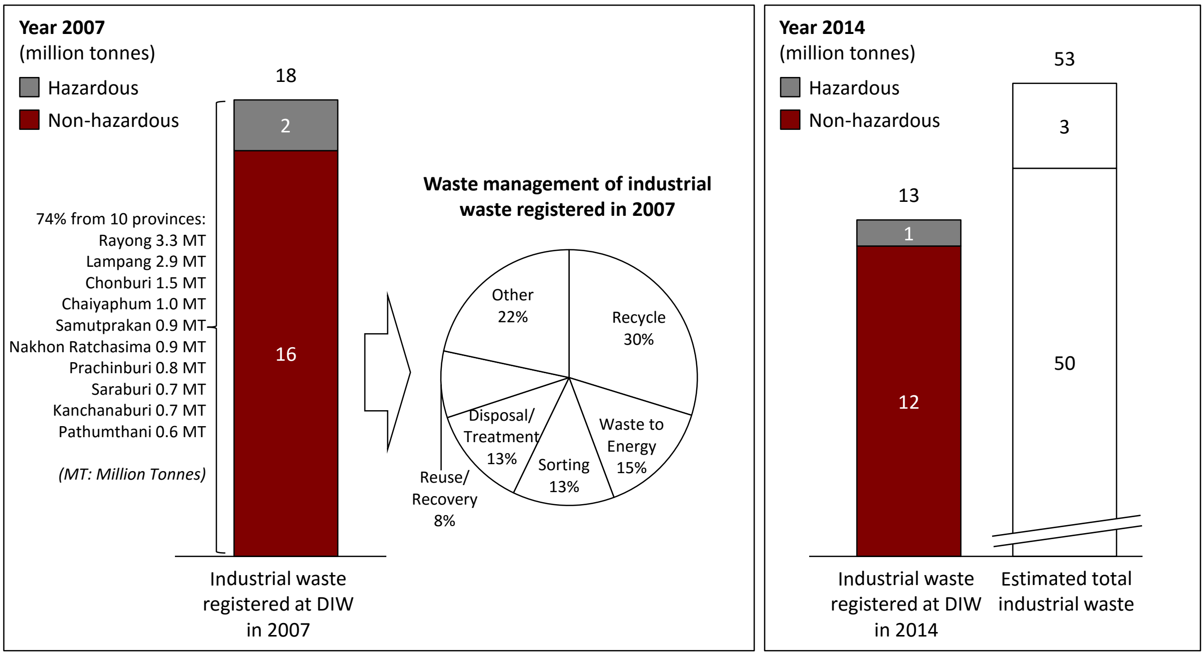
More recent data illustrate the challenge in obtaining accurate waste data and enforcing proper disposal methods. Officially, DIW registered 13 million tonnes of industrial waste in 2014. Of this amount, 12 million tonnes was reported as non-hazardous waste and 1 million tonnes as hazardous waste. DIW, however, estimated that the actual generation of industrial waste was much higher, at approximately 53 million tonnes in 2014, of which 50 million tonnes was non-hazardous and 3 million tonnes hazardous. DIW attributed the difference of 40 million tonnes to be the unreported amount, of which unreported hazardous waste was 2 million tonnes. The government regards this as a concern, as the waste may have been disposed of at community dumping sites or public areas, leading to contamination of the environment and adversely affecting communities.

As of February 2015, there are 69,955 factories that are potential waste generators but only 17,384 factories (25%) have registered on DIW's online waste management database, and only

5,297 factories (8%) have registered to bring industrial waste out of the factories. The DIW then set up a roadmap for industrial waste management for 2015-2019 targeting to increase registered factories by 12,000 per year, increase properly disposed non-hazardous and hazardous industrial waste by 8.01 and 0.47 million tonnes per year respectively.

EXHIBIT 10-1

Industrial Waste Generation (2007 and 2014)



Source: DIW

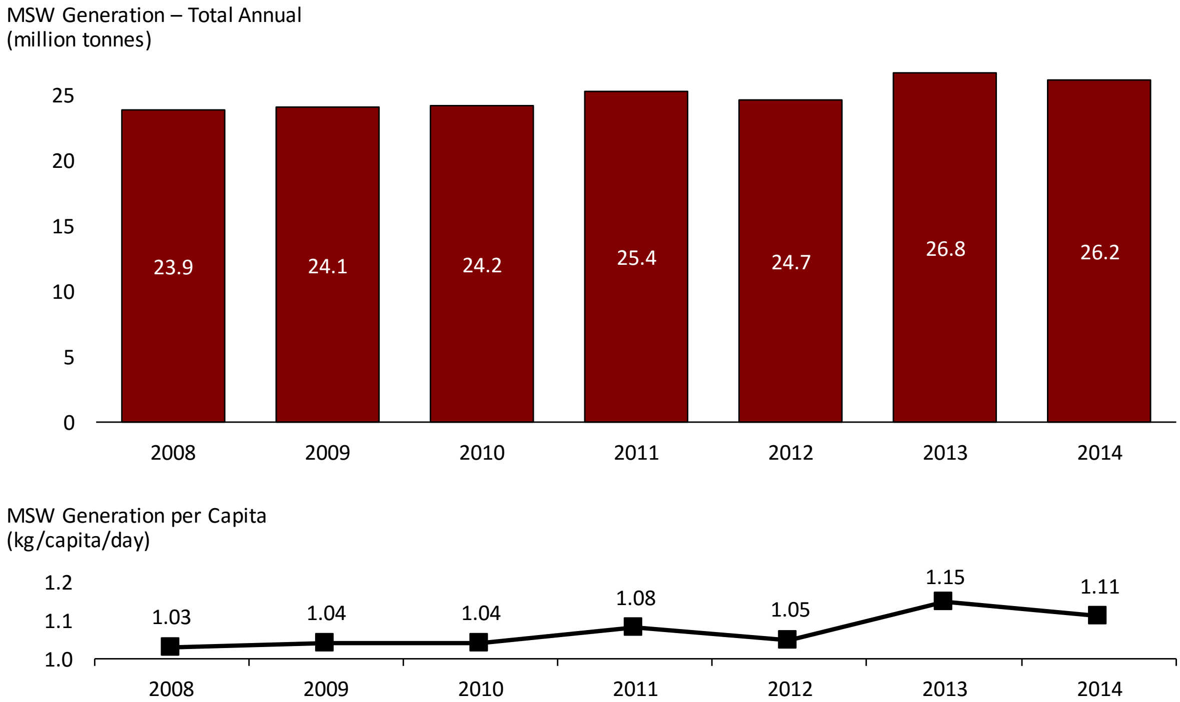
10.1.2 Municipal Solid Waste (MSW)

In 2014, MSW represented 66% of total waste generation in Thailand. MSW generation data from the Pollution Control Department (PCD) shows that MSW generation increased from 23.9 million tonnes (65,562 tonnes/day) in 2008 to 26.19 million tonnes (71,778 tonnes/day) in 2014.

Geographical location, climate, economic activities, social and urbanization affect the quantity of MSW generation. Generally, the greater the economic development and the higher the population, the greater the amount of MSW. For Thailand, MSW generation growth exceeds population growth which results in an increase in MSW generation per capita; from 1.03 kg/capita/day in 2008 to 1.11 kg/capita/day in 2014.

EXHIBIT 10-2

Thailand's MSW Generation – Annual Total and Per Capita (2008-2014)

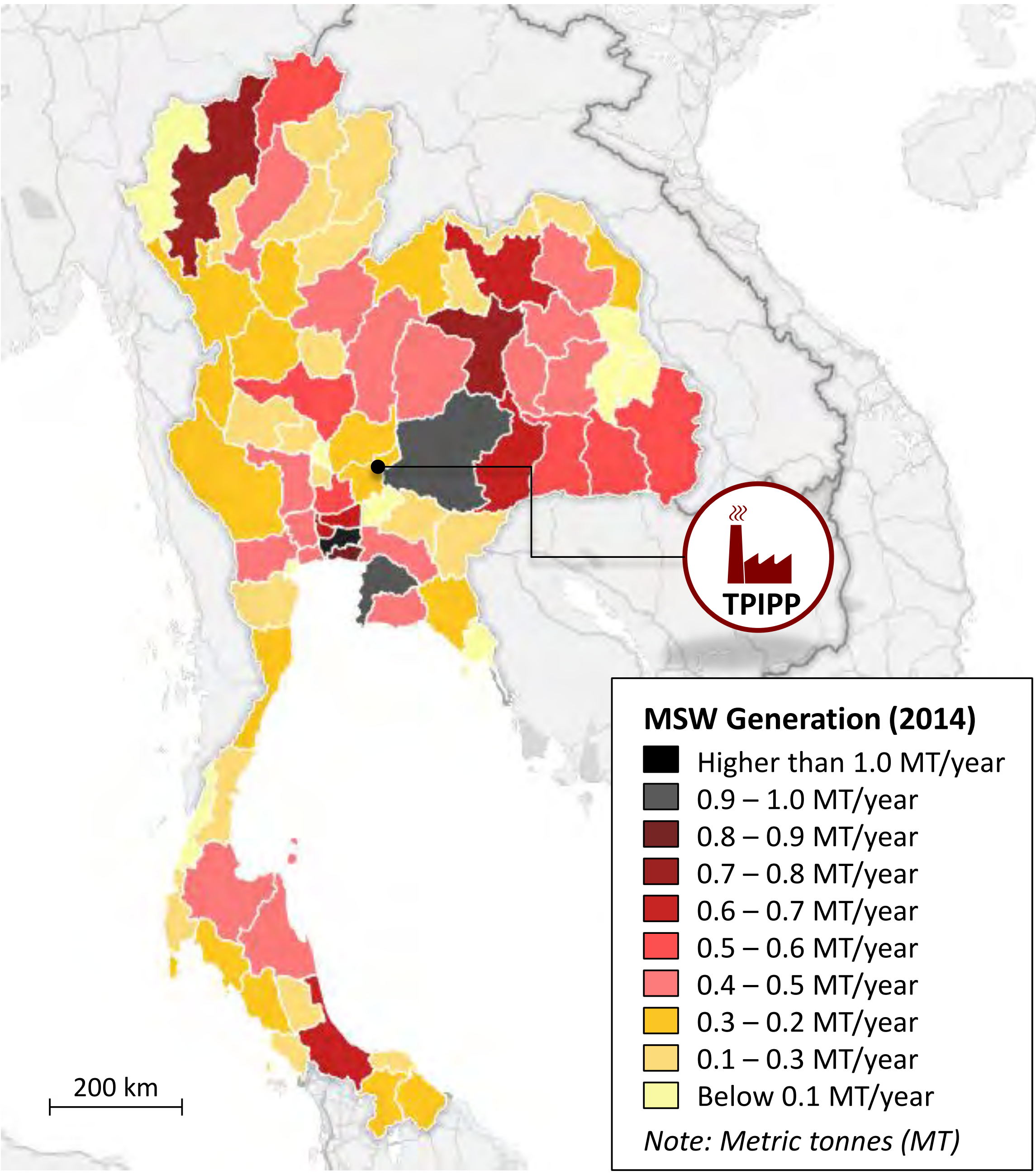


Note: Data for 2008-2012 estimated by PCD from 2013-2014 survey

Source: PCD

Note that 2013 and 2014 were the first two years in which PCD conducted nationwide surveys of MSW generation. These surveys were based on questionnaires completed in by each municipality. A level of discrepancy is expected and some of the annual variation could be caused by a change in reporting rather than an actual reduction in MSW generation.

EXHIBIT 10-3
Map of MSW Generation by Province (2014)



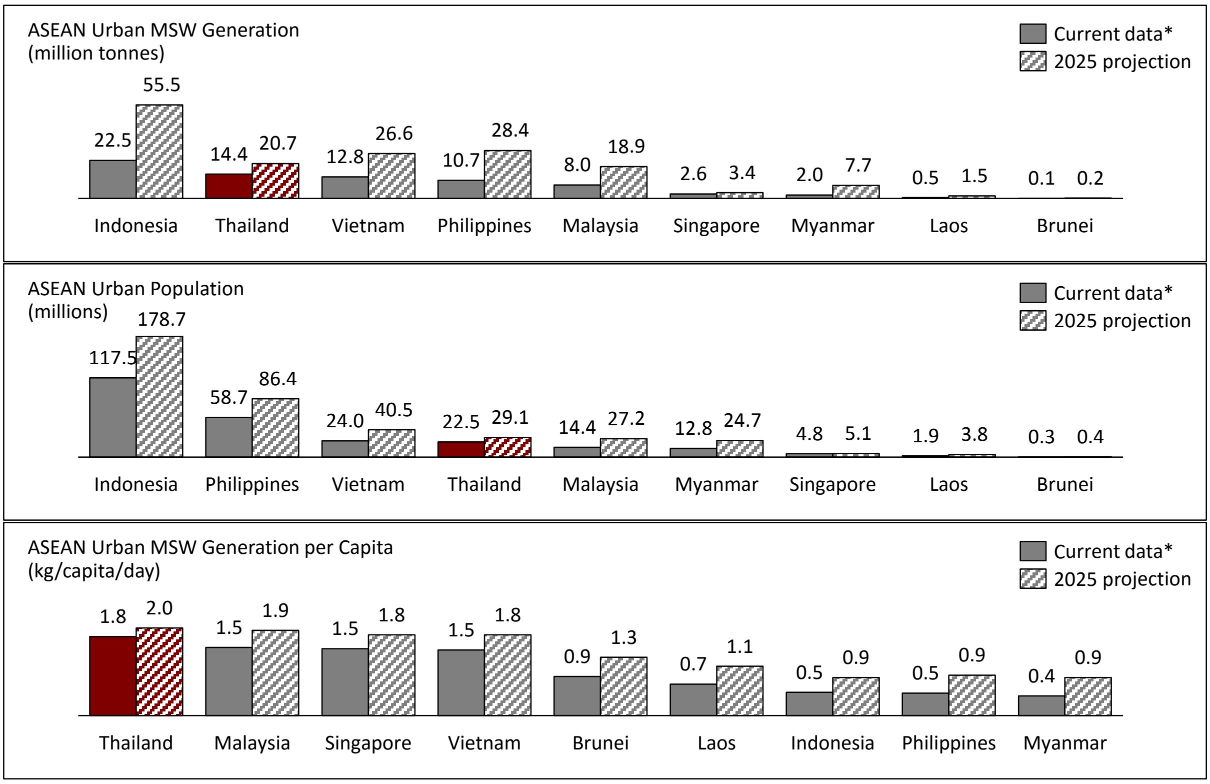
Source: PCD

Urban MSW

As in many countries, most MSW originates from urban areas. Compared with other ASEAN countries, Thailand ranks the highest in terms of urban MSW generation per capita, approximately 16% higher than Malaysia, Singapore and Vietnam. The forecast for 2025 by the World Bank shows that Thailand will still rank the highest in terms of MSW generation per capita compared to other ASEAN countries.

EXHIBIT 10-4

ASEAN Urban MSW Generation



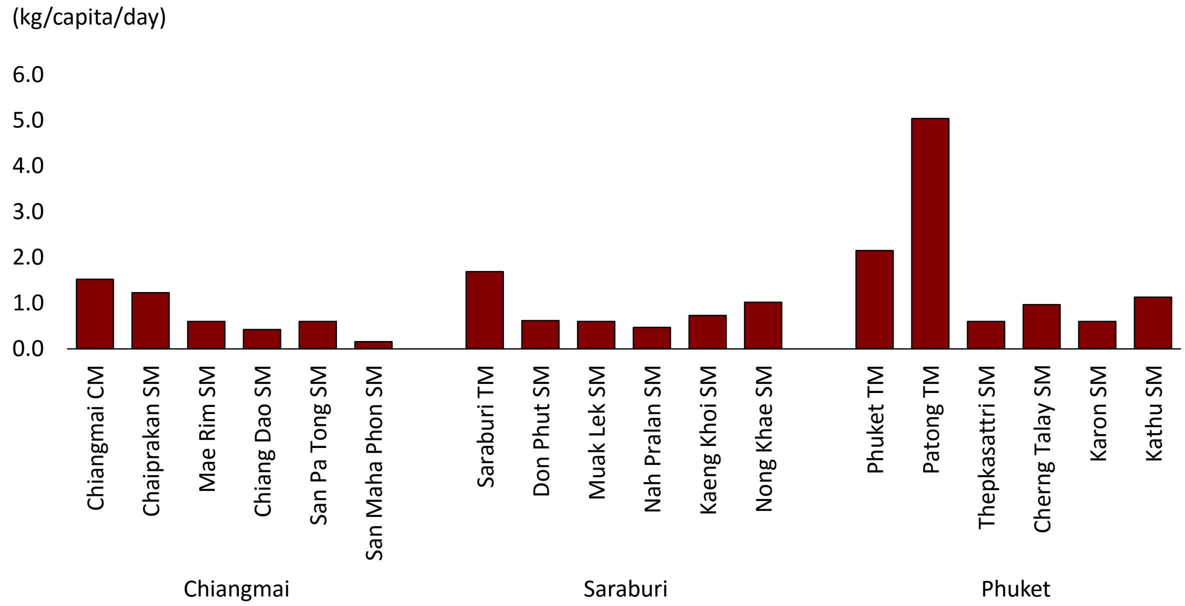
Note: Thailand, Singapore, Laos, Indonesia, Philippines (2008); Brunei (2006); Vietnam (2004); Malaysia (2002); Myanmar (2000); Cambodia data not available

Source: World Bank

MSW generation varies significantly from one area to another. According to data from PCD in 2007, different municipalities are selected to demonstrate that MSW generation varies greatly across different communities. Exhibit 10-5 shows the variations in MSW generation per capita in selected municipalities in Chiangmai, Saraburi and Phuket. The rate can be as high as 5.0 kg/capita/day in Patong Town Municipality, a major tourism area in Phuket province, or very low at 0.16 kg/capita/day in Sanmahapon Sub-district Municipality, which is a small town in Chiangmai province.

EXHIBIT 10-5

MSW Generation per Capita – Selected Areas (2003)



Note: City Municipality (CM), Town Municipality (TM), Sub-district Municipality (SM)

Source: PCD

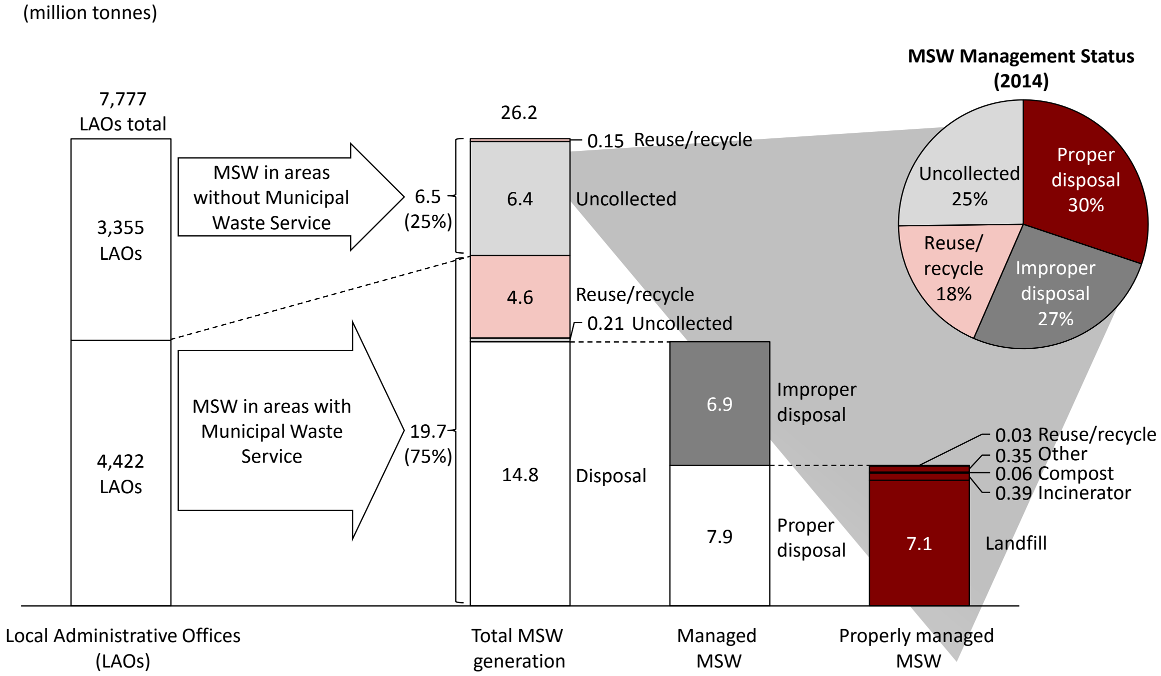
10.2 MSW Management

There are many government organizations related to waste management in Thailand overseeing different aspects from policy making to implementation, which will be covered in Section 10.5. Local governments are responsible for collecting and managing waste - and they have ownership of the waste once it is placed outside a home. Each local government faces different levels of complexity and has different capability, e.g. level of hazardous and infectious waste, trained staff, and availability of disposal sites. Each local government may use different methods for collecting, transporting and disposal of MSW in its area including hiring private waste management companies.

In 2014, 4,422 out of total 7,777 local governments provided MSW collection and disposal services (see section "Regulatory Framework" for details on local governments). MSW that was generated in these 4,422 localities accounted for 19.7 million tonnes (75%) of the total MSW generation in the country, while the remaining 6.5 million tonnes (25%) was left locally untreated.

EXHIBIT 10-6

Thailand's MSW Management (2014)



Source: PCD

As shown in Exhibit 10-6, out of the 19.7 million tonnes of waste collected in 2014, 4.6 million tonnes (17.7%) was reused or recycled, 0.2 million tonnes (0.8%) was uncollected and 14.8 million tonnes (56.5%) was sent to total 2,450 disposal sites in the country. Of the amount disposed, 7.9 million tonnes (30.2%) was sent to 480 proper disposal sites, while 6.9 million tonnes (26.3%) was sent to 1,970 improper disposal sites, most of which are open dump sites.

EXHIBIT 10-7

Proper and Improper MSW Disposal

Proper Disposal		Improper Disposal
Sanitary Disposal	**Acceptable Disposal**	
• Engineering Landfill • Sanitary Landfill • Incinerator • Waste to Energy (WTE) • Compost • Mechanical-Biological Treatment (MBT)	• Control Dump < 50 tonnes/day • Incinerator < 10 tonnes/day with air pollution control	• Open Dump • Control Dump >= 50 tonnes/day • Open Burning • Incinerator without air pollution control

Source: PCD

EXHIBIT 10-8

Number of Properly and Improperly Managed Disposal Sites (2014)

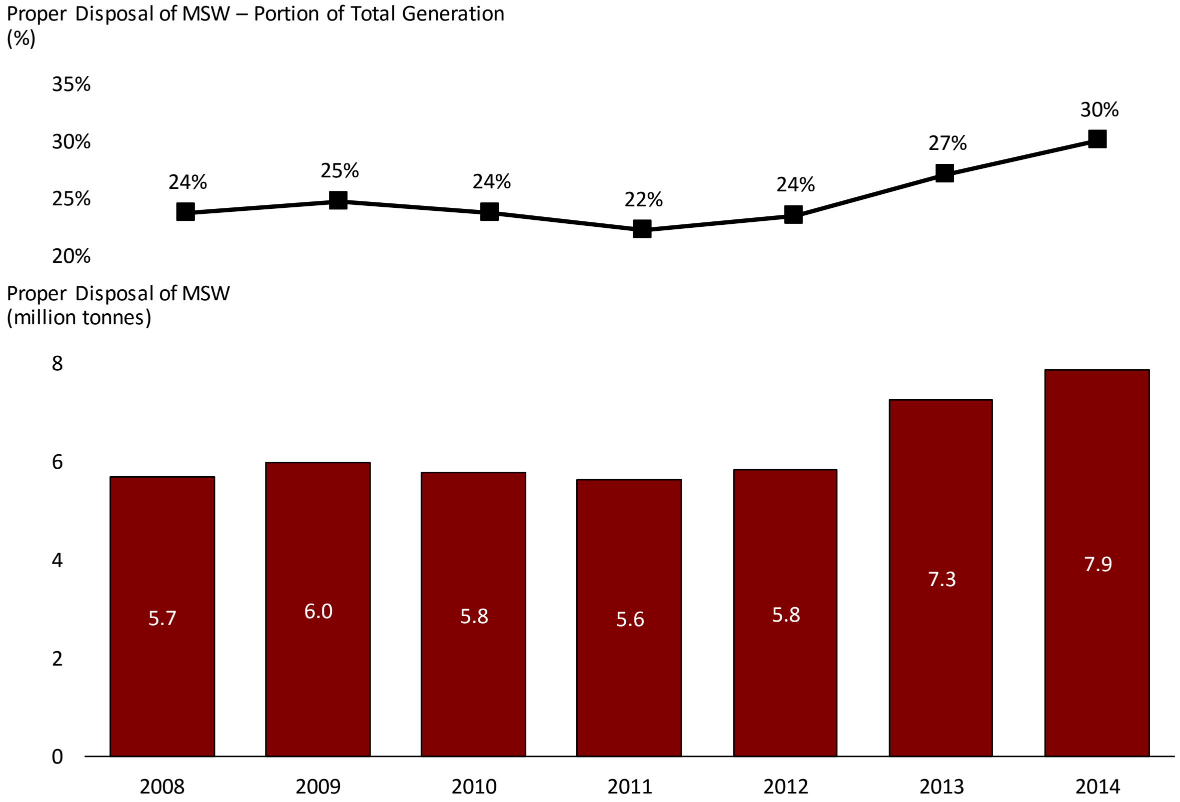
Proper Disposal Sites			Improper Disposal Sites		
Disposal Type	**Public**	**Private**	**Disposal Type**	**Public**	**Private**
Sanitary & engineered landfills	73	5	Controlled dumps > 50 tonnes/day	18	7
Controlled dumps < 50 tonnes/day	356	25	Open dumps	1,783	115
Incinerators with air pollution control	1	2	Incinerators without air pollution control	42	5
Incinerators < 10 tonnes/day with air pollution control	2	-			
Integrated system	12	-			
Mechanical-Biological Treatment (MBT)	1	1			
Waste to Energy (WTE) technology	-	2			
Total	**445**	**35**	**Total**	**1,843**	**127**
Grand total	**480**		**Grand total**	**1,970**	

Source: PCD

Thailand is facing many challenges in waste management. MSW generation has been increasing, while 25% of total MSW is still uncollected and untreated. 43% of local governments do not have MSW management services, and only 30% of the total MSW is properly disposed of. Although the share of proper disposal has been increasing over the past years, Thailand's waste disposal still relies heavily on landfill and open dump sites. Out of the total MSW, 26.8% went to landfills and 26.3% went to open dump sites around the country.

EXHIBIT 10-9

Thailand's Proper Disposal of MSW (2008-2014)



Source: PCD

Other developing countries also rely heavily on open dumping and landfill. Open dumping is the easiest method because it requires minimal budget and trained staff. However, it is considered an improper disposal method which adversely affects the environment and nearby communities. Sanitary landfill disposal is considered a proper method but it requires higher investment and more expertise to operate than open dumping.

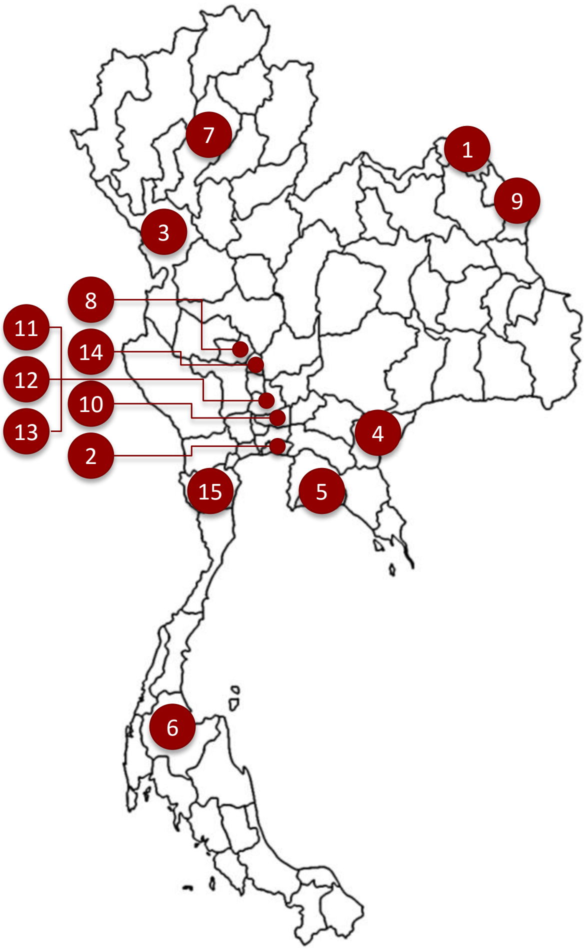
10.2.1 Impacts of Improper Waste Disposal

For decades, waste has been improperly disposed of and accumulated at various open dump sites in the country. In addition, hazardous and infectious waste was found illegally dumped at waste disposal sites as well as in abandoned areas. This has impacted local communities. In July 2015 PCD reported a total of 30.8 million tonnes of accumulated improperly managed waste at open dump sites in the country as of 2014.

In 2014, there were a total of 15 fires at disposal site. The most critical one was at Praekasa dump site in Samut Prakan province which took up to a week to be brought under control. The fire created toxic smoke that required the evacuation of residents within a 1.5 km radius of the site. An investigation of the incident found that there was also industrial waste illegally dumped into the Praekasa site.

EXHIBIT 10-10

Fire Incidents at Open Dump and Landfill Sites in 2014



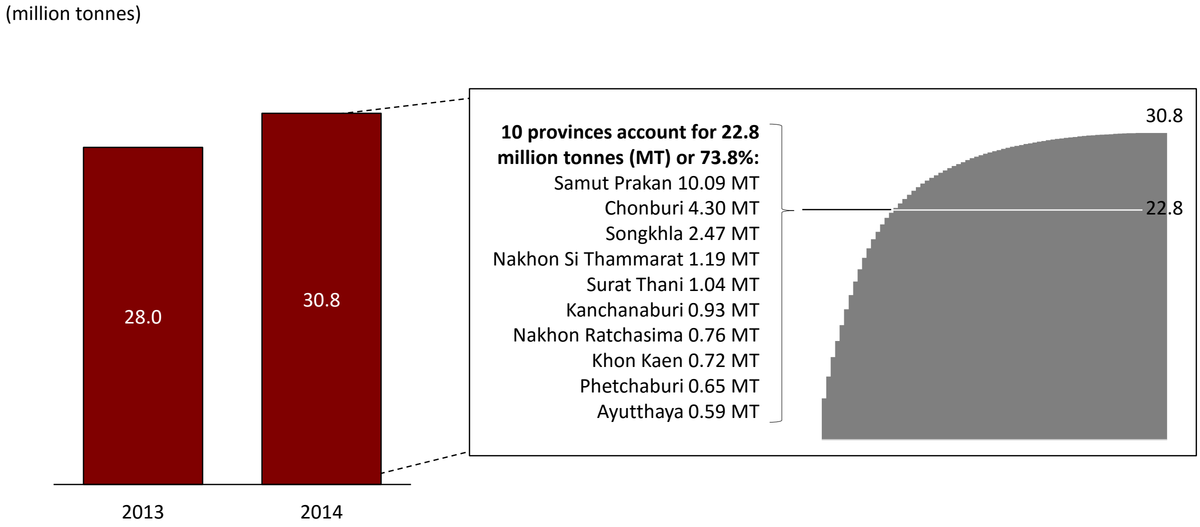
No.	Date	Location
1	March 13	Buengkan, Buengkan
2	March 16-22	Praekasa, Samutprakan
3	March 19	Chongkaeb, Tak
4	March 20	Aranyaprathet, Sakaeo
5	March 20	Samnakthong, Rayong
6	March 20	Surat Thani, Surat Thani
7	April 6	Kohka, Lampang
8	April 6	Khao Tha Phra, Chai Nat
9	April 21	Ban Pang, Nakhon Phanom
10	April 27	Lad Sawai, Pathumthani
11	May 3	Ayutthaya, Ayutthaya
12	May 15	Ta Ruea, Ayutthaya
13	May 18	Nakonluang, Ayutthaya
14	June 3	Intaburi, Singburi
15	June 12	Ban Huay Taklae, Phetchaburi

Source: Ecological Alert and Recovery Thailand

In the draft of the Waste Management Master Plan 2016-2021, PCD reported a total amount of accumulated improperly disposed waste of 30.8 million tonnes as of 2014 across the country. Of this amount, the top 10 provinces accounted for 73.8% of the total.

EXHIBIT 10-11

Accumulated Improperly Disposed MSW (2013-2014)



Source: PCD

10.3 Case Study: MSW Management in Bangkok

The waste management system of the Bangkok Metropolitan Administration (BMA) encompasses a variety of waste disposal methods and outsourcing models. BMA has among the most advanced waste management systems in the country, in that it manages to dispose of all its MSW by proper disposal methods.

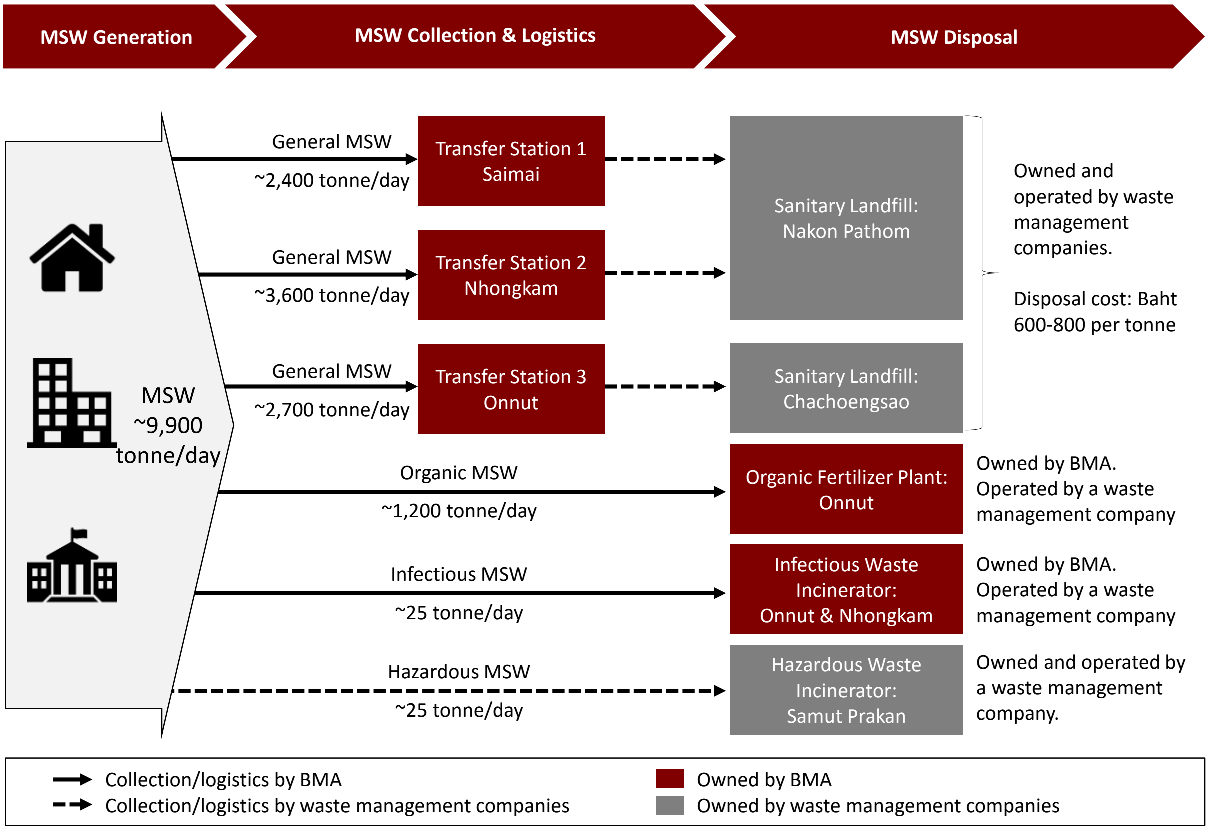
BMA performs some of the tasks by itself, and outsources others to a number of waste management companies. There are a number of existing models, e.g.:

- Bidding to collect MSW from BMA's transfer stations to the bidder's disposal sites (BMA pays 600-800 baht per ton)
- Awarded a contract to operate an organic fertilizer plant at Onnut transfer station
- Awarded another contract to build and operate an infectious waste incinerator at Onnut transfer station and another one in Nhong Kam
- Awarded another contract to dispose of hazardous waste at a company's facility in Samut Prakarn

In 2014, BMA reported MSW generation of 9,900 tonnes/day. BMA collected 20 baht per household for waste management services, and was able to collect from 89% of the 2.1 million households in Bangkok. BMA was able to collect a total of 456 million baht, equivalent to 126 baht per ton. Revenue is relatively low compared to the waste management cost incurred by hiring private waste management companies (600-800 baht per ton for disposal at sanitary landfills).

EXHIBIT 10-12

MSW Management in Bangkok (2014)



Source: BMA, AWR Lloyd research

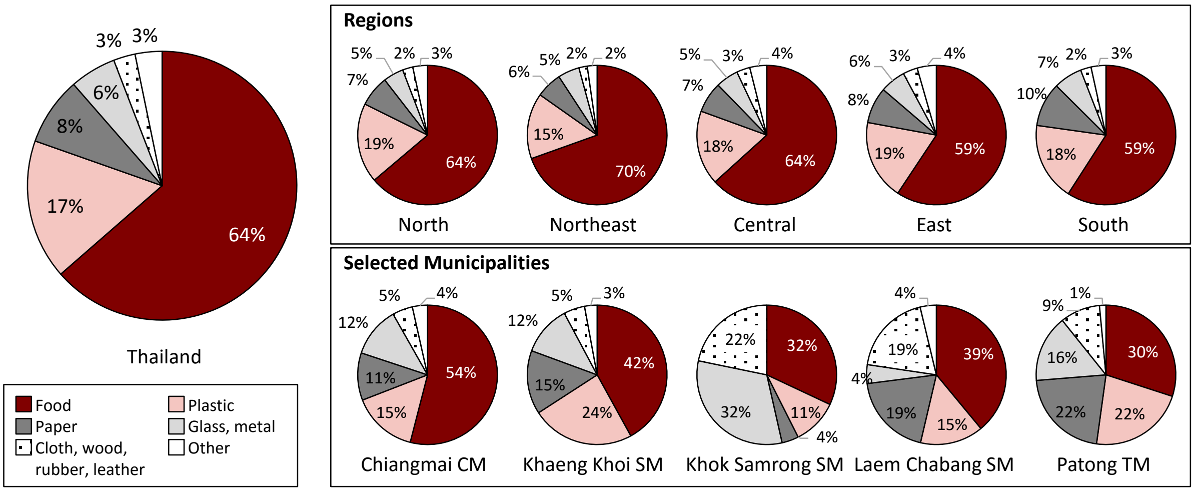
10.4 MSW Characteristics

As economic activities, climate, social and urbanization are different in different communities, physical and chemical characteristics of MSW vary greatly. In addition, each locality is also unique in its local waste collection, transportation and waste management. For example, localities differ in the level of implementation of waste sorting policy at households, schools, government offices, or public areas. This leads to different degrees in which reuse and recycling can be implemented before going to disposal sites. Waste pickers and tricycle waste buyers are common in many localities but may not be as extensive in some communities.

10.4.1 Fresh Waste

In 2003, PCD conducted a nationwide waste composition survey. The data shows high variation in waste composition between municipalities. The variation, however, becomes less obvious when comparing averages of different regions. Overall, major components of MSW in Thailand are food (64%), plastic (17%) and paper (8%).

EXHIBIT 10-13
MSW Composition (2003)

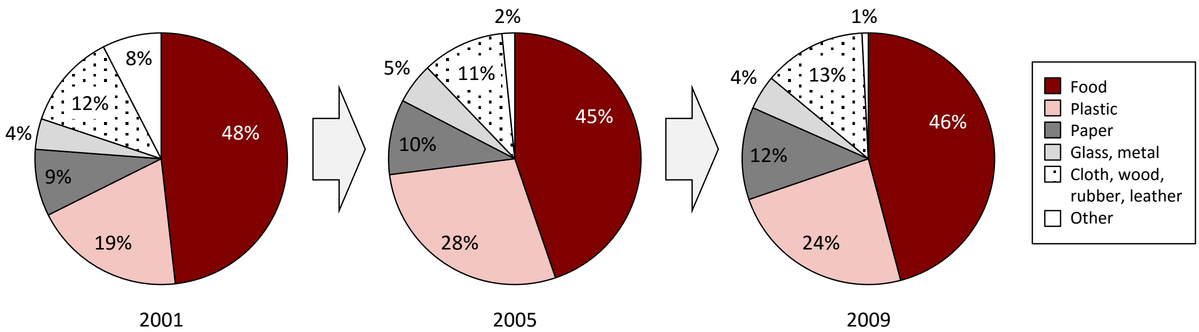


Note: City Municipality (CM), Town Municipality (TM), Sub-district Municipality (SM)

Source: PCD

As economic activities and urbanization evolve, waste composition and characteristics will typically change accordingly. As seen from data collected by BMA between 2001 and 2009, the combustible component (paper and plastic) of the waste has increased.

EXHIBIT 10-14
Bangkok's MSW Composition (2001, 2005, 2009)



Source: BMA

The physical and chemical characteristics of waste such as density, moisture content, volatile solids, dry solid heating value affect its suitability for certain applications and technologies. For example, the use of waste to produce fertilizer or biogas through the application of composting or anaerobic digestion requires a sufficiently high organic and moisture content. In contrast, WTE applying steam turbine technology requires a high share of combustible contents such as plastic and paper, and a lower moisture content so less heat is needed for evaporation.

Exhibit 10-15 shows these characteristics for MSW from different municipalities as surveyed by PCD in 2003, as well as the derived Lower Heating Value (LHV) (the amount of heat produced by combustion minus the heat required for the evaporation of the moisture). This shows that there are wide variations in MSW characteristics between different locations, especially in the LHV which ranges from a low 237 kcal/kg to 3,179 kcal/kg. While there may have been changes in waste composition since these data were recorded, it can be assumed that there are still considerably differences between locations.

EXHIBIT 10-15

Characteristics of MSW in Selected Municipalities (2003)

Source of MSW[1]	Density[2] (kg/m^3)	Moisture Content[2] (%)	Volatile Solids[2] (%)	Dry Solid Calorific Value[2] (kcal/kg dry)	Lower Heating Value[3] (kcal/kg)
Chiang Mai CM	200	61.5%	83.8%	5,497	1,446
Lampang CM	171	74.4%	91.0%	7,038	1,027
Phichit TM	177	71.9%	85.6%	6,244	1,018
Nakhon Sawan CM	157	61.0%	88.9%	4,501	1,068
Samut Sakhon CM	202	59.9%	89.4%	6,770	2,031
Pathum Thani TM	174	64.6%	82.2%	5,766	1,360
Lopburi TM	162	71.7%	83.6%	4,974	678
Phetchaburi TM	236	52.5%	92.6%	7,501	2,912
Udon Thani CM	204	64.7%	88.1%	4,668	940
Khon Kaen CM	213	72.3%	91.3%	7,239	1,243
Sisaket TM	197	75.2%	91.1%	8,448	1,318
Warin Chamrap SM	179	69.9%	83.9%	3,181	237
Trat TM	169	68.2%	90.5%	6,268	1,261
Koh Samui SM	230	72.0%	82.5%	6,221	1,016
Trang CM	203	71.0%	90.9%	6,751	1,203
Su-ngai Kolok SM	181	63.1%	94.4%	8,717	2,501
Nhongkam Transfer Station (BMA)	n/a	65.8%	87.9%	7,987	2,017
Saimai Transfer Station (BMA)	n/a	56.8%	84.4%	8,857	3,179
Onnut Transfer Station (BMA)	n/a	63.5%	82.5%	6,177	1,580

Note: 1) City Municipality (CM), Town Municipality (TM), Sub-district Municipality (SM)
2) PCD (2003); average of results from two surveys
3) AWR Lloyd analysis

Source: PCD

10.4.2 Buried Waste

Existing waste both from open dump and landfill sites has potential for WTE use. When waste is buried in an open dump site or a landfill, it undergoes a decomposition and digestion process. The extent of the process and the transformation of the physical and chemical characteristics of the waste depend on a number of parameters, and is different not only from an open dump site to a landfill, but also from one site to another of the same technology.

A 2007 study compared properties of fresh waste to the waste that had been buried for two years in a pilot landfill site in Nakhorn Pathom province. The site covered an area of 8,000 square meters with an approximate effective depth of 6 meters. The study was conducted on waste samples that were collected from the landfill at depths of 1.5, 3.0, 4.5 and 6.0 meters respectively. This appears to be the most recent and most comprehensive report on the subject.

EXHIBIT 10-16

Physical and Chemical Characteristics of Fresh and Buried Waste (2007)

Type of Waste	Density (kg/m³)	Moisture Content (%)	Waste Composition (%)					
			Food	Paper	Plastic and Foam	Other Organics	Other Inorganics	Unident-ifiable
Fresh MSW	250	65.2%	54.6%	8.9%	17.1%	10.2%	5.3%	3.9%
Two-year buried MSW								
At 1.5 m depth	240	39.6%	6.9%	n/a	69.1%	0.1%	2.2%	21.7%
At 3.0 m depth	840	60.1%	9.6%	3.8%	43.6%	4.0%	n/a	39.0%
At 4.5 m depth	1,360	57.1%	4.1%	n/a	13.5%	2.5%	2.7%	77.2%
At 6.0 m depth	1,260	54.2%	1.1%	n/a	26.6%	3.1%	4.2%	65.0%

Source: C. Chiemchaisri, W. Chiemchaisri, Sunil Kumar and J. P. A. Hettiaratchi

10.5 Regulatory Framework for Waste Management

The regulations and institutions that are related to municipal solid waste management in Thailand can be grouped into three levels:

- National level
- Provincial level
- Local level

On each level, there are a number of laws/acts, regulations, standards, and technical guidelines governing the supervision and management of solid waste.

10.5.1 National Level

There are four ministries overseeing SWM: The Ministry of Natural Resources and Environment, the Ministry of Public Health, Ministry of Industry, and the Ministry of Interior. Each of these ministries oversees several agencies involved in SWM.

Principally, the ministries set the national policy on waste management and the departments and agencies under the ministries are responsible for implementing the provisions of the laws and policies through regulations and technical guidelines.

In response to the National Environmental Quality Act of 1992, the National Environmental Board was formed to oversee the management of the country's natural resources and environmental quality. However, under Section 18 of the Public Health Act of 1992, the disposal of sewage and solid waste generated in the area of any local government shall be the mandate and duty of such local government.

10.5.2 Provincial and Local Level

Local administration is classified into five classes of local self-government units:

- Provincial Administration Organization (PAO)

- Bangkok Metropolitan Administration (BMA)
- City of Pattaya
- Municipalities (with three sub-classes: City, Town, Sub-district)
- Sub-district (Tambon) Administration Organization (TAO)

At the provincial and local levels, the PAOs, municipalities and TAOs are primarily responsible for waste collection, transport, treatment, and disposal. Each office is independent in making decisions within its legal boundaries. With reasonable cause, the local government may entrust any person with the SWM tasks on its behalf under the control and supervision of the local government or may permit any person to operate the disposal of sewage or solid waste.

10.6 Municipal Waste and Hazardous Waste Management Roadmap

The improper disposal of large volumes of MSW and hazardous waste over the years has resulted in large amounts of cumulative improperly disposed waste in Thailand. In addition, hazardous and infectious waste was found illegally dumped into abandoned areas and MSW disposal sites. To tackle these issues, in 2014, the government placed the issue of waste management on the national agenda by approving the Municipal Waste and Hazardous Waste Management Roadmap, which comprises four key aspects:

- Disposal of cumulative MSW (existing waste)
- Development of appropriate mechanism for the management of MSW and hazardous waste (new waste)
- Creation of standards for MSW and hazardous waste management
- Creation of national discipline to achieve sustainable management

Regarding the existing waste and the new waste, the roadmap has set the following guidelines.

Existing Waste

- Assess the current amount of waste to setup action plan
- Restore existing disposal sites to dispose of existing waste and accommodate new waste by either closing off or improve the disposal sites to be appropriate disposal sites, or disposing at private disposal sites, or utilizing the waste as fuel (RDF) or promote investment from private sector
- Enforce the law in the case of private disposal sites that improperly operate

The target areas are divided into three phases: (i) urgent (six months); (ii) medium term (one year); (iii) long term (more than one year). The target areas for the urgent phase (six months) are Ayutthaya, Lopburi, Nakon Pathom, Saraburi, Samut Prakan and Pathum Thani.

New Waste

- Creation of waste separation systems at the waste source
- Separation of hazardous waste for appropriate disposal at private disposal sites
- Development of an integrated MSW management system e.g. recycling, fertilizer production, Waste to Energy (WTE)
- Improvement of existing landfill sites to meet proper standards and extend their lifetime but does not impose any prohibition on the development of new landfills

Local administrative offices are encouraged to form clusters according to the amount of MSW generation in order to develop and share proper disposal sites.

Section 11. Thai Experience with WTE and RDF

11.1 Installed WTE Capacity

The development of WTE in Thailand has been building positive momentum over the last 5 years. According to ERC statistics, in March 2016 WTE capacity connected to the grid reached 132 MW up from only 26 MW in 2010. Of the total 23 operating WTE power plants, 17 are either landfill or gasification gas projects that employ gas engine technology. These are all VSPP projects with an average capacity of 2.1 MW. The remaining 6 projects employ combustion technology, ranging from 1 to 60 MW.

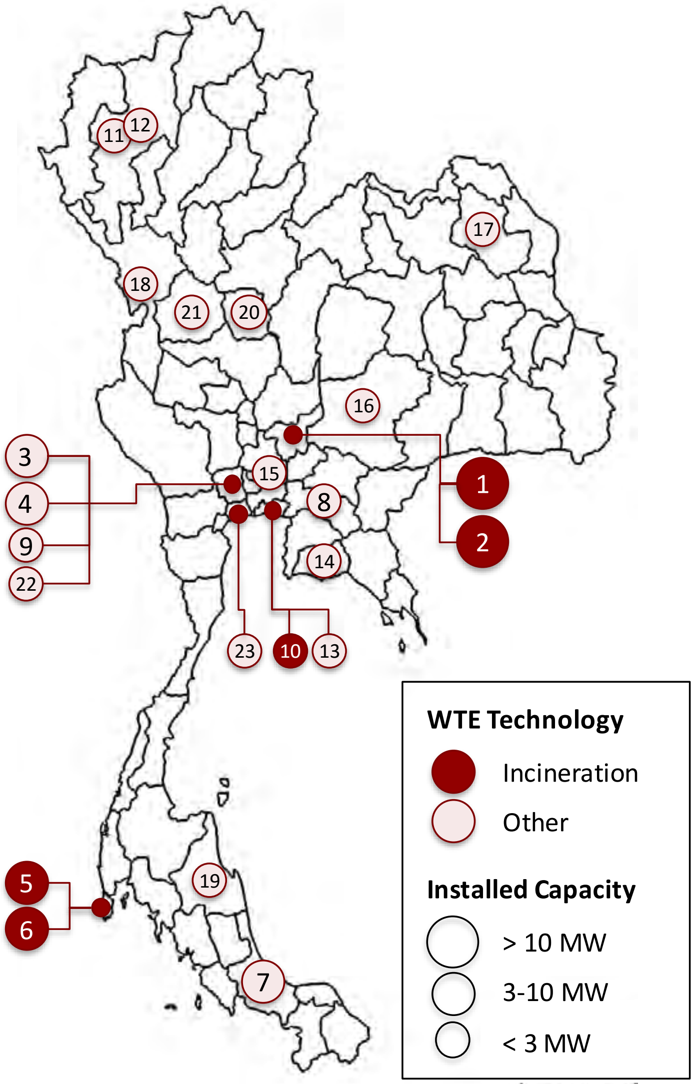
As with other renewables, the sharp increase in WTE development is partially driven by the announcement in 2006 of the promotional adder on top of the base tariff for the first 7 years of operation. Landfill gas projects receive an adder of 2.5 THB/kWh, while gasification and combustion projects receive 3.5 THB/kWh. It should be noted that the adder system has been replaced by a Feed-in Tariff, set at 5.08-6.34 Baht/kWh, plus an additional 0.7 Baht/kWh for the first 8 years of operation for VSPP projects up to 10 MW (see Section 8.2). Under Thai regulations for renewables, power generation from waste heat recovery (WHR) is not eligible for the adder subsidy and there are no WHR projects selling to the grid.

The WTE sector in Thailand is not new and projects designed to produce power from solid waste have been on the drawing board for over ten years. More developed countries in Europe and Japan have large sophisticated WTE businesses with combustion as a primary technology.

However, the conditions for successful industry development had not previously been in place. As discussed elsewhere in this report, three initiatives of the Thai government (the 2014 Municipal Waste and Hazardous Waste Management Roadmap; 2015 Draft Masterplan for Solid Waste Management; and the 2015 Alternative Energy Development Plan) create enabling conditions. Additionally, the characteristics of Thai waste are not ideally suited to combustion. These regulatory changes have provided incentives for well-placed companies to make investments and develop the capability to operate WTE businesses.

EXHIBIT 11-1

Map of Grid-Connected WTE Power Plants in Operation (March 2016)



No.	Company
1	TPI Polene Power
2	TPI Polene Power
3	Zenith Green Energy
4	Bangkok Greenpower
5	PJT Technology
6	PJT Technology
7	Gidec
8	Charoen Sompong
9	Active Synergy
10	Bangpoo Environmental Complex
11	Tha Chiang Thong
12	Bantal Powerplant
13	Charoen Sompong
14	Rayong City Municipality
15	Rak Ban Rao
16	Nakhon Ratchasima City Municipality
17	Kaset Wanon Niwat Cooperative
18	Genius Energy
19	Thungsong Alternative Energy
20	Koh Kaew Green Energy
21	Inthachan Clean Energy
22	Electricity from Waste Gas Project under the initiation of His Majesty the King
23	Sufficiency Energy

AWR Lloyd

EXHIBIT 11-2

Grid-Connected WTE Power Plants in Operation (March 2016)

No.	Company	Province	Type	Installed Capacity (MW)	Contracted Capacity (MW)	Start of Operation
1	TPI Polene Power	Saraburi	SPP	60.0	55.0	2015
2	TPI Polene Power	Saraburi	SPP	20.0	18.0	2015
3	Zenith Green Energy	Nakhon Pathom	VSPP	8.5	8.0	2010
4	Bangkok Greenpower	Nakhon Pathom	VSPP	8.2	8.0	2010
5	PJT Technology	Phuket	VSPP	7.0	6.5	2012
6	PJT Technology	Phuket	VSPP	7.0	6.5	2012
7	Gidec	Songkhla	VSPP	7.0	5.4	2014
8	Charoen Sompong	Chachoengsao	VSPP	2.4	2.4	2010
9	Active Synergy	Nakhon Pathom	VSPP	2.1	1.0	2009
10	Bangpoo Environmental Complex	Samutprakarn	VSPP	1.6	0.8	2012
11	Tha Chiang Thong	Chiangmai	VSPP	1.1	1.0	2010
12	Bantal Powerplant	Chiangmai	VSPP	1.1	1.0	2012
13	Charoen Sompong	Samutprakarn	VSPP	1.0	1.0	2007
14	Rayong City Municipality	Rayong	VSPP	1.0	0.6	2007
15	Rak Ban Rao	Pathumthani	VSPP	1.0	1.0	2009
16	Nakhon Ratchasima City Municipality	Nakhon Ratchasima	VSPP	0.8	0.3	2013
17	Kaset Wanon Niwat Cooperative	Sakon Nakhon	VSPP	0.8	0.7	n/a
18	Genius Energy	Tak	VSPP	0.4	0.4	2016
19	Thungsong Alternative Energy	Nakhon Srithammarat	VSPP	0.3	0.3	2010
20	Koh Kaew Green Energy	Pichit	VSPP	0.2	0.2	2012
21	Inthachan Clean Energy	Kampaengpetch	VSPP	0.2	0.2	2014
22	Electricity from Waste Gas Project under the initiation of His Majesty the King	Nakhon Pathom	VSPP	0.2	0.2	2009
23	Sufficiency Energy	Samutsakorn	VSPP	0.2	0.2	2009
	Total			**132.1**	**118.7**	

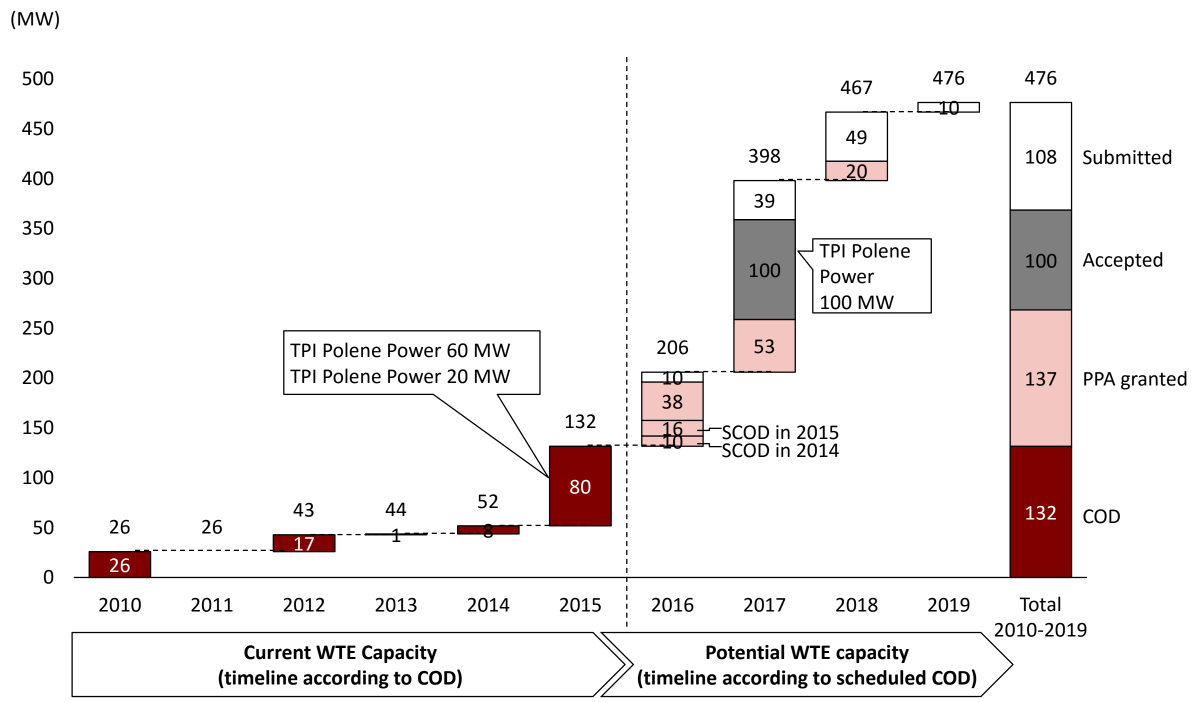
Source: ERC

TPI Polene Power Ltd (TPIPP) has the largest installed capacity in WTE and is the only company with operational projects selling electricity to EGAT under the SPP program. TPIPP also appears to be the largest producer of RDF in Thailand. As with the VSPPs, these two projects receive the adder of 3.5 THB/kWh.

Exhibit 11-3 shows the total grid-connected WTE capacity currently installed and under development in Thailand. An additional 344 MW of WTE capacity is under development, of which 74 MW is scheduled to come online within 2016. As mentioned above, these could still face delays or be cancelled.

EXHIBIT 11-3

Installed and Potential WTE Capacity under SPP and VSPP (March 2016)

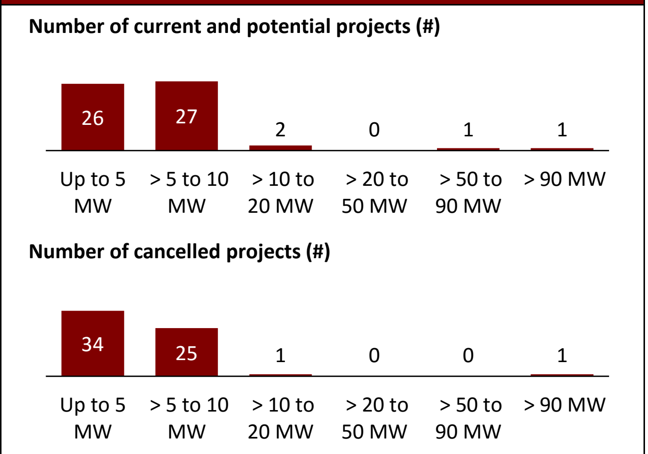


Source: ERC

To obtain a PPA for an SPP or VSPP WTE, project developers need to submit an application to ERC. As shown in Exhibit 11-4, ERC received a total of 118 applications for WTE projects, out of which more than half have been rejected or cancelled, either by the developer or by ERC. This implies that out of the 344 MW still under development, many are unlikely to reach COD.

EXHIBIT 11-4

Current Status of WTE Power Purchase Agreements (PPAs) (March 2016)

	Power Plants (#)	Installed Capacity (MW)	Contracted Capacity (MW)	Number of Projects by Installed Capacity
Current and potential projects				
Application submitted	13	108	97	
Application accepted	1	100	90	
PPA signed	20	137	125	
COD	23	132	118	
Total	**57**	**477**	**430**	
Cancelled applications	**61**	**387**	**338**	
Grand total	**118**	**864**	**768**	

Source: ERC

11.2 Developments in WTE and RDF

11.2.1 TPI Polene Power (TPIPP)

TPIPP is a first mover in the Thai large-scale WTE sector and the largest generator of power from solid waste in Thailand. As of March 2016, TPIPP had a total installed capacity of 150MW from two RDF-fired power plants (60 and 20 MW) and two waste heat recovery power plants (30 and 40 MW). The RDF power plants supply power to EGAT under long-term PPAs.

All four of these power plants are located nearby TPIPP's parent company's cement plants in Kaeng Khoi, Saraburi. When projects currently under development are completed, the total installed capacity of WTE and waste heat recovery power plants will be 220 MW. Together with the coal and coal/RDF power plants under development, the company's total installed capacity will reach 440 MW by the end of 2017, making TPIPP a significant participant in the Thai power supply industry. TPIPP also owns and operates 8 petrol stations, one gas station and three petrol and gas stations in Bangkok and other provinces in Thailand.

TPIPP is in the process of constructing three new power plants that would use RDF, coal and combined coal/RDF with a combined capacity of 290 MW. The first of these is a 70 MW RDF-fired power plant which is expected to be completed in Q1 2017. After completion, together with the 30 MW WHR plant (which is already in operation and sells electricity to TPIPL), the project is expected to sell 90 MW to EGAT under a PPA. The other two projects under construction are a 150 MW coal-fired power plant and a 70 MW combined coal and RDF power plant, which will sell electricity to TPIPL. In addition, the Company is in the process of installing RDF boilers in the 40 MW waste heat recovery plant, expected to be completed by the end of 2016.

EXHIBIT 11-5

TPIPP Assets in Operation and Under Development (December 31, 2015)

Operating assets			
	Installed Capacity	**COD**	**Comment**
Waste heat recovery (WHR)	40 MW	Q2 2009	Supplying to TPIPL, under conversion to RDF-fired
Refuse derived fuel	20 MW	Q1 2015	PPA for 18 MW with EGAT
Refuse derived fuel	60 MW	Q3 2015	PPA for 55 MW with EGAT
WHR	30 MW	Q1 2016	Supplying to TPIPL until 70 MW RDF plant finishes construction
Total Operating	**150 MW**		
Assets under development			
	Installed Capacity	**Scheduled COD**	**Comment**
RDF	70 MW	Q1 2017	Will operate as a 100 MW RDF-WHR plant in combination with operational 30 MW WHR plant, for sales to EGAT under a 90 MW PPA
Coal and RDF	70 MW	Q2 2017	For supply to TPIPL
Coal	150 MW	Q4 2017	For supply to TPIPL
Total under Development	**290 MW**		
Grand Total	**440 MW**		

Note: All power plants are located in the same industrial estate as TPIPL's cement production plants in Kaeng Khoi, Saraburi Province

Source: TPIPL

TPIPP sells all electricity to two offtakers: TPIPL and EGAT. A total of 75 MW is contracted to EGAT via SPP PPAs. EGAT has issued a Letter of Acceptance (LOA) to the Company for the sale of 90 MW from the combined WHR/RDF plant.

The Company currently operates an RDF production plant with a capacity to produce up to 2,000 tonnes of RDF per day. During 2015, the Company processed 0.4 million tonnes of waste and produced 0.2 million tonnes of RDF, with an average heating value of 4,181 kcal/kg. In January 2016, the Company began the capacity expansion of its RDF production plant. Once completed, the plant will have a daily capacity to process up to 6,000 tonnes of waste and produce up to 3,000 tonnes of RDF. This makes TPIPP the largest producer of RDF in Thailand.

The majority of RDF used in TPIPP's RDF-fired power plants is produced in-house by the company from MSW originating from a variety of sources. A smaller amount of RDF is sourced directly from waste management companies in the form of pre-sorted landfill waste, which can be used directly as RDF with minimal processing.

To provide feedstock for the RDF plant, TPIPP procures three primary types of waste:

1. *Unsorted MSW*: This is delivered by waste management companies authorized by municipal governments to dispose of MSW.
2. *Unsorted landfill waste*: This is supplied by waste management companies.
3. *Pre-sorted landfill waste*: The Company has signed agreements with waste management companies under which the Company will install semi-mobile waste-sorting machines at landfill sites.

TPIPP does not own trucks for collecting waste and all waste is transported to TPIPP by waste management companies.

EXHIBIT 11-6

Waste Acquisition by TPIPP (2013-2015)

Type of Waste	2013	2014	2015
Unsorted landfill waste (‘000 tonnes)	0.7	5.1	20.0
Unsorted MSW (‘000 tonnes)	141.8	186.7	346.9
Total (‘000 tonnes)	**142.6**	**191.7**	**366.9**

Source: TPIPP

11.2.2 Siam Cement Group (SCG)

SCG’s subsidiary SCI Eco Services produces RDF from MSW for use as alternative fuel in SCG’s cement kilns.

According to SCG’s Sustainability Report 2015, SCI Eco Services has RDF plants at three locations; Ban Mo District in Saraburi Province, Bang Rakam District in Phitsanulok Province, and Muang District in Phatthalung Province. MSW is processed at municipal landfills in these locations to separate incombustible materials and process the combustible materials into RDF. The RDF is then transported to the cement plants where it is ground into smaller size of less than 5 cm to be suitable as fuel in the cement kilns.

RDF is used in SCG’s cement plants at Kaeng Khoi District in Saraburi Province and Thung Song District in Nakhon Si Thammarat Province. In 2015, SCG used a total of 61,000 tonnes of RDF offsetting coal consumption by 57,000 tonnes..

In 2016 SCG plans to have additional RDF plants in Saraburi and Krabi Provinces. SCG also expects to increase the total use of RDF to 290,000 tonnes per year in 2020 offsetting coal consumption by 275,000 tonnes.. To produce this amount of RDF, SCG estimates it needs more than one million tonnes of MSW annually.

In addition, SCG generates electricity by utilizing waste heat from its cement kilns. This has reduced the use of grid electricity by 560 GWh per year, equivalent to an annual reduction of GHG emissions by 326,000 tons of carbon dioxide.

So far, SCG has used RDF only as a substitute for coal in its cement kilns. It has not made announcements to develop RDF power plants to generate electricity for internal use or sales to the grid.

11.2.3 Other private sector WTE companies

Besides cement companies, several other companies are operating and developing WTE projects in Thailand. The last few years have also seen several mergers and acquisitions in the Thai WTE market.

Until recently, the largest combustion or incineration-based WTE plant in Thailand was the 2 x 7 MW project developed by PJT Technology in Phuket, with a waste processing capacity of 600 tonnes per day. The project started operation in July 2012 and sells electricity to the grid under the VSPP program. PJT has signed a 15-year concession agreement with Phuket Municipality for the disposal of waste and generation of electricity. Under the concession, the company receives a tipping fee of 300 Baht per tonne, to be increased every three years based on the inflation rate. The agreement is valid until 2023, and can be renewed for another 15 years up to 2038.

PJT also owns and operates a 60 tonnes per day industrial WTE plant in Amata Nakorn Industrial Estate in Chonburi. In November 2015 Yunnan Water Investment Co. Ltd. from China acquired PJT Technology for USD 70 million. Yunnan Water's core business activity is sewage treatment, but in 2015 the company acquired MSW treatment and WTE facilities in China.

The International Engineering Public Company Limited (IEC) is developing a number of waste-related activities. It has set up a joint venture with Electricity Generating Public Company Limited (EGCO), called GIDEC, for the operation of a 6.5 MW WTE power plant in Hatyai, Songkhla province, using pyrolysis technology from Finland. Total investment cost was THB 800 million. The plant started operating in December 2014 and has a waste processing capacity of 300 tonnes per day. The plant receives fresh MSW from Hat Yai and nearby municipalities. The waste is sorted, shredded and dried before being fed into the pyrolysis system. IEC seems to be in discussions with landfill sites in Thailand to develop similar power plants.

IEC has also developed a waste plastic recycling project that produces plastic pellets for export from contaminated plastic from a landfill in Rayong province. The facility became operational in 2015 and has production capacity of 100 tonnes per day. Besides the waste projects, IEC also has stakes in 3 solar farms with a total capacity of 9 MW and in 2014 acquired an 8 MW VSPP biomass plant in Sakaeo, operational since 2013.

EXHIBIT 11-7

Notable Thai WTE Companies (March 2016)

Company	Location	Comment
True Energy	Pichit, Nakhon Sawan	Biomass developer that has moved into WTE. Two VSPP projects under development with signed waste PPAs (9.8 MW each)
GIDEC	Hat Yai	50/50 JV of IEC and EGCO, operating a 6.5 MW pyrolysis plant under VSPP
PJT Technology	Phuket	Two VSPP projects with signed PPAs in operation (7 MW each)
TPIPP	Saraburi	Three SPP projects (total 180 MW), two with signed PPAs with EGAT and operational (60 and 20 MW), one RDF/WHR plant under development (100 MW)

Source: AWR Lloyd research

11.2.4 Municipalities

In the response to the government's 2014 Roadmap for Municipal Waste and Hazardous Waste Management, in 2015 PCD drafted the Masterplan for Waste Management 2016-2021. The Masterplan identified 90 locations with the potential for setting up RDF production plants, in order to process MSW collected from clusters of localities. These identified 90 localities would have a combined capacity to process up to 16,763 tonnes of MSW per day, equivalent to 23.4% of total MSW generation in the country. The 90 high potential locations are spread around the country and include some of the areas where TPIPP sources waste.

In addition, the Masterplan also estimated the potential to generate electricity from MSW at the level of Local Administrative Offices. PCD has identified a total of 53 local government units with potential for WTE power plants. Of these 53, two municipalities (Phuket Town Municipality and Hat Yai Town Municipality) already have WTE power plants in operation, as discussed above. Three additional plants are under construction (Bangkok, Khon Kaen Town Municipality and Mae Kharee Sub-district Municipality in Phatthalung province), with a total capacity of 15.8 MW. The remaining 48 locations are in the process of feasibility study or negotiation with project developers. PCD estimated the total potential power generation capacity of all 53 local governments at 325 MW.

11.2.5 RDF Business in Thailand

RDF production is only becoming common in Thailand in the last few years, where it is used primarily to turn MSW into a more practical fuel source. The largest private sector RDF producers are associated with cement plants and operated by TPIPP, SCG and Siam City Cement. However, a wide range of municipalities, often in partnership with private companies also produce RDF. Cement plants are also the primary users of RDF and all six of the country's cement plants use RDF. RDF is also used in the power sector outside of dedicated WTE plants.

Coal and biomass power producers have been reported to be investigating the potential of RDF but as of yet have not broadly used it as a fuel source, due to difficulties of using it with existing burners or concerns about pollution. Other industries that use boilers, including beverages; textile; wood and furniture; paper; chemical; non-metallic; basic metal and fabricated metal industry, are reported to have similar concerns.

RDF Standards

Thailand does not have a national standard for RDF. Usually, the producers set their own criteria to measure RDF for their cement manufacturing process. The qualification is as below in the table.

EXHIBIT 11-8

RDF Specifications in the Thai Cement Industry

Parameter	TPI	SCI Eco Service	Geocycle
LHV (Kcal/Kg)	3,500	4,500	4,500
%MC	<35%	<20%	<25%
% Cl	0.5%	1%	1%
% S	-	<1%	-
% Total heavy metal	-	≤1%	-
% Heavy fraction	-	≤0.5%	-
Size	-	-	<1M

Source: Suranaree University of Technology (2015)

The RDF price is typically based on LHV and moisture content. In March 2015 the market price for RDF-3 grade A with a heating value greater than 5273 Kcal/Kg was 1,200 baht per ton, while the price of RDF-3 grade B cost less at 200 baht per ton. RDF prices are highly correlated with coal prices and may vary greatly.

EXHIBIT 11-9

Price and Heating Value for RDF (March 2015)

RDF-3 Grade A	Value
RDF cost (THB/tonne)	1,200
LHV (kcal/kg)	> 5,273
Physical characteristics: contains combustible plastic HDPE, LDPE	
RDF-3 Grade B	**Value**
RDF cost (THB/tonne)	200
LHV (kcal/kg)	< 3,321
Physical characteristics: contains combustible plastic PE, PS, paper, cloth, rubber and wood	

Source: Suranaree University of Technology (2015)

11.3 Waste Heat Recovery

WHR refers to the capturing of unused waste heat from industrial processes, in order to convert it into electricity, which can either be sold to the grid or used on-site, without any additional fuel consumption and with zero emissions. WHR is particularly suitable for energy intensive manufacturing processes, where as much as 20-50% of the energy consumed is typically lost as waste heat.

A 2014 study by the Institute of Industrial Productivity (IIP) shows the adoption of WHR-based power generation by the Thai cement industry. Eleven systems are installed on at least 16 clinker lines at seven cement plants, out of a total of 31 kiln lines at 13 plants. The eleven existing WHR systems represent more than 172 MW of electric capacity. The remaining potential for WHR in Thailand ranges from 30 to 60 MW, based on estimated clinker capacity at plants with a capacity greater than 1 million metric tonnes per annum. Moisture content of the clinker raw materials may be a limiting factor on WHR potential in Thailand.

EXHIBIT 11-10

Selected WHR Projects at Cement Plants (2014)

Cement Plant	Kiln Capacity (tpd)	Year Started	WHR Capacity (MW)	Installation Cost (Million USD)	Power Generation (MWh/yr)
SCG Kaeng Khoi KK6	5,500	2008	9.1	15.2	56,516
SCG Ta Luang	8,000	2010	18.0	26.3	89,421
Siam City (kiln 3)	20,000	2010	2 x 16.0	57.8	156,920
TPIPP	n/a	2009	2 x 20.0	n/a	164,937

Source: IIP, TPIPP

Section 12. Outlook and Prospects for the Company

TPIPP aspires to become the leading player in the rapidly growing Thai WTE industry. The company is already the largest single operator of WTE power plants with 83% market share of post-COD capacity of incineration-type plants and 61% of all WTE PPAs in Thailand, according to data available in the ERC database as of March 2016. As there are no other large scale PPAs in the pipeline, following completion of its third WTE power plant of 100 MW this market share will increase. By then WTE would account for over third of the company's installed capacity and a larger share of revenue and profit. In the medium and long-term, WTE is expected to be the important driver of growth for the company.

Operating three types of power plants (WTE, WHR and coal) enables the company to dedicate all waste generated power to the favorable adder structure and use lower cost power internally. The WHR and coal-fired power business lines are basically stable, selling power to a related company, and present relatively low risks in terms of fuel costs and tariffs. However, these segments may not offer the expansion opportunities of WTE and RDF. Given lower expected growth rates, WHR and coal are expected to represent an increasingly smaller percentage of TPIPP's cash flows in the future.

TPIPP is also well positioned to take advantage of future growth opportunities in the Thai WTE industry. Thailand's new WTE focus and regulatory framework are designed to drive the industry in a direction that would favor WTE businesses. This business structure also builds on solid international experience with successful WTE industries and companies operating in a range of countries.

12.1 Global WTE Industry

Around the world, producing energy from waste ranges from being an emerging opportunity to a developed industry, depending on the geographic market under discussion. Worldwide, there are multiple examples of companies building substantial businesses that profitably operate WTE plants at industrial scale. In all of these countries incineration is the most commonly applied technology. These examples could potentially serve as models or comparables for TPIPP.

As waste management has become more sophisticated, private sector companies that treat waste have emerged and grown. In Europe and Japan, in particular, these companies have used incineration as a primary disposal method and have generated revenue through the sale of energy. As China has made substantial efforts to address its solid waste problem, its companies have become successful and are starting to look overseas for acquisitions and growth as illustrated by the acquisition of PJT Technology. We believe that Thailand is now poised to formalize its waste management industry and that private sector participation by companies like TPIPP will result.

12.2 Thai WTE industry outlook

The Thai WTE sector appears to have the building blocks required for continued growth. The country is faced with a rapidly growing waste-disposal problem and is taking significant steps to address it. This includes both efforts to address waste management as well as incentives for generation of power from waste. Combined these would appear to provide a viable economic foundation for development of a Thai WTE industry and further opportunities for TPIPP.

Thai regulatory framework

As noted above, and similar to many other countries, Thailand has a regulatory framework in place that is supportive of the development of a WTE industry. The government's focus on this area has already resulted in strong policy activity that appears to be having an impact on investment in the industry. This includes the following:

- 2014 Municipal Waste and Hazardous Waste Management Roadmap: aims to impose standards for waste management, improve or close improperly managed disposal sites, and improve overall waste management practices.
- 2015 Draft Masterplan for Solid Waste Management: identified 90 locations with the potential for setting up RDF production plants and 53 localities with potential for WTE power plants.
- 2015 Alternative Energy Development Plan: prioritizes power generation from waste, biomass and biogas in the near-term, with a Feed-in-Tariff for WTE of 5.08-6.34 Baht/kWh, plus an additional 0.7 Baht/kWh for the first 8 years of operation for VSPP projects (up to 10 MW).

In combination, these create a powerful platform for increased WTE development. The Roadmap and Masterplan will likely lead to the need for alternative waste disposal methods, providing feedstock for WTE facilities. The RE support measures are expected to provide new opportunities for the establishment of WTE plants.

12.2.1 Waste Resources

The market size for WTE in Thailand, or any country, is ultimately determined by the amount of MSW generated annually. Thailand does have substantial WTE resources and could support a WTE industry of adequate size to support TPIPP's growth plans. Exhibit 12-1 provides scenarios for the WTE potential in the short-term (1 to 5 years) and long-term (20 years). These scenarios are based on available data for current MSW generation and assumptions related to power generation from MSW, as well as assumptions for the change in MSW volumes and characteristics.

Under our short-term scenario shown below, Thailand would have the potential for approximately 400 to 800 MW of WTE. Over the longer-term, we assume that MSW composition in the country would evolve. As discussed in Section 9.1.2, MSW composition tends to change as countries become more developed, with a higher share of paper and plastic. The resulting higher heating values, in combination with higher MSW volumes and a higher share of waste processed by WTE facilities, results in a potential of 850 to 2,000 MW over a 20-year horizon.

EXHIBIT 12-1

Estimated WTE Potential in Thailand

Parameter	Short-term Scenario (1-5 years)	Long-term Scenario (20 years)
MSW Generation	25 million tonnes/year	35-40 million tonnes/year
MSW used for WTE	25-35%	35-50%
Average Lower Heating Value	1,793 kcal/kg	1,972 - 2,151 kcal/kg
Power Generation Efficiency	20-25%	20-25%
Potential Generation	2,600 – 4,560 GWh	5,600 – 12,500 GWh
Load Factor	65-75%	70-75%
Potential WTE Capacity	400 – 800 MW	850 – 2,000 MW

Source: AWR Lloyd research

Revenue streams

WTE businesses in Europe and other developed markets can obtain the majority of their revenue from waste treatment fees. However, in Thailand tipping fees remain relatively low. In certain areas such as Phuket, Chonburi and Bangkok waste disposal companies are able to charge a significant disposal fee. However, generally these fees are much lower or unobtainable. This may change over time as stricter enforcement of regulations to prevent illegal dumping and open burning would impose higher costs on polluters. This would increase the ability to obtain fees for waste disposal, further improving industry economics.

For the present time, however, power sales are likely to be the dominant source of revenue for TPIPP and its competitors. Tariff levels do appear to be set high enough to support project economics. The government's commitment to support the WTE industry through the provisions of FITs in the future makes this appear likely to continue.

Technology and operations

The downstream business of power generation by incinerating waste and RDF in steam turbines is a mature industry in many countries. Boilers, turbines and other equipment that process RDF and waste available commercially, although optimizing them for the characteristics of Thai waste is a challenge that has had to be overcome by the existing players.

The main barriers to entry, however, are related to the sourcing of waste and the ability to cost-effectively treat waste before incineration. The track record in Thailand of commercially operating the upstream process of acquiring, processing and managing large volumes of solid waste is limited. The two cases of sustained commercial operations would appear to be Bangkok's MSW operations and TPIPP's existing projects. TPIPP has the only large scale WTE track record in Thailand.

Similar to other developing countries in tropical regions, Thailand's waste has high moisture content and may have been stripped of valuable byproducts in earlier recycling processes. This makes transportation more expensive, processing and combustion more inefficient, and recycling at a WTE facility less lucrative.

Fuel supply and acquisition

One of the key challenges in WTE is securing a long-term and affordable supply of waste. Experience with biomass power in Thailand has shown that a resource that was previously abundantly and cheaply available (e.g. rice husks), can turn into a scarce and expensive commodity because of the development of multiple power plants using the same resource. Many biomass power plants in Thailand that have depended on commercial markets have failed as the cost or availability of fuel became unfavorable.

In order to source fuel in the long-term through spot, or short-term contracts, a WTE company will have to be able to develop and preserve the ability to outcompete other users in acquiring resources. The factors that determine success include scale; electricity sales tariffs; distance to waste sites; tipping fees; power plant efficiency; cost of generation; composition of the waste; and the waste processing technologies employed.

RDF industry

WTE plants that use commercially available RDF procure resources from the same sources and thus face similar challenges. As discussed previously, the use of RDF by cement factories is a common strategy to offset the use of coal and reduce GHG emissions. In fact, cement plants may be the primary competitor to TPIPP for the purchase of RDF. With 14 cement plants in operation, the Thai cement industry has a considerable capacity to co-fire RDF with coal and several cement kilns in Thailand already do so. As mentioned above, TPIPP is the largest producer and consumer of RDF in Thailand.

However, without emission reduction obligations and emission trading mechanisms, its viability is highly dependent on the price of coal and other fuels, and under the current environment of low coal prices co-firing of RDF may not be economical. As mentioned above, the 2015 Masterplan for Waste Management highlights 90 locations around the country that have potential for developing RDF businesses. Development of a distributed RDF industry in Thailand would likely reduce the cost of transporting waste and advantage large centralized operators such as TPIPP.

12.3 TPIPP's Competitive Positioning

As mentioned above, TPIPP is a pioneer in developing large scale solid waste operation in Thailand and has created a strong operational track record. Following the development of its current pipeline, it is evaluating other opportunities including offsite WTE and RDF projects. It appears likely that these opportunities will exist giving TPIPP new growth opportunities. We believe that TPIPP is well-positioned to take advantage of these opportunities, although it is likely to face some challenges as the sector develops.

Opportunities

- TPIPP does appear to have picked an opportune moment to develop a Thai WTE business as the Thai government's prioritization of the sector reform looks likely to push the sector towards modernization along the lines of international practice.
- Globally, WTE businesses, primarily employing a similar incineration business model, have become mature and successful. In this region, China has recently developed an industry of scale and has several large WTE companies that serve as proof of concept for TPIPP.

- TPIPP's existing large developments in Saraburi is likely to give the firm a powerful competitive advantage through scale, operating experience and the opportunity to refine its technology. The Saraburi location also provides favorable access to municipalities with large volumes of solid waste.
- As shown in Figures 9.1 and 9.2, the use of incineration technology in Thailand to produce power is a relatively new industry. The only other operator with any industrial level track record of incineration plants is PJT Technology in Phuket. GIDEC in Songkhla operates a pyrolysis system not incineration, although it would have a similar feedstock acquisition model.
- As discussed earlier, it does not appear that there are any true head-to-head competitors to TPIPP that are positioned to develop scale WTE businesses in the near-term or near the Saraburi site.
- TPIPP has a track record of operating WTE power plants similar to the one being built. The first 20MW RDF unit operated at 82% utilization in 2015. The second facility has initially run at 34% utilization but is expected to operate up to its target from 2016 onward. The technology employed in the third plant is the same as in the second, so this would benefit from any lessons learned. We believe that TPIPP's track record is a significant competitive advantage.
- TPIPP's track record and experience in procuring waste is also a considerable competitive advantage. The company has 0perated a complex system of acquiring waste at factory gate and through arrangements at landfills. To date, it appears to have been able to procure adequate supply of waste at its factory gate and expects to do so for the foreseeable future. No other Thai WTE company has experience with similar waste volumes.
- Current uncertainties in the Thai regulatory regime for renewables may actually provide an advantage to TPI as the company does not need new PPAs in the short-term, but competitors may be delayed.
- The permitting process for its current pipeline is well under way. The Company expects the PPA process for the 100 MW RDF/WHR plant to proceed as planned.
- Sales of power to parent company TPIPL provides stable revenues as well as an opportunity to align power and energy production with needs and prices. PPAs with EGAT also provide predictable income. Tariffs for electricity sales to the Company's parent follow PEA tariffs. As these are adjusted for fuel prices there appears limited risks in terms of fuel pricing.
- Developing its business in an industrial estate should help avoid the public opposition problems faced by many other WTE developers and could be a strong competitive advantage.
- The Company believes that market structure will continue to enable it to procure waste at favorable terms and that it has advantages (including the adder for renewables) that allow it to outcompete others to acquire RDF at all but the highest coal prices. This is consistent with the economic analysis presented in this report

Challenges

- TPIPP typically acquires waste on spot or through contracts under three years in duration at the factory gate. This presents supply risk.

- SCG and other cement plants use WHR, waste and RDF for internal energy consumption as a coal replacement, but do not currently appear to have plans to export power. They could potentially be formidable competition if this were to change.
- Once the impacts of Thai waste sector reforms are clear and if Thailand returns to an environment of easy and favorable waste PPAs and FITs, competitors could more easily obtain PPAs. In this scenario, TPIPP could face challenges in procuring waste far from its power plants if competing facilities set up in those regions and thus have a lower cost of transportation. TPIPP could also face competition in developing new WTE facilities in new locations.
- There are several Thai companies, discussed in Section 11 that could compete with the company on offsite WTE projects in the future.
- Competing technologies such as gasification have made some inroads in European and Japanese markets, but are generally more expensive and suited to smaller operations. If gasification became a viable technology for future projects the company could adopt it as quickly as its competition.
- As in many other countries, WTE in Thailand is facing opposition from environmental groups and local communities who fear that waste incineration has negative impacts on the environment and the health of nearby communities. Thailand has seen public opposition stop the development of major industrial developments including coal and WTE plants.