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Sustainable Energy Transition in Thailand: Drivers, Barriers and Challenges of Waste-to-Energy at Krabi Province

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Abstract

Waste-to-Energy (WtE) has been considered as an option to eliminate Krabi's problems of municipal solid waste (MSW) management. A survey on WtE potential as well as key drivers, barriers, and challenges to overcome the barriers was conducted in this study. The study found high WtE potential due to huge amount of many years accumulated MSW in couple with the increasing trend of new daily waste generation. Meanwhile, Krabi is an island having land limitation for landfill. The urgent need to eliminate the huge amount of MSW has become a key driver for WtE implementation. One more key driver of WtE is Krabi Goes Green roadmap with target to generate electricity from 100% renewable energy by the year 2026. Another key driver is disruptive effects of MSW management roadmap under Section 44 of Thailand's Constitution 2017. By the way, implementation of WtE is facing with public opposing due to concerning of dioxin and air pollutant emissions from solid waste combustion. How to ensure zero emission of dioxin and air pollutants is very challenging to achieve public trust and acceptance. High temperature combustion as well as installation of high efficiency end-of-pipe treatment together with real-time monitoring system was recommended by some interviewees of the present study. In addition, due to MSW management and WtE power plant investment must involve with many organizations; therefore, stakeholders' open mind consultation and policy integration among relevant governmental agencies are highly recommended.

Keywords: Waste-to-energy; Krabi Goes Green; Green Tourism Declaration; Renewable energy transition; Sustainable energy transition.

Introduction

Increasing consumption across the country has made a significant burden of solid waste management especially in urban, semi-urban and tourism destinations. Landfill dumping is currently the only option to solve this problem, while many researchers found the improper waste dumping

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created both environmental and health impacts. [1–2]. It is reported that decay of organic waste would increase methane emission which is a high global warming potential greenhouse gas [3]. Meanwhile, plastic wastes, which tend to be major contents in MSW, are non-biodegradable, but small pieces of plastic wastes exhibit ecological impacts, especially harmful to marine animals [4]. By the way, plastic wastes are combustible with high heat generation. Therefore, waste-to-energy (WtE), using MSW as fuel for electricity generation, is considered as a win-win option for MSW management. Sanitary landfill of MSW to generate landfill gas is also one more option of WtE; however, land limitation for landfill site is a big burden for most cities [5–7]. Citizen's awareness and mindset are key important for successful MSW management; hence, national policy, legislation, and various elements connecting to energy, environment, and economic aspects, including entrepreneur and consumer responsibility are required [8–13]. Land limitation is a factor to drive a city towards landfill reduction and a zero waste city [14]. Therefore, a systematic integrated waste management in coupled with WtE power plant operation would be beneficial to communities.

As national alternative energy development plan (AEDP) has addressed the increasing quota for WtE from 500 MW up to 900 MW and also designated authority to District Administrative Office under Ministry of Interior [15], it has become good opportunity for WtE project development in most provinces. Meanwhile, Krabi Goes Green has set a target to generate electricity from 100% renewable energy by the year 2026 [16], and WtE power plant has become one of choices. This study was then conducted investigation of the WtE potential as well as key drivers, barriers, and challenges towards Krabi's sustainable WtE implementation.

Upon collection of relevant information from secondary sources, all information was integrated and illustrated in the forms of graphical chart, table, map, and flow chart.

According to information provided by PEA (2020), it is observed from Krabi's peak load statistic during 2000–2020 and load forecast during 2021–2037, as shown in Figure 1 that peak load demand in the province has continuously increasing from 35 MW in 2000, up to 159 MW in 2019, and tends to increase up to 320 MW in 2037 [17].

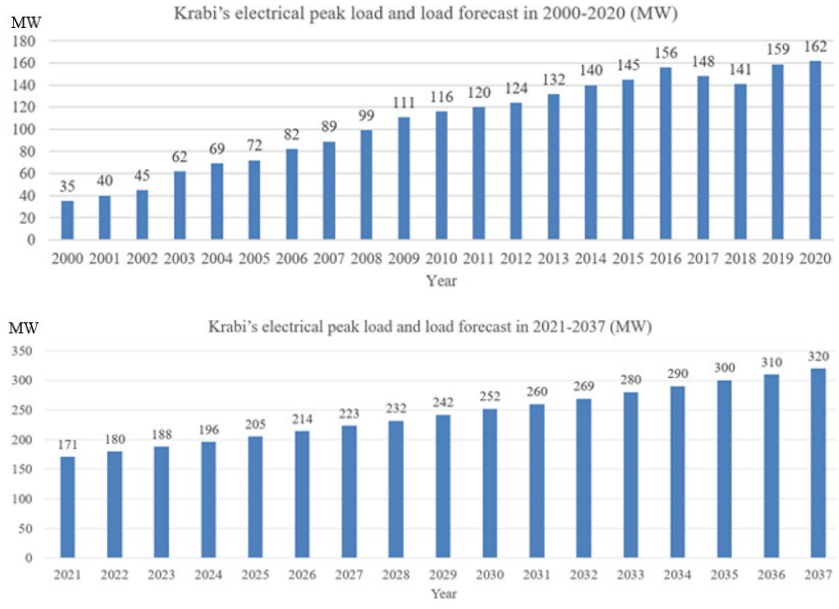

Figure 1 Krabi's electrical peak load and load forecast in 2000–2037 (MW).
Source: Provincial Electricity Authority (PEA), 2020

Krabi's electricity demand and supply during 1964–2020, as shown in Figure 2 (PEA 2020), illustrate that during 1964–1985, the domestic supply from a 60 MW coal fired power plant fulfilled its annual demand until decommissioning in 1995. Since then, electricity supply in the province has mainly relied on national grid from power plants in the southern part of Thailand until nowadays. Even though a 340 MW oil fired power plant was installed in 2004, its role is just for standby during high peak load because of high oil price. RE transition at Krabi was started in 2007 with a 9.5 MW biomass power plant, followed by biogas power plants since 2008. Solar PV farms and solar rooftops have been installed since 2018. While only one WtE power plant (6 MW) was installed in 2020 [18]. By the way, total RE power supply still could not meet its annual demand. More than half of Krabi electricity demand is still relying on national grid, which is not a sustainable practice. In order to achieve Krabi's sustainable energy, self-reliance on electricity supply from domestic renewable resources has become important and WtE is one of choices to be considered.

Regarding WtE potential, it was reported that solid waste in Krabi has been generated about 4,000–6,000 tons per month or about 56,000–66,000 tons per year during 2015–2020 (see also Table 1) and tends to be continuously increasing up to 165,593 tons per year by 2045, as shown in Table 2 [19].

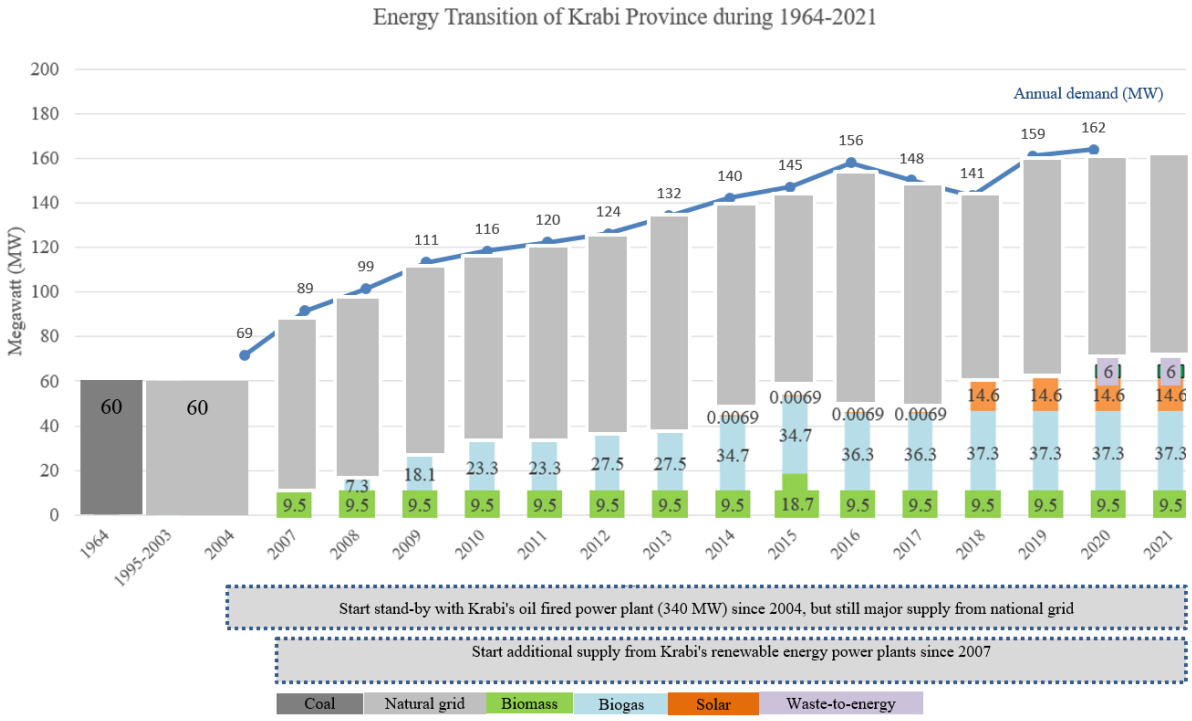

Figure 2 Krabi's energy transition during 1964–2021.
Source: Modified from Provincial Electricity Authority (PEA), 2021

Table 1 Solid waste (tons) of Krabi Municipality in 2015–2020

Year	2015	2016	2017	2018	2019	2020
January	4,825.79	5,272.45	5,758.50	5,956.11	6,047.24	5,886.46
February	4,333.76	4,938.30	4,977.81	5,558.31	5,462.73	5,086.71
March	4,548.20	4,873.53	5,266.58	5,721.67	5,719.63	4,771.72
April	4,447.70	4,529.53	5,206.82	5,564.28	5,426.90	3,510.47
May	4,708.60	4,874.28	5,422.16	5,813.17	5,356.91	3,924.58
June	4,690.66	4,945.14	5,054.21	5,415.83	5,122.70	3,820.07
July	5,130.27	4,785.75	5,464.33	5,758.73	5,725.16	4,362.04
August	5,262.53	4,977.54	5,698.49	5,897.58	5,656.64	4,492.39
September	4,594.86	4,819.87	4,775.08	5,021.55	4,908.69	4,294.56
October	4,428.80	4,804.62	4,998.38	5,297.96	5,350.49	5,306.46
November	4,429.28	4,835.61	4,821.61	5,217.98	5,343.14	5,283.85
December	4,895.56	5,150.08	5,003.71	5,009.20	5,866.08	5,556.68
Total	56,296.01	58,806.70	62,447.68	66,232.37	65,986.31	56,295.95

Source: Krabi Municipality, 2020

Table 2 Solid waste forecast of Krabi Municipality in 2021–2045

Year	Ton/Year	Ton/Day	Year	Ton/Year	Ton/Day
2021	58,780.32	161.04	2034	103,009.96	282.22
2022	61,372.54	168.14	2035	107,552.70	294.66
2023	64,079.07	175.56	2036	112,295.77	307.66
2024	66,904.95	183.30	2037	117,248.02	321.23
2025	69,855.46	191.38	2038	122,418.66	335.39
2026	72,936.09	199.82	2039	127,817.32	350.18
2027	76,152.57	208.64	2040	133,454.06	365.63
2028	79,510.90	217.84	2041	139,339.39	381.75
2029	83,017.33	227.44	2042	145,484.25	398.59
2030	86,678.39	237.48	2043	151,900.11	416.16
2031	90,500.91	247.95	2044	158,598.90	434.52
2032	94,492.00	258.88	2045	165,593.11	453.68
2033	98,659.09	270.30			

Source: Krabi Municipality, 2020

All sub-district administrative organizations (SAO) having authority in MSW management in Krabi have been grouped into 4 clusters: Krabi Municipality (cluster-1), Plai Phraya sub-district municipality (cluster-2), Khao Phanom sub-district municipality (cluster-3), and Khlong Thom SAO (cluster-4), as shown in Figure 3. The Krabi Municipality cluster is the biggest one having MSW about 113 tons per day. However, the cluster has huge amount of accumulated MSW needs to be eliminated, and it was estimated that such huge amount of MSW together with the new daily generated MSW would be used as fuel supply for the existing 6 MW WtE power plant at least 10 years. The other 3 clusters also plan to invest WtE power plants, but still facing with various barriers which will be mentioned in the results and discussion.

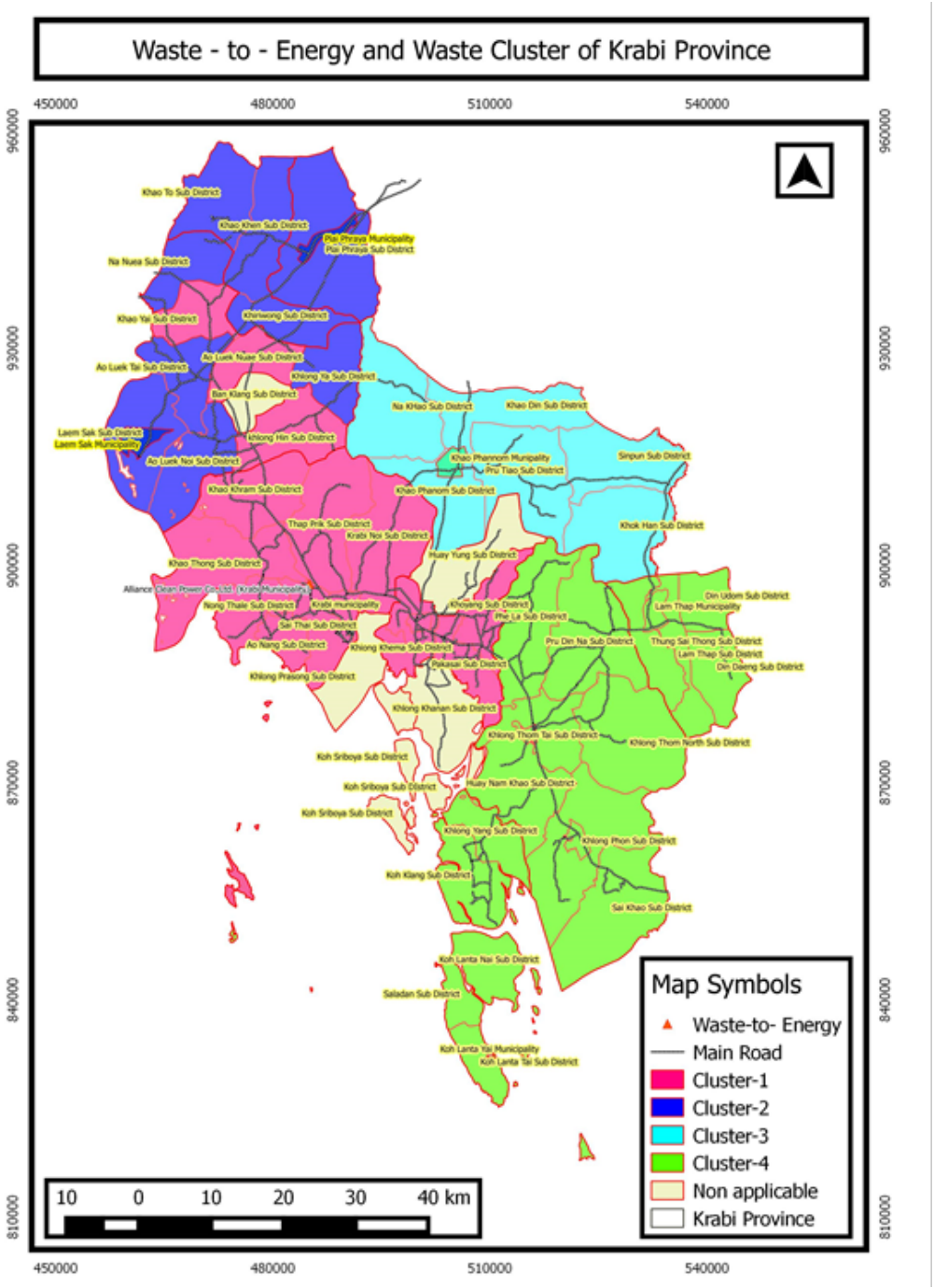

Figure 3 Waste-to-energy and waste cluster of Krabi Province.
Source: Modified from Krabi Municipality, 2020

The existing WtE power plant at Krabi was designed with a main purpose to eliminate the many years accumulated MSW in old landfill dumpling sites, the majority contents of which are non-biodegradable but combustible plastic wastes; hence, no need to pre-separate before feeding to incinerator. However, in the future if using daily generated wastes, it is suggested to install pre-separation units to separate recyclable wastes, metals, and wet biodegradable wastes. Equipment and flowchart of the WtE power plant are shown in Figure 4 where there is no pre-separation unit, but well equipped with post-combustion waste separation units to ensure environmental friendly process of the WtE power plant [20].

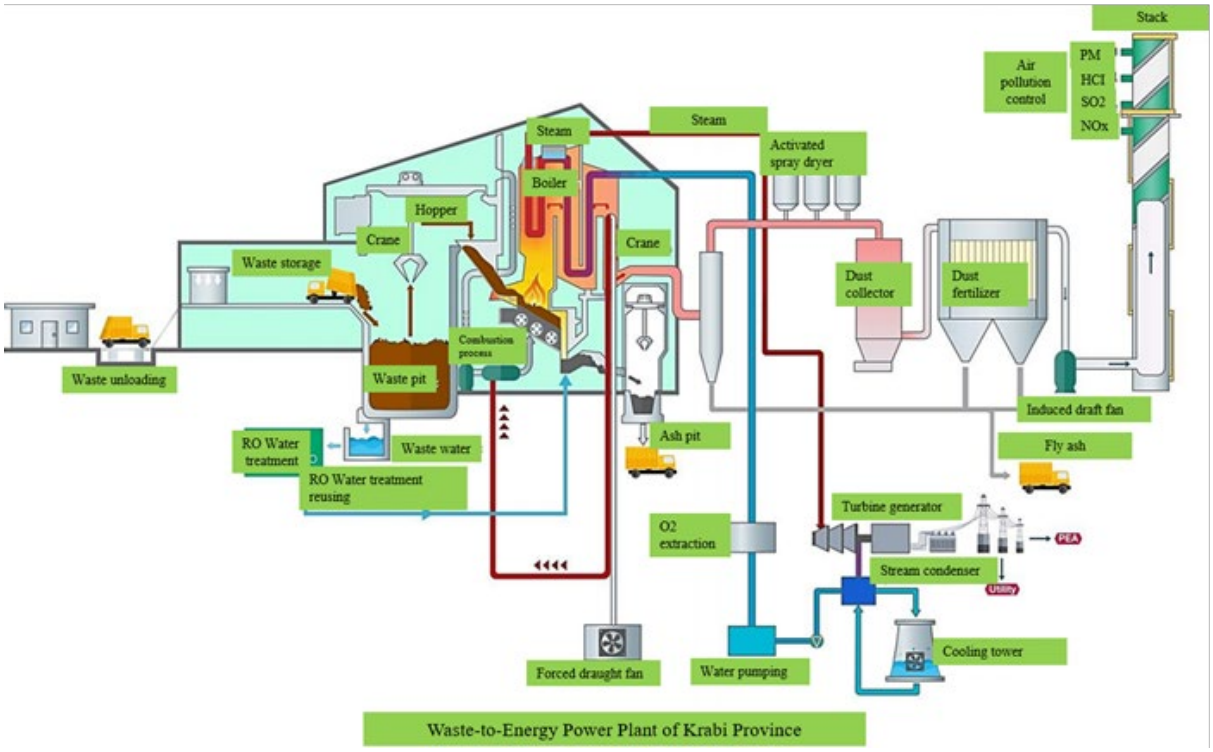

Figure 4 Waste-to-energy power plant of Krabi Province.
Source: Modified from Krabi Municipality, 2020

Research methodology

This study was conducted with qualitative approach based on conceptual framework as shown in Figure 5. Secondary information about Krabi' s electricity demand and supply as well as WtE potential were collected both from public available sources and directly requested from relevant agencies, especially PEA and District Administrative Offices, Ministry of Interior. All information was formulated in the forms of graphical chart, table, map and process flowchart, which was briefly presented in the introduction part. Primary information about key drivers, barriers, and challenges to overcome the barriers towards sustainable WtE implementation were collected by stakeholders' in-depth interviews, small group interviews, and on-site observation during July-September 2020.

List of key organizations to be requested for detail information as well as key interviewees from all relevant stakeholders (see also Tables 3–4), and also draft question outline for interviews were firstly prepared. Main issues planned to interview include what are key drivers for WtE initiation in Krabi Province, are there any barriers they are facing with, and what would be challenging solutions to overcome the barriers. Focus group discussion was firstly planned to be conducted, but in-depth interviews and small group interviews were conducted instead due to Covid-19 Pandemic during the period. Open-end questions were also used for some interviews to achieve information as deep as possible. Additional information clarification of some issues was conducted via either phone call or online call instead of revisiting as original plan.

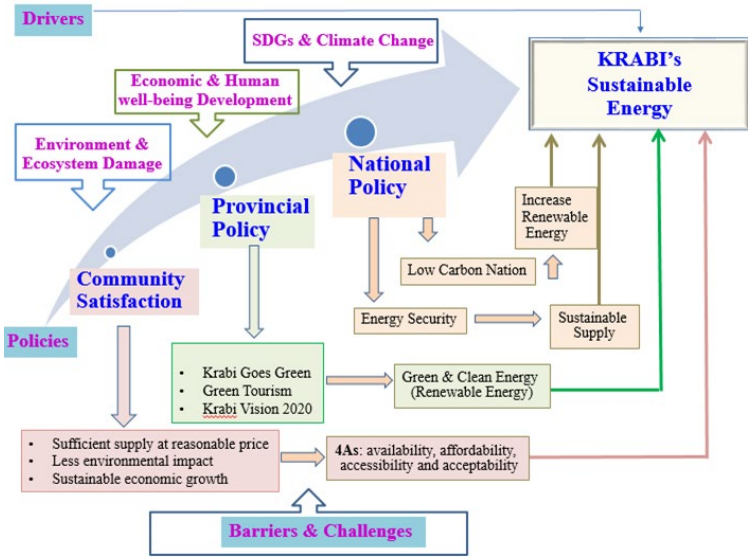

Figure 5 Renewable energy transition towards Krabi's Sustainable Energy, 2020.

Table 3 List of organization providing key information relevant to WtE, 2020

Information	Organization / Source
Very Small Power Producer (VSPP)	Energy Regulatory Commission (ERC)
Annual electricity demand and supply	Provincial Electricity Authority, Krabi Province
Krabi's electrical peak load	Provincial Electricity Authority, Krabi Province
Renewable energy installation	Provincial Electricity Authority, Krabi Province
Krabi's electrical load forecast	Provincial Electricity Authority, Nakhon Si Thammarat Province
Krabi Goes Green report	Krabi Goes Green Network, Thammasart University Public Health Policy Foundation, Greenpeace
Solid waste of Krabi Municipality	Krabi Municipality
Solid waste forecast of Krabi Municipality	Krabi Municipality
Waste-to-energy and waste cluster of Krabi Province	Krabi Municipality
Waste-to-energy power plant of Krabi Province	Krabi Municipality
Potential of waste-to-energy	Krabi Municipality
Krabi stragical plans	Krabi Provincial Administrative Organization
Krabi Vision 2020	Krabi Provincial Administrative Organization
Krabi Green Toursim	Krabi Tourism Association,
Krabi 100% renewable energy target	Krabi Goes Green Network

Table 4 Informant groups of interview, 2020

Informant groups	Numbers
Government / provincial governmental agencies (8)	
Provincial Electricity Authority, Krabi Province	1
Krabi Provincial Administrative Organization	1
Krabi Municipality and waste cluster	3
Krabi Provincial Cooperative Office	1
Krabi Provincial Industry Office	2
Tourism / network (7)	
Tourism industrial and administrative of Krabi Province	2
Krabi Goes Green network	2
Renewable energy investor	1
Save Krabi network	2
Total	**15**

Results and discussion

Even though Krabi has huge amount of MSW needs to be urgently eliminated, which is in turn an important RE source for electricity generation, the study found that as of June 2020, there is only one WtE power plant has been installed. What barriers they are facing and what would be challenges to overcome the barriers were investigated in this study. Results and recommendations are described below.

Key drivers, barriers and challenges

Regarding what would be key drivers, barriers, and challenges for WtE towards Krabi's sustainable energy, key drivers, barriers, and challenges to overcome the barriers for WtE implementtation were conducted via stakeholder's in-depth interviews, small group interviews as well as on-site observation. The keywords related to drivers, barriers, and challenges to overcome the barriers mentioned by interviewees are summarized in each category of social, technological, environmental, economic, political, and legal aspects, as shown in Table 5, and also briefly described below.

1) Key drivers

Public opposing and land limitation for new landfill site, huge amount of MSW over dumping capacity, and tourism destination are key social drivers mentioned by most interviewees. Very few opportunity for new landfill site in couple with huge amount of MSW needs to be urgently eliminated. These have force relevant stakeholders to seek alternatives for the MSW management and WtE has been considered as the only one option at this moment. Green Tourism Declaration was established with direction towards sustainable tourism in the province. Some districts has adopted zero waste concept under the Green Tourism Declaration.

External investors coming with technology transfer is a key driver in technological aspect, while income from power selling with quite high feed-in-tariff is a key economic driver.

Both national and provincial policies are key political drivers. National policy on low carbon city, AEDP, and PDP (Power Development Plan) to promote electricity generation from alternative energy, and also a disruptive policy under Section 44 of the Interim Constitution [21] that empowering authority to approve WtE power plant under code of practice (COP), environmental safety assessment (ESA), and initial environment examination (IEE) without EIA requirement, are key drivers forcing each province moving towards renewable energy (RE) transition, and WtE is one of choices.

RE target in Krabi Goes Green Roadmap as well as Krabi Green Tourism Declaration [22] are key divers forcing all stakeholders to seek for alternative options minimize the huge mountain of accumulated MSW in the province, which is in turn an opportunity for WtE power plant investment. Collaboration between Ministry of Energy and Ministry of Interior having main authority on MSW management, is one of the most important driver for WtE power plant investment.

City planning to achieve a green city under Green Tourism Declaration as well as climate change concerns are key environmental drivers for WtE implementation with aiming to achieve Krabi's green and low carbon city.

Enforcing power producers to pay for power plant fund as well as Public-Private Partnership (PPP) Act [23] and polluter pay principles (PPP) are key drivers in legal aspect. The power plant fund provides guarantee sustainable development for community nearby the power plant which is in turn increasing public acceptance. The both PPPs are key drivers ensuring budget for the power plant investment.

Table 5 Drivers, barriers, and challenges of Krabi's waste-to-energy transition

		Drivers	Barriers	Challenges
Social	Limited land	x		
	Opposing waste landfill	x		
	Tourism destination	x		
	Over capacity of waste dumping	x		
	Public mindset		x	
	Public participation			x
	Waste separation			x
Technological	External investors	x		
	External technological transferring	x		
	Limited technological transferring		x	
	Fluctuated solid waste quantity		x	
	Limited human resources		x	
	Lack of experts		x	
	Return on investment		x	
	Expensive cost of external technology		x	
	Capacity of technological innovation			x
Economic	Income from feed-in-tariff	x		
	Cost of land		x	
	Solid waste transportation		x	
	Indirect benefit sharing			x
	Community's power plant concept			x
	Imported solid waste			x
Political	Krabi Municipality plan	x		
	National energy policy	x		
	Governmental agencies collaboration	x		
	Provincial budget	x		
	Green Tourism Vision	x		
	Krabi Goes Green Vision	x		
	Low carbon city	x		
	Section 44 of the Interim Constitution of Thailand	x		
	Lack of provincial waste management		x	
	Integrated provincial waste policy			x
Environmental	City planning	x		
	GHG reduction	x		
	Environmental conservation zone		x	
	Public monitoring system			x
	Separate disposal and reduce at source for new wastes			x
	Marine waste transboundary			x
Legal	Power plant fund	x		
	Public and private partnership act	x		
	Waste purchasing legislation		x	
	Legal enforcement for improper disposal			x
	Environmental impact assessment (EIA)			x

2) Key barriers and challenges to overcome

Over consumption of single-use plastic (SUP) containers or packaging, in couple with improper disposal are common problems of waste management in all provinces across the country. Rapidly increasing of MSW is leading to over capacity of waste management, either dumping or sanitary landfill, resulting to huge mountain of accumulated MSW in many areas, especially in big cities having land limitation for sanitary landfill. WtE power plant is considered as the most promising option at this moment. That's why the national AEDP has revised the quota for WtE up to 900 MW and designated authority to District Administrative Offices to manage their own MSW. Unfortunately, negative public mindset on "waste" as well as less public trust on pollution control of the power plant are key barriers for both MSW landfill and WtE power plants. Most people do not want to have either landfill site or WtE power plant near their houses. They concern about toxic leakage and bad smell from the landfill dumpling site, and also concern about dioxin and pollutant emissions from organic waste combustion. How to ensure zero emission and raise public trust is very challenging. Some interviewees suggested that using high incineration temperature could prevent dioxin emission and high efficiency end-of-pipe treatment facilities together with real-time monitoring system installation would be compulsory for all WtE power plant.

Legal enforcement of improper waste disposal together with public awareness raising to reduce consumption of SUP containers and packaging, together with waste separation at disposal bins are also mentioned by some interviewees, even these strategies would bring to reduction of waste resource for the WtE power plant. Due to amount of MSW fluctuates by season, garbage purchasing legislation allows MSW ex-change across clusters or even across province to ensure solid waste supply for the power plant.

High land cost for power plant installation as well as high cost of long distance waste transportation is a big barrier for centralized power plant. Community power plant model was suggested by some interviewees to reduce cost of long distance transportation of the waste. The community power plant model is expected to encourage public acceptance due to the power plant belongs to community and everyone can enjoy benefit sharing from the power purchasing agreement. The community power plant model would also reduce budget limitation of some SAOs because the investment budget would come from community shareholders.

Lack of technology innovation and local experts on WtE technology are big barriers for long-term MSW management and WtE implementation. Import technology together with technology transfer and training of local technicians and engineers was strongly recommended from interviewees.

Lack of provincial MSW management plan and integrated policy among relevant government agencies are also key barriers for WtE power plant investment. Due to MSW management and power plant investment must involve with many organizations having different directions and conflict of interest. Open mind consultation to integrate policy of all relevant agencies are highly recommended. An investment plan for WtE power plant at Saladan District has been facing with public opposing even clear evidence of land limitation for extending the waste dumping sites. Having public participation in the planning process as well as approval process was recommended by interviewees. Even the existing WtE power plant, which belongs to Krabi Municipality cluster, still requires provincial MSW strategic plan with all relevant agencies' integrated policy to find out a solution for MSW supply chain because they need to transport MSW across clusters, and also from nearby provinces in the future.

Conclusion

Investigation of WtE potential as well as key drivers, barriers, and challenges towards Krabi's sustainable WtE implementation was conducted in the present study and found that there are huge mountains of many years accumulated MSW urgently need to be eliminated to achieve goal of Krabi Green Tourism Declaration, which is in turn a large potential resource and becoming a key driver for WtE power plant investment. National policies towards low carbon city, AEDP, PDP, and MSW management roadmap are key drivers forcing the province move towards a green and low carbon city. Krabi Goes Green 2020 and Green Tourism Declaration are also key drivers for WtE power plant implementation in the province. Therefore, MSW management should be one of priorities to be focused for provincial sustainable development, and provincial strategic plan for MSW management should be urgently established. WtE is a win-win option that not only to minimize MSW but also increase RE source for electricity generation. Even though Krabi has high potential of waste for energy, as of 2021 only one WtE power plant has been installed. Lack of policy integration among relevant government agencies as well as budgets for WtE facilities investment were found to be key barriers and very much challenging. One more challenging is to enhance effectiveness of the WtE implementation via waste clustering. Public acceptance is also a key barrier. Geographical land use is an obstacle for waste transportation and high land price is an obstacle for expansion of landfill clusters. Encouraging waste separation at source is one more key challenge to minimize MSW problems at Krabi Province.

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