Handbook for Quality Waste-to-Energy Infrastructures (Draft)

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March 2018

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List of abbreviations

APEC	Asia-Pacific Economic Cooperation
BOD	Biochemical Oxygen Demand
BOT	Build-Operate-Transfer
COD	Chemical Oxygen Demand
DC	Disposal Cost
EIA	Environmental Impact Assessment
EPC	Engieering, Procerement and Construction
FIDIC	Federation International des Ingenieurs Conseils
FIT	Feed-in Tariff
FOH	Forced Outage Hours
FOR	Forced Outage Rate
FS	Feasibility Study
IoT	Internet of Things
LCC	Life Cycle Cost
MCR	Maximum Consumption Rate
MDBs	Multinational Development Banks
O&M	Operation and Maintenance
PPP	Public-Private Partnership
PQ	Pre-qualification
QWTEI	Quality of Waste-to-Energy Infrastructure
JV	Joint Venture

Introduction

Handbook for Waste-to-Energy Infrastructures aims to provide basic concept, framework, lessons learned, best practices, and case studies in securing the quality of waste-to-energy infrastructures.

Background & objectives

As with roads or other infrastructures, waste management infrastructures play an important role in urban infrastructures. However, the significant difference between waste management infrastructures and other infrastructures is that waste management infrastructures do not yield profits for local governments. Waste management is not a service that users are willing to pay for; it is generally a service that is provided as a part of public service to protect public health. In other words, it is not a service that is conducted in pursuit of economic profit.

Waste-to-energy infrastructures (hereinafter referred as “WTE infrastructures”), which are defined as waste incineration and power generation plants that incinerate municipal solid wastes in this Handbook, are facilities that properly treat wastes with due consideration for public health at all times. During waste treatment, substances such as air pollutants and dust are generated, and these must always be properly treated so that environmental burden is minimized. Although cost-effectiveness is important in operation of any facilities, in construction and operation of WTE infrastructures, the top priority should always be given to minimize environmental impact.

The demand for WTE infrastructures is growing, and the competition among companies to win contracts for construction or operation of WTE infrastructures is getting fierce. As this demand is growing especially in South East Asia, the number of WTE infrastructures constructed in this region may rapidly increase in the coming years. Therefore, ensuring the quality of WTE infrastructures will be the key to ensuring future public health of this region.

Taking the above situation into consideration, this Handbook aims to undertake the following:

- Facilitate the readers understanding on how WTE infrastructures are ordered, constructed, and operated
- Provide and share useful suggestions of methodologies for securing the quality of WTE infrastructures

Scope

The main target of this Handbook is local government officers in charge of waste management. The Handbook was drafted so that it may also be useful for the central government which provides technical support and guidance to the local governments and the private operators that actually construct or operate WTE infrastructures.

The scope of this Handbook is limited to the quality of WTE infrastructures and does not include the quality of wastes that are treated in such facilities.

Points to consider regarding this Handbook

Although this Handbook uses “APEC Guidebook on Quality of Infrastructure Development and Investment” as reference, readers should bear in mind that there are significant differences between general power generation plants and WTE infrastructures.

Waste treatment is not a service that local governments conduct for economic profit

Local governments that are planning to introduce new WTE infrastructures may be overwhelmed by attractive proposals regarding WTE infrastructures given by different private companies from within and outside the country that utilize unique technologies and bring economic profits.

However, as mentioned above, waste treatment is not a service that local governments should conduct for economic profit but rather a service that is conducted to protect public health.

In reality, except in very special cases, there is no business model where waste treatment brings profit to local governments. The cost for waste treatment can only be covered by receiving financial support from the state through mechanisms such as feed-in tariff (FIT), minimizing the tipping fee to be paid by the local governments, and minimizing other costs. In principle, local governments themselves should never consider waste treatment as a lucrative business for the local government themselves.

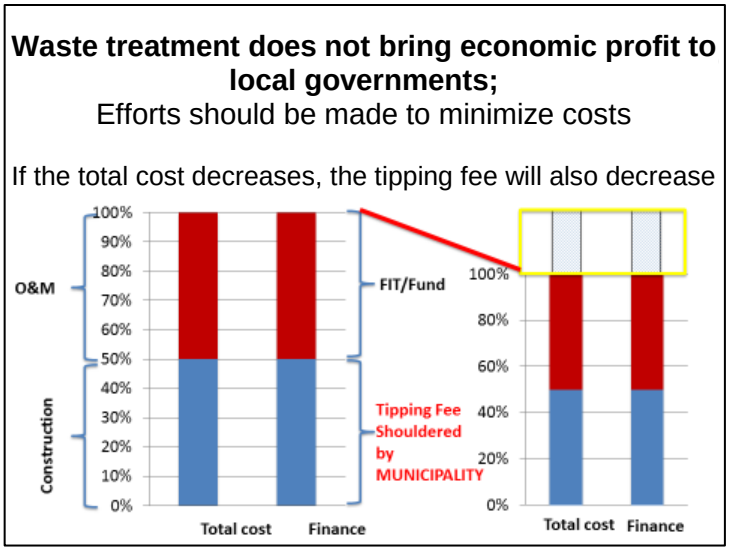


Figure 1: Cost structure of waste treatment businesses

The most important goal of waste treatment is sanitary treatment

In order to maintain and improve public health, WTE infrastructures appropriately treat the wastes through a combustion process where the remaining heat (unused energy) is recovered and used for electricity generation and other purposes. Although electricity generation and heat supply from WTE infrastructures are important sources of revenue, the main purpose of waste treatment is to maintain public health through treating wastes generated by citizens in a proper and sanitary manner.

Therefore, in constructing and operating WTE infrastructures, the priority should always be given to realizing appropriate treatment of wastes and not to efficient power generation or heat utilization. For instance, treating only wastes with high calorific values in order to improve the efficiency of power generation should not be conducted. The top priority should always be to treat large quantities of wastes in a safe and proper manner.

Outline

This Handbook first defines “the quality of waste-to-energy infrastructure” (Part I). The following Part II and Part III provide factors to be considered to secure the quality of WTE infrastructures during

feasibility study, planning and construction phase and at operation phase respectively. Throughout the Handbook, columns are provided to describe examples which can foster readers' understanding. Four appendixes are also attached to support the technical discussion of Part II and Part III.

Part I: What is "quality of waste-to-energy infrastructure (QWTEI)"?

In order to contribute to sustainable development of the APEC economies, it is essential to ensure and enhance the "quality of waste-to-energy infrastructure (QWTEI)" throughout its lifecycle. Part I identifies and defines QWTEI.

Readers should bear in mind that there are significant differences between WTE infrastructures and other infrastructures, despite the fact that WTE infrastructures fall into the category of infrastructure.

1.1 Quality of Infrastructure

"APEC Guidebook on Quality of Infrastructure Development and Investment" formulated in 2014 suggests three components of "the quality of infrastructure" as follows:

Components of "the quality of infrastructure" in general	Contents
Life cycle cost (LCC)	Initial cost, running cost, maintenance cost, etc.
Effect to the environment, etc.	Air emission (such as CO_2, nitrogen oxide (NO_x), sulfur oxide (SO_x), particle matters (PM)), waste water, waste treatment, etc.
Safety	Natural disaster resilience, cyber security, etc.

1.2 Quality of waste-to-energy infrastructure (QWTEI)

WTE infrastructures have unique characteristics as mentioned above. They play a central role in municipal waste management and thus are required to operate in a stable manner to maintain public health at all times.

Therefore, in addition to the general components mentioned above, components specific to WTE infrastructures which have great importance should also be added to ensure their quality. As the main objective of WTE infrastructures is not to generate power but to contribute to improving the public health, the five components of "public health", "stable operation", "environmental conservation", "safety", and "economic efficiency" should be ensured.

This Handbook defines the five components above as QWTEI. "Stable operation" is further divided into three concepts: "initial performance", "stability", and "ability to smoothly stop and recover". In order to protect "public health", components of "acceptance capability of waste fluctuation" and "durability" should also be added. Consequently, this Handbook frames the QWTEI as a composition of eight components as shown in the figure below.

(1) Initial performance
(2) Stability
(3) Ability to smoothly stop and recover
(4) Acceptance capability of waste characteristics
(5) Durability

(6) Environmental and social considerations
(7) Safety
(8) LCC

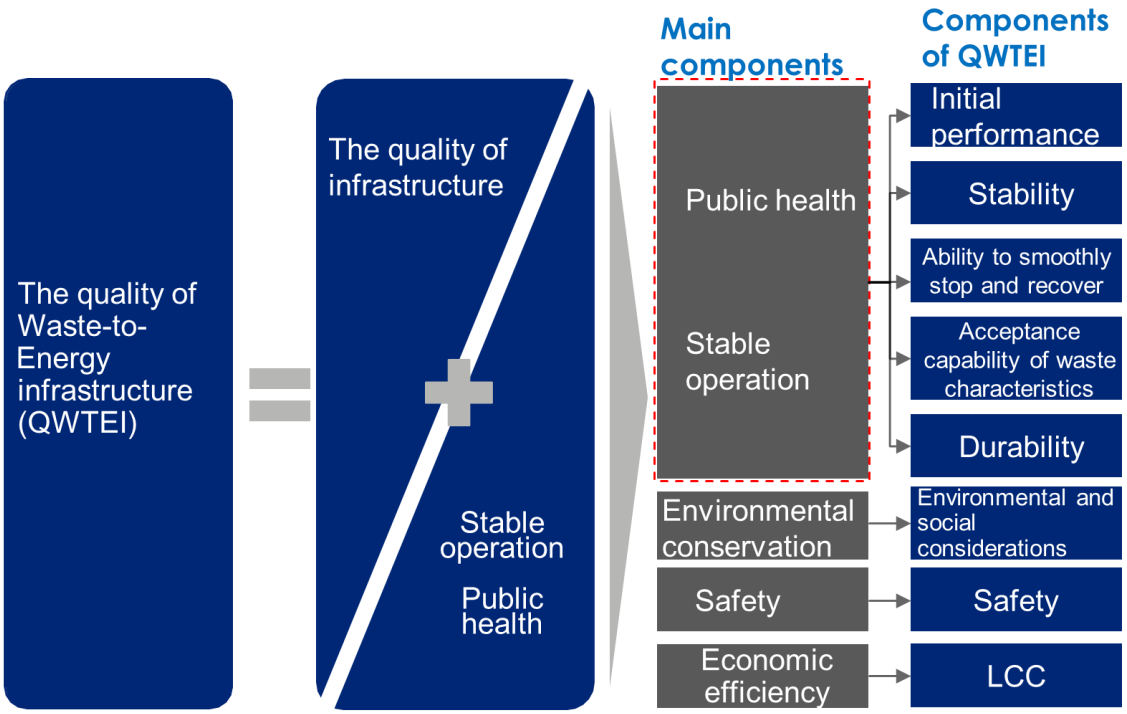


Figure 2: Components of QWTEI

Unlike general power generation facilities, WTE infrastructures must properly incinerate and treat "wastes" which always fluctuate in characteristics. Therefore, the main determinants of QWTEI range from heat exchange equipment such as boiler and turbine to equipment such as waste feeder, combustion chamber, flue gas treatment device, and electronic control units. Since WTE infrastructure generally degrades over time, conducting adequate maintenance and ensuring a mechanism to further enhance the QWTEI during operation phase are also an essential element. The QWTEI can be achieved through appropriate operation and maintenance (O&M) cycle, which in this Handbook is defined as "Self-Elevating Mechanism for Sustainable Operation and Management Practice" (refer to Figure 7).

1.3 Components of QWTEI

1.3.1 Initial performance

"Initial performance" is defined as the ability to commence operation of WTE infrastructure as initially planned and scheduled. It includes the ability to meet the scheduled completion date, the usability for O&M operators, compliance with specifications unique to regional and project-specific conditions and utilization of latest technologies. After completing the construction of the WTE infrastructure, trial operations should be conducted in order to verify that the WTE infrastructure performance meets the bidding specifications. Once it is confirmed that the performance meets the specifications, the WTE infrastructure is handed over to the employer.

Effective ways to ensure initial performance include the followings:

- Conduct sufficient market sounding before bidding:

The technical requirements of the employer should match with the available technologies that can be provided by the private sector

- Set the minimum necessary requirements as initial conditions for bidding:
  Tender specifications or requirements should be drafted for both construction and operation phase.
- Establish a system so that construction track record, method and period of construction can be thoroughly evaluated prior to the bid award:
  A system should be established where a third party other than the employer is able to evaluate the applicants in a fair and proper manner based on the official documents.
- Verify the facility's performance before delivery
  The initial performance of the facility should be verified prior to delivery; as long as the performance does not meet the required conditions, it cannot be delivered. If performance is not sufficiently verified, even minor changes in the specification may lead to inability in ensuring initial performance or long-term stable operation.

1.3.2 Stability

"Stability" is defined as the ability of the WTE infrastructures to continuously treat wastes in a stable manner. Generally the performance of WTE infrastructures naturally degrades over time. However, when the degradation level is outstanding, it may be due to the following reasons: excessive input of hazardous waste, metals and other incombustible wastes, large deviation from initial waste characteristics caused by the mixing of unspecified types of waste, inappropriate O&M caused by failure in conducting repair works or equipment replacement during periodic maintenance and daily inspection. Retaining performance of WTE infrastructures is extremely important as their unstable operation will impair the area's waste management. If there are no other alternatives to protect public health, there will be great impact on the social economic activity of the region.

In order to reduce the level of degradation of the WTE infrastructure, firstly, the fluctuation in waste characteristics that can be accepted should be carefully considered during the planning or the tender stage. Secondly, its operation needs to be optimized by taking the following actions: planning and implementing appropriate maintenance, continuous training of operators and maintenance engineers, periodic checkup of operation status by installing diagnosis equipment, performance evaluation based on actual data, and periodic repair. Thirdly, as WTE infrastructures may be damaged during their service life by wind, salinity, snow, thunders, or earthquakes, appropriate countermeasures should be taken in accordance with the characteristics of the site.

1.3.3 Ability to smoothly stop and recover

"Ability to smoothly stop" is defined as the ability to prevent forced outages as much as possible as well as to safely halt the infrastructure without damaging equipment. "Ability to recover" is defined as immediate recoverability from forced outage. Forced outage in this case refers to total shutdown or partial shutdown of the WTE infrastructure except for scheduled outage.

In order to minimize forced outage of WTE infrastructures, it is important to properly detect signs from information such as operation data, and the facility should be promptly halted when it becomes difficult to properly treat the wastes. In order to minimize the duration of the forced outage, it is necessary to accurately grasp the status of the facility, identify the fundamental cause of the problem and devise an appropriate repair plan. Damages to the facility due to emergency stop can be minimized not only

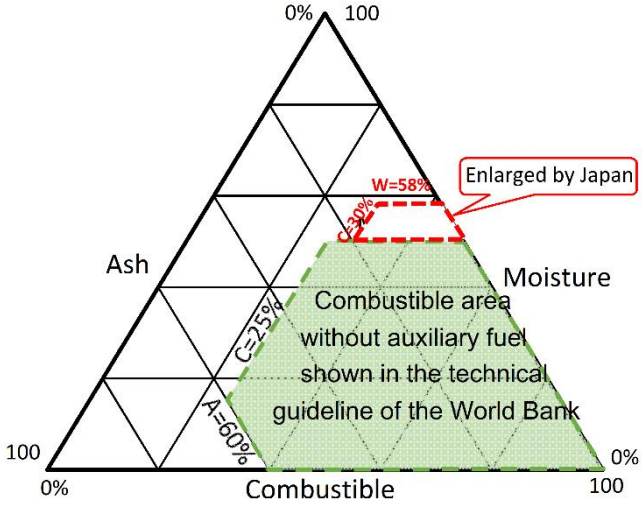
by having the facility with enough structural strength but also by avoiding operation exceeding designed intensity and safety rate with reliable protective devices.

1.3.4 Acceptance capability of waste fluctuation

"Acceptance capability of waste fluctuation" is defined as the ability to determine the necessary function and equipment of facility in order to respond to fluctuation of waste characteristics in short and long term. The calorific value or chemical characteristics of municipal wastes generally fluctuate depending on the season or day of the week. At the WTE infrastructure wastes are incinerated and the generated heat is utilized for power generation or heat supply. Unlike in thermal power plants, the waste quality cannot be specified, and as a result, the operator is always faced with waste quality fluctuations. The operator is required to properly incinerate all wastes if its calorific value and volume (maximum consumption rate or "MCR" is generally specified), three parameters (i.e. moisture, ash, and combustible content), and contained substances are within the designed range. The operator must properly respond to fluctuation of such elements and ensure continuous operation.

Measures to respond to fluctuations include securing redundancy of facility (e.g. homogenization of waste quality by sufficiently mixing the wastes inside the bunker) and responding by operation control (e.g. operation planning taking into consideration the waste reception plan).

Within APEC countries, the calorific value of wastes in ASEAN countries is smaller than that of European countries, so measures should be taken to ensure continued performance of the facility, including addition of auxiliary fuel such as oil when treating high moisture content waste during the rainy season. The characteristic of wastes that can be incinerated without auxiliary fuel is shown by the green shaded area in Figure 3. With Japanese technologies, incineration of wastes with higher moisture and ash content (i.e. zone indicated by red broken line) has been achieved. In performance-based results, waste rich in moisture content shows self-sustained combustion.



Source: Municipal Solid Waste Incineration, World Bank technical Guidance Report, the World Bank (1999)

Figure 3: Characteristic of combustible wastes illustrated by three parameters

1.3.5 Durability

"Durability" is defined as the ability to design plant mechanisms and machinery for the longest possible

service life. WTE infrastructures must continuously treat wastes for many years. Therefore, materials that are sufficiently durable should be selected and periodic maintenance should be conducted for combustion chamber and gas-cooling reactor which are likely to be heavily damaged by high heat and acidity. In general, the warranty period of the WTE infrastructure is within one or two years of commissioning, and if there are some defects, repairs during this period are free of charge. However, in most cases, they will need to be repaired after a certain time from commissioning exceeding the warranty period. As WTE infrastructures are usually operated for 20 to 25 years, the ability to conduct repairs as planned is required.

1.3.6 Environmental and social considerations

"Environmental and social considerations" are defined as the ability to prevent or suppress environmental damages attributable to WTE infrastructures and co-existence with local community.

As the construction and operation of a WTE infrastructure can have significant impacts on the environment, it is crucial to implement effective measures to avoid or minimize such impacts. This can be achieved by carefully examining features of the facility affecting the environment from the planning phase and properly implementing necessary actions through carrying out procedures such as environmental assessment and O&M enhancement. Implementing environmental preservation measures is also crucial from a finance perspective since many multinational development banks (MDBs) have already required borrowers to comply with the International Finance Corporation (IFC) performance standard as one of the conditions for financing. Air pollution, waste water, waste, noise and vibration, and ecosystem are factors which need to be considered from the perspective of prevention of environmental damages.

In terms of the co-existence with local community, the primary factors to consider are the employment of local residents and the procurement of local goods and services.

(1) Air quality control

The primary air pollutants from WTE infrastructures are HCl, NOx, SOx, PM, dioxins/furans, and small quantities of heavy metals (e.g. mercury, cadmium, lead, chrome hexavalent, arsenic, selenium). Measures against air pollution include ensuring sufficient combustion time in the combustion chamber, quenching of the emitted gas after combustion, neutralization of acid gas by injection of chemical agents, installation of high-efficiency dust collector, and denitrification by methods such as utilization of catalyst. It is also important to request operators to regularly or continuously monitor and to submit records of emission at monitoring points such as chimney outlets and the surrounding areas.

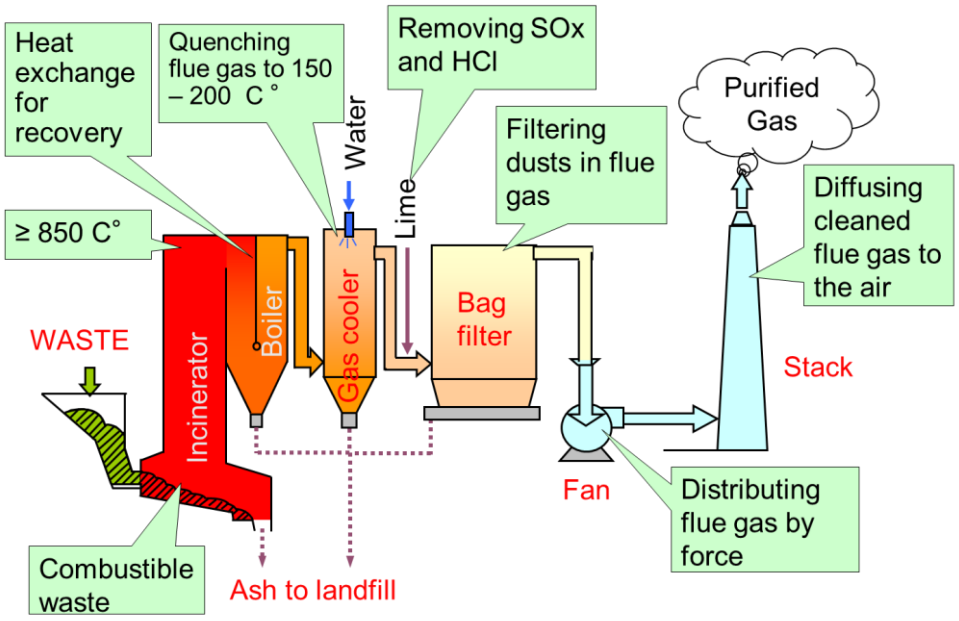


Figure 4: Air quality control measures at WTE infrastructures

(2) Waste water measure

WTE infrastructures discharge waste water through different processes such as cleaning of oil-containing equipment, treatment of bottom and fly ash, water production for boilers, cleaning of flue gas, daily water use by employees, and the maintenance and cleaning of equipment. The waste water generally contains a small quantity of acid, alkaline and suspended substances. In addition, in case there is waste water with high concentration of organic contaminants which require separate treatment, a different waste water control measure must be applied. The quality of water, which is measured by potential of hydrogen (pH), biochemical oxygen demand (BOD)/chemical oxygen demand (COD), suspended solids (SS), total nitrogen, total phosphorus, and other hazardous substances, should be adequately controlled, according to each competent regulation or stricter limits. Waste water treatment should be conducted by utilizing technologies such as coagulating sedimentation, filtration, adsorption, and neutralization. In addition, regular or continuous measurement and submission of the record should be requested to the operator in order to manage continuously quality of waste water generated from the infrastructure.

(3) Incineration residue (bottom and fly ash)

Wastes generated from WTE infrastructures are mainly bottom ash from the combustion process, fly ash generated as a by-product through the flue gas treatment, and sludge from waste water. If safety can be ensured, bottom ash can be effectively reused as raw material for cement, roadbed material, and other purposes. As fly ash contains heavy metals such as cadmium, lead, mercury and arsenic, proper disposal measures such as elution prevention at the final disposal site are required.

(4) Noise and vibration

Noise and vibration at WTE infrastructures are generated from equipment such as boilers, turbines, pumps, fans, and compressors. Measures against noise include attention to the place of installation of the equipment that is the noise source, securing sufficient distance from site boundary, introducing noise suppression covers, low-noise equipment and soundproof walls. Measures against vibration include installing vibration isolators, installing independent foundations for equipment and securing

sufficient distance from site boundary. It is also important to require the operator to measure, record and submit the level of noise and vibration. The same consideration should be applied during the construction phase. The level of noise and vibration should be measured, recorded, and submitted, and appropriate countermeasures should be implemented by contractors in the same manner as during the operation phase.

(5) Preservation of ecosystem

The impact on ecosystem during construction and operation of WTE infrastructures and the adoption of appropriate measures to preserve the ecosystem surrounding the construction site should be considered especially when the facility is developed on a new site.

(6) Employment of local residents

The construction and operation of a WTE infrastructure create a large scale of long-term employment. From the perspective of the co-existence with local community, employing a certain number of people from the local economy contributes to securing long-term employment, developing the local economy, and also enhancing cultural and economic capability of local residents. This could be achieved, for instance, by requiring contractors and subcontractors to hire appropriate number of employees from the local community. Meanwhile, construction and operation of WTE infrastructures require utilization of advanced and highly-skilled technologies such as those regarding waste incineration and flue gas treatment. Therefore, in principle, recruited local residents should be given tasks that require technical capabilities that are more general.

(7) Involuntary resettlement

If involuntary resettlement is unavoidable for the construction of a WTE infrastructure, the project should be well planned and executed so that the quality of life and livelihoods of those affected, particularly of vulnerable people, is well-restored, economic growth is enhanced and poverty is reduced as a result of economic growth. A well-thought involuntary resettlement plan should be formulated at the planning stage.

(8) Local procurement of goods

In order to stimulate local economy, it is desirable to make utmost efforts to procure a certain quantity of goods and services from the local community depending on the industrial level of the region to the extent where it does not harm the principle of free trade and the feasibility of the project. This could be achieved, for instance, by comparing the industrial level of local community with the quality required for the project and setting an appropriate and feasible ratio of goods and services to be procured.

1.3.7 Safety

“Safety” is defined as the ability to prevent or suppress damages to humans or facilities except for damages to the environment. It is a prerequisite to secure safety of surrounding residents, employees involved in the project and facilities by preventing external damages during both the construction and operation phases of WTE facilities. Safety can be primarily classified into (1) disaster prevention, (2) information security, and (3) crime prevention.

(1) Disaster prevention

Major risks in WTE infrastructures include natural disasters, fire, explosion, the leakage of hazardous substances, and industrial accidents such as workers being caught in machines, electroshocks, and

falling. To prevent these risks and secure human and facility safety, it is essential to build a solid disaster prevention system and an appropriate working environment with the active involvement of related disaster prevention agencies.

(2) Information security

There exists an increasing threat and risk that cyber-attacks against operation systems of WTE infrastructure may trigger a power failure and blackout. As a prevention measure, the following measures should be considered the ability to disconnect the control system of the WTE infrastructure from the IT system network, the installation of a firewall fitting well with each control systems' protocol, the creation of necessary manuals and the conduction of appropriate employee training. Although there are currently very few WTE infrastructures which are remotely operated, considerations should be taken to prevent risks of remote operation in the future.

(3) Crime prevention

As WTE infrastructures are often located in areas far from city centers, prompt response to crimes may be difficult. However, as crime actions against the WTE infrastructure may disrupt waste treatment, causing significant damage to citizens' life and socioeconomic activity, it is important to establish necessary security measures against intrusion and any other criminal actions.

1.3.8 LCC

"LCC" is defined as the sum of the cost throughout the life cycle of a WTE infrastructure, provided the WTE infrastructure satisfies all the requirements of the other seven components of the QWTEI mentioned above. LCC can be roughly classified into construction cost and running cost including disposal cost. The ratio of the cash value of the two differ by the method of ash disposal at each infrastructure, with the cost for chemical agents being a large component of running cost. Additional costs such as repair cost and cost generated by forced outage should also be included.

If the type of bidding of the WTE infrastructure is public-private partnership (hereinafter referred to as "PPP"), the cost, including the running cost and social cost such as cost of CO_2 emission, must be estimated before placing of the bid. LCC should be assessed by collecting detailed information to the extent possible about the actual figures. Estimation should be made based on performance of previous applicants and a system should be established so that proper evaluation can be conducted. In case of a WTE infrastructure, costs such as utility costs for auxiliary fuel or power for heating may fluctuate depending on system type or region. Therefore, for items that are not likely to fluctuate depending on the applicant, the employer should set standards and make them public so that accurate cost estimation can be conducted.

1.3.9 Components of QWTEI in different phases

The components of the QWTEI will be defined separately for each phase, namely feasibility study, planning and construction phase, and operation phase. The definitions of the eight components during each phase are provided in the figure below.

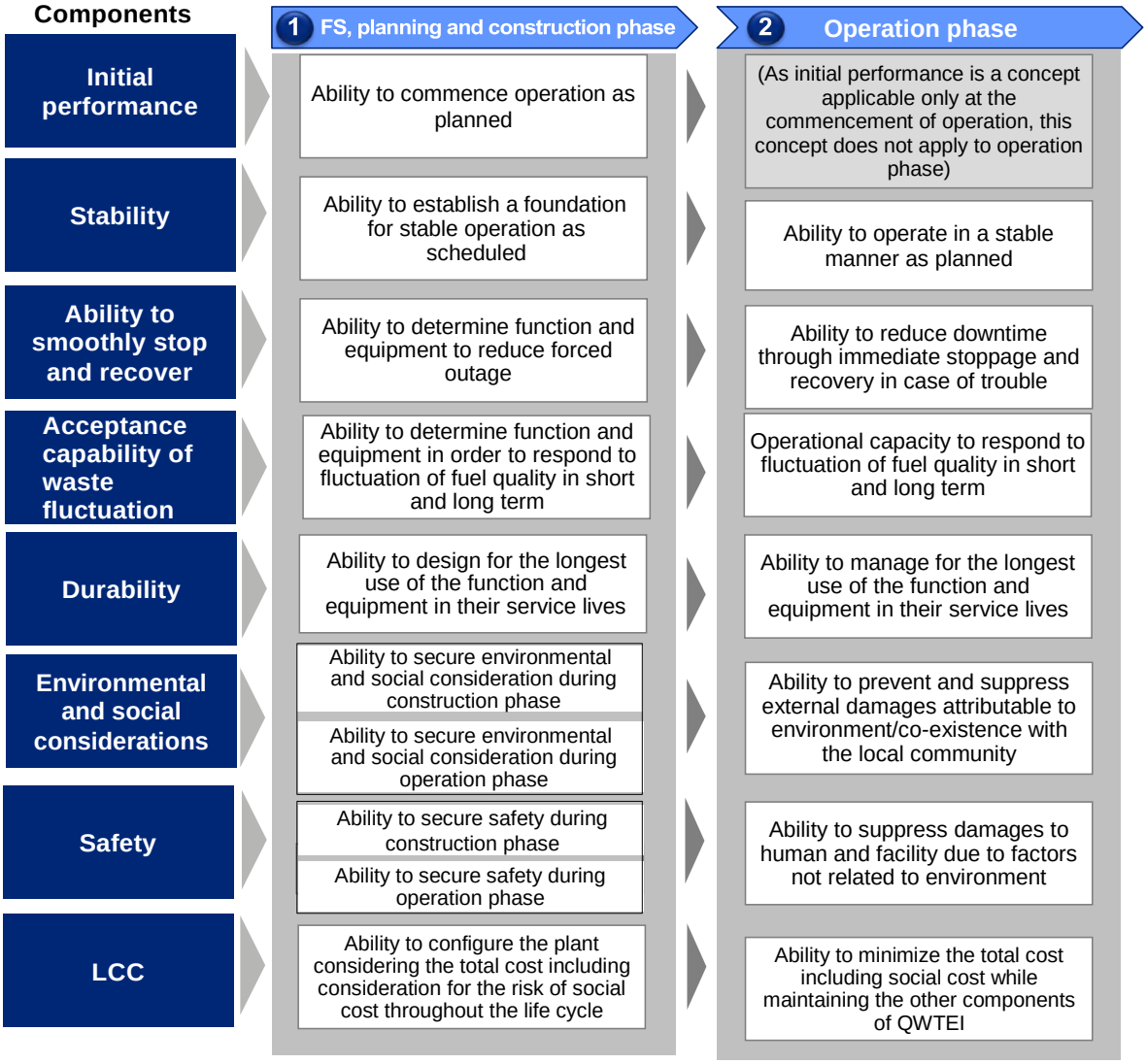


Figure 5: Definitions of components during each phase

Column 1: Establishment of laws necessary for ensuring QWTEI

As a precondition for realizing quality WTE infrastructures, each country or region should enact basic laws to support such facilities. With regard to the construction of WTE infrastructure projects considered in this Handbook, basic laws including provisions regarding, for example, the following items should be established after appropriate consultation with relevant departments:

- Basic and long-term waste management plan
- Waste management
- Consideration to the environment and residents living near waste treatment facilities
- Standards regarding waste treatment
- Technical guidelines and standards
- Supervision of waste treatment operators by the central government (including issuing of operating permits and regulations for the operators)
- Supporting measures by the central government such as subsidies
- Method do determine/change the tipping fee and the electric power charge (including cases where FIT is utilized)
- Measures to ensure transparency and prevent corruption
- Procurement (including utilization of the private sector)

In addition to the enactment of basic law regarding waste treatment infrastructures covering the above-mentioned items, supportive documents such as guidelines should also be developed as necessary for implementation of the laws in each country or region.

In many countries and regions, waste treatment is being conducted under PPP scheme in the recent years. In order to effectively utilize the PPP scheme, basic laws regarding PPP should also be established, and these should include provisions regarding the following items.

- Organization responsible for promoting PPP
- Administrative procedures for PPP projects regarding project formulation, procurement, and implementation
- Projects that are within the scope of PPP scheme (waste treatment projects should be within the scope)
- Relationship and coherency with other relevant laws
- Support measures with regard to PPP projects by the government

In order to develop WTE infrastructures in an efficient and effective manner, basic and long-term plan of the sector should be drafted based on laws mentioned above and mid-long-term sectoral vision. Furthermore, such plans should be coherent with nation or region-wide mid-long-term plans as well as cross-sectoral strategies on economic development and environment, including climate change.

Column 2: Importance of conducting appropriate cost-benefit analysis for WTE projects

If appropriate cost-benefit analysis of WTE project is not conducted at the feasibility study and planning stage, the plan may be canceled, or the construction works may be delayed or canceled. Such incidents have actually occurred in many countries and regions including ASEAN countries. In such cases, as mentioned below, either the cost, the benefit, or both were not appropriately evaluated, and the result of the cost-benefit analysis was too optimistic. This caused loss of business chance for many years.

- Cost: Only the initial cost presented by the operator was evaluated and the LCC including running costs such as cost for disposal and repair was not properly evaluated. Further, important components such as acceptance capability of waste quality/amount fluctuation and durability were not considered.
- Benefit: Initial performance, stability, and ability to smoothly stop and recover were not properly evaluated and important components such as acceptance capability of waste quality/amount fluctuation and durability were not considered. As a result, the revenue from power sales was overestimated, and the tipping fee which the local government must pay was underestimated.

In order to prevent such cases, conducting appropriate cost-benefit analysis which takes into account the components of QWTEI is essential.

Part II: Feasibility study, planning and construction phase

Adequate procurement of construction is vital to securing the QWTEI. As mentioned in the previous sections, the primary objective of QWTEI is to ensure public health. In other words, the employer procures a WTE infrastructure so that it will function as the main facility to protect public health of the area. In order to attain this objective, the employer should understand the components of QWTEI explained in Part I and the indicators and methodologies of evaluation explained in this Part.

2.1 Evaluation of the QWTEI

2.1.1 Concept of the evaluation of the QWTEI

Evaluating the QWTEI during feasibility study, planning and construction phase is almost synonymous with evaluating the applicant's engineering, procurement, and construction capability and financial capability.

It is often the case that the employer obtains knowledge related to the ability of applicants through the information submitted by the applicants and also the past track records the employer actually awarded to the same applicants. They are often not sufficient and thus it is recommended to share information with other employers who have worked with the applicants in the past. It is desirable to evaluate the applicants' capability with the information provided not only by the applicants but by the applicant's ex-employers. If just the employer is to confirm such information, important information may be overlooked due to constraints such as lack of time. Therefore, in such cases, hiring a third party other than the applicant for confirmation of information may be effective[1].

2.1.2 Performance indicators regarding construction and financial capability which an employer should request the applicants to submit

(1) Initial performance

It is critical to require a contractor to select appropriate facilities and equipment to obtain performance as agreed in the contract between the employer and the contractor. The contractor needs to construct the WTE infrastructure not only in compliance with the contract but also in enough consideration so that its initial performance will be realized in actual operation. There already exist some mechanisms for preventing non-compliance, such as imposing penalties for non-conformance with the required performance in performance test and for delay in completion owing to contractors' fault. However, selecting an appropriate contractor through the pre-qualification (hereinafter referred as "PQ") process to prevent such non-compliance is crucial for ensuring QWTEI. The performance indicators to evaluate the applicant's ability of realizing "initial performance" are as follows:

Performance indicators	Appendix 1
Number of construction completion	No.1
Conformity with specified performance	
Track record of faulty construction including delay in completion	No. 2

[1] Third party here refers to parties other than the employer or the applicant such as experts or consultants. When evaluating information that is difficult to collect or confirm, careful consideration should be taken before the bidding by the project owner.

(2) Stability

Enough consideration for O&M should be paid in designing the infrastructure in the bidding phase in order to assure “stability”. The facility should be designed to include a system that enables collection and analysis of O&M log data, equipment to achieve optimization of O&M, and other factors (refer to “3.2.2” for further details). The performance indicator to evaluate the applicant’s ability of realizing “stability” is as follows:

Performance indicators	Appendix 1
Record of continuous operation and explanations of long-term outage	No. 3

(3) Ability to smoothly stop and recover

In order to maintain “ability to smoothly stop and recover” during operation phase, it is necessary to take actions such as installing devices for early detection of defects and protection units as well as to ensure and enhance the easiness of maintenance. The performance indicator for “ability to smoothly stop and recover” is as follows:

Performance indicators	Appendix 1
Track record of long-term forced outage within the warranty period	No. 4

(4) Acceptance capability of waste fluctuation

The calorific value and the chemical properties of wastes which are incinerated fluctuate depending on season or week of the day. WTE infrastructures shall continue to be operated by adjusting with such fluctuation. Especially in cases where the calorific value of the wastes is expected to be low, applicants that have sufficient experience in incinerating such wastes should be selected. The performance indicator for “acceptance capability of waste fluctuation” is as follows:

Performance indicators	Appendix 1
Accepted range of waste quality (calorific value, minimum consumption rate)	No. 5

(5) Durability

WTE infrastructures must continually treat wastes for many years. Thus, material used for equipment surrounding the combustion unit and gas-cooling reactor should be sufficiently durable as they are likely to be heavily damaged by high heat and acidity. Therefore, sufficient experience and knowledge is required to select appropriate materials in order to ensure durability of equipment. The performance indicator for “durability” is as follows:

Performance indicators	Appendix 1
Frequency of repair of main parts (e.g. boiler tubes, refractories)	No. 6

Column 3: Importance of selecting operators that can respond to fluctuation in waste quality/amount and ensure durability

Even if fluctuation in waste quality and amount was sufficiently considered at the planning or bidding phase, troubles may occur in actual treatment in four or five years after commissioning. In reality, such troubles have occurred in many countries and regions. In some cases, the trouble was caused by quality or amount of received wastes which were not within the designed range. However, in some cases, troubles have occurred even when the quality and amount of wastes were within the designed range. In such cases, the troubles are often associated with the operator or the manufacturer of equipment. In order to avoid such cases, operators that possess sufficient experience or technology with regard to waste treatment should be appropriately selected in the procurement stage based on the following evaluation criteria:

- Record of continuous treatment of waste of which fluctuates in quality and amount
- Record of installation and continuous operation of equipment that is sufficiently durable
- Record of operation of similar WTE infrastructure for 90 days or more

In view of the number of years of operation of WTE infrastructure, stable operation record for a period of 20 or more years should be evaluated.

For details, refer to “Appendix 1: Metrics of performance indicators during feasibility study, planning and construction phase”.

(6) Environmental and social considerations

The contractor of a WTE infrastructure is required to possess environmental protection capabilities conforming to, and preferably exceeding the regulations of the economy where the facility is to be constructed. A contractor who can barely surpass the regulations may lack allowance and margin for unexpected deviations from initial assumptions and thus impose high risks to the society. Therefore, it is important to accurately evaluate the applicant’s environmental capabilities. While some of the indicators overlap with those for “initial performance”, the performance indicators for “environmental and social consideration” are as follows:

Performance indicators	Appendix 1
Number of projects meeting the guarantee performance in relation to environmental performance (evaluated in “number of construction completion” under “initial performance”)	No. 1
Conformity with specified performance (evaluated in “conformity with specified performance” under “initial performance”)	No. 1
Track record in relation to non-conformance of the environment protection law	No. 7
Track record in relation to employment of local residents	No. 8

(7) Safety

"Safety" is evaluated from two perspectives: external factors during operation phase and internal factors during construction phase such as industrial accidents. The former can be evaluated in terms of preparedness against attacks and natural disasters from outside the WTE infrastructure. The latter can be evaluated in terms of preparedness against troubles and accidents in the construction site. As the contractor plays a pivotal role in minimizing/mitigating factors affecting its safety, the employer needs to carefully gauge contractor's ability and other aspects in this regard. While some of the indicators for "safety" overlap with those for "initial performance", the performance indicators are as follows:

Performance indicators	Appendix 1
Number of projects satisfying the guarantee performance in relation to safety (evaluated in "number of construction completion" under "initial performance")	No. 1
Ability to meet required safety performance (evaluated in "conformity with specified performance" under "initial performance")	No. 1
Track record of fatal accidents	No. 9

(8) LCC

The employer needs to select an applicant with the ability to optimize LCC by evaluating information submitted by applicants with some reasonable assumptions, provided that the WTE infrastructures satisfy all seven other components. Meanwhile, if the project is conducted under the PPP scheme, evaluation of LCC is equivalent of evaluation of the bidding price. Therefore, the performance indicator to evaluate applicants' ability of realizing "LCC" is as follows:

Performance indicators	Appendix 1
LCC considering all other seven components	This indicator should not be evaluated in the same manner with the other indicators, as it has direct impact on the bidding price

(9) Financial capability

There remains a risk of a contractor's default during construction due to lack of funds and other reasons, even if the contractor satisfied all the performance indicators of the eight components. Therefore, financial ability of the contractor should also be considered based on the information obtained through the financial statements for past years. The performance indicators for "financial capability" are as follows:

Performance indicators	Appendix 1
Turnover	No. 10
Liquid asset	No. 11
Soundness	No. 12

2.2 Requirements of bidding to secure the QWTEI

2.2.1 Bidding procedure for construction of WTE infrastructure

As mentioned in the previous section, it is important to conduct a sound bidding procedure for determining a contractor able to satisfy all eight components in order to secure the QWTEI throughout the life cycle. The bidding procedure for a WTE infrastructure is provided in Figure 6. For details regarding international tenders, readers are recommended to refer to documents such as "Conditions of EPC and Turnkey Projects" commonly referred to as the "Silver Book" by Federation Internationale des Ingenieurs Conseils (FIDIC) which can serve as a useful guide.

"Applicant" in this Handbook refers to someone that wishes to be the primary contractor with the employer by direct contract. Subcontractors are not included in the definition of applicant.

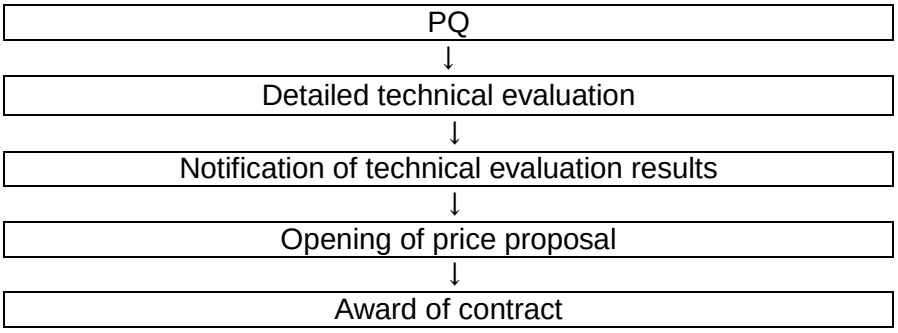


Figure 6: General bidding procedure for a WTE infrastructure

1) PQ is conducted in order for an employer to determine applicants with sufficient ability to perform the contract. The evaluation at this stage will be conducted based on the applicants' track records and other relevant information including financial information. In this Handbook, conducting appropriate PQ is considered the most important element for ensuring QWTEI.
2) The employer provides technical specifications to the qualified applicants, and these applicants are required to submit a technical proposal along with the price bid proposal of the technical proposal. If the time between notification of technical specifications and due date of submission of related proposals is too short, applicants will not have sufficient time to prepare the technical proposal. Therefore, the employer should secure adequate time from notification of technical specifications to due date of submission of related proposals in order to ensure QWTEI (i.e. to avoid construction of WTE infrastructure based on technical proposal that has not been carefully considered). In general, regarding construction of large-scaled WTE infrastructures, at least six months should be secured for preparation of proposals. If there are deviations between the technical specifications and the proposal by the applicant, decisions should be made on whether such deviation is acceptable or not simultaneously with the technical evaluation. When doing so, the decision should be taken from the viewpoint of the whole infrastructure and not from the viewpoint of each equipment specifications. During technical evaluation, applicants are evaluated based on information that is more detailed than that considered in the PQ stage.
3) The results of the technical evaluation are notified, and only the applicants with sufficient technical ability to perform the contract advance to the next stage.
4) The applicant that obtain the highest total score for technical proposal and bidding price taking

into account LCC is awarded preferential negotiation rights.

After negotiations between the employer and the applicant regarding the contract, the contract is signed, and the project is implemented. Before implementation of the project, the employer may, in order to guarantee the bid and redemption of contract, require a bid bond and performance bond to applicants and winning bidder respectively. Furthermore, even after conclusion of contract, the employer should carry out technical audit on certain phases of the construction to confirm that the contractor is adequately performing construction in accordance with contract and rules, which indirectly secures QWTEI.

2.2.2 Requirements of bidding procedure for the construction of WTE infrastructures

An employer prepares PQ and bidding specifications which specify criteria of the QWTEI a WTE infrastructure should satisfy and selects applicants with sufficient ability to achieve the requirements. Evaluation items and criteria applied in PQ and technical evaluation should be explained to applicants in advance so that evaluation can be conducted in a transparent manner. Examples of evaluation items when selecting an applicant for a WTE infrastructure project are provided in Column 4. Examples of evaluation criteria for PQ and technical evaluation regarding the WTE infrastructure projects are provided in Appendix 2 and Appendix 3.

Colum 4: Examples of evaluation criteria for comprehensive evaluation of bids

When conducting comprehensive evaluation of bids based on both financial and technical aspects, appropriate evaluation criteria should be selected for technical items. Such evaluation criteria should be selected in line with QWTEI, and examples are shown in the table below.

With regard to evaluation of technical items, the evaluation criteria should be made public in order to ensure transparency and fairness. Further, evaluation should be conducted by an evaluation committee which should include external experts as necessary.

Table 1: Example of evaluation criteria

Evaluation criteria	Information to include in proposal (examples)	Viewpoint of evaluation
Efficient operation	• Response to fluctuations to waste quantity and quality (plant operation plan) • Response to troubles	• Concreteness • Reliability • Effectiveness expected
Environmental conservation	• Gas emission limits (e.g. termination criteria, controlled values) and measures to comply with them • Measures to control noise, vibration, and odor • Plans to install structures to prevent damages by disasters such as earthquakes, hurricanes, and fires • Plan to utilize rainwater (e.g. amount to be used)	• Relevance • Concreteness • Reliability • Effectiveness expected
Plant design for safe and stable operation	• Treatment performance (e.g. method to ensure stable treatment, incineration performance curve) • Previous troubles and technical innovation to overcome them • Fail-safe design (e.g. prevention of failures, minimization of damages at times of failures)	• Relevance • Concreteness • Reliability • Effectiveness expected
Energy utilization	• Annual plans on power generation/sales and improvement plans • Plans to utilize residual heat • Energy recovery rate • Plans to minimize energy consumption	• Quantitative comparison • Concreteness • Effectiveness expected
Building design	• Landscape design (e.g. perspective), spatial and greening plan • Consideration to the surroundings • Multi-purpose utilization of the facility	• Relevance • Effectiveness expected
Eco-friendly learning plan	• Paths for facility visitors (image), plans on installation and renewal of educational facilities • Educational menu • Acceptance of facility visits • Energy utilization	• Concreteness • Feasibility • Effectiveness expected
Conciliatory strategy	• Information sharing • Proposal of support measures at times of disasters (e.g. early recovery, provision of space for evacuation) • Assistance to citizens regarding multi-purpose use of the facility	• Concreteness • Feasibility • Effectiveness expected
Contribution to the surroundings	• Utilization of local businesses • Cooperation regarding material procurement (e.g. utilization of local materials) • Employment of operators and plans on training	• Quantitative comparison • Concreteness • Feasibility • Effectiveness expected

Safe construction	• Work schedule and management method • Quality control, safety management plan, waste prevention (including soil), measures regarding muddy water and groundwater • Measures regarding surrounding environment	• Relevance • Concreteness • Reliability
Grand layout plan of a WTE infrastructure	• Layout plant of the facility • Plans to ensure safe work flow (e.g. separation of traffic by purpose, separation of pedestrians with vehicles, outdoor and indoor work flow) • Securing waiting spaces	• Relevance • Convenience • Effectiveness expected
Prolonging of a WTE infrastructure	• Expected life of main facilities and plans on repair • Plans on inspection and maintenance (including 30-year plan and operation extension plan) • Provision of work path and space for repairs	• Relevance • Concreteness
Stable operation	• Personnel allocation and organizational chart (e.g. personnel and organization at normal times and times of emergencies/troubles) • Income and expenditure plan • Insurance for times of low earnings	• Relevance • Concreteness • Effectiveness expected • Quantitative comparison
Risk control plan	• Expected risks and control measures • Plans to prevent reception of improper wastes • Response to unplanned repairs	• Precision • Concreteness • Effectiveness expected
Smooth handover to the project owner after contract period	• Proposal regarding handover of the project	• Relevance • Concreteness
Technical (non-financial) score: 60 points		
Financial score: 40 points		
Total score: 100 points		

Column 5: Case of waste treatment project in Tuas, Singapore

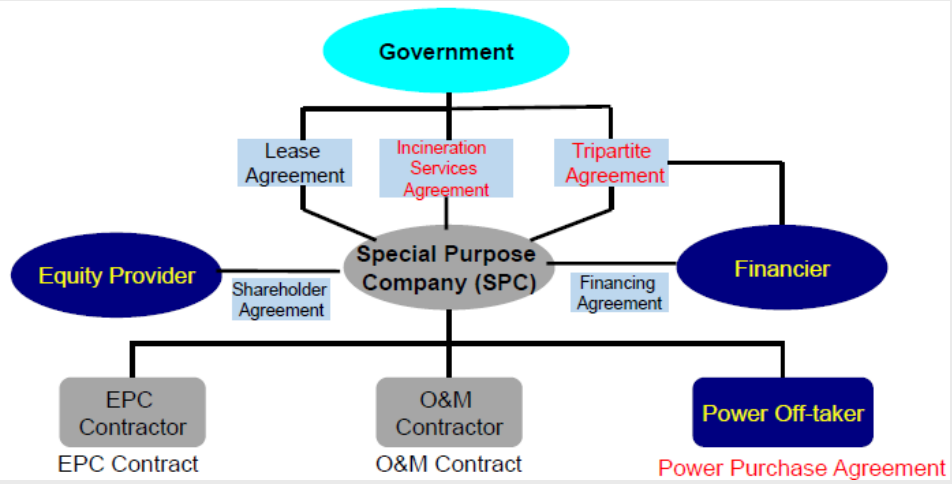
The first WTE infrastructure introduced in Singapore was operated by the government, but for its renewal in 2001, outsourcing of construction works and operation to private contractor was considered. Initially, the bidding was conducted in a manner where the private contractor would bear the risk of fluctuation in demand. However, only one company which did not fulfill the technical requirements participated in the bid. This was because many companies considered that they could not bear the demand risk in addition to the significant initial cost of WTE project.

In light of the failure, new bidding specifications were considered. In order to select a competitive WTE operator and make the project sustainable, it was decided that the incineration service agreement would be signed between the government and the contractor with the following conditions.

- The government is to bear the responsibility of ensuring the quality and amount of wastes as stipulated in the contract
- The government is to make payment to the contractor as stipulated in the contract regardless of the hours of operation
- The contractor is to comply with the requirements stipulated in the contract with regard to technical specifications, service level, and commerce.
- The contractor is to pay penalties if it does not fulfill the service level requirements

As a result, many companies participated in the bidding, and a company that fulfilled the requirements was selected. The operation of the WTE infrastructure started in 2009, and to this day it has continued without significant troubles.

The key to this success was the existence of a contract among three parties, namely the government, the operator, and the financier. As the financier also signed the contract, the financer holds the right to step in if the operator falls into bankruptcy. Furthermore, if the operator is no longer able to provide the necessary services, the government holds the right to step in and take over.

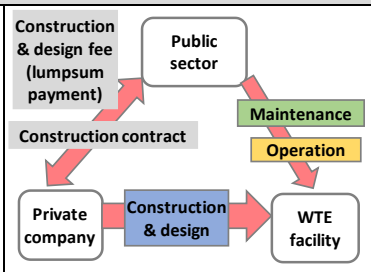
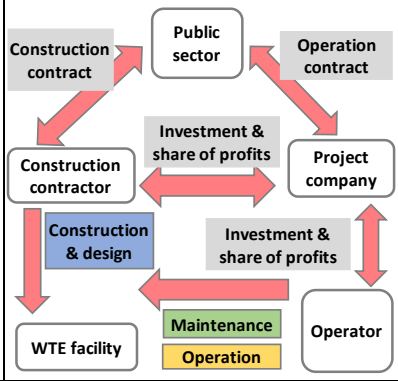
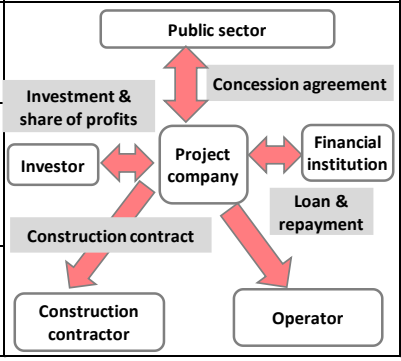


The reliability of the tipping fee which is essential in ensuring the economic sustainability of the business is based on the past record of payment from the Government of Singapore to the operator.

2.2.3 Examples of business scheme

In many cases, construction and operation of WTE infrastructures are contracted under the PPP scheme. In Japan, for instance, WTE infrastructures were traditionally constructed with public funds, and separately, their operation was outsourced to private entities. Meanwhile, under the PPP scheme, construction and operation of the WTE infrastructure is contracted out to a single entity in a package. Therefore, the financial burden on the public sector becomes smaller. The major business schemes for construction and operation of WTE infrastructures are shown in the table below.

Table 1: Examples of business scheme

Business scheme			Finance	Construction	Operation	Ownership of		Advantage	Disadvantage
						During project	After project		
Design-Build (Publicly constructed and operated)			Public	Public	Public	Public	Public	As the public sector is in charge of all aspects (i.e. financing, design, construction, and operation), the project tend to be more trusted by citizens.	As the public sector bears all risks, the design tend to be on the safe side. As a result, the cost for construction and O&M may become high and create large financial burden. As the construction cost is paid in lumpsum,
PPP (Public Private Partnership)	Design-Build-Operate		Public	Private and public	Private	Public	Public	1. The risk on the private sector is unified as construction and operation is contracted in one package 2. The financing risk on the private sector decreases as the public sector finances the project 3. The public expenditure for operation cost is levelled out.	As the public expenditure for construction cost is not levelled out, funding the initial investment may be difficult.
	Build-Transfer-Operate		Private	Private	Private	Public	Public	1. The public sector does not need to finance the project 2. The private company is granted the right to design, construct, operate, and maintain the facility as a package 3. Stable financial management is possible, as financial institution provides loans and conducts financial monitoring	1. Implementation of the project may become difficult if division of risk between the public and private sectors become unclear 2. If the risk on the private company becomes too high, there may be no applicants
	Build-Operate-Transfer		Private	Private	Private	Private			
	Build-Own-Operate		Private	Private	Private	Private			

Under the PPP scheme, the applicant is evaluated by the tipping fee per unit of waste. However, in order to ensure QWTEI, all the items mentioned in this Part should be considered in the evaluation process.

Even if construction and operation of WTE infrastructures are contracted under the PPP scheme, as mentioned in the beginning of the Handbook, the main purpose of the WTE infrastructure is to protect public health. This point should be taken into consideration when making the economic evaluation.

Column 6: Measures by the central government to support WTE projects

During the feasibility study, planning, and construction phase of WTE projects, the central government should in general conduct the followings:

- Secure the land for the WTE infrastructure
- Secure the quality and amount of wastes
- Secure the connection between WTE infrastructure and power transmission network
- Conduct environmental impact assessment (EIA)

Furthermore, in order to ensure economic sustainability of the project and to facilitate participation by the private sector, the following actions should be taken by the central government:

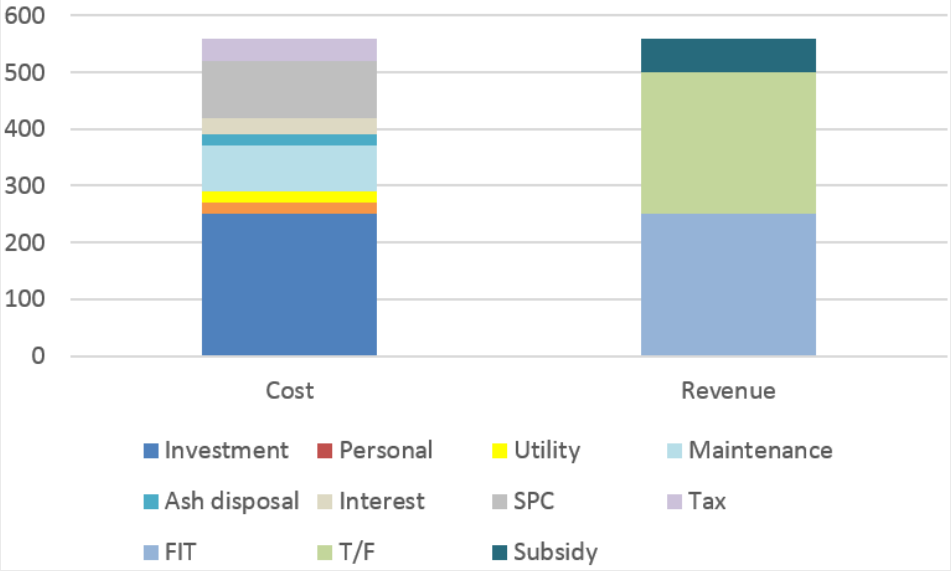
- Grasp the fluctuation in quality and amount of wastes and guarantee supply of auxiliary fuel, comply with the provisions of the contract
- Compensate revenue for times when the monthly average calorific value of the wastes falls below the planned minimum calorific value
- Guarantee payment by the central government with regard to revenue of the local government (e.g. tipping fee, power sales)

However, it should be noted that conducting the actions mentioned above will increase the risk for the central government. Therefore, careful consideration should be taken in project formulation so that QWTEI would be secured in the long term. In order to facilitate such project formulation, the local government should obtain data regarding quality and amount of wastes and their fluctuation. If there are local governments that do not have such data, the central government should promote establishment of a system where fluctuation in quality and amount of wastes is recorded.

Column 7: Method to determine the tipping fee (case study)

Although the method to determine the tipping differs in each country, the basic principle in ensuring economic feasibility of the WTE projects is universal; the LCC for construction and operation of the WTE project which includes items such as initial investment, personnel cost, utilities, and cost for maintenance must balance with the profit during the project period.

The sales from power sales including sales supported by the FIT scheme may play an important role for securing sufficient profit. However, there are very few cases where the cost of WTE project is covered only by the power sales, and the rest of the cost is generally covered by the tipping fee. In most cases, the cost of the project is supported by the tipping fee paid by the local government as shown in the figure below. In addition, financial support schemes provided by the central government are often utilized.



Part III: Operation phase

Realizing stable waste treatment in the mid to long term by conducting effective O&M is important. Effective O&M can be achieved through application of “Self-Elevating Mechanism for Sustainable Operation and Management Practice” by O&M operators. This mechanism can contribute to maintaining and enhancing the QWTEI which will otherwise be subject to aging deterioration. The O&M operators here refer to WTE infrastructure operating companies or consigned vendors. The first section of this Part clarifies the QWTEI, which should be enhanced during operation phase. The second section sets out management system to enhance O&M operation.

3.1 Method to evaluate QWTEI during operation phase before construction

In many cases, construction and operation of WTE infrastructures are contracted in one package. In fact, many WTE infrastructures are contracted under the PPP scheme. Therefore, this Handbook explains the method for employers to evaluate private operators under the PPP scheme, especially under the build-operate-transfer (BOT) scheme. In actual projects, at the point when the employer places the bidding or when the applicant signs the contract with the employer, the details of the WTE infrastructure are almost all determined which implies that QWTEI is already nearly determined at that point.

Therefore, it should be noted that thorough evaluation by properly applying the principles explained in this Handbook before the bidding is crucial to ensure QWTEI.

3.2 Evaluation of the QWTEI

3.2.1 Basic concept for the evaluation of the QWTEI

Evaluating the QWTEI during operation phase is synonymous with self-checking of performance and quality of O&M by operators.

3.2.2 Definition of the components of the QWTEI

The components constituting the QWTEI of a WTE infrastructure during operation phase, in other words, the ability of an O&M operator, are as follows:

Components of QWTEI	Definition during operation phase
Initial performance	(As the initial performance is a concept applicable only at the commencement of operation, this concept does not apply to operation phase)
Stability	Ability to continue operation as scheduled; namely, ability to conduct daily inspection and monitoring
Ability to smoothly stop and recover	Ability to reduce downtime through immediate stoppage and recovery in case of trouble
Acceptance capability of waste characteristics	Ability to continue operation regardless of short and long-term fluctuation of waste characteristics

Components of QWTEI	Definition during operation phase
Durability	Ability to control operation so that the infrastructure or devices function throughout its maximum service life; namely, ability to properly draft and implement O&M plan, ability to operate facilities for more than 20 or 25 years, ability to conduct periodic maintenance and repairs
Environmental and social consideration	Ability to prevent and suppress external damages attributable to environment/ co-existence with the local community
Safety	Ability to suppress damages to human and facility due to factors not related to environment
LCC	Ability to minimize the total cost including social cost while maintaining the other components of the QWTEI

3.2.3 Performance indicators of the QWTEI

The performance indicators that are used by O&M operators for appropriate measurement of the QWTEI are as follows. Details of the measurement approaches are provided in Appendix 4.

(1) Initial performance

As initial performance is a concept applicable only at the commencement of operation, this concept does not apply to operation phase

(2) Stability

The performance indicators for “stability” are as follows:

Performance indicators	Appendix 4
Incineration rate	No. 1
Incineration residues	No. 2
Grate combustion rate	No. 3
Utilities consumption rate	No. 4
Temperature control in specific points	No. 5
Quantity of flue gas	No. 6

(3) Ability to smoothly stop and recover

The ability to smoothly stop and immediately recover from shutdown is a requirement for enhancing QWTEI. The performance indicators for “ability to smoothly stop and recover” are as follows:

Performance indicators	Appendix 4
Forced outage rate (FOR)	No. 7
Long-term FOR	No. 8

(4) Acceptance capability of waste fluctuation

The ability to continue operation regardless of short and long-term fluctuation of waste characteristics

is a requirement for enhancing QWTEI. The performance indicator for “acceptance capability of waste fluctuation” is as follows:

Performance indicators	Appendix 4
Operation records in case of maximum and minimum condition of each parameter	No. 9

(5) Durability

Controlling operation so that the infrastructure or devices function throughout its maximum service life will enhance QWTEI. The performance indicator regarding “durability” is as follows:

Performance indicators	Appendix 4
Repair record of main equipment	No. 10

(6) Environmental and social considerations

The performance indicators for “environmental and social considerations” are as follows:

Performance indicators	Appendix 4
SOx and NOx discharge rate	No. 11
Dioxins and furans discharge rate	No. 12
CO_2 reduction rate	No. 13
Water quality	No. 14
Noise/vibration	No. 15
Waste recycling rate	No. 16

(7) Safety

As WTE infrastructures handle wastes and hazardous substances as well as require large-scale works such as periodic repairs and restructuring of main equipment, “safety” must be ensured to prevent industrial accidents. The performance indicator for “safety” is as follows:

Performance indicators	Appendix 4
Number of casualties caused by industrial accidents	No. 17

(8) LCC

Operation of WTE infrastructures may continue for more than 20 years. In order to optimize LCC, both the initial cost and the running cost should be reduced or prevented from sudden increase. In order to reduce the running cost, the operation cost should be optimized taking into account all other components of QWTEI and ensuring public health. The performance indicator for the optimization of “LCC” is as follows:

Performance indicators	Appendix 4
LCC considering all other seven components (in the previous fiscal year)	No. 18

3.3 Requirements to sustainably enhance the QWTEI

3.3.1 Concept of Self-Elevating Mechanism for Sustainable Operation and Management Practice

As reiterated, enhancing the quality of O&M is a decisive element to sustain and further enhance the QWTEI. The O&M operators are recommended to implement a management cycle, which we call "Self-Elevating Mechanism for Sustainable Operation and Management Practice" (see Figures 7 and 8), to sustain and further enhance the quality over the years. The mechanism comprises of six O&M requirements shown below.

O&M requirements	Definition
Measuring ability	Ability to measure and collect data
Data control ability	Ability to comprehensively record, manage and store data
Analytical ability	Ability to identify problems through comprehensive consideration and interpretation of the collected data
Problem-solving ability	Ability to identify and solve causes of unexpected problems/risk factors through use of analytical data
Organizational reiteration ability	Ability to reiterate the entire process from measuring data to problem-solving
Sustainable management ability	Ability to design an organization and other factors which maximizes the QWTEI which treat wastes

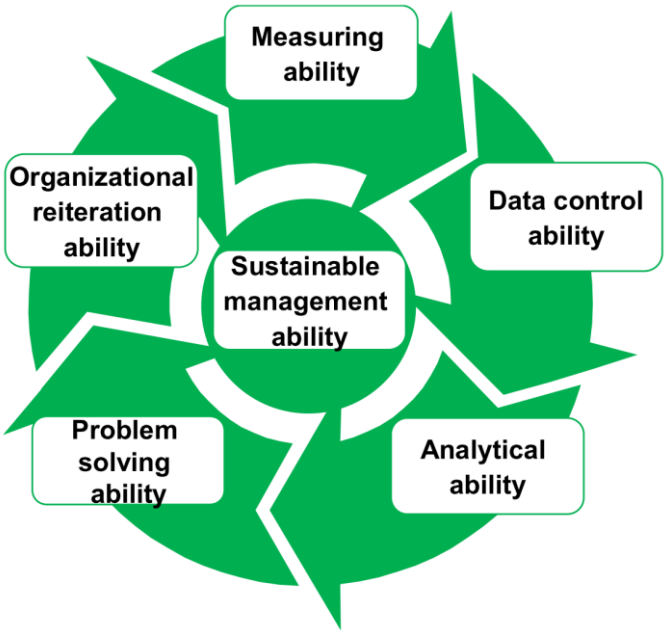


Figure 7: Self-Elevating Mechanism for Sustainable Operation and Management Practice

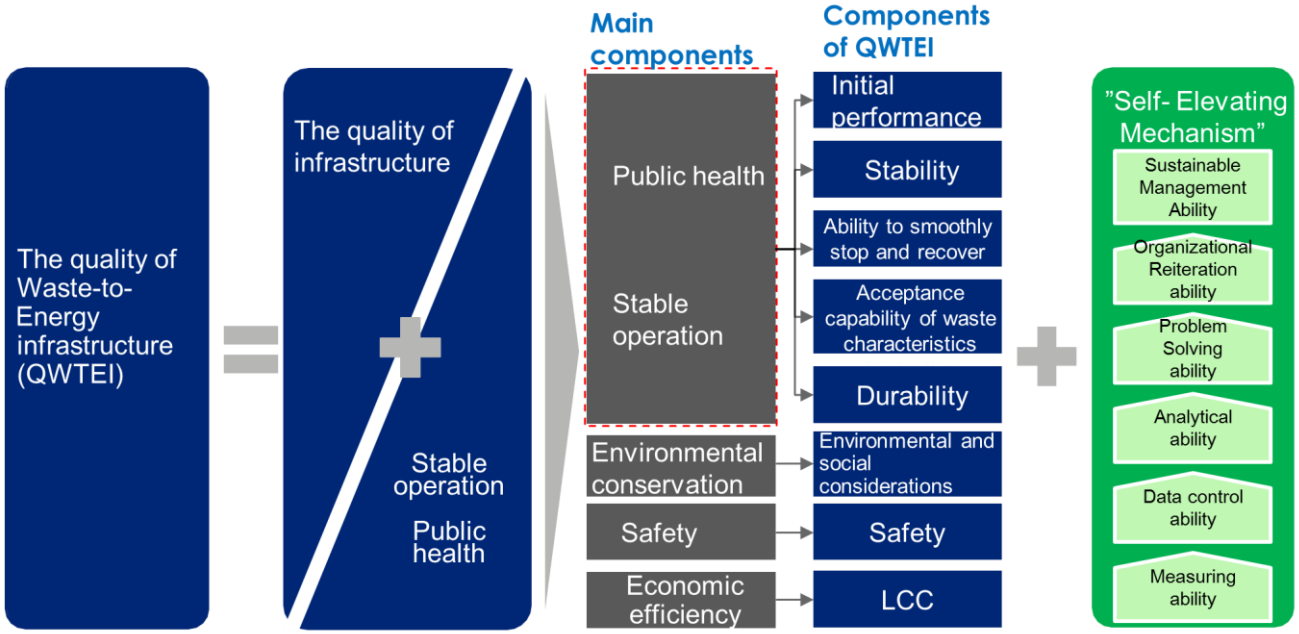


Figure 8: Realization of the enhancement of QWTEI by "Self-Elevating Mechanism for Sustainable Operation and Management Practice"

3.3.2 O&M requirements of WTE infrastructure

Provided below are details of the six O&M requirements for successful Self-Elevating Mechanism for Sustainable Operation and Management Practice.

(1) Measuring ability

"Measuring ability" is defined as the ability of an O&M operator to measure and collect data. It is a critical element for sustaining the O&M quality to develop a system to measure necessary and sufficient data on a timely basis. The requirements to fulfill this capability are as follows:

Classification	Details of the requirement
Measure/Collect	• System in place to enable timely measurement • Clarity of the points to measure • Optimal measuring frequency • Appointment of personnel responsible for measuring and monitoring • Ability to determine an appropriate measuring method

(2) Data control ability

"Data control ability" is defined as the ability of an O&M operator to comprehensively record, manage, and store data. Organizational, physical, and technical measures regarding safety handling of data must be fulfilled. The requirements to fulfill this capability are as follows:

Classification	Details of the requirement
Organizational measures	• Improved system and clarification of the authority and responsibility for protecting information
Physical measures	• Physical protection (e.g. lock, stipulation of criteria for taking data out) of equipment and device for preventing data leakage and damage

Classification	Details of the requirement
Technical measures	• Technical protection (e.g. access authorization, introduction of an antivirus software) of system for preventing data leakage

(3) Analytical capability

"Analytical capability" is defined as the ability of an O&M operator to comprehensively interpret the measured data and identify the true causes of troubles. Administrating and accumulating collected data alone is not sufficient. Analyzing and interpreting the data is a critical process for identifying what needs to be solved. The requirements to fulfill this capability are as follows:

Classification	Details of the requirement
Hiring personnel with analytical capability	• Hiring employees with high analytical capability and appointing to appropriate positions
Equip analytical tools	• Provision of tools necessary to conduct data analysis

(4) Problem solving ability

"Problem solving ability" is defined as the ability of an O&M operator to solve and eliminate the true causes of unexpected problems/risk factors through the maximum use of analytical data. After analyzing the data and identifying the potential risks, the next step required is to solve problems. Important processes required are to forecast unexpected situations, to prepare reaction plans and to take appropriate preventive and mitigation actions based on the analysis. The requirements to fulfill this capability are as follows:

Classification	Details of the requirement
Reaction to sign of risk	• Prompt identification of the sign of risk • Selection/planning/implementation of appropriate measures to cope with identified cause of signs • Implementation of appropriate preventive measures to cope with the identified risk factors in the future • Monitoring the effectiveness of remedy/recurrence prevention measures, sharing the progress with relevant stakeholders
Reaction to realized risk	• Prompt identification of causes • Selection/planning/implementation of appropriate measures to cope with identified causes • Implementation of appropriate preventive measures to cope with identified causes of the problem in the future • Monitoring the effectiveness of remedy/recurrence prevention measures, sharing the progress with relevant stakeholders

(5) Organizational reiteration ability

"Organizational reiteration ability" is defined as the ability of an O&M operator to reiterate the entire process from the measurement of data to problem solving. Having measured, controlled, analyzed, and solved problems, the next step required is to establish the system to maintain this cycle. Maintaining this cycle is difficult if the system is overly dependent on workers' experience and knowledge. Procedures should be made replicable as a whole organization. This know-

how needs to be converted to explicit knowledge to the extent possible and to be utilized for human resource development. The requirements to fulfill this capability are as follows:

Classification	Details of the requirement
Transfer of know-how through systemized explicit knowledge	• Establishment, update, and usage of database with sets of O&M know-how
Transfer of know-how through human resource development	• Systematic implementation of human resource development programs aimed at measuring capability, data control capability, analytical capability, and problem-solving capability (refer to clause 3.3.3 or further details)

(6) Sustainable management ability

"Sustainable management ability" is defined as the ability of an O&M operator to design an organization to maximize the potential of a WTEWTE infrastructure. In order to maintain and continuously elevate QWTEIWTEI, measurement, data control and analysis, usage of data, problem solving, and reiteration must be made repeatable by incorporating it in the organizational structure. The requirements for fulfilling this ability are as follows:

Classification	Details of the requirement
Corporate execution system	• Establishment of a management system/chain of command regarding the QWTEI, O&M requirement, and efficient operation of several WTE infrastructures considering relevant factors • Operating a WTE infrastructure efficiently, while maintaining compliance to various O&M requirements.

3.3.3 Training for O&M workers

Developing the capability of the operation and maintenance workers involved is vital in realizing high quality O&M. To enhance the workers' capability, it is imperative to provide sufficient initial training as well as to formulate a mid to long term training plan and develop the capability of the workers involved on a daily basis. It is also needed to prepare a training manual for O&M, train the workers based on the manual and periodically reflect any issues solved through "Self-Elevating Mechanism for Sustainable Operation and Management Practice".

Training from a remote location through the use of Internet of Things (IoT) may be made possible in the future (refer to 3.3.4 for further details).

3.3.4 Utilization of IoT

O&M can be optimized by standardizing O&M based on the analysis of various log data produced through the equipped system. In addition, it is required to timely convey the optimal O&M procedure to O&M workers. In other words, the QWTEI can be maximized through the conversion of closed internal knowledge within an employee to systematic and explicit knowledge by utilizing IoT. Furthermore, enhancement of O&M skills and accumulation/succession of knowledge will be realized through appropriate training towards the O&M workers utilizing IoT.

3.4 Additional issues to consider

3.4.1 Retaining skills and knowledge gained during the feasibility study, planning and construction phases for the operation phase

It is of value to the overall project for the skills and knowledge gained during the feasibility study, planning and construction phase to be retained to assist the commissioning and the operation. This can be achieved by the O&M operator of the WTE infrastructure employing engineers from the feasibility study planning and construction phase, or by seconding future O&M workers into the feasibility study planning and construction project teams. This issue should be considered during the preparation of contracts for the project to ensure the involvement of the appropriate employer's workers from the early stages of the feasibility study, planning and construction phase. In case of projects under the PPP scheme, although the same company will implement both construction and O&M, the same consideration should be taken so that skills and knowledge can be effectively utilized.

3.4.2 Improving leadership and decision-making for the O&M phase

Following the final commissioning of the WTE infrastructure, its operation phase could last for more than twenty years. Therefore, it is important for the WTE infrastructure to ensure that workers with the appropriate knowledge, experience and skills are available to operate and maintain as well as undertake major equipment renewal over the life of the infrastructure. In particular, the control system and main equipment of WTE infrastructure are likely to be upgraded several times over the life of the facility. The leadership and decision-making processes require wider skills in addition to technical O&M. The cost of each of these intra-asset lifetime reinvestments can represent large sum of the total cost. Economic cost benefit analysis which is vital for protection of public health will require skill and experience of the O&M team members.

3.4.3 Financial capability to identify operational funding

While the major investment cost in a large-scaled WTE infrastructure is the initial planning and construction costs, the cost for periodic repairs or updates throughout the lifetime of the facility could exceed the original investment cost. Therefore, it is vital for the on-going incremental investments receive all due care from the feasibility study to operation phases so that QWTEI is ensured. This process requires personnel with economic analysis, commercial and accounting skills, as well as the expected technical skills of the O&M team. These broader skills are not required on a permanent basis and can be obtained internally or externally from the organization as required.

Appendix 1: Metrics of performance indicators during feasibility study, planning and construction phase

<table>
<tr><th>No.</th><td>1</td><th>Performance indicator</th><td colspan="2">Number of construction completion</td></tr>
<tr><th colspan="2">Component</th><th>Measurement unit</th><th>Scope of evaluation</th><th>Evaluation period</th></tr>
<tr><td colspan="2">Initial performance</td><td>Number of constructions</td><td>Applicant</td><td>Most recent 10 years (optional)</td></tr>
<tr><th colspan="5">Purpose of evaluation</th></tr>
<tr><td colspan="5">• To confirm that the applicant has sufficient capability to construct a WTE infrastructure satisfying the required specification</td></tr>
<tr><th colspan="5">Evaluation method/Evaluation logic</th></tr>
<tr><td colspan="5">• Request the applicant to submit a relevant track record and confirm the facts with a third party</td></tr>
<tr><th colspan="5">Measurement methodology (method to accumulate information of the indicator/component to be evaluated)</th></tr>
<tr><td colspan="5">• Formula for number of construction completion
Number of completed WTE infrastructure projects (*1) using similar equipment (*2) in which the applicant participated as an Engineering, Procurement and Construction (EPC) contractor within or outside its country

*1: Definition of completed WTE infrastructure projects
(1) Treatment capacity of the entire facility is XX t/h or more and treatment capacity of one incinerator is XX t/h or more
(2) Boiler/steam turbine plant
- E.g. For equipment with a steam temperature below 300 degrees C: Substantial operation record of more than xx hours within or outside its country
- E.g. For equipment with a steam temperature of 300 degrees C or higher: Substantial operation record of more than xx hours within or outside its country
(3) Environmental equipment: Substantial operation record of more than xx hours within or outside its country

*2: Definition of similar equipment
(1) Treatment facilities that are uniquely for industrial or hazardous wastes are excluded
(2) E.g. Boiler/steam turbine facility: Output is greater than the planned equipment by XX%, standard steam temperature and pressure are 400 degrees Celsius and 4MPa respectively
(3) Environmental equipment (NOx, SOx, PMs, dioxins/furans): Equipment with functions equivalent of those planned</td></tr>
<tr><th colspan="5">Note</th></tr>
<tr><td colspan="5">• Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc.
• It is necessary to create a place to share information with operators having track records.</td></tr>
</table>

No.	2	Performance indicator	Track record of faulty constructions including delay in completion	
Component		Measurement unit	Scope of evaluation	Evaluation period
Initial performance		%	Applicant	Most recent 10 years (Optional)

Purpose of evaluation

- To confirm that the applicant has sufficient technical capability to fulfil the contract

Evaluation method/Evaluation logic

- Request the applicant to submit a relevant track record and confirm the facts with a third party

Measurement methodology (method to accumulate information of the indicator/component to be evaluated)

- Formula for track record of faulty construction including delay in completion
  (Number of similar WTE infrastructure projects in which the applicant participated as an EPC contractor within or outside its country and which were deemed faulty due to the applicant's fault (*1)) / (Number of similar WTE infrastructure projects the applicant received as an EPC contractor within or outside its country) × 100

*1: Definition of projects deemed faulty due to the applicant's fault
Projects in which the applicant substantially made monetary payment to the employer (e.g. liquidation damage attributable to non-conformance with the required performance, liquidation damage for delay in construction)

Note

- Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc and taking into consideration the latest trends.
- It is necessary to create a place to share information with operators having track records.

No.	3	Performance indicator	Record of continuous operation and explanations of long-term outage	
Component		**Measurement unit**	**Scope of evaluation**	**Evaluation period**
Stability		Number of days	Applicant	Most recent 20 years (Optional)

Purpose of evaluation

- To confirm that the applicant has sufficient capability to fulfil the maintenance of the WTE infrastructure delivered

Evaluation method/Evaluation logic

- Request the applicant to submit a relevant track record and confirm the facts with a third party

Measurement methodology (method to accumulate information of the indicator/component to be evaluated)

- Record of continued operation of similar facilities
  Continuous operation time of each incinerator and the entire facility in major similar WTE infrastructure projects in which the applicant participated as an EPC contractor within or outside its country should be mentioned (*1). The target is WTE facilities that operated for 330 days annually as a whole or those in which one incinerator operated for 90 consecutive days.

- Operation years of similar facilities
  The facilities which operated for 20 years or more in major similar WTE projects in which the applicant participated as an EPC contractor within or outside its country should be mentioned.

- Explanation of long-term outage
  If there was a long-term outage of an incinerator which lasted for 90 days or longer in the projects mentioned above, explanation regarding the outage should be given (*2).

*1: Definition of continued operation time
The time that the facility continuously operated in full capacity while properly treating the wastes. The definition of “full capacity” can cover errors in a certain extent.

If the quantity of wastes received was too small for the infrastructure to operate for more than 330 days/year, a different standard should be established.

*2: Regarding repairs that lasted for 90 days or more, whether they were repairs that had been planned or not should be confirmed

Note

- Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc.
- It is necessary to create a place to share information with operators having track records.

No.	4	Performance indicator	Track record of long term forced outages within the warranty period	
Component		Measurement unit	Scope of evaluation	Evaluation period
Ability to smoothly stop and recover		%	Applicant	Most recent 10 years (Optional)
Purpose of evaluation				
• To confirm that the applicant has sufficient capability to construct a WTE infrastructure with good quality not to cause long-term forced outage				
Evaluation method/Evaluation logic				
• Request the applicant to submit a relevant track record and confirm the facts with a third party				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Formula for track record of long term forced outages within the warranty period (Number of similar WTE infrastructure projects in which the applicant participated as an EPC contractor within or outside its country and which experienced long term forced outages due to factors excluding wars, civil wars, insurrection, disasters, etc. (*1)) / (Number of similar WTE infrastructure projects the applicant received as an EPC contractor within or outside its country) × 100 *1: Definition of projects which experienced long term forced outages Projects which experienced Forced Outage Hours (FOH) equal to 30 consecutive days or longer within the warranty period.				
Note				
• Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc. • It is necessary to create a place to share information with operators having track records.				

No.	5	Performance indicator	Accepted range of waste quality (calorific value, minimum consumption rate)	
Component		Measurement unit	Scope of evaluation	Evaluation period
Acceptance capability of waste fluctuation		MJ/kg, %	Applicant	—
Purpose of evaluation				
• To confirm that the applicant has sufficient capability to continuously operate the WTE facility by properly responding to fluctuation of waste characteristics				
Evaluation method/Evaluation logic				
• Request the applicant to submit a relevant track record and confirm the facts with a third party				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Acceptable range of waste quality (minimum and maximum limits) and operation records (including data of calorific value) • Minimum consumption rate: minimum limit from the rated capacity (in %) and operation records				
Note				
• Standard range of designed calorific value of waste shall be 6 MJ/kg or higher • Standard minimum consumption rate shall be 70% or higher of rated capacity • Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc. • It is necessary to create a place to share information with operators having track records.				

No.	6	Performance indicator	Frequency of repair of main parts (e.g. boiler tubes, refractories)	
Component		Measurement unit	Scope of evaluation	Evaluation period
Durability		Year	Applicant	Most recent 10 years

Purpose of evaluation

- To confirm that the applicant has sufficient experience in constructing WTE infrastructures with materials having sufficient durability and to confirm that it has sufficient capability to continuously operate such infrastructures

Evaluation method/Evaluation logic

- Request the applicant to submit a relevant track record and confirm the facts with a third party

Measurement methodology (method to accumulate information of the indicator/component to be evaluated)

- Frequency and quantity of repair of boiler tubes
- Frequency and quantity of repair of refractories of combustion chamber

Note

- Standard service life of boiler tubes shall be xx years or more (specify a part to be evaluated)
- Standard service life of refractories shall be xx years or more (specify a part to be evaluated)
- Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc.
- It is necessary to create a place to share information with operators having track records.

No.	7	Performance indicator	Track record in relation to non-conformance with the environment protection law	
Component		Measurement unit	Scope of evaluation	Evaluation period
Environmental and social consideration		%	Applicant	Most recent 10 years (Optional)

Purpose of evaluation

- To confirm that the applicant has sufficient capability to construct a WTE infrastructure while preserving the surrounding environment

Evaluation method/Evaluation logic

- Request the applicant to submit a relevant track record and confirm the facts with a third party

Measurement methodology (method to accumulate information of the indicator/component to be evaluated)

- Formula for track record in relation to non-conformance with the environment protection law (Number of similar WTE infrastructure projects in which the applicant participated as an EPC contractor within or outside its country and which experienced non-conformance with the environment protection law (*1)) / (Number of similar WTE infrastructure projects the applicant received as an EPC contractor within or outside its country) × 100

*1: Definition of projects which experienced non-conformance with the environment protection law
Projects in which the applicant, the applicant's board of directors, or the project manager received public prosecution or administrative disposition relating to the local environment protection law

Note

- Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc.
- It is necessary to create a place to share information with operators having track records.
- The focus is on non-conformance with local laws and not with voluntary restrictions

No.	8	Performance indicator	Track record in relation to employment of local residents	
Component		Measurement unit	Scope of evaluation	Evaluation period
Environmental and social consideration		%	Applicant	Most recent 10 years (Optional)
Purpose of evaluation				
• To confirm that the applicant has sufficient capability to construct a WTE infrastructure while returning value to the local economy through creation of employment				
Evaluation method/Evaluation logic				
• Request the applicant to submit a relevant track record and confirm the facts with a third party				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Formula for track record in relation to employment of local residents (Number of similar WTE infrastructure projects in which the applicant participated as an EPC contractor within or outside its country with the rate of employment of local residents (within the construction site during the contract period) (*1) of xx % or more) / (Number of similar WTE infrastructure projects the applicant received as an EPC contractor within or outside its country) × 100 *1: Definition of the rate of employment within the construction site during the contract period (Total working hours of employees possessing the nationality of the country in which the project is implemented at the construction site during the contract period) / (Total working hours of employees at the construction site during the contract period) × 100				
Note				
• Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc. • It is necessary to create a place to share information with operators having track records.				

No.	9	Performance indicator	Track record of fatal accidents	
Component		Measurement unit	Scope of evaluation	Evaluation period
Safety		%	Applicant	Most recent 10 years (Optional)

Purpose of evaluation

- To confirm that the applicant has sufficient capability to construct a WTE infrastructure while securing the labor safety and the safety of the construction site and surrounding citizens

Evaluation method/Evaluation logic

- Request the applicant to submit a relevant track record and confirm the facts with a third party

Measurement methodology (method to accumulate information of the indicator/component to be evaluated)

- Formula for track record of fatal accidents
  (Number of similar WTE infrastructure projects in which the applicant participated as an EPC contractor within or outside its country and which experienced fatal accidents attributable to construction work (*1)) / (Number of similar WTE infrastructure projects the applicant received as an EPC contractor within or outside its country) × 100

*1: Definition of fatal accidents attributable to construction work
Accidents which involved one or more deaths and were caused by workers of the construction work (whether caused by the applicant, sub-contractor, or vendor etc., and within or outside the construction site)

Note

- Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc.
- It is necessary to create a place to share information with operators having track records.

No.	10	Performance indicator	Turnover	
Component		Measurement unit	Scope of evaluation	Evaluation period
Financial capability		USD or local currency	Applicant	Most recent 5 years (Optional)

Purpose of evaluation

- To confirm that the applicant has sufficient financial capability to fulfil the contract of a WTE infrastructure construction

Evaluation method/Evaluation logic

- Request the applicant to submit audited income statement or if not required by the law of the applicant's domicile country or region, other financial statements acceptable to the employer for the last 5 years

Measurement methodology (method to accumulate information of the indicator/component to be evaluated)

- Formula for turnover
  The average annual turnover (indicated in the income statement) for the past 5 years

Note

- Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc.

No.	11	Performance indicator	Liquid asset	
Component		**Measurement unit**	**Scope of evaluation**	**Evaluation period**
Financial capability		USD or local currency	Applicant	Most recent year
Purpose of evaluation				
• To confirm that the applicant has sufficient financial capability to fulfil the contract of a WTE infrastructure construction				
Evaluation method/Evaluation logic				
• Request the applicant to submit the evidence that applicant has rights to liquid asset				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Formula for liquid asset The amount of liquid asset (*1) that is demonstrated by the applicant *1: Definition of liquid asset Current assets which are highly convertible to cash (e.g. cash and cash equivalents, accounts receivable, notes receivable, securities held for trading purposes)				
Note				
• Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc.				

No.	12	Performance indicator	Soundness	
Component		**Measurement unit**	**Scope of evaluation**	**Evaluation period**
Financial capability		USD or local currency	Applicant	Most recent year
Purpose of evaluation				
• To confirm that the applicant has sufficient financial capability to fulfil the contract of a WTE infrastructure construction				
Evaluation method/Evaluation logic				
• Request the applicant to submit audited balance sheets or if not required by the law of the applicant's domicile country or region, other financial statements acceptable to the employer for the last 1 year				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Formula for soundness (e.g. net assets) Net assets (*1) derived from the latest balance sheet *1: Definition of net assets The difference between total assets and total liabilities				
Note				
• Precise evaluation standards shall be determined by the employer based on the size, complexity of the project, etc. • As the minimum requirement, an applicant's net assets calculated as the difference between total assets and total liabilities should be positive.				

Appendix 2: Examples of evaluation criteria for PQ

	Subject	Requirement	Remarks
1. Eligibility			
1.1	Conflict of interest	The applicant has no conflicts of interest in accordance with Instructions to Applicants (ITA).	
1.2	Ineligibility	The applicant has not been declared ineligible by the employer as described in ITA.	
2. Historical contract non-performance			
2.1	History of non-performing contracts	Non-performance of a contract did not occur within the last xx years prior to the deadline for application submission based on all the information on the fully settled disputes or litigation. Fully settled disputes or litigation mean disputes or litigation that have been resolved in accordance with the dispute resolution mechanism under the respective contract and for which the applicant's right to appeal to the court of second instance has been expired.	
2.2	Pending litigation	The claimed damages in all pending litigation shall in total not represent more than xx% of the applicant's net worth and shall be treated as resolved against the applicant.	
3. Financial capability			
3.1	Financial performance	The applicant shall submit audited balance sheets or, if not required by the law of the applicant's country or region, other financial statements acceptable to the employer for the last xx years to demonstrate the current soundness of the applicant's financial position and its prospective long-term profitability. As the minimum requirement, the applicant's net assets calculated as the difference between total assets and total liabilities shall be positive.	Financial capability: "Soundness"
3.2	Average turnover	The applicant shall submit audited income statement or, if not required by the law of the applicant's country or region, other financial statements acceptable to the employer for the last xx years and the minimum average turnover calculated based on the total certified payments received for contracts in progress or completed during the last xx years need to be USD xx or equivalent.	Financial capability: "Turnover"
Notes: 3.1 Financial performance 1. In contracts for procurement of works, applicants will be required at the bidding stage to demonstrate their construction cash flow to verify the soundness and stability of their financial circumstances. The construction cash flow should be calculated by following the procedure below, and the requirement clearly indicated by the employer at the bidding			

stage:

"Indicate the construction cash flow for a number of months (to the nearest half-month), determined as the total time needed by the employer to pay a contractor's invoice, allowing for (a) the actual time consumed for construction, from the beginning of the month invoiced, (b) the time needed by the engineer to issue the monthly payment certificate, (c) the time needed by the employer to pay the amount certified, and (d) a contingency period of one month to allow for unforeseen delays. The total period should not exceed xx months. The assessment of the monthly amount should be based on a straight-line projection of the estimated cash flow requirement, over the particular contract period, neglecting the effect of any advance payment and retention monies, but including contingency allowances in the estimated contract cost."

2. Financial information provided by an applicant should be of the applicant or partner of Joint Venture (JV) and not of sister or parent companies.

3. The financial statements provided by applicants should be carefully reviewed for proper evaluation, and the judgement for acceptance or rejection from financial circumstances should be determined based on such proper evaluation. If any abnormality which may cause financial issues occurs, the employer should seek reviews and interpretations from experts.

4. Applicant's qualification			
4A. Experience			
4.1	General construction experience	The applicant shall have experience under a construction contract in the role of a contractor, management contractor or subcontractor for at least the last xx years prior to the application submission deadline.	
4.2	Specific construction experience	The applicant shall have experience exclusively in the role of an EPC contractor in at least xx contracts which have been successfully completed within or outside its country within the last xx years and that are similar to the proposed works. The similarity shall be based on the physical size (more than xx MW capacities in one power generation unit), complexity, methods/technology or other characteristics as described in scope of works. In addition, the applicant is required to submit performance test results to ensure its compliance with the performance required by the employer. The applicant is required to have satisfied all the performance requirements by the employer for at least xx% of the projects delivered.	Initial performance: "Track record in relation to construction completion" and "Conformity with specified performance"
4.3	Specific operating experience	At least xx of the contracts provided by the applicant as a track-record shall have successful operation experience of more than xx hours as a total facility at the PQ application closing date. The technical data and information on the contracts are to be provided with contract details of the end-users. The applicant shall submit the original certificate issued by the end-user (free form) at the time of bid submission.	Initial performance: "Number of construction completion"

4.4	Track record of faulty construction including delay in completion	The ratio of construction deemed faulty (contracts in which the applicant substantially made monetary payment to the employer at completion) shall be less than xx%, with respect to the similar contracts in which the applicant participated as an EPC contractor within or outside its country within the last xx years.	Initial performance: "Track record of faulty construction including delay in completion"
4.5	Track record of continuous operation	The applicant shall submit record of continuous operation in similar WTE infrastructure projects in which the applicant participated as an EPC contractor within or outside its country. The target is WTE infrastructures that operated for more than 20 years or those in which one incinerator operated for 90 consecutive days. If there was a long-term outage of an incinerator which lasted for 90 days or longer in the projects mentioned above, explanation regarding the outage should be given.	Stability: "Record of continuous operation and explanations of long-term outage"
4.6	Track record of long-term forced outages within the warranty period	The ratio of projects experiencing long term forced outages due to reasons other than wars, civil wars, insurrection, disasters, etc. (projects experiencing FOH equivalent to 30 days or more within the warranty period) shall be less than xx%, with respect to the similar projects in which the applicant participated as an EPC contractor within or outside its country within the last xx years.	Ability to Smoothly Stop and Recover: "Track record of long-term forced outage within the warranty period"
4.7	Acceptable range of waste quality (calorific value, minimum consumption rate)	In similar projects in which the applicant participated as an EPC contractor within or outside its country, the applicant must have experience in proper treatment of wastes when their designed calorific value was 6MJ or higher[2] and the minimum consumption rate was 70% of the rated capacity or higher[3].	Acceptance capability of waste fluctuation "Accepted range of waste quality (calorific value, minimum consumption rate)"
4.8	Frequency of repair of main parts (e.g. boiler tubes, refractories)	In similar projects in which the applicant participated as an EPC contractor within or outside its country within the last xx years, there shall be record that the service life of boiler tubes and refractories of combustion chamber were X years or more.	Durability "Frequency of repair of main parts (e.g. boiler tubes, refractories)"
4.9	Track record in relation to non-conformance with the environment protection law	If there was non-conformity to environmental protection law and its regulations in similar projects in which the applicant participated as an EPC contractor within or outside its country, the applicant will not be given the eligibility to participate in the bid.	Environmental and social consideration: "Track record in relation to non-conformance with the environment protection law"

[2] Condition of operation when auxiliary fuel was not used
[3] Condition of appropriate operation regardless of use of auxiliary fuel

4.10	Track record in relation to employment of local residents	The ratio of projects with xx% or more of workers hired from the target local area ((Total working hours of employees possessing the nationality of the country in which the project is implemented the at the construction site during the contract period/ Total working hours of employees at the construction site during the contract period) x 100) shall be more than xx%, with respect to the similar projects in which the applicant participated as an EPC contractor within or outside its country within the last xx years.	Environmental and social consideration: "Track record in relation to employment of local residents"
4.11	Track record in relation to fatal accidents	The ratio of projects experiencing fatal accidents attributable to the construction work (accidents which involved one or more deaths, whether caused by the applicant, sub-contractor, or other vendor and within or outside the construction site) shall be less than xx%, with respect to the similar projects in which the applicant participated as an EPC contractor within or outside its country within the last xx years. If its safety record is extremely poor, the applicant will not be given the eligibility to participate in the bid.	Safety: "Track record of fatal accidents"
4B. Equipment capabilities			
4.12	Operating experience of WTE infrastructures	The main components of a WTE infrastructure shall be products that are developed, designed, and manufactured by the applicant so that technical and substantial support of maintenance can be properly conducted. Maintenance of not only components but also the whole facility shall be conducted. The applicant should have experience in operating WTE infrastructures with xx incinerators and their total successful operating hours shall be more than xx hours, with the longest operating hours' units operating more than xx hours at the PQ application closing date. The data and information on the reference WTE infrastructures are to be provided with contract details of the end-user. The applicant shall submit the original certificate from the end-user (free form) at the time of bid submission.	
4.13	Similarity of the proposed WTE infrastructure	The proposed WTE infrastructure shall be technically similar to the reference WTE infrastructures specified above. The "technically similar" shall mean xx-type machine and shall denote that it has the same configuration with the same dimensions, the same design parameters and the same or better materials as the reference WTE infrastructure.	Example: Specify method of treatment (e.g. stoke grate, fluidized bed, gasification)

4.14	Incinerator	Each manufacturer shall have the operation experiences of at least xx reference WTE infrastructures with incinerators with capacity of XX t/h or higher which were put into operation in the last XX years.	
4.15	Steam turbine	Each manufacturer shall have the operation experiences of at least xx reference condense steam turbines with a capacity of more than xx MW which were put into operation in last xx years. The proposed steam turbine shall be of similar configuration to the reference steam turbines.	
4.16	Boiler	Each manufacturer shall have the operation experiences of at least xx reference boilers with a capacity of more than steam temperature xx degrees and steam pressure xx MPa which were put into operation in last xx years. The proposed boilers shall be of similar configuration to the reference boilers.	
4.17	Flue gas treatment equipment	Each manufacturer shall have the operation experiences of at least xx facilities that have capacity to treat flue gas to a level lower than the emission limit values as described in the requirements in the last xx years.	
4.18	Fly ash treatment equipment	Each manufacturer shall have the operation experiences of at least xx fly ash treatment facilities that have capacity to treat fly ash to a level that can meet the leaching standards in the last xx years.	
4.19	Continuous monitoring system	Each manufacturer shall have the operation experiences of at least xx facilities in which continuous monitoring systems for Dusts, HCl, SOx, and NOx contained in flue gas are operated in the last xx years.	

Notes :

4.1 General construction experience

A management contractor is a firm which takes on the role of contract management as a general contractor of sort could do. It does not normally perform directly the construction work(s) associated with the contract. Rather, it manages the work of other (sub) contractors while bearing full responsibility and risk for price, quality, and timely performance of the work contract.

4.2 Specific construction experience

Experience information provided by an applicant should be of the applicant or partner of JV and not of sister or parent companies.

Appendix 3: Examples of qualification criteria in bidding specification

<table>
<tr><th>Requirement</th><th>Remarks</th></tr>
<tr><td colspan="2">1. Update of information</td></tr>
<tr><td>The applicant and applicant's subcontractors shall continue to meet the criteria including data proposed by the applicants used at the time of PQ.</td><td></td></tr>
<tr><td colspan="2">2. Financial resources</td></tr>
<tr><td>Using the attached bidding forms, the bidder shall demonstrate that it has access to, or has available, liquid asset, unencumbered real assets, lines of credit and other financial means (independent of any contractual advance payment) sufficient to meet:

a) The cash flow requirements estimated to be USD xx for the subject contract. In case of joint venture (JV), all partners combined shall meet the above requirement: each partner shall meet at least xx% of the above requirements; one partner shall meet at least xx% of the above requirement.
b) The cash flow requirements on works currently in progress and for future contract commitments. In case of JV, all partner combined shall satisfy the above requirement.</td><td>Financial capability: "Liquid asset"</td></tr>
<tr><td colspan="2">3. Personnel</td></tr>
<tr><td colspan="2">The applicant must demonstrate that it will have the personnel for the key positions that meet the following requirements:
<table>
<tr><th></th><th>Position</th><th>Total work experience (years)</th><th>Similar work experience</th></tr>
<tr><td>1</td><td>Project manager</td><td>xx</td><td>xx</td></tr>
<tr><td>2</td><td>Lead engineering manager</td><td>xx</td><td>xx</td></tr>
<tr><td>3</td><td>Lead engineering civil works</td><td>xx</td><td>xx</td></tr>
<tr><td>4</td><td>Lead engineering machineries</td><td>xx</td><td>xx</td></tr>
<tr><td>5</td><td>Lead engineering electrical works</td><td>xx</td><td>xx</td></tr>
<tr><td>6</td><td>Lead engineering instrumentation & control</td><td>xx</td><td>xx</td></tr>
<tr><td>7</td><td>Site manager</td><td>xx</td><td>xx</td></tr>
</table>
The applicant shall provide details of the proposed personnel and their experience records using the forms provided in the bidding documents.</td></tr>
<tr><td colspan="2">4. Additional experiences certificates</td></tr>
<tr><td>The applicant shall submit the original certificate submitted by the end-user (free form) if the same was not submitted during the PQ stage.</td><td></td></tr>
</table>

(Reference) The evaluation of the applicant's ability to realize "LCC" will be based on the bidding price defined by the employer. The relevant performance indicator during feasibility study, planning and construction phase for "LCC" is the "LCC ensuring all other components".

Appendix 4: Metrics of performance indicators in operation phase

Note: If the project is to be conducted under the PPP scheme, the evaluation period should be revised as evaluation shall be conducted at time of bidding

No.	1	Performance indicator	Incineration rate	
Component		Measurement unit	Scope of evaluation	Evaluation period
Stability		%	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the quality of periodic maintenance and operating capability and equipment as a WTE infrastructure by determining its stability				
Evaluation method/Evaluation logic				
• The rate of waste actually incinerated to the required incineration quantity				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Formula for incineration rate Incineration rate = (Quantity of waste actually incinerated) / (Waste incineration capacity)				
Note				
• Quantity exceeding the designed capacity should not be conducted.				

No.	2	Performance indicator	Incineration residues	
Component		Measurement unit	Scope of evaluation	Evaluation period
Stability		%	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the quality of periodic maintenance and operating capability and equipment as a WTE infrastructure by determining its stability				
Evaluation method/Evaluation logic				
• Confirm whether complete combustion is realized				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Ignition loss				
Note				
• Ignition loss shall be 3% or lower.				

No.	3	Performance indicator	Grate combustion rate	
Component		Measurement unit	Scope of evaluation	Evaluation period
Stability		kg/m^{2}h	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the quality of periodic maintenance and operating capability and equipment as a WTE infrastructure by determining its stability				
Evaluation method/Evaluation logic				
• Confirm the waste combustion rate				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Grate combustion rate				
Note				
• Grate combustion rate shall be 150kg/m^{2}h or higher.				

No.	4	Performance indicator	Utilities consumption rate	
Component		Measurement unit	Scope of evaluation	Evaluation period
Stability		per t-waste	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the quality of periodic maintenance and operating capability and equipment as a WTE infrastructure by determining its stability				
Evaluation method/Evaluation logic				
• Smaller consumption rate of utilities required per unit of waste to be treated is desirable.				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Consumption rate of water, slaked lime, activated carbon, auxiliary fuel and electricity that was required to treat one ton of waste				
Note				
• When calculating the electricity consumption, internal power consumption rate should be included				

No.	5	Performance indicator	Temperature control in specific points	
Component		Measurement unit	Scope of evaluation	Evaluation period
Stability		°C	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the quality of periodic maintenance and operating capability and equipment as a WTE infrastructure by determining its stability				
Evaluation method/Evaluation logic				
• Confirm whether heat is properly and continuously controlled in points such as combustion chamber and inlet of bag filters				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Measure the average temperature and fluctuation rate inside the combustion chamber and at inlet of bag filters				
Note				
• Standard temperature shall be 850°C or higher in combustion chambers and below 200 degrees Celsius at inlet of bag filters.				

No.	6	Performance indicator	Quantity of flue gas	
Component		Measurement unit	Scope of evaluation	Evaluation period
Stability		Nm^3/h	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the quality of periodic maintenance and operating capability and equipment as a WTE infrastructure by determining its stability				
Evaluation method/Evaluation logic				
• Confirm that the quantity of flue gas is not exceeding the designed quantity				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Measure the quantity of flue gas with automatic monitoring devices				
Note				
• Not only stable operation but also compliance with laws regarding flue gas quantity shall be confirmed.				

No.	7	Performance indicator	Forced outage rate (FOR)	
Component		Measurement unit	Scope of evaluation	Evaluation period
Ability to smoothly stop and recover		%	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the WTE infrastructure's reliability and its ability to recover through O&M				
Evaluation method/Evaluation logic				
• Compute the FOR of the WTE infrastructure				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Formula for FOR FOR = FOH / (SH + FOH) × 100 The definition of each item in the above formula is as follows: SH: Service Hours				
Note				
None				

No.	8	Performance indicator	Long-term FOR	
Component		Measurement unit	Scope of evaluation	Evaluation period
Ability to smoothly stop and recover		%	Entire WTE infrastructure	Most recent 5 years (Optional)
Purpose of evaluation				
• To evaluate the WTE infrastructure's reliability and its ability to recover through O&M from large scale troubles				
Evaluation method/Evaluation logic				
• Compute the rate of decline in waste treatment due to long term forced outages (30 days or more) within the last 5 years to the total waste treatment capacity at reference WTE infrastructures				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Formula for Long-Term FOR Long-term FOR = $\Sigma(WASTE_{FOH30})/(\Sigma(WASTE)\times 100$ The definition of each item in the above formula is as follows: $\Sigma(WASTE_{FOH30})$ [t]: The total amount of waste that could have been treated during the long-term FOR (30 or more days) which occurred at the reference WTE infrastructure (for five years) $\Sigma(WASTE)$ [t]: Sum of the maximum waste treatment amount during parallel operation (for 5 years)				
Note				
• Indicate the number of outages lasting for 30 days or more as well as their causes in addition to the long-term FOR				

No.	9	Performance indicator	Operation records in case of maximum and minimum condition of each parameter
Component		**Measurement unit**	**Scope of evaluation**	**Evaluation period**
Acceptance capability of waste fluctuation		MJ/kg, %	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the ability to continue operation regardless of short-term and long-term fluctuation of waste characteristics				
Evaluation method/Evaluation logic				
• To evaluate the range of characteristics of wastes that were properly treated based on results of waste characteristics study and operation records				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Determine the waste treatment rate when minimum and maximum lower heating value (MJ/kg) were recorded • Determine the waste treatment rate when minimum and maximum ash content (%) were recorded				
Note				
• The date of sampling of the waste characteristics study shall be adopted for the determination.				

No.	10	Performance indicator	Repair record of main equipment
Component		**Measurement unit**	**Scope of evaluation**	**Evaluation period**
Durability		Month, year	Entire WTE infrastructure	Most recent 5 years
Purpose of evaluation				
• To evaluate the ability to properly function the infrastructure or devices throughout its maximum service life				
Evaluation method/Evaluation logic				
• Evaluate the repair frequency of membrane walls of superheater • Evaluate the repair frequency of refractories				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Record the repair frequency of membrane walls of superheater • Record the repair frequency of refractories				
Note				
• Regarding parts that are frequently repaired, adjustments in material or equipment should be made				

No.	11	Performance indicator	SOx and NOx discharge rate	
Component		Measurement unit	Scope of evaluation	Evaluation period
Environmental and social consideration		g/t-waste	Entire WTE infrastructure	Most recent year

Purpose of evaluation

- To evaluate the quality of environmental consideration by evaluating the impact on the atmospheric environment based on the actual operation

Evaluation method/Evaluation logic

- Evaluate initiatives other than those for the effectiveness of the flue gas treatment facility (e.g. exchange of chemical agents, adjustment of combustion settings) by computing the discharge rate
- SOx and NOx will be computed based on the results of a regular flue gas measurement. If the measurement is conducted multiple times a year, the average will be computed.
- Load frequency may have an impact, but this will not be considered as the impact could be considered minimal.

Measurement methodology (method to accumulate information of the indicator/component to be evaluated)

- Formula for SOx discharge rate
  SOx discharge rate = Annual SOx emission (g) / Annual waste treatment quantity (t)
- Formula for NOx discharge rate
  NOx discharge rate = Annual NOx emission (g) / Annual waste treatment quantity (t)

The definition of each item in the above formulas is as follows:
Annual emission = SOx/NOx concentration (mean value) × Annual waste treatment quantity × Flue gas quantity (per unit)

Note

None

No.	12	Performance indicator	Dioxins and furans discharge rate	
Component		**Measurement unit**	**Scope of evaluation**	**Evaluation period**
Environmental and social consideration		mg/t-waste	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the quality of environmental consideration by evaluating the impact on the atmospheric environment based on the actual operation				
Evaluation method/Evaluation logic				
• Evaluate initiatives other than those for the effectiveness of the flue gas treatment facility (e.g. alteration of chemical agents, adjustment of combustion settings) by computing the discharge rate • Dioxins/furans will be computed based on the results of a regular flue gas measurement. If the measurement is conducted multiple times a year, the average will be computed. • Frequency of load fluctuation may have an impact, but this will not be considered as the impact could be considered minimal.				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Formula for dioxins and furans discharge rate Dioxins/furans discharge rate = Annual emission of dioxins/furans (mg)/ annual waste treatment quantity (t) The definition of each item in the above formulas is as follows: Annual emission = Concentration of dioxins/furans (mean value) × Annual waste treatment quantity × Gas emission rate (per unit)				
Note				
None				

No.	13	Performance indicator	CO_2 discharge rate	
Component		**Measurement unit**	**Scope of evaluation**	**Evaluation period**
Environmental and social consideration		kg- CO_2/t-waste	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the quality of environmental consideration by evaluating the impact of CO_2 based on the actual operation				
Evaluation method/Evaluation logic				
• Annual CO_2 emission is computed based on formula adopted by the employer which takes into account items such as annual fuel consumption.				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Formula for CO_2 discharge rate CO_2 discharge rate = Annual CO_2 emission (kg)/Annual waste treatment quantity (t-waste)				
Note				
• The reduction rate of methane gas emission at the final disposal site is often taken into account.				

No.	14	Performance indicator	Water quality	
Component		Measurement unit	Scope of evaluation	Evaluation period
Environmental and social consideration		pH, mg/l, MPN/100ml	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the quality of environmental consideration by evaluating the impact of water quality based on the actual operation				
Evaluation method/Evaluation logic				
• The evaluation will be based on whether requirements are being met by measurement of water quality (discharge concentration) • If the measurement is conducted multiple times a year, all results will be evaluated.				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Examples of the items to be measured are pH, BOD, COD, N-hexane, total nitrogen, total phosphorus, SS, and Escherichia coli				
Note				
• The water discharge from a WTE infrastructure includes water discharge attributable to employees working at the WTE infrastructure. • In principle, the waste water quality should be in compliance with the local effluent standards.				

No.	15	Performance indicator	Noise/vibration	
Component		Measurement unit	Scope of evaluation	Evaluation period
Environmental and social consideration		dBA, dB	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the quality of environmental consideration by evaluating the impact of noise and vibration based on the actual operation				
Evaluation method/Evaluation logic				
• The measurement will be conducted at the border of the infrastructure to understand the environmental impact on the surroundings • Other sources of noise and vibration in the surrounding area should be considered • If the measurement is conducted multiple times a year, the average will be computed				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Examples of the items to be measured are the levels of noise (dBA)/vibration (dB)				
Note				
None				

No.	16	Performance indicator	Waste recycling rate	
Component		**Measurement unit**	**Scope of evaluation**	**Evaluation period**
Environmental and social consideration		%	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the quality of environmental consideration by evaluating the impact of waste on the environment				
Evaluation method/Evaluation logic				
• The recycle rate of waste that the operator is responsible for disposing of (e.g. bottom ash, treated fly ash, sludge from waste water) should be computed per WTE infrastructure • Recycle includes material recycle, thermal recycle and sales of recycled items				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Formula for waste recycle rate Waste recycle rate = Σ Waste recycled (t) / Σ Waste generated (t)				
Note				
Basically, as proper treatment disposal is required, this performance indicator shall not be given significant importance in evaluation				

No.	17	Performance indicator	Number of casualties caused by industrial accidents	
Component		**Measurement unit**	**Scope of evaluation**	**Evaluation period**
Safety		Number of people	Entire WTE infrastructure	Most recent year
Purpose of evaluation				
• To evaluate the adequacy of measures taken within the WTE infrastructure in relation to equipment troubles and industrial accidents of the workers working in the WTE infrastructure				
Evaluation method/Evaluation logic				
• The evaluation will be based on Industrial Safety Accident Rate (ISA)				
Measurement methodology (method to accumulate information of the indicator/component to be evaluated)				
• Formula for ISA $\text{ISA} = \frac{(Number\ of\ casualties\ caused\ by\ industrial\ accidents)}{(Total\ number\ of\ hours\ worked)} \times 1{,}000{,}000$				
Note				
• The number of employees should include all employees working at the WTE infrastructure as well as all the subcontractors.				

No.	18	Performance indicator	LCC considering all other seven components	
Component		Measurement unit	Scope of evaluation	Evaluation period
LCC		(USD or local currency)/ (t-waste)	Entire WTE infrastructure	Every 5 years after construction (Optional)

Purpose of evaluation

- To evaluate the balance of total benefit (total waste treatment quantity) and total cost (sum of total treatment cost and social cost) of a WTE infrastructure

Evaluation method/Evaluation logic

- Evaluate the adequacy and economic efficiency of both equipment and O&M by considering the total power generation and social cost (environmental impact) in the indicator
- If the project is implemented under the PPP scheme, this indicator shall be compared with the planned LCC proposed by the applicant

Measurement methodology (method to accumulate information of the indicator/component to be evaluated)

- LCC considering all seven other components
  = (Total treatment cost + Social cost) / (Total treatment quantity)
  Details provided in the note below.

The definition of each item in the above formula is as follows:
Total treatment cost: Construction cost (CC), O&M cost, and disposal cost (DC)

Note

- The construction cost of the WTE infrastructure includes not only the cost which is directly required to construct the infrastructure but also transportation cost of material and equipment, custom duties, customs fee, insurance premium, etc.
- The evaluation period should be approximately 5 years. Comparison should be made with the accumulated LCC

A: If LCC for the period throughout the operation is evaluated (LCC (total)), the evaluation will be based on the period from the construction of the WTE infrastructure to its disposal

LCC considering all seven other components (total) is as follows:

$$\frac{\text{(1) Past cost} + \text{(2) Future cost of } \Sigma(\text{CC, O\&M cost, DC})}{\text{(3) Past portion + (4) Future portion of } \Sigma \text{ TPG}}$$

* The future cost and the future portion will be discounted to the present value. The past cost and the past portion will be the accumulated value of actual results and no adjustments such as price levels determination will be made.
* When conducting relative evaluation, assumptions such as adjustments for price levels and currencies and social costs should be adequately uniformed to obtain best effect.

B: If LCC for the future operation is the only factor evaluated (LCC (Future)), the evaluation period will include the current period operation and all future operation.

LCC considering all seven other components (future) is as follows:

$$\frac{\text{(2) Future cost of } \Sigma \text{ (CC, O\&M cost, DC)}}{\text{(4) Future portion of } \Sigma \text{ TPG}}$$

* The future cost and the future portion will be discounted to present value.

Explanation of each item

[(1) Actual cost]
Σ (CC+ O&M cost + DC)

[(2) Future cost]
$\sum(\text{O\&M cost (a)} + \text{DC(b)}) \times (1+r)^{-y}$

a. O&M cost in y year
   O&M cost (e.g. treatment quantity after y years (t-waste)) x O&M cost per unit of waste ($/t-waste)
b. Disposal cost in y year