Chapter 10

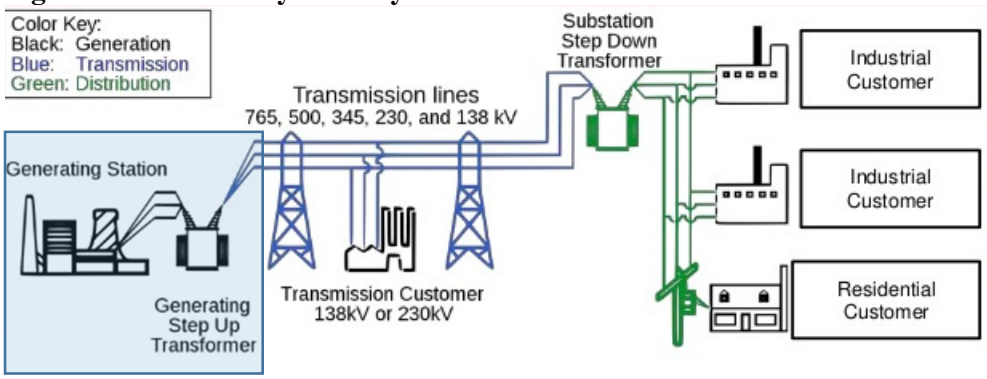
Manufacturing of Thermal Power Generation Equipment

Gloria O. Pasadilla[1]

10.1. Industry Overview

The electric power industry has several major activities: power generation, transmission, and distribution. After electricity is generated, it passes through high voltage transmission lines. Power then goes to a substation where a transformer adjusts the voltage to a lower level to be distributed for consumer and industrial use. Figure 10.1 describes the electricity industry value chain, where power generation is shown to be an upstream activity. The focus of this case study is on power generation because the firm is a global player in power generation technologies.

Figure 10.1. Electricity industry value chain



Source: Courtesy of North American Electric Reliability Corporation (NERC)

The electricity industry has undergone deregulation all over the world, particularly through the privatization of many previously state-owned electricity companies and dismantled monopolies. In general, industry restructuring has carved out the power generation and retail supply segments (billing, metering, and installation) and introduced more market competition in these sub-industries to increase efficiency. In most places, transmission and distribution remain as monopolies, however, because it is unviable to build competing grids.

Power generation, the upstream part of the electricity value chain, involves the transformation of mechanical energy into electrical energy. Central to virtually all power generation is the turbine. When the blades on the shaft of a turbine is rotated the generator produces electricity through a process called magnetic induction[2]. The sources of energy that help to turn the blades of the turbine to generate electricity vary. Coal is the cheapest energy source but emits the most amount of harmful substances into the environment. Other energy sources are nuclear, natural gas, geothermal, hydro, as well as renewable sources like solar energy or wind.

[1] Senior Analyst at APEC Policy Support Unit
[2] "Electricity – a Visual Primer." Available: http://www.slideshare.net/MavensManor/electricity-a-visual-primer-5913813

Electricity generation causes more greenhouse gas emission than transportation[3]. Increased global awareness of the need for environmental sustainability has driven technological research to find alternative energy sources such as renewable energy, as well as to create improved designs of turbine and other power plant equipment that minimize emissions and reduce waste. The company in this study presents itself as a provider of both thermal power and environmental technologies because its new designs of power plant equipment use technologies that are environmentally friendly.

10.2. Background Information on the Firm[4]

The company is headquartered in Japan and is a big player in the production of thermal power generation machines and equipment. It has five production sites in Japan, but some products and/or parts and components are also manufactured in different continents either through a fully-owned subsidiary or a joint venture company. For example, in Asia, it has manufacturing plants in China, India, and the Philippines; In Europe, there is a manufacturing plant in Germany, while UK and Belgium have repair facilities; North America, Canada and the US have manufacturing plants. This is in line with the company strategy of manufacturing at sites close to where products are to be delivered. In total, its company brochure lists 54 different enterprises across the globe, either subsidiaries or joint venture companies that are engaged in either manufacturing, maintenance services and repairs, corporate functions and sales, or a combination of several functions. Of these 54 enterprises, it is significant to note that the majority are services companies.

The company's major products are gas turbine combined cycle power plants; integrated gasification combined cycle power plants; boiler & turbine generation plants; geothermal power plants; gas turbines; boilers; steam turbines (Figure 10.2); generators; equipment peripheral to power generating plants; and fuel cells. Its research and development activities have helped to upgrade and redesign products either to minimize waste or limit harmful gas emissions and thus make electricity generation more environmentally friendly.

Beyond producing products for power plants, the company's business also includes design, build, and maintenance of power plants; as well as a whole suite of after-sales services and support. Example of after-sales services include: 1) preventive maintenance which includes remaining life estimation service, maintenance schedule management, as well as maintenance personnel education programs; 2) original spare parts supply; 3) operation support to reduce power consumption or greenhouse gas emissions; 4) performance enhancement through operation control adjustments or equipment rehabilitation; and 5) integrity inspections, for example, for the high pressure and temperature vessel or piping in boilers.

[3] US Environmental Protection Agency. Available: http://www.epa.gov/climatechange/ghgemissions/sources.html

[4] Information on the firm has been sourced from its corporate website and company brochure.

Figure 10.2. Example of firm's product: Steam engine and generator installed in an energy center in the United States

Source: Company website

10.3. Description of the Value Chain

This case study considers an EPCM (engineering, procurement, construction and maintenance) project where the firm may be the lead, or a member, of a consortium bidding for the construction of a power plant. There are, in fact, few EPC projects in which the company is the prime contractor; in most projects, the firm is only a member of a consortium where its primary responsibility is to supply the key machines and equipment for the power plant. The value chain, in this case, begins with the bidding stage, then moves to the equipment design and pre-construction of power plant stage, followed by the manufacturing and construction stage, and ends with the commissioning and operation of the power plant.

Other types of projects which do not involve construction from scratch also exist. Some projects may simply involve retrofitting and upgrading existing power plant facilities, or the construction of additional power plant features for environmental sustainability purposes. These types of projects will have a shorter value chain and will, in some respects, exhibit similar characteristics as an EPC turnkey project. On the other hand, the value chain described above omits an increasingly important part of the value chain, i.e. the disposal of old machines.

Bidding stage

If the firm is the prime contractor or the leader of the consortium bidding for a project, it will identify potential partners, especially the local construction company that will carry out the plant construction. Then it will carry out research on the economic and legal environment, and the relevant policy framework, especially in respect of environmental policies. It will check the site or location of the power plant to assess if its geographical configuration necessitates major redesign or adjustments in the company's existing equipment should it win the contract. It will carry out feasibility studies and a financial projection before submitting the bid.

In cases where the firm is only part of a consortium led by another prime contractor, the latter is considered the firm's 'customer'. Usually, these 'customers' are either utility companies or independent power providers in the economy where the power plant is to be built. In this case, all the feasibility studies and financial projection of the entire project are the responsibility of the prime contractor, but the firm also does its own research on the economic conditions, the legal environment of the economy, as well as assess the site or location of the proposed plant to be able to configure the right machines according to land type or topography. The firm participates in the preparation of the bid submission. In power plant projects, the cost that the case study firm provides to the consortium will typically constitute a major part of the total project cost and could help the consortium win or lose the bid.

Design, pre-manufacturing and pre-construction of the power plant

If the firm is in-charge of the plant construction, it will typically outsource the construction work to a local subcontractor which is typically a construction or engineering company. The construction company then takes care of securing all the requisite government permits and often the overall project management of the construction process under the overall supervision of the firm.

Once the contract is awarded, the firm proceeds with the equipment design. Sometimes the design has either been done during the bidding phase, or is not necessary since the project's requirement could be served by the company's existing suite of products. If at all, minimal design changes may be needed only to configure the machine to the specific local or geophysical conditions.

This pre-manufacturing phase follows the same pattern as other manufacturing activities. The firm procures materials and services, and transports them to the manufacturing plants. Most outsourced parts and component manufacturing are usually supplied within the company group. These are then assembled either in Japan or in one of its manufacturing plants that is nearest the soon-to-be constructed power plant.

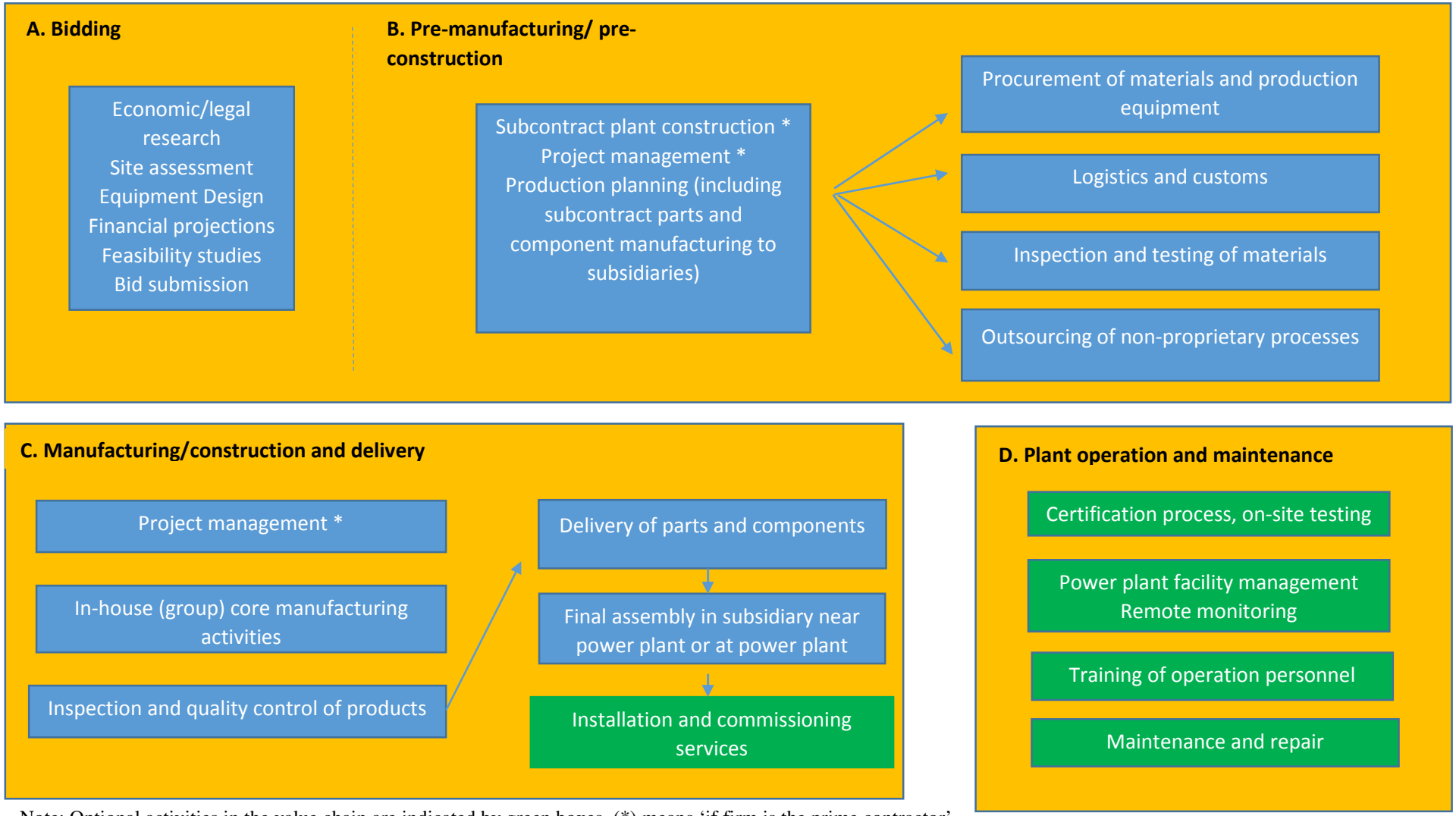
Manufacturing of machines /construction stage and delivery

In this stage, the firm's involvement depends on a per project basis. In some, the firm may be heavily involved in the engineering services for building projects, while in others it only needs to focus on the engineering services related to the machine manufacturing. Once the machine is ready for delivery and the power plant is ready to receive it, the firm takes care of the delivery, storage, and other logistical arrangements to bring the machine to the site of the power plant. Because of the bulkiness of these machines, the firm's strategy has been to manufacture or assemble their products in the nearest manufacturing plant as much as possible to save on delivery cost. The parts and components, however, are procured globally from its other subsidiaries or third party suppliers. Examples of parts and components procured globally include: rotors for gas turbines, tube materials for boilers, steel plates, and cylinders. The firm may or may not install the machines themselves at the power plant site.

Commissioning and operation of the power plant

The firm ensures that the machines are working according to specification, tests them on-site, provides the necessary personnel to install them (if asked) and train local operators. If installation services are not part of the contract, the firm, nevertheless, sends a guide to help with very sophisticated machines. Depending on the project, it may entrust the facility management and the operation of the plant to the firm. In this case, engineering services during operation are usually entrusted to the affiliated company in the relevant economy. This is why the services global network of the firm is extensive. Besides attending to after-sales services like maintenance and repair, the firm may sometimes be called upon to take responsibility for the engineering services of the entire plant facility.

Figure 10.3. Dimensions of the value chain covered by case study



Note: Optional activities in the value chain are indicated by green boxes. (*) means 'if firm is the prime contractor'
Source: APEC Policy Support Unit based on firm interview

10.4. Services along the Value Chain

What services activities are involved at each stage of the chosen value chain? Figure 10.4 shows a few examples of the services at each stage of the EPCM value chain. It is not an exhaustive list, and only covers the major services associated with bidding, pre-manufacturing/construction, construction, and operation of the plant[5]. The detailed table in Appendix A identifies at least 39 major service categories; 74 if services sub-categories of the Central Product Classification (CPC) are considered. For example, site preparation services in the construction phase can be further subdivided into demolition services, site formation and clearance services, and excavating and earthmoving services. The same goes for other major service categories like transportation services which can be either land, rail, water, or air transport services.

The firm was unable to give an estimate of the value of these services. But for the firm as a whole, the rough estimate of the current share of services in the value of the company is about one-third, while manufacturing is two-thirds. However, the services share is expected to increase due to aging of existing power plant facilities all over the world and the rising cost of building completely new facilities.

Importance of after-sales service to the firm

In particular, the firm expects to generate more revenues from after-sales services although it acknowledges the tough competition in this market segment from other global players. Based on the after-sales services offerings on its corporate website, it appears that this segment of its business is given a high priority. The company provides detailed descriptions of various after-sales services. For example, it offers advanced inspection techniques or robotic coating of damaged tubes or parts, both for their own products as well as those of third-party supplied equipment. Just to give a flavour of the services offered in this industry, the maintenance and repair of a steam engine consists of several services – mostly engineering – such as: rotor welding and machining, blading replacement, valve inspection, repair and calibration, vibration testing and analysis, dynamic rotor balancing, and technical advisory services.

After-sales service business is defined by the firm as composed of the following: supply of parts; repair of existing parts or machines; installation services; removal of some machine parts; monitoring of operational status of customer power plants through which they can anticipate and propose repairs and maintenance needs. In some cases, the firm signs a long-term service agreement for equipment which lasts between 6 or 12 years, where the company provides the necessary manpower to carry out inspection, provides replacement parts and maintenance engineering support, trouble shoots, and monitors remotely around the clock. In addition, the firm also offers a parts supply agreement in which the firm guarantees the supply of parts for the duration of the contract at an agreed price.

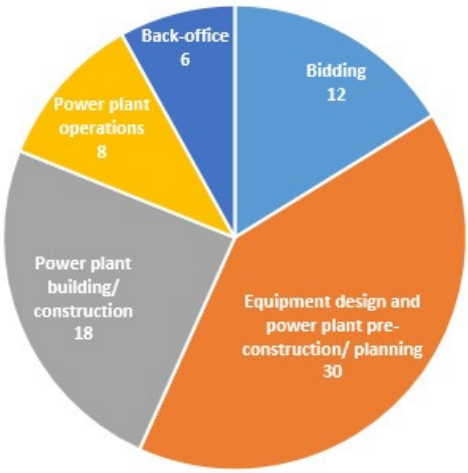
[5] For example, cleaning services and water treatment services could be among the services listed but are not included. Only the major services have been chosen in the figure. More details are available in Appendix A Tables A.1-5.

Figure 10.4. Examples of services in EPC value chain

Back-office:
- Financial services
- Legal services
- IT services

Power plant operations:
- Engineering services
- Maintenance and repair services
- Training services

Power plant building/ construction:
- Engineering services
- Site preparation services
- Construction services
- Certification and commissioning services



Bidding:
- Research services on economic conditions, legal environment, etc.
- Land survey and site assessment services

Equipment design and power plant pre-construction/ planning:
- Architectural services
- Design services for equipment, analysis and monitoring software
- Planning and management services
- Procurement and logistics services

Source: Compiled by APEC Policy Support Unit

Besides repair and maintenance, other services that the firm offers are: repowering of existing facilities to raise its output and efficiency, and conversion or rehabilitation of existing machines like boilers to limit gas emissions and enhance performance. It has advanced integrity inspection technology to evaluate the deterioration of the machine from creep[6], fatigue, corrosion, etc. and assess the remaining life of the machines, thereby be in the position to propose modernization and upgrading program.

Outsourcing, bundling, and other aspects of services supply

The large scope of an EPC value chain necessitates the outsourcing of many activities. If the firm is the prime contractor, it usually subcontracts the construction of the facility to a local subcontractor who knows better the legal and regulatory environment for everything related to construction. In the subcontracting agreement, many services are typically bundled under construction services, such as staffing services, staff housing services, the acquisition of various government permits, transportation and logistics, as well as the testing of construction materials. This, in itself, is a large value chain that would merit a separate study.

In the more frequent case of the firm being only part of a consortium, its task is limited to manufacturing and delivering the machines, including installation in some cases. Once the firm has delivered, tested on-site and certified the machines, the rest depends on the plant operator, except in cases when the machines are still under warranty. Yet, even in the case where the firm is not the prime contractor, it is closely involved throughout the EPC value chain. In the bidding phase, for example, a project in-house assessment is made in terms of financial viability. Independent from the site assessment services undertaken by the prime contractor or local construction company, the firm also outsources either to a

[6] The tendency of a solid material to move slowly or deform permanently under the influence of mechanical stresses. It can occur as a result of long-term exposure to high levels of stress or temperature (Wikipedia.com)

subsidiary or third party the service of assessing the topography of the plant site. The firm is sure, however, to do its own research (with help from a subsidiary or third party) on environmental and other relevant regulations in order to adjust its machines if necessary.

In the pre-manufacturing phase, the design and engineering front-end services[7] for the machine, the procurement services, testing and inspection, and other engineering services are all done in-house or by a subsidiary/ JV company. For IT design and software for control systems, the services may either be provided in-house or outsourced to a third party, usually an instrument and control (I&C) company. Manufacturing may take place in the different subsidiary manufacturing plants, exploiting each plant's comparative expertise, say, in manufacturing boiler tubes, or blades, etc. These are then delivered for final assembly to the strategically chosen subsidiary that is closest to the power plant site. For example, if the power plant is being constructed in an Asian economy, the final assembly takes place in the same economy if one exists, or else in the nearest subsidiary.

Delivery and other logistical arrangements are usually outsourced to a third-party logistics provider. Installation may be undertaken by in-house personnel or by the contractor, but the certification and commissioning services as well as on-site testing are usually provided by the firm's staff. Repairs and maintenance are done by the firm or its subsidiary, and this depends on the contract. Their machines may also be serviced by third party service providers.

In general, most of the services are carried out in-house or by the firm's subsidiaries. Because of its extensive subsidiary network, most of the required services and materials are available within the corporate family, except for services in which the group may not have specific expertise, such as in logistics or I&C software design. Likewise, because most of the inputs are from its own subsidiaries, the trust factor on the quality of inputs and services is high, resulting in less need for strict testing and inspection, except on a random basis.

10.5. Policies Affecting the Value Chain

Policy discussions with the firm covered several fronts. Interestingly, on whether the policy environment determines the firm's decision to establish in any economy, the firm said that it is not a principal determinant in the decision. Rather, more important is whether they can find a good and reliable partner in the place. In the past, establishment in various economies was part of a tariff jumping strategy because tariffs for their products were then very high.

Currently, investments in new manufacturing plant are no longer a priority because the firm thinks it has enough capacity to meet growth in the energy market in Asia and the world. Rather, more recent investments are in support or services centers, or subsidiaries with a service focus. The decision on where to locate new services subsidiaries usually depends on the number of products sold in the market, as this drives the need for more services support.

Trade policy

The firm usually faces no major problems with customs because their products are specialized machines. But uncertainty about whether or not its imports will be accorded a preferential tariff obliges them to assume in their bid that the highest tariff will be payable. This makes the cost of the project (and their bid price) higher than if they knew for certain beforehand what tariff rate will be used. Ultimately, the higher cost occasioned by this uncertainty is borne by the customer (the utility) and

[7] Defined as the work required to produce process and engineering documentation of sufficient quality and depth to adequately define the project requirements for detailed engineering, procurement and construction or manufacturing. See http://www.fluor.com/epc-services/engineering/Pages/front-end-engineering-design.aspx.

eventually by the end-users. Clear guidelines and agreement on tariffs and other relevant policies at the outset would be helpful in lessening the cost of the project.

Human capital needs

A major concern is the large employee turnover, especially of engineers, in their subsidiaries in developing economies. This is related to the small pool of quality engineers relative to those in developed economies. In turn, this is connected to the quality of education in the respective host markets. The firm's strategy is to train local talent in order to minimize the need to use many Japanese expatriates which costs the company more. But the firm also sees the need for different Asian economies to upgrade their education and skills development. Human capital development and skills matching is important to support large manufacturing and service facilities that are set up in the economy.

Labour mobility

To support their customers, sometimes it is necessary to dispatch engineers from Japan or elsewhere in less than 24 hours to prevent a plant shutdown[8]. But in some economies with visa restrictions, it takes time to send the necessary personnel. Though the application process in itself is not difficult for the firm, it is still time consuming, and delays can become costly. The firm thinks that minimizing the visa processing period would greatly help, particularly for very short-term and temporary stays of intra-corporate transferees.

Other labour-related regulations that pose a threat are indirect regulations on corporate officers' qualifications. For example, in one Asian economy, a regulation being discussed in its legislative assembly is the language test requirement for managers and directors. If approved, this requirement effectively puts restrictions on foreign directors, putting unnecessary burden on them in carrying out their responsibilities.

Services provided by foreign personnel, such as the installation and commissioning of machinery or to act as EPC project technical advisor, are usually subject to a withholding tax if the personnel stays beyond a certain threshold number of days, which in some economies is up to 60 days. The additional cost incurred is something that the firm takes as a given. But in some economies, particularly in those where Japan has no bilateral agreement on double taxation, the withholding tax can go beyond the fees for technical services and also include a tax on royalties.

Intellectual property

Some economies require the local transfer of intellectual property (IP), whether for imported components or for manufacturing. The firm has resolved the potential difficulty arising from such a regulation by forming a joint venture to which it licenses the IP with restricted conditions, i.e. only for the purpose of manufacturing for the specific market (exclusive market)[9]. The joint venture receives all the drawings and technical designs but must ensure no leakage of the IP. Any improvement work on the licensed IP, however, will belong to the joint venture.

So far, the arrangement appears satisfactory. The firm is, however, aware that other companies have experienced either leakage in the use of their IP or non-observance of the restrictions on IP use by their

[8] The firm already uses advance technology to carry out remote monitoring, obviating the need for frequent plant visits by their employees. Still, a regular physical visit, usually by employees in the subsidiary located nearest the plant, is undertaken as a preventative measure.

[9] In general, as long as the local partner is reliable and qualified, both in the technical and business sense, a simple licensing agreement is sufficient to protect intellectual property, without the need to form a joint venture.

local partner. In particular, these companies found machines being sold in other Asian economies that made use of their licensed technology when its use is supposed to be restricted to one particular economy in Asia. Improved IP protection and the implementation of rules in different economies, as well as the careful choice of local partners, are important to safeguard corporate intellectual property.

Equity limitation

As a rule, the firm prefers to be free to decide whether to acquire local partners, i.e. have a fully-owned subsidiary, or form a joint venture. This decision is made on a case-by-case basis. In some places acquisition is the best way to enter the market. In certain economies, however, there is preference for joint ventures or even an expectation that these will be established. The vehicle for ensuring that this occurs is rules on foreign equity shares. In some cases where the firm finds a good local partner, it does not consider foreign equity limits an operational constraint. This view is clearest with respect to manufacturing, but less so with after-sales services. The reason for this is that the firm considers that its reputation, and possibly its IP, is at greater risk in this market segment[10].

Though there has been a relaxation of equity restrictions in some economies in the case of the energy industry, restrictions still abound in construction services. Some of these restrictions include permits or licenses to become a contractor, with specified conditions on how to obtain such licenses for example, years of engineering experience, education, etc. If licensing for the engineering profession is restrictive, establishing a foreign-owned construction company in the economy concerned becomes virtually impossible. Restrictions like this in construction services affect the firm's capacity to lead consortia as the prime contractor in particular economies.

Local content requirements

The firm feels that there is need for clear guidelines on local content requirements. It noted that in some projects in the region, the local content requirement is too high and detailed rules on its computations are not very clear. It is particularly problematic especially if there are not enough companies in the host economy that can satisfy the stringent technical requirement by the firm for power plant construction projects. In some cases, it is virtually impossible to meet the local content requirement.

Health, safety and environment regulations

To ensure compliance with government regulations on health, safety, and environment, there is a need for government to visit and inspect facilities. However, overly frequent visits add unnecessarily to firm costs, particularly because the inspectors' costs of transportation, accommodation, and other expenses are usually borne by the power plant management. For large enterprises, these costs may be negligible. But if an independent power provider - the firm's customer - is small, it will try to recoup these additional costs either through hard bargaining with the equipment provider and other suppliers on price, or pass the cost on to final end-users of electricity.

[10] For example, the sales partner or maintenance service partner in the host economy must satisfy a certain technical level required to supply the necessary customer service or be able to detect problems and inform the company in time. For this to happen, the case study firm has to train local staff, including possibly making them undergo short stints at the factories in Japan. Likewise, the case study firm can dispatch its engineers to the host economy to train local engineers. Such intensive investments in human capital training calls for a long-term, stable relationship based on shareholding.

Transparency

The energy generation business has to deal with various government regulations, for example on environmental issues, land ownership, permits, and various taxes. But in many economies, information is difficult to obtain and the firm has to rely on local companies to get the information.

Likewise, when there are delays in plant construction, the firm has often felt that it is left unaware of the project status and of the difficulties that arise in the implementation process[11]. Since the firm bases its manufacturing schedule on the plant construction schedule, delays in project implementation have a huge impact on cost. For example, the firm might have finished manufacturing the bespoke equipment for a project and if the plant is not yet ready, it incurs storage and maintenance costs. If the firm delay the manufacture of particular types of equipment for a specific power plant, the delay cascades down on all their suppliers as well as on the schedules of the different subsidiaries that may be involved in supplying parts for the equipment. Most of the factors causing delay are difficult for foreign firms to observe or anticipate, particularly if the government is not transparent.

The risk of delays and other similar risks that are frequently prevalent in developing economies are typically factored into project costs, but only to a limited degree because of competition from other bidding consortia. In sum, for big infrastructure projects like power plants, a government's capacity to implement the project according to agreed timelines can minimize overall cost and thus ultimately improve the provision of electricity at a cheaper cost.

[11] Delays may be caused by factors beyond the control of the utility or customer. For example, a large tract of land where the plant is to be constructed may not be ready as planned because the government has failed to evict or transfer dwellers in the area. This type of situation is usually hard for foreigners to observe and anticipate.

Appendix A

List of potential services for designing, building and operating a power plant

Table A.1. Services during bidding stage

Service		Corresponding CPC Ver. 2 Code	Supplied in-house	Outsourced to affiliated companies and reasons[12]	Outsourced to third-party suppliers and reasons	Remarks
1	Research on economic conditions, legal environment, etc. on economy where power plant will be built	81212 – Research and development services in economics	Yes	Yes		
		81213 – Research and development services in law	Yes if prime contractor; or else No	Yes if prime contractor; or else No		
2	Land survey; site assessment services	83411 – Geological and geophysical consulting services	No	Yes , proximity	Yes	
		83412 – Geophysical services	No	Yes , proximity	Yes	
		83421 – Surface surveying services	No	Yes , proximity	Yes	
		83442 – Testing and analysis services of physical properties	No	Yes , proximity	Yes	

[12] Examples of reasons: i) government services; ii) required by laws and regulations; iii) lack of feasibility to supply service in-house; iv) external economies of scale; v) lack of expertise; vi) need to ensure access to the best services; vii) need for strong relationship with related stakeholders (government agencies in many instances) to supply the services; viii) outsourcing during peak seasons.

3	Back-office services (e.g. feasibility study, project bid preparation)	Preparation of bidding document	Yes; with prime contractor[13]	Yes		
		Headquarter services	Yes			
4	Design services	83912 – Industrial design services	Yes			If necessary to adjust existing design to local conditions
5	Telecommunication services	CPC 841: Telephony and other telecommunication services			Yes, needs economies of scale	
		CPC 842: Internet telecommunication services			Yes, needs economies of scale	
6	Planning and management services	Selection of contractors for facility construction	Yes if prime contractor			

[13] With respect to the equipment firm is supplying.

Table A.2. Services during design stage of equipment and pre-construction/planning stage of power plant

Service		Corresponding CPC Ver. 2 Code	Supplied in-house	Outsourced to affiliated companies and reasons[14]	Outsourced to third-party suppliers and reasons	Bundled
7	Site assessment services	83411 – Geological and geophysical consulting services	Yes, if prime contractor		Yes [15]; use of outside expertise	
		83412 – Geophysical services	Yes, if prime contractor		Yes; use of outside expertise	
		83421 – Surface surveying services	Yes, if prime contractor		Yes; use of outside expertise	
		83442 – Testing and analysis services of physical properties	Yes, if prime contractor		Yes; use of outside expertise	
8	Architectural services for power plant building	8321 – Architectural services and advisory services	Depends on project		Yes to construction services company; engineering company; lack of in-house expertise	
		8323 – Landscape architectural services and advisory services			Yes to construction services company; engineering company; lack of in-house expertise	

[14] Examples of reasons: i) government services; ii) required by laws and regulations; iii) lack of feasibility to supply service in-house; iv) external economies of scale; v) lack of expertise; vi) need to ensure access to the best services; vii) need for strong relationship with related stakeholders (government agencies in many instances) to supply the services; and viii) outsourcing during the peak season.

[15] Normally works with prime contractor to check if there is need to adjust the equipment to the specific land topography, type, or proneness to calamities, etc.

9	Design services for equipment as well as analysis and monitoring software	83912 – Industrial design services	Yes			If necessary to design a new one; or else adjust existing ones.
		8392 – Design originals; original design concepts, produced on own account: · industrial product designs · aesthetic designs · graphic designs	Yes			If necessary to design a new one; or else adjust existing ones.
		83141 – IT design and development services for applications	Depends on project; Yes (depends on project and economy)		Yes, to Instrumental and Control (I&C) Company; lack of expertise	Simple control design requirement from economies may be done in-house
		83142 – IT design and development services for networks and systems	Depends on project; Yes (depends on project and economy		Yes, to Instrumental and Control (I&C) Company; lack of expertise	Simple control design requirement from economies may be done in-house
		83143 – Software originals - copyrighted intellectual property produced without contract for outright sale	Project basis		Yes; lack of expertise	
10	Government-related pre-building services (e.g. securing	91132 - Public administrative services related to fuel and energy	Prime contractor		Yes, for efficiency	Usually bundled with construction services

	government permits for construction)					
		91133 - Public administrative services related to mining and mineral resources, manufacturing and construction	Prime contractor; Project basis		Yes, for efficiency	Usually bundled with construction services
11	Planning and management services	83223 – Project site master planning services	Project basis			
		83330 – Project management services for construction projects	Project basis		Yes, construction company/ engineering company; efficiency considerations	
		Selection of contractors for facility construction	Yes if prime contractor	Yes if prime contractor		
		83190 – Other management services, except construction project management services (Selection of contractors for architectural design)	Yes if prime contractor	Yes if prime contractor		
		83190 – Other management services, except construction project management services (Selection of contractors for engineering design)	Project basis			
12	Construction services	CPC 54: Construction services		Yes if prime contractor	Yes; outside expertise	*Bundled with construction materials, leasing of equipment,

						labor supply as well as accompanying components such as housing, medical, insurance, etc.
13	Research and development services	8112 – Research and experimental development services in engineering & technology	Yes	Yes; simple engineering or adjustments to machines		
14	Procurement services	83116 – Supply chain and other management consulting services	Yes	Yes		
		85999 – Other support services n.e.c.	Yes	Yes		
15	Customs clearance services and logistics of raw materials	67110 – Container handling services	No		Yes; outside expertise	
		85999 – Other support services n.e.c. (business brokerage)	Yes		Yes	
16	Technical testing of raw materials	83441 – Composition and purity testing and analysis services	Yes	Yes	No	
17	Transport services of raw materials	651 – Land transport services of freight	No	No	Yes; efficiency	
		652 – Water transport services of freight	No	No	Yes; efficiency	
		6531 – Air transport services of freight	No	No	Yes; efficiency	
		67910 – Freight transport agency services and other freight transport services	No	No	Yes; efficiency	
18	Environmental consulting services	83931 – Environmental consulting services			Yes; lack of expertise	

Table A.3. Services during building/construction stage of power plant

Service		Corresponding CPC Ver. 2 Code	Supplied in-house	Outsourced to affiliated companies and reasons	Outsourced to third-party suppliers and reasons	Bundled
19	Engineering services during building/construction	83310 – Engineering advisory services	Yes			
		83321 – Engineering services for building projects	Project basis		Construction / engineering company; due to economies of scale	
		83324 – Engineering services for power projects	Yes			
20	Site preparation services	54310 – Demolition services	Project basis			
		54320 – Site formation and clearance services	Project basis			
		54330 – Excavating and earthmoving services	Project basis			
21	Importation of power plant equipment: Customs clearance and logistics	85999 – Other support services n.e.c.		Yes	Yes	
22	Importation of power plant equipment: Freight transportation services	6511 – Road transport services of freight		Yes	Yes	
		6512 – Rail transport services of freight		Yes	Yes	

		652 – Water transport services of freight		Yes	Yes	
		653 – Air and space transport services of freight		Yes	Yes	
23	Importation of power plant equipment: Storage and warehousing services	67220 – Bulk liquid or gas storage services	Prime contractor			
		67290 – Other storage and warehousing services		Yes; proximity		
24	Construction services	54 – Construction services	Project basis		Construction/ engineering company	*Bundled with construction materials, leasing of equipment, labor supply as well as accompanying components such as housing, medical, insurance, etc.
25	Installation services for equipment and related components such as wiring	546 – Installation services	Project basis	Yes	Construction/ engineering company	
26	Certification and commissioning services of power plant building and equipment by firm	8344 – Technical testing and analysis services	Yes	Yes		
27	Government inspections on fire prevention, health hazards, environmental	91132 – Public administrative services related to fuel and energy	Project basis		Yes; required by law	

	protection and other aspects	9129 – Public administrative services related to other public order and safety affairs	Project basis		Yes; required by law	

Table A.4. Services during operations stage of power plant

Service		Corresponding CPC Ver. 2 Code	Supplied in-house	Outsourced to affiliated companies and reasons	Outsourced to third-party suppliers and reasons	Bundled
28	Engineering services during operations	83310 – Engineering advisory services	Project basis			
		83324 – Engineering services for power projects	Yes (if part of contract)	Yes (if part of contract); to affiliated companies in relevant economy		
29	Information technology (IT) services for on-site and remote monitoring of power plant	8315 – Hosting and information technology (IT) infrastructure provisioning services	Yes (if part of contract)			
		8316 – IT infrastructure and network management services	Yes (if part of contract)			
30	Telephone-based support services	85931 – Telephone call centre services	Yes (if part of contract)	Yes (if part of contract); to affiliated companies in relevant economy		
31	Diagnostic, inspection, maintenance and repair of equipment	87156 – Maintenance and repair services of commercial and industrial machinery	Yes (if part of contract)	Yes (if part of contract); to affiliated companies in relevant economy		
32	Installation services for replacement parts and equipment as well as related components such as wiring	546 – Installation services	Yes (if ordered)			
33	Training services for workers	9291 – Other education and training services	Project basis			

Table A.5. Back-office services (before, during, and after plant construction)

Service		Corresponding CPC Ver. 2 Code	Supplied in-house	Outsourced to affiliated companies and reasons	Outsourced to third-party suppliers and reasons	Bundled
34	Financial services	71 – Financial and related services	Yes if prime contractor		Yes; economies of scale	
35	Insurance services	713 – Insurance and pension services			Yes; economies of scale	
36	Accounting, auditing and bookkeeping services	822 – Accounting, auditing and bookkeeping services			Yes; required by law	
37	Legal services	821 – Legal services			Yes; lack of in-house expertise	
38	Information technology services	8313 – Information technology (IT) consulting and support services			Yes; economies of scale	
39	Visa and immigration services for foreign employees	91290 – Public administrative services related to other public order and safety affairs			Yes; efficiency	

Source: Compiled by APEC Policy Support Unit