Study on Standardization of Technical Data Required for Regional Power Interconnection & Power Trading

February 2019

Abbreviations

ADB	Asian development Bank
BERC	Bangladesh Electricity Regulatory Authority
CBET	Cross Border Electricity Trade
CERC	Central Electricity Regulatory Commission
DAM	Day Ahead Market
DISCOs	Distribution Companies
EMS	Energy Management System
FACTS	Flexible Alternating Current Transmission System
GENCOs	Generating Companies
ICT	Information Communication technology
IEGC	Indian Electricity Grid Code
IPP	Independent Power Producer
ISO	Independent System Operator
KEPCO	Korean electric Power Company
KPX	Korean Power Exchange
KWh	Kilo Watt Hour
MIT	Massachusetts Institute of Technology
MO	Market Operator
MWh	Million Watt Hour
NEA	Nepal Electricity Authority
NEPRA	National Electricity Power Regulatory Authority
NLDC	National Load Dispatch Centre
NTDC	National Transmission & Dispatch Company
OECD	Organization for Economic Co-operation and Development
PPA	Preliminary Project Approval
PPIAF	Public Private Infrastructure Advisory Facility
RERA	Regional Electricity Regulators' Association of Southern Africa
RLDC	Regional Load Dispatch Centre
SAARC	South Asian Association for regional Cooperation
SAPP	South African Power Pool
SCADA	Supervisory Control and Data Acquisition
SEC	SAARC Energy Centre

SLDC	State Load Dispatch Centre
TAM	Term Ahead Market
TRANSCOs	Transmission companies
TSO	Transmission System Operators
WAPDA	Pakistan Water & Power Development Authority. Pakistan Water and Power Development Authority
WB	World Bank

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1 Executive Summary

The South Asian Association for Regional Cooperation (SAARC) includes the members Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. On Nov 27, 2014 an agreement was signed between these countries for Energy Cooperation (Electricity). Objective of the agreement is to allow cross border trade of electricity on voluntary basis while fulfilling the rules and regulations of respective members. Member States can share and update technical data and information on the electricity sector in an approved template. It is necessary that before updating and sharing such data, consensus on nature and amount of data is identified and the concerned Member state also agreed upon it.

Exchange of information and data are necessary before the physical exchange of electricity and its services among industry members across the supply chain. Furthermore, the collection of data, its processing, storing and exchanging would be totally decentralized. All industry partners i.e. generators, distributers, consumers and retailers must collect and produce data just like daily activity. While trading electricity it is necessary for both countries to share technical data on generation and transmission aspects related to bilateral or multilateral cross border power trade. Regional generation capability and transmission planning must be kept in mind during import and export of electricity.

SAARC members are on different stages in electricity market. India lies in most advance stage while Pakistan, Sri Lanka and Bangladesh lies in developing stage and other lies in primitive stages. The grid code of electricity, laws, rules and regulation defined the information and data for planning, trade and operation of the system. Grid codes of SAARC member states defined the format for necessary data and information to be exchanged but no code had defined for bilateral or regional power trade purposes.

Code synchronization regarding standard template for information and data is necessary for economic, efficient, safe and reliable electricity trade in bilateral and regional level. Consequently, this study is aimed for initiating development of minimum set of standard data template for implementation of the SAARC agreement and promotes regional electricity trade in South Asia. This study had overviewed the existing format of data exchanging in internal and bilateral trade among SAARC member states. Moreover, It also covered best practices of data and information exchange practices outside SAARC region like Southern African Power Pool (SAPP), Spanish Power Exchange Market Operator and Korea Exchange Market. Proper market design and essential data must be defined for establishment of South Asia Regional Power exchange Market. Study has recommended minimum set of standard Data and information needed at interconnection for scheduling, metering, accounting and billing of electricity

2 Introduction

2.1 Background (Related to Framework Agreement, 2014)

The SAARC (South Asian Association for Regional Cooperation) Member States, specifically Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Asian nation and Sri Lanka had signed SAARC Framework Agreement for Energy Cooperation (Electricity) dated on 27th Nov 2014. Objective of the agreement is to modify cross border trade of electricity on voluntary basis subject to laws, rules and laws of various member States and supported bilateral/ trilateral/mutual agreements between the involved member states.

The agreement recognized electricity as a vital product for promoting economic process and betterment of life and emphasized the necessity to push regional power trade, energy potency, energy conservation and development of labeling and standardization of appliances and sharing of information.

For increasing economic cooperation and making new opportunities in electricity sector, framework agreement had been signed for Cross Border Electricity Trade (CBET) and Exchange of Power among the SAARC member states that may result in optimum utilization of regional electricity generating resources, increased grid security, and electricity trade arising from diversity in peak demand and differences due to the season.

The framework agreement carries the spirit of commonness and mutual cooperation and subject to laws, rules and international obligations of the Member states. It includes Responsibilities and Taxes Freedom, Data Updating and Sharing Promoting completion, Planning of Cross Border Inter Connection, Build Operate and Maintain, Transmission Service Agreement, Electricity Grid Protection, System Operation and Settlement Mechanism, Transmission Access, Facilitating Buying and Selling Entities, Knowledge sharing and Joint Research in Electricity Sector, Regulatory Mechanism and as well Dispute Settlement.

Bangladesh, Bhutan, India and Nepal have approved the framework agreement. Other countries are on their way to approval. The SAARC Energy Center (SEC) is regional excellence in this sector and this study is proposed to facilitate the agreement's implementation. According to article 5 it is clear that prior to the updating and sharing of such data, consensus on the nature and frequency of the data is identified and agreed by the Member States concerned.
The exchange of data and information is a prerequisite for the physical exchange of electricity and the exchange of electricity services among industry participants throughout the supply chain. The data system is usually largely decentralized in the way data is collected, processed, stored and exchanged. All participants in the industry, such as retailers, large consumers, generators and distributors, collect and produce data on a daily basis. Exporting and importing countries must share technical data on generation and transmission aspects associated with the cross-border bilateral / multilateral trade in power.

The source of electricity generation in different SAARC Member States is different. Bhutan and Nepal have a hydro-dominated system, Bangladesh and India have a system of natural gas and coal and Sri Lanka and Pakistan have mixed system The following information is shown in detail in Table 1 below. The internal electricity market in SAARC Member States is at different stages. India is on an advanced stage, while Pakistan, Sri Lanka and Bangladesh are on developed stage and rest are in initial stages. The electricity grid code and other electricity laws, rules and regulations defined the exchange of information and data. Code harmonization with the standard information and data template is mandatory for the economic, efficient, safe and reliable trade in electricity at bilateral / sub - regional and regional levels. This in-house study is therefore intended to initiate the development of a minimum set of standard data set templates for the smooth implementation of the SAARC Framework Agreement and to promote regional trade in electricity in South Asia.

Table 1: Proportion of energy demands met by different sources of electricity in SAARC member states

	Electricity Generation Sources							
SAARC Member State	Hydro-electric power	Oil	Coal	Thermal energy	Natural gas	Biofuel and Waste	Nuclear Energy	Renewable Energy
Bhutan	99%	1%	-	-	-	-	-	-
Nepal	93%	-	-	6.9%	-	-	-	0.1%
Bangladesh	57%	17%	3%	-	-	22.9%	-	0.1%
India	0.09%	5.48%	80.35%	-	12.74%	-	-	1.34%
Sri Lanka	35%	15%	22%	16%	-	-	-	12%
Pakistan	29%	35.2%	-	-	29%	-	5.8%	-

Below table-2 shows the resources of SAARC countries in which details of all resources, electricity production and reservation from these resources is given. It highlights neighboring countries ' resource potential, such as Myanmar, Kazakhstan, Turkmenistan, Uzbekistan and Iran. These countries have reserves of fossil fuels, while Central Asian Republics such as Tajikistan and Kyrgyz Republic have considerable export potential for hydropower.

Table 2: Resource Funding of SAARC countries ' neighbors

	Coal	**Oil**	**Natural Gas**	**Hydro Power**
Tajikistan	Negligible endowment	Negligible endowment	Reserves: 3.6 billion tons Production: 32,000 tons (2002)	Potential: 40,000 MW Developed: 4000 MW
Kyrgyz Republic	Reserves: 0.8 billion tons Production: 400,000 tons (2003	Negligible endowment	Negligible endowment	Potential: 26,000 MW Developed: 3000 MW
Uzbekistan	Reserves: 4 billion tons Production: 2.8 million tons	Reserves: 594 million bbl. Production: 150,000 bbl/day	Reserves: 66.2 tcf Production: 2.07 tcf/year	Potential: Modest Developed: 1700 MW
Kazakhstan	Reserves: 37.5 billion tons Production: 95 million tons (2004	Reserves: 29 billion bbl Production: 1.3 million bbl/day	Reserves: 65 to 70 Trillion Cubic feet (tcf) Production: 0.570 tcf/yr	Potential: 20,000 MW Developed: 2000 MW
Turkmenistan	Reserves: 546 million bbl. Production: 260,000 bbl/day	Reserves: 71 tcf Production: 2.1 tcf/year	Negligible endowment	Potential: Modest
Iran	Reserves: 461million tons Production: 1.1 million tons	Reserves: 132.5 billion bbl Production: 4.2million bbl	Reserves: 971 tcf Production: 3.5 tcf/year	Potential: 42,000 MW Developed: 2000 MW
Myanmar	Reserves: Modest Production: Modest	Reserves: 3.2 billion bbl Production: 7.3 million bbl (During 11 months of 2005-2006)	Reserves: 18 tcf Probable: 89.7 tcf Production: 362 bcf (10.53 bcm) Exports: 0.28 tcf (8.06 bcm) (During 11 months of 2005-2006)	Potential: 39,720 MW Developed: 747 MW

2.2 Objectives (Related to Framework Agreement, 2014)

The main objective of this in-house study is to define a set of minimum / vital / standard data and information for SAARC Regional Power Interconnections and Power Trading through the facilitation and implementation of the Energy Cooperation Framework Agreement.

2.3 Scope

The study report may cover, but not limited to, regional as well as international data pertaining to cross border electricity trade to be shared among the power exporting and importing Member States including existing generation facilities, transmission network, generation additions and transmission developments.

2.4 Methodology adopted in the study

This task shall be undertaken in-house and reviewed internally by the SEC; relevant data / template corresponding to the bilateral trade in power in South Asia collected and reviewed if available and accessible, Relevant data / template for international practices (regional / cross – border electricity trade in regions other than South Asia) collected and reviewed, draft report / data template shall be prepared on the basis of data collected and reviewed from SAARC and international practices, For comments and suggestions, the developed set of standard technical data and information will be shared between the Member States

2.5 Limitations

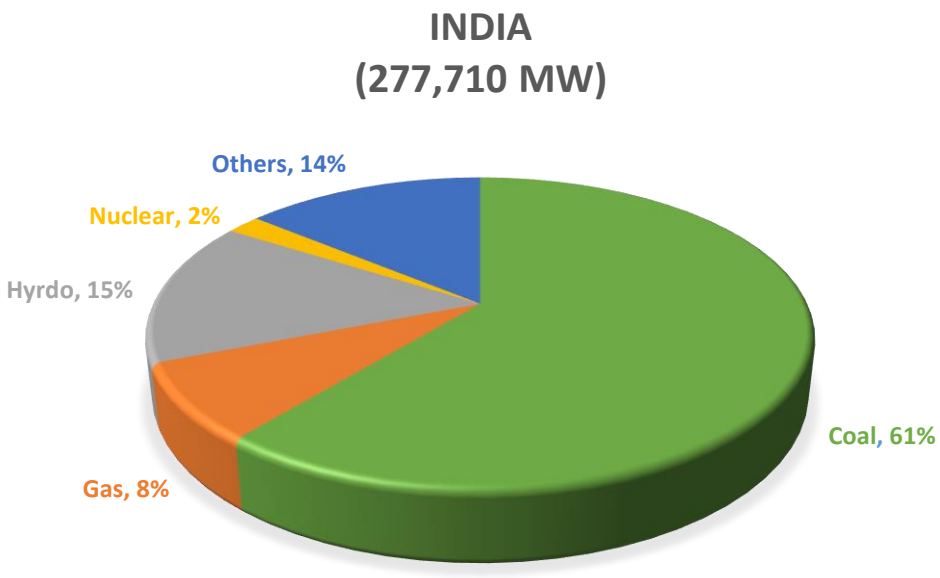
This study is based on publicly available policies, rules, regulations, grid codes, SAARC operating rules and the rest of the world.

3 Electricity Market

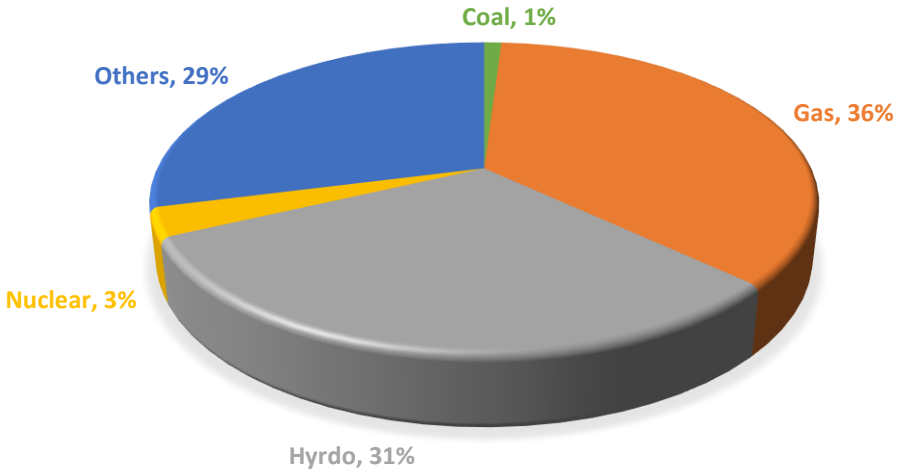
3.1 Introduction

The region of South Asian including Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka consists of almost 1.7 billion people which are one-quarter of world's population. Regardless of having huge population the region is still considerably lags in human development catalogs and economics. Less power generation and grid connected supply are taken as the two main hindrances. All SAARC members are hoping to become fully developed countries in the mid of current century. To achieve this goal "sustainable development goals" (SDGs) and fast economic development are two main requirements. Currently the entire region of South Asia is facing energy deficiency problem. They need secured energy and power generation, distribution and supply. The present installed power generation capacity of all South Asian members is shown in Fig.1. It varies significantly nation to nation in South Asia as seen in this figure. The power generation of Maldives is totally based on fossil fuel while hydro based power generation s used in Bhutan and Nepal. Natural gas is primary energy for Bangladesh while Coal predominantly is for India.

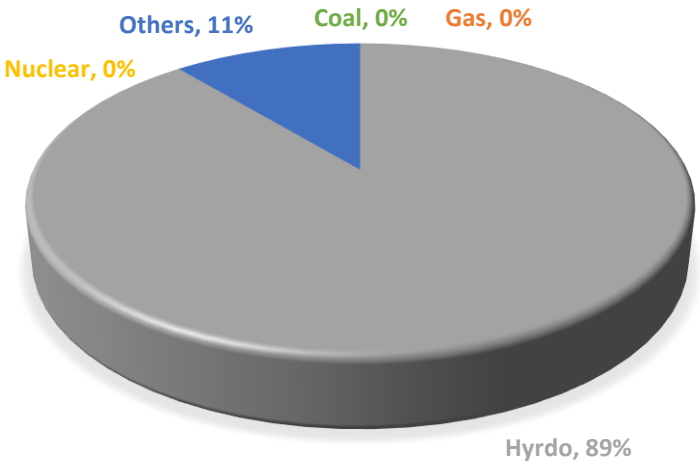
Generally reductions of energy price and energy consumption are two ways to reduce the energy cost. Due to increased needs it is still difficult to reduce consumption of energy, so the energy conservation is not suitable to this problem. Therefore the main focus is now on energy price and power that customers pay. Due to complexity of procurement process there is a need of Power exchange through which both buyers and producers can get benefits. In Power exchange hub the market price is determined on the basis of requirement and supply. The importance of power trading through exchange has grown much rapidly in Europe due to increasing demand of energy consumption. To fulfill the energy deficiencies of South Asian nations they initialize an interconnected power system concept and this study is based on that what is the minimum Set of Standardized Technical Data Required for Regional Power Interconnections and Regional Power Trading.



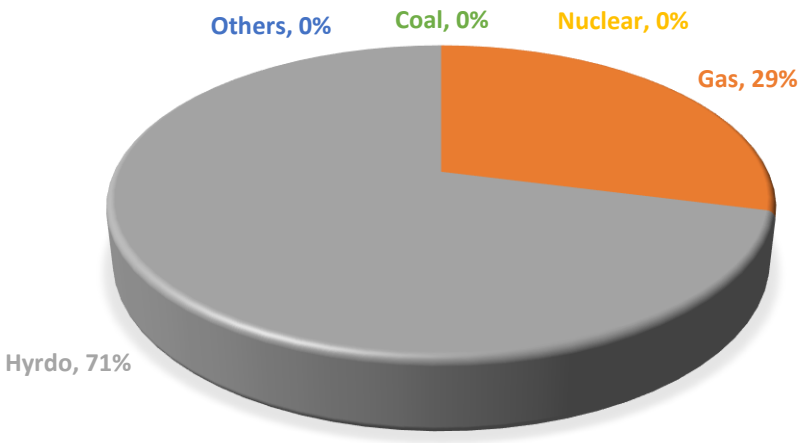
PAKISTAN
(23,087 MW)



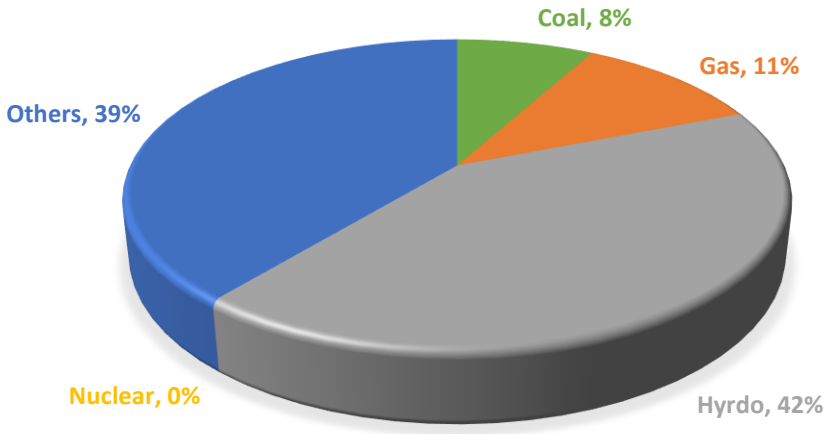
NEPAL
(800 MW)



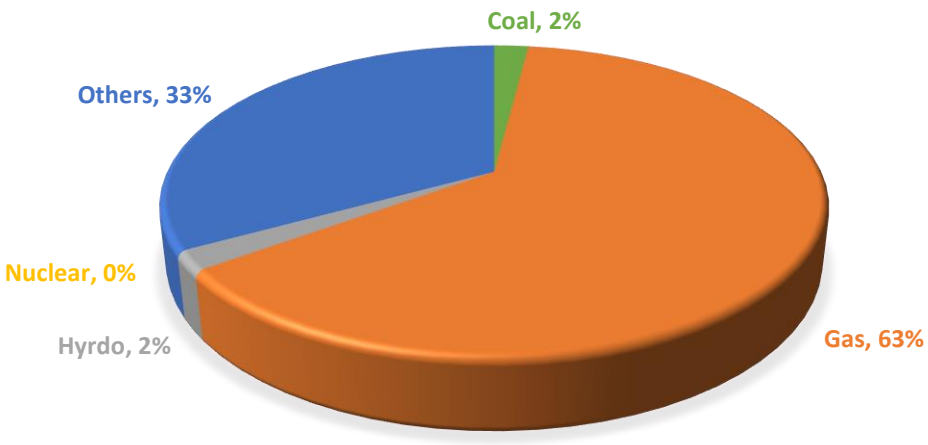
AFGHANISTAN
(840 MW)



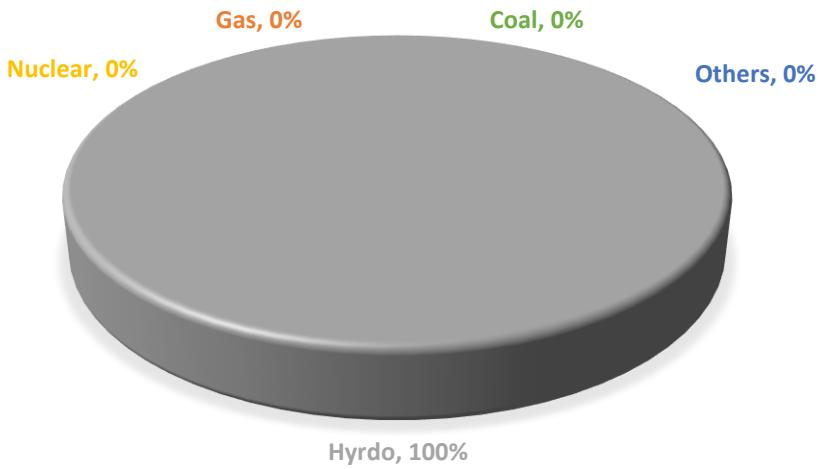
SRI LANKA
(3,940 MW)

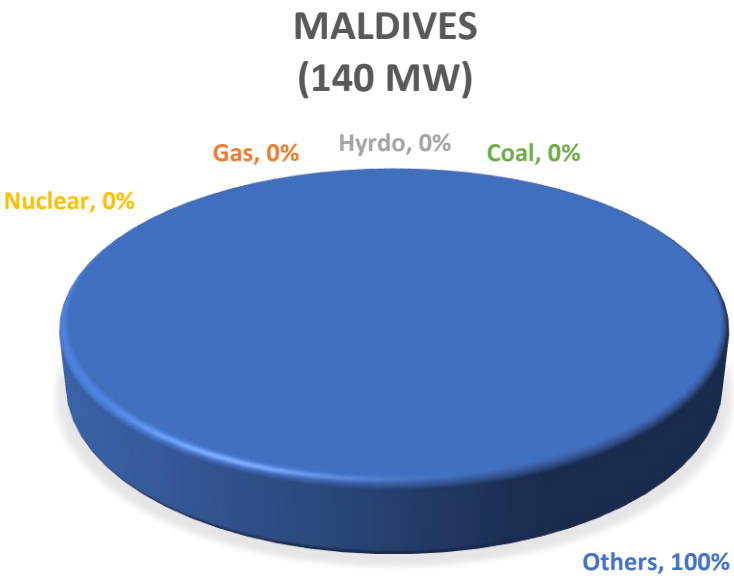


BANGLADESH
(11,877 MW)



BHUTAN
(1,488 MW)




MALDIVES
(140 MW)
Gas, 0%
Hyrdo, 0%
Coal, 0%
Nuclear, 0%
Others, 100%

3.2 Electricity Market and Participants

This section includes various important factors which are discussed as follows

3.2.1 Competitive Power Market: Objectives & Scope

For most of the twentieth century, consumers had to purchase electricity; they had to purchase electricity from utilities that had the monopoly and no other option. Utility organizations were integrated vertically i.e. responsible for generating and transmitting electrical energy from power plants to load centers and distributing it to house - to - house consumers.

Consumers have choices in the open electricity market and buyers and sellers can trade according to the market principle, i.e. Demand and supply law. The electricity market, integrated regionally, creates economic and financial benefits.

3.2.1.1 Economic Factors/Benefits

- Large economies of the region have the greatest shortages looming from which resource rich countries can get benefit.
- Larger unit sizes are more efficient generation capacity
- Load shapes and time differences can be effectively utilized
- Intermittent resources will be supported
- Interconnections unlikely to be expensive in relative terms
- Hydro dominated nations (particularly Bhutan, Nepal) will gain from thermal power in lean seasons and peak hours
- The markets will help utilize the power when the economic value is the highest

3.2.1.2 Investment Factors

- Markets create a mechanism to address governance issues replaces dog capacity procurement decisions
- Market access attract private capital on much larger scale.
- Transparent market pricing mechanism provide an effective reference
- Renewable energy resources can be harnessed

Major objective of competitive electricity market national/bilateral/trilateral/sub regional/regional is to create opportunity for investor to recover their cost and enjoy benefits and provide consumers safe, reliable, quality electricity supply at most economic tariff.

3.2.2 Market Participants, Roles and Responsibilities

Market Participants and Market Facilitators are major drivers/actors of electricity market. Producers (Generators), Traders, Suppliers (retailer, marketer, load-serving entity etc.) and Consumers are the participants of Electricity Market. Transmission System Operators, Market Operators and Distribution System Operators are facilitators of Electricity Market.

Roles and responsibilities of actors of electricity market are highlighted below:

3.2.2.1 Electricity Market participants:

Transmission network moves the electricity from the power stations to the distribution networks. When the electricity reaches the distribution networks, it passes through substations, which use transformers to lower the voltage of the electricity ready to deliver for every use.

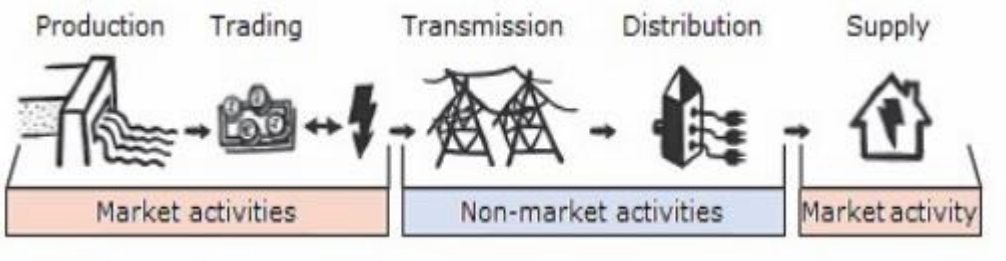


Figure 1. A schematic representation of electricity market participants

Electricity is produced by power plants using various renewable energy sources (e.g. water, wind power, solar power) and non-renewable sources (coal, oil, gas, nuclear power). Market opening allows consumers to be supplied with electricity with respect to the type of electricity production and used energy source. Environmentally conscious consumers can choose electricity produced in an environmentally friendly way, from renewable sources, or in combined heat and power generation plants.

The tasks of the electricity TSO is carried out by the TRANSCOs. High-voltage network that includes 400, 220 and 110 kV transmission lines provides reliable and quality supply of electricity to large consumers and distribution companies. These companies performs the tasks related to maintenance, development and construction of the transmission network, managing and operating the transmission network and the provision of ancillary services.

The distribution networks are operated by the company DISCOs. Distribution networks include electricity lines and utilities at low voltage level (0.4 kV), medium-level (10, 20 and 35 kV) and in some case on high-voltage level (110 kV).

3.2.2.2 Generating Companies (GENCOs)

They are responsible for Production and selling electrical energy. They provide sell services such as regulation, voltage control and reserve that the system operator and maintain the quality and security of the electricity supply.

3.2.2.2.1 Transmission System Operators:

Transmission System Operators (TSOs) are responsible for the transmission grid and all involved technical constraints. Every contract established, either through Bilateral Contracts or through the pool, must first be communicated to the TSOs, who analyses its technical feasibility from power system point of view (e.g feasibility of power flow to address all needs). Refer to figure for more details below

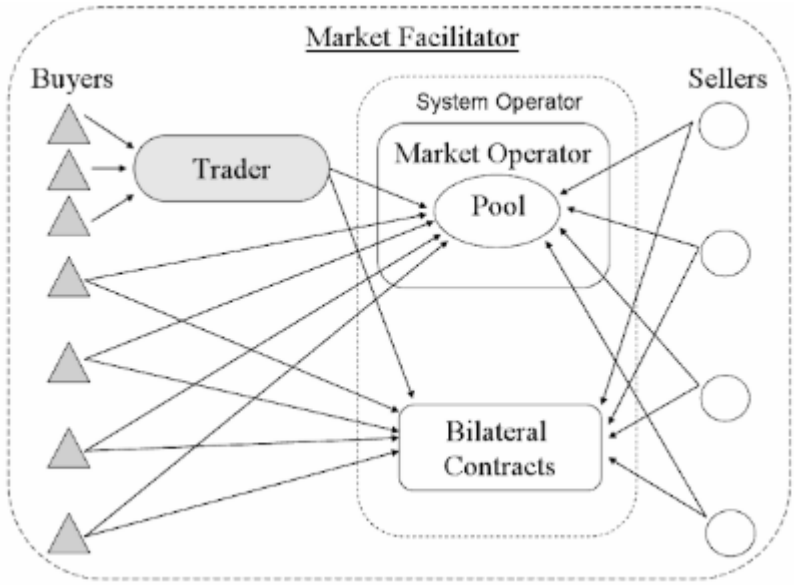


Figure 2. Multi-Agent Simulator of Competitive Electricity Market multi-agent model

3.2.2.2.2 Market Operators:

Market Operators are usually responsible for pool mechanisms. They will receive bids from sellers, buyers and traders, analyze them and establish the marginal price and accepted bids. The process of determining accepting bids is done according to technical validation by the system operator, after, the market operator communicates to sellers, buyers, and traders the acceptance, or not, of their bids and optionally, the market price.

3.2.2.2.3 Distribution System Operators:

Distribution System Operators (DSOs) are responsible to "maintain a secure, reliable and efficient electricity distribution system" not to participate in the retail market by "discriminating between systems users or classes of system users, particularly in favor of its related undertakings. Accordingly, DSOs' role is to facilitate the market, not participate in it. This is especially valid when managing metering, providing information to market participants and smoothing the process of changing supplier.

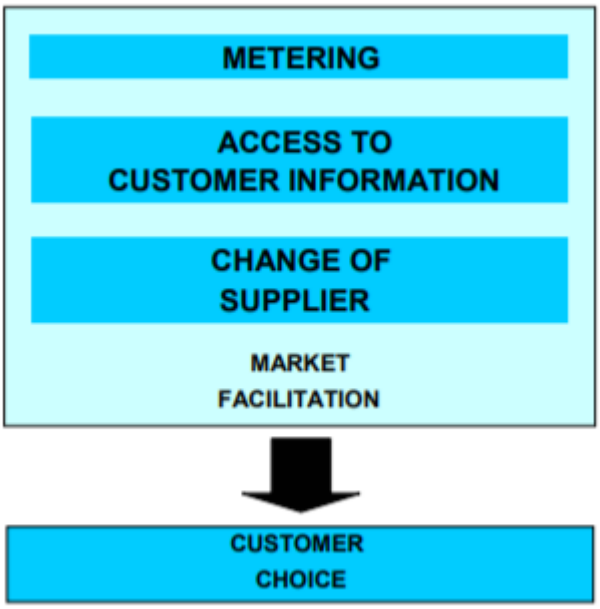


Figure 3. The three channels through which DSOs facilitate markets

3.2.2.3 Generating Companies (GENCOs)

They are responsible for Production and selling electrical energy. They provide sell services such as regulation, voltage control and reserve that the system operator and maintain the quality and security of the electricity supply.

3.2.2.4 Distribution Companies (DISCOs)

They own and operate distribution networks. They have a monopoly for the sale of electrical energy to all consumers connected to their network (in traditional environment). Sale of energy to consumers is decoupled from the operation, maintenance and development of the distribution network (in fully regulated environment) and retailers compete to perform this energy sale activity and may be a subsidiary of the local distribution company.

3.2.2.5 Retailers

They buy electrical energy on the wholesale market and resell it to consumers. Retailers are not allowed to participate in this wholesale market and do not have to own any power generation, transmission or distribution assets.

3.2.2.6 Market Operators (MO)

They typically runs a computer system that matches the bids and offers that buyers and sellers of electrical energy have submitted. MO shall take care of the settlement of the accepted bids and offers and forwards payments from buyers to sellers following delivery of the energy.

3.2.2.7 Independent System Operators (ISO)

Their primary responsibility is to maintain the security of the power system. In a competitive environment, the system must be operated in an independent manner that does not favor or penalize one market participant over another. ISO normally own only the computing and communications assets required to monitor and control the power system.

3.2.2.8 Transmission Companies (TRANSCOs)

They own transmission assets such as lines, cables, transformers and reactive compensation devices and operate this equipment according to the instructions of the independent system operator.

3.2.2.9 Regulator

The regulator is the governmental body responsible for ensuring the fair and efficient operation of the electricity sector. Regulators determines or approves the rules of the electricity market and investigates suspected cases of abuse of market power and sets the prices for the products and services that are provided by monopolies.

3.2.2.10 Small Consumers

They buy electrical energy from a retailer and lease a connection to the power system from their local distribution company.

3.2.2.11 Large Consumers

They will often take an active role in electricity markets by buying their electrical energy directly through the market. Some of them may offer their ability to control their load as a resource that the ISO can use to control the system and may be connected directly to the transmission system.

3.3 Electricity Market Design, Models and Type of Electricity Market

3.3.1 Design and Models of Power Market

Depending upon roles and responsibilities of market players i.e. generation, transmission, distribution, trader companies, consumers, regulator and pricing mechanism, Power Market may be categorized as Monopoly, Purchasing Agency, Wholesale competition and Retail competition

Model-1 Monopoly

The Monopoly model, which is shown in Figure 1, corresponds to the traditional monopoly utility. Sub model (a) corresponds to the case where the utility integrates the generation, transmission and distribution of electricity. In sub model (b), generation and transmission are handled by one utility, which sells the energy to local monopoly distribution companies

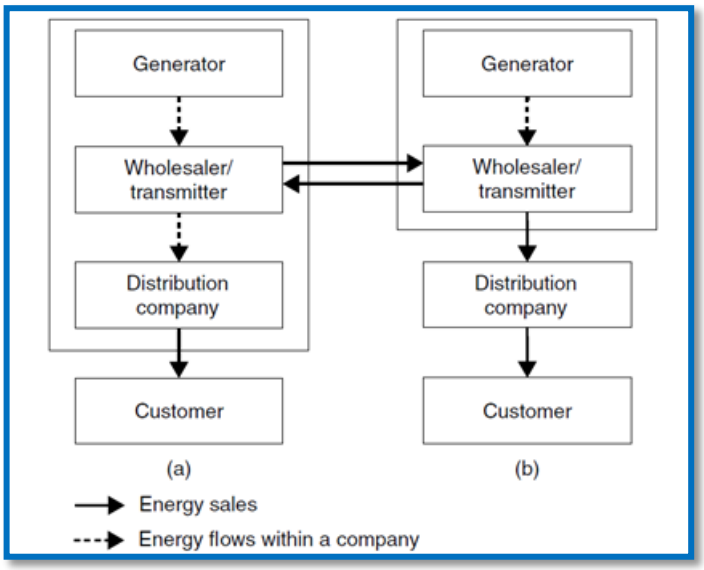


Figure 4. Monopoly of Electricity Market.
Sub model (a) Completely Vertically Integrated
Sub model (b) distribution is handled by one or more than one companies

Model-2 Purchasing Agency

Utility may be designated as power purchasing agency from generation companies. Figure 2-2 shows a possible first step toward the introduction of competition in the electricity supply industry.

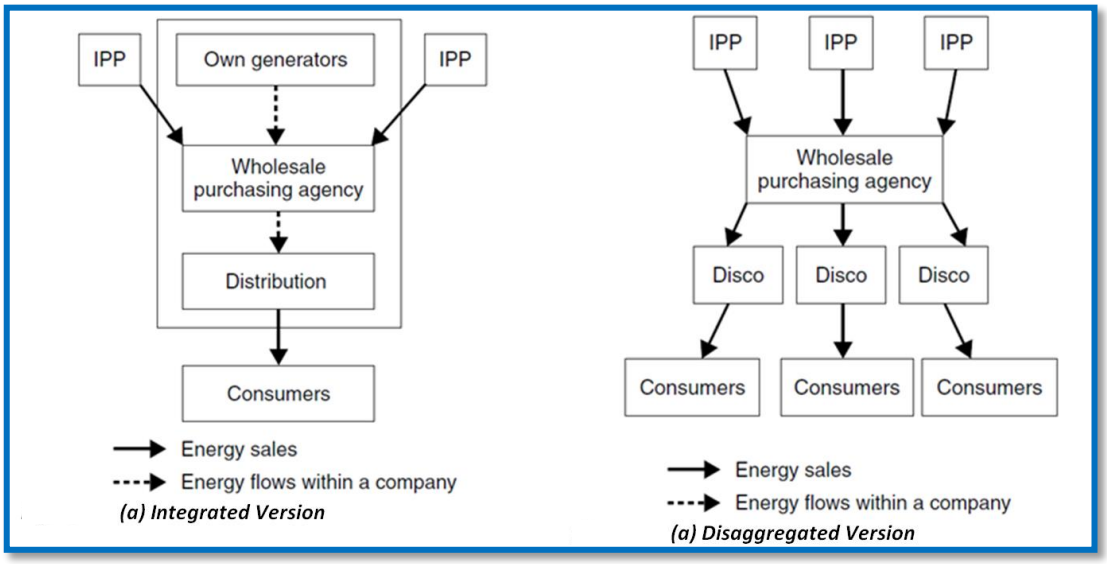


Figure 5. Purchasing Agency Model of Electricity Based Integrated Version & Disaggregated Version

In the integrated Version of Purchasing Agency of electricity market as shown in Fig 2(a), generation units are separated from the integrated utility. Utility that acts as a purchasing agent and Independent power producers (IPP) are connected to the network and sell their output to the utility

In the disaggregated version of Purchasing Agency of electricity market as shown in Fig 2(b), shows further evolution of this model where utility purchases all its energy from the IPPs and the utility no longer owns any generation capacity. The distribution and retail activities are also disaggregated from the utility. Discos then purchase the energy consumed by their customers from the wholesale purchasing agency and the rates set by the purchasing agency regulated by regulator in order to control monopoly power over the discos and monopsony power toward the IPPs.

This model has the advantage of introducing some competition between generators without the expense of setting up a competitive market as in the more complex models.

Model-3 Wholesale Competition

In the wholesale Competition model, which is shown in Figure 2-3, no central organization is responsible for the provision of electrical energy. Instead purchase the electrical energy consumed by their customers directly from generating companies. These transactions take place in a wholesale electricity market.

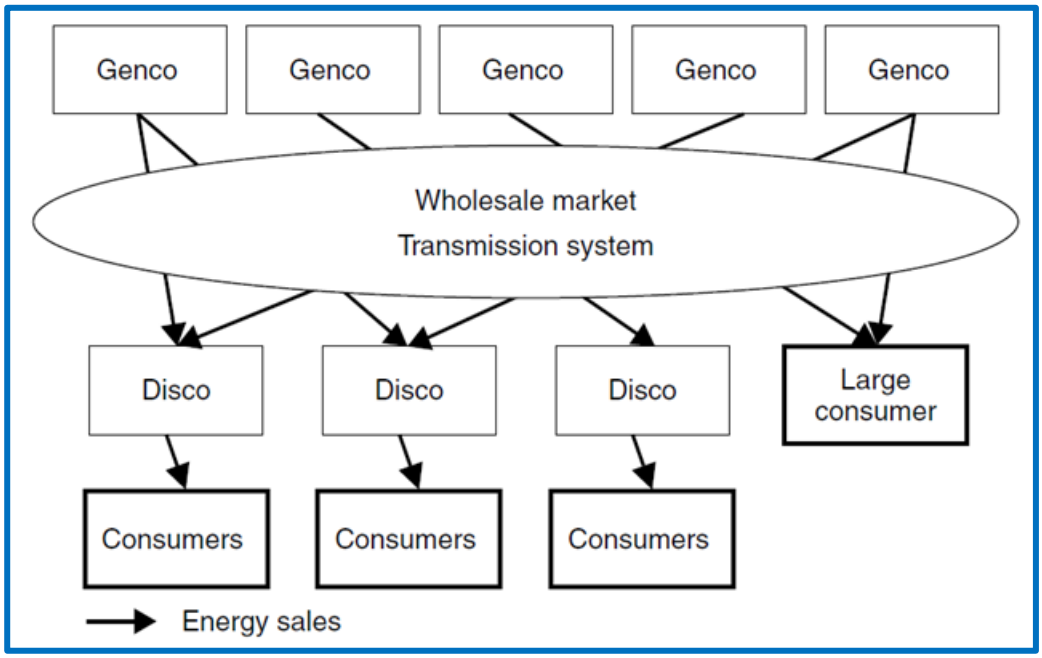


Figure 6. Wholesale Competition Model of Electricity Market

This wholesale market can take practically in the form of a pool or of bilateral transactions. The operation of the spot market, and the operation of the transmission network are remained centralized and Generation, Transmission and distribution are separated. At the retail level, the system remains as centralized and discos purchases electrical energy on behalf of the consumers located in its service territory and operates the distribution network. This model is considerably more competitive for the generating companies because the wholesale price is determined by the law of supply and demand. Big consumer can directly purchase electricity form wholesale market and for welfare of small consumers, the retail price of electrical energy must remain regulated because they cannot choose a competing supplier.

Model-4 Retail Competition

Figure 2-4 explains the ultimate form of competitive electricity market in which all consumers can choose their supplier.

In this model, the “wires” activities of the distribution companies are normally separated from their retail activities and they no longer have a local monopoly for the supply of electrical energy in the area covered by their network. In Purchasing Agency model of electricity market, the largest consumers choose to purchase energy directly on the wholesale market and small and medium consumers purchase it from retailers, who in turn buy it in the wholesale market. Once sufficiently competitive markets have been established, energy prices are set through market interactions and the retail price no longer has to be regulated. Implementing this model, however, requires considerable amounts of metering, communication and data processing.

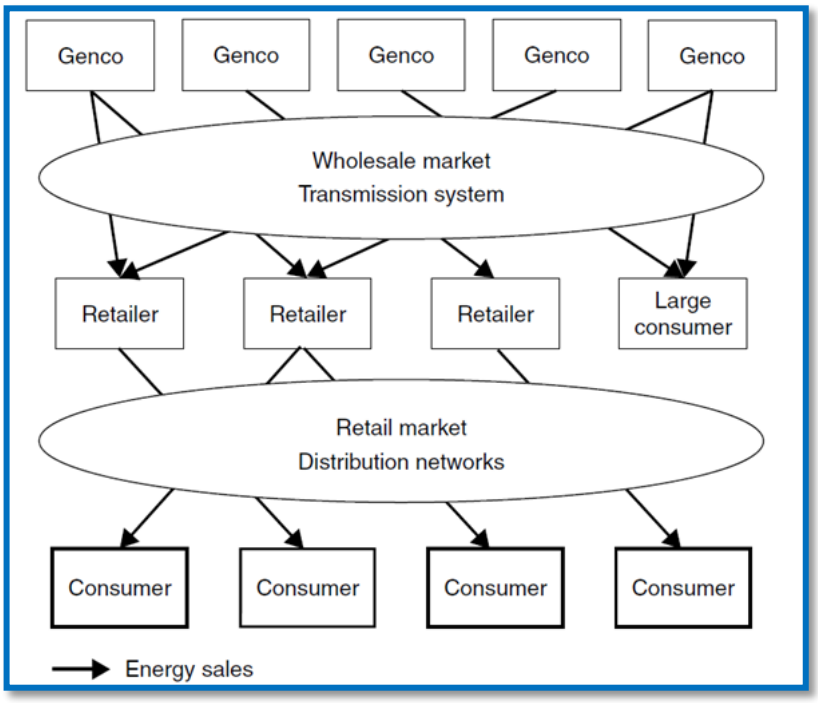


Figure 7. Retail competition model of electricity market

In this model, regulation is mandatory for operation of the transmission and distribution network and the cost of the transmission and distribution networks is still charged to all their users as per approved the regulatory authority.

3.3.2 Types of Markets

Power markets are a mechanism established for matching the supply and the demand for electricity through the discovery of an equilibrium price. For Power market operation, it is to agree on the quality, quantity and price of the goods, three other important matters must be decided when a buyer and a seller arrange a trade are time and date of delivery, mode of settlement (Technical and Financial) and any attached conditions related to transaction. Roles of Buyers and sellers to settle these matters will define the type of contract that they conclude and hence the type of market in which they participate.

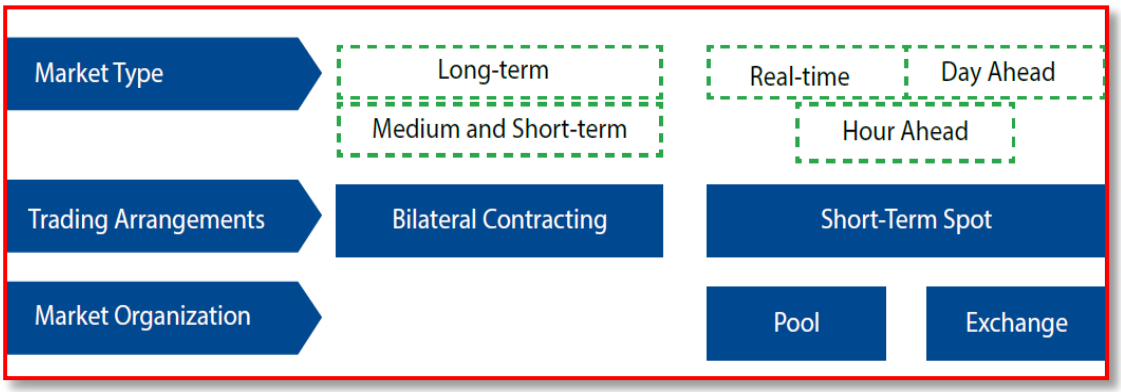


Figure 8. Different types of Electricity Market

3.3.2.1 Spot market

In a spot market, the seller delivers the power immediately to the buyer and the buyer pays for them “on the spot” and subjected not any conditions attached to the delivery. Seller can sell exactly the amount as available and buyer can purchase exactly the amount needed. Prices in a spot market tend to change quickly and a sudden increase in demand (or a drop in production) sends the price soaring because the stock of goods available for immediate delivery may be limited. Similarly, excess in production or fall in demand depresses the price. Spot markets also react to news about the future availability of a power and changes in the spot price are essentially unpredictable otherwise the market participants would anticipate them.

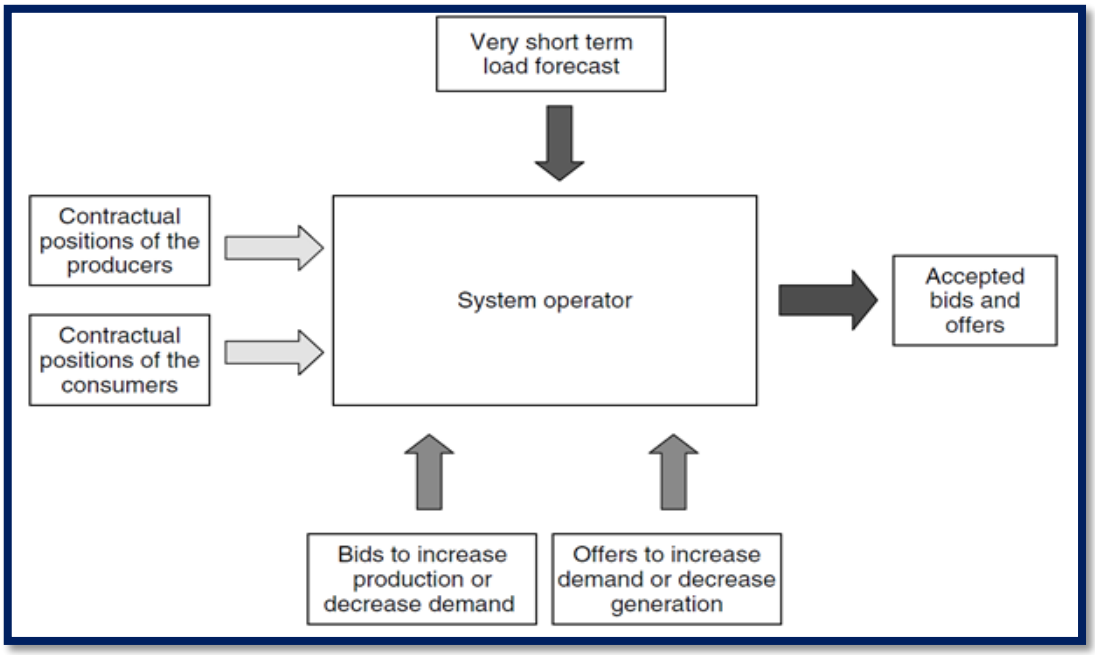


Figure 9. Schematic diagram of operation of managed Spot Market for electricity

3.3.2.2 Forward Contracts and Forward Markets

This forward contract specifies quantity and quality of what to be delivered, date of delivery, date of payment following delivery, penalties if either party fails to honor its commitment and price to be paid

3.3.2.3 Future Contracts and Futures Markets

In a perfect competitive market all participants act as price takers and perfect completion ensures that the marginal cost of production is equal to the marginal value of the goods to the consumers. Such a situation encourages efficient behavior on both supply and demand sides and these interactions progressively lead to an equilibrium in which the price clears the market, that is, the supply is equal to the demand. For trading electrical energy according to this free-market ideal, the equilibrium between the production and the consumption of electrical energy should be set through the direct interaction of buyers and sellers.

3.3.2.4 Open Electrical Energy Markets

3.3.2.4.1 Bilateral trading

Bilateral trading involves only in between two parties a buyer and a seller. Participants thus enter into bilateral contracts without any involvement, interference or facilitation from a third party.

3.3.2.4.2 Customized long-term contracts

The terms of such contracts are flexible since they are negotiated privately to meet the needs and objectives of both parties. They usually involve the sale of large amounts of power over long periods of time several months to several years.

3.3.2.4.3 Trading "over the counter"

These transactions involve smaller amounts of energy to be delivered according to a standard profile, that is, a standardized definition that explains how much energy should be delivered during different periods of the day and week.

3.3.2.4.4 Electronic trading

Participants offer their bids to buy energy and bids to sell energy directly in a computerized marketplace. All market participants can observe the quantities and prices submitted but do not know the identity of the party that submitted each bid or offer.

3.3.2.4.5 Electricity pools

Electricity pool avoids relying on repeated interactions between suppliers and consumers to reach the market equilibrium; a pool provides a mechanism for determining this equilibrium in a systematic way.

Price is determined as per rule of demand- supply. Intersection of demand curve and supply curve will determine the clearing price. All the bids submitted at a price lower than or equal to the market clearing price are accepted and generators are instructed to produce the amount of energy corresponding to their accepted bids.

3.4 Exchange of Data and Information

The electricity industry and electricity markets collects, process, store and exchange significant volumes of data each day. The data is essential for the physical exchange of electricity and electricity services between industry participants across the supply chain.

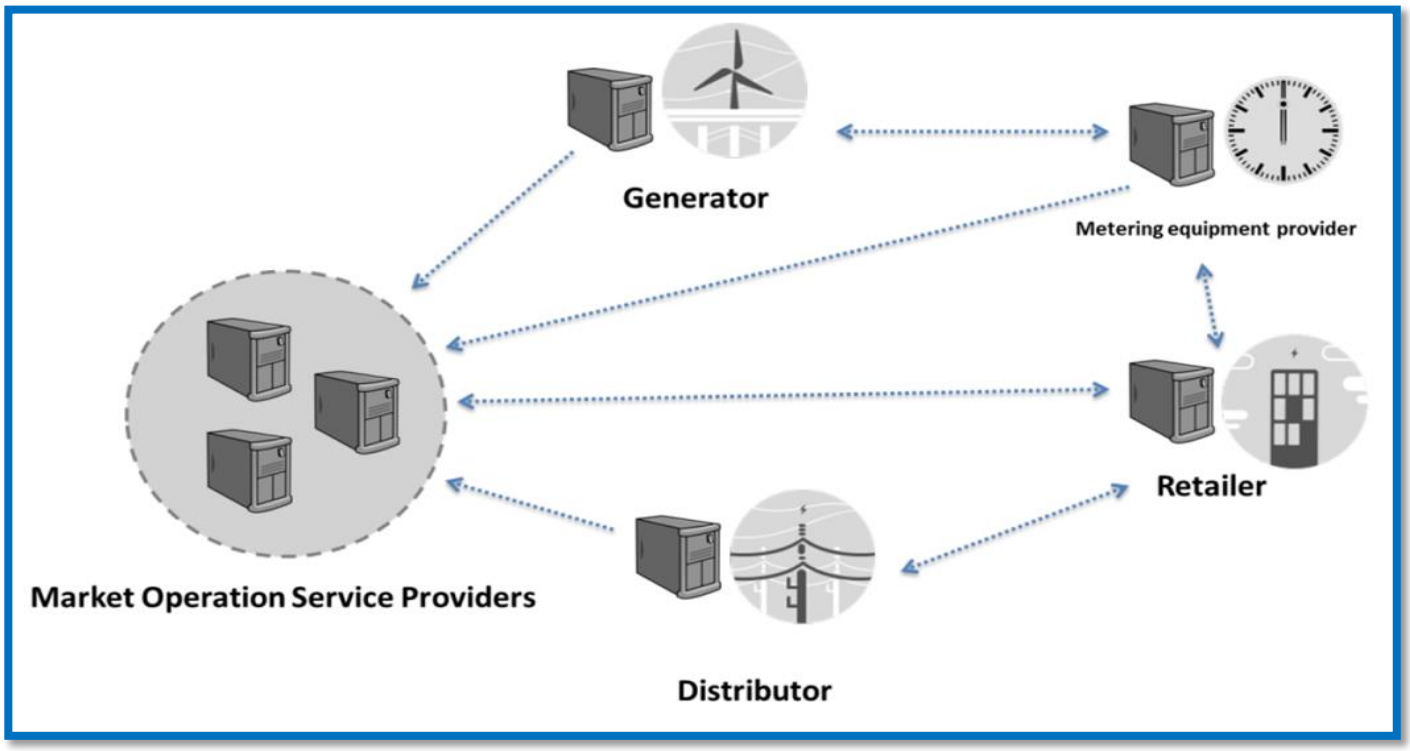


Figure 10. Overview of the data system and data exchange

The data system should be designed and developed in a defined way. Data is collected, processed, stored and exchanged—is largely decentralized. All industry participants, such as retailers, large consumers, generators and distributors, each collect and produce data as part of their everyday activities. They must also exchange data between themselves and through market operator to enable transactions between participants. The Market Operator provides the platform for the electricity market and the exchange of electricity services between participants

Robust mechanism for exchange of data and information is mandatory for electricity trade market and data and data exchange arrangements may be required to:

- Promote innovation and more participation in the electricity industry
- Promote competition and efficient operation of the electricity industry for the long-term benefit of consumers
- Ensure that participants pay or are paid the correct amount for the electricity and electricity services they use and produce
- Reduce barriers to entry and making it easy for parties to enter and operate in the electricity industry
- Reduce the transactions costs of industry arrangements and working in a well-organized manner
- Use of more standardized approaches promotes competition and efficiency by reducing the cost of doing business
- Enable mass participation and multiple trading relationships

More standardization of formats and processes, in particular, would minimize barriers to entry by making it easier to interface with other participants in the data system. Standard set of data to be exchanged in electricity trade upon type of electricity market. Electricity Market operation guideline defines set of data and information, frequency, utilization and protection of data and information.

Article 5 Data updating and sharing Member of SFAEC (Electricity) highlighted that SAARC states may share and update technical data and information on the electricity sector in an agreed template. Article 7 suggests to plan the cross-border grid interconnections through bilateral/trilateral/mutual agreements between the concerned states based on the needs of the trade in the foreseeable future through studies and sharing technical information required. Articles 9, 10 and 11 described Transmission Service Agreements, Electricity Grid Protection and System Operation and Settlement Mechanism respectively. For planning purposes and coordinated procedures for the secure and reliable operation of the inter-connected grids and to prepare scheduling, dispatch, energy accounting and settlement procedures for cross border trade standardized templates for minimum data set to be shared is mandatory and is mentioned in table 2-1.

Table 3: Data format for Planning Purpose, Cross border Intersection, Electricity Market Operation and Grid Operation

Planning Purpose	Cross-Border Intersection	Electricity Market Operation	Grid Operation
Load Data	Structural data	Buyers, Sellers, Traders registration	Capacity Available
Existing Imports/ Exports	Scheduled Data	Data for Bid from Seller	Bid Data from Buyers and sellers
Existing base and peak hydro data	Fore Casting Data	Data for Bid from Buyer	Selection of potential/viable bids
Existing thermal data	Real time data	Data of Matching	Others (Voltage, frequency, incident record and outage planning)
Committed and future system	Individual instruction by operators	Data for Market Trend	
		Data for Scheduling and load settlement	
		Data for Financial Settlement	
		Metering Data	

3.5 Cross Border Power Interconnection

A cross-border interconnection facility basically allows electric power to be interchanged between two or more national power grids and such facility comprises transmission line and ancillary facilities like switchgears, and control and protection equipment etc. in the adjacent substations or elsewhere in the national power grids to be connected. The operability of the interconnected national power grids depends on technical properties and on decisions the responsible transmission system operators (TSOs) need to take on key nontechnical issues. TSOs perform a number of key functions in real-time, including (i) Monitoring, control, and coordination of operations and (ii) Scheduling and settlement of energy exchanges between national power grids. Transmission System Operators of both countries rely on real-time data processing hardware and software systems, comprising supervisory control and data acquisition (SCADA) and energy management system (EMS). Fig 2-8 represents the model of cross border interconnection facility

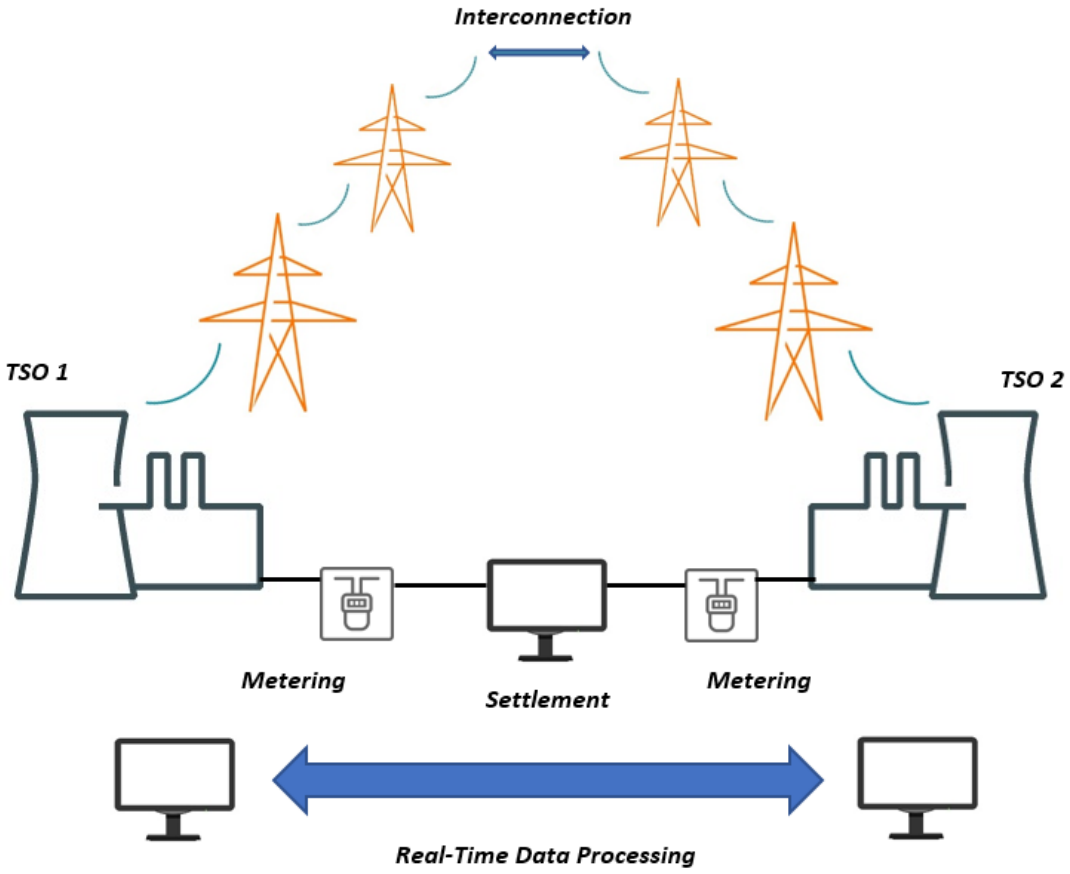


Figure 11. Cross-Border Interconnection Facility

In order to better understand the extent of dependence on imports and the inadequacy to electricity shortages, the market- wise power demand on a country- by- country basis must be examined.

3.5.1 Afghanistan

Figure 9 shows the sector- wise energy consumption of the estimated total energy consumption of 4.8 mtoe in Afghanistan in 2006. The transport industry accounts for the greatest share of commercial energy consumption. In the industrial sector, only 10 percent of energy was consumed in 2006 because of the low level of industrial activity. The energy consumption of the agriculture sector is insufficient and not sufficiently reported

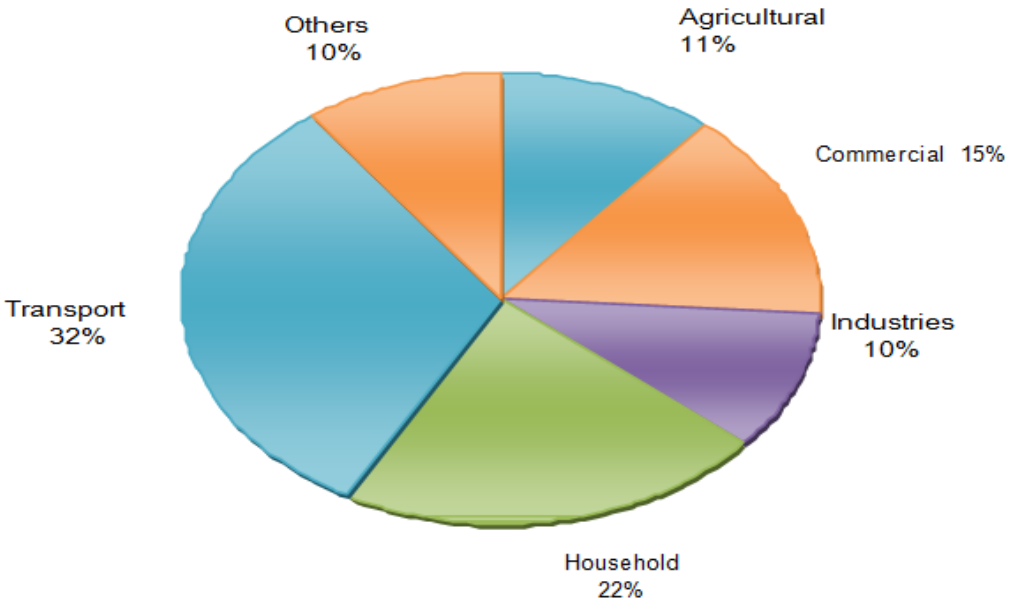


Figure 12. Energy consumption in Afghanistan in 2006 w.t Sector

3.5.2 Bangladesh

Natural gas is Bangladesh's main source of commercial energy. The power and fertilizer industries in Bangladesh are the biggest consumers of natural gas. In 2006/07, electricity, fertilizer, industry, domestic and captive energy consumed 41 percent, 17 percent, 15 percent, 12 percent and 12 percent respectively of natural gas. Figure 10 shows the sectorial use of natural gas for more than a decade in a million toe.

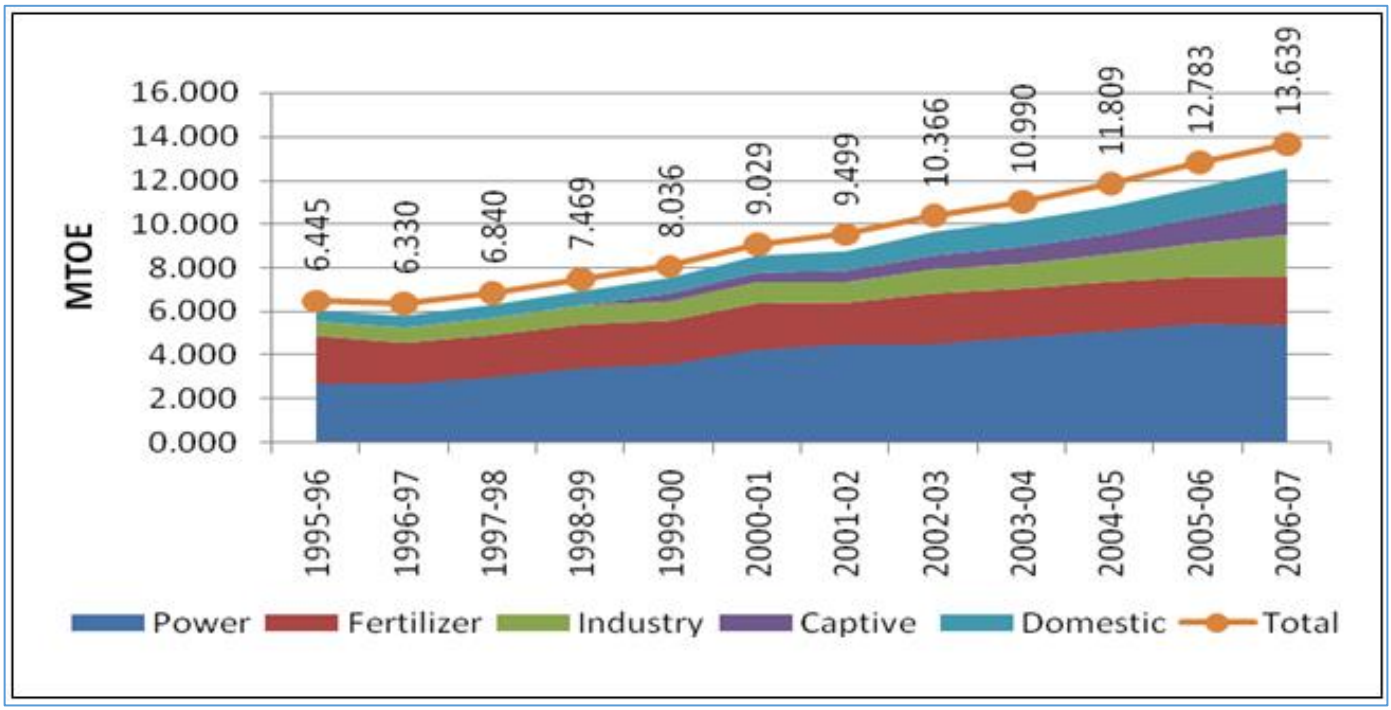


Figure 13. Consumption of natural gas in Bangladesh in the sector

Above in Figure 10 shows that although the power sector was the main consumer of natural gas, the demand for gas is increasing significantly in the industrial, captive and domestic sectors. Since the electricity sector consumes a large part of the gas, it is important to analyze Bangladesh's sector- wise energy consumption. The main consumers are industry and household sectors, accounting for 44% and 42% of the electricity consumed in Bangladesh (2006). Figure 11 shows the use of power in a sector over a decade.

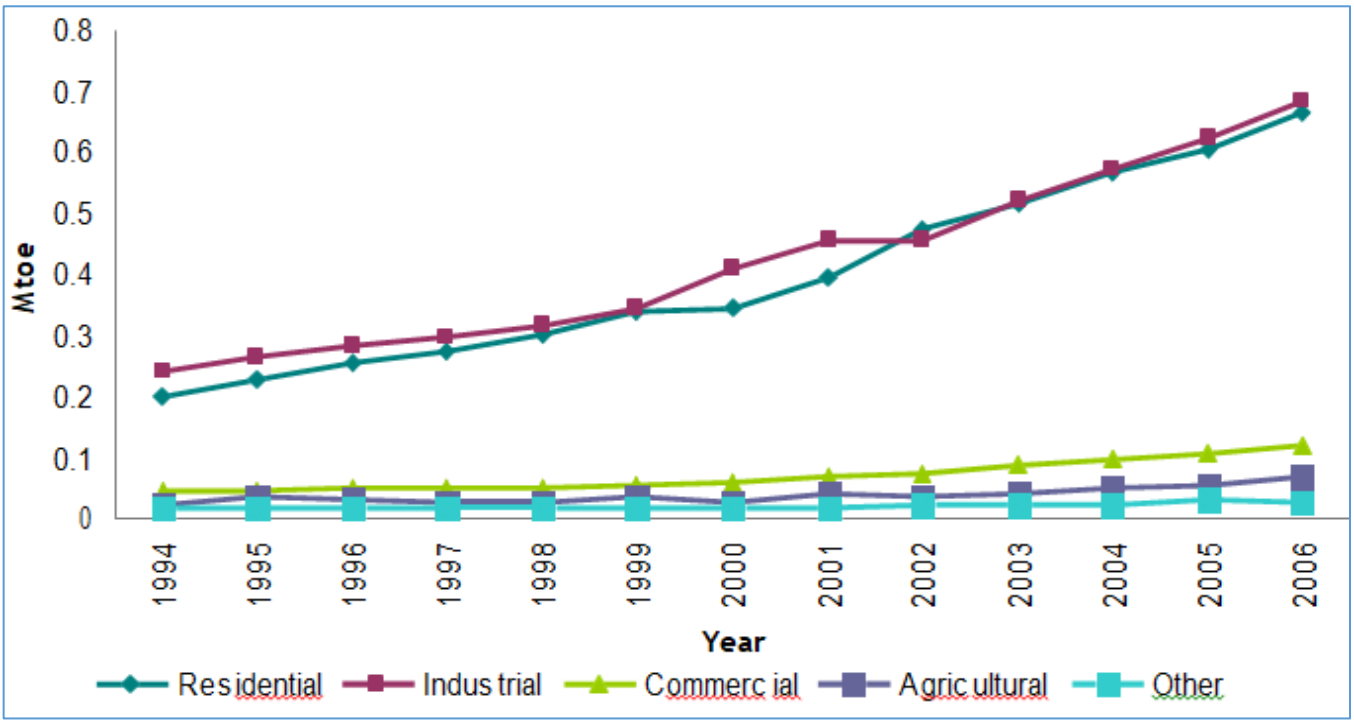


Figure 14. Power consumption in Bangladesh in the sector

3.5.3 Bhutan

Figure 12 shows the growth pattern of Bhutan's sector- wise demand for electricity

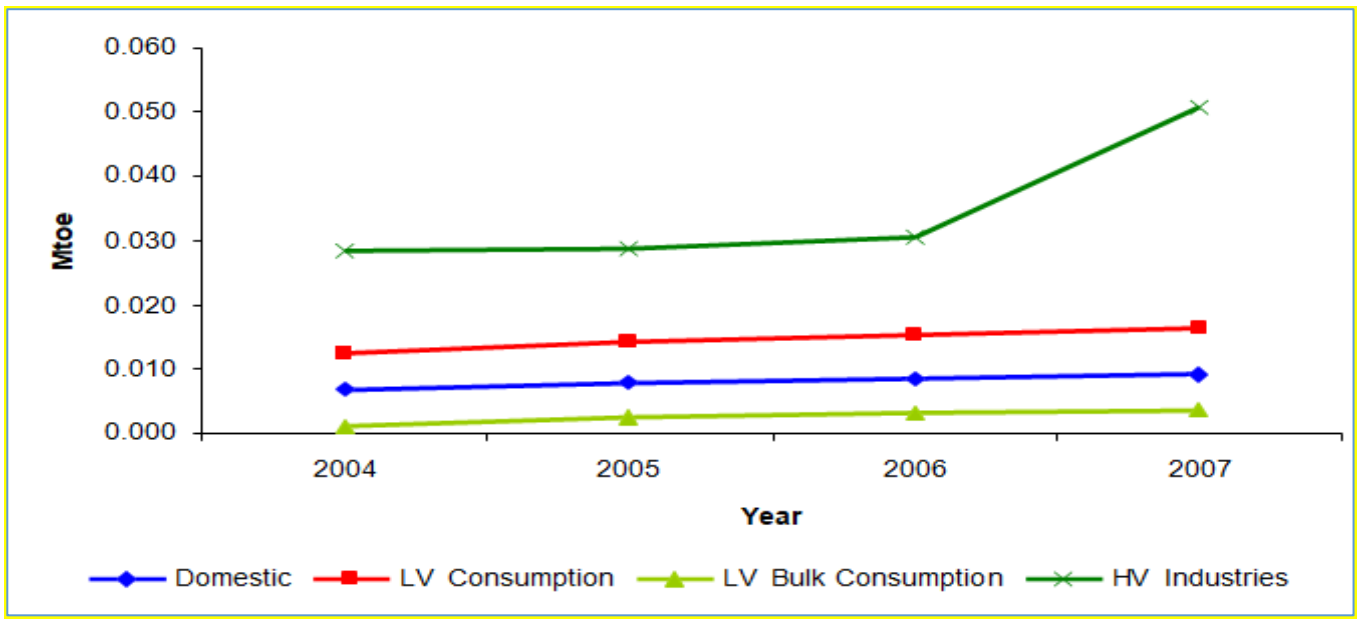


Figure 15 .Demand of Electricity in Bhutan in Sector

Commercial energy is largely used in Bhutan in the form of electricity. The electricity sector is expected to see an average growth rate of about 8 percent in 2008- 2020 and the industrial sector will continue to be the biggest consumer of electricity.

3.5.4 India

The industrial, transport and household sectors account for the greatest share of energy consumption in India. Figure 13 shows a breakdown in the commercial energy consumption of fuel wise.

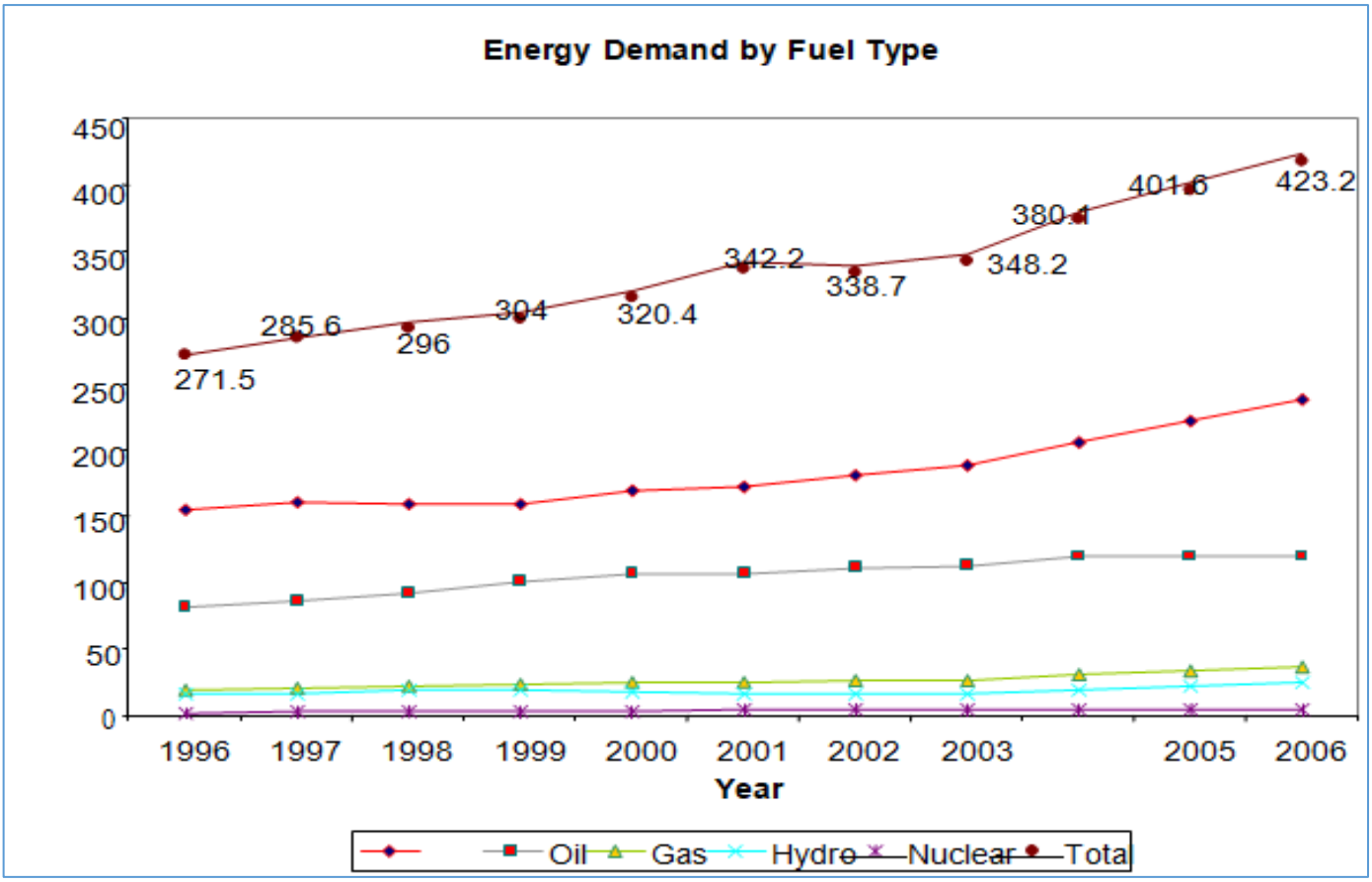


Figure 16. Commercial Energy Consumption in India in Sector

Traditional sources cover most of the domestic demand for energy in rural areas, where fuel wood and biomass are widely used; LPG and electricity are mainly used in urban areas.

3.5.5 Maldives

In Maldives, energy is used primarily in the form of diesel, biomass, LPG and kerosene. In view of the sectorial breakdown of the total energy consumption in Maldives, it is observed that the household sector alone accounts for over 50% of the total energy demand. Figure 14 shows the increase in the share of energy demand in Maldives in various sectors from 2003 to 2005. The figure shows the domination of the household industry in the country's energy consumption. Other sectors, such as production and public use, have steadily increased over the years, but the demand for energy from government buildings has declined.

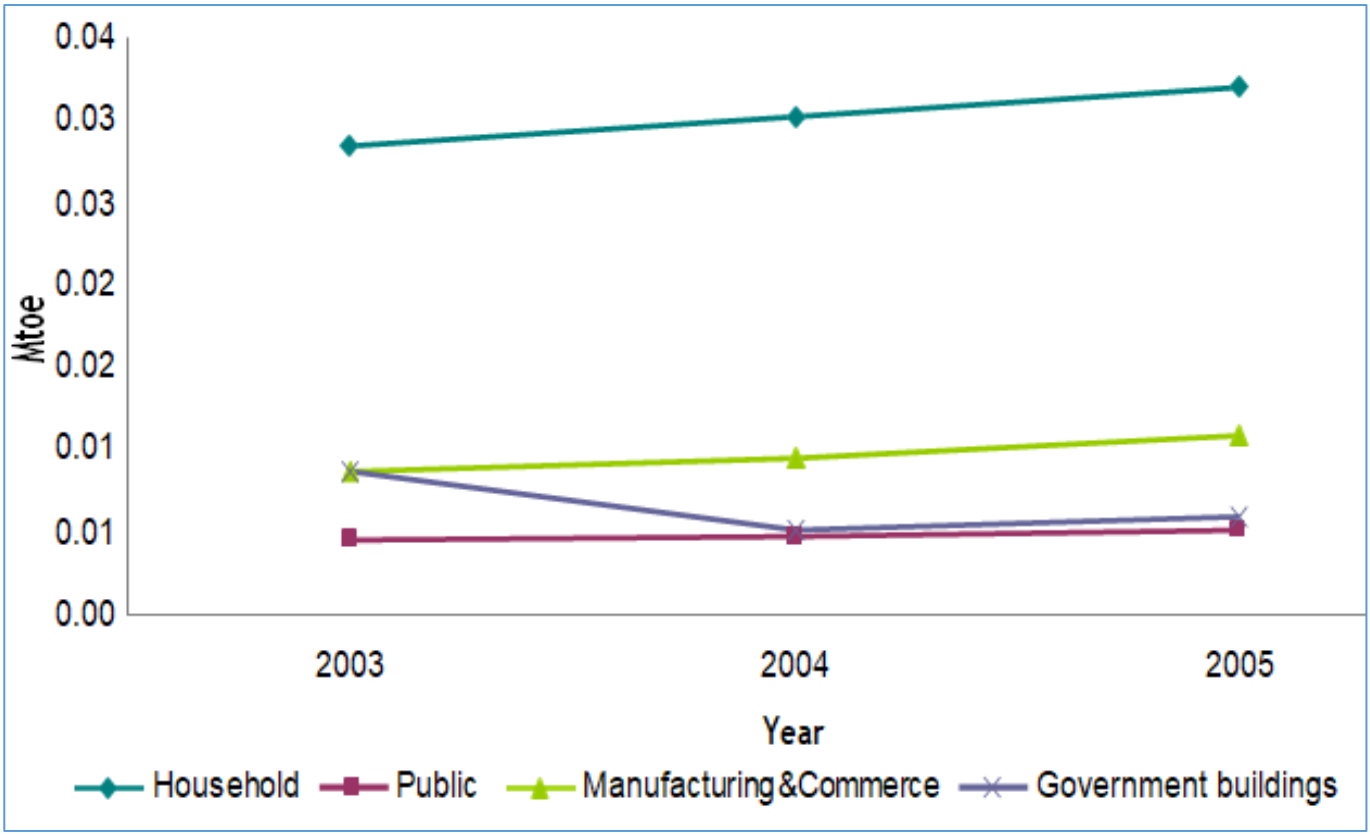


Figure 17. Demand of Energy in Maldives in Sector

Diesel is the main source of energy in Maldives, accounting for approximately 78% of the commercial energy consumption between 2003 and 2005. In 2005, household and manufacturing sectors accounted for around 50% and 28% of total diesel demand.

3.5.6 Nepal

Traditional fuels dominate Nepal's overall energy consumption, accounting for around 87 percent of the total fuel type energy consumption in 2006. The household sector accounts for the large share of total energy consumption, but the share of the domestic sector fell from 91.7% in 1996 to 89.2%.

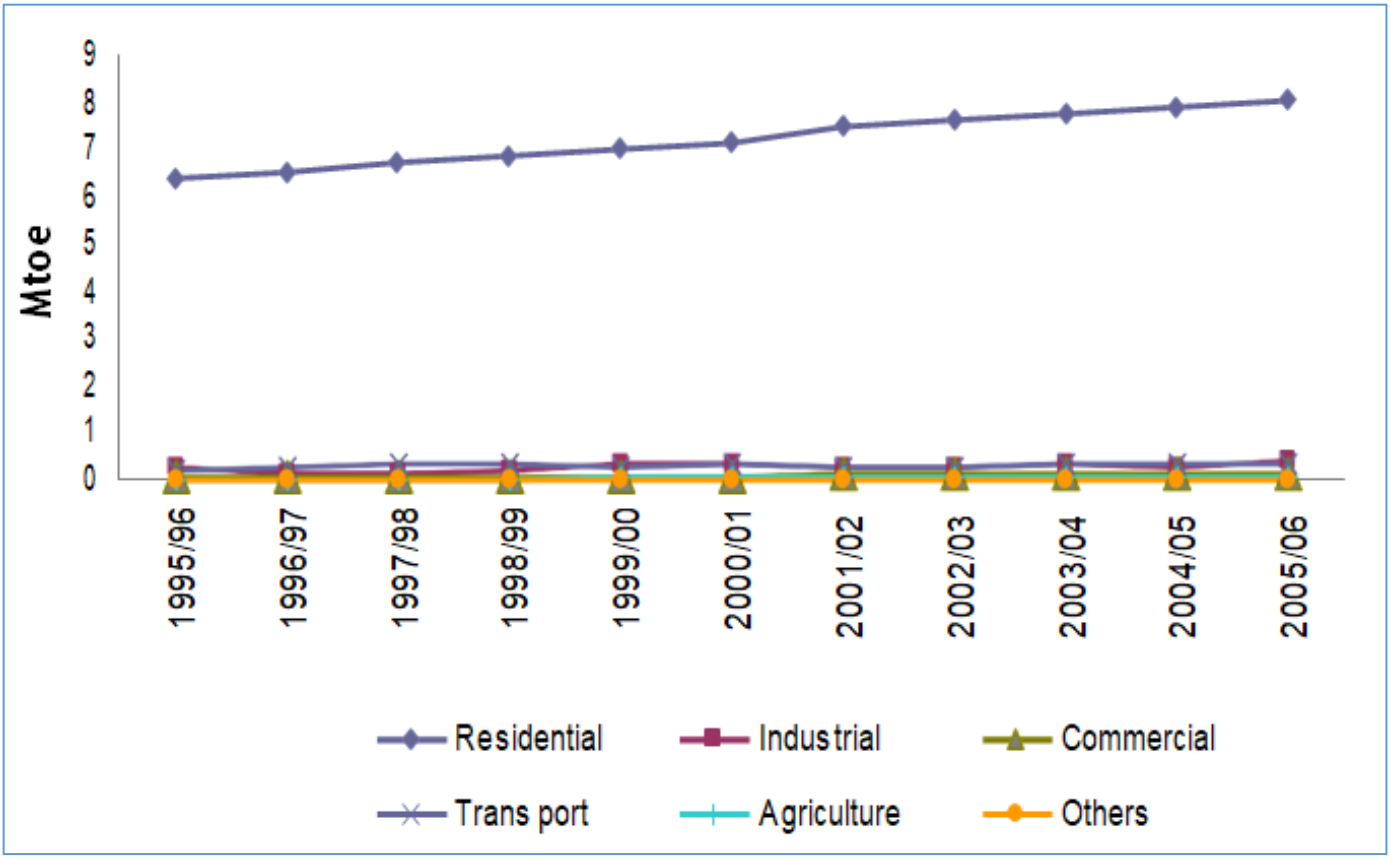


Figure 18. Energy Consumption in Nepal in Sector

In 2006, industrial, commercial, transport, agriculture and others accounted for 4.5%, 1.5%, 3.7%, 0.8% and 0.2% of energy consumption, respectively. Figure 15 shows the increase in energy consumption (in million toe) in various sectors over the course of the decade 1996 to 2006.

3.5.7 Pakistan

Natural gas is Pakistan's main commercial fuel. Natural gas consumption in the sector is governed by the Federal Government's allocation. The priority order is: the domestic, fertilizer, power and general industries. In 2006, the power sector was the largest gas user with 9.98 mtoe consumption, followed by industry 6.16 mtoe, domestic with 4.00 mtoe and fertilizer with 3.03 mtoe. Other users include 0.91 mtoe transport (CNG), 0.84 mtoe fertilizer (as fuel), 0.69 mtoe, 0.36 mtoe steel and 0.36 mtoe cement. Figure 16 shows the sectorial use of natural gas in Pakistan in 2006.

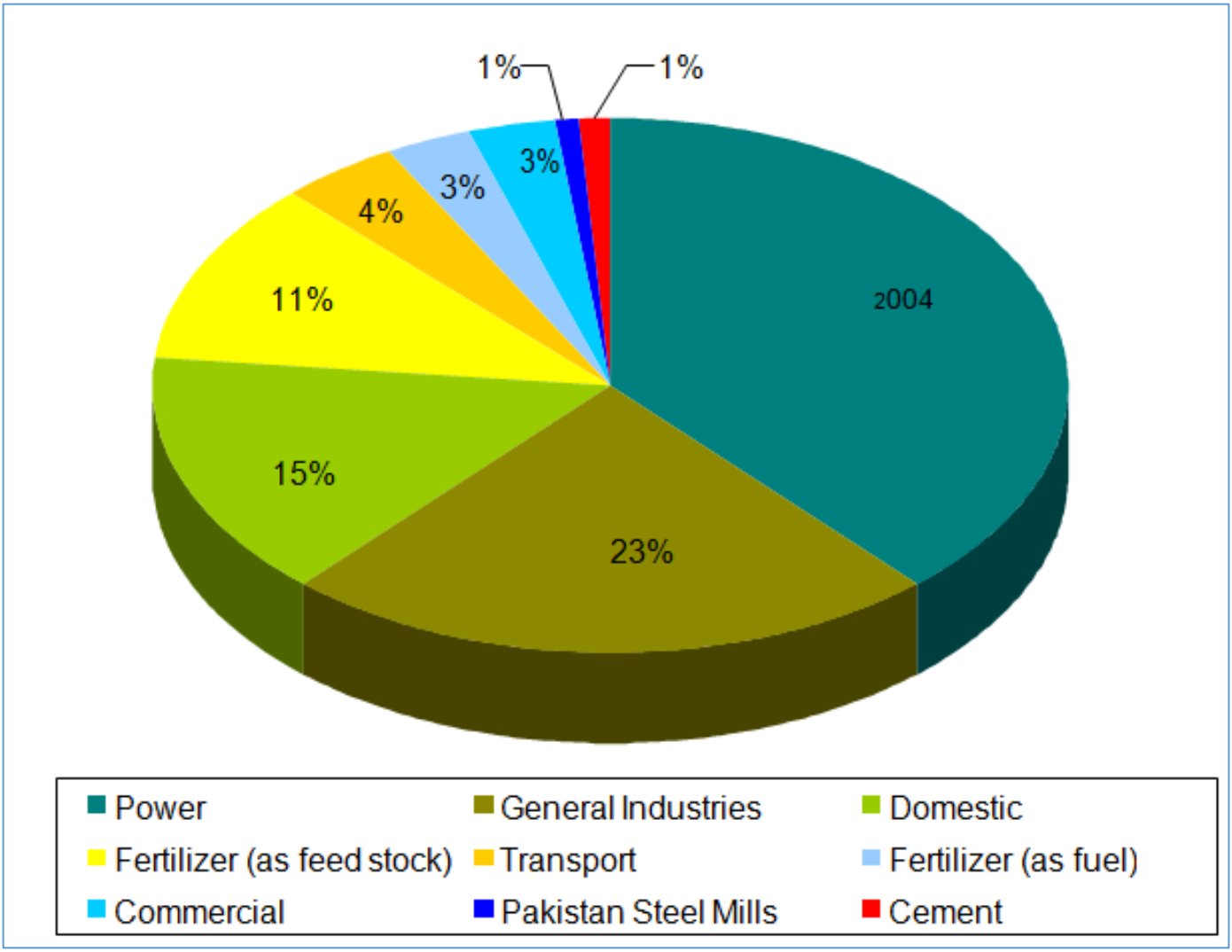


Figure 19. Consumption of Natural Gas of sector in Pakistan in 2006

Since the electricity sector is the main consumer of natural gas, it is essential to analyze the sector's wise power consumption. It is noted here that the domestic sector was the largest electricity user with a consumption of 2.5 mtoe, followed by industry with 1.61 mtoe in 2006. Figure 17 shows the sector- wise power consumption in Pakistan in 2006.

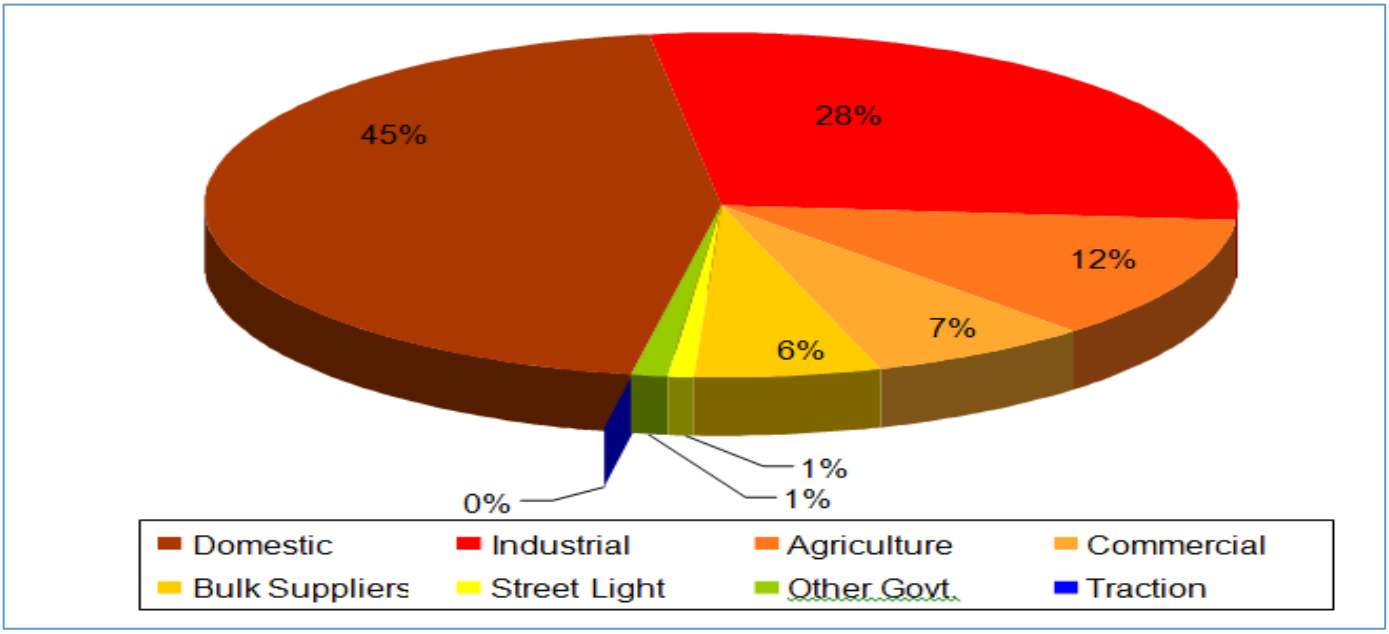


Figure 20. Consumption of Power of Sector in Pakistan in 2006

3.5.8 Sri Lanka

The energy demand for end use in Sri Lanka consists mainly of three sources: electricity, oil and biomass. This sector accounted for approximately 48% of total energy consumption in 2005, followed by an equal share of 26% in the transport and industry sectors

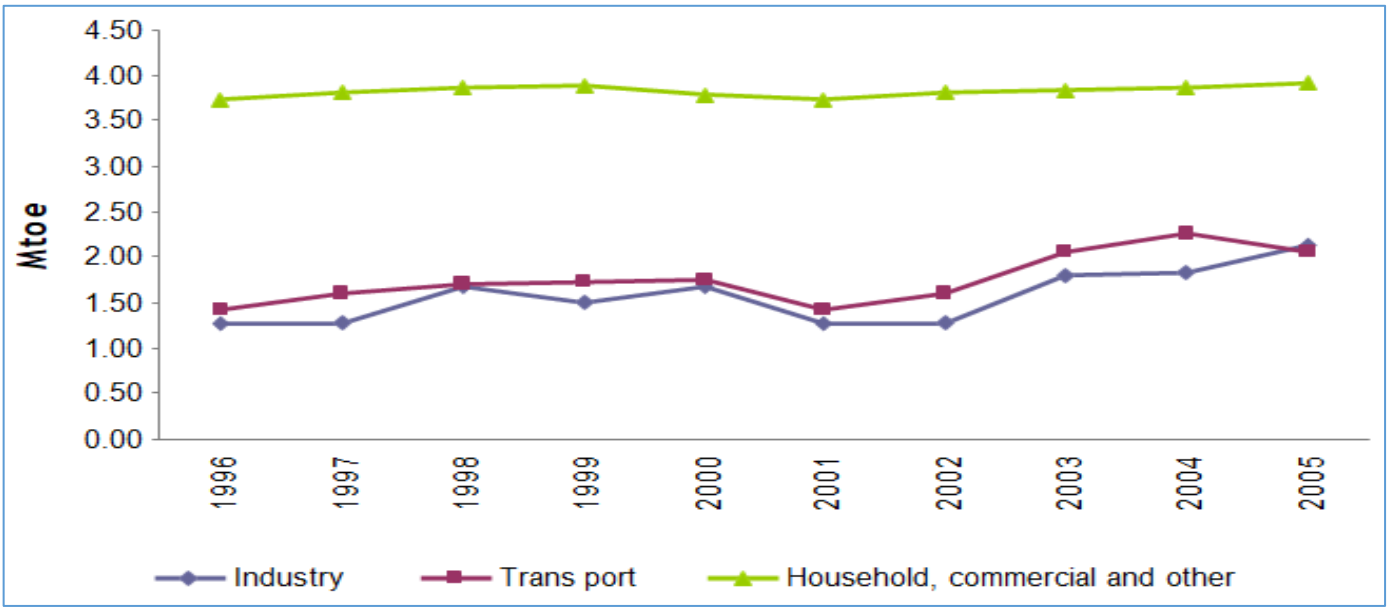


Figure 21. Energy Consumption in Sri Lanka in Sector

Above Figure 18 indicates the growth of the energy consumption (in million toe) over the decade in these three sectors. Biomass alone accounts for about 50 percent of Sri Lanka's energy demand. In the household, commercial and other sectors, over 70% of biomass is consumed. Of the 11.84 million tons of biomass consumption in 2005, approximately 8.3 million tons were consumed in this sector and the rest in the industry. Of the petroleum products consumed, diesel is mainly used in the transport sector and furnace oil is used primarily for the generation of electricity.

3.6 Summary of sectoral consumption of energy

The three main energy users in the SAARC region are domestic, industrial and transport sectors. The household industry is also the main consumer of traditional fuels. As industry drives economic growth, as SAARC Member States aim at higher GDP growth rates, industry's energy demand will increase. That would be the case with the transport industry. In the case of the household sector with increasing incomes, as mentioned earlier, it is expected that the household sector will move from traditional sources to commercial energy sources. This would give the Member States more pressure to supply more commercial energy. Being completely dependent on petroleum products, the majority of which are imported, the transport sector would also have a significant impact on energy imports. Another aspect of the sectoral analysis is that these sectors are most vulnerable to any disruption of the energy supply.

3.7 Financing Infrastructure Development

Cross border Infrastructure Development requires external financial support. In the European Union, financial instruments are available for identifying and designing cross border projects, to develop a large internal market and strengthen regional competitiveness. The European Community Budget finances part of costs using ‘structural funds’ and the European Investment Bank plays a significant role in funding such projects. The funds available from the structural funds are below market rates; this implies some form of subsidy to promote cross-border infrastructure.

Cross border infrastructure is highly capital intensive and, once built, last long. This factor have important impacts on financing and inherent risk profile of such projects.

4 Data and Information Exchange for Cross Border Electricity Trade

4.1 Data and Information Exchange in SAARC Member States

4.1.1 Afghanistan

Da Afghanistan Breshna Sherkat (DABS) is responsible for electricity Generation, Transmission, System Operation and Distribution. No country Specific code exists in Afghanistan and Power Services Regulation Act, 2016 has mentioned about data and information requirements.

4.1.1.1 Confidential Information

The technical, financial and business documents and information belonging to design, restoration of insurance status, activities, planning, maintenance, management and financing of energy services and other activities related to the electricity facilities of suppliers, users and consumers.

4.1.1.2 Publication of Documents through Website

The Department may publish the notifications, decisions, licenses, suggestions and agreements related to interpersonal network connection and other such non-confidential documents through the relevant website. The Departments may make available to the applicants the copy of documents set forth in paragraph of this article in exchange of price specified by law.

4.1.2 Bangladesh

Bangladesh Energy Regulation Commission Electricity Grid Code (Grid Code), 2012 has defined data and information requirements for power market operation in Bangladesh. It must be complied by Entities including the Buyer, Generator, Licensee, Supplier, System Operator, System Planner and User, who uses the Transmission System

4.1.2.1 National Load Dispatch Centre (NLDC)

NLDC control room is situated in Dhaka, operating round the clock for the purpose of managing the operation of the Transmission System and coordinating of generation and distribution on a real-time basis.

4.1.2.2 Site Responsibility Schedule

Data for site responsibility schedule includes Name of Power Station/Substation Site Owner, Tel. Number, Fax Number, Item of Plant/Apparatus, Plant Owner, Safety Responsibility, Control Responsibility, Operation Responsibility, Maintenance Responsibility and Remarks.

4.1.2.3 Dispatch instructions

Dispatch instructions shall be in standard format will recognize declared availability, economic data and other parameters that have been made available by the Generators to the NLDC. These instructions shall include time, Power Station, Generating Units, name of operators sending and receiving the same.

Dispatch instructions include but not limited to:

- Switching a Generating Unit into or out of service
- Details of reserve to be carried on a unit
- Increase or decrease MVAR generation to assist with voltage profile
- Begin pre-planned Black Start procedures
- Hold spinning reserve
- Hold Generating Units on standby

Dispatch instructions/ feedback from Generators shall be issued by telephone or computer to computer communication, and shall be confirmed by exchange of names of operators sending and receiving the same and logging the same at each end. All verbal instructions shall be complied with forthwith and written confirmation shall be issued promptly by fax, tale-printer or otherwise.

4.1.2.4 Contingency Planning

Generally, user's persons authorized for operation and control shall be available at user's end for communication and acceptance of all operational communications throughout the contingency and communication channels shall be restricted to operational communications only till normality is restored. During the restoration process following Transmission System failure / blackout conditions normal standards of voltage and frequency shall not apply. Careful, prompt and complete logging of all operations and operational messages shall be ensured by all Users to facilitate. A list of essential loads and priority of restoration shall be prepared in standard format which includes Priority, Type of Load, Name of Substation and Remarks.

4.1.2.5 Cross Boundary Safety

The Control Persons shall co-operate to establish and maintain the precautions necessary for the required work to be carried out in a safe manner. Both the established isolation and the established earth shall be locked in position, where such facilities exist, and shall be clearly identified. Each Control Person responsible for maintaining a legibly written safety log, in chronological order, of all operations and messages relating to safety coordination sent and received by them.

4.1.2.6 Operational Event / Accident Reporting

Typical examples of reportable incidents that could affect the Transmission System are the following:

- Exceptionally high/low system voltage or frequency
- Serious equipment problem, e.g. major circuit, transformer or bus-bar
- Loss of major Generating Unit
- Falling of Transmission line/Tower due to natural calamity
- System split Transmission System breakaway or Black Start
- Major fire incidents

- Major failure of protection
- Equipment and transmission line overload
- Minor equipment alarms

4.1.2.8 Metering

The Generator shall install operational meter to provide operational information for both real time and recording purposes in relation to each Generating Unit at each Power Station in respect of Bus Voltage, Frequency, MW, MWhr, MVAR, Power Factor and any other additional data. It shall be installed to measure Active energy for export, Active energy for import, Reactive energy for import, and Reactive energy for export.

4.1.2.8.1 Transmission System Operational Metering

Transmission company shall install operational metering and provide operational information for both real time and recording.

4.1.2.8.2 Generation / Commercial (Tariff Metering)

Commercial (Tariff) metering installed at Connection points between the Transmission System and Generating Stations, and the Transmission System and Distribution Systems.

4.1.2.9 Data Acquisition

For effective control of the Transmission System, the NLDC needs real time data as MW generated in each power station, MW consumed at each grid substation, MVAR generated or absorbed in each power station, MVAR consumed at each grid substation, Voltage at all system buses, Frequency in Transmission System and MW & MVAR flow in each transmission line

System planning data is shown in Table 3.

Table 4 System planning data

<table>
<tr><th>Generation</th><th>Transmission</th><th>Distribution</th></tr>
<tr><td rowspan="5">Routine Submission</td><td>Single line diagram</td><td rowspan="3">General Data</td></tr>
<tr><td>Substation layout diagrams</td></tr>
<tr><td>Line Parameters</td></tr>
<tr><td>Transformer Parameters</td><td rowspan="3">Connections data</td></tr>
<tr><td>Equipment Details</td></tr>
<tr><td rowspan="4">Submission on Request by License</td><td>Relaying and Metering</td></tr>
<tr><td>System Studies</td><td rowspan="3">Load data</td></tr>
<tr><td>Demand Data</td></tr>
<tr><td>Reactive Compensation Equipment</td></tr>
</table>

System planning data is shown in Table 4.

Table 5 Operational planning data

Outage Planning Data	**Schedule and Dispatch Data**	**Response to frequency Change Data**
General data	36 hours ahead hourly MW & MVAR Declared	Hourly Generation Summation
Demand Estimates	Availability Capacity	
Estimates of Load Shedding	Status of Generating Unit	
Year Ahead Outage Program	Status of Generating Unit speed control system	Logged readings of Generators
Generation Outage Program	Governor in service (Yes / No)	
Year Ahead Distribution Utility's Outage Program	Spinning reserve capability (in MW)	
Generation Schedule Data	Backing down capability with/without oil support (in MW)	Detailed report of Generating Unit tripping on monthly basis
Licensee's Overall Outage Program	Hydro reservoir levels and restrictions	
	Hydro reservoir levels and restrictions	
	Provisional day after Declared Availability Capacity notification	

4.1.3 Bhutan

4.1.3.1 Bhutan Electricity Authority Grid Code Regulation 2008

Under the terms of the Grid Code Regulation, the System Operator and Transmission Licensee shall receive information from Users relating to their systems in respect of their generation or supply business. Prior written consent of the User concerned, unless by the Ministry or the Authority is needed to the System Operator and Transmission Licensee to disclose information to any other person other than required by the Grid Code Regulation. System Operator with all requested data and technical and economical characteristics on design, construction and operation of facilities has to be connected to the Transmission Grid. Data and notices to be submitted to the System Operator under this Grid Code Regulation shall be delivered in writing either by hand or sent by registered post unless otherwise specified in the Regulations.

4.1.3.2 Planning Policy

The Transmission Licensee shall consider authenticated data collected and in consultation with all the utilities of the Power System. The Power System Master Plan developed by the Ministry, transmission planning criteria and guidelines of the Ministry, Power data, hydrological statistics and other reports shall also be referred.

4.1.3.3 Planning Data

To execute the coordinated planning of the operation and expansion of the system, all Licensees and Users shall provide all data to the System Operator. Such data should include, Load forecasts, Technical and economical characteristics of generation units, including capital and operational costs of the units, and Technical and economical characteristics of the relevant transmission and distribution systems.

4.1.3.4 Site Responsibility Schedule (SRS)

At the connection, the Distribution Licensee shall furnish required data to the Transmission Licensee which shall prepare SRS. At a generating station, the Transmission Licensee shall furnish the necessary data to the Generation Licensee who shall prepare SRS. The information shall be included in the SRS are schedule of HV apparatus ,schedule of plant, LV / MV apparatus, services and supplies, schedule of telecommunications and measurement apparatus, safety rules applicable to each plant/apparatus, the ownership of equipment, the responsibility for control of equipment, the responsibility for maintenance of equipment, the responsibility for operation of equipment, the manager of the site, the responsibility for all matters relating to safety of persons at site and the responsibility for all matters relating to safety of equipment at site.

4.1.3.5 Operations and Operational Planning

Overall real-time operation of the Transmission System shall be supervised by the System Operator from the National Load Dispatch Centre (NLDC). All Licensees shall provide an adequate and reliable communication facility internally and with the System Operator to ensure exchange of data information.

4.1.3.6 Outage Planning

All Licensees shall provide the System Operator their proposed outage plans for the next financial year by 1st December of each year. These shall contain identification of each generating unit/line/interconnecting transformers (ICTs), the preferred date for each outage and its duration and where there is flexibility, the earliest start date and latest finishing date.

4.1.3.7 Periodic Reports

A quarterly report shall be issued by the System Operator to all relevant agencies. The report shall contain the following but not limited to:

- Performance of Generating Stations
- Peak demand, energy availability and requirement
- Export and import of electricity to/ from neighboring countries
- Frequency profile

- Voltage profile of selected substations
- Major generation and transmission outages
- Transmission constraints
- Instances of persistent or significant non-compliance with the
- Grid Code Regulation

.

4.1.3.8 Event Information

Any Event on the other User's system having an operational effect on Transmission System shall be reported by the concerned User to the System Operator. The reportable incidents that require reporting are as follows:

- Tripping of any inter-connecting transformer (ICT), transmission line or capacitor bank
- Tripping of any generating units
- Major protection failure
- Exceptionally high/low voltage frequency
- Breaker, transformers, bus-bar fault etc.
- Overloading of equipment or transmission lines
- Activation of any alarm or indication of abnormal operating condition
- Breakdown or faults or temporary changes in the capabilities of the plant and/or apparatus
- Loss of load

4.1.3.9 Form of Written Reports

A written report shall be sent to the System Operator or a Licensee, as the case may be, and shall confirm the oral notification together with the following details of the Event:

- Time and date of Event
- Location
- Plant and/or equipment directly involved
- Description and cause of Event
- Antecedent conditions
- Demand and/or generation (in MW) interrupted and duration of interruption
- All relevant system data including copies of records of all recording instruments including data from Disturbance Recorders and Event Recorders
- Sequence of tripping's with time

- Details of relay flags
- Remedial measures and recommendation for future improvement; and
- Any other relevant information

4.1.3.10 Scheduling and Dispatch Code

The entire Bhutan Grid operates in synchronism with the Indian Grid. The Scheduling and Dispatch Code for Bhutan has to be technically compatible with the Scheduling and Dispatch Code of the Indian Electricity Grid Code Regulation. Demarcation of interface responsibilities with the Eastern Regional Load Dispatch Centre(ERLDC), Kolkata (West Bengal), for export/import schedule at the India-Bhutan border. Format for availability declaration by generators to be sent to system operator includes message number, date, power station, expected maximum ex-power plant power (MW), expected ex-power plant energy (MWh), anticipated in-flow (m3/s) and anticipated line constraints/ outages/ other constraint.

Every day, generating stations directly connected to transmission system should advise their respective energy station-wise ex-power plant demand and energy capabilities. Format for anticipated hourly ex-power plant availability for the day (MW) contents
Hour: At One hour interval
Projects: Tala Chukha Basochhu Kurichhu

The capabilities of each of the generating stations and the corresponding hourly estimated demand of the entire power system shall be compiled by the system operator every day for the following day in the standard format that shall be forwarded by the system operator to ERLDC. A format for compilation for such information by the System Operator includes Message no., date, time (BST),expected transmission system availability for date, hours, total ex- power plant availability ,total ex- transmission system, domestic transmission system losses, total available for export ex- power plant, export transmission system losses and total available for export at border

4.1.4 India

Indian Electricity Grid Code (IEGC) defined roles and responsibilities of Regional Load Dispatch Centers (RLDCs) and State Load Dispatch Centers (SLDCs). Central Electricity Regulatory Commission (Open Access in inter-State Transmission) Regulations, 2008 and Short-Term Open Access in Inter-State Transmission (Collective Transaction), 2008 had defined standard format for exchange of Data and Information between/among concerned authorities for Power Trade in India.

4.1.4.1 Submission of Application

Short-term customer intending to avail the short-term open access for use of the transmission lines shall make an application to the nodal agency. The application for a bilateral transaction shall contain application number, name, schedule request, buyer/seller details, application, payment details of non-refundable application and declaration

4.1.4.2 Concurrence of State Load Dispatch Center

The proposed bilateral transaction has a State utility entity as a buyer or a seller. The concurrence of the State Load Dispatch Centre shall be obtained in advance and submitted along with the application to the nodal agency.

4.1.4.3 Affidavit

Applicant while making application for Scheduling of Bilateral Transactions shall submit to the nodal agency an affidavit, duly notarized, as per the standard format

4.1.4.4 Concurrence of Regional Load Dispatch Center

RLDC shall first consider the Applications received by them, before giving concurrence. It shall indicate constraint to other RLDCs for the Applications received.

4.1.4.5 Concurrence of Regional Load Dispatch Center

For advance scheduling for a bilateral transaction, an application may be submitted to the nodal RLDC up to the fourth month, considering the month in which an application is made being the first month. In case of perceived congestion in transmission corridor, nodal RLDC on next day (i.e. 2nd day after the applicable last date for submission of Application) will inform the concerned applicant(s) as per contents:

A written report shall be sent to the System Operator or a Licensee, as the case may be, and shall confirm the oral notification together with the following details of the Event:

- Transmission Corridor
- Congestion Period (Date, Hours)
- Margin Available original route (MW)
- Total Schedule applied by all the applicants (MW)
- Margin Available on alternate route – 1 **( )** (MW)
- Margin Available on alternate route – 2 **( )** (MW)

The applicants must inform the nodal RLDC for request for revision of schedule due to congestion as per format:

- Transmission Corridor
- Congestion Period (Date, Hours)
- Applied Schedule (MW)
- Revised Schedule on original route (MW)
- Revised Schedule on alternate route -1 ( ) (MW)
- Revised Schedule on alternate route -2 ( ) (MW)

The nodal RLDC shall convey its acceptance to applicant as per format “Acceptance for Scheduling” that contents:

- Name of applicant and Registration Code
- Name of injecting Entity / State / Region
- Name of Drawee Entity /State / Region

- Wheeling Region(s)
- Open Access Scheduling Requested: Date, Hours, MW, Route, Total MW
- Open Access Scheduling Accepted: Date, Hours, MW, Route, Total MW
- Bidding Details: Transmission System, From Date, To Date, Applicable Bid Rate (Rs. /MWh)
- Payment Schedule
- Transmission Charges
- Operating Charges
- Non-Refundable application fee

4.1.4.6 Procedure for Scheduling of Bilateral Transaction on "FIRST-COME-FIRST-SERVED" Basis

All payments associated with bilateral transaction shall be made by the applicant to the nodal RLDC. The charges for scheduling of bilateral transactions will be worked out on the basis of total MWh approved at the point of injection. The transaction wise payment details shall be submitted as per format which includes the name of applicant, registration code, ref. No., date of payment, acceptance No. & date, application No. & date, payment due, payment due date, amount paid and details of bank draft / cheque.

The entities which are making application for the first time or intend to make, must submit the "One- Time" information as per format for ""Registration Form" to the concerned nodal RLDC. The format for Registration includes registration code, name of applicant, address for correspondence, status of applicant, contact details, trading license number and type, concerned SLDC, connectivity details to the grid and declaration.

4.1.4.7 Short-Term Open Access in Inter-State Transmission (Collective Transaction)

State Utilities and intra-State Entities proposing to participate in trading through Power Exchange(s) shall obtain "Standing Clearance", "No Objection Certificate" from the respective State Load Dispatch Centers (SLDCs), as per the defined format that contents:

- Name of the SLDC issuing NOC
- Region
- Name of the Entity
- Status of Entity
- Point(s) of Connection
- Max. MW ceiling allowed for Injection
- Max. MW ceiling allowed for Drawl
- Validity Period
- Transmission losses (besides Regional Transmission losses)

- Transmission charges (besides Regional Transmission charges)

Power Exchange(s) shall submit the Application for Scheduling each day, to the NLDC as per defined format that contents:

- Application No.
- Date
- Name of Power Exchange
- Scheduling Request for
- Injection (Drawl)
- Open Access Charges

The details for Scheduling Request for Collective Transaction shall be submitted by Power Exchange (s) to the NLDC as per the defined format that contents:

- Date
- Time
- Scheduling Request
- Time Period
- Region

Regional Entity Wise Scheduling Request for Collective Transactions for all concerned Regional Entities:

- Bid Area (Name & Code)
- Regional Entity (Name & Code)
- Time Period
- Sum of Injection(MW) by all Sellers within the State
- Sum of Drawl (MW) by all Sellers within the State

The individual transactions for State Utilities/intra-State Entities shall be scheduled by the respective SLDCs. Power Exchange(s) shall send the detailed breakup of each point of injection and each point of drawl within the State to respective SLDCs. The details for Scheduling Request for Collective Transaction shall be submitted by Power Exchange (s) to the respective SLDCs as per defined format which contents:

- Scheduling Request
- Name of the Regional Entity

- Code of the Regional Entity
- Summary of Injection/Drawal for Scheduling of Collective Transaction through Power Exchange
- Time Period Sum of injection by all entities within the State Trade Schedule (MW)
- Sum of Drawal by all entities within the State Trade Schedule (MW)
- Details of each point of Injection (-) /Drawal (+)
- Time Period
- Name ….1, 2,3,4
- Code
- Trade Schedule (MW)

4.1.5 Maldives

Country Specific Grid Code and Policies, Laws and Regulation of Maldives regarding standard format for data and information exchange regarding power trade and system operation are not available in public domain.

4.1.6 Nepal

Nepal Electricity Authority (NEA) is responsible for Purchasing Power from Private Sector Importing from India, Self-generation and Transmission. NEA Grid code 2005 has defined standard formats for data and information exchange for Power Generation and transmission.

4.1.6.1 Standard Planning Data and information

For Standard Planning Purposes, System operator for Planning shall be provided information and data as:

- About the power station (Location map and site map, Approximate construction period; Total installed capacity in MW, Transmission voltage and point of connection with Grid)
- Generating unit (Maximum and minimum operating head; Type and capacity of turbine; Generator
- Grid Data (name of line, voltage of line (kV), No. of circuits, route length (km), conductor sizes, line parameters (per unit values))
- Substation Data (substation layout, electrical circuits; grounding arrangements; phasing arrangements; switching arrangements, conductor sizes)
- Details of the Transformer (rated primary and secondary voltage (kV), winding arrangement, tap changer type, number of steps, and size, positive sequence resistance and reactance at max., min. and nominal tap position, zero sequence reactance for three-legged core-type transformer; BIL value (kV))
- Details on switchgear, circuit breakers and disconnect switches installed at the Connection Point
- Details of these equipment (capacitors, reactors, static VAR compensators)

4.1.6.2 Detailed Planning Data and information

For Detailed System planning, the system operator shall be provided following data:

- Name of Power Station
- Number and capacity of Generating Units(MVA)
- Single line diagram of Power Station and switchyard
- Neutral Grounding of Generating Units
- Earthing arrangements
- Full description including settings for all relays and protection systems
- settings for all relays installed
- of inter- tripping of circuit breakers
- estimated fault clearance time
- full description of operational and commercial metering schemes
- Parameters of Excitation Control System
- Parameters of Governor
- Operational Parameter
- Switchyard with following details (Step-up transformer with following details, Circuit Breakers and Isolators)
- Parameters of Generator and Turbine
- Loads

4.1.6.3 Annual Outage Programme

Power generator shall prepare annual outage plan form maintenance and shared with System Operator. Such annual plan should consist of Name of Generating Plant, Name of generating Company and Month wise (four weeks) generation units, Power Transformer, Unit Circuit Breaker, Line Circuit Breaker and other equipment.

4.1.6.4 Monthly Availability Declaration of Power on Weekly Basis

Generation Companies shall provide data and information regarding month wise scheduled power generation plan as Power Availability, which includes Average Discharge Available, Average MW Available in Month, Max MW Available in Peak in the Month, Min MW Available in the Month and Energy Availability which includes Average MWh / Day available the Month, Peaking facility MWh / Day, Total declared MWh in the Month and Design MWh for the Month.

4.1.6.5 Detailed Planning Data and information

Generation companies have to submit week wise Generation Outage Plan for a month:

- Name of Generating Plant
- Name of generating Company
- Generating units (1,2,3….): Outage Hours and Outage MW
- Power Transformer: Outage Hours and Outage MW
- Unit Circuit Breaker: Outage Hours and Outage MW
- Line Circuit Breaker: Outage Hours and Outage MW
- Other equipment etc.: Outage Hours and Outage MW
- Residual Previous Works
- Partial Last week

4.1.6.6 Weekly generation Outage Programme

Generation companies have to submit day wise Generation Outage Plan for a week (seven Days).

4.1.6.7 Schedule Outage Request

Formal request for power plant shutdown in Standard format shall be submitted to System operator seven business day a head for maintenance. It contents Location, Description of Works, start date and time, Finish Date and Time, and Duration of Shutdown Requested.

4.1.6.8 Forced / Maintenance Outage Request

Formal request for power plant shutdown in Standard format shall be submitted to System operator 48 hour for forced/ maintenance. It contents Start Date, Start Time, Location and Description of works, Finish date, Finish Time and Duration of Shutdown

4.1.6.9 Transmission Line Shutdown Implementation

Generator may request for shutting down transmission for maintenance and formal request for works which may include shutdown requested by, date of shutdown, earliest start time and latest completion time, description of work and type of outage. Further information about shut down placement i.e. disconnection, open circuit breaker and open isolator. Moreover details on grounding user shall close ground switch at end -1,NEA shall close ground switch at end-2.The following steps should be taken shut down release which has lock no, user SO, ISO, open grounding switch at end ,remove the lock isolator at end and verify CB is open at end.

4.1.6.10 Monthly Availability Declaration on weekly Basis

Generation Companies shall provide data and information regarding a month wise scheduled power generation plan on weekly basis as:

- Power Availability
- Average Discharge Available
- Average MW Available in Month
- Max MW Available in Peak in the Month
- Min MW Available in the Month
- Energy Availability
- Average MWh / Day available the Month
- Peaking facility MWh / Day
- Total declared MWh in the Month
- Design MWh for the Month

4.1.6.11 Monthly Availability Declaration on Hour to Hour Basis

Generator company shall provide complete schedule MW produced in every hour of each day of the month with daily Date and hourly time.

4.1.6.12 Weekly Availability Declaration

Generator company shall provide complete schedule MW produced in every hour of each day of the week with daily date and hourly time.

4.1.6.13 Daily Availability Declaration

Generator company shall provide complete schedule MW of Individual Unit produced in a day:

- Unit: Unit 1, Unit 2, Unit 3, ….
- Remarks for Shutdown
- Time hour: 0:00 to 24:00

4.1.6.14 Verbal dispatch Instruction Confirmation

Load Dispatch Centre (LDC) may instruct Generators verbally. Such instructions shall be recorded officially in standard format that contains time and verbal instruction.

4.1.6.15 Daily Generation Report Form

Power Producers are responsible for maintaining report of Daily Power production of plants:

- Energy Meter Reading Previous
- Energy Meter Reading Present
- MW: Unit 1, Unit 2, Unit 3, Total
- Reactive MVAR
- Calculated MVA
- PF
- Time hour: 0:00 to 24:00

4.1.6.16 Daily Generation Log Sheet

t includes hourly time, frequency, units of generation in (MW, MVAR, Power Factor), Total Generation (Active MW and Reactive MVAR), Transmission Voltage kV, and Step up Transformer..

4.1.6.17 Fault Registration Form

It includes date, time, affected parts of the power plant, description of the fault, causes, tripped breaker, alarms & indications on protection relay, outage time and loss of generation

4.1.6.18 Monthly Generator Performance Form

It includes:

- Unit 1, 2….
- Transformer 1, 2….
- Present Reading at ……. Hrs. On…
- Previous Reading at ……. Hrs. On…
- Difference
- Multiplying Factor
- Energy (MWh)
- Cumulative from Beginning of the Year
- Total Energy Supplied to Interconnection Point
- Total Hours in Month
- Percentage running hours

- Average Power Production(MW)
- Maximum Demand
- Plant Load factor
- Number of Tripping on Plant Side
- Type of Tripping
- Number of tripping on System of transmission Line
- Types of tripping on site

4.1.6.19 Monthly Generation Report

It includes:

- Date 1, 2, 3….
- Total Generation MWh
- Delivery in the Interconnection Point (MWh)
- Local Distribution (MWh)
- Demand Generation of NEA and outages and refined output (MWh)
- Demand of Generation of Plant Outage and Reduced Outputs (MWh)

4.1.6.20 Monthly Outage and Reduced Output Report

It includes:

- Date: 1, 2, 3……
- NEA outage and reduced output
- From Hrs.,
- To Hrs.,
- Produced hours
- Load before event (MW)
- Load After Event (MW)
- Demand generation losses
- Description of event

4.1.6.21 Maintenance Output Report

It includes:

- Type of outage (maintenance or forced)
- Actual start date and time of outage
- Actual finish date and time of outage
- Length of outage
- MW output before outage
- MW output during Outage
- Description of work

4.1.6.22 Loading Status and Scheduled Outages

It includes:

- Substations
- Voltage level and feeders name
- Maximum Load
- First week, second week, third week Amp, Date and Time
- Frequency of Shutdown and Load shedding
- Duration of Shutdown and Load shedding

4.1.6.23 Forced Outage of Transmission Lines and System Failures

It includes:

- Station
- Voltage level and feeders Name
- Terminal related relay operated and outage
- Line Related relay operated and outage
- Total Forced Frequency

4.1.6.24 NEA's Standard Format for Meter Reading Form

It includes:

- This Month Reading
- Difference
- Meter Multiplier
- Main Meter (To Grid and From Grid)
- Check Meter (To Grid and From Grid)
- % Difference (To Grid and From Grid)

4.1.7 Pakistan

National Electric Power Regulatory Authority (NEPRA) is designated authority for regulation power sector of Pakistan and authorized licenses for transmission and distribution of electric power. National Transmission & Dispatch Company (NTDC) responsible for construction, Maintenance and operation of transmission lines and load dispatch. NTDC Grid Code, 2005 is to facilitate the development of operation and maintenance of an efficient, coordinated, safe, reliable and economical system for the transmission electric power. The code has standardized data for Generators, Distributors Companies, Transmission Connected Consumers, any other person with a User System directly or indirectly connected to the NTDC Transmission System to which Power Plants and / or Consumer are connected, Externally-connected Parties, Externally- connected Consumers and Special Purpose Transmission License (SPTL).

The System Operator shall establish, operate and maintain a web site, proving, necessary, information about the transmission system status, pricing, congestion, operating procedures, technical and operational committee meetings and other relevant information and data. The code has categorized data as Standard Planning Data (PC), Detailed Planning Data(PC), Operational Data (OC), Scheduling Dispatch Code Data (SDC) and Connection Code Dada(CC).

All data required by NTDC from user and by user from NTDC are following data are as following:

- Generating Unit Technical data
- Generation Planning Parameters and Generation Offer Data
- Generating plant outage programs, output usable and inflexibility information
- Independent Generating Plant Output Forecast
- User's data System Data
- User outage information
- Load characteristics (directly or indirectly connected to NTDC System)
- Connection Point Demand and Active Energy Data of users directly or indirectly connected to NTDC system and Generation Summary
- Data Supplied by NTDC to user

4.1.7.1 Generating Unit Technical data

The generators are required to submit to NTDC/ System operator technical information on each of their generating units. The information must include a realistic performance chart for each unit. By 10:00 a.m., a week ahead of the operational day, each user must report the System Operator of changes to circuit details as per defined in the code.

4.1.7.2 Weekly Operational Policy

The system operator shall forward each generator in respect to its power plants a weekly Operational policy. It includes response data for frequency changes, primary response to frequency fall, secondary response to frequency fall, high response to frequency rise, generators, governor & droop characteristics, unit control options and control of load demand.

4.1.7.3 System Warnings

Exchange of information relating to Operational and events on the Total System of NTDC includes instructions on equipment, plant and appreciation tests. The system warning shall be issued relating to inadequate plant availability, subsequent load demand control, and to advice of a risk of major system disturbance. System Warning Contents Warning type, To: For Action, Consequences, and Response from Recipients /Code Participants.

4.1.7.4 Report of Major event

Formal exchange of reports relating to occurred events on the system shared between system operator, distribution companies, operators of power plants, transmission connected consumers and operators of externally connected system parties shall be reported. Such report includes time & date of major event, location, plant/ apparatus involved description of the major event, demand/ generation lost, generating unit frequency, generating unit MVAR performances and estimated duration of non-availability of power plant or that of demand interruption.

4.1.7.5 Planning Data

For planning of future works including the development of new facilities, reinforcements, up-rating, extensions and augmentation of existing facilities, standard planning data is required. Standard planning data include User's System Data, Generating Unit Data, Rated Parameter Data and Network Operational Data.

4.1.7.6 Short Term Planning of Generation Outage (0 Year)

Generator and System Operator shall exchange information on a quarterly basis. Generator is required return their most update outage proposals, thereby enabling the system operator to open generator availability as per the generation requirement.

4.1.7.7 Medium Term Planning of Generation Outage (1-2 Year)

Medium term is two financial years 0 or Years 1 & 2. There shall be an exchange of information concerning the Final Generation Outage Programme between each Generator and the System Operator on a financial Year basis.

4.1.7.8 Long Term Planning of Generation Outage (3-5 Year)

Long Term is for three-year period causes 3, 4 and 5. The system operator shall notify respective Generator of any forecasted outage on the NTDC transmission System for construction maintenance work.

4.1.7.9 User's System Data

User System data consists electrical parameter as:

- Single line diagram with information like rated voltage (kV), operating voltage (kV), line length (km), conductor name, type of tower, positive phase sequence reactance and resistance, zero phase reactance / resistance / susceptance.
- User's equipment installed at a site like switchgear, bub-station Infrastructure, reactive compensation equipment etc.

4.1.7.10 Data Supplied by NTDC to user

NTDC's Notification of its Forecasted Annual System Peak shall include Demand (Active Power), Annual Minimum Demand (Active Power), Total Active Energy of the NTDC in the preceding NTDC Financial Year and a Forecasted Active Energy Requirement for the Current Financial Year. NTDC System Demand and Energy Forecast shall incorporate all the data supplied by the Network users and Network operators.

4.1.7.11 Operating Response and Frequency Response

A reserve to make up the operating margin that the system operator may make use of under certain operating conditions to cover for the availability / unavailability or sudden outage of generation and transmission facilities. Generator capacity to response which used to provide operating reserve and frequency response shall be made available to the system operator by the operators of power plants. Frequency response, capability profile, primary response to frequency fall, secondary response to frequency fall, high response frequency rise, generator, governor & droop characteristics, unit control and control of load demand is needed.

4.1.7.12 Inter Safety Precautions Form

For the co-ordination, establishing and maintaining of necessary safety precautions, specific the standard procedure in needed. Form of record of inter-system safety precautions shall include HV apparatus identification, location, isolation, and identification and established safety precautions.

4.1.7.13 Generation Scheduling and Dispatch Parameters

For generation scheduling and dispatching, following parameters shall be shared:

- Basic data: Minimum Generation (MW), Sustained Response Capability
- Two shifting limitations
- Minimum on time
- Block Load
- Maximum Loading rates
- Maximum number of changes

4.1.7.14 Power Plant Daily Scheduling Notice

For generation scheduling and dispatching, following parameters shall be shared:

- Settlement period: 0000 To 2400 at 30-minute time interval
- Units: Oil, Gas
- Contracted Capacity
- Available Capacity

4.1.7.15 Generation Scheduling and Dispatch Parameter (GSDP) Revision

In the case of power production subjected to vary from scheduled and relevant to Power Purchase agreement, or Power Station Operation & Dispatch Agreement (PSODA), revised data shall be shared for scheduling and Dispatch purposes as Unit ID, Generation Scheduling, Dispatch Parameter affected, Contracted Value Revised Value and Time Duration.

4.1.7.16 Power Plant Daily Scheduling Notice

For notification of revised availability, following information shall be shared:

- Settled Period: 0000 to 2400 at 30-minute time interval
- Units: Oil, Gas, Turbine units 1, 2, 3…

4.1.7.17 Power Plant-Daily Scheduling Notices

Power Plants shall share daily scheduling information includes Availability Notice, Energy Bid Price Notice, Scheduling and dispatch parameters and Relevant data etc.

4.1.7.18 Notification of Revision of Power Plant-Daily Scheduling

Power Plants shall notify Unit Range ID, Declared MW, Revised MW, Valid: From… to …, and Reason for Change.

4.1.7.19 Unit Nomination

For Participating Power Plant for generation details of units shall be shared

4.1.7.20 Power Plant Daily Scheduling Notice

For notification of revised availability, following information shall be shared:

- Name of Participating Generator
- Name of Generating Unit

- Date of Scheduling Day Comments
- Supplemental Energy Bid

4.1.8 Sri Lanka

For Sri Lanka, Grid Code 2015 describes the format for Data and Information for electricity trade and System operation.

4.1.8.1 Preliminary Project Planning Data

Transmission Licensees, Generation Licensees, Distribution Licensees and Transmission Bulk Customers have to provide data for preliminary project planning. Following data and information to be made available by the Transmission Licensee to a prospective User

- Single line diagram of the transmission system showing the existing and proposed lines
- Transmission System's relevant data on plant and equipment
- Connection requirements of Transmission Licensee's
- Map of Sri Lanka showing the existing lines of the existing and proposed transmission System and proposed lines
- Data related to Grid Substations indicating 33 kV (in case of 132/33kV or 220/33 kV Grid Substations), 11kV (in case of 132/11kV Grid Substations) outlets as applicable
- Long Term Transmission Development Plan
- Long Term Generation Expansion Plan

4.1.8.2 Committed Project Planning Data

Transmission Licensees, Generation Licensees, Distribution Licensees and Transmission Bulk Customers have to provide data for committed project planning.

4.1.8.3 Standard Planning Data

Transmission Licensees, Generation Licensees, Distribution Licensees and Transmission Bulk Customers have to provide data for standard project planning. Generation licensees with generation from conventional resource-data to be furnished to transmission licensee has to provide generation, thermal connection, station capacity ,generating unit data ,auxiliaries and start up data. Moreover hydroelectric connection of station capacity and generating unit data.

4.1.8.4 Grid Operation Data

Annual generator outage plan from Generation Licensees, annual generator Outage Plan from System operator and Release of Generating Units data are needed for grid operation

4.1.8.5 Grid Dispatch Information and Data

For rolling dispatch plan, information and data from transmission licensee, generators, hydropower stations, distribution licensee and transmission customers are needed. Transmission licensee shall provide annual maintenance plan, transmission restrictions, ancillary service requirements, transmission capacity to be commissioned during the year and decommissioning.

Generation licensees shall provide generator's contract prices, annual maintenance plan, foreseen restrictions, fuel availability and fuel prices.

Transmission customers shall provide demand load forecast for the calendar year, total and discriminated by delivery points to each transmission customer, monthly energy demand and peak capacity.

4.1.8.6 Grid Metering Data

The Transmission Licensee will establish a database for metering data and meter installation. The information and data will include:

- Name of the Licensee/customer/account number
- Unique ID number for the installation
- Site-specific adjustment factors to be applied
- All metering data such as demand, energy, at specified intervals as required by the Transmission Licensee and the relevant tariff
- All information related to meters and instrument transformers
- Test certificates of the metering equipment
- Communication details
- Date of commissioning and commissioning documents
- Testing, calibration history and the persons who carried out the work
- Fault, repair, and maintenance history of the installation
- Contact details of the User representatives

Table 6 Technical Information of Asian Region

Country	Single Phase Voltage (volts)	Three phase Voltage (volts)	Frequency (Hz)	Generation in GWh	Transmission & Distribution Losses
Afghanistan	220	380	50	833	N.A
Bangladesh	220	380	50	74700	16.4%
Bhutan	230	400	50	6976	N.A
India	230	400	50	1387000	20.3%
Maldives	230	400	50	169	N.A
Nepal	230	400	50	3279	30.85%
Pakistan	230	400	50	123900	17.03%
Sri-Lanka	230	400	50	14900	10.57%

4.2 Data and Information Exchange between SAARC Member States

4.2.1 Afghanistan and Central Asia

Afghanistan meets a major part of electricity demand through imports from Iran, Turkmenistan, Uzbekistan and Tajikistan. Currently, the carrying capacity of total installed transmission lines is 326MW from Uzbekistan, 164 MW from Iran, 433 MW from Tajikistan, and 77 MW from Turkmenistan. The national grid is not synchronized with the systems of the four countries from which Afghanistan imports power, resulting in higher costs and reduced reliability of supply. There are five transmission lines used for power import which feed into NEPS from Turkmenistan, Uzbekistan and Tajikistan. Three lines import power from Iran. None of these import sources are interconnected to other power systems.

Construction of the 500 kV CASA 1000 transmission line between Sangtuda (Tajikistan) and Nawshehra (Pakistan) through Torkham (Afghanistan) commenced in May 2016. Afghanistan announced last year that it would abandon its proposed 300 megawatt share of energy imports via the CASA-1000 project due to a lack of demand. Its allocation would then be transferred to Pakistan, which is now set to receive 1,300 megawatts, rather than the initial 1,000 megawatts proposed. Thus Pakistan would be the main importer of energy under the CASA-1000 project.

4.2.2 Bangladesh and India

Bangladesh and India agreed bilateral electricity trade. NTPC Vidyut Vyapar Nigam (NVVN) is the Nodal Agency for trading of power with Bangladesh. NVVN has signed an agreement with Bangladesh (Bangladesh Power Distribution Board (BPDB)) for supply of 250 MW power for 25 years from various central generating stations of NTPC. The supply has commenced from October 2013 after completion of the transmission link between India & Bangladesh. Power Purchase Agreement has been signed between BPDB and NVVN and back to back Power Supply Agreements have also been signed with Tripura State Electricity Corporation Ltd (TSECL) for supply of 100MW power to BPDB under radial mode. Commercial agreement between two parties is not publically available. The first 175 megawatts of power flowed from India to Bangladesh in September 2013. This first electricity grid interconnection among SAARC countries with a 400 kV AC link between India and Bangladesh through a HVDC back-to-back station in Bangladesh.
Location of the HVDC station

This monopole back-to-back HVDC system links India's eastern electrical grid to Bangladesh's western grid. The HVDC station in Bangladesh is connected to the country’s existing 230 kilovolt (kV) grid. A new 400kV alternating current high-voltage overhead line provides the cross-border connection to the 400 kV substation in India. This project also enables the power generation of Bangladesh from less inefficient diesel power plants to be reduced, helping the country to lower emission levels.

4.2.3 Bhutan and India

The framework "Inter-Governmental Agreement between the Royal Government of Bhutan and the Government of the Republic of India concerning development of Joint Venture Hydropower Projects through the Public-Sector Undertakings of the two Governments” was signed on 22 April 2014 in Thimphu by Secretary, Ministry of Economic Affairs, Royal Government of Bhutan and Secretary, Ministry of Power, Government of India. The Inter-Governmental agreement provides the framework for implementing four HEPs (Hydro Electric Plants) totaling 2120 MW, subject to completion of the due process of appraisal of their DPRs including techno-economic viability, on a Joint Venture-model between Public Sector Undertakings of the two countries. Three hydro-electric projects (HEPs) totaling 1416 MW, viz., the 336 MW Chukha HEP, the 60 MW Kurichhu HEP, and the 1020 MW Tala HEP, are already operational in Bhutan and are supplying electricity to India. Three more HEPs totaling 2940 MW, i.e., the 1200 MW Punatsangchhu-I HEP, the 1020 MW Punatsangchhu-II HEP and the 720 MW Mangdehchhu HEP, are under construction, and are scheduled to be commissioned by 2018.

Table 7 Joint Venture-Model between Public Sector Undertakings of the two Countries

Hydro Electric Project	Capacity	JV partners
Kholongchu HEP	600 MW	SJVN Ltd. of India and Druk Green Power Corporation (DGPC) of Bhutan (50:50 JV, 70:30 DER)
Bunakha HEP (with 230 MW downstream benefit from Tala, Chukha and Wangchu HEPs)	180 MW	THDC Ltd. of India and Druk Green Power Corporation (DGPC) of Bhutan (50:50 JV, 70:30 DER)
Wangchu HEP	570 MW	SJVN Ltd. of India and Druk Green Power Corporation (DGPC) of Bhutan (50:50 JV, 70:30 DER)
Chamkarchu HEP	770 MW	NHPC Ltd. of India Druk Green Power Corporation (DGPC) of Bhutan (50:50 JV, 70:30 DER)

4.2.4 Nepal and India

Nepal imports power from India as per Bilateral Agreements/Treaty (Kosi Agreement, Gandak Agreement, Mahakali Treaty), Power trade from 22 radial mode inter connection, Dhalkebar- Mujaffpur 400kV Transmission Line. Nepal and India had signed Koshi Agreement and Mahakali treaty for transboundary and boundary projects. These agreement and treaty has mentioned provisions on information sharing. Relevant articles from them stated below

4.2.4.1 Article 2.III of Kosi Agreement

HMG shall be entitled to obtain for use in Nepal any portion up to 50 percent of the total hydro-electric power generated by any Power House situated within a 10- mile radius from the barrage site and constructed by or on behalf of the Union, as HMG shall from time to time determine and communicate to the Union:
Provided that: HMG shall communicate to the Union any increase or decrease in the required power supply exceeding 6,800 KW at least three months in advance.

4.2.4.2 Article 2.b of Makali Agreement

“A supply of 70 million kilowatt-hour (unit) of energy on a continuous basis annually, free of cost, from the date of the entry into force of this Treaty. For this purpose, India shall construct a 132-kV transmission line up to the Nepal-India border from the Tanakpur Power Station” (which has, at present, an installed capacity of 120,000 kilowatt generating 448.4 million kilowatt-hours of energy annually on 90 percent dependable year flow)

Agreement between the Government of Nepal and the Government of India on electric power trade, cross border transmission inter connection and grid connectivity signed on 21 October 2014. ARTICLE-II (a) of the agreement states “The Parties shall mutually work out a coordinated procedure for secure and reliable operation of the national grids interconnected through cross border transmission interconnection(s) and prepare scheduling, dispatch, energy accounting, settlement and procedures for cross-border power trade and unscheduled interchange”.

The government of India has appointed NVVN as the Nodal Agency for Cross-Border power trading with Nepal. A PPA was signed between NVVN and Nepal Electricity Authority for supply of 80MW power to Nepal through the Muzafferpur-Dhalkabar transmission line. For importing power form India, Nepal Electricity Authority Load Dispatch Center and counter part in India communicate as per format defined by Laws of India. ARTICLE-IV (d) of the agreement sates “The parties shall put their best efforts to ensure unrestricted flow of power subject to safety, security, and stability and reliability requirements of their power grids as per the applicable standards”.

4.2.5 Pakistan and Iran

Pakistan imports electricity from Iran to serve the demand in Baluchistan province. The system is operated in a radial mode. As per their bilateral agreement in 2002 agreement, Pakistan can import up to 39 MW. In June 2006, WAPDA signed an MOU with Iran to increase the supply by 100 MW to meet Gwadar port area demand and plans to increase to 1000 MW. Pakistan now imports 74MW after Jakigur 230/63 kV substation project was commissioned.

4.2.5.1 Existing Interconnection Projects:

Import of 74 MW Power by Pakistan in border areas of Pakistan (in Baluchistan Province): :

- 70 MW at 132 kV (continued since 2003. Initially, it was 35 MW)
- 4 MW at 20 kV (continued since 2002)
- (Tariff: US cents 7-10. Contracts is renewed after every 3-years)

4.2.5.2 Planned Interconnection Projects:

- Import of 100 MW at Gwadar through 220 kV D/C T/Line (contract signed)
- Import of 1000 MW at Quetta through ±500 kV HVDC Bipole (MoU signed) For import of power from Iran, Tariff is linked with International Oil prices

Import of 74 MW Power by Pakistan in border areas of Pakistan (in Baluchistan Province): :

- Polan (Iran) - Gwadar (Pakistan) through 220 kV D/C Line
- 220 kV D/C T/Line (about 50 km) from Polan upto Pak-Iran Border
- 220 kV D/C T/Line (about 75 km) from Gwadar upto Pak-Iran Border
- 220 kV Substation at Gwadar with 2x160 MVA T/Fs

4.2.6 Indian Power/Energy Exchanges

The Indian Energy Exchange is an electronic system based power trading exchange which provides a competitive wholesale market for the buyers and sellers of the Indian power sector come together to trade in energy. IEX is India's premier power trading platform which provides a transparent, neutral, demutualized and automated platform for physical delivery of electricity. It enables efficient price discovery and counter-party risk management for participants of the electricity market and industries eligible for open access. About 4,000 participants across utilities from 29 States, 5 Union Territories (UTs), 1,000+ private generators (both commercial and renewable energy) and more than 3,500 open access consumers are engaged the Exchange platform to manage their power portfolio in the most competitive and reliable way.

4.2.6.1 Product Segments of IEX

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4.2.6.1.1 Day-Ahead Market (DAM)

Participants do electricity trade on 15-minutes block basis, a day prior to the delivery of electricity. Both buyers and sellers submit their electronic bid during the bid call session. The Market Clearing Price (MCP) is fixed on the basis of intersection point of demand and supply curve and is common for both selected buyers and sellers.

4.2.6.1.2 Term-Ahead Market (TAM)

Contracts under TAM cover a range for buying/selling electricity for duration of up to 11 days. It enables participants to purchase electricity for the same day through intra-day contracts, for the next day through day-ahead contingency, on daily basis for rolling seven days through daily contracts, and on weekly basis through weekly contracts.

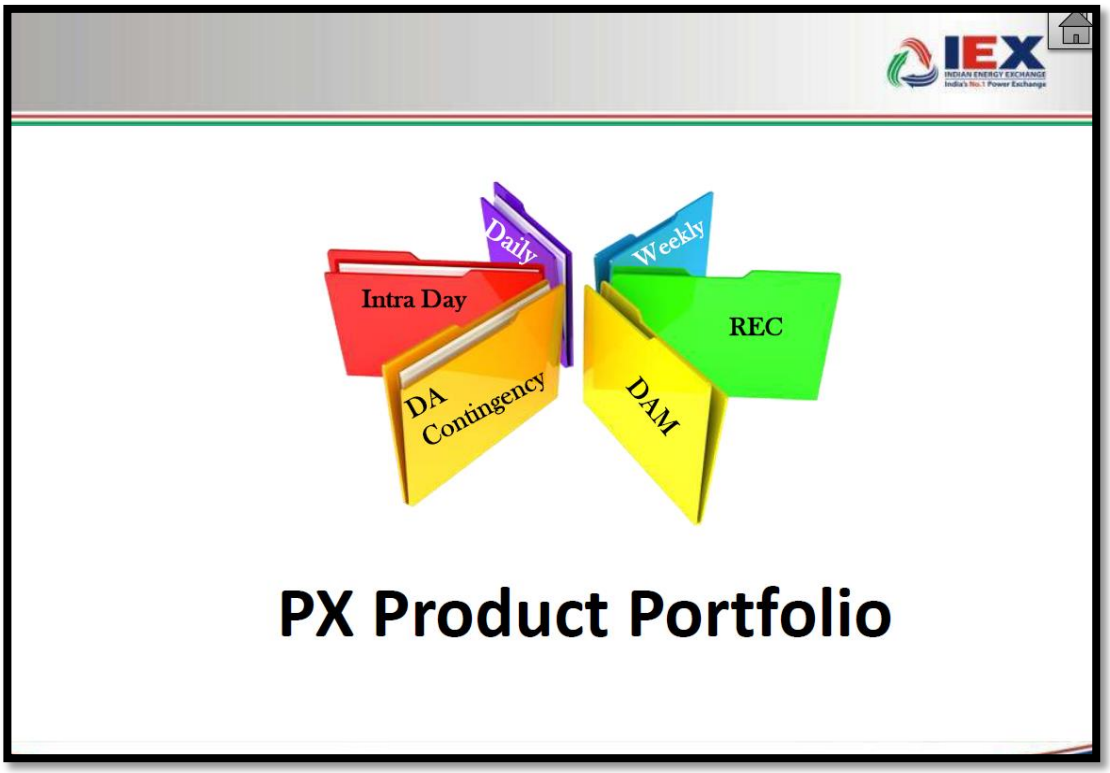

Figure 22. IEX Power Exchange Portfolio

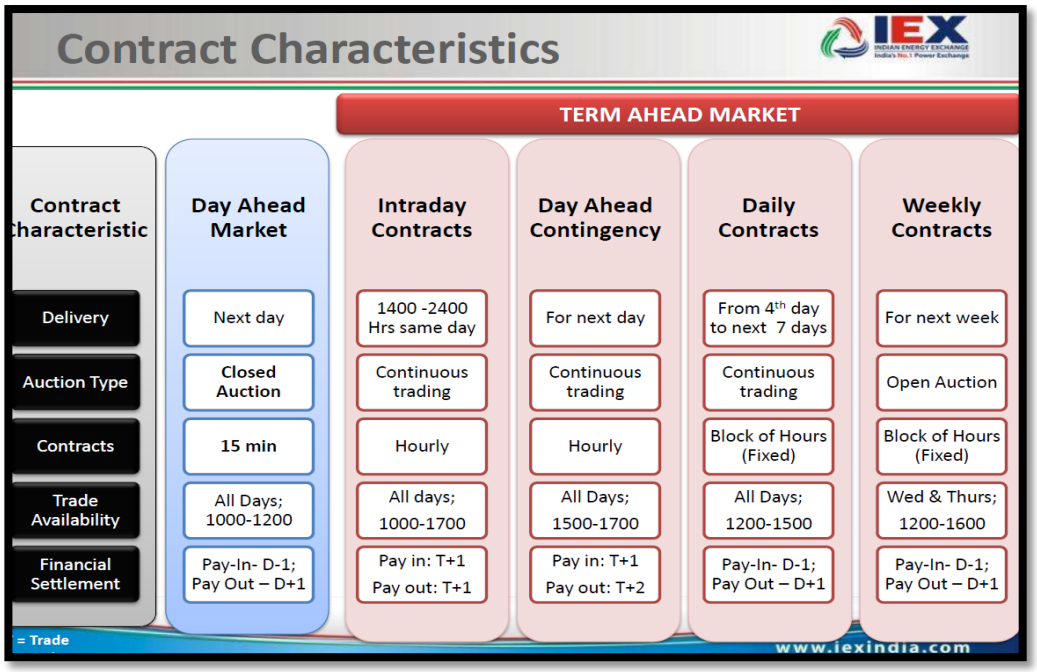

Figure 23. IEX Contract Characteristic

4.2.6.2 Features of Day Ahead Market

Day Ahead Market operated in step by step that includes Bidding, Matching, review Corridor and Funds Availability, Results, Confirmation and Scheduling.

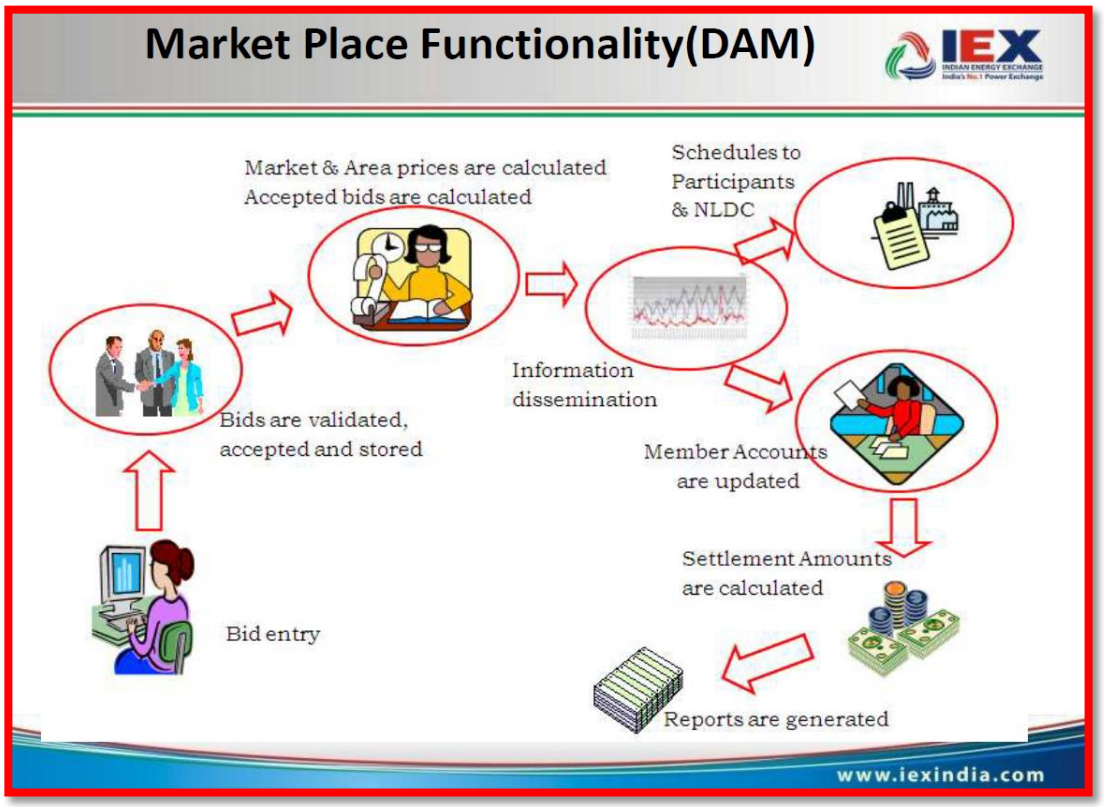

Figure 24. IEX Market Place Functions

Figure 25. IEX Day Ahead Market (DAM) Trading Process

4.2.6.3 Bidding

Participants enter bids for sale or purchase of power for delivery a day before delivery. Bids for a total of 96 blocks of 15 minute in a day can be entered. Bidding session is 10:00 hrs. To 1200 hrs. Bids can be single and/or block including linked bids. The entered bids are stored in the central order book and the bids entered during this phase can be revised or cancelled till end of bid call period.

4.2.6.4 Matching

At the end of the bidding session, bids for each 15-minute time block are matched using the price calculation algorithm. All purchase bids and sale offers are aggregated in the unconstrained scenario and supply and demand curves are drawn on Price Quantity axes. The intersection point of the demand and supply curves gives the market clearing price (MCP) and market clearing volume (MCV). MCP and MCV are determined for each block of 15 minutes as a function of demand and supply which is common for the selected buyers and sellers. Selected members are communicated about their partially or fully executed bids and other trade related information. By 1300 hrs., transmission corridor required to fulfill successful transactions are sent to NLDC.

4.2.6.5 Transmission Corridor and funds availability

For preliminary calculation, MCP and MCV are used for the provisional obligation of the selected participants and the provisional power flow. Funds available in the settlement accounts of the participants are verified. Bidder with insufficient funds in the account deleted. Required corridor capacity and provisional power flow is sent to NLDC and corridor allocation is requisitioned based on availability. By 1400 hrs., NLDC reverts with actual transmission corridor availability during all 15-minute time blocks across congestion prone bid areas.

4.2.6.6 Results

IEX recalculates MCP and MCV as well as area clearing price (ACP) and area clearing volume(ACV) as per the reserved transmission capacity confirmed by NLDC.ACP is used for the settlement of the contracts.

4.2.6.7 Confirmation

Final results for confirmation and application for scheduling of collective transactions are sent to NLDC.NLDC sends the details of the schedule to respective SLDCs.

4.2.6.8 Scheduling

RLDCs /SLDCs incorporate Collective Transactions in the Daily schedule. A scheduled transaction is considered deemed delivery. Deviations from schedules are dealt under UI or Deviation Settlement or Imbalance Settlement regulations. The Regional Entities (those connected at ISTS networks) are governed by CERC Regulations and Embedded Entities (those connected to state transmission or distribution network) are governed by respective State Commission’s regulations.

4.2.7 Guidelines on Cross Border Trade of Electricity

Ministry of Power, Government of India had introduced Guidelines on Cross Border Trade of Electricity, 2016. This Guideline shall facilitate cross border trade of electricity between India and neighboring countries and Promote transparency, consistency and predictability in regulatory approaches across jurisdictions and minimize perceptions of regulatory risk. As per Central Electricity Regulatory Commission (Cross Border Trade of Electricity) Regulations, 2017 (Draft), India will nominate Designated Authority and Settlement nodal Agency for facilitating cross border power trade with her neighboring countries and with approval of the Designated Authority, shall be eligible for cross border trade of electricity through Indian Power Exchange(s) under the categories of Term Ahead Contracts, Intra Day Contracts and Contingency.

Article 21, Data and Communication Facilities of the regulation highlighted that reliable and efficient voice and data communication systems shall be provided to facilitate necessary communication and data exchange and such Communication must be established from generating station to control room of System Operator of a neighboring country and from there to control room of System Operator of India. The cross border transmission link shall necessarily be established along with adequate data and communication facilities.

In Article 22, System Recording Instruments of the regulations mentioned that recording instruments including Data Acquisition System/Disturbance Recorder/Event Logging Facilities/Fault Locator (including time synchronization equipment) shall be provided and shall always be kept in working condition in the ISTS and transmission system of the neighboring country for recording of dynamic performance of the system.

In Article 36 Event Information in the regulation stated that events like tripping of elements impacting the electricity flow across the cross border transmission links, complete / partial blackout etc. would be reported by the concerned System Operator of India to the system operator of a neighboring country and vice versa. Information shall be shared in written covering the date and time of the event, location, plant/equipment affected and any other relevant detail.

As per Article 28, Data Updating and Sharing of the regulation the entities of neighboring country shall be required to share and update technical data and information to the CEA as per the format to be specified by Designated Authority. A copy of the PPA shall be submitted to the DA within 30 days of signing of the PPA and if required by the Designated Authority, the developer shall submit the commercial and financial information to the CEA.
If there is enough power generation, one country can fulfil demand of other neighboring country and prerequisite for that is a seamless SAARC power grid within next few years. Secondly, SAARC countries are located in different time zones and peak demand in each of them occurs at different point of time. Thus, the seamless connectivity can also address issue of load shedding. For instance, Nepal has its annual peak demand in winter while India and a few other states have the same in summer. If Nepal produces enough power, it can supply its surplus power to India and can import surplus power from India in winter.

5 Best International Practices on Data and Information Exchange

5.1 South African Power Pool (SAPP)

The Southern African Power Pool (SAPP) was created with the primary aim to provide reliable and economical electricity supply to the consumers of each of the SAPP members namely Angola, Botswana, Congo, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zambia and Zimbabwe consistent with the reasonable utilization of natural resources and the effect on the environment. Mission of SAPP is “Aim to provide the least cost, environmentally friendly and affordable energy and increase accessibility to rural communities”.

5.1.1 Meetings between Regulators

For making decision on cross-border trading, regulators for sharing information so that each regulator can develop a full and accurate understanding of all terms and conditions of proposed cross-border agreements; and discuss any principles or substantive terms and conditions in order to reach a consistent or common approach to their decisions on the cross-border transaction. The license will impose requirements to provide certain information to the regulator for making decision n cross border power trade, monitor compliance, decisions on regulatory issues, notification of problems to be negotiated, change in the agreement etc.

5.1.2 The South African Grid Code - The System Operation Code Version 7.0

Article 16 of the code defined Communication of system conditions, operational information and defined System Operator responsibility for sharing information as:

- Monitor and/or determine system conditions from time to time, and communicate these, or changes from a previous determination, to all participants
- Responsible for providing operational information as may be agreed with the affected participants
- Inform participants of any network condition that is likely to impact the short and long-term operation of that participant
- Timely communicates any changes or modifications to the TS to the relevant participant
- Report on both technical and energy aspects of IPS performance monthly and annually. This reporting shall include daily demands, energies, losses, interruptions and QOS aspects as detailed in the Information Exchange Code
- Annually publish expected fault levels, including the rupturing capacity of relevant NTC equipment, for each point of supply.

5.1.3 The South African Grid Code the Information Exchange Code Version 7.0

The Information Exchange Code defines the reciprocal obligations of parties with regard to the provision of information for the implementation of the Grid Code. The information requirements are defined that may have needed to the National Energy Regulator of South Africa (NERSA) and customers ensure non-discriminatory access to the transmission system and the safe, reliable provision of transmission services.

5.1.4 Confidentiality of information

Information exchanged between parties governed by this code shall not be confidential, unless otherwise stated. For protection of information, confidential information shall not be transferred to a third party without the written consent of the information owner. Parties receiving information shall use the information only for the purpose for which it was supplied and the information owner may request the receiver of information to enter into a confidentiality agreement before information, established to be confidential, is provided.

The information may be needed for planning information, operational information and post-dispatch information

5.1.4.1 System planning information

Customers shall provide information as per the National Transmission Company (NTC) request on a regular basis for the purposes of planning and developing the TS.

5.1.4.2 Distributor and End Use Customer Data

Following information shall be supplied to the NTC prior to connection and then updated as and when changes occur:

- Demand and network data
- Transmission system connected transformer data
- Shunt capacitor or reactor data requirements
- Series capacitor or reactor data requirements
- FACTS devices and HVDC data
- Information on customer networks

5.1.4.3 Generator Planning Data

Power generation companies should provide information about power plants to the NTC prior to connection. it shall include power station data, unit data, reserve capability, unit parameters, speed governor system, turbine and boiler models, control devices and protection relays, pumped storage, unit forecast data and mothballing of generating plan.

5.1.4.4 Generation Maintenance Plan

Generator companies shall submit annual maintenance plan, 52-weeks ahead maintenance plan per week, annual maintenance/outage plan per generator and monthly variance reports

5.1.5 Operational Data

For SCADA database, definition for each electrical configuration (ELC) or electrical object in the station ELC type, e.g. transformers, units, feeders, etc., and is accompanied by a picture showing the ELC and all its associated devices as they would be indicated on the system operator. It includes Device , category, Type , Control, Generator, Hydro units and Distributor and end-use customer like Transmission equipment ,Interruptible load etc.

5.1.6 Market operational schedules

Following information/data shall be given to System operator:

(a) Energy market schedules

- Unit Minimum Generation in MW
- Unit incremental prices
- Unit elbow points in MW
- Unit Maximum Continuous Rating in MW
- Unit Price for Emergency Generation

(b) Ancillary services market schedules

- Unit identification number
- Contract hour
- Instantaneous reserve contract
- Flexibility Boolean
- Flag for being contracted for AGC
- AGC Regulation contracted
- Regulation contracted down
- 10-minute reserve contract
- Reserve available from 10-minute
- Reserve demand-side resources
- Reserve from supply-side resources

5.1.7 Post-dispatch information

The System Operator shall provide the minimum operational information in real time and as historic data in relation to all units at each power station:

- Unit high limit
- Unit low limit
- Unit AGC mode
- Unit AGC status
- Unit set-point
- AGC pulse

- Unit sent out
- Unit auxiliary
- Unit contract
- Unit spinning

The system operator shall provide the following minimum operational data in near real time in relation to the overall dispatch performance:

- ACE area control error
- Average ACE previous hour
- HZ system frequency
- Frequency distribution current hour
- Frequency distribution previous hour
- System total generation
- Control area total actual interchange
- Control area total scheduled interchange
- System sent out
- System spinning reserve
- AGC regulating up
- AGC regulating down
- AGC regulating up assist
- AGC regulating down assist
- AGC regulating up emergency
- AGC regulating down emergency
- AGC mode
- AGC status
- Area control error output
- System transmission losses
- Cahorra Bassa tie-lines
- BPC tie-lines
- Zesa tie-lines

- Nampower tie-lines
- AGC performance indicators

5.1.8 Generator Performance Data

For evaluation of Generation following parameters are needed:

- Measurement of availability
- Components of the energy availability factor (EAF)
- Unplanned capability loss factor (UCLF)
- Other capability loss factor (OCLF)
- Planned capability loss factor (PCLF)
- Unit capability factor (UCF)
- Measurement of availability and reliability
- Unplanned automatic grid separations per 7000 operating hours
- Successful Start-up Rate (SSUR)
- Protection management
- Ability to island
- Excitation system management
- Reactive capabilities
- Multiple-unit trip risks
- Governing requirements
- Restart after station blackout capability
- Black start capability
- Intermediate load capability
- External supply disturbance withstand capability
- Loading rates

5.1.9 Planning schedules

Demand forecasted done for ten years.

5.1.9.1 Schedule 1: Ten-year demand forecast

It Includes Year wise GWh, Maximum demand (MW, MVar), Expected minimum demand (MW, MVar).

5.1.9.2 Schedule 2: Embedded generation > 50MVA

IIt Includes Generator, Tx substation name at closest connection point, Operating power factor, Installed Capacity (MW), Plant type, On-site usage (Normal, Peak), Net sent out (Normal, Peak), Generation net sent out contribution at peak (Year 1, 2, 3……,10).

5.1.10 Generator HV yard information

The following information to generators about equipment and systems installed:

- Circuit breaker
- C.T. and V.T.
- Surge arrestor
- Protection
- Power consumption
- Link
- Outgoing feeder
- Transformer
- Compressed air system
- Fault recorder

5.2 Korean Power Exchange Model

Korea Power Exchange (KPX) in control of the operation of Korea's electricity market and the power system, as well as the execution of the real-time dispatch and the establishment of the basic plan for supply-demand. Vision of KPX is "Reliable Power Business Platform" with mission (i) Reliable System Operation (ii) Fair Transparent Market Operation and (iii) Reliable, Pioneering, Fair, Global

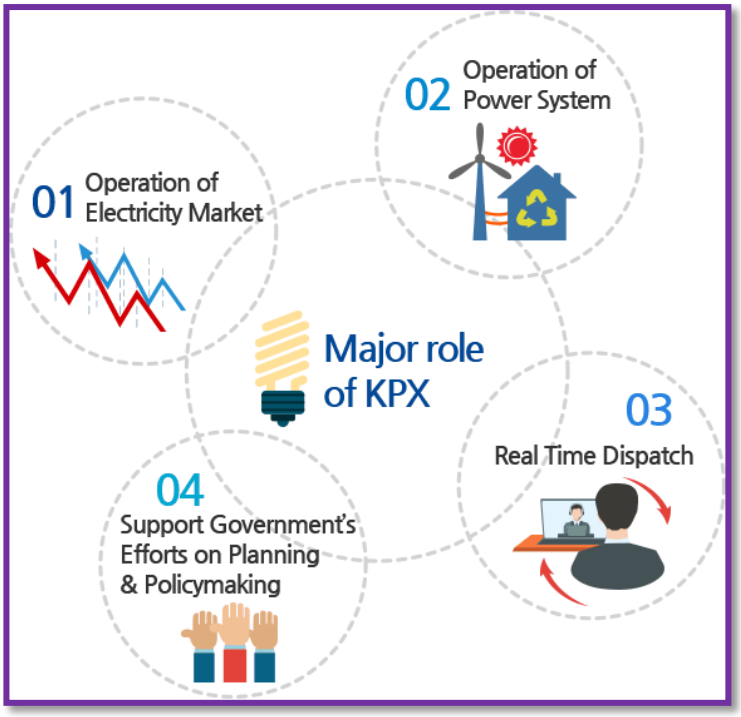

Figure 26. Korean Power Exchange

5.2.1 Electricity Market Trading Process

KPX operates the power market where sellers, power generating companies and the single buyer (KEPCO) participate. The power market is dubbed the pool and electricity generated from all power plants comes in one place for trading. KPX conducts fair and transparent market operations in bidding, settlement, metering, market surveillance, and information dissemination to dispute resolution as per the Pool Rule. Power trading volume and price are determined by the supply-demand curve.

5.2.2 Power trading procedure

KPX operates the cost-based pool, where power is traded as follows:

Figure 17. Korean Power Exchange (KPX) Trading Procedure

When the wholesale market is introduced, market prices and trading volume shall be determined based on the price bidding without having to classify costs into fixed and variable costs. Currently, however, both fixed (capacity payment) and variable costs for each generating unit are examined monthly by the Generation Cost Assessment Committee (GCAC) based on the documents submitted by the generators.

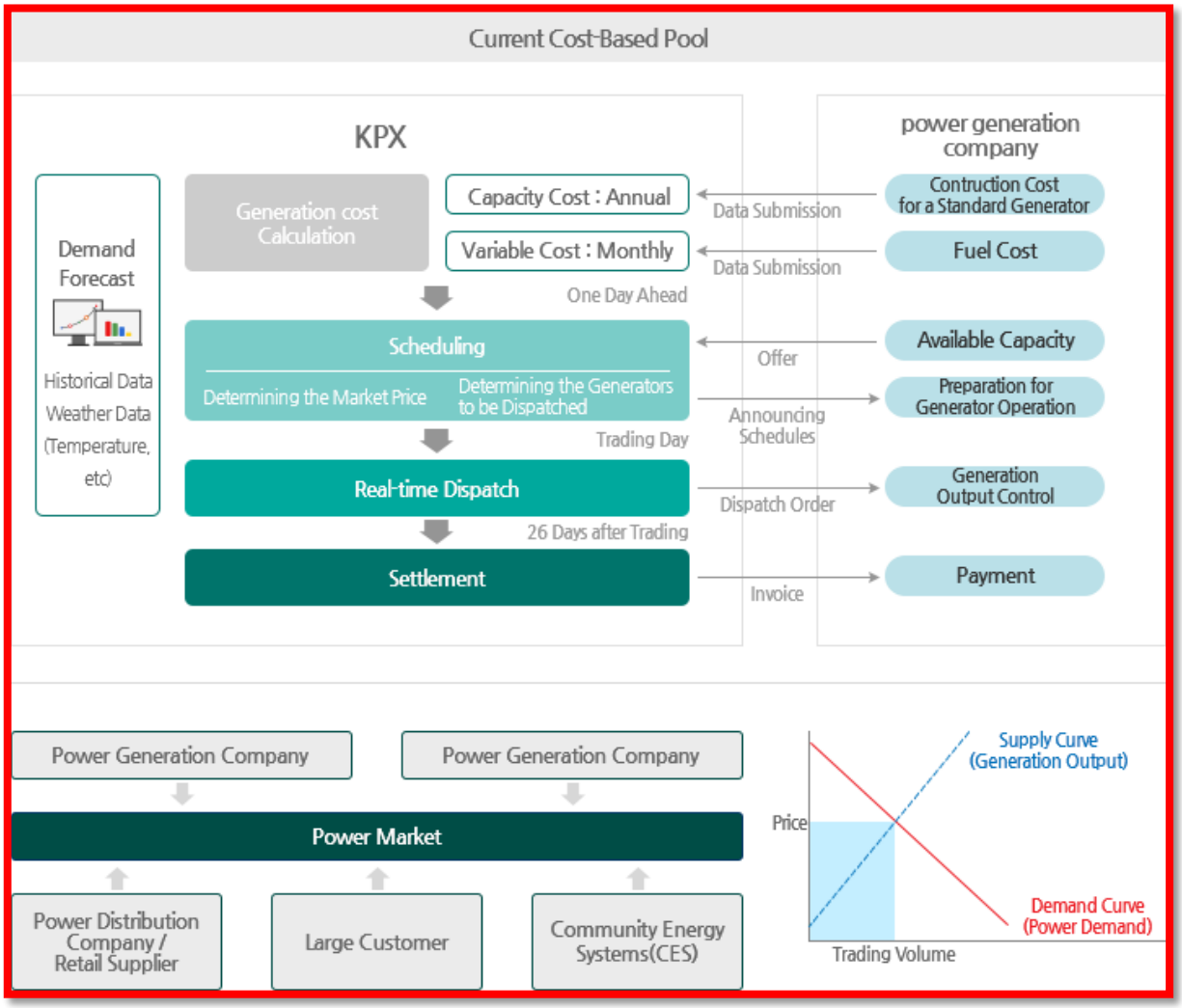

Figure 28. Korean Power Exchange (KPX) Electricity Market Trading System

5.2.3 Electricity Market Trading System

KPX carries out complicated power trading from bidding to settlement promptly and accurately using computer systems. Market participants and interested customers have direct access the necessary information anytime, anywhere through the Internet.

5.2.3.1 Bidding System

Bidding done through exclusive terminal units and posting of available capacity results on the Internet.

5.2.3.2 Scheduler System

Price Setting Schedule (PSS) is established and calculates the marginal price (SMP/BLMP) a day ahead and publishes an operation schedule considering various fuel and transmission constraints.

5.2.3.3 Metering System

Remote measurement of hourly performed volume generation through electronic meters installed on all generating units.

5.2.3.4 Settlement System

After performing initial and final settlement, payments upon the request of market participants, adjusted and issues bills.

5.2.3.5 Energy Management System (EMS)

EMS supervises, control and carries out data acquisition on generation plants and substations. It maintains real-time demand/supply balance, controls generator outputs and system stability, and monitors ancillary service capability and simulates system disturbances for dispatcher training.

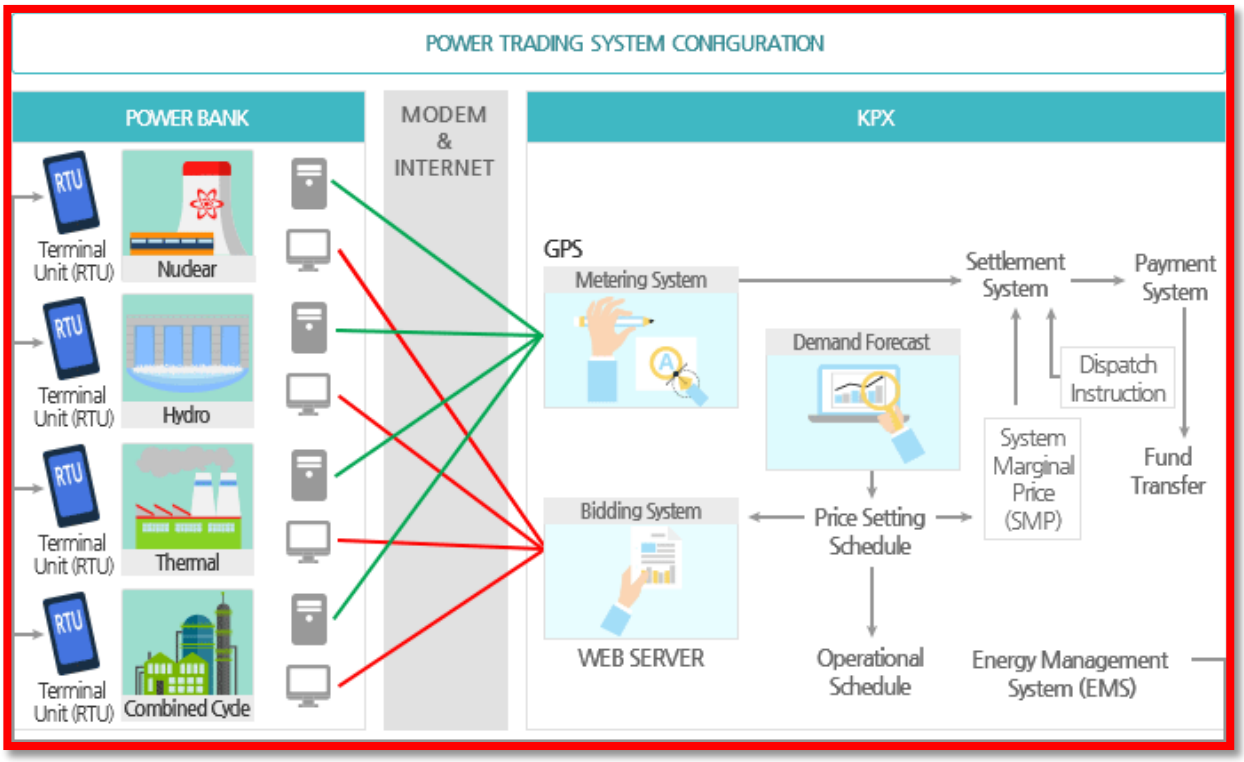

Figure 29. Korean Power Exchange (KPX) Power Trading System Configuration

5.2.3.6 Market Price Determination

The principle by which the electricity price is set in the power market is identical to the principle behind determining the prices of general commodities ― balance of supply and demand.

5.2.3.7 Market Price

The market price is composed of the two components namely system marginal price (SMP) and capacity payment (CP).

5.2.3.8 Method of Determining the System Marginal Price

The system marginal price (SMP) refers to the cost of the most expensive generating unit included in the price computer program setting schedule (PSS).

5.2.3.9 Market Price Setting Procedure

The demand forecasted for the trading day and receives offers for available capacity from generation companies one day ahead. Market price determined by producing a Price Setting Schedule (PSS). In the PSS, the SMP values for each trading hour are calculated to meet the demand for each hour. Congestions or generation constraints such as fuel limitation and district heat supply are not considered in this procedure. Thus, establishing an efficient Operation Schedule that determines the unit commitment (merit order) and output level of generating units is essential to minimizing the total production cost while meeting the necessary demand

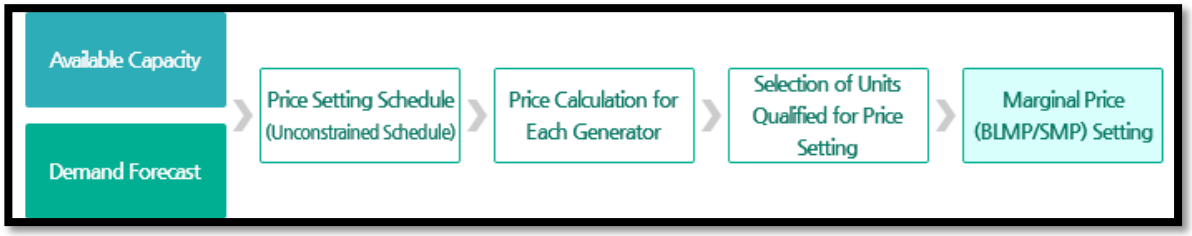

Figure 30. Korean Power Exchange (KPX) Price Determination Procedure

5.2.4 Grid Operation

KPX operates the necessary bulk power system to transmit the generated electricity to the load centers. The power system mainly consists of generators, transmission lines and substations, and distribution line.

KPX manages the transmission network operational planning in advance by analyzing the power flow prevent overload and to maintain the system voltage at appropriate levels.
KPX establishes contingency plans for reliable system operation by performing fault analysis, power flow calculation, stability analysis, and outage schedule adjustment control failures of power facilities or outages.

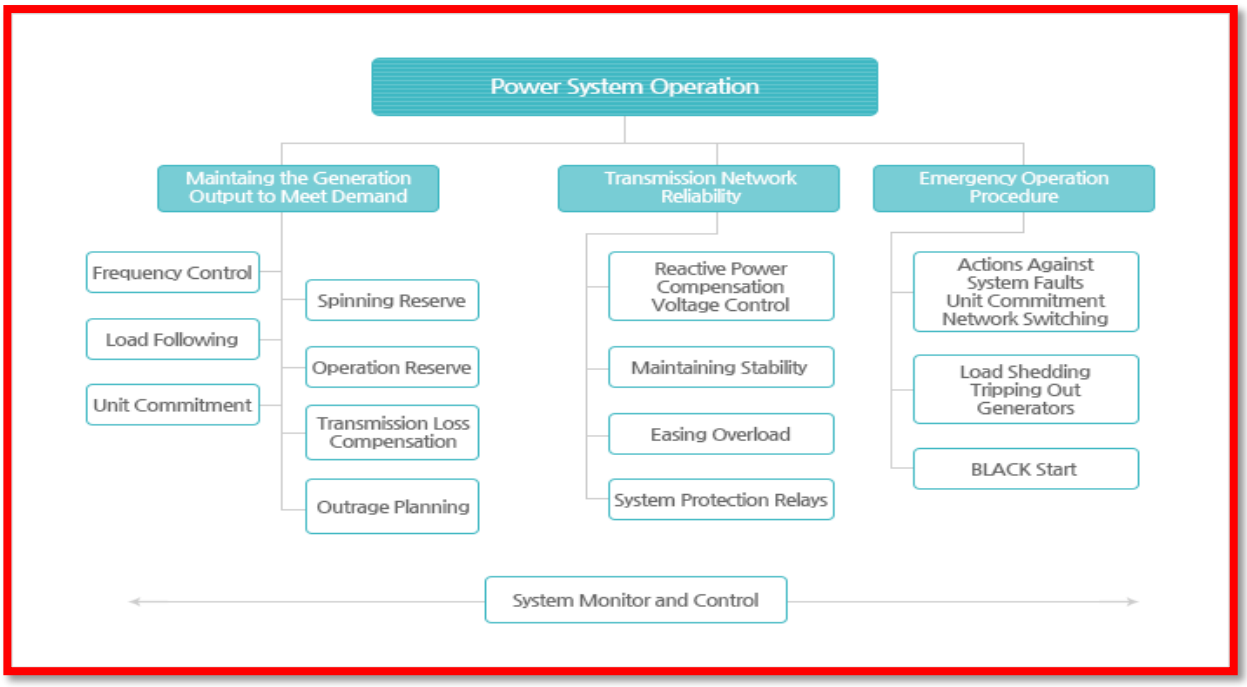

Figure 31. Korean Power Exchange (KPX) Power System Operation

5.3 Spanish Electricity Exchange Market

Spanish Electricity Market started operations since 1998. All generators, distributors, commercial companies and final consumers negotiate all power exchanges through the spot market. The Spanish Power Exchange Market Operator (Compañia Operadora del Mercado Español de Electricidad COMEL) is responsible for the management of the market and for the economic settlement of all transactions between market participants.

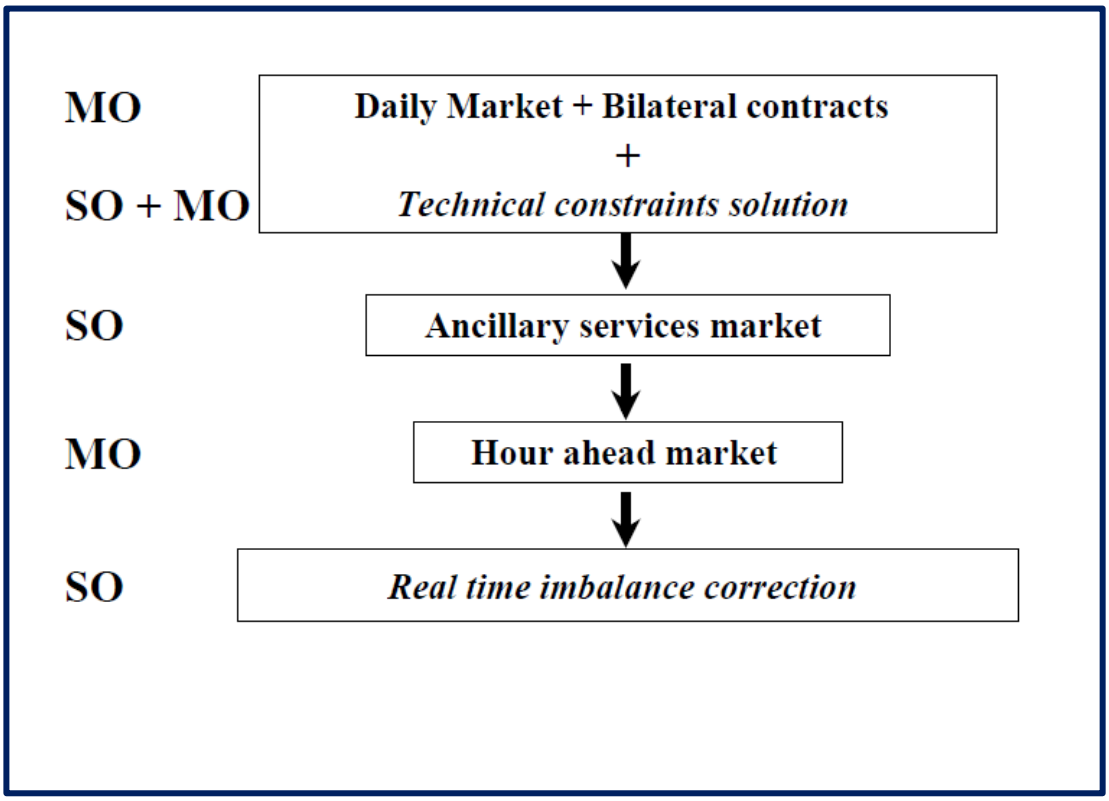

Figure 32. Spanish Electricity Exchange Market –Electricity Production and Process

The electricity production market is composed by four independent, although interrelated markets and processes shown in Figure 4-7. The daily market managed by the Market Operator. This is the fundamental Spanish electricity market and all the rest of the markets and processes are based on its results. The bilateral physical contracts are also integrated on it and also includes the technical constraints solution process that is done in cooperation by the and the System Operator. The ancillary services market, managed by the and hour ahead market, managed by the MO. It provides the agents the opportunity to adjust the previous market results to the changes on the delivery/production situation. The real-time imbalance correction process is managed by the SO. It takes care of the generation/load imbalances that appear on real time.

5.3.1 Power Exchange Market (Daily market organization)

The market is organized as a day ahead market, all the energy bids for the following day presents by the agents to the MO. The market is organized on an hourly basis so the bids and the energy assigned will be in hourly energy blocks and the results informed to all participants including the daily energy values that the parties of the bilateral contracts communicate to the market that they will execute.

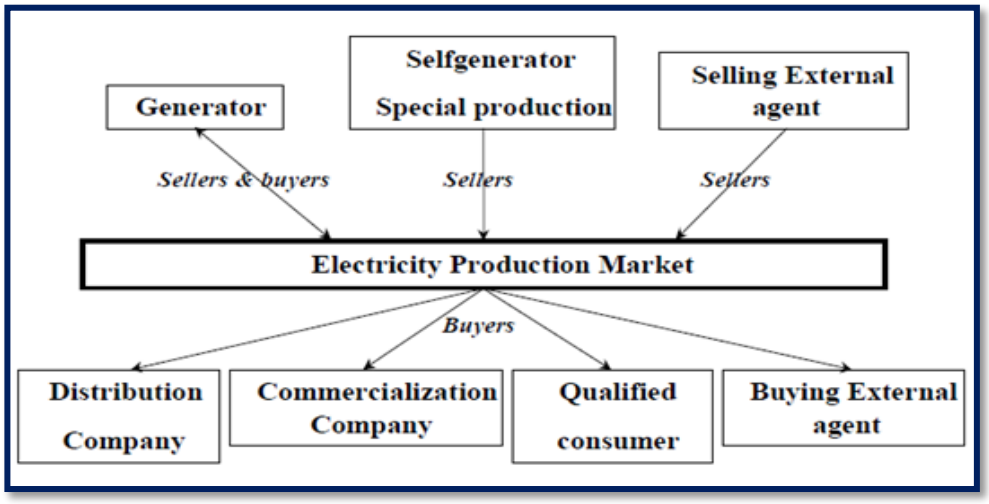

Figure 33. Agents in the Spanish Electricity Production Market

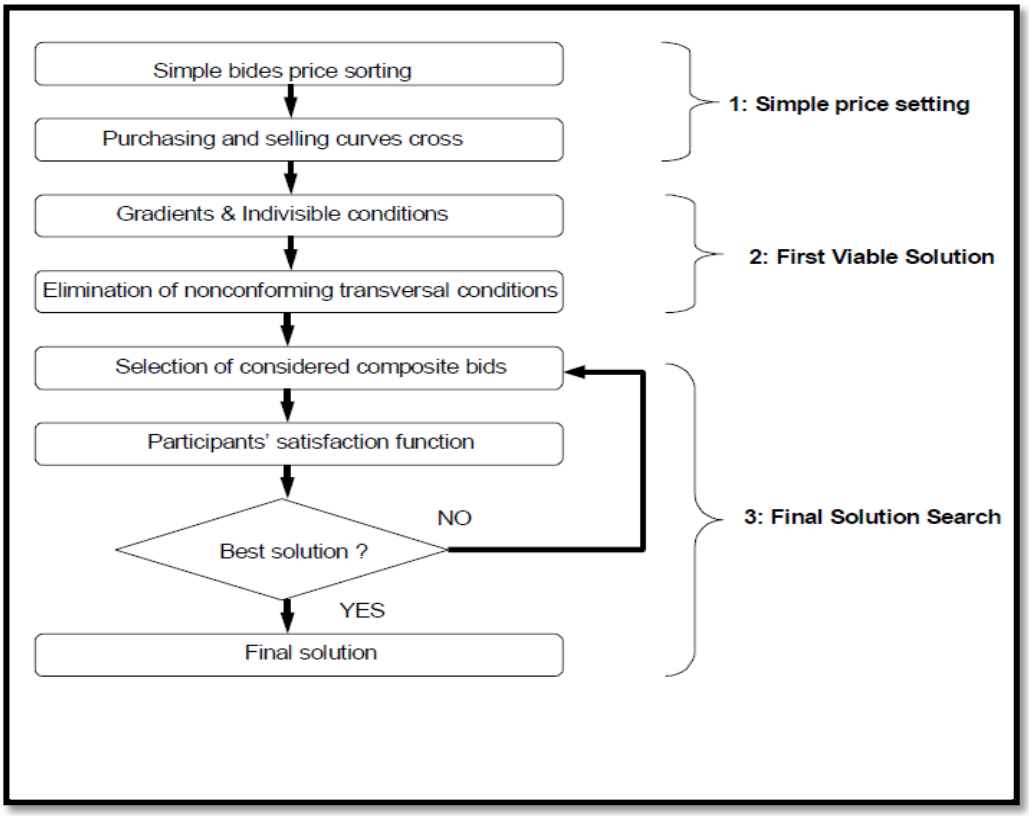

Figure 34. Daily Matching Algorithm in Spanish Electricity Exchange Market

The daily matching algorithm shown in Figure 31 works in steps mentioned below:

Step 1: Simple price setting
All bids are considered as simple ones, without any complex condition. A solution (the simple solution) is obtained.

Step 2: First Viable Solution
Starting from the former solution, complex conditions are considered. Energies allocated to each unit are modified to fulfill their complex conditions. At the end of the process, a solution which meets all such restrictions is obtained.

Step 3: Search of the Final Solution
Once a viable solution has been obtained, the algorithm searches in the solutions space for another viable solution which increases the participants satisfaction with the results. The participants satisfaction has been measured as the minimization of the benefit that the units out of the solution would obtain at the solution market prices. The final solution is the one on which no unit out of the solution would fulfill its complex conditions at the solution's market prices (benefit obtainable equal to 0). When searching in the solutions space, the solutions first tested are those which show, at the previous market prices, the minimum distance to the final solution (minimal benefit obtainable at such prices by the units which are out of the solution).

Marginal prices for each hour of the session horizon and the corresponding bid energy assignments are fixed by matching process.

5.3.2 Power exchange Information System (PEIS)

Internet based system developed to provide a platform for buyers and suppliers. System also designed for market operation, data analysis and settlement are shown in Figure 32. The system includes the following functionalities:

- Receiving Buying and Selling bids
- Obtaining the market price for each of the considered periods
- Providing all market agents with all information needed
- Producing all settlements and clearinghouse activities
- Interchange information with external bodies

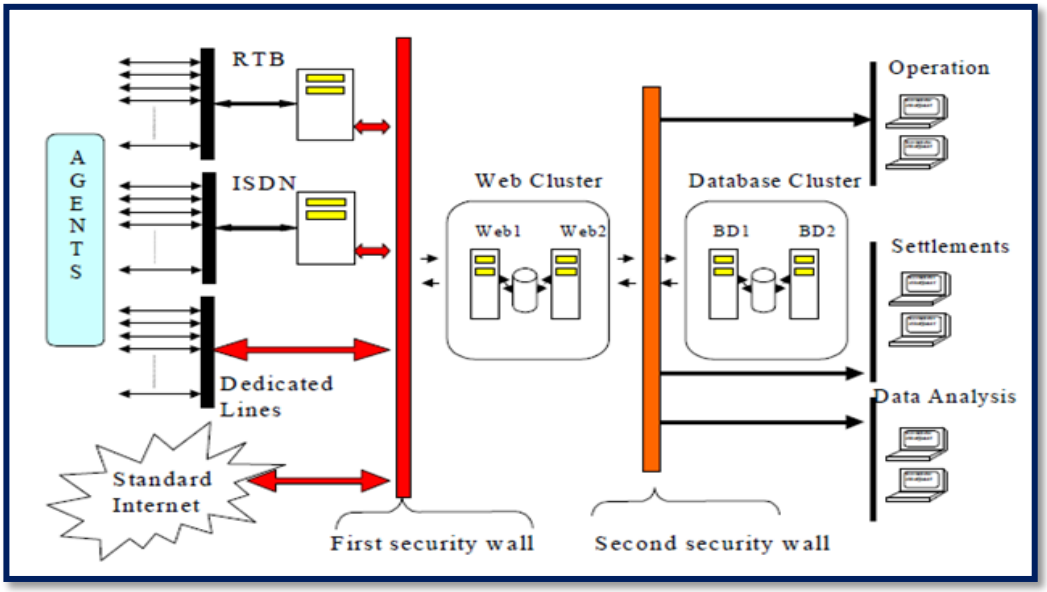

Figure 35. Spanish electricity Exchange Market's System Configuration

PEIS is built on a star configuration. All external agents accesses to the system are done through the Web Server cluster.

The server connects to the database for introducing or accessing information. All information related to the market is stored in the database. A double firewall protection ensures system security.
Four alternative communication means have been introduced :

- Analog phone lines
- ISDN lines

Each agent, depending on its particular needs, may choose the mean which better adapts to his needs, from communicating through a standard internet connection, to a private direct line. All communication channels and equipment are duplicated and switch automatically in case of failure.

A Public Key Infrastructure (PIU) system, based on smart cards with authentication certificates is used to ensure security during data transmission and data privacy between agents. The application makes extensive use of secure http protocol following the Secure Sockets Layer (SSL3) standard.

5.3.3 Daily Market

The daily market starts through the submission of electric power sale and purchase bids by market participants. These bids shall be submitted to the market operator, and shall be included in a matching procedure effective for the daily scheduling horizon, corresponding to the day following the market session, and comprehending twenty-four consecutive hourly scheduling.

5.3.4 Recording of Production Unit data in the Market Operator’s Information System

The system of market operators has administrative registry of power production plants, or in the administrative registry of distributors, resellers and qualified customers. it includes document proving with sufficient reliability, the legal capacity and powers of the person signing, taxpayer identification number and registration of production units in the market operator’s information system by entering the data that the production unit holding participant.

5.3.5 Format Power Sale Bids

The data regarding production units stored in the market operator's information shall be production unit code defined by the market operator, description of the production units, types of production units, type of bid (sale or purchase), code of the electric system to which it belongs, minimum and maximum hourly power in MWh, maximum rising, maximum descending gradient, start-up and stop gradient, in mw/minute and indication of whether the hydroelectric management unit is made up of run-of-the-river hydro units.

In the electric power sale bids, they submit to the market operator, sellers shall include production unit code, description of the bid, type of bid, which will obligatorily be a sale bid, daily scheduling horizon date and default bid for each production unit and scheduling period.

5.3.6 Information from Market Operator to Sellers

The market operator shall inform sellers in the daily market as:

- Automatic confirmation of the reception of the electric power sale quotation
- Placement of the bid content information at the market participants' disposal in such a way as to allow them to reproduce the matching process in their computer systems as from the end of the predetermined period of confidentiality
- Verification of the electric power sale quotation made by the seller, and automatic notification of the verification result
- acceptance of the electric power sale bid
- Inclusion or non-inclusion in the matching results, and, as appropriate when the participant requests this justification

5.3.7 Format for Buyer Bid

Purchase bids shall be submitted to the market operator. The market operator shall register the purchasing units in the market operator's information system, recording the data which the purchasing unit owner shall have registered as well as the information provided by the said unit owner. The data to be recorded in the market operator's information system shall be:

- Purchasing unit code (defined by the market operator)
- Description of the purchasing unit
- Type of purchasing unit
- Type of bid (sale or purchase)
- Code of the electric system to which it belongs
- Minimum and maximum hourly power in MWh, expressed to no more than one decimal place.

5.3.8 Data shared by distribution Company

Distributors shall send data through the market operator's information system, either via screen or file transfer. the data to send for a scheduling period includes special-regime producer's code, date when the data will come into effect (effective date), description of the information and hourly values of surplus forecasts, in MWh to no more than one decimal place.

5.3.9 Data shared with Grid Company

Market participants shall send the market operator the supplies that are to be made in each of the grid connection bus bars to satisfy the demands accepted in the matching result. Each market participant shall send the market operator a file containing each purchasing unit's supplies. The supply files shall contain, for each purchasing unit or set of resellers' units, the split factors expressed as percentages. The supplies must be received before the deadline hour established. Those not received before the deadline shall be processed based on factors deduced from an equivalent previous day. If errors are found in a purchasing unit's split, they shall be modified by standardizing them. The market operator shall inform the system operator of the purchasing units' supplies by bus bar in MWh with no more than one decimal place.

5.3.10 Settlement and Credit and debit notes

After making the monthly settlement, the market operator shall notify the market participants who had acted as buyers or sellers, by whatever means or medium which leaves a record of the transmittal and reception of the notification, of the provisional debit and credit notes indicating the payments and collections which they are to make or receive, respectively, in each monthly settlement period. The market operator shall issue the debit and credit notes at least three days before their due dates.

5.3.11 Format for Buyer Bid

Publication by the market operator of the following information:

- Aggregate supply and demand curves of the daily and intra-day markets
- Sales capacities and intra community and international exchanges by border
- Results of the power schedules, aggregated by participant and calendar month, of the electric power production market publish on monthly basis
- Bids submitted by the participants in each of the daily and intraday markets on monthly basis published three months after the end of the month reported

5.3.12 Coordination between Market Operator and System Operator

This information shall be contained in files and its format and transmittal shall be defined by both operators, and the information pertaining to each participant shall be placed at the latter's disposal. As soon as the process or market whose information the files contain is completed, the files shall be sent to the system or market operator, as appropriate, and simultaneously the market participants shall be sent the data corresponding to their purchasing and production units.

5.3.13 Information the System Operator must supply to Market Operator

The information that the system operator shall send is Information relative to the instances of outage of production units, Information sent before the close of the session, Demand forecast and Bids pertaining to long-term international contracts.

5.3.14 Information which the market Operator must supply to the System Operator

The market operator shall provide the following information to the system operator:

5.3.14.1 Daily Market

Base matching schedule (PBC) contains the result of the assignment of power as a solution of the daily, Daily market marginal prices and File containing the marginal prices resulting from matching.

5.3.14.2 Daily Market bid data

This file contains all the valid bids, both matched and unmatched, received in daily market process, Daily market order of financial precedence, the completely matched, partially matched and unmatched bids arranged in order according to the criteria established in the pertinent rule.

5.3.15 Publication of information

All the information provided by the market operator to a market participant on another participant or participants in compliance with these rules, and whose transmission does not arise from the existence of a claim or complaint, shall be given to the general public, except the information supplied to distributors giving the data that are exclusively pertinent to their distribution system, aggregated for each of their bus bars as defined and notified by the system operator, which the distributors must maintain confidential. To disseminate information to the general public, the market operator may make use of its public website.

6 Proposal for Minimum Set of Standardized

6.1 Data to be exchanged between operators for cross border links observable area

For inter-connection studies the requester shall make a request for connection in the planning stage to the Appropriate Transmission Utility. In case a requester is seeking interconnection to a distribution system, such a request will be made to the distribution licensee. The Appropriate Transmission Utility or distribution licensee shall carry out the interconnection study to determine the point of inter-connection, required interconnection facilities and modifications required on the existing grids, if any, to accommodate the interconnection. The study may also address the transmission system capability, transient stability, voltage stability, losses, voltage regulation, harmonics, voltage flicker, electromagnetic transients, machine dynamics, Ferro resonance, metering requirements, protective relaying, sub-station grounding and fault duties, as the case may be.

6.1.1 General Structural Information

- Substations' regular topology and other relevant data by voltage level
- Transmission lines
- Transformers connecting the DSO's, demand facilities or power generating facilities
- Maximum and minimum active and reactive power of power generating modules
- Phase-Shifting Transformers
- High Voltage DC lines
- Reactors, capacitors, and static VAR compensation
- Operational security limits
- Type of regulation concerning tap changes
- Voltage regulation range
- Regarding HVDC lines and FACTS device, the dynamic models of the device and its associated regulation suitable for large disturbances
- Topology of transmission system > 400kv
- Model or equivalent of transmission system < 400 kV having significant impact on its transmission system
- Protection set points of the lines included as external contingencies in neighboring operator's contingency lists

6.1.2 Generator specific structural data for dynamic stability analysis

- Electrical parameters of the alternator suitable for dynamic stability analysis, including Inertia
- Protection Models
- Step up transformers description
- Minimum and maximum reactive power
- Prime movers and excitation system models suitable for large disturbances

6.1.3 Real Time between all operators via an IT Tool

- Frequency
- Frequency restoration control error or an equivalent parameter
- Measured active power exchange between LFC area
- Aggregated generation in feed
- System state
- Set –Value of the FR controller
- Power Exchange via the virtual tie-lines

6.1.4 Real Time data only between operators within its observable area

- Actual Substation Topology
- Active and Reactive power in bay, including transmission, distribution and lines connecting significant grid user
- Active and reactive power in transmission bay, including transmission, distribution and significant grid user connecting transformers
- Regulating positions of transformer, including phase-shifting transformers
- Measured or estimated bus bar voltage
- Reactive power in reactor and capacitor bay or from a static VAR compensator
- Restrictions on active and reactive power supply capabilities with respect to the observable area

6.1.4.1 Data to be provided to transmission operators by distribution operators of each transmission system connecting distribution systems in the observable area

It comprises of:

- Structural Information (Every 6 Months) in which substations are differentiated by voltages
- Lines that connect the sub-stations
- Transformers from the sub-stations
- Significant grid users
- Reactors and capacitors connected to the substations
- Total aggregated generating capacity
- The related information concerning the frequency behavior and best possible estimate of power generating modules by primary energy source

6.1.4.2 Data to be provided to operators by owners of each generation facility directly to the transmission network in the observable area

It comprises of:

- **Structural Data** in which general data, including installed capacity and primary energy source, data for short-circuit calculation, FCR, FRR and RR data for power generating facilities offering or providing this service, protection data, voltage and reactive power control capability, data and models necessary for performing dynamic simulation, power generating facility transformers data for generators, turbine and power generating facility data including time for cold and warm start for generators and data necessary for restoration for restoration of generators.
- **Scheduled Data** day ahead and intra-day basis of its active power output and active power reserve amount and availability and availability and its scheduled unavailability or active power capability restriction. Any forecasted restriction in the reactive power control capability
- **Real time Data** position of the circuit breakers at the connection point or another point of interaction agreed with the operator active and reactive power at the connection point or another point of Interaction agreed with operator. In the case of power generating facility with consumption other than auxiliary consumption, net active and reactive power

6.1.4.3 Data to be provided to operator by owners of interconnectors and other lines connected directly to the transmission network

It comprises of:

- **Structural data:** HVDC owner has to provide name and plate data of the installation, transformer data, data on filters and filter banks, reactive compensation data, active power control capability, reactive power and voltage control capability, active or reactive operational mode prioritization if it exist frequency response capability, dynamic models for dynamic simulation, protection data, fault ride through capability, ac line and interconnection or owners to provide, name plate data of the installation electrical parameters and associated protections.

- **Scheduled Data HVDC** owner has to provide on a day–ahead and intra-day basis, its active power schedule and active power reserve and availability. Without delay its scheduled unavailability or active power restriction. Any forecasted restriction in the reactive power or voltage control capability.AC line and interconnector owners to provide the scheduled unavailability or active power restriction data.

- **Real Time Data** about position of the circuit breakers, operational status, active and reactive power.

6.1.4.4 Data provided to operator by transmission facilities directly connected to transmission network in the observable area

It comprises of:

- **Structural Data** in which electrical data of the transformers connected to the transmission system, characteristics of the load of the demand facility, characteristics of the reactive power control and its behavior at the voltage ranges are included.

- **Schedule Data** is divided as scheduled active and forecast reactive consumption on a day ahead and intraday basis, including any changes of these schedules or forecast, any forecast restriction in the reactive power control capability, minimum and maximum power to be curtailed in demand response.

6.1.4.5 Data to be exchanged between operators for cross –border links observable area

Real-time Data must comprise of detail about active and reactive power at the connection point moreover minimum and maximum power to be curtailed.

6.1.4.6 Data provided to operator by transmission facilities directly connected to distribution networks or aggregators within the observable area

It comprises of:

- **Structural Data**: Structural minimum and maximum active power available for demand side response. Maximum and minimum duration of any potential usage of this power for demand side response

- **Scheduled Data**: Forecast of unrestricted active power available for any planned demand side response.

- **Real time Data**: Active and reactive power at the connection point. Moreover confirmation that the estimated actual values of demand response are applied.

6.2 Data for Power Market/ Electricity exchange

6.2.1 Coordination between Market Operator and System Operator

Table 8 Data format for Registration in market information system.

Data Format			
Supplier	**Buyer**	**Electricity Trader**	**Electricity Transmission Company**
Full Name	Full Name	Full Name	Full Name
Short Name	Short Name	Short Name	Short Name
Owner of Company	Owner of Company	Owner of Company	Owner of Company
Full Address	Full Address	Full Address	Full Address
Contact: email and phone number	Contact: email and phone number	Contact: email and phone number	Contact: email and phone number
Contact person (Full name designation, contact number and email)	Contact person (Full name designation, contact number and email)	Contact person (Full name designation, contact number and email)	Contact person (Full name designation, contact number and email)
Country of company Registration	Country of company Registration	Country of company Registration	Country of company Registration
Company Registration Certificate	Company Registration Certificate	Company Registration Certificate	Company Registration Certificate
Tax Clearance	Tax Clearance	Tax Clearance	Tax Clearance
Details of Power Plants	Details of Industry/ Consumptions		Details of Transmission Lines
Nearest Substation	Nearest Substation		
Location of Metering	Location of Metering		
Bank Details for transaction and guarantee	Bank Details for transaction and guarantee		

6.2.2 For Bid Submission by Buyer and Supplier

Table 9 Data format for bidding

Data Format				
Bidding by Supplier	**Bidding by Buyer**	**Bid Reception Conformation by Market Operator**	**Bid Matching**	**Financial Settlement**
Code number of supply bid	Code number of Buying Bid	Name of Buyer or Supplier	Total Number of Participants	Name of Buyer or Supplier
Location of bid submission	Location of bid submission	Purchasing code or Selling Code	List of Matched Bids (selling and buying)	Purchasing code or Selling Code
Name of Bid Submitter, Designation, Contact No. and Email	Name and ID of Buyer	Declared Maximum Buying Capacity or Selling MWh	Volume of Matched Electricity Demand and Supply	Volume of Transacted Electricity Trade
Verifications	Name of Bid Submitter, Designation, Contact No. and Email	Electricity Buying or selling Quantity	Matching Available best tariff	Rate offered for Transacted Electricity per unit
Power Plant Information	Verifications	Rate offered for Buying or selling Electricity per unit	Total Amount of Transaction	Total Volume of Transacted electricity
Declared Maximum Generation Capacity MWh	Use of Power	Time of Bid Submission		Total Amount of Transaction
Electricity Supply Quantity	Declared Maximum Buying Capacity MWh	Location of Bid Submission		Recommendation of bank Transfer
Cost of Electricity per unit	Electricity Buying Quantity			
Bank details	Price of Electricity per unit			
	Bank details			

7 Recommendations and the Way Forward

7.1 Institutional Set Up to be Established

- Regional Power Trade Committee (Lead Head of States of SAARC member Countries) for approval process
- Coordination Committee (Lead by Secretaries of Ministries related to power) for coordination
- Panel of Experts for designing electricity market model, market operation rules, grid code and relevant policies
- Regional Electricity Regulation Authority managing Regional Power Trade Committee, Coordination Committee, Panel of Experts
- Regional Level institute for Utilities, Market Operators, Buyer and Sellers, Traders, Grid Operators etc.

Panel of experts shall propose viable electricity market and market operating guidelines where standard data shall be proposed and designed. For regional level planning, long term and short term planning shall be shared among countries. These plans should be compiled by regional regulatory authority and shared to stakeholders. Skilled personnel should be engaged for designing standard format for regional competitive power market. Necessary infrastructure and quality of infrastructure like dedicated internet, cyber security, protection system etc. shall be defined and developed accordingly. Roles of Regional System Operator, National System Operator and Transmission Line Operators shall be clearly defined. Communication shall be done between Regional Market Operator, Regional System Operator and National System Operators and Regional Transmission Line Operators. Guideline/Policy of data and information exchange shall be defined. And standard format for exchanging data and information shall be developed with consensus and harmonized manner. Data designed by CERC, India are in used for bilateral electricity trade. Such format can be used to come up for the design of the practical oriented format as a first step.

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