New Business Opportunity for Thailand Demand Response of Utility

Parinya Sonsaard[1,2] and Nipon Ketjoy[1,*]

ARTICLE INFO

Article history:
Received: 13 June 2020
Revised: 31 July 2020
Accepted: 19 August 2020

Keywords:
Load Aggregator
Automated Demand Response
Grid Modernization
Smart Grid

ABSTRACT

Grid Modernization is a process to develop an electrical system in order to be a modernized. Smart Grid is the key infrastructure that most of the utilities use. Furthermore, laws, regulations, and codes of each country need to be improved according to new technologies and business. Demand Response (DR) is one of the key functions to modernize the electrical system which can reduce the peak demand that will occur in a short period annually. This research consists of Thailand's DR development framework as a guideline to implement the DR market of Thailand's utilities and newcomers. DR consists of price-based DR and incentive-based DR. The incentive-based DR is a reliable tool of the utility which they can order their customer or a load aggregator (LA) to reduce or postpone demand use at a specific time. The incentive-based DR is a new business model of the electrical energy market in Thailand, which can be made by a utility or LA. LA is required to invest in the infrastructure and end-device to manage and control the appliance of a participated customer. Both price-based DR and incentive-based DR will be implemented by Thailand's policymakers. Moreover, the utility has to study DR technology and DR business model before doing DR business so that utility decide to invest in the DR business.

1. INTRODUCTION

Thailand's utilities plan to improve the existing electrical grid to be more efficient in order to support the government's policy of country's development and various applications in the long run due to changes in society, economy, and technology.

New technologies, such as Electric Vehicle (EV), Distributed Generation (DG), Virtual Power Plant (VPP), and Blockchain will generate electricity and trade between customers (Peer to Peer). Utilities must well prepare Energy Trading Platform to trade between DG and customers in a new energy market.

Based on the driving forces, the future of the electricity trading market will change. Therefore, Thailand's utilities also have to transform business to survive such changes as well.

Utilities are planning for the improvement of the transmission and distribution system in order to modernize the future electrical system technology. The utility will apply smart grid technology to manage various electrical systems more efficientlly and also use the most effective assets. Based on the formulation of a conceptual framework for improving the transmission and distribution system to be modernized, supporting future electrical system technology, the utility has to apply various technologies that will be used in the generation system, transmission system, distribution system, and cyber security. A new business model includes the customer behavior for an investment which will allow the utility to be able to support the changes in the new electricity market.

Demand Response (DR), one of the key technologies in the future, is the use of the reduction of electricity usage during high demand period in order to reduce the demand for electricity in the country. DR will save the investment and operation cost in the generation, the transmission, and distribution system. Thailand has tested DR pilot projects which are the manual DR and provide low incentive since 2014 [1]. Low incentive does no capture customers' attention to commercialize DR.

This study proposes Thailand's DR business market of Thailand utilities that will change a role of current Thaialnd's energy market moving toward a new era of Thaialnd's energy market. This paper also proposes LA development in each state which supports semi-automated DR and automated DR.

[1]*School of Renewable Energy and Smart Grid Technology, Naresuan University, Thailand 65000.*
[2]*Provincial Electricity Authority, 200 Ngamwongwan Road, Ladyao, Chatuchak, Bangkok, Thailand 10900.*
**Corresponding author:* Nipon Ketjoy; E-mail: niponk@nu.ac.th.

2. DEMAND RESPONSE

2.1 Demand response definition

Demand response (DR) is a change in electrical demand from regular patterns which responds to price or incentive signals given by a utility to persuade a participated customer to lower electrical demand during a period of high demand to stabilize the electrical system [2].

2.2 Role of DR in electrical system planning

DR which is a key function of electrical system in the near future can change the electrical demand in specific period instead of using a peaking power plant. DR can be grouped into two categories as shown in Fig. 1 [3]:

1) Price-Based DR

Price-based DR or economic DR one of the DR options can manage demand by price signals as follows:

a. Time of Use rates (TOU)

b. Day-ahead hourly pricing (Day-ahead or near-real-time: RTP)

c. Real-time hourly pricing (RTP)/ Critical peak price (CPP)

2) Incentive-Based DR

Incentive-based DR or reliability DR is another of DR options can manage demand by incentive to participated customers as follows:

d. Capacity/ancillary services programs

e. Demand bidding/buyback

f. Emergency programs

g. Interruptible programs

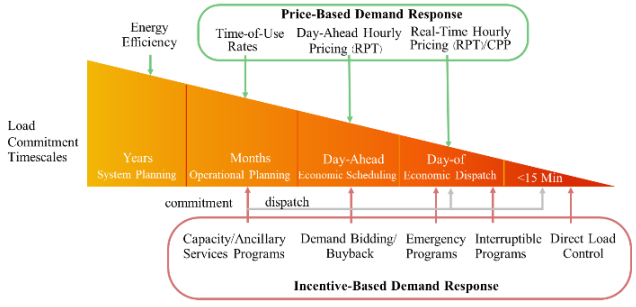

Fig. 1. Role of DR in electrical system planning and operation.

2.3 Levels of DR automation

Levels of DR automation can be defined as follows [4]:

1) Manual DR

A utility or a LA send an email or a short message to a participated customer, then a participated customer manually switches off apparatus.

2) Semi-Automated DR

A utility or a LA send a command to a participated customer, then a participated customer acknowledges an energy management system which was programmed to reduce to use energy.

3) Fully-Automated DR

A utility or a LA send a command to a participated customer, then a participated customer's energy management system reduces energy usage automatically as a participated customer was programmed.

3. THAILAND DEMAND RESPONSE ARCHITECTURE

The current Thailand's electrical energy market is an enhanced single buyer (ESB) which means only Electricity Generating Authority of Thailand (EGAT) who can purchase electric energy from any power producer in Thailand and import from other countries. Thailand's electricity retailers can purchase eletricity only from EGAT as shown in Fig.2. A very small power producer (VSPP) may can sell electric energy to retailer depending upon policy.

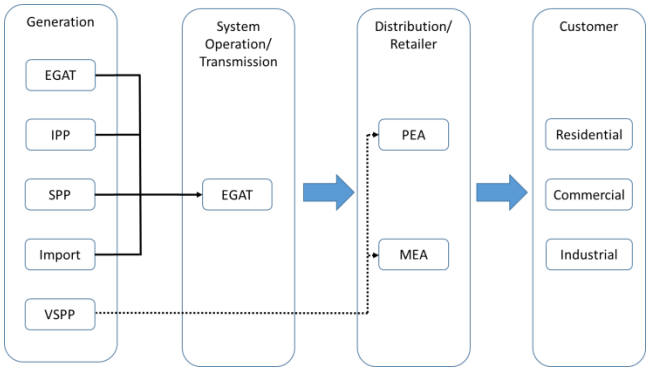

Fig.2. Current Thailand' electricity energy market.

Fig.3 shows Thailand's DR architecture will use for DR market in Thailand [5]. EGAT acts as Demand Response Management System (DRMS). Provincial Electricity Authority (PEA) and Metropolitan Electricity Authority (MEA) acts as a Load Aggregator Management System (LAMS). In the near future, the private sector will act as LAMS level 2.

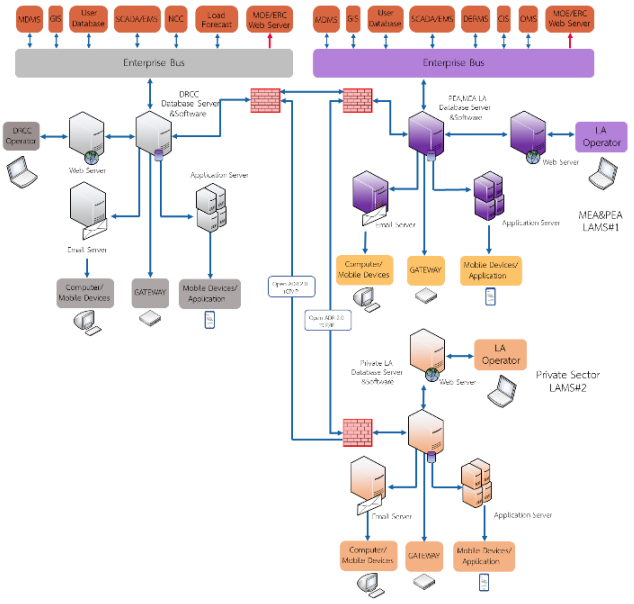

Fig. 3. Thailand's Demand Response Architecture.

4. THAILAND AUTOMATED DEMAND RESPONSE IMPLEMENTATION FRAMEWORK OF THAILAND UTILITY

In Thailand, fully-automated DR or automated DR (ADR) and semi-automated DR implementation can be described as follows:

4.1 Open ADR standard

OpenADR, the standard for implementation of DR, is open and interoperable for command and information exchange among DR market [6]. Fig.5 shows an OpenADR standard architecture contains components as follows [6]:

1) Virtual Top Node

Virtual Top Node (VTN) is a DR server that can send OpenADR command to VEN and receive metering data from VEN. This function is for a demand response control center (DRCC).

2) Virtual End Node

Virtual End Node (VEN) is a client device which respond to VTN command such as an energy management system (Building Energy Management System: BEMS, Home Energy Management System: HEMS, Factory Energy Management System: FEMS), direct load control: DLC, a thermostat. This function is for a participated customer.

3) Virtual End Node/ Virtual Top Node

VEN can be a server which can get a command from VTN and send command to VEN as VTN. This function is for an LA which is called load aggregator management system (LAMS).

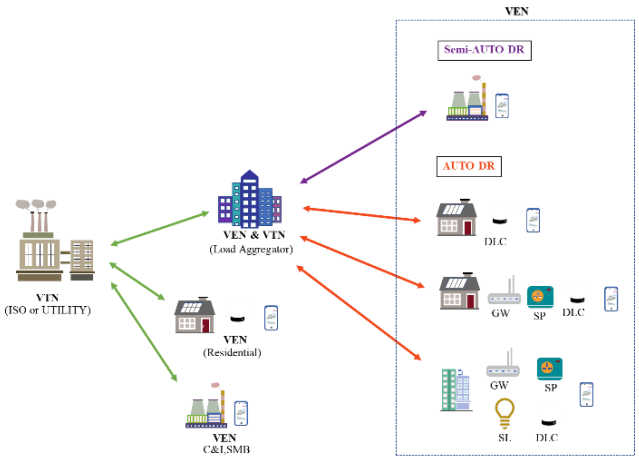

Fig. 4. OpenADR 2.0 b standard [5].

4.2 Thailand's ADR implementation

Thailand's utility plans to implement ADR using OpenADR protocol as shown in Fig.5. EGAT acts as demand response control center or demand response management system or virtual top node (DRCC/DRMS/VTN) who maintains electrical system stability and calls DR. DRCC sends command to a LAMS to reduce peak demand of participated customer. PEA/MEA acts as load aggregator level 1 (LA#1/VEN/VTN). LA#1 gets command from DRCC before LA#1 calculates and selects target customer to reduce peak demand. A participated customer acts as VEN which is willing to join DR program. Private sector acts as load aggregator level 2 (LA#2). Green line is communication for command signal and metering data which is two-way communication from DRCC to LA#1, then from LA#1 to LA#2 or customers [7]. LAMS shall use utility's smart meters to measure and verify the reduction of electricity demand and energy. An additional real-time meter may be required to measure a real-time load reduction of a participated customer.

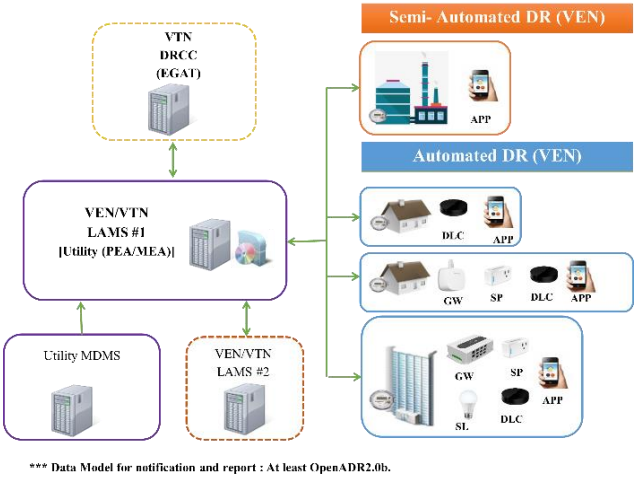

Fig. 5. PEA's Pilot DR Implementation Plan.

4.3 Thailand's future energy market

Thailand future electricity market has to change a role of the utilities as shown in Fig.6 and Fig.7. Fig.6 shows Thailand future eletricity market at the beginning stage. Fig.7 shows Thailand future electricity market at the mature stage. The details shown in section 5.

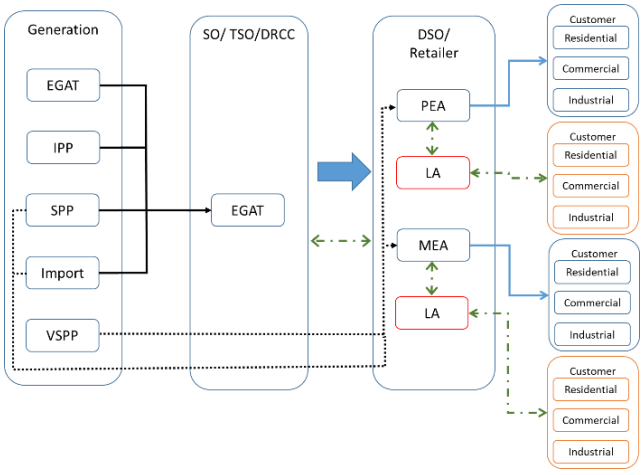

Fig. 6. Thailand's future electricity market at the beginning stage.

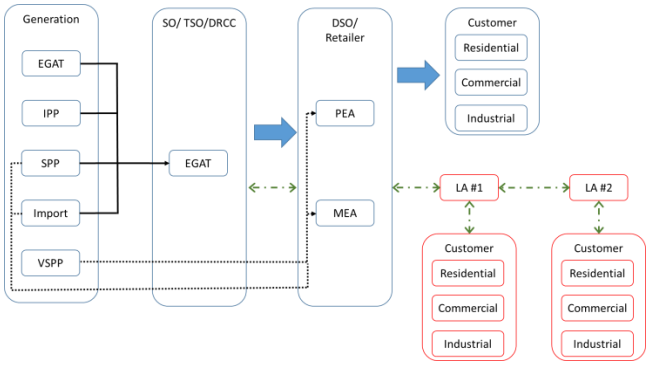

Fig. 7. Thailand's future electricity market at the mature stage.

4.4 Thailand's DR draft program and tariff

Thailand Energy Regulation Commission had a public hearing on draft of Thailand's DR program and tariff on September 8th, 2016. The DR program and tariff are shown in Table.1, Table.2, and Table.3 [1].

Table 1. Draft of Thailand's DR Program and Tariff

Detail	DR Program			
	Critical Peak Pricing (CPP)	Interruptible Load Program (ILP)	Direct Load Control (DLC)	Emergency DR Program (EDRP)
Objective	- Yearly Peak Cut	- Emergency - Yearly	- Emergency - Yearly	- Gas Supply
		Peak Cut	Peak Cut	- Yearly Peak Cut
Goal	100 MW	200 MW	50 MW	150 MW
Target Group	Customer Category 3, 4, 5	Customer Category 3, 4, 5 Group 1 IL ≥ 1 MW Group 2 1 MW ≥ IL ≥ 500 kW	1.Residential and Small Commercial Customer > 12 kV 2. Customer Category 3, 4, 5	Customer Category 3, 4, 5
Participation	Enroll with Utility	Enroll with Utility	Enroll with LA	Enroll with LA
Period	April-May	9.00 A.M. - 10.00 P.M.	Summer and Emergency	Gas Supply
Dispatching	April-May	1 Hour Ahead	15 Minute Ahead	24 Hour Ahead
Baseline	-	Meter Reading Before Calling	Meter Reading Before Calling	10 Day Before, Working Day and Weekend
Tariff/ Incentive	As shown in Table.2	As shown in Table.3	Incentive (Baht/kW/ Month) #1 42 ≤3 Hr./Time, 2 Time/Day, 10 Time/Month, 40 Time/Year #2 21.42 ≤3 Hr./Time, 1 Time/Day, 10 Time/Month, 20 Time/Year #3 42.84 ≤6 Hr./Time, 1 Time/Day, 10 Time/Month, 20 Time/Year	Incentive 5.63 Baht/kWh
Penalty	High Rate at CPP Period	Current Interruptible Rate	Current Interruptible Rate	54.14 Baht/kW

Table 2. Tariff of Critical Peak Pricing (CPP)

Voltage (kV)	Critical Peak	Peak	Off-Peak
>69	9.1617	4.1283	1.3379
12-24	9.3424	4.2097	1.3475
<22	9.6659	4.3555	1.3646

Table 3. Tariff of Interruptible Load Program (ILP)

Voltage (kV)	#1	#2	#3
>69	31.3	52.72	31.3
12-24	56.12	94.53	56.12
	≤ 3 Hr./Time, 2 Time/Day, 10 Time/Month, 40 Time/Year	≤ 3 Hr./Time, 1 Time/Day, 10 Time/Month, 20 Time/Year	≤ 6 Hr./Time, 1 Time/Day, 10 Time/Month, 20 Time/Year

5. THAILAND DEMAND RESPONSE BUSINESS MARKET

In this part, the development of DR energy market and LA business of Thailand's utilities is proposed. It will change from ESB into a new era of energy market as other countries that will change role of current utility described in Fig.6 and Fig.7. The detail of energy market change in Thailand consists of:

5.1 Thailand's future energy market

Thailand energy market will have system operator (SO: EGAT), transmission system operator (TSO: EGAT), demand response control center (DRCC: EGAT), distribution system operator (DSO: PEA/MEA), Retailers (PEA/MEA/Private sector), and load aggregator (LA). LA will be a new player in the energy market. PEA/MEA/EGAT and a private sector can be LA.

1) At the beginning stage

At the beginning stage, generation utility (EGAT) will establish the DRCC to manage and control LA for the DR program. A distribution and retailer utility (PEA/MEA) will establish the LA business unit to support the DR program. LA is not responsible for a retailer as a utility. LA is a newcomer of the electrical energy market to aggregate and manages a group of participated customers. DR and LA business may be small market and gain low profit in this stage. PEA and MEA have to prepare the control system to be a DSO which plays an important role in the future distribution system.

2) At the mature stage

After DR business was started in the market, DR and LA business will become mature. LA will obtain high profit of this business. This market will consist of LA#1 and LA#2 which are established by a utility and a private sector. LA#1 has to have a sufficient group of participated customers and LA#2.

5.2 Role of future Thailand's electricity sector

Thailand's electricity sector will change its role. LA will be a newcomer in the market. The role of future Thailand's electricity sector is described as follows:

1) Generation

In an ESB era, most of the generation has to sell electricity energy to EGAT. Only very small power producers (VSPPs) can sell electricity energy to PEA/MEA. EGAT is responsible for electrical energy generation and purchase and sell to PEA/MEA.

In the next era, the generation can sell electricity to a utility (EGAT/PEA/MEA) or customers.

2) System Operator/ Transmission System Operator/ Demand Response Control Center

System Operator (SO)/ Transmission System Operator (TSO)/ Demand Response Control Center (DRCC) is one of the key of the electrical market where it has to keep system stability between generation and load. DR is one of the key functions so that SO can keep system stability.

3) Distribution Operator/ Retailer

In an ESB era, PEA/MEA is distribution utility which is responsible for distribution network and retailer.

In the next era, PEA/MEA is a Distribution Operator (DSO)/ retailer and private company may be a retailer.

4) Load Aggregator

Load Aggregator: LA which is a newcomer in the energy market is responsible for managing a group of the participated customer of DR program in order to reduce maximum demand when calling of utility.

- At the beginning stage, PEA/MEA may have LA business unit in the same organization.
- At the mature stage, PEA/MEA has to set up a new company of LA business which is separated from main organization. Private company can be a LA.

5) Customer

A participated customer of the DR program is a customer who can reduce energy use when a utility calls DR event. The customer can get the benefit of joining the program as capacity payment (CP) and energy payment (EP). CP is an incentive for a participated customer which is paid according to reducing electrical demand per kW. EP is an incentive for a participated customer which is paid according to reducing electrical energy per kWh.

5.3 Thailand's load aggregator business

LA will be a new business in electricity energy market where a group of participated customers is selected, collected and managed in response to the command from a

utility. DR business will have LA level 1 and level 2 which have role LA#1 and LA#2 as follows:

1) Load Aggregator Level 1

LA level 1 (LA#1) is the primary level where a LA receives command and sends information between DSO and LA#1 directly. LA#1 pays an incentive that gets from DRCC to a participated customer and gets a commission from DRCC. LA#1 has to create an incentive to a participated customer who is sufficiently motivated. LA#1 has to pay a fee for meter data of a participated customer.

2) Load Aggregator Level 2

LA level 2 (LA#2) is the secondary level where a LA receives command and sends information between LA#1 and LA#2. LA#2 is a group of participated customers that do not large enough to be a LA#1.

5.4 Thailand's load aggregator business organization of utility

In the near future, LA is the new business in Thailand where the utility has to prepare staffs and technologies.

At the beginning state, PEA/MEA will be the DSO/Retailer and the LA business will be the business unit under PEA/MEA as shown in Fig.8. The staff and facilities of the LA business unit will be shared from PEA/MEA. The LA business unit will consist of the supporting group and the engineering group under the Director of the LA business unit. The supporting group will consist of the marketing team, the financial team, and the law team. The engineering group will consist of the engineering team, the network operations center (NOC), and the information and communication technology (ICT) team.

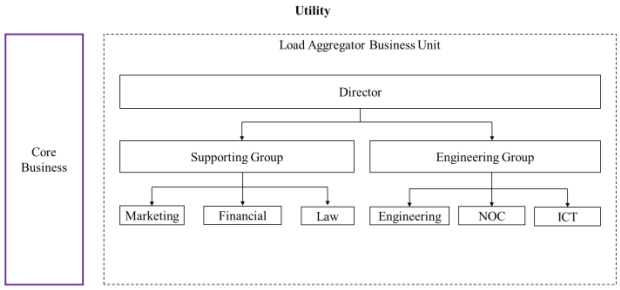

Fig. 8. LA business organization of utility at the beginning stage.

At the mature state, LA business will separate from PEA/MEA and it will be LA#1 as shown in Fig. 9. LA#1 will consist of the supporting group, the marketing group, and the operation group under the CEO's LA#1. The supporting group will consist of the financial team and the law team. The marketing group will consist of the commercial customer team, the industrial customer team, the corporate customer team, and the residential team. The operation group will consist of the engineering team, NOC, and the ICT team.

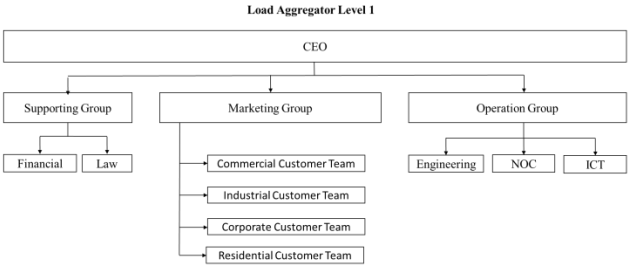

Fig. 9. LA business organization of utility at the mature stage.

LA#2 is a private sector supporting the small group of the participated customer that will be a small company

5.5 Thailand load aggregator business model and structure

Fig.10 and Fig.11 show the route of command, information of metering and verification, and incentive payment among the DRCC, the LA, and the participated customer.

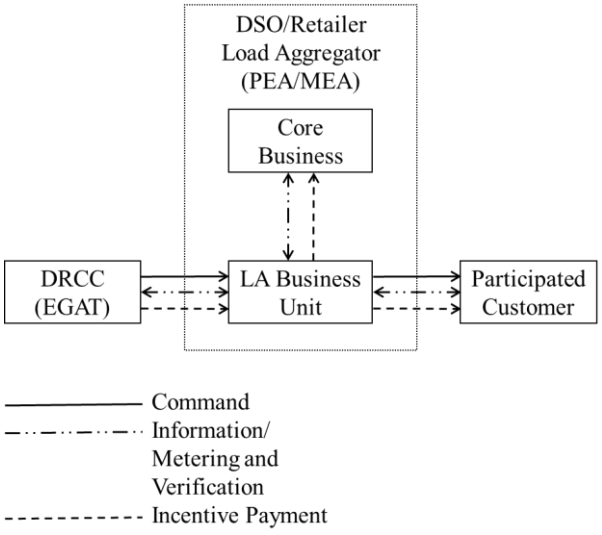

Fig. 10. Thailand's LA business model and structure at the beginning stage.

At the beginning state, DRCC sends a command to PEA/MEA (LA business unit), then LA business unit uses a LAMS to select a participated customer and send a command to a participated customer. The participated customer has to accept or decline the command.

The information from a participated customer sends from a smart meter to LA business unit to measure and verify the reduction of demand of a participated customer for an incentive payment. The DRCC receives information from LA business unit to measure and verify the reduction of demand of a group of the participated customer of LA business unit.

The incentive will be paid by DRCC to LA business unit. Accordingly, the LA business unit will pay to a participated customer. The LA business unit will get the

commission from the incentive before LA business pays to the participated customer.

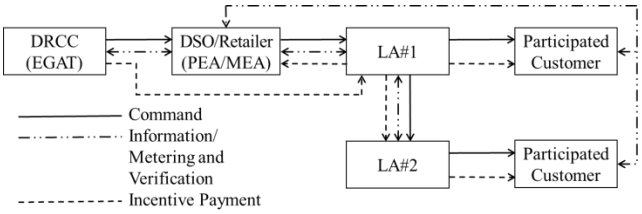

Fig.11. Thailand's LA business model and structure at the mature stage.

At the mature state, DRCC sends a command to DSO, then DSO sends a command to LA#1. LA#1 uses an LAMS to select a participated customer and/or LA#2 and send a command to a participated customer and/or LA#2. The participated customer and/or LA#2 has a choice to accept or decline the command.

The information from a participated customer is sent from a smart meter to DSO. LA uses information from DSO to measure and verify the reduction of demand of a participated customer for an incentive payment. The DRCC gets information from DSO and LA to measure and verify the reduction of demand of a group of the participated customer of LA#1 and LA#2. LA#1 has to pay for information usage to DSO.

The incentive will be paid by DRCC to LA#1. Accordingly, the LA#1 will pay to a participated customer and/or LA#2. The LA#1 and/or LA#2 unit will get the commission from the incentive before LA#1 and/or LA#2 pays to the participated customer.

6. SUMMARY AND CONCLUSIONS

DR is a change in electrical demand which responds to price or incentive signals given by a utility to reduce electrical demand during a period of high demand.

This study presents the new role of future DR energy market in the energy market composed of SO, TSO, DRCC, DSO, LA#1, LA#2, and participated customers. LA is one of the key success factors in DR business. Furthermore, the development of LA business in Thailand's energy sector is proposed.

In the near future, Thailand energy market will change from ESB into the energy market or the power pool market, so will each other country market. In Thailand, the energy market which may be different from other counties have three key utilities (EGAT, MEA, and PEA). Newcomers, LAs, energy market operators, and prosumers will change a role of Thailand's energy sector. EGAT will change a role from generation and transmission into generation, SO, TSO, and DRCC. PEA and MEA will change a role from distribution and retailer into DSO, retailer, and LA#1. The customer will become the prosumer; consumer and producer. DR will be a key function of the future electrical energy market where it will be used for system security instead of a peaking power plant. LA will be a new business where a group of participated customers is selected, collected and managed as requested by DRCC. LA is a key success factor of DR business because it has to select, collect and manage quality of a participated customer in response to DR program. However, a participated customer can choose a LA offering reasonable incentive and having highly efficient management profile. PEA and MEA have an opportunity to be an LA#1 in order that PEA and MEA have a good relationship with customers; otherwise, they may lose some margin when DR is called by DRCC.

Finally, Thailand utilities have to improve their electrical system using smart grid technology so that their power system will be modernized. DR is one of the key technologies to save the investment cost in generation, transmission, and distribution system by the reduction of electricity usage during high demand period in the country as many countries do. Moreover, a utility must prepare the new business process and business model for a new era of Thailand's energy market.

ACKNOWLEDGMENT

The authors would like to thank Provincial Electricity Authority (PEA), Thailand for the financial support, information, and facilities.

REFERENCES

[1] Energy Regulatory Commission. 2016. Public Hearing on Draft of Demand Response Program and Demand Response Tariff. Retrieved October 23rd, 2016 from the World Wide Web: https://www.erc.or.th/ERCWeb2/Front/PublicHearing/PublicHearingDetail.aspx?rid=306&muid=36&prid=74.

[2] Federal Energy Regulatory Commission. 2018. Reports on Demand Response & Advanced Metering. Retrieved March 3rd, 2019 from the World Wide Web: https://www.ferc.gov/industries-data/electric/power-sales-and-markets/demand-response/reports-demand-response-and.

[3] U.S. Department of Energy. 2006. Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them: A Report to The United States Congress Pursuant to Section 1252 of the Energy Policy act of 2005.

[4] P. A. Marry. 2005. Development and Evaluation of Fully Automated Demand Response in Large Facilities. California Energy Commission Public Interest Energy Research (PIER) Program, p. E-1.

[5] Energy Policy and Planning Office. 2016. Final Report: Study Project to Establish Guidelines for the Interoperability Development of Smart Grid Networks for Demand Response Application, pp. 7-25-7-28.

[6] OpenADR ALLIANCE. 2019. Frequently Asked Question. Retrieved October 6th, 2019 from the World Wide Web: www.openadr.org/faq

[7] Provincial Electricity Authority. 2018. Terms of Reference: Pilot Project Automated Demand Response of Provincial Electricity Authority, pp. 5-10.