Study on the Communication Requirements for AMI

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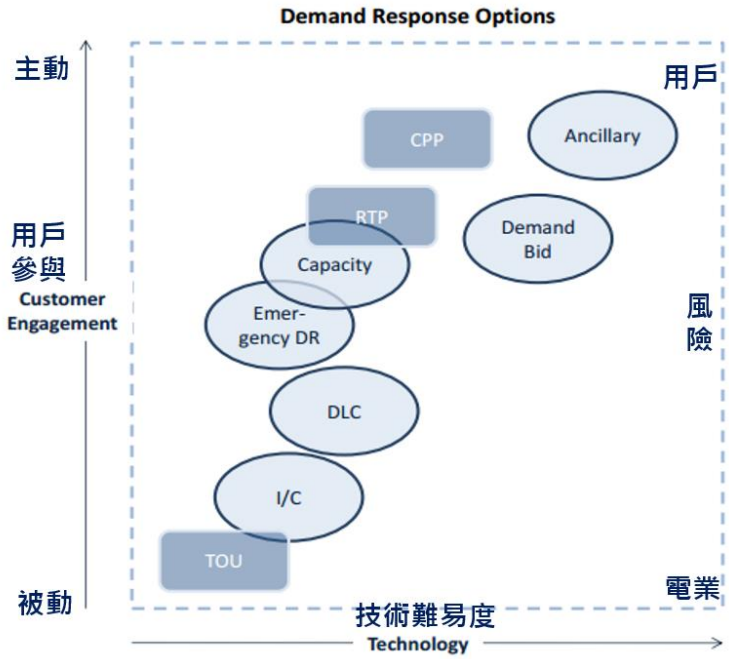
Research purpose

AMI attains the integration of smart meter and management system by transporting data from renewable energy generators, customers with demand response contracts and distribution system to the control center. It enables the power company to provide innovative service to both energy consumer and producer. With the help of bi-directional communication function, AMI can assist the utility and consumers in understanding the electricity consumption and user behavior patterns. AMI with bi-directional communication function enhances the application and effect of demand side management.

The demand side management can be divided into different categories according to the smart grid roadmap by International Electrotechnical Commission (IEC), including Meter Data Management System (MDMS), Billing, Customer Portal, Customer Information System (CIS), Demand Response Management System (DRMS). By integrating the above systems, the utility can perfect the smart grid markets. To extract more value from the deployments of AMI, the roadmap of demand side management is a key factor for Taiwan Power Company (TPC). Therefore, this research put forward the recommendations for strategies to develop the demand side management under new era of AMI.

Research results

In order to enable higher touch customer engagement DR options, new technologies were introduced, connecting the utility and consumer with bi-directional and real time communications. However, it comes with greater risk. The relation between customer engagement and technology requirement in different DR options are shown in Fig.1.



reference：2010_U.S._Smart_Grid_Vendor_Ecosystem_Report.pdf

Fig. 1. comparation of demand response options

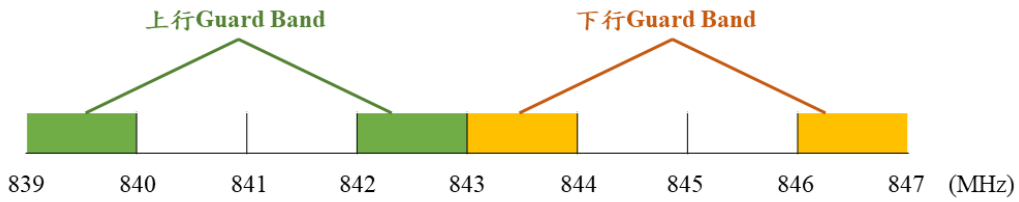
TPC can refer to this comparison while planning the implementation of DR progress, starting from carrying out the Time of Use (TOU) rate plan, then introducing new technologies step by step. With a view to satisfying the communication requirements of other advanced demand response options, such as Direct Load Control (DLC), Interruptible / Curtailable Load (I/C), Emergency DR, Capacity Market, Demand Bidding Programs, Real-Time Pricing (RTP), Critical Peak Pricing (CPP) programs and Ancillary Services. Moreover, according to the use cases of AMI deployments and applications in North America, integrating smart meter data with billing system and CIS is always a necessary and ongoing process involved. Furthermore, application of the data in MDMS and DRMS with big data analysis improves the DR program implementation. It's very vital to enhance the connection between all the management systems, to achieve the end-to-end application from AMI to the enterprise

Table 1 communication requirements of demand response

	ESI ⇔ load	Utility ⇔ load
bandwidth	1 kbps–30 Mbps	1 kbps–75 Mbps
latency	● < 1 ms to 1500 ms-(MAC+PHY) ● < 4 ms to 15 s-(End-to-end application)	● 10 ms to 5 s-(MAC+PHY) ● 10 ms to 15 min–(End-to-end application)
Payload	● Size:10–1500 bytes ● Freq.:50k packets/s– 1 packet/min	● Size:10–1500 bytes ● Freq.:50k packets/s – 1 packet/min
Communication technologies	● ISO 16,484–5/ANSI-ASHARE 135 ● ISO-IEC 14,543–3 ● IEEE 802.15.4 ● IEEE 802.11a,b,g,n IEEE 802.3 ● ECHONET	NR, LTE, WiMAX, GSM, EDGE, UMTS, GPRS, WCDMA, CDMA, Proprietary microwave and satellite.

reference：Communication technologies for smart grid applications: A survey

Advanced information and communication technologies enable AMI units to send data bi-directionally in order to provide killer applications such as demand response, whose requirements are shown in Table1. On July 2, 2018, the Ministry of Transportation and Communications (MOTC) allocated special spectrum 839-847 MHz for meter usages for the utilities. In FDD (Frequency Division Duplexing) systems, guard bands are required to reduce the adjacent-channel interference (ACI) by setting two symmetrical segments of spectrum for the uplink and downlink channels. That is, only 2 MHz remains for each bandwidth for uplink and downlink transmission in the discussed case as shown in Fig. 2, and the data rate is about 6 Mbps based on 64-QAM. Assuming that there are 10 thousand AMI data transporting at a time, with each data package 1 kbps, the requirement of data rate increase to 10 Mbps, exceeding the bandwidth limit. Thus, the limit of spectrum bandwidth must be considered when we try to set up a plan for future demand response.



reference：this research

Fig. 2. spectrum of smart metering

In addition, China assigns 840.5-845 MHz as the spectrum for the unmanned aerial vehicle (UAV), which potentially leads to interference. A few applications use this band for wireless communication around the world, causing the lack of modem; in other words, the customized modem for AMI communication is in need. The above issues must be considered when we set up plan for the AMI deployments and applications.