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Author(s)	Lee, WK; Fung, KB
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The Development of a Smart Metering Scheme

LEE, W. K. and FUNG, Kwok Bong

The University of Hong Kong
Department of Electrical and Electronic Engineering
Pokfulam Road, Hong Kong

Abstract

Collaboration is a term to characterize contemporary relationship between a supplier and a consumer. In the old days, an energy meter is the interface service-counter that prompts the double-coincidence of wants between the parties. Nowadays a meter can have smartness beyond registration of consumption units by the supplier. It can carry intelligence to serve demand side management. When the electrical-load-signature technology has been efficiently developed, then a user has to accept that the barrier to load monitoring and surveillance by other parties is no longer a technical issue, but primarily an ethical issue only. On the other hand, it is anticipated that experience curves shall drag down the cost of intelligent home management system to an extent that most of the homes can equip one system to enhance installation operation efficiency and human comfort. It is perceived that when a platform can be developed to permit the intelligence of two sides to share information, then each of them may support the other as a neighboring aide. This paper discusses on philosophies and models that shall develop the concepts.

Keywords: smart meter, demand side management, electrical load signature, home management.

1. INTRODUCTION

There are many reasons for redefining conventional business relationships. First, novel technology emerges; and second, the concept of value chain evolves; and third, the notion of sustainability develops. The changes of technical feasibility and entity values call upon the transformation of cold-tone exchange relationships into warm-setting collaboration relationships. Traditionally the relationship between an electricity supplier and her electricity consumer is represented by relationship-pairs such as source-and-sink; seller-and-buyer; or provider-and-customer. What then shall be the direction of new relationship?

New businesses appreciate collaboration models.[5] A new collaboration relationship like a partner-yet-neighbor connection is budding. In the past, the content of the aforementioned traditional relationship is measured by a device called electricity meter which, in most of the circumstances, also serves as the demarcation of responsibilities between the two parties. This meter is analogous to the service-counter interfaced between the seller and the buyer in general businesses. The meter obtains consumption history in terms of electrical values, based on which the supplier charges the user as per the agreement between the two parties. The benefits are entirely derived by double-coincidences-of–wants when the supplier wishes to sell, and at the same time, the user uses to buy.

Nowadays, thanks to digital technology, a meter can have smartness beyond such conventional capability; and by parallel technology, the user being served may also install an equally intelligent home management system at the demand side for developing efficiency and comfort. It is perceived that when a platform can be developed to permit the two intelligence sharing information [2], then each of them may support the other as a neighboring aide.

By installing incentives, the supplier may motivate a user to develop an equipment-selection and power-consumption habit which endows with a win-win scenario to the two parties. However, of course, technology must not infringe the generally accepted human values.

The University of Hong Kong has commenced research in load signature for some years [1],[3],[4]. Smart metering is a new extension of the study [2].

2. MODELS AND ARCHITECTURE

2.1 The Value Development Model

The model suggests that other than an interface meter connecting supply to the installation, the interface shall be a pair of contacts contributed by both parties; and communicated with each others as shown by Figure 1. Other than selling and buying of electricity, the contacts shall derive new and related values through communication and collaboration.

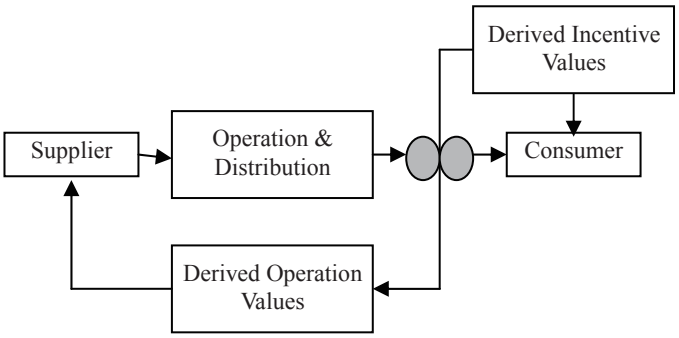

Fig 1

2.2 The Value Channel

The collaborative contacts are partners. Despite instant response between the partners may not desirable for 24-7 hours, yet a real-time dialogue is essential. It requires an advanced telecommunication technology to support value creation between the supplier in the upstream and the consumer in the downstream of the chain.

Between the supplier and the consumer, electricity is delivered through a network system or an integration of network systems which additional players are involved. For example, there are system operators, distributors, and in metropolitan cities: estate management. Understanding the players in the value channel (Figure 2) is one of the first steps in developing the smart connection.

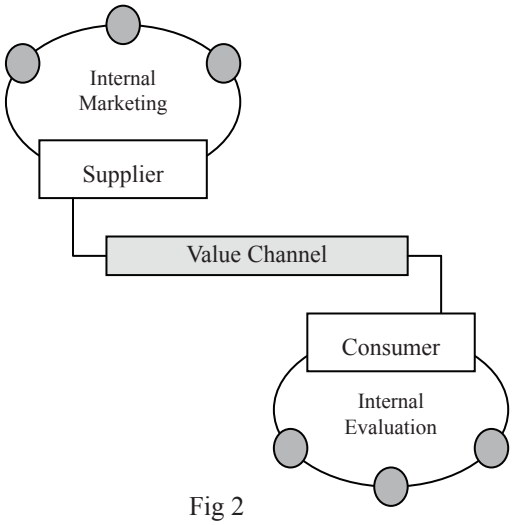

Fig 2

In the internal marketing loop of the supplier, the nodes are its departments [5]. And in the evaluation loop of the consumer, the nodes are its appliances.

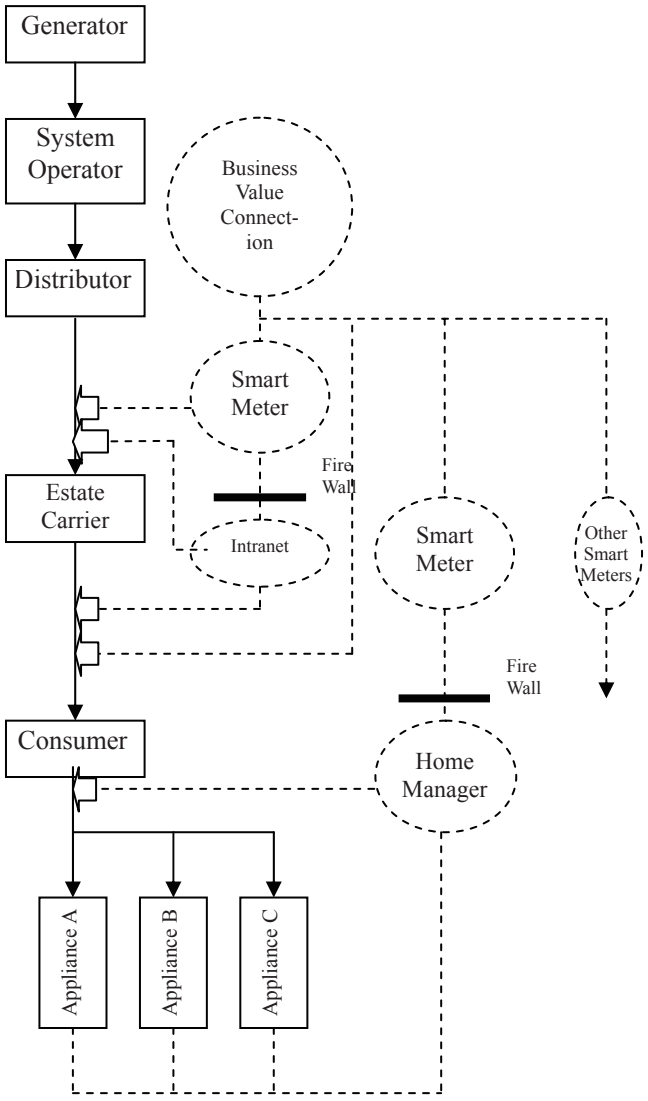

Fig 3

To simplify the discussion, this paper clusters the "Generator; System Operator; and Distributor" as the "Supplier" in subsequent paragraphs. With the simplification, the key players in the chain are: "Supplier – Estate Management – Consumer". In Hong Kong, where land space is scarce, offices and homes are contained as a component in a high-rise building and/or an estate of blocks. The involvement of estate management is common. Thus the individual offices and homes, instead of obtaining electricity directly from the public network, they obtain electricity from the communal estate network. In other words, the estate management provides a carrier to connect their components to the suppliers. The estate management is a member in the power-delivery value channel.

3. VALUES AND BENEFITS

3.1 Meaning of Adding Values

Adding values along the chain may mean any of the following, or a combination of a number of them. Both the marginal value and the aggregate value are considered:

- Increasing value
- Decreasing cost
- Increasing value larger than increasing cost
- Decreasing value smaller than decreasing cost
- Creation of new value

Not all values are measurable or quantifiable. Hence it is common to divide them as:

- Tangible values
- Intangible values

Values and benefits are substantially time functions. Hence they can be categorized as:

- Short-term values
- Long-term values
- Sustainable values

Hence it is valuable to consider "values" along all the aforementioned divisions. Yet in general, the supplier shall probe to maximize values in all the categories, tangible or intangible, and the consumer shall explore tangible short-term and intangible sustainable values.

It is envisaged that the values are projected values before the incidents take place. As each incident is determined by many variables which unlikely to be fully explored and predicted, hence the realized values may eventually be different than the projected values. The consideration links with probabilities of outcomes: opportunities and risks.

3.2 Interaction for Adding Values

Market emerges and grows through interaction between sellers and buyers. Needs are satisfied through understanding and utility. Exchanges are welcome when both sides feel rewarded. While smart meter provides a new opportunity to link with the consumer in the chain, fundamental market norms are primary keys in constructing new value model.

New businesses appreciate collaboration models. A new collaboration relationship like a partner-yet-neighbor connection is budding in all value-booming industry, including the electricity market. The meter is an interface between parties. Traditionally the device is cold-tone, yet new market opportunities demand warm-setting atmosphere and trust-bearing collaboration relationships.

3.3 Values and Benefits for Supplier

The apparently demand-side-management brings values to supply-side-management. Through cooperation of the consumer, indeed substantial number of consumers, the supplier shall derive operational benefits, e.g.

- Power quality improvement
  Realize less harmonics, better power factor, smaller voltage drop, etc.
- Power shedding flexibility
  Establish some consumers becoming long-term power shedding partners for commitment to potential emergency.
- Power-up sequence possibility
  Determine sequence of powering up installations and equipment at each recovery of supply as to avoid excessive surge by loads and recharging devices.
- Power and surge diversity improvement
  Load management through time-shift and time-division-multiplex (TDM) for a better diversity.
- Critical load management
  Extend the load management as a tool to crisis management
- Spinning reserve alternative
  Enjoy generation alternatives through consumer participation by shifting load or by self-generation.
- Utilization improvement
  Achieve higher utilization of generator, cable & equipment capacity by less harmonics; higher power factor; smaller voltage drop, and better load diversity.
- Energy management
  Effect energy management by utilization improvement and also by sustainability culture developed among consumers.
- Database of load signature and performance
  Build trust in consumers and in appliance manufacturers for their commitment to enable legal collection of data.
- Collection of research information
  Utilize data to develop research for the society
- Sustainability and philanthropy commitment
  Contribute to defend scarcity of resources and moderate imbalance and deficiency within population.

3.4 Values and Benefits for Consumer

At the other end of the chain, the consumer shall derive incentive benefits. Such as:

- Human comfort and convenience
  Human physiological and belonging needs
- Bill amount reduction
  Primary and tangible value to induce collaboration in load shedding, load shifts, load TDM, steady consumption, etc.
- Appliance reliability and maintainability
  Supplementary value
- Information enhancement
  Information utility value
- Energy audit and consultancy
  Social value
- Sustainability commitment
  Social value
- Energy efficiency upgrade for less
  Social value through tangible supplementary value
- Cooperation bonus and points
  Tangible supplementary value

3.5 Values and Benefits for Estate Management

In Hong Kong, a housing estate accommodating more than 5,000 families is not uncommon. Each housing estate is realized as a cluster of homes in which communal facilities also contribute aforementioned effects to greater values. In addition, linking homes together may serve a larger pool of participative loads to enable more flexibility and a higher achievement rate. The estate as a whole may have a collective bargaining power with the supplier. The latter, on the other hand, may visualize the estate management as a service distributor in the value channel which provides new service and operation value yet lessens the supplier's responsibilities in the value chain. However, of course, the scheme may not work fully when final users choose to cooperate directly with the supplier instead of collectively with the estate management.

The housing estate is an effective community to promote sustainability. Currently most of the sustainable generations are in smaller scale, yet sizeable for housing estates. When a norm of micro-grid system as a hybrid component can be developed for estates, then more benefits can be derived by the smart communication among the value partners.

3.6 Values and Benefits for Manufacturers

The success of the smart metering scheme requires partnership with appliance manufacturer to release appliance signatures and operation patterns of their products. Despite they may not be technical secrets, yet at this moment manufacturers may still be skeptical in this collaboration. Yet it is anticipated that eventually some manufacturers may be aware that the release of information is a new opportunity for building product differentiation, and new brand value; not to mention they may be leading a competitive edge which eventually becomes a norm of the society.

4. TECHNOLOGY AND CULTURE SUPPORT

4.1 Electrical Load Signature

Nowadays power electronics bring in non-linear appliances and facilities that introduce significant harmonics to the supply system. Understanding the operation signatures of an appliance helps the system operator managing the power quality. [1],[4]

Load signature is also beneficial to consumers and manufacturers. Besides serving as a basis for energy management and load diversity, it provides a health record and monitor for the appliance concerned. It provides room for improvement in energy efficiency upgrade and equipment upgrade.

When load signatures are available, then a procedure of sign-up; sign-in and sign-out may be established for load connection. [4]

4.2 Home Automation and Smart Meter Technology

The home automation manager is the warden of the installation that carries the appliances. [2] The manager understands the behaviour of individual members. It has the tasks:

- Monitor performance
- Perform specified and conditional control
- Adjust operations intelligently without compromising noteworthy comfort and convenience
- Communicate with value partners (e.g. smart meter) for new operational values
- Support sign-in and sign-out

A Smart Meter System is the mediator between power system and final loads. It dialogues with the home manager to recommend control and management of load operation in respect of system condition. Through contractual terms for "forward operation" and quotation for "spot operation", the smart meter may initiate the voluntary participation of consumers in power quality. The operation may include load

shedding, load shift, load TDM, hybrid changeover and equipment upgrade. The smart meter can also be developed as a data-link to convey messages in a bidirectional manner. The consumer sends connected-load signatures information to the supplier, and the supplier studies similar and relevant signatures for artificial-intelligence, then gives advices to the consumer.

Housing estate can also be a member in the value channel. The intelligent estate manager is similar in intelligence yet with a larger coverage monitoring than a home manager. For ownership reason, it leaves the control tasks to the home managers. The estate manager may also take up part of the tasks of the smart meter, and collectively monitor load signatures. This may be effective as many loads in the same estate are similar, and likely identical.

4.3 Consumption Culture

The smart meter system should promote a consumer culture that treasures social values besides tangible values. By tangible values alone, the achievement of operational benefits will be economically dependent. The scheme will receive less support when the economy is booming in a society. This is because incentives will then have faded values. The culture develops a persistent force that enables consumers to form good habits in load operations. A culture also facilitates steady energy consumption by a family.

4.4 Tariff Reform

Regardless how the two partners share the culture of sustainability and system quality, the smart meter scheme works on a give-and-take value-exchange mechanism. [4] For this reason, the tariff may have to be modified for feasibility.

A uniform all-time tariff is not suitable. A multi-tier tariff has to be adopted. It can be time dependent and/or mode dependent. Alternatively or conjunctively, it can accommodate rebates, points or discount coupons for cooperation in discrete or cumulative manner. Use of the points and coupons can be extended to electricity and energy related business.

The multi-tier tariff may also rate on both spot-data and interval-data. Spot-data means the instantaneous values of energy, power factor, current, and its harmonic content. Interval-data means the same set of values over a period of one week, one month, one season or one year. The interval-data may be a measurement of summation, average, moving average, cusum value, steadiness, smoothness, etc.

5. CONCLUSION

This paper looks forward to new responsibilities and opportunities of smart meters. The technology has already moved us toward that direction. Yet there are still hurdles to be overcome. A new culture has to be developed. Probing non-intrusive new information is an ethical issue. And as intelligence develops at both sides, demarcation of tasks and responsibilities has to be redefined. Whilst the model is collaborative, it may induce new complication to the current simple contractual agreement between the supplier and the consumer. With cooperation of estate management and manufacturers, the benefits brought by smart meters to the power system can be remarkable. Wining is achievable by all participants.

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