COLLABORATIVE BUSINESS MODEL IN FUTURE DISTRIBUTION NETWORK WITH SHARED NETWORK ACCESS (SNA)

Fang ZHAI
Tsinghua University – China
mailfangzhai@gmail.com

Zhipeng ZHANG
University of Bath – UK
Z.Zhang2@bath.ac.uk

Furong LI
University of Bath - UK
F.Li@bath.ac.uk

ABSTRACT

In order to resolve the prospective demand increase and the underutilized network assets, this paper proposes a novel and collaborative business model , shared network access (SNA), for distribution network operators (DNOs). This SNA mechanism encourages the incumbent DNOs to give up their exclusive access to distribution network and lease spare capacity or back up capacity to independent parties, acting as the secondary DNOs, who have the SNA license and can offer special services for flexible demand and consumers with lower reliability. Through this scheme, flexible demand can be integrated efficiently and the efficiency of network utilization can be improved. Moreover, this paper adopts a business model approach to investigate the key aspect of leasing strategy within the proposed SNA business model. Quantification of potential benefits in different parties under SNA model also demonstrates the advantage of this model.

INTRODUCTION

The structure of future energy system will see a huge change with an increasing number of flexible demand connected to the distribution networks, such as electric vehicles (EV), heat pump (HP) and energy storage companies. According to International Energy Agency (IEA) 2017 report [1], the global electric car stock surpassed 2 million vehicles, after crossing the 1 million threshold in 2015. These prospective demand increase and bi-directional power flow will bring severe network pressures in terms of thermal and voltage violations.

Because distributed network operators' (DNOs) revenue is based on a fixed rate of return on invested capital, DNOs have been incentivized to spend a large amount of money on network investment to meet the load growth, assuming all load requires the same level of high reliability. As a result, a substantial amount of capacity has been designed to support the temporary system peak while remaining underutilized over the majority time. More critically, the current business model would further aggravate the efficiency of asset utilization with flexible resources increasingly connected to the edge of the system.

Compared to distribution network, the telecom industry also faced similar dilemma between rapid increasing mobile broadband demand and scarce spectrum resource in the last decade. Limited spectrum resource could not meet fast growing mobile broadband demand. The challenges of making new spectrum solely available to a new system have been evident. In order to avoid excessive investment on new spectrum and establish a competitive environment, the communication regulators developed a new business model called Licensed Shared Access (LSA) for mobile network operators (MNO), which allows mobile network operators with LSA license to borrow incumbent users' spare spectrum and return when incumbent MNOs need it. By different mobile operators sharing spectrum, the efficiency of spectrum utilization is definitely improved under LSA model.

Inspired by licensed shared access (LSA) for spectrum sharing in telecommunication, this paper presents a collaborative business model based on a new distribution network scheme, shared network access (SNA) for DNOs to integrate the increasing flexible demand efficiently. In contrast with existing model, SNA model can offer a new business opportunity for incumbent DNOs to maximum the usage of spare or back-up capacity existing in the current network. Incumbent DNOs still have network ownership but lease these capacities in special time interval to independent second parties, which possess SNA license and offer special service for flexible demand and consumers, acting as secondary DNOs.

In addition, this paper adopts a business model approach to investigate the key aspect of leasing strategy within the proposed SNA business model. More specifically, comparing with well-established knowledge of finance/operating lease in economics, this paper concentrates on solving leasing strategy between the incumbent DNOs and the secondary DNOs, which is the key point in SNA model. The discussions focus on the following questions:

1) What kind of business opportunities SNA may open for incumbent DNOs and secondary DNOs?
2) How to describe leasing strategy between incumbent DNOs and secondary DNOs?
3) What benefits SNA may bring to all of market participants in distribution network?

Through the discussions above, this model depicts how SNA can benefit all of market participants involved and improve the whole distribution network efficiency. To illustrate and quantify the benefit of the proposed SNA business model, this paper employs a simple two-bus system to show potential benefits of mobilizing the originally spare capacity. The quantitative result illustrates the net benefits of the proposed SNA business arrangement.

The rest of paper is organized as follows. First, the shared network access (SNA) concept is introduced. The business opportunities SNA brings is also described in this section. Second, the leasing strategy in SNA is presented. Next is the demonstration of SNA business model. The conclusion is drawn in the last.

SHARED NETWORK ACCESS CONCEPT

Shared Network Access (SNA) is a collaborative mechanism to handle the increasing flexible demand and improve the efficiency of whole distribution network utilization. The principle in this concept is to let incumbent DNOs give up their sole access and lease spare capacity to independent parties (also called secondary DNOs), to supply the flexible demand which can tolerate lower reliability electricity. **Fig.1** depicts what type of customer the secondary DNOs target in a simple two-bus system.

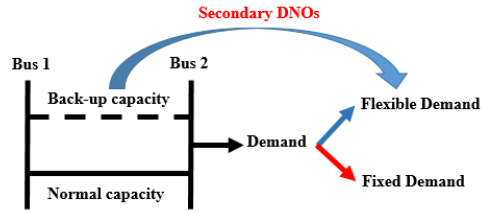

Fig.1 Simple two-bus network with different demand

Through leasing spare or back-up capacity, which is underutilized in majority of time, secondary DNOs can have access to supply the flexible demand with low reliability, without triggering tremendous network investment. Along with earning additional leasing profit and deferring the network reinforcement, incumbent DNOs still own the network and take it back in any necessary moment. Most importantly, potential value of unused capacity in network can be captured for all of market participants in SNA framework, including incumbent DNOs, secondary DNOs and customers. The business opportunities and responsibilities are shown as followed:

- SNA Regulators: i) define the sharing framework with incumbent and secondary DNOs; ii) issue the SNA license; iii) introduce competition in distribution network field.
- Incumbent DNOs: i) identify space and back-up capacity in distribution network for sharing; ii) specify the leasing strategy with secondary DNOs; iii) earn network rent profit; iv) defer the network reinforcement.
- Secondary DNOs: i) obtain the license to have authority to use sharing capacity for flexible demand; ii) return line management at the peak time or system contingency; iii) enter the electricity distribution market without huge network investment; iv) supply low reliability electricity with special service.
- Customers: i) enjoy cheaper electricity price and have motivation to consume more flexible demand; ii) have the potential to manage the electricity consumption reliability.

LEASING STRATEGY IN SNA BUSINESS MODEL

So far, many literatures have elaborated on the concept and elements of business model. Often referred [3] defined the business model as consisting of nine elements: Value proposition, Customer segments, Channels, Customer relationships, Key activities, Key resources, Key partners, Cost structure and Revenue streams. These elements are also divided into four part, which is product model (including Key activities, Key partners and Key resources), strategy model (including Value proposition), customer model (including Customer relationships, Customer segments) and profit model (including Cost structure and Revenue streams). Detailed discussion in SNA business model is beyond the scope of this paper. Here we focus on the most significant and complicated part in SNA framework, the leasing strategy between incumbent DNOs and secondary DNOs, which contains product model, strategy model and profit model in business model elements.

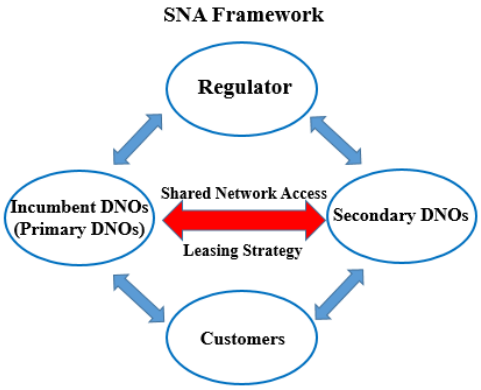

Fig.2 The framework of distribution network under SNA concept

In the field of economics, a lease is a contract between two parties: the lessee and the lessor. The lessee is liable for periodic payments in exchange for the right to use the asset. The lessor is the owner of the asset, who is entitled to the lease payments in exchange for lending the asset. Applied to SNA framework, the lessor is the incumbent DNO, who possesses the spare capacity in the distribution network and the lessee is the secondary DNO, who offers the special service for flexible demand. There are too many types of leasing in commercial world, such as sales-type lease, sale and leaseback or leveraged lease. The Financial Accounting Standards Board (FASB) distinguishes two types of leases: operating lease (also called commercial lease) and the financial lease (also called finance or capital lease). The criteria to distinguish two types of leasing are: 1) Ownership. The ownership of the asset is shifted from the lessor to the lessee by the end of the lease period; 2) Bargain purchase option. The lessee can buy the asset from the lessor at the end of the lease term for a below-market price; 3) Lease term. The period of the lease encompasses at least 75% of the useful life of the asset; 4) Present Value. The present value of the minimum lease payments required under the lease is at least 90% of the fair value of the asset at the inception of the lease. If any of criteria can be satisfied, the lessee records it as a financial lease.

Because the network ownership does not change in SNA scheme and the exchange of capacity usage is frequent (could happens several times in a day), we consider it as operating lease. In leasing contract, DNOs make an agreement on the returning time, such as line breakage or peak time in one day. In that period, the secondary DNO must give the line back and cut its demand. On the other hand, compensation should be made when returning behaviors occur beyond the contract. As for lease payments in operating lease, in a perfect capital market, the payment should be set so that the NPV of the transaction is zero and the lessor breaks even. Expressed a formula, this relationship can be written as follows:

PV (Lease Payments) =
Purchase Price – PV(Residual Value)

For a given discount of d and time T, the lease payment L can be calculated as:

$$L = \frac{PV(purchase) - FV(residual)/(1+d)^T}{1+(1-1/(1+d)^T)/d}$$

Thus, the amount of the lease payment will depend on purchase price, residual value, lease periods and an appropriate discount rate. Employed this formula in SNA model, purchase price is the initial network line investment, residual value is the remaining value of leasing network and the discount rate is based on network depreciation. Critically, residual value is clearly high because these capacities don not utilize in the most of time under the current network business model. Moreover, T is not exactly equal to the leasing time. The returning time to the incumbent DNO should be considered.

To sum up, a leasing strategy in SNA scheme contains the return agreement, the definition of rent and the compensation rules. The return agreement specify the time intervals when the secondary DNO should give up the management of network and return to the incumbent DNO. As for the definition of rent, the method in economics to calculate operating lease rent can be adopted except re-estimate residual value and the leasing time.

DEMONSTRATION OF SNA BUSINESS MODEL

In this part, we employ two different methods to quantify the benefits of incumbent DNOs and secondary DNOs respectively. The demonstration is both on a simple two bus bar system shown in Fig. 3.

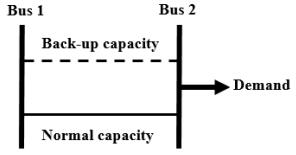

Fig.3 Simple two bus bar system with demand D

Incumbent DNO

Under the SNA model, incumbent DNOs not only earn rent profit, as illustrated in above, but also defer network investment cost due to the utilization of spare capacity and the customized reliabilities services for flexible demand from secondary DNOs. The present value of network investment cost is determined by the time horizon to which the loading of network component reaches its maximum rated capacity [4]. The financial benefits from deferring network investment can be quantified as:

Conventional Business Model

Under conventional business model, if a network component l, such as a circuit, has a normal capacity C_l, back-up capacity B_l, and supports a power flow D_l, the time horizon to reinforcement n_l is:

$$n_l = \frac{log(C_l + B_l) - logD_l}{log(1+r)}$$

Where r is a given load growth rate.

SNA Business Model

Adopting SNA agreement, the time horizon to reinforcement is changed. Assume the flexible demand accounts for $F\%$ in power flow D_l, thus the proportion of fix demand being $1-F\%$. The new time horizon to meet the fix demand reliability is:

$$C_l = D_l(1-F\%)(1+r)^{n'_{l1}}$$

That is,

$$n'_{l1} = \frac{logC_l - log(1-F\%) - logD_l}{log(1+r)}$$

Similar to fix demand, if the flexible demand is supplied by an independent party with a promised reliability of R, the number of years it takes until such supply reliability cannot be met is defined as

$$D_l \times (1-F\%) \times (1+r)^{n'_{l2}} + R \times F\% \times D_l \times (1+r)^{n'_{l2}} = C_l + B_l$$

That is,

$$n'_{l2} = \frac{logC_l - log(1-F\%) - logD_l}{log(1+r)}$$

The time horizon to reinforcement n'_l under SNA model is the smaller of n'_{l1} and n'_{l2}. Hence, for a given discount rate of d, the change of present value is

$$\Delta PV = PV_l - PV'_l = Asset_l\left(\frac{1}{(1+d)^{n_l}} - \frac{1}{(1+d)^{n'_l}}\right)$$

$$n'_l = \min\{n'_{l1}, n'_{l2}\}$$

Applied in two bus bar system, the normal and back up capacity of circuit l are rated at 25MW and 20MW respectively, and both cost £3193400 at modern equivalent asset value [1]. The initial D_l is 20 MW. Assuming a discount rate of 6.9% and a load growth rate, r of 1.6% per annum, Fig. 4 demonstrates the financial benefits of incumbent DNOs from introducing SNA model. If the flexible demand can tolerate 30% reliability, the financial benefit can increase about 60%

compared to the situation of 80% reliability with the same level of flexible demand penetration.

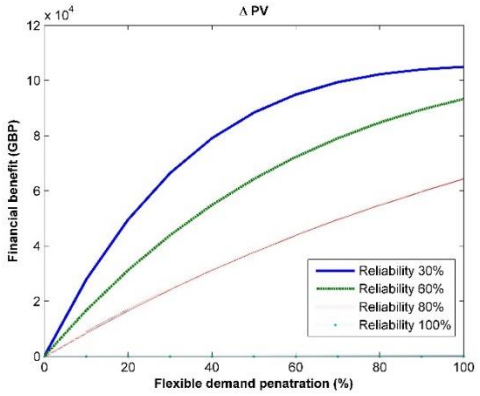

Fig. 4 Financial benefits for incumbent DNO under SNA model

Secondary DNO

The financial benefits for secondary DNO is derived mostly from the earning streams by supplying flexible consumptions within the network. Without the burden of huge network investment and 100% reliability task, the electricity price can experience a massive decline. We apply the concept of price elasticity of electricity to quantify the demand increase due to the electricity price decline, thus leading to the formula to evaluate financial benefits for secondary DNO under SNA mechanism. Price elasticity of electricity is defined as

$$\mathrm{E}_d = \frac{\Delta Q / Q}{\Delta P / P}$$

where Q represents electricity consumption, P is the electricity price. The above formula usually yields a negative value, due to the inverse nature of the relationship between price and quantity demanded, as described by the "law of demand". Thus, the financial benefits is

$$profit = R \times F\% \times D \times (1 + E_d \times m\%) \times price \times (1 - m\%) \times T$$

where the definition of R, F and D are the same as above, and m is the percentage of electricity price decline. T is the usage time.

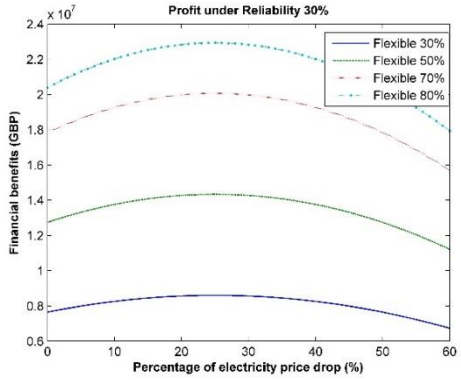

Fig. 5 Financial benefits for secondary DNO under SNA model

As referred in [6], price elasticity is rated at two and electricity price is rated as 0.177 £/kWh. Fig. 5 shows that under a given reliability the financial benefit for secondary DNO, which demonstrates huge potential benefits in SNA model.

CONCLUSIONS

This paper proposes a sharing-economy based business model for incumbent DNOs in future distribution network. Aiming to integrate flexible demand efficiently, the proposed business model in this work incentives incumbent DNOs to give up sole access and lease spare capacity or back up capacity to independent parties, who can provide cheaper service for flexible demand with reliability. More importantly, by bringing competition in distribution network, customers firstly can have access to enjoy special risk-management service in electricity supply with cheaper price. Compared to existing model, this scheme can not only integrate flexible demand more efficiently and better utilize the network spare capacity, but also stimulate the demand increase and benefit all of market participants.

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