Research on Resident Appliance Sharing Service (RASS)

Zhe Wang, Yang Dong, Xinyang Wu, Xiaoqing Hu, Tianguang Lu, Jiayu Wang and Zijian Wang

***Abstract*—With the development of Internet financing, the sharing economy model has been widely used in various fields. The resident appliance sharing service (RASS) is based on a pre-paid mode; the owner of an appliance provides equipment for those who need to use the appliance, and charges accordingly. Expenditure on the use of electrical appliances by users include purchase costs, use costs, and maintenance costs. Economic analysis is conducted, using electrical equipment purchase costs and user fees as economic indicators.**

This paper introduces the mechanism of RASS and analyzes the conditions for and constraints on the implementation of this mechanism. An economic benefit model of RASS is established and economic analysis of the appliance owner and user is conducted via a case study. The results show that the appliance owner can collect the cost of the equipment through a pay-per-click scheme, thereby recovering purchase costs and allowing the user to save the equipment purchase cost. This is ultimately shown to achieve a win-win outcome for appliance owners and users.

***Index Terms*—Internet finance, resident appliance sharing service (RASS), pre-paid, variable cost and fixed cost breakeven**

I. Introduction

With the development of Internet financing, several related services have been used in a range of fields. Mobike and Ofo operate public bicycles, charging for their services via mobile phone applications [1,2]. Alipay allows customers to use mobile devices rather than bank cards to make payments online [3]. These applications of Internet financing are based on supporting mobile payment technologies, and make finance management more convenient for users [4]. In the electricity field, Internet financing is mainly used for electricity payments. The State Grid Corporation of China (SGCC) has established the ESGCC, an Internet mall combining electricity information with an electricity payment system, product sales and other services [5]. Electricity consumers can make payments online instead of wasting time on directly visiting their suppliers [6].

Based on Internet services, the sharing economy has become popular worldwide [7]. Airbnb and Uber are the biggest success stories in the sharing economy [8]. Airbnb mainly offers apartment rental services, providing travelers with a global network of accommodation offered by locals [9]. Uber is a venture-funded startup company responsible for a mobile app that connects passengers with drivers of vehicles for hire or pick-up services [10]. In China, Haier provides customers with a laundry service or air conditioning rental service via a mobile app [11]. According to demand, customers can travel to the location of a service then prepay to enjoy the service.

Recently, relevant studies have focused on the economics of the electricity field. Reference [12] provided an electricity forecasting service for applications (EFSA), based on prepayment, that forecasts the consumption cost of an electrical appliance (EA) before the required electricity is generated. Reference [13] put forward a new electricity pricing mechanism for residents under a fixed electricity pricing environment, and proved that Internet financing can bring profits for virtual electricity retailers (VERs).

Currently, residents can also sell unused items online. Due to budget or demand, customers may only want to use an item once or a few times, so they do not want to buy it. Self-laundry and box-in telephone services based on payment are widely used among the public. But as the size and range of demand increase, basic public rental services cannot meet customers' requirements. A new method needs to be established for customers to use EAs for economic optimization. The resident appliance sharing service (RASS) operates via a pre-paid mode; the owner of an appliance provides equipment to those who

Zh. Wang is with the State Grid Shanghai Municipal Electric Power Company, Shanghai, 200122 China (corresponding author, e-mail: bigtimewang3168@sina.com)

Y. Dong is with the State Grid Shanghai Municipal Electric Power Company, Shanghai, 200122 China (e-mail: 498323565@qq.com)

X. Wu is with the State Grid Shanghai Municipal Electric Power Company, Shanghai, 200122 China (e-mail: 719633962@qq.com)

X. Hu is with the State Grid Jiangsu Wuxi Power Supply Company, Wuxi, 214000 China (e-mail: 617355692@qq.com)

T. Lu is with the Department of Electrical Engineering, Shanghai Jiao Tong University, Shanghai 200240 China (e-mail: ltghao@sjtu.edu.cn)

J. Wang is with the State Grid Shanghai Municipal Electric Power Company, Shanghai, 200122 China (e-mail: mrwangjy@icloud.com)

Zi. Wang is with the school of Electrical Engineering, Southeast University, Nanjing, 210096 China (e-mail: 569606029@qq.com)

978-1-5386-6461-2/18/$31.00 ©2018 IEEE

need to use the appliance, and charges accordingly. The owner of the EA can recycle their purchase costs through an unused items rental service, and customers can economically optimize the satisfaction of their requirements.

II. Resident Appliance Sharing Service (RASS)

A. Description of RASS

RASS is based on Internet financing and the sharing economy. The owner of an appliance provides equipment to those who need to use the appliance, and charges accordingly.

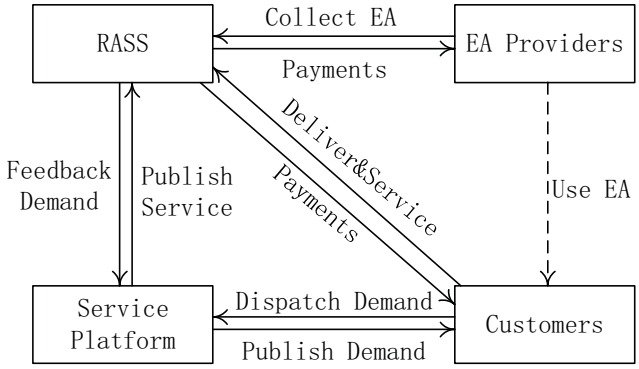

Fig. 1. Process of RASS

Fig. 1 represents the process of RASS. RASS is the institution responsible for formulating operational standards, publishing demand and offering appliance collection, delivery and servicing and payment management. RASS publishes its service via a platform and expands these services based on feedback and advice from customers. Customers use providers' electricity appliances but engage in transactions only with RASS. Under the rules governing RASS, electricity providers can receive rewards.

B. RASS Operations

Due to the basic restriction that electricity appliances cannot operate without electricity, RASS operation requires sufficient electricity support. Another unsolved hazard is the management of electricity appliances; incorrect operation may damage their lifespan, causing a series of compensation problems. To avoid the situation mentioned above, two RASS modes are considered.

1) RASS Mobile Car Delivery Service

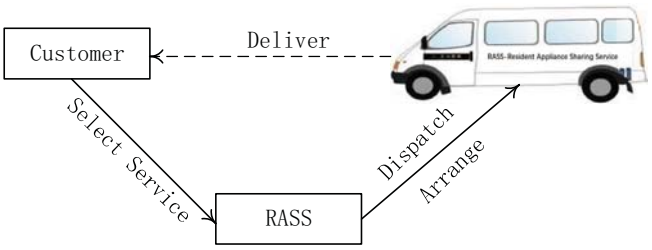

Fig. 2. Operation of RASS mobile car delivery service

Fig. 2 shows the RASS mobile car delivery service, which is a flexible mode of RASS operation. This service comprises electricity supply devices, professional staff, the EAs that customers require and other necessary RASS-related items. After a customer applies for the service, RASS arranges for a car to deliver the required EA to the customer, allowing the customer to enjoy the service with the assistance of professional staff.

2) RASS Station

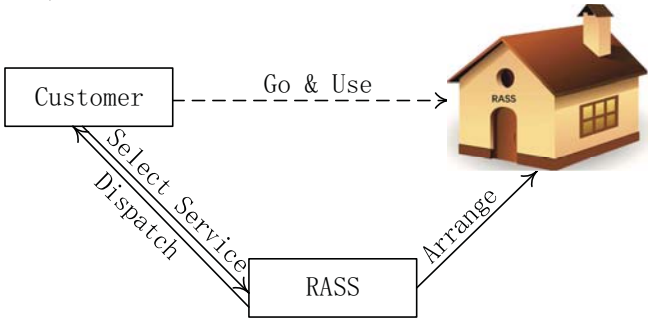

Fig. 3. Operation of RASS station

Fig. 3 shows the operation of a RASS station, another mode of RASS. This operation mode is widely used globally. Prepaid laundry services are the best example. In the RASS station mode, customers select and apply for services, then RASS dispatches the services required via RASS stations able to meet the customers' requirements. Customers can travel to these stations to use the services if appropriate.

III. Pricing Model of RASS

A. Variable Cost and Fixed Cost Breakeven

TABLE I
Charging Structures for Taxi Service and RASS

	Taxi Service	RASS
Fixed cost	Boarding fee	Rental fee
Variable cost	Mileage fee	Consumption fee
*Additional Charges	Fuel	Water, cleaning, package

*If necessary

Compared with the taxi service, the pricing model of RASS is based on variable cost and fixed cost breakeven. Table I

compares the charging structures of the taxi service and RASS. The pricing method for the taxi service includes a boarding fee, a mileage fee and additional charges such as fuel if necessary. RASS has a similar charging structure, composed of rental fee, consumption fee and water, cleaning or package fees as additional charges.

B. Pricing Mode of RASS

Based on variable cost and fixed cost breakeven, a pricing mode of RASS is designed. The charges incurred by customers, the income of EA providers and the profit obtained by RASS are considered.

1) Charges of Customers

$$C_{o,i} = \sum\left(C_{r,i}, C_{con,i}\right) \tag{1}$$

$$C_{r,i} = \frac{C_{p,i}}{N} \tag{2}$$

$$C_{con,i} = C_e \times \int_0^T P_i(t)\,dt \tag{3}$$

$$C_{c,i} = \sum\left(k \times C_{r,i}, l \times C_{con,i}\right) \tag{4}$$

$$k = \begin{cases} n \times \dfrac{N}{C_{p,i}} & if\ \dfrac{C_{p,i}}{N} \le n \\ 1 & if\ \dfrac{C_{p,i}}{N} > n \end{cases} \tag{5}$$

where

$C_{o,i}$ is the use-cost of EA i.

$C_{r,i}$ is the rental cost of EA i

$C_{con,i}$ is the consumption cost of EA i

$C_{p,i}$ is the purchase cost of EA i.

N is the maximum working time of EA i.

C_e is the electricity price calculated during EA operational period.

P_i is the working power for EA i.

t is the working time for EA corresponding to customer use time.

$C_{c,i}$ is the charge incurred by RASS customer i.

k is the coefficient of use cost.

n is the coefficient of rental cost.

l is the coefficient of electricity price.

2) Income of EA Provider

$$C_{pro,i} = m \times C_o \tag{6}$$

where

$C_{pro,i}$ is the income of the provider generated by EA i.

m is the income coefficient of the EA provider. (1-m) is the coefficient of the RASS share of the lease from the EA provider.

3) Profit of RASS

$$C_{RASS,i} = \sum\left[(k-m) \times \frac{C_{p,i}}{N} + (l-m) \times C_e \times \int_0^T P_i(t)\,dt\right] \tag{7}$$

where

$C_{RASS,i}$ is the profit of RASS from EA i.

IV. Case Study and Countermeasures

A. RASS Scenario

The purpose of RASS is to ensure convenience for both EA providers and customers. A scenario is studied here as a typical application of RASS.

Scenario: The customer is a coffee lover with a semi-automatic espresso machine. Due to differences in automation, semi-automatic espresso machines only work with ground coffee. The customer has bought coffee beans by mistake, and thus requires a coffee grinder to grind the beans to powder.

TABLE II
Parameters of Coffee Grinder

Parameter	Symbol	Value
Voltage and frequency (V&Hz)	U & f	220 & 50
Working power (W)	P	100
Maximum capacity (g)	-	350
Purchase cost (yuan)	C_p	200
Maximum grams for grinding (kg)	-	350

TABLE III
Charging Standard for RASS

Parameter	Symbol	Value
Electricity price (yuan/kWh)	C_e	1
Coefficient of rental cost	n	10
Coefficient of electricity price	l	1.5
Income coefficient of EA provider	m	0.9

The customer has 300 g coffee beans, then applies for and uses RASS in 15 mins. According to the equations above:

1) Charges of customs $C_{c,i}$:

$$C_{r,i} = \frac{C_{p,i}}{N} = \frac{200}{1000} = 0.2(yuan)$$

$$C_{con,i} = C_e \times \int_0^T P_i(t)dt = 1 \times 0.25 \times 0.1 = 0.025(yuan)$$

$$C_{c,i} = \sum(k \times C_{r,i}, l \times C_{con,i})$$

$$= 10 + 1.5 \times 0.025 = 10.0375(\text{yuan})$$

2) Income of EA Provider

$$C_{pro,i} = m \times \sum (C_{r,i}, C_{con,i})$$
$$= 0.9 \times (0.2 + 0.25)$$
$$= 0.2025(yuan)$$

3) Profit of RASS

$$C_{RASS,i} = C_{r,i} - C_{pro,i}$$
$$= \sum \left[(k-m) \times \frac{C_{p,i}}{N} + (l-m) \times C_e \times \int_0^T P_i(t)dt \right]$$
$$=10.0375\text{-}0.2025=9.835(\text{yuan})$$

B. Analysis

TABLE IV
RESULTS OF CASE STUDY

Parameter	Original	RASS
EA provider	*-0.225 yuan*	*+0.2025 yuan*
Customer	*-200.225 yuan*	*-10.0375 yuan*
RASS	-	*+9.835 yuan*

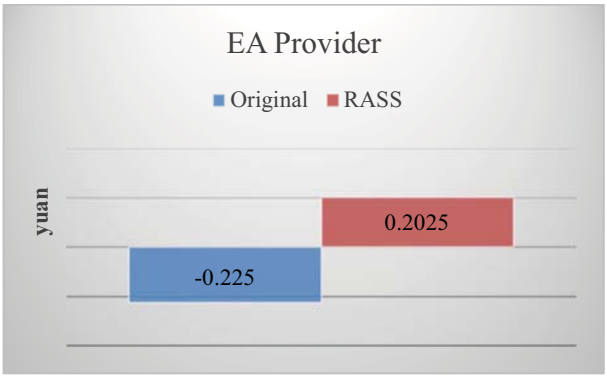

Fig. 4. Results of EA provider

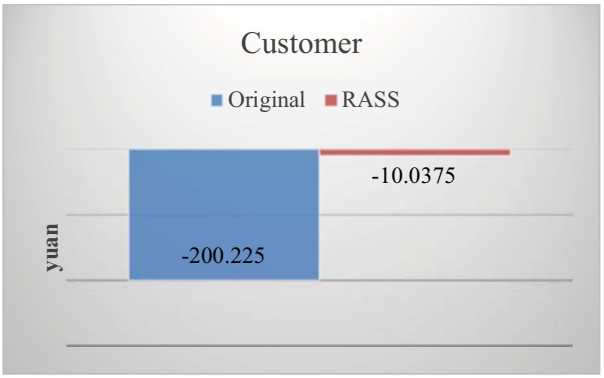

Fig. 5. Results of Customer

Table IV shows the results of the case study. The EA provider collects the cost of its equipment via RASS (see Fig.4), thereby recovering its purchase costs. Meanwhile, customers save their equipment purchase costs and enjoy a high-quality EA service (see Fig.5).

C. Countermeasures

RASS offers a means of connection that helps to satisfy the requirements of both EA providers and customers. Some approaches to ensuring successful operation should be considered in the future (see Fig.6).

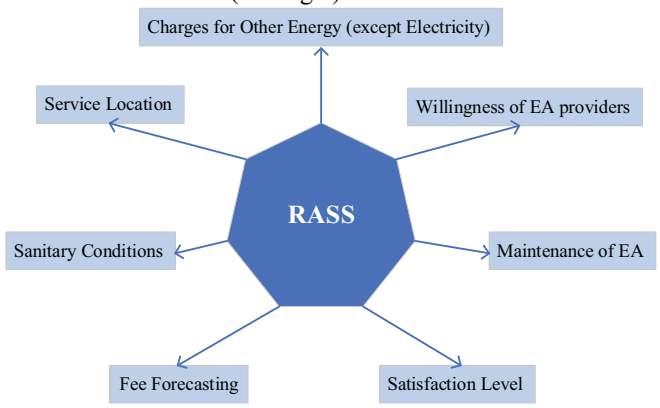

Fig. 6. Countermeasures for RASS

1) Charges for Other Energy (except Electricity)

Meeting the requirements of an EA working environment is fundamental to RASS preparation. Forms of energy other than electricity, such as water, are also used in EA environments. The standards underlying charges for other types of energy should be edited based on the rules for RASS.

2) Maintenance of EA

To maintain RASS operations and protect the economic status of EA providers, RASS is responsible for preserving the normal status of EA. The maintenance cost of an EA is paid by RASS during RASS operations. To limit future expenditure, RASS should make rules clarifying the responsibility for EA

damage with customers.

3) Sanitary Conditions

Sanitary conditions are another key issue influencing the quality of RASS. In some EA cases, machines need to be cleaned before being operated again, especially in areas such as food processing and clothes cleaning. RASS should ensure that conditions are sanitary before services are provided to maintain the quality of customer experiences.

4) Fee Forecasting

According to customer demand, RASS should carefully forecast its fees. Customers focus on the economic efficiency of EA rental and use. Careful fee forecasting can help customers to make smart decisions.

5) Satisfaction Level

Satisfaction is determined by charges for and experiences of RASS. RASS should put forward diverse plans to attract a range of customers. Ensuring a high level of economic efficiency and a good service experience is important for most customers.

6) Willingness of EA providers

The willingness of EA providers can be divided into two categories. Some EA providers do not want to recycle EAs after completing their contracts with RASS. Others may only offer EAs to RASS temporarily, then recycle and continue to use the EAs after their RASS contracts are completed. RASS should figure out the willingness of EA providers before contracts are signed and develop different plans for them.

7) Service Location

Two modes of RASS operation are mentioned in Chapter 2. Service location may also influence customers' decisions. The requirement to travel far to enjoy a service may reduce customers' willingness to engage with RASS. In high-price locations, higher operational costs may place more economics pressure on RASS.

V. Conclusion and Further Work

RASS is a new business mode designed for residents. EA providers supply equipment to those who need to use appliances, and charge accordingly. The results of a case study indicate that EA providers can collect their equipment costs and recover their purchase costs, while customers can save equipment purchase costs and enjoy a high-quality EA service.

Future researchers should focus on the formation and refinement of the mechanism of RASS market operation. Ensuring convenience is critical to RASS development.

Acknowledgment

I am grateful to all of the people who have helped me and who care about me.

References

[1] S. Wen, F. Luo and X. Li, "Research on the Business Model of Shared Bicycle," *Technological development of enterprise. J.,* vol. 37, no.1, pp. 86-89, Jan. 2018.

[2] J. He, "The Research of the Strategy of Mobike Technical Limited Company about Bike-sharing," M. B.A Dissertation., Wuhan Textile University., Wuhan, May, 2017.

[3] M. Qiu, "The Impact on China's Commercial Banking System by Internet Finance-with 'Ali Finance' as an Example," Dissertation., Henan University., Zhengzhou, Jun, 2014.

[4] C. Yang, "The Channel Switching behavior Research of the Internet Payment User Based on Mobile Payment Service Value," PH.D Dissertation., Jiangsu., Zhenjiang, Jun, 2016.

[5] Y. Sun, "Value Added Method of Information in State Grid Electronic Mall Based on Deep Mining," *Electric Power ICT. J.,* vol. 14, no.11, pp. 14-21, Nov. 2016.

[6] W. Cheng and J. Yang, "Power at hand in Beijing," *State Grid. J.,* no.9, pp. 86-87, 2015.

[7] J. Hamari, M. Sjöklint and A. Ukkonen, "The sharing economy: Why people participate in collaborative consumption," *Journal of the Association for Information Science & Technology. J.,* vol. 67, no.9, pp. 2047-2059, 2016.

[8] B. Libert, Y. Wind and M. Beck, "What Airbnb, Uber, and Alibaba Have in Common," *Harvard Business Review Digital Articles. J.,* 2014.

[9] G. Zervas, D. Proserpio and J. Byers, "The Rise of the Sharing Economy: Estimating the Impact of Airbnb on the Hotel Industry," *Social Science Electronic Publishing. J.,* 2013.

[10] A. Mukherjee, "Hail These Cabs," *Business Today. J.,* 2014.

[11] D. Miu, "Rental Mode: the Air Conditioning Solution for College Student," *Modern Economic Information. J.,* no.1, pp. 129, 2016.

[12] Z. Wang and Y. Li, "Electricity Forecasting Service for Appliances (EFSA)," in *2015 IEEE Student Conference on Research and Development (SCOReD)*, Kuala Lumpur, pp. 1-5. IEEE, 2016.

[13] Z. Wang, Y. Li and Y. Shen, et al. "Virtual electricity retailer for residents under single electricity pricing environment," *Journal of Modern Power Systems & Clean Energy. J.,* vol. 5, no. 2, pp. 248-261, 2017.

Zhe Wang was born in 1988. He received his B.S. degree in Electrical Engineering & Automation from Shanghai University of Electric Power, Shanghai, China in 2011; his M.S. degree in Electronic & Electrical Engineering from the University of Strathclyde, Glasgow, UK in 2012; and his Ph.D. in Electrical Engineering from Southeast University, Nanjing, China in 2017. He now works for the State Grid Shanghai Municipal Electric Power Company. His current research interests include the electricity market and DSM.

Yang Dong was born in 1993. He received his master degree in Electrical Engineering from Huazhong University of science and technology, Wuhan, China, 2017. His current research interests include smart grid and integrated energy service.

Xinyang Wu was born in 1991. He received his master degree in Electrical Engineering from Shanghai JiaoTong University, Shanghai, China, in 2017. His current research interests include smart grid and superconductivity.

Xiaoqing Hu was born in Jiangsu, China. He worked in the power dispatching control center of State Grid Jiangsu Wuxi power supply company. He received the Ph.D. degree in electric power engineering from Southeast University, Nanjing, China, in 2017. His research interests include regional power grid scheduling, demand response, load controls, and smart grid.

Tianguang Lu received the B.S. degree in electrical engineering from Shandong University, Shandong, China, in 2013. He is currently working toward the Ph.D. degree at the School of Electronic Information and Electrical Engineering, Shanghai Jiaotong University, Shanghai, China.
He was an Electrical Engineer Intern with ABB (China) Inc. in 2015, and a Visiting Student Researcher with The University of Texas at Arlington,

Arlington, TX, USA, in 2016. He is currently a Visiting Student Researcher with Iowa State University, Ames, IA, USA. His research interests include power distribution systems, microgrids, and renewable energy. His research is supported by National Natural Science Foundation of China.

Jiayu Wang was born in 1991. He received his master degree in Electrical Engineering from North China Electrical Power University, Baoding, China, 2017. His current research interests include Urban grid operational control and risk analysis .

Zijian Wang was born in 1992 in Anqing of Anhui Province. He received a bachelor's degree in electrical engineering from Tianjin University of Science and Technology in 2014. He is currently studying for a master's degree at the department of electrical engineering in Southeast University, Nanjing. His main research interests are demand-side management, power market and so on.