1. ECONOMIES OF SCALE AND INVESTMENT CAPACITY

1.1. Key elements for the implementation stage

For the implementation of pay as you throw (PAYT) and know as you throw (KAYT) schemes, it is recommended to consider the key elements listed below:

- Before the implementation stage, it is highly recommended to pilot the PAYT/KAYT scheme to be implemented, so that certain aspects of the design that could compromise the budget on a larger scale can be revised. This is especially relevant when the investment is quite high because a lot of technology is going to be implemented. Pilot testing can save costs in the long term.
- Implementing different PAYT schemes adapted to each zone of the municipality might be recommended when there are different kinds of urbanism, socioeconomic or business structures across the municipality. In that case, the implementation at different stages would be also recommended, which can also facilitate budget availability.
- A gradual implementation could be done by type of user. Generally, it would start with the commercial implementation, followed by the domestic one, and in the city centre, followed by the surrounding neighbourhoods.

1.2. Public entities that provide economic support for the study and implementation of fair fees

Each region or country has its own public entity that provides economic support (via public aid, financial subsidies, etc.) intended to promote the study and implementation of Fair Fees or Pay-As-You-Throw (PAYT) systems, depending on the degree of incorporation of the concept of Fair Fee or PAYT in the regulations of the country or region.

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2. OPERATIONAL COSTS AND POSSIBLE BENEFITS

2.1. Costs and income

The waste charge should be designed aiming to collect the net costs (gross costs - income) of the waste management service. Therefore, this section lists the costs and income that must be considered to design a PAYT and KAYT scheme.

The costs to consider are:

- Investment pay-off
- Collection costs, including special collections such as bulky fraction, Textile, WEEE, Oil, etc. Including industrial profit and indirect expenses.
- Treatment costs of the different fractions (Residual fraction, Bio-waste, packaging, etc.).
- Waste charges can be charged depending on the country, region, or municipality (for example a landfill charge or an incineration charge)
- Initial communication campaign to present the PAYT charge to users, so they are aware of how their performance regarding waste separation might affect their charge amount.
- Communication costs such as monitoring and returning the information received by users.
- Administrative and technical staff of the municipality to do all the processing of the data.
- Waste Collection Centre costs (for non-ordinary fractions).
- Costs for the collection a treatment service inspection.
- Maintenance of landfill in use and after its closure.
- When setting up a PAYT charge, if a bonus is introduced, the final bonus expected to be received by all users must be added as an initial cost so that this does not count as a deficit.

The income to be considered are:

- Financial subsidies received.
- Secondary material sales that report income for the municipality.
- Income from extender producer responsibility.
- Others (depending on the country or region) (for example the return of the landfill charge or incineration charge in Catalonia (Spain)).

2.1.1. Specific costs for the implementation of PAYT schemes in door-to-door collection systems

The PAYT implementation tackles a series of costs associated with the material required. These materials are generally associated with the technology necessary to identify the user of the collection service. The ranges of unit costs that have been estimated for the investment of the implementation of PAYT charges with a door-to-door collection model are presented in Figure 1.

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Figure 1. Unit costs of the material required for PAYT implementation

MATERIAL NEEDED FOR THE IMPLEMENTATION OF PAYT IN DOOR-TO-DOOR COLLECTION SYSTEMS	PRICE UNIT (NO VAT)
Domestic bucket with RFID	(4 € (10 L) - 8-9 € (40 L)
Bags with QR code or RFID	0,080 – 0,15 € (20 L-40 L)
Buckets for commercial waste with RFID	40-45 € (120 L), 55-60 € (240 L), 80-90€ (360 L) - 210-230 € (1.100 L)
Adaptation in buildings (see list below)	
Hangers (for 40 litres buckets)	15-20 € (1 hanger - 25-30 € (3 hanger)
Monolith or totems (for 40 litres buckets)	140-150 € (6 hangers) - 220-240 € (12 hangers)
Container Carrier with access control (multi-family blocks)	2.500 - 3.000 €
Smart containers in the street for multi-family blocks	(see the budget for closed containers)
TAG reading technology (see list below)	
Activation service/Project implementation	2.800 - 3.000 €/project
Embarked equipment for TAG reading	5.800 - 6.800 € / vehicle
Embarked equipment installation and maintenance	450 - 500 € / vehicle
Manual reader (bracelet) / wristband	1.200 - 1.500 €/unit
Reading technology maintenance fees (see list below)	
Fee per bracelet	5 - 8 €/month
Fee per vehicle with UHF antenna	35 - 40 €/month
Software fee (not applicable in all cases)	32 - 50 €/month

2.1.2. Specific costs for the implementation of PAYT charges with smart containers

The estimated needed investments for the implementation of PAYT charges with smart containers is presented in Figure 2. The second column indicates the price range of the user identification technology. The third column indicates the price range of the chamber system, which is identification technology with a container with a cylindrical drum to measure the volume of waste delivered.

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Figure 2. Estimated price for the technology needed to lock the containers

		User identification systems price range	Chamber system price range
Technology per container		355 € - 900 €	1,382 € - 1,400 €
Installation per container		90 € - 100 €	50 €
Hardware maintenance		5 €/container/month	9 €/container/month
RFID Cards or Smartcards		1.35 € - 3.76 €	
SmartTag		2.65 €	
Volumetric sensor		325 €-390 €	
Waste limitation metallic mesh[a]		193 €	
SOFTWARE	A **Software online (manteinance is included)**	8 €/container/month 0.25 €/month/smartcard	
	B **Software license**	1,950€ - 6,900 €	
	B **Software installation**[b]	1,000 € - 6,000 € (for 3,000 inhabitants)	
	B **Software and hardware maintenance**	150[c] - 472 €/month	
Project implementation[d]		700 € - 6.500 €	
QR bag		0.098 €	
Alphanumeric bag		0.079 €	

a) Consist of a metallic shape grill with square holes for the main purpose of distributing the material homogenously, it also helps to control the material volume the user can introduce in the container.
b) It depends on the number of inhabitants registered.
c) It refers only to software maintenance, for the unidirectional systems.
d) It depends on the number of containers installed.

Note: Price ranges for a minimum of 5 technological manufacturers and suppliers, prices of 2017.

Source: User Identification for Municipal Waste Collection in high density contexts (ENT, 2019); https://ent.cat/wp-content/uploads/2019/07/User-identification-for-municipal-waste-collection_4.pdf

2.1.3. Specific costs for the implementation of PAYT charges with collection points located in rural or isolated areas

In municipalities with isolated residential areas, closed waste collection areas can be implemented, so that these residents can also participate in the PAYT charge when they are identified to access the collection area. This collection area and user identification system implies different investments that

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should be considered. The estimated unit prices associated with those investments are presented in Figure 3.

Figure 3. Material needed for the implementation of PAYT in closed waste collection areas and estimated prices

MATERIAL NEEDED FOR THE IMPLEMENTATION OF PAYT IN ISOLATED RESIDENTIAL AREAS	UNIT PRICE (WITHOUT VAT)
Bucket or containers inside the area (Without locking them and without TAG)	35-45 € (120 L), 50-60 € (240 L), 70-85 € (360 L) - 190-220 € (1.100 L)
Bucket or lock containers inside the area	(see budget from Figure 2)
Wooden fence of the area	8.000 - 15.000 €/u
Technology to lock the area	2.500 - 5.000 €/u
Electronic Key or card to enter the area	1,75 - 3,5 €/u
Software maintenance and remote assistance	40 - 50 €/month
Video surveillance camera	3.000 - 4-000 €

2.1.4. Material needed in any type of PAYT waste charge implementation

Regardless of the waste charge model implemented, there will always be costs associated with the communication campaign, the software or module that allows for automation of the calculation of the waste charge per user according to deliveries or access to closed containers, and the Citizen App that allows bidirectional communication between the local entity and the taxpayers.

The communication campaign is very relevant to ensure that taxpayers understand how to participate. The costs, however, are very variable depending a lot on the municipality where the implementation takes place and on the complexity of the model.

The costs of the fee calculation software or module and Citizen App are presented in Figure 4.

Figure 4. Software and App costs to calculate and implement PAYT waste charges

OTHER COMMON COSTS TO ALL MODELS OF SELECTIVE COLLECTION, FOR FAIR FEE IMPLEMENTATION	
1) FAIR FEE CALCULATION MODULE OR SOFTWARE, BASED ON WASTE DELIVERIES	
Fair Fee module	1.300 - 1.800 €
Data import from other software / interconnection	1.800 - 2.000 €
Implementation and staff training	1500 - 1.800 €
Maintenance	100 €/month
2) APP FOR CITIZENS AND BUSINESSES	
Bidirectional App	2.000 - 3.500 €
Maintenance	0,3 €/taxpayer-license/year - 100 €/month

2.2. Waste flow balance and economic benefits

When a PAYT waste charge is implemented, generally the charged fractions such as the residual fraction or packaging fraction tend to reduce. The rate of selective collection tends to improve, and the generation of bio-waste tends to increase and improve in quality. Bulky items and textiles tend to increase as well. The magnitude of this, however, always depends on the incentives that are applied.

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On the other hand, it must be considered that at the beginning of the implementation some citizens might illegally dump waste. Figure 5 presents a list of the effects observed on waste flows when PAYT waste charges are implemented.

Figure 5. Potential waste flow changes by the introduction of PAYT waste charges

WASTE FRACTION	EXPECTED TREND
Charged fractions (packaging and remain fractions) in door-to-door collections	Tend to reduce
Fractions collected at monitored waste collection areas	Tend to disappear whether charged fraction containers are deleted from collection areas
Percentage of selective collection from door-to-door collected waste fractions	Tend to increase at non-charged fractions
Domestic bio-waste fraction (bonused)	Tends to increase
Business' bio-waste fraction from door-to-door collection	Tends to increase and improve its composition
Bulky waste collected	Tends to increase
Textile collected at specific containers	Tends to increase
Waste delivered to Waste Collection Centre	Tend to increase
Irregular dumping	Tends to increase. Thus, the trend depends on the adopted selective collection model, the services provided and the implementation of sanctioning mechanisms.

Changes in waste flows affect the general economic balance. When residual waste is reduced, and the collection of recyclables increases, the cost of waste management decreases because of the income from selling secondary materials or from the extended producer responsibility schemes. Hence, generally, the implementation of the PAYT charge implies a reduction of the net costs (balance) of the waste general service.

As a reference for the implementation of PAYT charges, Figure 6 presents a statistical comparison of the selective collection results analysed between municipalities that operate with open containers without user identification and those that operate with door-to-door collection, with door-to-door collection and PAYT charge, and with smart containers. It shows that the combination of door-to-door collection and PAYT charge is the system that reports the best results, with an average of 85% selective collection. The results of smart containers are still uncertain because most experiences have been based on pilot tests and not across a whole municipality. Nevertheless, the experiences carried out report quite positive results.

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Figure 6. Results of selective collection depending on waste collection model and PAYT charge scheme

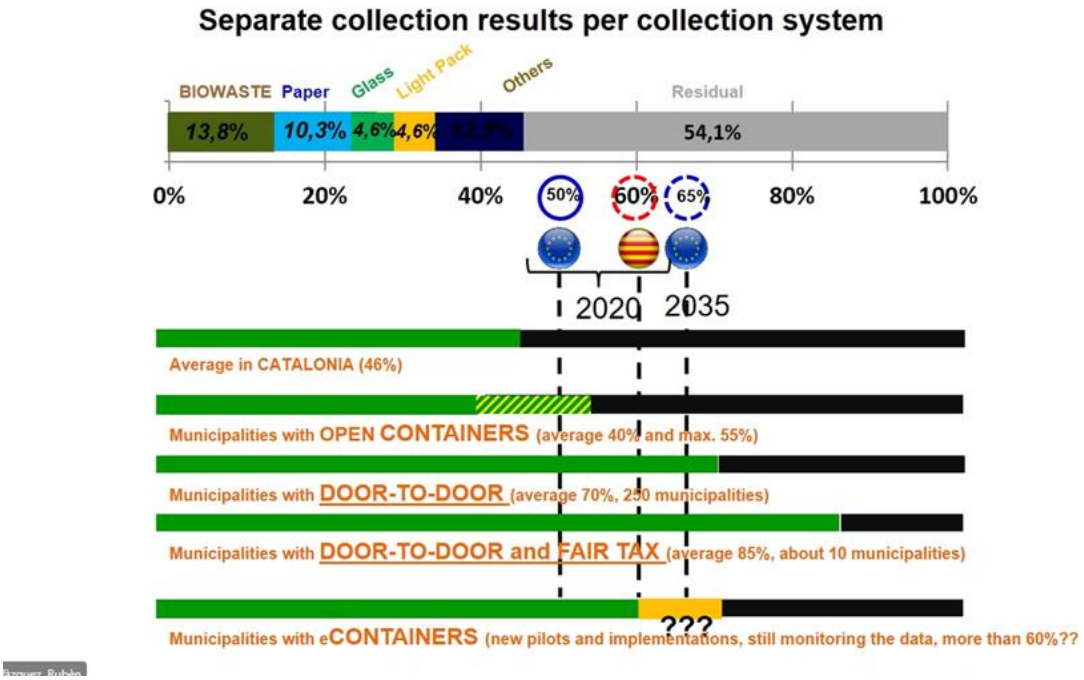
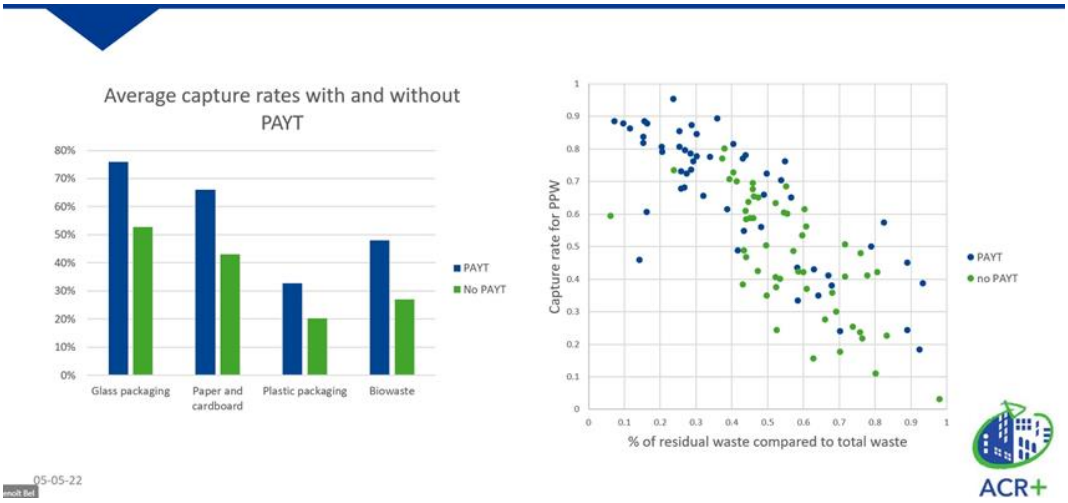


Figure 7 presents the correlation between the implementation of PAYT schemes and the reduction of the waste generated and the recovery of recyclable materials (obtained with data from Catalonia (Spain), 2021).

Figure 7. Relation between PAYT schemes implementation, the reduction of residual waste and the percentage in recyclables recovery



Source: ACR+.

2.3. Percentage of net costs covered by charge collected

The net cost balance is the difference between gross costs minus income received from recyclable fractions. The percentage of collection coverage of net costs can be calculated dividing the economic collection of the waste charge (numerator) by the calculated net costs (denominator), as shown in Figure 2.

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Figure 8. Waste charge net costs coverage

$$\textbf{Gross costs (€) – Recyclable income (€) = Net costs (€)}$$

$$\textbf{Percentage of collection coverage (\%)} = \frac{\textbf{Waste charge colection (€)}}{\textbf{Net Costs (€)}}$$

Spain has just approved a new waste law that requires municipalities a 100% waste charge coverage of the net costs by 2025. It is important to highlight that the closer you get to the collection goal with the waste charge, the more margin for bonuses and PAYT schemes you have.

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3. OVERALL ECONOMIC BALANCE

Below, are detailed aspects such as the waste and economic balance in PAYT Systems (section 3.1), the PAYT scheme and charge modulation (section 3.2), the actions to minimize charge circumvention phenomena (section 3.3) and tendering and charge regulation (section 3.4).

3.1. Pay as you throw, waste flows, economic balance and environmental externalities

As it is introduced in section 2.2, PAYT schemes usually influence waste flows by lowering the production of residual waste and increasing the collection of recyclable materials. This has a direct effect on the net costs because managing recyclables is generally cheaper, due to the potential value these materials have in the market. This effect is especially relevant when there is extended producer responsibility (EPR) schemes for the recyclable fractions that cover their management costs, or when there is a charge for landfill dumping or incineration.

Nevertheless, not in all municipalities or regions the reduction of residual waste necessarily reports a deep enough reduction of costs to ensure the economic sustainability of the PAYT scheme. Hence, it is relevant to combine PAYT waste charges with other tools that allow internalizing the environmental impacts of not properly separating waste. As an example, in Spain the effect of EPR usually provokes that the cost of managing paper, cardboard, or/and glass are generally null for municipalities because it is covered by the producers.

3.2. PAYT scheme and charge modulation

Fair Fee's structure is composed by a general part and a variable part. The general part is independent from waste generation, and it is where social and environmental bonuses or discounts (such as the use of waste recycling centres, home composting, or green trade) are applied. In addition, some behaviours could not be measured in the variable part, such as the fact that some households only have 1 resident or that some households make some sort of packaging prevention. In those cases, some sort of reduction of the general or fix part could be taken into consideration.

The variable part may be structured in two parts:

1. A minimum part, which must be charged to all taxpayers (independently of their waste generation).

2. A variable part, which depends on each taxpayer individual waste generation. The variable part could represent between the 5-40% of the charge collection. It must be had in mind that a greater variable part leads to a greater incentive on preventing waste generation.

On the other hand, charge modulation must take into account the existing waste collection system. Therefore, charge modulation works under the assumption that taxpayers' use of the monitoring waste fractions is recorded.

Calculating the net costs of the waste service and charge's bonuses and discounts is the first step in the charge modulation process. To do that, the design of taxpayers' behaviour histograms is a must. These histograms should report information on waste fractions uses for each taxpayer typology. However, it must be considered that this estimation is subjected to statistical error, and taxpayers' participation could be increased once fair fees are applied.

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Once the taxpayers' participation has been estimated, the exact unit prices of each variable part of the waste charge can be calculated. These would permit the achievement of the charge collection target. In PAYT schemes, the assignation of a minimum range of uses (which is independent from taxpayers uses) is recommended. In the case of the participation bonus, it is recommended to establish minimum deliveries so that the bonus starts to be calculated on the variable part and a maximum number of deliveries from which the bonus would no longer be calculated to avoid fraudulent use.

3.3. Minimizing charge circumvention phenomena

When introducing a fair fee there are potential risks of non-payment of the variable part. This can exist in both door-to-door and smart containers collection systems, and they are detailed below:

3.3.1. Risks of fraud in door-to-door collection system

At door-to-door collection system, risks of fraud are related to:

- Illegal dumping in bins, containers and/or nearby in open spaces. The inclusion of a penalty regime in the municipal ordinance can reduce these situations.
- Waste tourism in nearby municipalities or in other neighbourhoods that operate with open containers placed at the public road. In this case, the bonus of some of the fractions of the fee (ex. bio-waste) can serve as a deterrent.
- Risk of improper increase of the fractions that are not taxed. It is a medium risk, as the operator can make visual inspections during collection.

In addition, there can be mentioned some other specifications for door-to-door collection systems:

- Diaper collection is a service that requires to define its users at the ordinance. It is recommended to limit it for homes with babies and/or elderly people with incontinence problems. Likewise, deliveries should be done in a standardized and translucent bag.
- It is recommended that door-to-door collection system is designed, at least for 4 fractions (all except for the glass fraction). Likewise, contribution areas or open containers placed at the public road should be eliminated in order to prevent bad practices by the users. Alternatively, an entry price could also be established in those places where emergency areas cannot be eliminated. Furthermore, an emergency service could be established.
- Application of a mouth reducer of the public waste bins. Its purpose is to avoid the delivery of waste bags inside.

3.3.2. Risks of fraud in smart containers waste collection system

At smart containers systems, risks of fraud are related to:

- Illegal dumping (especially next to containers).
- Malfunctions of the technology and/or errors in the closing systems that can lead to errors in the records of use.
- Waste tourism. In this case, the application of bonuses on certain fractions (ex. bio-waste) can be a dissuasive tool.

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- Improper waste increment for unclosed fractions. To solve that, it is recommended to close as many fractions as possible, as well as reducing the volume of the entrance of those containers that are not closed. In addition, the possibility to introduce a bag with QR or alphanumeric code, or tag RFID could permit to control improper waste in charged fractions via subsequent inspections. Or another possibility could be to distribute users per container (not all users can use all containers, only 1 or 2 of them) and then make subsequent waste characterizations for charged fractions.

In addition, there can be mentioned some other specifications for smart containers collection system:

- In those cases, where the residual fraction is subjected to PAYT schemes, nappy users should have an additional number of uses which shouldn't be subject to any additional cost. Alternatively, it could be placed, next to container areas, a specific closed bucket for diaper collection.

- For businesses, it is important to carry out a more specific monitoring and to equip the containers with volume regulation, which should be adapted to that kind of users.

- In the case of public waste bins, the risk is like door-to-door systems. Therefore, bins should be reduced and penalties should be implemented for their misuse.

3.3.3. Participation control

Once the users are identified, certain actions can be taken. For those users who participate regularly and that have installed the App, information related with their use of the service, kind and quantity of fractions delivered, and others should appear in the App of the service.

However, it should be noted that it is important to do a constant job of disseminating how the model works to those users who do not participate in the system. Below, more serious and customized actions are described that can be taken when taxpayers who are not using the service properly are detected:

- For businesses, visits can be made directly to the establishment during opening hours. In addition, warning letters should be sent in case of recidivism.

- For domestic users, warning stickers via door-to-door or informative warning letters should be sent, notifying that their behaviour is known and reminding them the obligation to separate properly their waste fractions in the current waste collection system in their municipality. Visits by environmental educators can be also contemplated.

In both cases it is important to stablish the proper channels to inform constantly about the obligation to participate correctly in the waste selective collection, and the possible sanctions that can be received for not doing so. Finally, if it is considered that there had been enough warnings, the imposition of sanctions should be carried out.

3.4. Tendering and contract regulation

This section summarizes the legal aspects that municipalities must have in mind when establishing waste charges:

- Waste charge collection: it can be articulated in different ways. It must be considered which is the organization that carries out the collection, who manages the information and how it is transferred to make the collection and the number of annual receipts, among others. When the objective is the fair fee implementation, there are some differences that should be considered. In the case of

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pre-payment systems, the variable part is transferred directly through the collaborating businesses that sell the bags. On the other hand, in post-payment systems, the amount depends on the records identified through the identification systems.

- Fiscal Ordinance and Economic Memory: The Fiscal Ordinance must include the new waste charge structure and its waste unit prices. Its modification and approval must be accompanied by an economic report showing clearly the balance of costs and incomes. c its structure must consider the following sections: introductory section with the legal context, service net costs, expected charge collection (with breakdown of costs attributable to domestic service and business service) and, finally, the justification that the charge is adapted to the principle of economic equivalence (arguing that the collection won't exceed the service net cost)

- Municipal Waste Regulation Ordinance: Besides, it is necessary to draw up a municipal ordinance (or to modify it in order to properly regulate the form of waste delivery and the containers used). It is necessary to specify whether they have TAG and the description of standardized bags. The rights and duties of citizens, businesses and the municipality must be described as well as infringements and resulting penalties.

- Consistency: Consistency between the municipal and the fiscal ordinance is fundamental. Besides, fiscal ordinances must consider some relevant issues, such as the specification to whom the charge is addressed, charge structure, charge rate, the way it is calculated the variable part, and billing frequency, among others.

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