Optimal tariff system for integration of distributed resources based on a comparison of Brazil's and Germany's system

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***Abstract*— The energy trading in Brazil is conducted in two different environments: the Free Market (ACL) and the Regulated Market (ACR). In ACL, the free and specials consumers can freely negotiate their own energy. In contrast, the captive consumers belong to ACR, and do not have the option to choose their energy supplier. Germany also has a similar system, where the big consumers (industrial) can freely negotiate their energy and the small consumers (residential) must choose a provider and pay a fixed price for the energy, where prices vary very little from one provider to another. Recently in Brazil, it was created the white tariff providing conditions that stimulate some consumers to shift consumption from peak periods to those periods that the distribution network has idle capacity. Regarding distributed energy resources (DER), there are also some peculiarities between the two countries. The objective of this paper is to verify the impacts that German residential consumers and the distribution network would have with the implementation of an hourly tariff equivalent to the white tariff of Brazil. The tariff structure and energy market regulation from both countries are compared and several simulations considering real data from German consumers and tariffs are done.**

Keywords—Energy Market; Brazil; Germany; DR; DSM; Residential consumer; Time of Use Tariffs.

I. Introduction

To stimulate the shifting on electric energy demand and avail better the system, Brazil created a modality called the white tariff. This modality, encourage the consumers to shift their demand for the period where the grid is less used, reducing their invoice at the end of the month and the necessity of grid expansion to meet peak hours. The white tariff seems a good option to apply in Germany, stimulating the consumers to shift their demand from peak hours, where is necessary turn on power plants with bigger generation cost, to periods during the day, taking advantage of the low price of renewable energy. In this work, the impacts of implementation of white tariff for low consumption households in the Germany are presented.

The paper is structures as follow. In Section II, the tariff structure of residential consumers in Brazil and Germany are presented. The Brazilian white tariff is analyzed in Section III. In Section IV, the white tariff is applied in the German load profiles and the results are presented in Section V. Finally, the conclusions are presented in Section VI.

II. The Tariff Structure of Residential Consumers in Brazil and Germany

A. *Tariff structure in Brazil*

The energy trading in Brazil is realized in two different ways, according to law n° 10.848/2004. In the first one, named Free Market (ACL), the generators (public service, self-generators, independents producers, brokers, importers and exports) and the free and specials[1] consumers are free for negotiate energy purchase, negotiating quantities, prices and supply delivery dates. Every energy contract must be registered on the Chamber of Electric Energy Commercialization (CCEE) that had its creation authorized by Decree n° 5.177/2004 for enabling the commercialization of electric energy on National Interconnected System (SIN) [1]. In the second, called Captive Market (ACR), the captive consumers do not have the option to choose their energy supplier. They buy energy only from the utility that they are connected and pay the regulated tariffs defined by the Brazilian Regulatory Agency (ANEEL).

The energy consumers are classified into two groups according to [2]. The first one is called Group A, and is composed of consumer units with a supply voltage greater

[1] Free consumers – those with a load greater than or equal to 3,000 kW – can freely negotiate their energy purchases. Special consumers – those with a load greater than or equal to 500kW – can freely negotiate their energy purchases with the condition that at least 51% of the energy is from alternative sources.

than or equal to 2,300 V, or those attended with underground distribution system in secondary voltage subdivided according to the supply voltage. The second group, named Group B, is composed by consumer units with a supply voltage lower than 2.3 kV, subdivided into the following subgroups [2]: residential (B1), rural (B2), other classes (B3) and public lighting (B4).

Since January 2015, tariff flags system was introduced by Normative Resolution n° 547/2013 of ANEEL. The system has three colors that indicate if energy is costing more or less, considering the generation condition. The green flag means no additional cost. Yellow or Red flag indicate that generation cost are increasing and there will be additional costs.

Equation (1) shows how the conventional tariff price is calculated in Brazil.

$$C_{in} = C_{ta} * D_{tm} * T_f \qquad (1)$$

Where:

C_{in}: Conventional Invoice [R$].

C_{ta}: Conventional tariff defined by utility [R$/kWh].

D_{tm}: Total consumption measured in the month.

T_f: generation condition of the system[R$/kWh]

The white tariff is available for consumer units supplied in low voltage, and by adopting this modality, the consumer pays different values depending on the time and day of the week. On weekdays, the value varies in three different levels: peak, intermediary and off-peak and only one value for weekends (off-peak). The weighted total demand for a working day is calculated by (2).

$$WT_{wd} = kz * (5 * D_p + 3 * D_{in} + D_{op}) \qquad (2)$$

Where:

D_p: Demand in Peak.

D_{in}: Demand in Intermediary.

D_{op}: Demand in Off Peak.

kz: Relation between off peak TUSD and the conventional tariff monomial TUSD [12].

The value of white tariff is calculated by (3).

$$WT = C_{ta} * \left(\sum_{i=1}^{p} WT_{wd_i} + \sum_{i=1}^{q} kz * D_{s_i} + \sum_{i=1}^{r} kz * D_{d_i} \right) \qquad (3)$$

Where:

p: Number of working days in the month.

q: Number of Saturdays in the month.

r: Number of Sundays in the month.

D_s: Demand in Saturday.

D_d: Demand in Sunday.

B. *Tariff structure in Germany*

In Brazil, the low voltage consumers can choose between white and conventional tariff. In the German system, the consumers have just conventional tariff and pay only one price independent of the day or hour of use. Equation (4) shows how the conventional tariff price is calculated in Germany.

$$C_{in} = C_{ta} * D_{tm} \qquad (4)$$

Where:

C_{in}: Conventional Invoice [€].

C_{ta}: Conventional tariff defined by utility [€/kWh].

D_{tm}: Total consumption measured in the month.

Since 1998, any consumer can freely choose between every electricity company. The system operator publishes annual statistics of the network-use fees; according to this, every consumer is enabled to choose their electricity provider. This market opening concept is easy to apply on key account consumers with contract based on payments of electricity consumption and a high amount of energy demand. Their energy consumption can be planned by scheduled supply and by same time measurements of supply and consumption. In this first case, the system operator can realize a reliable and secure network management based on the information by scheduled demand and real time measurement. However, for the smallest customers there is no existing energy measurement-system due to the technical and organizational complexity and considerable costs associated with installing a load profile meter.

Nowadays, the measurement system only counts the consumptions, there is no possibility to reach tariff change signals. Also small consumers can choice their supplier freely, but the price is equal for each kWh. In Germany currently the Smart Meter rollout is planned, which will be the requirement for the application of different tariffs [4],[5]. For power system simulation, representative load profiles are created, of way empirical, for different user (household, agriculture ...), through the existing measurements and profiles of different groups that were differentiated regarding specific time parameters such as hourly, daily (i.e. weekdays, Saturday, Sunday) and seasonal (i.e. winter (Wi), transition time (TT), summer (Su)) time intervals [6]. Fig. 1 shows all standardized profiles for residuals.

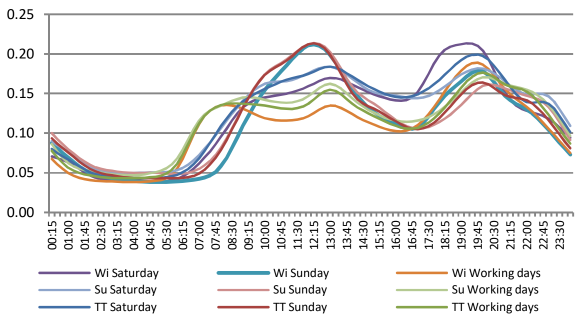

Fig. 1 Standardized Load Profiles [kWh]. Adapted from [6].

Under the assumption of annual electrical work of all customers of the specific group, the total resulting load curve is calculated and in correct time relation subtracted from the measured transfer power to pre-suppliers. The pre-suppliers calculate their aggregated load curve in the same way, at every stage of the supply chain. Hence, it is possible to calculate all supply relationships on every stage of the supply chain which allows conducting a scheduled load forecast. To quantify the individual customer schedules and load profiles based on the annual customer consumption all profiles were normalized on a specific annual consumption of 1000 kWh/year. In this paper, the white tariff will be applied for residential consumers and the simulation will be made at households and those with (electrical) minor business demand, without installed heat pump, storage heating etc.[6] .

III. Analyzing The Brazilian White Tariff

For Group B consumers, two options of tariff are available: conventional and white tariff. The conventional has only one value, independent of day or hour of use. The white tariff is a tariff modality applied to consumer units of Group B, with the exception of subgroup B4 and low-income of subgroup B1. There are three different tariff prices on weekdays depending the hour of use [8]. Fig. 2 illustrates the white tariff on weekdays. Peak hours are the three consecutive hours within workdays, set by the distribution utility, approved by ANEEL and valid for the entire concession area [9], the tariff cost is five times higher than off-peak period. The intermediary hours are one hour immediately after and one hour immediately before the peak hours [10]. The hours complementary to these five hours presented on weekdays are the off-peak period where the consumers pay the product of conventional tariff and *kz* factor independent of the hour of use. In addition, within weekends and national holidays, illustrated in Fig. 3, the consumers pay the off-peak tariff.

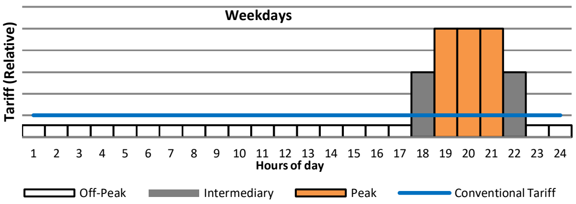

Fig. 2 White tariff: weekdays. Adapted from [11].

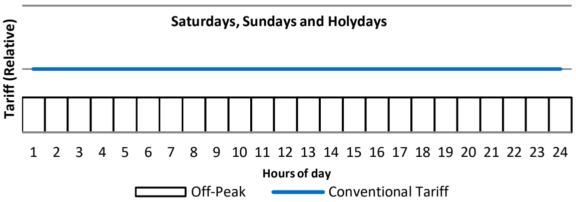

Fig. 3 White tariff: Saturdays, Sundays and Holidays. Adapted from [11].

To adequate the tariff structure, the utility and consumers can propose changes, proving a tariff more adequate and better to the public interest than standard proposed. For the white tariff, the following parameters can be proposed: using or not intermediary post; using of intermediary post on hourly different that established, always combined with the peak post; using the relation among peak, off-peak and intermediary, different that that established; using the *kz* factor different of standard [8].

The *kz* factor is the relation between off peak and the conventional tariff. Each profile has their *kz* factor that is called *kz* intrinsic. This value represents the proportional relation between the price of conventional and white tariff. The utility can define a value for *kz* depending on the characteristic of its consumers. It can be calculated by (5).

$$kz = \frac{D_{tm}}{\left(\sum_{i=1}^{p}\left(5 * D_p + 3 * D_{in} + D_{op}\right)_i + \sum_{i=1}^{q} D_{s_i} + \sum_{i=1}^{r} D_{d_i}\right)} \qquad (5)$$

Before, in Brazil, the *kz* factor was calculated using a single value for the whole country considering the profile of all utilities and calculating an average value of the aggregate curves. Thus, the calculated value in PRORET (Regulatory Procedures of Tariffs from ANEEL) *kz* was equal to 0.55. This value was the same for the different classes of Group B which applies the white tariff (residential, rural, commercial and industrial). However, due to the diversity of consumer habits in Brazil, in each area of concession, this method of calculation of *kz* factor can lead to an undesired effectiveness of the white tariff caused by, for example, inhibition of new consumer units to adopt the tariff and also awarding the consumer without its counterpart, the decrease in consumption in peak period. Fig. 4 shows, through a real example, the distortion incurred when using a single *kz*, based on the aggregate load curve Brazil. The B3 subgroup, composed predominantly commercial and industrial classes, use the system with greater intensity during the daytime, while the subgroup B1, residences, the use occurs more intense at night. If the same value of *kz* was applied, the B3 subgroup, which has an intrinsic *kz* equal to 0.62, could consume more energy in their peak hours without increasing energy costs or get a discount without having any change of habits consumption, since its higher consumption occurs outside the white tariff peak period. This would occur because the *kz* of B3 subgroup is higher than the national average that is 0.55. However, for the subgroup B1, the opposite effect would occur. As the intrinsic *kz* of that group (0.5) is lower than the national average, consumers of this subgroup would have significant increases in their bills if the same habits remained or even reduce consumption at the peak period. That is why the adoption of a higher intrinsic *kz* to the subgroup would function as an inhibitor of consumer's adherence to the white tariff. For these reasons, it is necessary to define a *kz* for each subgroup [12].

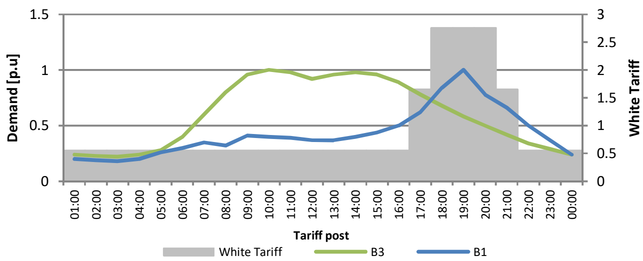

Fig. 4 Example load curve profiles of residential subgroups (B1) and other classes (B3). Adapted from [12].

Even calculating a specific *kz* for each subgroup, within the subgroup itself consumption has different habits, which could largely benefit consumers without reducing their consumption at peak hours. This would have a negative impact on sales of the utility. In this way, it could base on the value of the different distribution curves using the calculated maximum value of *kz* between these curves. Fig. 5 shows the load curves of different consumer-type subgroup B1 of the distribution utility. From some simulations could conclude that these results reached by the use of curves of a distribution utility can be extended to other distribution utilities with reasonable accuracy [13].

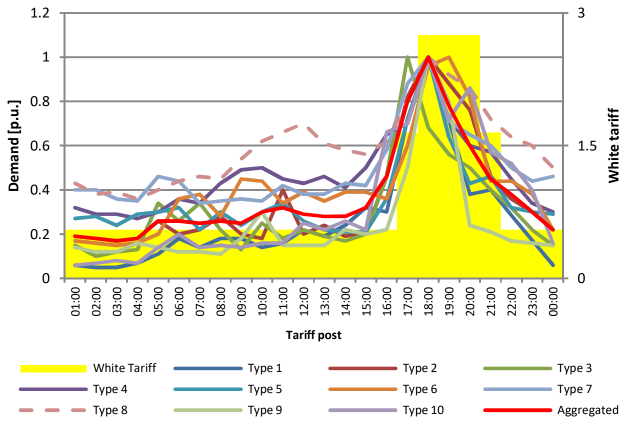

Fig. 5 Consumers-type or subgroup 1. Adapted from [13].

In order to compare the conventional tariff and white tariff, some simulations were done. Table 1 shows the results. The required modulation in peak period refers to the equivalence between conventional tariff and the white tariff and was calculated considering the *kz* factor 0.58 of consumer Type 8 that is the bigger *kz* Factor showed. The participation on B1 market represents the composition of Market characterized by supplying consumer units with residential end. Required modulation in peak is the demand amount consumers may shift from peak to off-peak. The relative consumption in peak refers to consumption in peak period regarding to total consumption of topology.

Table 1 Characteristic of consumers-type. Adapted from [13].

Consumer	Relative consumption in peak	Intrinsic *kz*	Participation on B1 Market	Required modulation in peak
Type 9	39.24%	0.42	5.96%	-52.28%
Type 1	38.07%	0.42	15.70%	-53.94%
Type 2	31.54%	0.45	14.97%	-47.45%
Type 10	30.51%	0.46	5.52%	-48.25%
Type 3	30.56%	0.46	14.21%	-44.43%
Type 5	27.63%	0.5	8.54%	-32.58%
Type 6	25.75%	0.51	8.57%	-29.76%
Type 4	21.58%	0.55	11.98%	-14.58%
Type 7	22.18%	0.55	8.09%	-14.31%
Type 8	19.11%	0.58	6.46%	0,00%
Aggregated	29.20%	0.48	100.00%	-39.18%

The maximum *kz* obtained and presented in the table was 0.58. This *kz* is associated with the consumer who has the lowest consumption in the peak period and has lower load modulation potential. This consumer also represents only 6.46% of the market. However, considering the value of *kz*, the rest of consumers (93.54%) would need to modulate their load of 14.31% to 52.28% depending on each type. These numbers represent that users would need an excessive effort to enable the white tariff, becoming in often an impediment factor from the consumer point of view. Thus, on the hand this maximum value of *kz* considered almost nullify the loss risk of the utility. On the other hand, would have a low consumer acceptance. Another analysis that can be made is that the consumer of type 8 has a little impact on the formation of peak demand and in the need for expansion and maintenance of the system, would be consistent he has a lower cost. If *kz* of the aggregate curve were used, it could be seen that about 44% of the B1 market has a higher *kz* than 0.48 and can obtain an economic benefit without the demand modulation necessity.

On the side of consumers, the greatest benefit would be to consumers similar to type 8, representing 6.46% of the market, which has a potential benefit in reducing bill of 8.04%, impacting -0.52% in the utility revenue. On the side of the utility, consumers similar to type 4, representing 11.98% of the market, would obtain a benefit of 5.70% causing a decrease in 0.68% of distribution revenue. Fig. 6 shows the other results.

For the calculation of the aggregated, the impact without modulation, in the utility revenue would be about -1.97 which corresponds to 0.7% of total revenue in the simulated case. The most appropriate would be to use the weighted average of the specific *kz* of each type belonging to the subgroup, to calculate the factor *kz* [13].

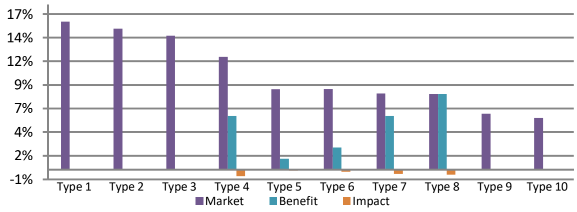

Fig. 6 Benefits and impacts of migration to white tariff. Adapted from [13].

IV. Applying The White Tariff In the German Load Profile

The mainly objective of the white tariff is to shift the demand during the peak times to periods of less demand. During the day, the generation cost in Germany is lower because of the good conditions for wind and solar power. In the evening, the cost for generating energy is higher because is necessary to use other sources of energy such as coal power plant. Other problem is that it is often necessary to turn off some renewable power due to power system congestion problems. In that case, the utility pays a value for turn it off. The white tariff would be a good solution for those situations, reducing the consumption at night where the generated power is more expensive. On the other hand, shifting the consumption to during the day or to off-peak period, will sometimes make not necessary to turn off many wind power, reducing the tariff price. For the calculation, a month with 31 days, being 22 working days, 4 Saturdays and 5 Sundays were considered. The value of 0.30 €/kWh was used to the tariff price in Germany.

Fig. 7 shows the consumer standardized profile for households related with the white tariff. The peak hour is defined by utility and need to be approved by regulator. Despite, the utility can define the hour, it is necessary that the peak hour is consecutive and the intermediary hour is together with peak hour. A quantity of hours to intermediary period can be chosen. In this example, the peak hour is from 6 pm to 9 pm where energy is more expensive in Germany. The consumption of standardized load profile, on working day divided by hour of use is presented in Fig. 8. The white tariff has different prices depending on the hour of use just in working days. For holidays and weekends, the customer pays the only value that is calculated by product of *kz* and conventional tariff.

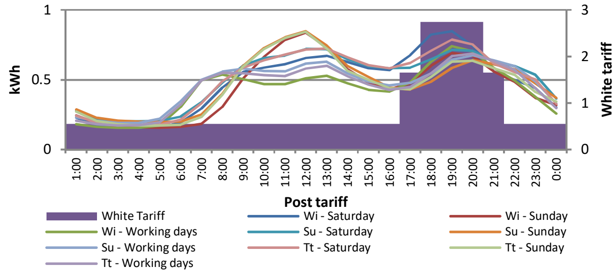

Fig. 7 Standardized profile related with white tariff.

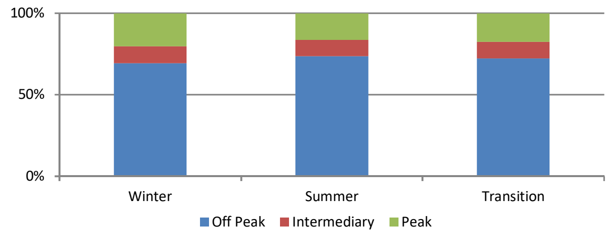

Fig. 8 Consumption on working days.

Table 2 shows the value of intrinsic *kz* for each season and demand of each curve. We can observe that for each season there is one different value.

Table 2 Demand of standardized profiles [kWh].

	Winter	Summer	Transition Time
Off peak (working days)	7.0827	8.2793	7.8007
Intermediary (working days)	1.0685	1.1151	1.08
Peak (working days)	2.0725	1.8615	1.9026
Saturday	11.546	12.132	12.0549
Sunday	10.742	11.416	11.0794
***kz* intrinsic**	0.59	0.62	0.61

Fig. 9 shows the influence of *kz* factor. For the intrinsic *kz* of 0.59 it is indicated that the white and conventional tariffs are equal. If the utility defines a *kz* below this one, this represents that for this consumer it is interesting to change to the white tariff – even without changing its habits he can obtain benefits. However, if the *kz* defined by utility is higher than the intrinsic *kz*, to have some benefits this consumer need to modulate his consumption for off-peak. A maximum value of *kz* considered almost nullify the loss risk of the utility, on the other hand would have a low consumer acceptance.

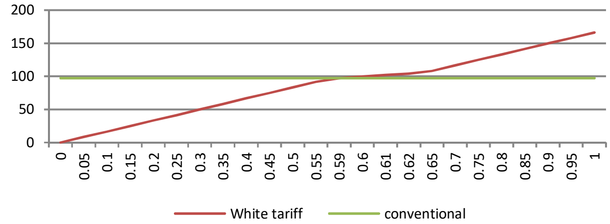

Fig. 9 The *kz* factor and tariff price [kWh] in the winter.

V. RESULTS

The white tariff was applied to standardized normalized profiles for consumer annual consumption of 1000 kWh/year. In addition, data about households based on consumption are presented in Table 3.

Table 3 Average consumption in the Germany by households [kWh].

Electric water heaters				
households	**Ø**	**with**	**without**	**Quantity [millions] [7]**
1-Person	2229	2880	1714	16.4
2-Person	3202	3781	2812	13.8
3-Person	4193	5053	3704	5
4-Person	4955	6103	4432	3.7
5-Person	5928	7310	5317	1.3

A. Season Data

Winter season present an intrinsic *kz* equal to 0.59. Fig. 10 shows the proportionality of *kz* factor between white and conventional tariffs, being the white tariff the price pay by the customer, depending on the *kz* settled by the utility, if he wants to change the modality. Otherwise, if it is better for the consumer, he can continue to pay the conventional tariff, which has the same value independent of *kz*.

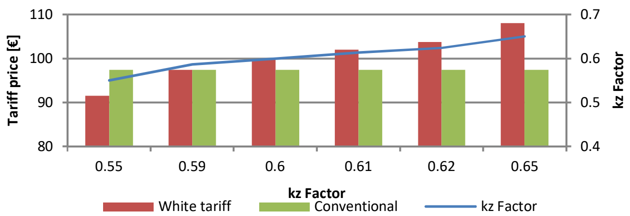

Fig. 10 The *kz* factor in the winter season.

Table 4 shows information about the *kz* factor applied in each season. Analyzing, for example, the winter season, if the utility settles the *kz* below of the intrinsic of 0.59 for this season, like the example showed of 0.55 the price of the conventional tariff would vary over 6% in relation to white tariff. Thus, the consumer does not need to shift his demand and further increasing their demand in 16% in the peak period. The amount of energy the new peak period for *kz* settled can be calculated rearranging (3) and resulting (6).

$$D_{p_{new}} = \frac{\frac{WT}{C_{ta}} - kz_{new} * \left(\sum_{i=1}^{q} D_{s_i} + \sum_{i=1}^{r} D_{d_i} + \sum_{i=1}^{p}(3 * D_{in_i} + D_{op_i})\right)}{5 * \sum_{i=1}^{p} kz_{new}} \quad (6)$$

Where:

Kz_{new}: kz settled by utility.

D_{p_new}: new demand in peak period to kz settled.

The amount of energy that needs shifting can be calculated by (7).

$$D_{p_{desloc}} = D_p - D_{p_{new}} \quad (7)$$

Where:

D_{p_deslc}: demand to be shifted.

This is not interesting, because the utility would lost revenue and the demand would increasing in the peak period. On the other hand, if was applied a *kz* factor above intrinsic *kz*, like the example showed of 0.65, the price of white tariff would be 11% higher than the conventional tariff and the consumer would have some benefits, shifting his peak demand at least about 24%.

Table 4 The *kz* factor data for winter, summer and transition time.

	Winter		Summer		Transition time	
***kz* factor**	**Δ%**	**Shifting**	**Δ%**	**Shifting**	**Δ%**	**Shifting**
0.55	-6%	-16%	-12%	-37%	-10%	-31%
0.59	0%	0%	-6%	-18%	-4%	-12%
0.6	2	6%	-4%	-11%	-2%	-6%
0.61	5%	11%	-2%	-5%	0%	0%
0.62	6%	15%	0%	0%	2%	5%
0.65	11%	24%	4%	11%	6%	15%

B. *Setting the kz*

When the utility chooses the *kz* factor, some aspects may be consider. For example, in Brazil, the white tariff is optional, if the customer wants to change the modality, the utility pays the meter exchange. This cost should be considered because it affects directly on the utility revenue. Another factor to be considered is the different profiles of the customer. Fig. 11 shows the relation between the *kz* factor and utility revenue impact. For example, if a *kz* of 0.61 was settled, the utility would decrease its revenue in the summer in about 2%. The transition time is not affected and in the winter an increasing of revenue about 5%, considering no change in the habits of consumers that chose to change the modality.

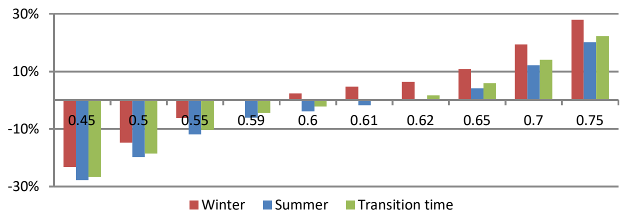

Fig. 11 Analyze the impact of chosen kz.

The value *kz* would cause less impact on revenue, if it is higher than 0.62. Thus, in all seasons the consumers need shifting their loads. For example, if was chosen a *kz* of 0.61, in the summer that has an intrinsic *kz* of 0.62, the consumer receives benefits without shifting its loads and the utility would have a decrease about 2%. Considering that the summer has about 123 days, which would cause a big impact on utility revenue. Fig. 12 shows the relation between *kz* and revenue. As the *kz* chosen was 0.62, the utility does not have any lost and the consumer chooses white tariff without shifting its load. Thus, the simulation following use the *kz* settled by 0.62.

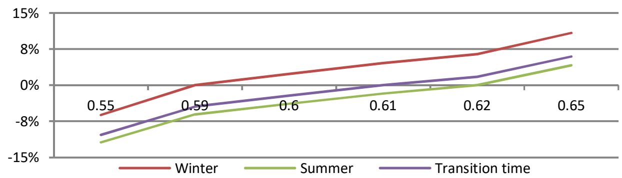

Fig. 12 Utility revenue impact.

C. *Modality change*

From the consumer point of view, Fig. 13 shows the amount of load that the users need to shift, if opt by white tariff, in each season, for at least pay the same price as for the conventional tariff. For the settled modality of 0.62, the white tariff would be interesting, if the consumer shift its demand by 15% in the winter, 5% in the transition time and in the summer no shifting would be necessary. Those values are for the consumer who pays the same value in white tariff and in the conventional tariff. Shifting to a higher value indicate a decreasing of white tariff. Similarly, the lower shifting indicates an increasing of white tariff.

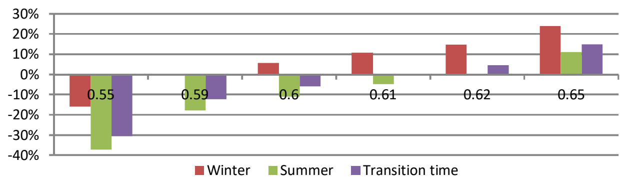

Fig. 13 Shifting out the peak.

D. *Shifting the load profile*

The amount of energy necessary off-peak is calculated by (6). The amount of energy in kWh shifting from peak to off-peak for winter represents an increasing of 4% in off-peak demand according to Table 5. The energy shifting was distributed evenly over off-peak period. For the summer, no shifting is necessary to keep the same price between white and conventional tariff.

Table 5 Shifting the load profile.

	Winter	Summer	Transition Time
Off-peak [%]	15%	0%	5%
Shifting peak to off peak [kWh]	0.3058	0	0.08671
Increasing off-peak [%]	4%	0%	1%

Fig. 14 shows the new load profile in winter season with a shifting load of 15% off-peak and Fig. 15 shows the new load profile in summer. Summer has an intrinsic *kz* equal to the settled by the utility. Thus, the load profile is the same, a shift in the load is not necessary to have the same price between white and conventional tariffs. Fig. 16 shows the new load profile in Transition time that needed shifting out peak just 5 % of their load because their intrinsic *kz* is close to settled by the utility.

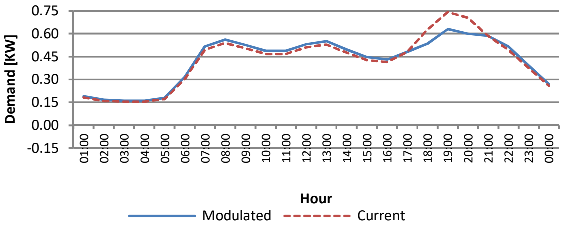

Fig. 14 Shifting demand working day in the winter.

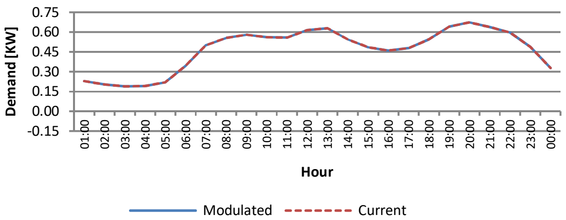

Fig. 15 Shifting demand working day in the summer.

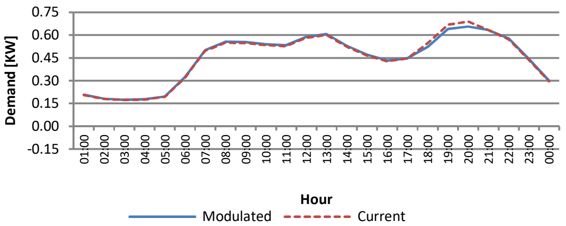

Fig. 16 Shifting demand working day in the Transition time.

Table 6 presents the revenue impact, caused by the different number of persons in each household. The conventional and white tariff are the value payed by consumers depending the modality chosen by them. For a *kz* of 0.62 and considering that the customer chooses the modality without shifting their load, the utility revenue increase about 6% per month in the winter.

Table 6 Revenue impact, in euro, by Household per month in the winter.

Number of Persons	White tariff	Conventional	Revenue impact
1	231.24	217.20	14.04
2	332.18	312.02	20.17
3	434.99	408.59	26.41
4	514.05	482.84	31.21
5	614.99	577.65	37.34

Depending on how much demand the consumer will shift, the utility revenue impact will increase. Table 7 shows the relation between the demand shifted and revenue impact. The revenue impact was calculated considering a household with two people, as Germany has about 13,800,000 households with two people. For the consumer to take some advantage with a *kz* of 0.62 he needs to shift about 20% of his demand

Table 7 Impact demand shifted, in euro, per month in the winter with a *kz* factor of 0.62.

Demand shifted	White tariff	Convent. tariff	Revenue impact	Consumer impact
0%	332.18	312.02	278,304,622.17	20.17
10%	321.25	312.02	127,448,825.47	9.24
20%	310.32	312.02	-23,406,971.24	-1.70
30%	299.39	312.02	-174,262,767.94	-12.63
40%	288.46	312.02	-325,118,564.65	-23.56
50%	277.53	312.02	-475,974,361.35	-34.49

To choose the *kz* factor, the utility may consider the benefits and how much money it will save with demand shifting, turn off less renewable power during the day and reducing investment in expansion grid. Table 8 shows a smaller revenue impact if the utility uses a *kz* factor equal to 0.68, but many customers do not change to white tariff modality because a big habits change will be necessary. For the consumer to take some advantage with a *kz* of 0.68 he needs to shift about 50% of his demand.

Table 8 Revenue impact per month in the winter with a *kz* factor of 0.68.

Demand shifted [%]	White tariff [€]	Convent. tariff [€]	Revenue impact [€]	Consumer impact [€]
0%	362.01	312.02	689,949,499.11	50.00
10%	350.10	312.02	525,547,235.55	38.08
20%	338.19	312.02	361,144,972.00	26.17
30%	326.27	312.02	196,742,708.44	14.26
40%	314.36	312.02	32,340,444.89	2.34
50%	302.45	312.02	-132,061,818.67	-9.57

VI. CONCLUSIONS

The objective of the white tariff is to encourage the consumer to change his consumption habits, as it could decrease the tariff price, shifting the load from peak period, where the energy is more expensive. During the evening, the renewable energy generation is reduced by natural conditions, like sun and wind, and to keep the energy supply, others sources are necessary, increasing the tariff price. Shifting the load to off-peak period, the energy cost tends to reduce because with the increase of demand in this period, will not be necessary to turn off the wind power generator, improving the use of renewable energies.

Decreasing the peak demand has benefits to the grid because the investments in expansion will be lower and also the cost with maintenance. The utility needs to be careful choosing the *kz* factor. A low *kz* can cause a negative impact on its revenue. On the other hand, a high *kz* does not encourage the customers to adopt the white tariff.

Other costs are associated with the white tariff, like the energy meter exchange. In Brazil, as most of the meters are still electromechanics, the utility pays for the digital energy meter when the consumer requests the change of modality.

The consumer may analyze its profile to know how much effort will be necessary to shift his load and also change his habits, for at least, pay the same price for the white tariff.

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