

## Consumer control in Smart Grids

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### Electricity consumers profiling- German Load Profiles

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#### Abstract

In this paper various standardized German Electricity consumer profiles for annual electricity consumption below 100'000 kWh or a connected capacity below 50 kW are summarized. First, this document introduces a brief methodology of the standardized load profiles and a presentation of the characteristic profiles itself, including appropriate explanations and curves. The necessity of these profiles as a result of the market opening concept is pointed out and is supplemented by a basic explanation of the load profile calculation and some allocation rules for mixed consumers. Furthermore, this paper shows the used standardized load profiles for households, business, agriculture, public lightning and night storage heating depending on the two important factors day of the week and period of the year.

Keywords: electricity consumer profiling; load profile

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#### 1. Electricity consumers profiling methodology

Distribution system operator use a simplified method to handle the electricity supply to small end customers and to calculate the balancing energy demand. Additionally, a use of a measurement system requires a non-profitable high technical, organizational and cost effort. According to this, load profiles have to be compiled for consumers with an annual consumption below 100'000 kWh or connected capacity below 50 kW. With respect to existing acts the following pages present a short overview of the necessity and the methodology how electricity consumer load profiles were created in Germany and why they are used for small costumers. The second part of this paper provides a description of the most important standardized load profiles as well as some explicit load diagrams.

##### 1.1. Necessity of consumer load profiles in Germany

Based on some further regulatory statues in Germany, since 1998 any consumer can freely choose between every electricity company. Therefore every system operator has to guarantee a consistent availability of the grid for every electricity provider, while receiving a financial compensation (network-use fees) for grid use (energy transmission) and services like measurements, system services and furthermore. Because the system operator publish annual statistics of the network-use fees every consumer is enabled to choose each electricity provider by its costs or any other criteria.

This market opening concept was and is still easy to apply on key account consumers with contract based 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. In contrast this case of key

account consumers there is no existing energy measurement-system for most small costumers. But to ensure a balanced energy transfer, actual consumption values are required. Due to the technical and organizational complexity and considerable costs associated with installing a load profile meter, this was avoided. Nevertheless, the market opening required a reliable energy scheduled forecast for small costumers.

Accordingly, there was a need of simple network access, uniform and traceable supply relationship, a simple way of measuring and accounting as well as an applicable delimitation of delivery at the various stages of supply for small customers. By publishing network-use fees the network usage was regulated but not supply and “energy transit” through various stages of the supply chain. The supply company (producer/trader) is responsible to supply its customer and has to fulfill the entire electricity demand on time, at any time. Additionally, transmission operators have to be able to configure their network management for the expected load flows based on expected consumer demand forecast to prevent for example grid bottlenecks especially in the HV-network. This results in a need of a pre defined schedule, based on the expected system load (e.g. of the next day). [1]

### 1.2. Load profiles calculation

The methodology of creating load profiles is based on specific measurements. In order to minimize the failure between supply and demand, profiles were differentiated regarding specific time parameters such as hourly, daily (i.e. weekdays, Saturday, Sunday) and seasonal (i.e. winter, transition time, summer) time intervals. In addition to this first differentiation characteristics of various customer groups were taken into consideration that allow a more effective and realistic load forecast. The resulting profiles are called representative load profiles. The empirical load profiles for specific customer groups were based on existing measurements and profiles of different groups of customers. Using representative load profiles allows the use of simple and clear criteria to assign an appropriate load profile to each customer who is willing to change his energy supplier.

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 to conduct a scheduled load forecast. To apply representative load profiles correctly assumptions have to be made: (1) a distinction by time parameters for every customer group (see above) and (2) deviations have to be corrected by network operator management. [1]

### 1.3. Normalization of annual curves

After the load profiles were defined based on given data, all profiles were normalized on a specific annual consumption of 1000 kWh/year. The reason to use the normalization is to quantify the individual customer schedules and load profiles based on the annual customer consumption.

The normalization was applied on the annual consumer curves of the load profiles household, business and agriculture. The profile data of each profile are given in ¼ h values for one year (365 days) and each day (96 ¼ h-load values). The annual load profile data were registered in a 365 x 96 matrix (“365 days” times “96 ¼ h-values a day”). Subsequently, the single ¼ h-values of the matrix have to be multiplied by a constant factor, to achieve in summarization, of all values of the 365 x 96 matrix, 1’000’000 units (1000 kWh). As a result the single values of the matrix present ¼ h –consumption in Wh (watt hour; = 1/1000 kWh). [1]

## 2. Characterized Electricity Consumer Load Profiles

This following section introduces the characteristic load profiles for the tariff costumer group, differentiated by household and several costumer groups as well as some additional profiles. The profiles include household (H0), seven business load profiles (G0-G6), three different agriculture load profiles (L0-L2), night storage heating (ULE) and public lighting (B1). The load profiles comprise ¼ h power values for one day, which are normalized to an annual consumption of 1’000 kWh. They are differentiated by working days (“*Werktag*”), Saturdays (“*Samstag*”) and Sundays (“*Sonntag*”) in the three periods of the year winter (“*Wi*” 11/1 – 03/20), transition time (“*Üz*” 03/21 – 05/14 / 09/15 - 10/31) and summer (“*So*” 05/15-09/14) [2].

### 2.1. Load profile- H0 Household

This profile incorporates are all households and those with (electrical) minor business demand, without installed heat pump, storage heating etc.

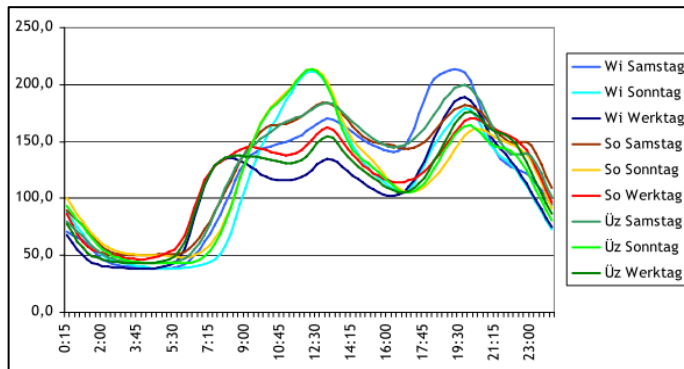


Fig. 1: Load profile - H0, households [2]

### 2.2. Load profile Business

#### 2.2.1. Business general – G0

This profile can be applied if an assignment to one of the business profiles G1-G6 is not possible or not wanted. This profile is the weighted average of the total group G1-G6.

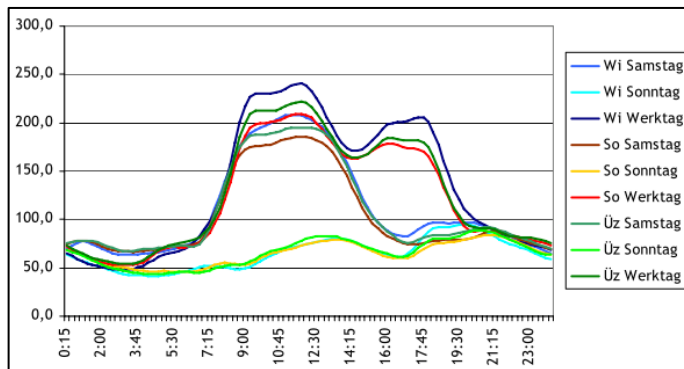


Fig. 2: Load profile - G0, business general [2]

#### 2.2.2. Business on working days 8am – 6pm – G1

This profile applies to consumption points with typical consumption between 8am to 6pm on Working days and no or low consumption on weekends. That includes facilities such as for example offices, doctors and lawyer's offices, machine shops, print shops, schools, kindergartens and day care centers, government offices and banks.

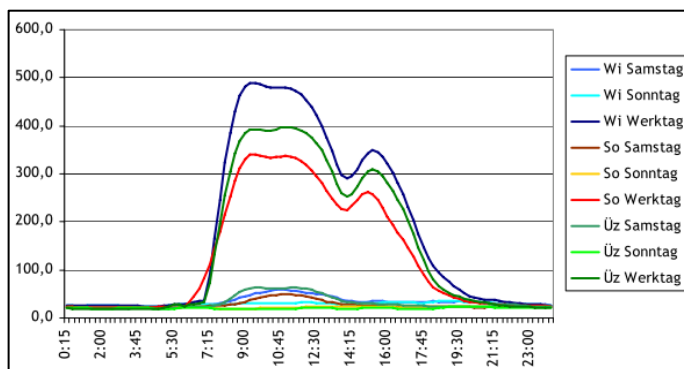


Fig. 3: Load profile - G1, business on working day 8am - 6 pm [2]

### 2.2.3. Business with high and predominantly consumption in evening hours – G2

This profile can be assigned to institutions with predominantly oriented lightning power consumption. These include for example petrol stations and shops with considerable window space. Furthermore, evening restaurants and leisure facilities are suited for this profile, unless they have their consumption focus on the weekend like fitness- and trainings- and youth centers.

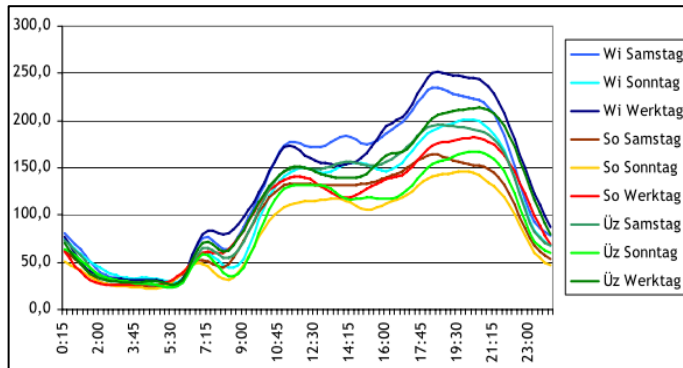


Fig. 4: Load profile - G2, business with high and predominantly consumption in evening hours [2]

### 2.2.4. Business continuously – G3

This is a classification of consumption points, which have a relatively uniform consumption with a noticeable continuous base throughout the year and also during the week. Examples are sewage plants, drinking water pumps, community facilities in residential complexes, cold stores, shops with significant demand for cooling and systems with forced ventilation.

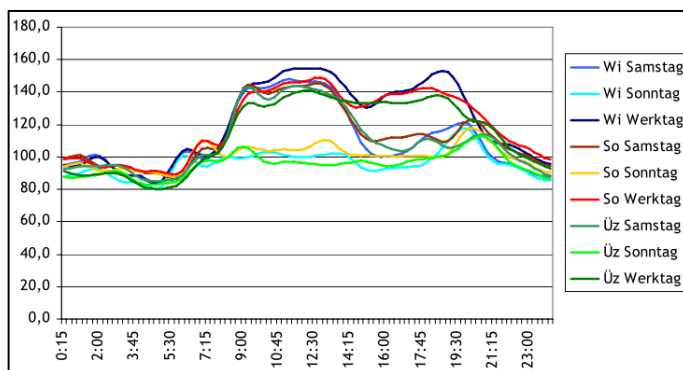


Fig. 5: Load profile - G3, business continuously [2]

### 2.2.5. Business shop/barbershop – G4

This is the typical profile for general shops of all kinds (opening times working days till night, Saturday until afternoon) and barbershops. Individual afternoons with no business operation or extended opening time to 8pm did not make any differences and have just little consequences in comparison to the base of the total group. Sales oriented bakeries, which prepare baked goods (“in-store baking”), are also included in this profile.

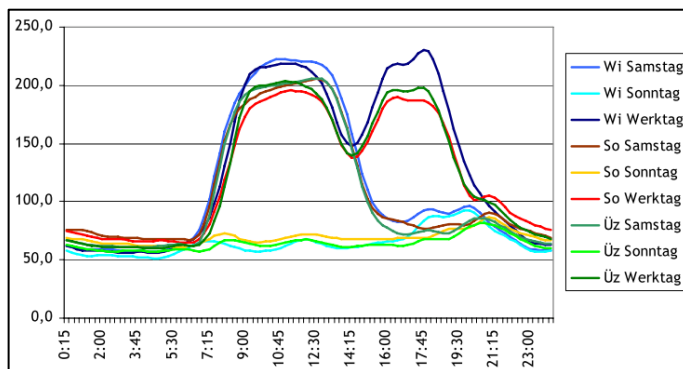


Fig. 6: Load profile – G4, business shop/barbershop [2]

### 2.2.6. Business bakery – G5

Bakeries have their main energy consumption on working days, early until 3am and until midnight in the night from Friday to Saturday. The daily consumption in comparison to the total demand is relatively low and is mainly determined by the selling activity. Sales oriented bakeries, which prepare baked goods (“in-store baking”) behave like other stores and are included in the profile G4.

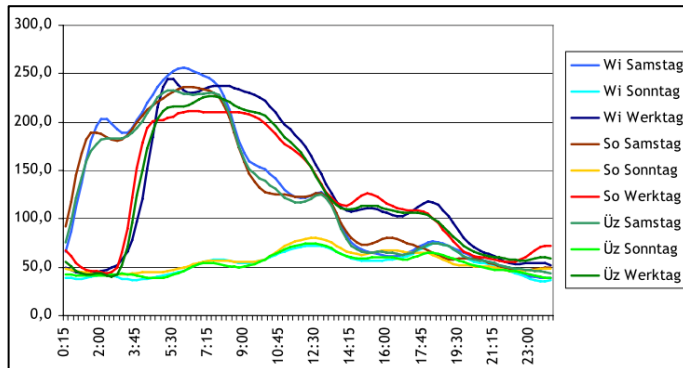


Fig. 7: Load profile - G5, business bakery [2]

### 2.2.7. Weekend business – G6

Certain companies have their main energy consumption on the weekends. These are mainly shops, which are characterized by leisure activities of the population such as youth clubs, tourist restaurants, petrol stations with car wash, movie theaters with diner, sports- and leisure facilities.

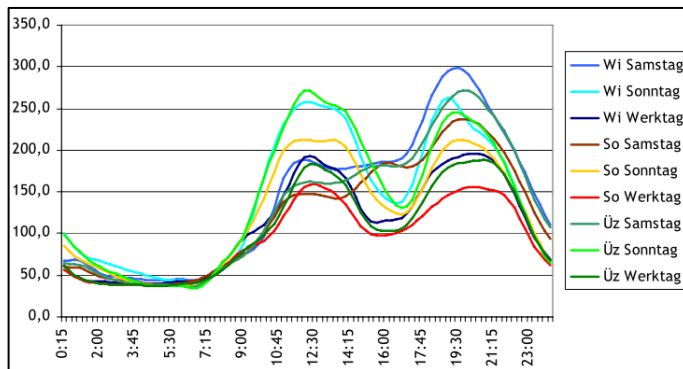


Fig. 8: Load profile - G6, weekend business [2]

## 2.3. Load profile Agriculture

### 2.3.1. Farm – L0

This load profile is used if an assignment to typical agriculture load profiles L1 and L2 or to a characteristic business profile is not possible.

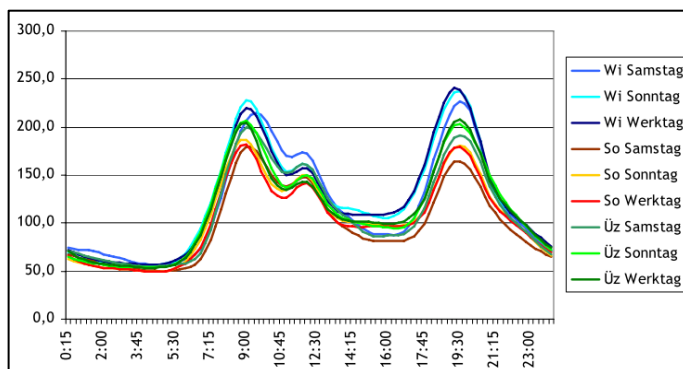


Fig. 9: Load profile - L0, farm [2]

### 2.3.2. Agriculture dairy farming / sideline animal breeding – L1

This profile is used for dairy farms, where the electricity consumption is dominated by the two periods of time milking and the subsequent cooling of the milk.

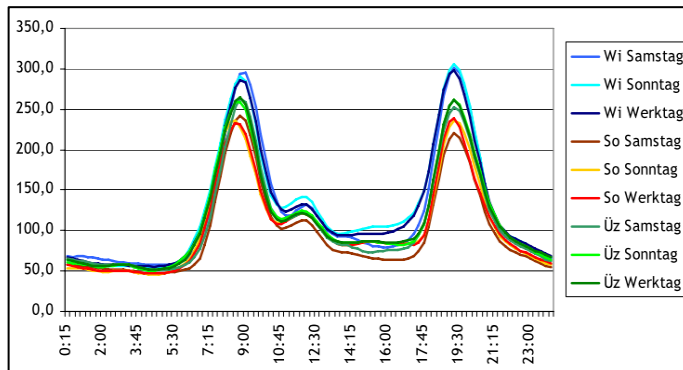


Fig. 10: Load profile - L1, agriculture dairy farming / sideline animal breeding [2]

### 2.3.3. Other agriculture – L2

In many cases, farms traditionally are characterized by a coexistence of household and production which is taken into consideration with this profile. This mean profile is applied for such business. The appropriate business profile has to be selected as far as on a farm is a largely daytime independent production.

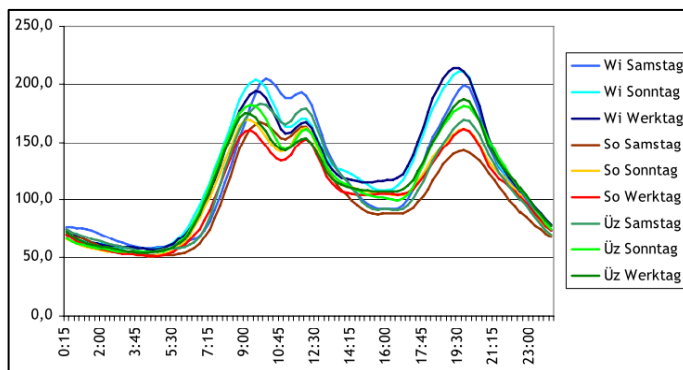


Fig. 11: Load profile - L2, other agriculture [2]

## 2.4. Further profiles

### 2.4.1. Night storage heating – ULE

This load profile is applied for night storage heaters without daily recharging. These systems show a distinct consumption focused in winter and a moderate consumption in the transitional period. For simplicity, no consumption is assumed in the summer.

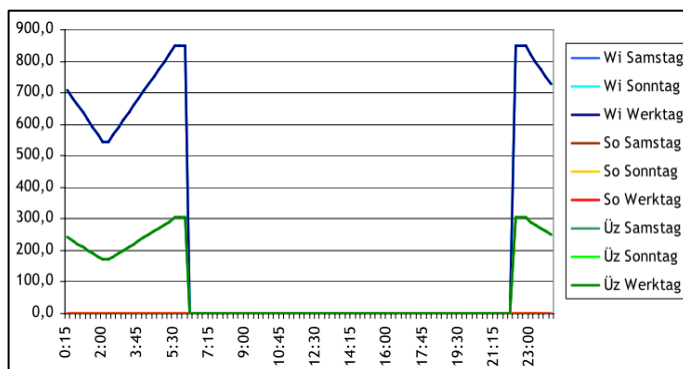


Fig. 12: Load profile - ULE, night storage heating without daily recharging [2]

### 2.4.2. Public lighting – B1

For the preparation of this load profile it was assumed that the lighting system is working constantly during the entire switch-on time. Any partial shutdowns during the night hours were not included.

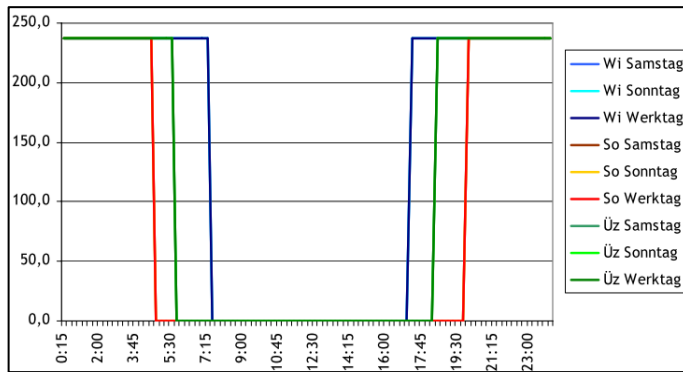


Fig. 13: Load profile - B1, public lighting [2]

### 2.5. Allocation rules for mixing consumers

Customer installations with one measuring point and mixed consumer characteristic (e.g. household and business) have to be allocated to this standardized VDEW<sup>1</sup> - load profile, which has the main consumption part. The values of allocation are given in Table 1.

Table 1: Values of allocation [2]

Consumption characteristic	Annual energy consumption	VDEW-load profile
Household / Business	< 8'000 kWh	Household H0
	≥ 8'000 kWh	Business (G0-G6)
Agriculture / Business	< 16'000 kWh	Agriculture (L0-L2)
	≥ 16'000 kWh	Business (G0-G6)
Household / Agriculture	< 8'000 kWh	Household H0
	≥ 8'000 kWh	Agriculture (L0-L2)
Household / Business / Agriculture (if just one measuring system is available)	< 8'000 kWh	Household H0
	≥ 8'000 kWh and < 16'000 kWh	Agriculture (L0-L2)
	≥ 16'000 kWh	Business (G0-G6)

## 3. Conclusion

This paper represents briefly a summarization of standardized load profiles in Germany which are applied on different groups of consumers with a consumption below 100'000 kWh or connected capacity below 50 kW. There are 11 different normalized load profiles which describe the demand behavior of households, business and agriculture consumers. Two additional profiles (public lighting and night storage heating) show the possibility to apply consumer load profiles on further characteristic consumers. These 11 profiles with their individual characteristics depend on daytime, weekday and season. These profiles are applied to simplify accounting and the calculation of electricity demand for electricity provider and system operators without using price intensive measurement systems.

<sup>1</sup> German Electricity Association (VDEW)

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