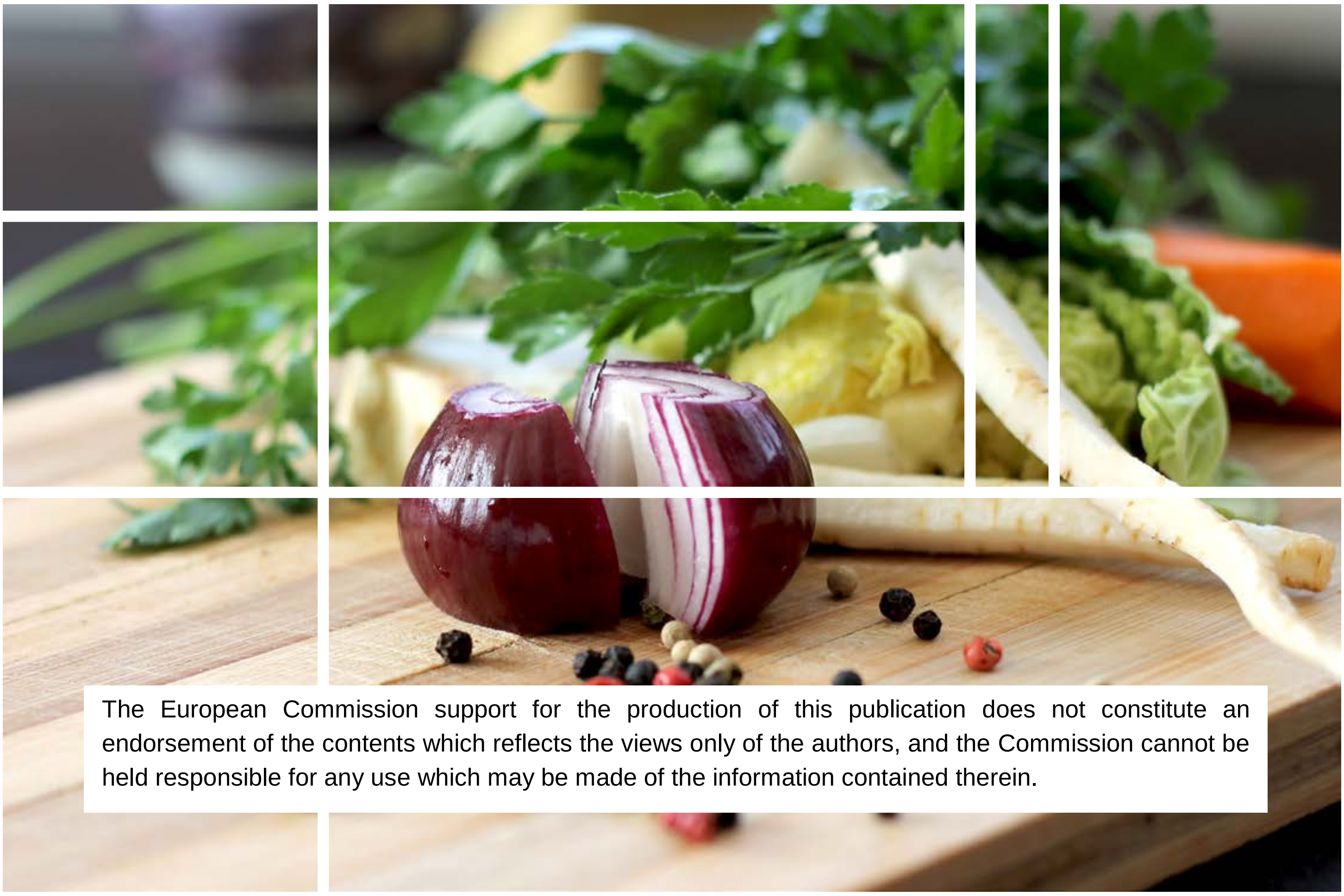
PROJEKT REKUK

Vocation Training for Chefs and Executive Chefs of Large-Scale Kitchens in Sustainable Food and Kitchen Management

Module Energy Script



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1 Glossary

1.1 General Glossary

Chef: professional cook who often manages the kitchen, e.g. in restaurants, large-scale kitchens, hotels.

Communal catering/public catering: Large-scale catering facilities in the public sector. These include patient catering in hospitals and elderly residences, catering in educational institutions and businesses. In contrast to gastronomy the focus here is to provide well-balanced meals and maintaining cost efficiency, providing qualitative meals outside the home.

Executive Chef: Chef who has an overall responsibility for the kitchen: purchase, staff, menu, sometimes manager of several kitchens / restaurants. Sometimes referred to as kitchen manager.

Large-scale kitchen: Large-scale kitchen is a term for a kitchen that is used for commercial purposes and in which meals for numerous consumers get cooked, namely gastronomy and communal feeding (hospital, company canteen, nursing homes, halls of residence, student halls etc.).

Organic foods/produce: These products are produced within the scope of organic farming and has a certification marks which are regulated by law.

Regional food/ products: Regional food is food that is produced there where it is consumed. A common definition for regional or national products is that they are produced within a radius of 150 km around the processing commercial kitchen.

In fact, what is considered regional varies by country. In Italy the regions are geographically defined and it is common to use those definitions when referring to regionality. In other countries a max. distance of 150 km is determined. This distance was chosen because if the distance is greater the return benefits of sourcing produce locally diminish. In Germany and Austria, the word “regional food” is not regulated by law.

Seasonal foods: Foods available only at a certain time of the year from outdoor production (meaning available from local sources), typical fruits and vegetables. Some produce is available year-round as fresh or stock goods like onions, potatoes and apples.

Stakeholder: Member of an interest group.

1.2 Module Specific glossary

Direct Energy: Direct Energy is the energy that is used for the preparation of the meals in the kitchen.

Energy consumption: Energy consumption: is spilt in direct and indirect energy consumption.

Indirect energy: Indirect energy is the part of the energy that is consumed by production of foodstuff.

Kilowatt-hour (kWh): This unit is used to bill and collect electricity and heating costs. A watt hour times 1000 is a kWh. This module deals with direct energy. Indirect energy is covered in module 1 – Food Use and Module 2 - Menu Design.

Base load: Base load is the load on the power grid (or other supply grid) that is not undercut during the day.

Peak load: Park load is a short high demand of power in power grids (or other supply grids).

2 Building Equipment and Kitchen Appliances

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2.1 Learning Objectives

After completing the module, the participant should be able to:

- He/she has acquired broad factual, theoretical and practical knowledge of the energy consumption in all cooking and food preparation processes in a large-scale kitchen.
- He/she has acquired the following cognitive and practice-related skills for the daily solution of energy-related questions in the large-scale kitchen.
- He/she exercises self- and team-management in a changing work context of the daily routine (e.g. new products, new diet requirements, new equipment) in the field of the energy management of the large-scale kitchen.

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2.2 Energy Efficiency

Energy efficiency is a unite to measure the effort (consumption) of energy that is used to achieve a specific product/result.

For example, a fridge is energy-efficient when it reaches approximately 7 ° C with low energy consumption. The less electricity the refrigerator consumes to reach the benefit, the higher its energy efficiency, and the more electricity it consumes, the lower (worse) this is. [Eichler Markus, s.a.].

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2.3 Module Energy – Relevance for large-scale kitchens

Cooking is a very energy intensive process. For example, 10 kg of ice can be thawed with 1 kWh, 10 l of water can be brought to boiling, and nearly 2 l of water evaporated. Powerful appliances are often used to prepare food. But cooking is not the only process which requires a lot of energy; the accompanying processes, such as dishwashing, cooling, heating and other processes related, also cause a high energy consumption. A tape sink from the year 2015 requires about 125 kW hours / day.

In addition, the energy used in large-scale kitchens is usually generated from fossil fuels, which in turn have a negative impact on the environment. A large-scale kitchen producing 250,000 meals must use 887,500 kWh for it, equalling 210,000 kg of CO_2 emissions [Energieagentur, 2002].

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2.4 Influence on the energy consumption

The energy efficiency of the individual kitchen appliances as well as the handling of kitchen appliances has massive influence on the energy consumption. The number and duration of use of each individual kitchen appliances are essential as well as the operating behavior of the employees.

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2.5 Why is the energy consumption of large-scale kitchens split in categories and descriptions of the categories

It makes sense to divide the large-scale kitchens energy consumption in categories, the 8 categories are: refrigeration, ventilation, washing, lighting, heating, cooking, meal distribution and warm water conditioning. Through the categorisation of the most important activities in the large-scale kitchen the energy consumption in large scale kitchens can be represented accurately. Following that the most energy intense sectors or appliances can be identified. For this purpose, the appliances that are used should be assigned to their respective categories and data should be collected. It makes sense to record the: energy source, the rated output, the degree of efficiency, the operating period and the number of appliances of the same type that are in use in order to determine the energy consumption of the individual appliances. Additionally, the manufacturer, type and appliances that are expected to have high energy consumption should be recorded. [Daxbeck et al., 2010]

Refrigaration

The category refrigeration includes all appliances that are used in the large-scale kitchen to cool. For example, refrigerator or shock froster, cooling or refrigerating rooms and ventilation, because it might be run by the same cooling aggregate.

The refrigeration that are the most relevant for energy consumption are determined by their rated output and operating period. Compression refrigeration appliances, which are frequently used in large-scale kitchens are made up of a compressor, a condenser a throttling device and an evaporator – the compressor consumes the most energy.

The energy consumption is recorded for the whole refrigeration unit and includes the consumption of the compressors, ventilator of the condenser and additional pumps that might be installed.

Ventilation

The category ventilation includes the general room ventilation as well as ventilation hoods that are frequently used in large scale kitchens. The most relevant elements to energy consumption are the fans. Control units consume very little power compared to fans, so little that they do not have to be included in the calculations. The Ventilation is often combined with heating, however concerning energy consumption it makes sense to have an own heating category, especially if there is a dining hall.

Washing

The category washing includes all appliances that are used to clean the cutlery, dishes, crockery and serving tools and trolleys.
Generally speaking, usually washers like: pot- and dishwashers in addition to flight-type dishwashers and washing plants for the serving trolleys.
The appliance most relevant to energy consumption is the flight-type dishwasher.
The relevance of a washing appliance is calculated from its rated output and operating period. The energy consumption in this category is the sum of all the most relevant washing appliances in the respective large-scale kitchen.

Cooking

The category cooking includes every kitchen appliance that is used in preparing meals.
Examples of this are cutting machines, mixers and cooking appliances such as: stoves, ovens, skillets, cooking pots and steamers.
Compared to kitchen appliances appliances that are used to prepare the dishes are more relevant to energy consumption because they have a higher rated output and are typically used for longer periods of time.

Meal distribution

The category distribution includes the energy consumption of the appliances that are used for the meal distribution. Thermic appliances are used for the distribution of the meals including: warm water bath, plate dispenser and meal transport trolleys. The rated output of these appliances tends to be relatively low, compared to washing or cooking appliances but the deployment of many appliances of the same type can lead to high energy consumption.
The potential transport of the meals is also included in this category. Here the primary energy source that is used for transport is taken into account. The procession of the energy source and possible losses are not considered.

Refrigeration devices are often used in meal distribution in large-scale kitchens, however they are already included in the category refrigeration and can be ignored for this category.

Lighting

The category lighting includes all light fixtures that are used in large-scale kitchens and dining halls. Differences between day and night energy consumptions and working weeks and weekends are considered in the calculations.

Heating

The category heating includes the energy consumption that is expanded for the heating in the large-scale kitchen and dining hall. The used energy sources (for example district heat) are recorded. The energy consumption of fans or pumps that are used to distribute the heat do not have to be taken into consideration here.

Warm water conditioning

The energy that is expanded to heat the water is taken in account in the category warm water conditioning. Energy that is necessary to create pipeline pressure or extract the water from its origin does not have to be considered here.

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2.6 Sources of energy & definitions

The defined sources of energy are: electricity, district heat and natural gas. These sources of energy are used in large-scale kitchens.

During the conversion process and the transport of the energy sources in the system oft he large-scale kitchen there are losses, for example heat lost to the environment. The energy losses (or better exergy losses) are accounted for because the whole input of primary energy sources is taken into consideration for the calculations.

The losses and energy consumption that happens externally to the large-scale kitchens is not taken into account.

Natural gas is a primary energy source that comes from fossil sources. Electricity and district heat are secondary energy sources. Secondary energy sources are sourced from primary energy sources and used in large-scale kitchens or useful energy is transformed into thermic or kinetic energy.

During the transformation of secondary energy sources transformation and transport losses occur, however they are not taken into account because they occur outside of the system of the large-scale kitchen and are considered by energy providers when they determine prices for their service.

2.7 Possible survey methods for energy data

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2.7.1 Survey and data inventory

One possibility to survey energy consumption data with specific data referring to energy sources is surveys. With an energy consumption analysis, the energy that is consumed in large-scale kitchens is determined and the efficiency is questioned.
For this purpose, surveys are helpful.
They should assess energy consumption date (for the specific large-scale kitchen and for each category) and energy provider data, cost per used energy source and general data concerning the large-scale kitchen; for example: operating mode, number of production days, meals per week and information on the transport of the meals. With the general kitchen data, the energy indicator and the energy consumption per meal can be determined and additionally the differences between large-scale kitchens are made obvious if more than one large scale kitchen is investigated.
It is important to record the energy consumption and appliance data of the kitchen appliances which are used in different kitchen processes.
To achieve this the device name, manufacturer, type, number, energy output, operation period, the energy source that was used and the efficiency are recorded.
Subsequently an analysis is performed. to identify the appliances that have the potential for high energy consumption. The assessment is based on the rated output and operation time of the respective appliance.
The actual energy consumption can be estimated with this data. If specific data cannot be collected measurements are a good way of filling data gaps. [Daxbeck et al., 2010]

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2.7.2 Energy consumption measurements - Electricity

Large-scale kitchens tend to not have detailed energy consumption data that is necessary for a detailed determination of consumption. To determine the consumption with adequate accuracy partial measurements of consumption are necessary.
Through the filled-out surveys it becomes obvious which energy consumption data is available to the large-scale kitchens. From the filled-out survey a course of action can be determined to close relevant gaps in the data. The closing of the data gap happens trough on-site inspections, where an inventory of the most relevant kitchen appliances is compiled and measurements are conducted.
An electricity consumption measurement for the individual appliances is only possible if they are run on electricity and have their own fuse or their own connection in the power distribution unit. [Daxbeck et al., 2010]

With the rated output and the operation time the appliances with the highest energy consumption are identified, in this process the number of appliances per type is also taken into account.
The appliances with higher energy consumption are then measured. The goal should be that about 70-80% of the theoretical maximal electricity consumption can be covered by measuring a number of appliances that is as low as possible. It is simply not feasible to take measurements for all appliances in a large-scale kitchen. The goal is to cover the largest possible chunk of energy consumption by the least amount of measurements possible.
For the energy consumption measurements, it is advisable to make an individualised plan for each new large-scale kitchen that is measured as the composition of their appliances can vary considerably. Additionally, to measurements for individual appliances the total infeed of the large-scale kitchen is measured. This helps visualize the part of the energy consumption that cannot be attributed to a specific appliance.
When the measurements a taken the beginning, and ending times and the date on which the measurement was taken should be recorded. [Daxbeck et al., 2010]

Figure 2-1 Three phase-power meter [Daxbeck et al., 2011]

The energy supply of the appliances in large-scale kitchens and the total infeed over three phase AC. Because of this the power consumption measurements have to be undertaken with a three phase AC power meter, for example the power meter TES 3600 (Figure 2-1).
The measuring unit has four current clamps and four voltage test leads, one for each phase and a neutral conductor. The unit records current, power and voltage automatically in minute intervals. The data that is recorded by the unit can be extracted and analysed with a specialized software.

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2.7.3 Data processing

The results of the power consumption measurements should be assessed for each measurement in each large-scale kitchen respectively.
The results are best displayed in load curves to show the output dynamic of the accumulated infeed. Following that it makes sense to add the load curves of the measured appliances and compare it to the load curve of the total infeed. This allows for an evaluation of the power consumption measurements and to gauge which percentage of the power consumption was recorded with the measurements of the individual appliances.
For most appliances, it is sufficient to record the power consumption for one day and projected from that by using the total number of appliances and days of service. Power consumption that is projected that way can then be compared to measured yearly power consumption if those have been recorded.
The last step should be to convert all consumption of electricity, district heat and natural gas to the unit of kilowatt hour (kWh) and summed up to show the total consumption of energy of the large-scale kitchen. This is going to be examined in chapter 2.5. The projections from measurements have proven themselves to be accurate.

2.8 Methods for calculating the energy consumption of large-scale kitchens

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2.8.1 Calculation of electric-power consumption

In case of missing data of power consumption of individual large-scale kitchen appliances, the yearly consumption is estimated using rated output, manufacturers data, operation time and power consumption measurements. When measuring power consumption, the accumulated daily infeed of a large-scale kitchen should be measured and compared to the yearly power consumption of the large-scale kitchen.
Power consumption measurements should include the daily total infeed of a large-scale kitchen and can then be compared via load curves to the measurements of the individual kitchen appliances. This way it is possible to check if the individual measurements of the kitchen appliances account for the daily total infeed. If at least 70% of the total power consumption can be allocated to individual kitchen appliances the power consumption for each appliance can be estimated. When projecting the yearly power consumption from the data additional contributing factors can be taken into account such as the power consumption of the kitchen appliances during service hours and reduced consumption in off hours. This estimate should be made to estimate the energy consumption structures in the large-scale kitchen and which categories consume the most.

It also gives insight into how accurate the estimated values are because the estimated consumption values that are projected from the data can be compared to the yearly consumption.
The kitchen appliances whose consumption is measured should be selected by the expected power demand and choosing the ones that are expected to have the highest consumption. This is calculated using rated output and operation time.
Using this method some categories that have a high number of appliances of the same type can be underrepresented. To avoid this a number of typical appliances for a sector can be measured. For example, for the category meal distribution a small number of typical appliances like Bain-Marie or plate dispenser can be measured to determine a factor that shows the relation of the theoretical maximum power consumption and the actual power consumption. With the help of this factor (also see chapter 2.6), which should be calculated for the unaccounted appliances that were not measured and assign the consumption to one of the 8 categories (refrigeration, ventilation, washing, lighting, heating, cooking, meal distribution and warm water conditioning). [Daxbeck et al., 2010]

2.8.2 Calculating district heat consumption

If the district heat consumption is not specifically recorded for the kitchen, but the consumption data is only available for the whole building the consumption is calculated with a simple estimate. That estimate is based on the relation of floor area of the whole building versus the floor area of the large-scale kitchen. A perquisite for this is that district heat is used only for heating in the kitchen. If this is not the case a rough estimate of the energy consumption of heating and warm water conditioning can be made.

2.8.3 Calculating natural gas consumption

The natural gas consumption is estimated like the district heat if there are no detailed records available.

2.8.4 Calculating the summed-up energy consumption

The unit of the energy sources is converted to kilowatt hours (kWh). If the energy consumptions are all in the same unit they can be summed up.

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2.9 Factors and key figures

Equation 2-1 1 4 The factor represents a measure of the ratio between maximum and actual energy consumption

$$\text{Factor} = \frac{\text{measured energy consumption}}{\text{measured operational time} \times ratedoutput}$$

The factor (Equation 1) represents an adjustment of the rated output, which serves to approximate the actual electricity consumption.

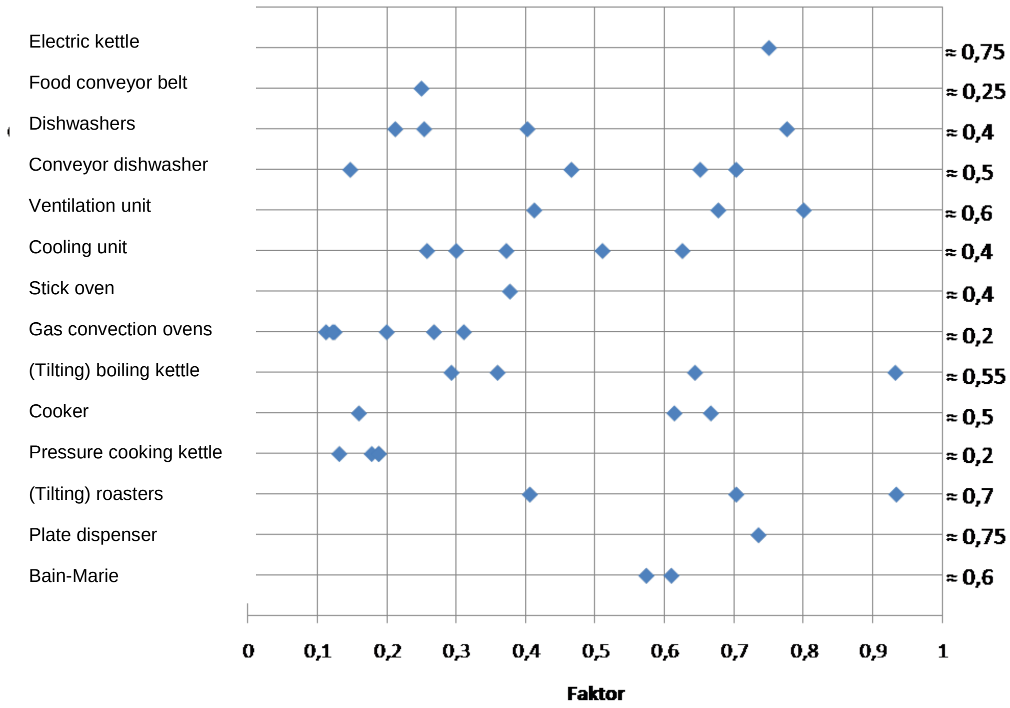

Figure 2-2 Factors of the measured appliances [Daxbeck et al., 2010]

Figure 2-2 shows that the factors for the individual devices are not clearly grouped. For example, in the five measured gas convection ovens, a dispersion of 0.1 to 0.32 is obtained. The more the value 1 is approached, the higher the energy consumption of the devices.

Possible explanations for the deviations [Daxbeck et al., 2010]:

- Usage and utilisation parameters were not recorded
- Data collection from an operating cycle is too short
- The number of devices measured is too low
- Very different operational times.

2.9.1 Key figures

The key figure was determined over the entire energy consumption (electricity, gas, district heating) for the Austrian large-scale kitchens and averaged at approx. 3.5 kWh per meal. According to another study by [Jenny, 2008] On average, the energy consumption per meal is about 4 kWh per meal.

A more detailed explanation to factors and key figures regarding energy consumption in large scale kitchens can be found in the handbook for this module.

2.10 Method for identifying saving potentials

For the identification of possible saving potentials in the direct energy consumption the load curves of the eight categories and of individual appliances should be used.

The starting point should be their share of the overall energy consumption.

If the sum of the measured appliances roughly coincides with the load curve of the total energy infeed the individual load curves can be analysed and brought to the attention of the kitchen management (depending if an external person or an in-house technician is taking the measurements) Also see Figure 2-3.

With the input of kitchen management saving potentials can be identified.

An advantage of this method is that the kitchen gets and overview of the energy consumption of the whole large-scale kitchen as well as the appliances most relevant to energy consumption.

After identifying the categories with the highest energy demand, it is recommended to check the state of the art for appliances and estimate if buying new appliances can lead to relevant savings. A common recommendation is to replace appliances every 20 years.

More information on the energy consumption of appliances and energy saving cooking methods can be found in the handbook to this module.

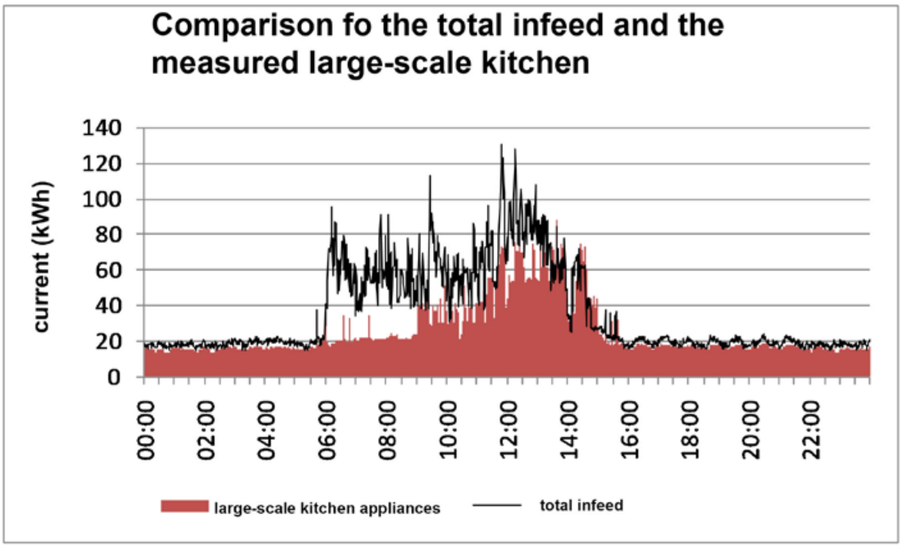

Figure 2-3 Example of a comparison of a total infeed (black) and an estimate made by measuring the appliances that are assumed to be the most energy intensive (red) vs current/output [Daxbeck et al., 2011]

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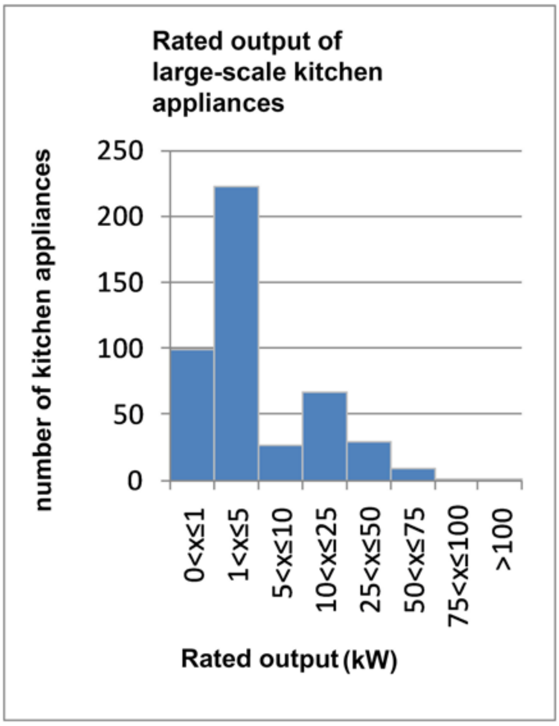
2.11 Power supply and power consumption in large-scale kitchens

For heating -and to some extent for steam supply of the large-scale kitchen appliances district heat or natural gas can be used.

The most informative parameters in large-scale kitchens are the rated output and the operation time. With these a rough overview of the energy consumption structure in the large-scale kitchen can be made.



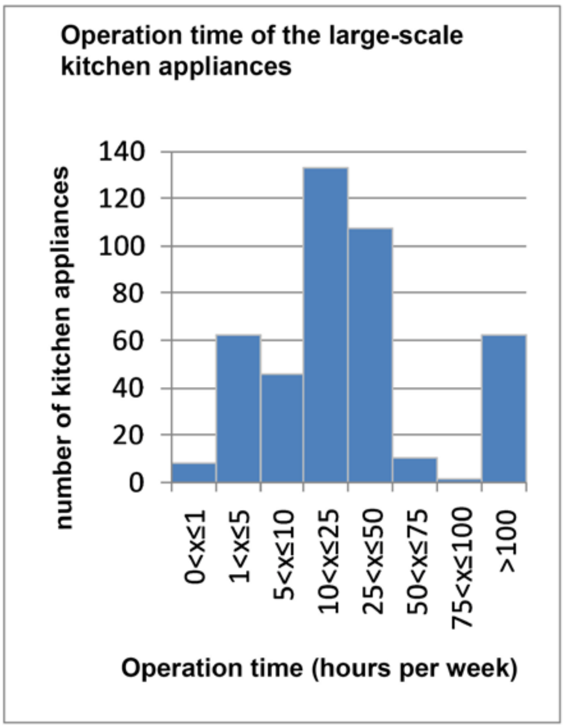


Figure 2-4 Kitchen appliances of a test kitchen by rated output (left) [Daxbeck et al., 2011]

Figure 2-5 Kitchen appliances of a test kitchen by operation time (right) [Daxbeck et al., 2011]

Figure 2-4 shows large-scale kitchen appliances grouped by rated output. The rated output is the maximum power an appliance can take. In this example about 70% of the appliances have a rated output between 0 and 5 kW.

Those are mostly appliances that belong to the categories meal distribution (for example: trolleys, Bain-Marie, plate dispenser) and refrigeration (refrigerators and deep freezers). The cooking appliances tend to have between 10 and 50 kW rated output.

Washing appliances (flight type dishwashers) tend to be on the upper end of the spectrum but usually there is only one per large-scale kitchen.

Figure 2-5 shows the operation time in hours per week to show a representative value. About 55% of appliances are operate between 10 and 50 hours per week. The appliances that are operated for 100 hours a week or more are mostly comprised of refrigeration and ventilation appliances. With refrigeration appliances, it can be assumed that they run 24 hours a day-including off days.

Some large-scale kitchens however are closed over longer periods of time and don't consume energy during those periods, this has to be taken into account when making calculations.

For the remaining categories, the average operation time is 15 hours a week for the category cooking and 20 to 25 hours for the meal distribution.

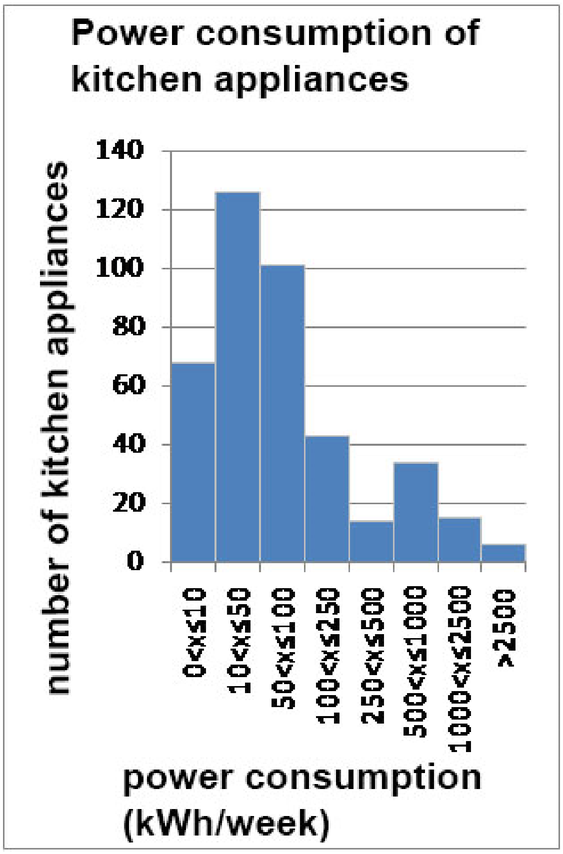


Figure 2-6 energy consumption by number of appliances [Daxbeck et al., 2011]

The values pictured in Figure 2-6 are theoretical values and don't necessary comply with reality. It is assumed that the estimation is yielding values that are too high but it makes sense to use the estimation for selecting appliances whose actual power consumption is then measured with a power meter.

3 Cooking Process

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3.1 The power consumption of which categories is taken into account

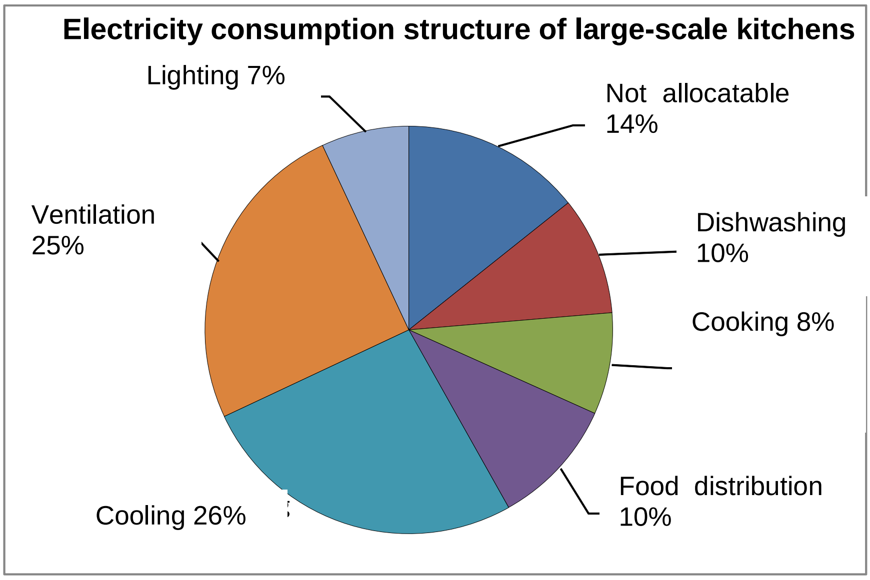

Figure 3-1 Average power consumption, taken from six Austrian large-scale kitchens. [Daxbeck et al., 2011]

Figure 3-1 shows the average power consumption of six Austrian large-scale kitchen by category. The large-large scale kitchens were: two hospital kitchens, one student home and three office kitchens. Each kitchen had large individual differences in the different categories.

3.1.1 Example Refrigeration

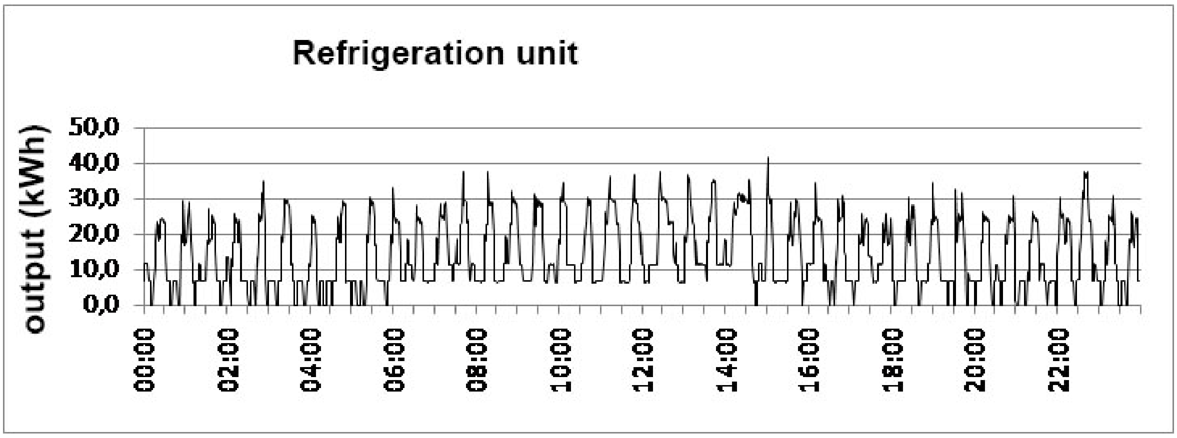

Figure 3-2 Summed up load curve of the refrigeration appliance of an office kitchen [Daxbeck et al., 2011]

The current pictured in Figure 3-2 was measured over the course of two days and summed up to get a general overview over the current performance.

Here it is obvious that the energy consumption rises during service hours. This can be explained trough loss of cold trough kitchen activities. On average the power consumption during service hours (between 6 and 18 hours) is 14,5% higher than the average consumption of the refrigeration appliances. This means that the power consumption during non- work days is lower and has to be taken into account when calculating the annual consumption.

The three most important categories in the kitchen the refrigeration example was taken from are: refrigeration with 25%, washing with 20% and ventilation with 12%.

3.1.2 Example meal distribution

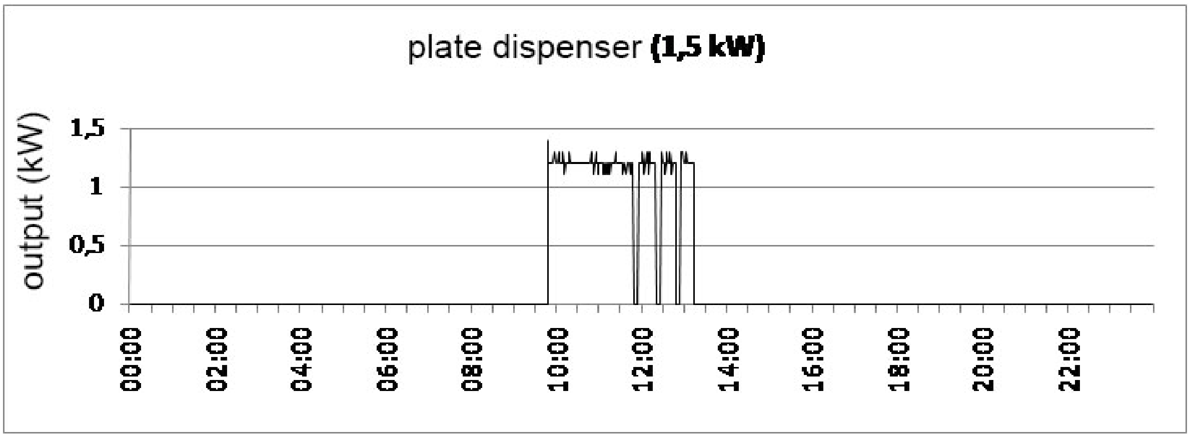

Figure 3-3 Load curve of a plate dispenser in an office kitchen [Daxbeck et al., 2011]

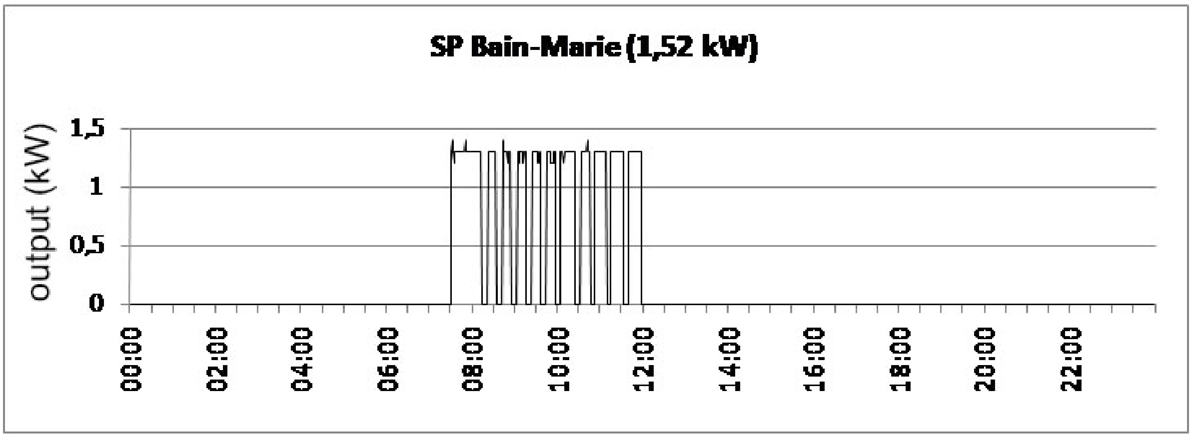

Figure 3-4 Load curve of a Bain-Marie in an office kitchen [Daxbeck et al., 2011]

In the category meal distribution two measurements were taken to document the output curve of the large scale kitchens. The theoretical maximal energy consumption (for example for plate dispensers, Bain-Marie) is 240 kWh per day – which is about 4% of the theoretical maximal energy consumption.

Figure 3-3 and Figure 3-4 are the load curves of a plate dispenser and a Bain-Marie. The average output of these two kitchen appliances is at about two thirds of the rated output. The energie consumption in the meal distribution category is estimated at 160kWh for this test kitchen, which is 5 to 7 % of the annual consumption.

3.2 Accuracy of the calculations to estimate energy consumption

The estimates of energy consumption that were done for six test kitchens during the course of project SUKI (Sustainable Kitchen) [Daxbeck et al., 2011] and the resulting diversions are 20% on average. While this is a small sample it can be assumed that the diversions in other large-scale kitchens are the same.
If the load curve of the large-scale kitchen appliances complies with the energy input that means that the major energy consuming appliances have been successfully identified.
If more appliances of the same type are in use the accuracy decreases but that can be taken into consideration when calculating the yearly consumption. Estimates are calculated with (rated output x operation time) and the factors that are taken from the measurements. More information on this topic can be found in the handbook.

3.2.1 Why is an optimisation reasonable and necessary plus an example

An optimisation of the energy consumption of large-scale kitchens is necessary. The trend to out of home catering in Austria is still going strong.
Reasons for that are rising spatial, social and professional mobility, rise of one-person households and increasing distances between work-place and place of residence.
About a fifth of moneys that is spent on food is spent on eating out of the home. In Austria that is about 3 billion Euros.
Austria's large-scale kitchens produce about 1,5 million meals a day and as a result consume big chunks of direct and indirect energy.
The direct energy consumption is comprised of the need for: natural gas, electricity and district heat etc. for the lighting, heating, ventilation, appliances, refrigeration and cooking. The energy saving potential in large-scale kitchens is very high. Studies show that on average between 20 and 25% percent of the energy consumed could be conversed.
This number is even higher if measures for winning back energy are implemented like heat recovery and combined heat and power production.

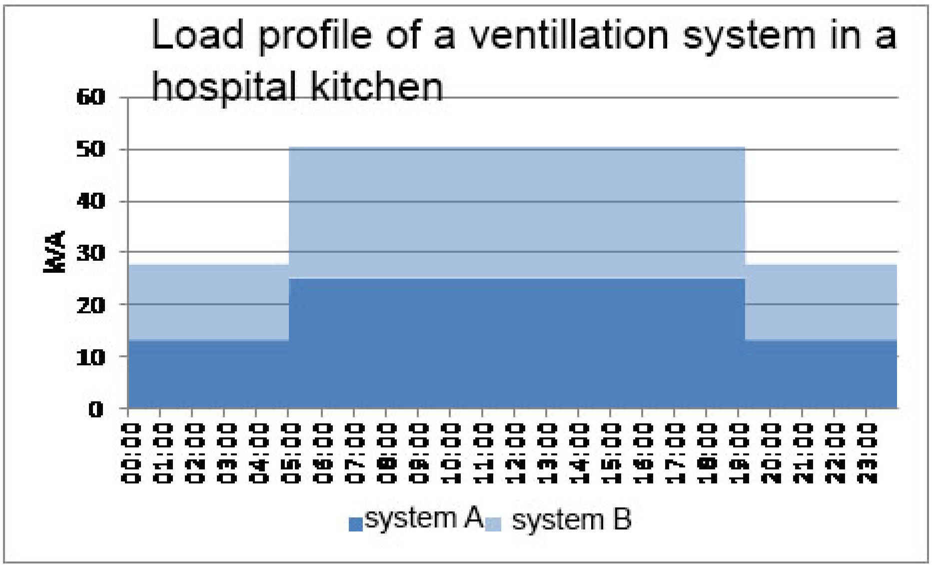

Figure 3-5 The load profile of a ventilation system of a hospital kitchen [Daxbeck et al., 2012]

The ventilation should be adjusted to the current need for ventilation, or the activities that currently take place in the kitchen.

A reduction of the air volume by 20% reduces the ventilator load by 50% [HKI Industrieverband Haus- Heiz- und Küchentechnik e.V., 2016] and also the power consumption.

Automation or time control of the ventilation is a useful tool but should be checked and optimized at regular intervals and adjusted to changing conditions – if necessary.

Energy savings can also be realized through phase control (implementing 3 minutes off, 3 minutes on) or trough speed regulation using a frequency inverter. A phase control management system can reduce energy consumption by factor 2, a speed regulation mechanism can lead to a reduction up to factor 8 [HKI Industrieverband Haus- Heiz- und Küchentechnik e.V., 2016]. Another possibility to regulate the air volume to the needs is to use sensors that measure air quality, more specifically CO_2.

Table 3-1 Energy and CO2 savings by means of ventilation control [Daxbeck et al., 2011]

Saving scenarios for ventilation	**Energy savings [MWh/year]**	**CO_2-savings [t/year]**	**CO_2-savings [%]***
No measure	0	0	0%
Reduced volume of air [1]	179	70	19%
Time control [2]	82	32	8%
Phase control [3]	183	72	19%
Speed regulation [4]	268	105	28%

**referring to the combined emissions in the kitchen*

[1] *Assumption: Reduction oft he air volume by 20% or 50% reduction of ventilator output*
[2] *Assumption: Output mode 1: 6 hours, output mode 2: 12 hours*
[3] *Assumption: 50/50 phase control*
[4] *Assumption: energy consumption reduction by factor 4*

The ventilation of the kitchen consumes as pictured in Figure 3-5 in this example approximately 29% of the total energy used. With the control mechanisms listed in Table 3-1 between 82 – 268 MWh, can be saved.

3.2.2 Best Practice Examples:

3.2.2.1 Kitchen HLUW Yspertal:

After installing a heat recovery system the waste water is now used to pre-heat the fresh water, that is then lead to the hot water boiler. An electronic control system makes sure that only pre-heated water can get into the hot water boiler.

Results and Project data:
Cost savings 1.840 Euros per year
Cost reduction 5,2 percent of the energy costs

3.2.2.2 Large-scale kitchen of the St. Franziskus Stift in Münster

In the large scale kitchen St. Franziskus Stift in Münster ventilation systems by the company Ergo Power GmbH were installed. They are equipped with optical and thermal sensors that makes sure the ventilation device only switches on when it's needed. The energy consumption sank more than 70% after installing the device and the need for heating sank almost 60%.

Results and Project data:
Systems: 2 ventilation systems from the company Ergo Power GmbH
Investition costs: 18.000 Euros
Time until ammortisation: 2 years

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3.3 Possible optimisation measures

A number of possible optimisation measures exists, some of which do not require financial investments. A simple change of behaviour, e.g. switching off the appliances when they are not in use, can lead to considerable savings. Another good basis is monitoring the energy consumption, in order to identify appliances with a high consumption and react based on that information.

Load management in the form of reduction of the demand peaks is another good possibility. Here, appliances with a high consumption are not switched on at the same time to avoid expensive consumption peaks.

Other technical possibilities are heat recovery measures and cogeneration of heat and electricity. In the handbook, these methods are described in greater detail.

Summary of possible optimization measures at a glance:
- behavior (operator):
o Switching on and off of the heat pools
o Filling devices with warm rather than cold water
o Better utilisation of dishwashing and cooling units
- Choice of food:
o Reduction of food with very high energy consumption
- Choice of equipment
o Replacing old (dishwashing) technology with energy-efficient new appliances
- Known nominal power of the devices is itself not enough to define successfully optimisation measures
- Avoid energy consumption peaks.

4 Examples

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4.1 Example hospital kitchen:

Table 4-1 measured large-scale kitchen appliances [Daxbeck et al., 2011]

appliance	rated output (kW)	Operation time (h/d)	Max. Energy consumption (kWh)	Measured energy consumption (kWh)
Flight type dishwasher	130	7	910	76
Pressure cooker	45	7	328	22
Combination steamer	45	4	193	60
Oven	50	3	143	22
Tilting frying pan	16	7	118	19
Cooking kettle	15	5	75	21
stove	22	1	22	13
Service trolley*	2,67	4	11	422
ventilation	-	24	-	650
refrigeration	-	24	-	368
			SUM	**1.673**

* *about 80 service trolleys are used in this hospital kitchen, that's why the measured energy consumption is higher compared to the theoretical maximal energy consumption.*

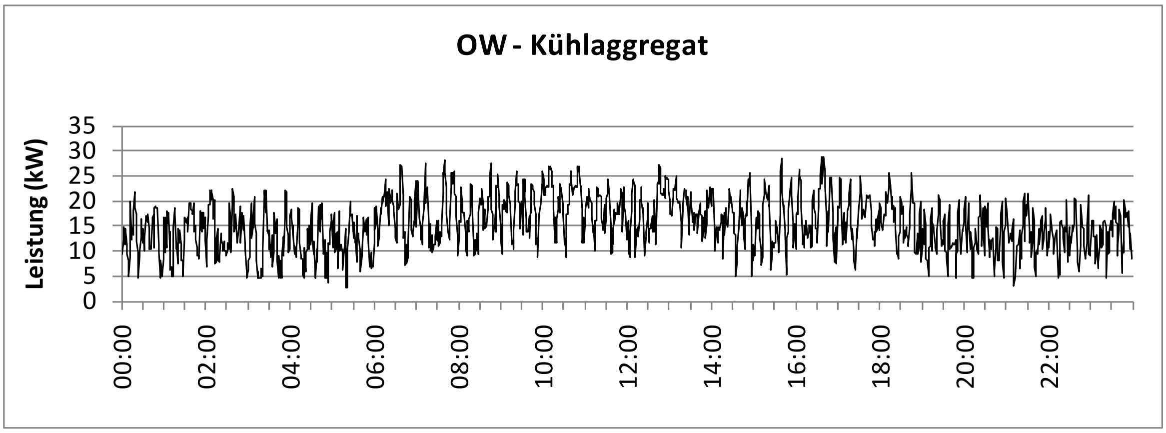

Figure 4-1 load curve of a cooling unit [Daxbeck et al., 2011]

The room ventilation is run centrally trough cooling unit, shown inFigure 4-1. In this example the energy consumption measurements were taken in September, which makes the energy consumption for ventilation a little bit higher than usual because the temperatures for September are above the annual average temperatures – this should be factored into the calculations.
For the category meal distribution as shown in Table 4-1 depicting the energy consumption of a hospital kitchen was chosen because it is atypical. 80 thermal service trolleys are used to transport the meals. The theoretical maximal energy consumption for the units is not particularly high (rated output is 2,667kW), but due to the high number of units this category is very energy intensive and consumes 17% of all energy. The food service trolleys are fed over two symmetrically stressed 3 wire lines. It is sufficient to measure one of those wire lines and multiply it by two since the lines are symmetrically loaded to determine the daily energy consumption of the food trolleys.
The food service trolleys in the example hospital kitchen are used seven days a week, usually two times a day for lunch and dinner. For this the food service trolleys are filled with warm water and heated with electricity to the desired temperature.
According to the kitchen staff the heating up period is about two hours each time. In this kitchen, the great number of food service trolleys is taken into account when the energy consumption is calculated. This means that the energy consumption before lunch (until 12) is taken into the calculation as seven times and the energy consumption for the afternoon five (after 12) is taken into the calculation as five times over the course of the year. The annual consumption of the food service trolleys is estimated at approximately 139.118 kWh.

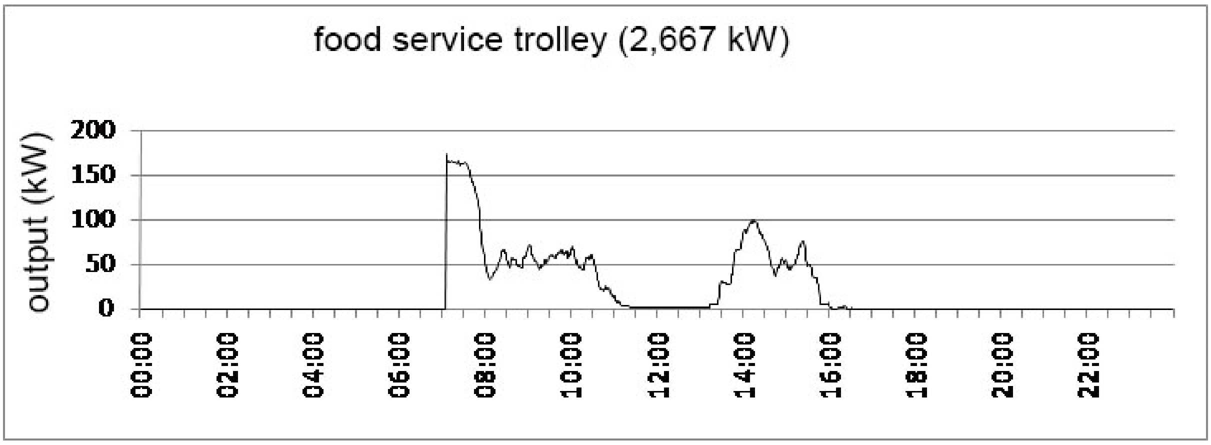

Figure 4-2 load curve of the food service trolleys [Daxbeck et al., 2011]

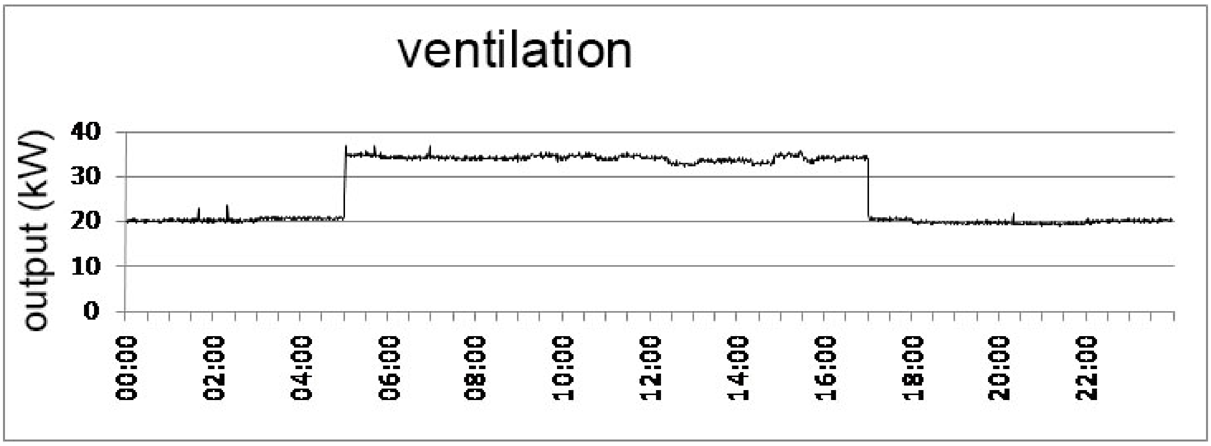

Figure 4-3 load curve of the ventilation [Daxbeck et al., 2011]

The structure of the energy consumption of the hospital kitchen is portrayed inFigure 4-4. The three most energy intensive categories are ventilation with 33% (see Figure 4-3.) the meal distribution with 19% (see Figure 4-2) and the refrigeration with 18& of the total energy consumption.

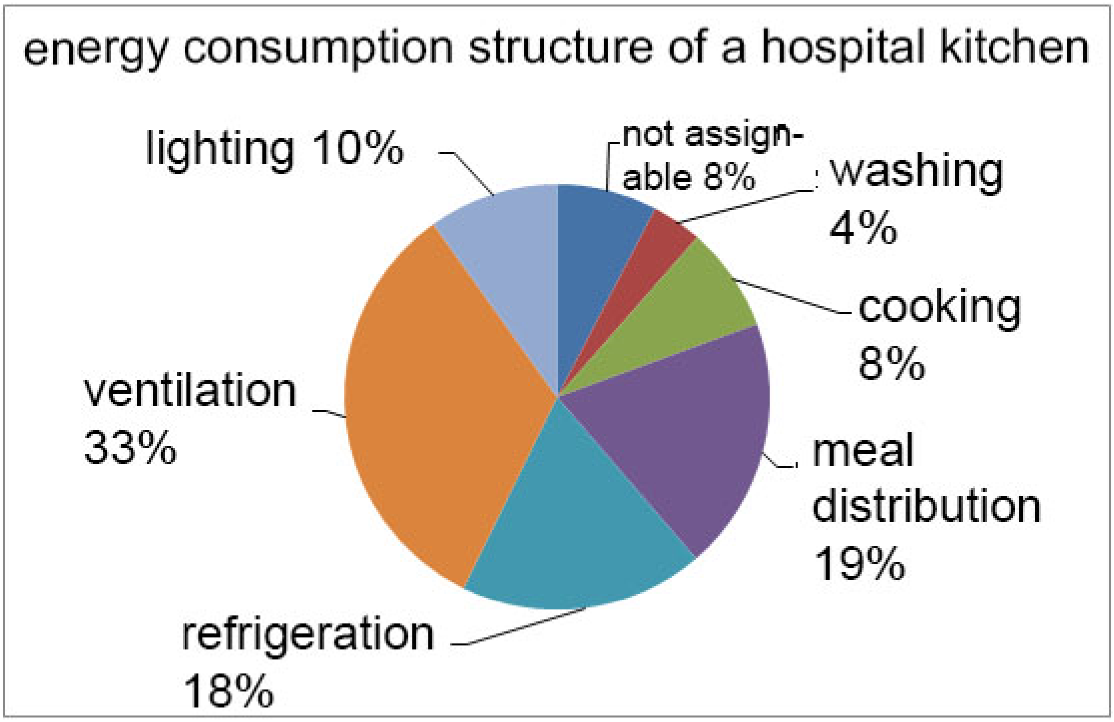

Figure 4-4 energy consumption structure of the example hospital kitchen [Daxbeck et al., 2011]

4.2 Example: Boarding house (school)

Table 4-2 Measured large-scale kitchen appliances in the kitchen of a boarding house [Daxbeck et al., 2011]

appliance	Rated output (kW)	Operation time (h/d)	Max. Energy consumption (kWh)	Measured energy consumption (kWh)
Infeed: Kitchen general	-	-	-	31
Infeed: Kitchen (appliances)	-	-	-	153
Refrigeration	-	24	-	40
Ventilation (kitchen and dining hall)	-	-	-	53
dishwasher	13,6	3	40,8	6
Tilting frying pan	14,7	1,5	22	18
			SUM	**301**

The daily load curve of the large-scale kitchen appliances in this kitchen is portrayed in Figure 4-5. It shows peaks of up to 60 kW during the preparation of breakfast at 7am and during preparation of lunch at 11 am. In total the appliances consumed 153kWh over the course of the day that was measured (see Table 4-2).

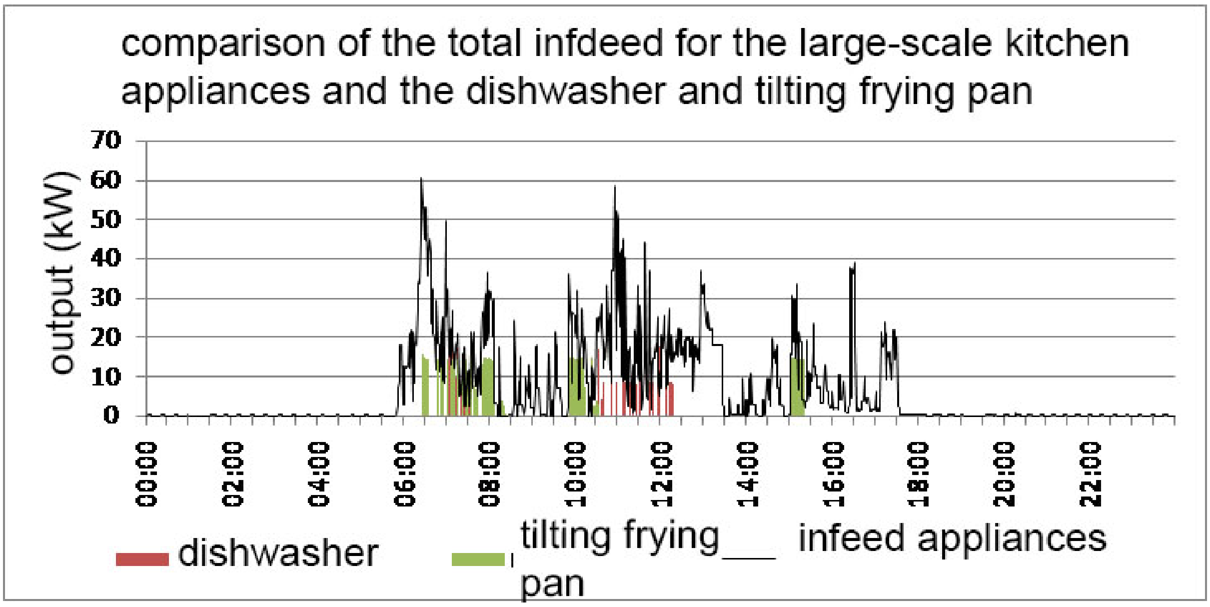

Figure 4-5 compares the total infeed of the large-scale kitchen appliances oft he boarding school. The tilting frying pan and the dishwasher are marked with colors [Daxbeck et al., 2011]

The refrigeration supply of the cooling cell happens over the cooling aggregate which is located in the rooms next to the kitchen – directly next to the cooling cell.

The energy consumption of the cooling aggregate is not recorded individually – therefore a measurement was taken to determine the energy consumption of the whole kitchen and the share of the refrigeration category.

Figure 4-6 shows the load curve of the cooling aggregate. The average demand of the cooling is at 1,6kW with peaks of over 8kW. The energy consumption during service hours (between 6 and 18 o'clock) is at 1,9kW – 0,5kW higher than during off hours (between 18 and 6 o'clock).

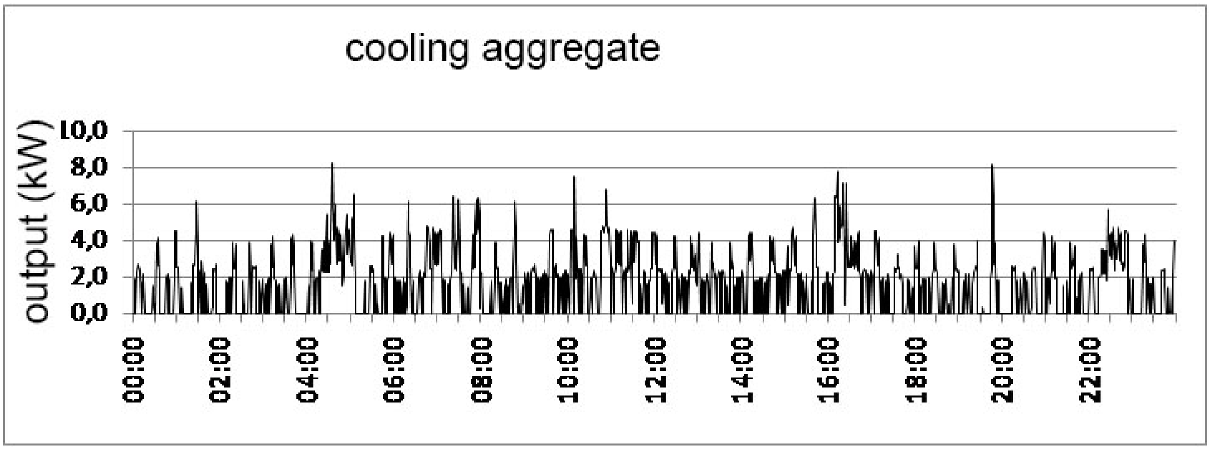

Figure 4-6 load curve of the cooling aggregate [Daxbeck et al., 2011]

The load curve of the ventilation of this kitchen is pictured in Figure 4-7 shows a two step progression. Between 6 and 18 o'clock the output is at 4kW and between 18 to 22 o'clock it's reduced to 2kW. From 22 to 6 o'clock the ventilation is switched off.

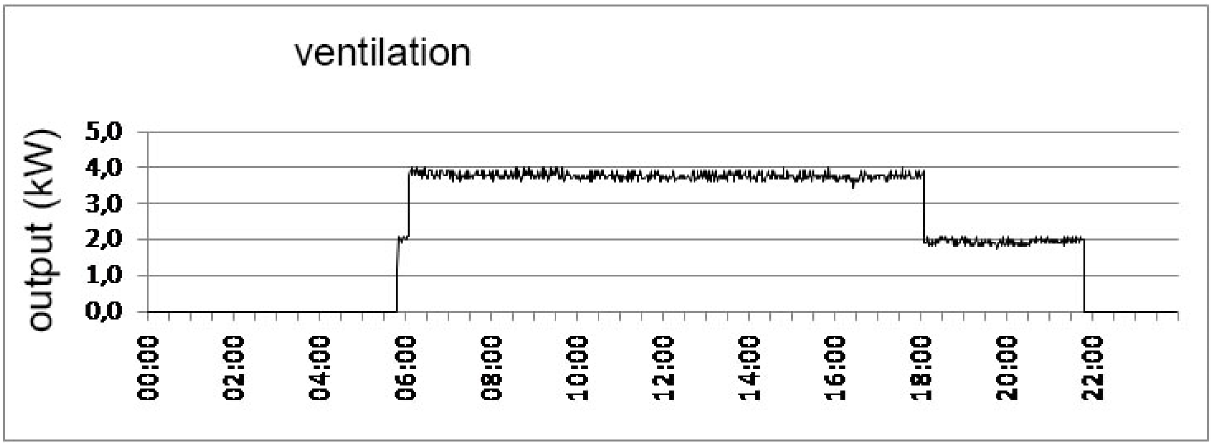

Figure 4-7 load curve of the ventilation in the kitchen and dining hall [Daxbeck et al., 2011]

Figure 4-8 shows the energy consumption structure in the kitchen. With six measurements that were made around 90% of the energy consumption of the kitchen could be explained. The category cooking is the most important from an energetic point of view with a 27% share on the total energy consumption. The categories refrigeration and ventilation are the second and third most important categories with shares of respectively 22% and 19% of the total energy consumption.

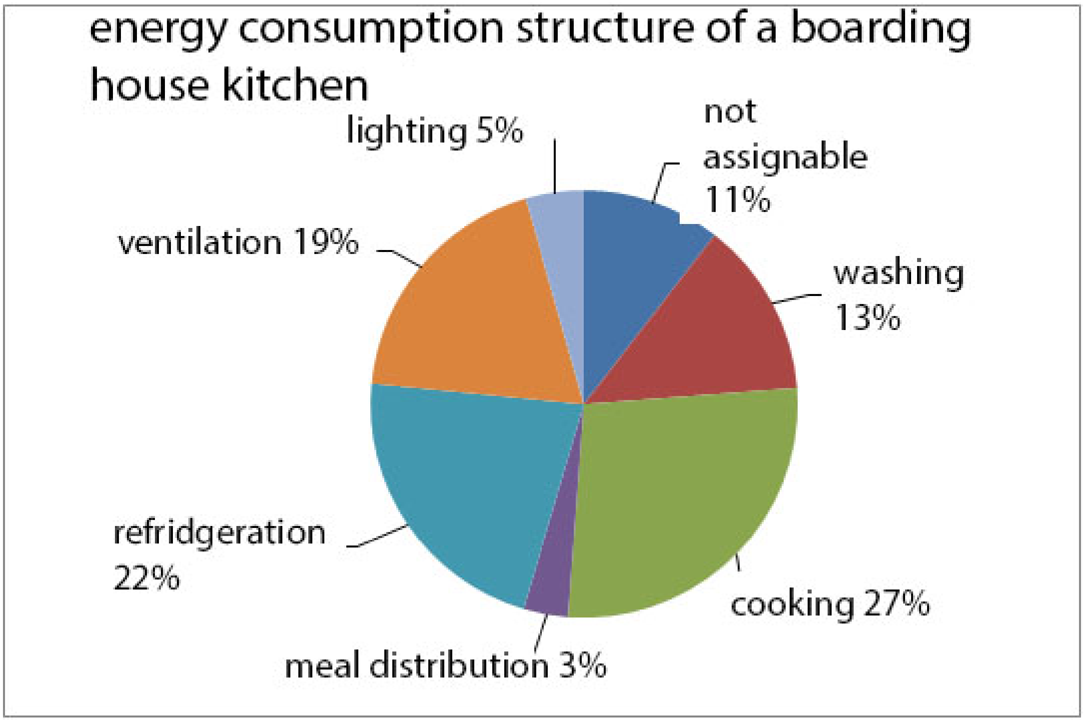

Figure 4-8 energy consumption structure of a schools boarding house kitchen [Daxbeck et al., 2011]

4.3 Example office kitchen

Table 4-3 Measured large-scale kitchen appliances and sectors of an office kitchen [Daxbeck et al., 2011]

appliance	Rated output (kW)	Time of operation (h/d)	Max. Energy consumption (kWh)	Measured energy consumption (kWh)
infeed 1 (kirchen-appliances))	-	-	-	415
infeed 2 (lighting)	-	-	-	67
Flight style dishwasher	43	2,5	107,5	84
Ware washing machine	34	5,5	187	52
ventilation	-	-	-	332
refrigeration	-	24	-	44
			SUMME	**858**

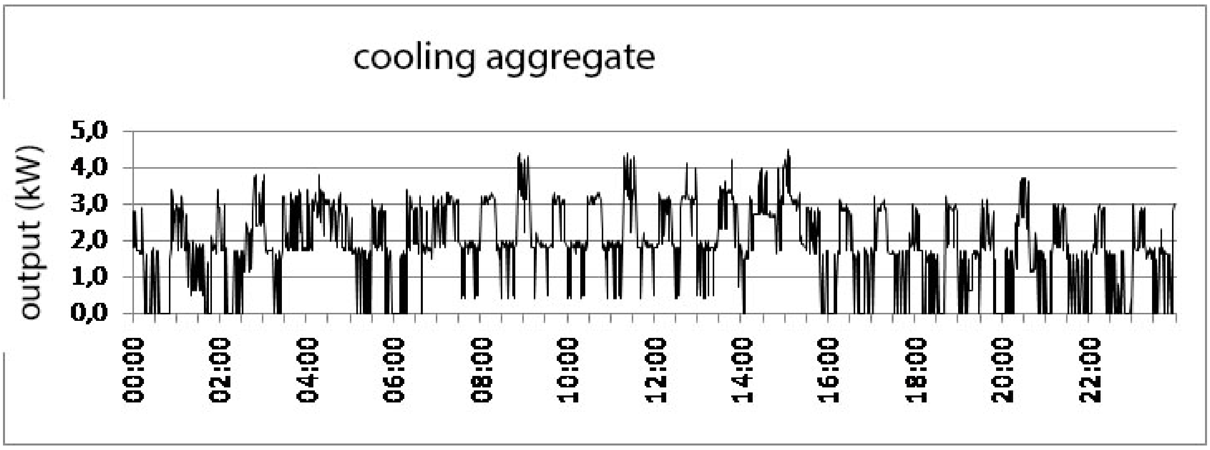

Figure 4-9 load curve of the cooling aggregate [Daxbeck et al., 2011]

Figure 4-9 pictures the load curve of the cooling aggregate. In this kitchen the kitchen does not have a separate cooling unit so the consumption could not be measured.

Figure 4-10 shows the load curve for lighting. The difference between the energy consumption during service and non-service hours is noticeable. During non-service hours (from 18 to 6 o'clock) the average consumption is around 16% lower than the daily average. It can be assumed that the energy consumption in the night, during non-service hours is representative of the energy consumption on off days. The rise of the energy consumption on work days can be explained with cooling losses due to kitchen activities (like opening the refrigerator door,

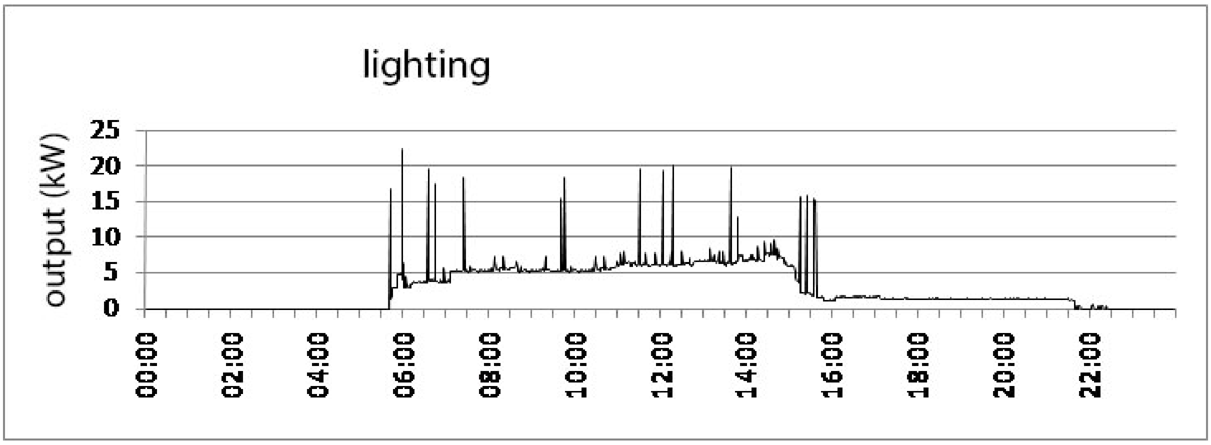

Figure 4-10 load curve of lighting [Daxbeck et al., 2011]

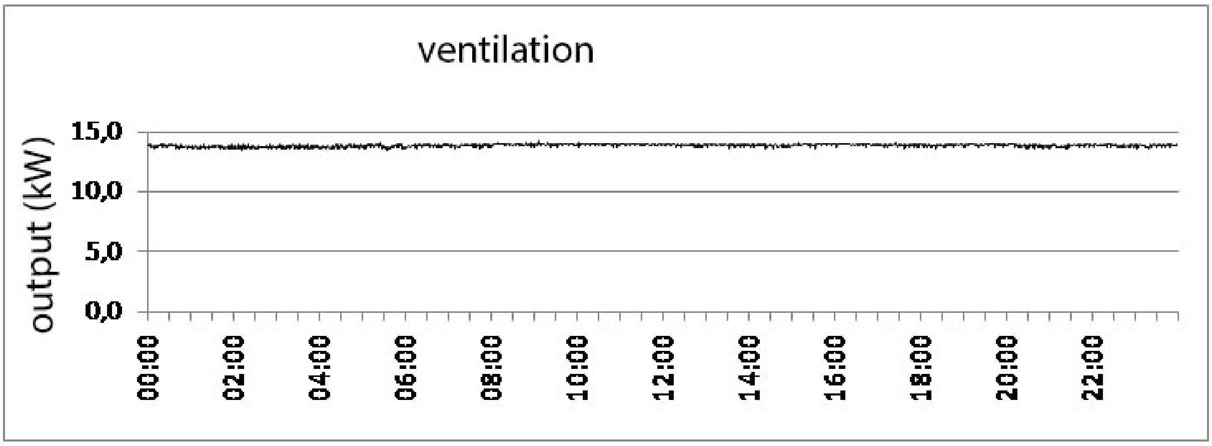

Figure 4-11 load curve of ventilation [Daxbeck et al., 2011]

The ventilation is an important category for energy consumption in this test kitchen.
Figure 4-11 shows the load curve of the ventilation in a day of the kitchen including the dining hall. The measurements showed that the ventilation unit runs on one performance level for 24 hours – at 14kW. That is unusual because the ventilation is usually regulated to match kitchen activities. Here it is recommended to check the controls of the ventilation and regulated them to match the actual demanded air volume. There are huge potential savings and if the performance level is adjusted to the kitchen activities savings of up to 50% are possible.

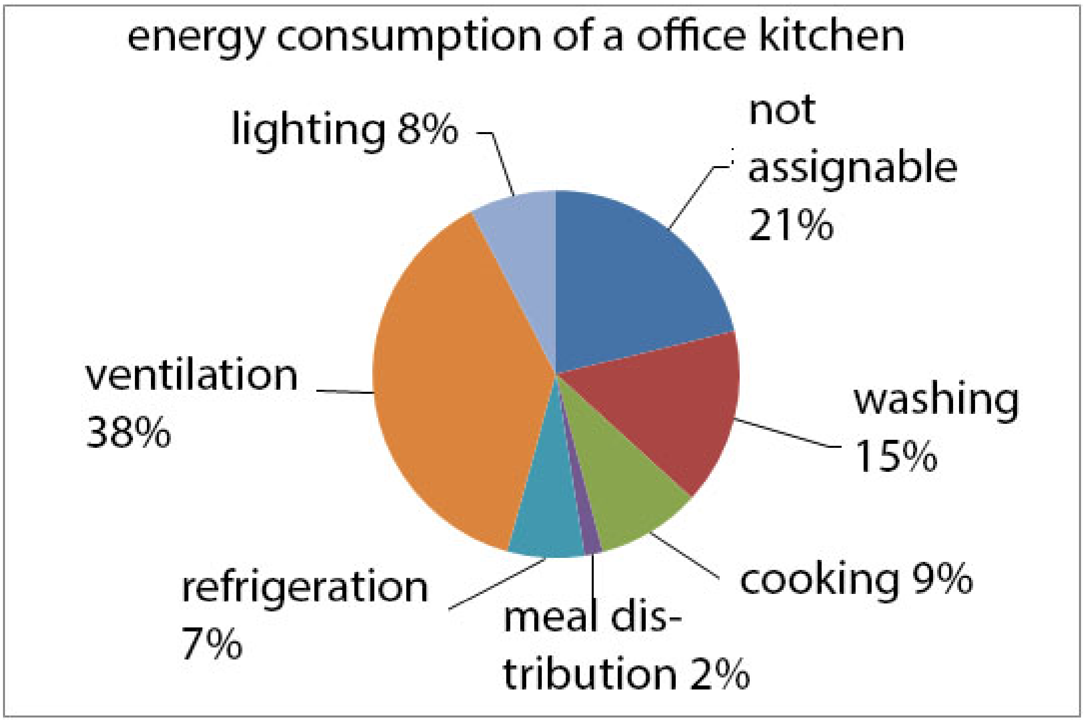

Figure 4-12 energy consumption of the office kitchen [Daxbeck et al., 2011]

After the category ventilation with 38% the category washing is the second most important with 15% of the total yearly energy consumption of the office kitchen. Another 8% belong to the lighting category and for the cooking a consumption of 9% was determined. Peculiar to this kitchen was that the category refrigeration was far below average with 7% of the total energy consumption see Figure 4-12.

4.4 Comparison of the large-scale kitchen in regards to energy efficiency

The sectors community catering and gastronomy have different energy consumption indicators for the energy consumption in large-scale kitchens.

The President U.Jenny of ENAK (Energetischer Anforderungskatalog an Geräten für die Verpflegung und Beherbergung) sets 4kWh per mea las an average [Jenny, 2008].

A study that was subsidised by the European Union, concerning energy efficiency in large-scale kitchens evaluated between 50 and 60 kitchens, some with an output of up to 4000 meals a day in five different European countries (France, Switzerland, Slovakia, Finland, Austria and Greece) a statistical indicator for energy consumption in the sector gastronomy (see Formel 3-1) [AIR-IX Consulting Engineers et al., 2002]. The term „NR“ refers to the number of produced meals per day.

Equation 4-1 energy consumption of the office kitchen [AIR-IX Consulting Engineers et al., 2002].

$$\text{Benchmarkvalue } \left(\text{Energy Consumption per meal}\right) = 105 \times \text{NR}^{-0,63}$$

More information on this topic can be found in the handbook

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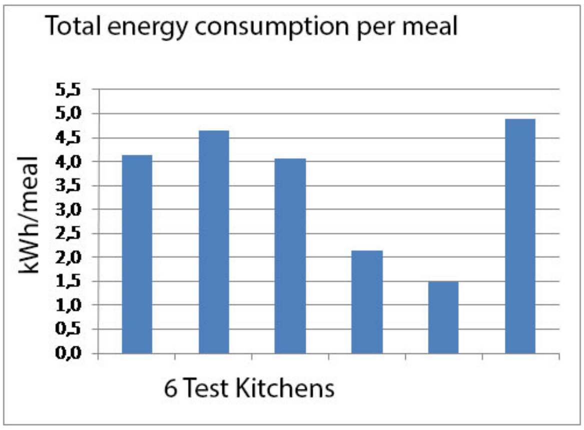
4.5 Energy consumption per meal

In order to make energy consumption comparable, one possibility is to evaluate the energy consumption of large kitchens based on energy consumption per meal. This indicator provides an overview of the energy efficiency of large-scale kitchens and allows the comparison between the large-scale kitchens, regardless of the absolute energy consumption and the number of meals produced. In Figure 4-13, the energy consumption indicators for the six Austrian large-scale kitchens are reproduced. The energy consumption indicator was determined over the entire energy consumption (electricity, gas, district heating) for the Austrian large-scale kitchens and averaged about 3.5 kWh per meal. On average, the energy consumption per meal is about 4 kWh per meal [Jenny, 2008]. For the two of the office kitchens, a relatively low value when compared to the other kitchens was determined.

In Figure 4-14 the average values of the energy indices determined for the categories are reproduced in order to identify those categories which are significant from the energetic point of view. It can be clearly seen that the room heating is by far the most energy-intensive category in the large-scale kitchens. This is due to the fact that the dining halls have been included in the calculation, which leads to a considerable increase in the energy consumption of the large kitchens. Other important categories are ventilation, washing, cooking and refrigeration. This statement is to be regarded as a guideline, as the individual categories have different, kitchen-related, different values for each individual kitchen.

These figures show the energy consumption per number of meals, sector and the kitchen of six large kitchens tested in 2012.



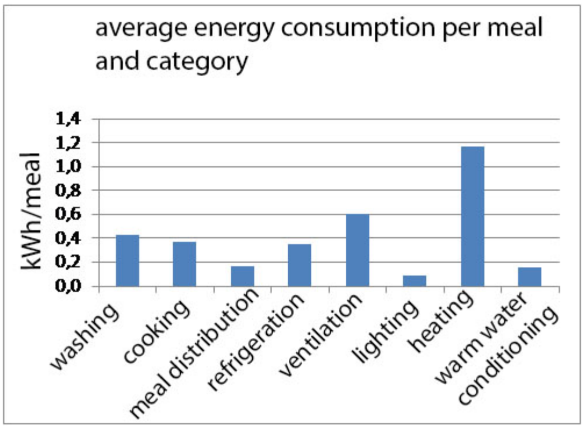


Figure 4-13 Energy consumption per meal and large-scale kitchen (left) [Daxbeck et al., 2011]

Figure 4-14 Average energy consumption per meal and category (right) [Daxbeck et al., 2011]

More information on this topic and a precise list of the individual kitchens by category and energy consumption can be found in the handbook.

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