Chances and barriers for energy services companies? A comparative analysis for the German brewery and university sectors

Joachim Schleich, Ulla Boede, Dirk Koewener and Peter Radgen, Fraunhofer Institute for Systems and Innovation Research

1. SYNOPSIS

For the German brewery and university sectors, barriers to energy efficiency are analysed, and success and limiting factors for energy services companies to overcome important barriers are analysed.

2. ABSTRACT

This paper explores barriers to the Rational Use of Energy (RUE) in two sectors in Germany that are usually neglected by energy efficiency policy: the brewery and university sectors. In particular, it is analysed to what extend energy services companies (ESCOs) may help overcome some of these barriers. Several case studies were conducted in breweries and universities to analyse barriers to RUE using ideas from economic, behavioural, and organisational theory. Based on the empirical evidence, policy measures are proposed. To assess whether energy services companies may help overcome barriers such as transaction costs, bounded rationality, lack of capital, or information deficits, success factors and limiting factors are identified for both sectors. Important factors include the nature of the RUE-technologies and the changing operating environment. In the brewery sector, ESCOs are unlikely to succeed since RUE-technologies are rather company specific, process integrated, or affect the core production process. Smaller breweries, who would benefit the most from contract energy management, face considerable business risk stemming from a stagnating German beer market with continuing horizontal concentration, and from investment risks associated with the introduction of the returnable PET-bottle. In the university sector, ESCOs are expected to succeed, since RUE-measures are rather cross-cutting, and since current reforms imply more financial flexibility and autonomy for universities, result in a shift in competencies from the state administrations to the universities, allow for increased internal transferability of funds, and foster the introduction of business accounting.

3. INTRODUCTION

The German brewery sector is the largest in Europe and a major energy consumer within the food sector, but usually neglected by energy efficiency policy. Similarly, the university sector has drawn relatively little attention. For energy efficiency policies to be effective, it is important to consider potential barriers to the rational use of energy (RUE) when designing such policies. Overcoming these barriers may not only save energy costs but also contribute significantly to the reduction of greenhouse gases, and thus may help to achieve national and international emission reduction targets. In a recently completed research project for the European Commission several case studies were carried out in selected breweries and universities to analyse barriers to energy efficiency using ideas from economic, behavioural and organisational theory (Sorrell *et al*. 2000). Based on the empirical evidence, policy measures were identified. In particular, it was analysed, to what extend energy services companies (ESCOs) may help overcome the relevant barriers. In the subsequent sections the findings of this research project are presented for Germany.[1] First, the German brewery and higher education sectors will be characterised focussing on energy consumption and energy management. In Section 5 findings about the relevance of the various barriers are presented along with policy recommendations. Sector 6 contains an analysis of success factors and limiting factors for energy services companies in these sectors. Section 7 offers a brief summary and conclusions.

4. SECTOR OVERVIEW, ENERGY CONSUMPTION, AND ENERGY MANAGEMENT

Breweries

Sector overview

In Germany, there are more than 1200 breweries with a total of 47,000 employees and annual production of about 115 Mio hl. In 1996, total consumption was 108 Mio. hl leading to total sales of _ 10 Billion. About 7.5% of output, i. e. 8500 hl beer, are exported, while less than 2200 hl beer are imported. More than 70% of total production was brewed in 22 large breweries/brewery groups, with more than 1 million hl output each. The three largest brands are Warsteiner, Krombacher, and Bitburger. Small breweries with an annual production of under 30,000 hl_{VB}/a are quite widespread. In addition there are about 200 "pub breweries" catering mainly to the needs of one pub. The German beer market is largely saturated and beer consumption per capita has been decreasing continuously since 1975 from then 147.8 l/capita to now less than 130 l/capita. In the medium run beer consumption is expected to drop to 110-115 l/capita. On the supply side there are excess capacities of about 30% due to decreasing demand, productivity growth, and added capacities in the new German states. As a result, prices have been decreasing in real terms and profits are at an all-time low. The market is currently in a process of transformation. Closures, take-overs and mergers reduce excess capacities, and the market shares of the big breweries and brewery groups are increasing. This concentration process is likely to be accelerated through the introduction of the PET-bottle in a market where the returnable multi-use glass bottle is dominating. If the lighter PET-bottle becomes the dominant container for beer, most breweries will be forced to switch their capital-intensive filling and cleaning processes made for glass bottles to new processes for PET-bottles. The risk is, that only large breweries have sufficient capital to survive this switch. A possible scenario for the future structure of the German beer market includes on the one side large brewery groups with more than 1 Mio hl of output per year serving the national market and, to a lesser extend, international markets. On the other side, there remain niche markets for small regional breweries with less than 100,000 hl.

Energy consumption

Breweries belong to the energetically more important branches of the food and luxury food industry. *Energy costs* typically account for 1-3% of total sales. *Total fuel consumption* in 1995 amounted to approx. 4,100 GWh (1,139 PJ), and the *electricity consumption* to 1,086 GWh, of which 74 GWh (6.8%) was provided by auto production. In 1997 average specific fuel consumption figures based on a survey of 66 breweries was 1.72 MJ/l and average specific electricity consumption was 0.4828 MJ/l (13.44 kWh/hl). The following table displays average specific energy consumption figures for German breweries in 1997.

Table 1. Average specific energy consumption figures for German breweries in 1997

Size	0-20,000 hl	20,000-50,000 hl	50,000-100,000 hl	100,000-500,000 hl	> 500,000 hl	Average
Fuel consumption (MJ/l)	2.45	1.96	1.74	1.49	1.07	1.72
Electricity consumption (MJ/l)	0.6591	0.5083	0.4734	0.4388	0.3758	0.4838

Source: Schu *et al*., 1999

About 40-60% of fuel consumption is required for heating mash and wort in the brewhouse, and 15-5% for filling. Electricity is mainly required for cooling, which accounts for 25-40%, as well as for cleaning and filling (transport of materials, generation of compressed air, CO_2 recovery), which account for 15-40%. Electricity consumption trends show an increase due to automation, but also since some RUE-measures require electricity in order to reduce heat demand (e.g. in heat recovery). Important technical measures for the rational use of energy in the brewery sector are listed in Table 2.

Table 2. Selected technical measures for the rational use of energy in breweries

Brewing process
Heat recovery from wort cooling
Copper vapour heat recovery
Thermal and mechanical vapour recompression of wort vapour
Packaging
Increase in beer racking temperature
Variation of washing cycle with size of cask/keg
Bottle washer/pasteuriser heat recovery
Refrigeration
Improved systems for accurate temperature control
Refrigeration heat recovery
Cooling of tank instead of storage room
Compressed air
Regular inspection and repair of leaks
Generation of air only when needed and at minimum required pressure
Pre-cool inlet air/duct from outside
Compressor heat recovery

The list of measures in Table 2 implies, that technical measures for the rational use of energy in the brewery sector are primarily process integrated and directly affect the core production process.

Energy management

On-site interviews were conducted in five German breweries between December 1999 and March 2000. Some key features of energy management in those breweries are as follows:

- *Organisation*: usually a technical manager is responsible for energy management, which takes up less than 20% of his time; production is typically organised in cost centres such as brewing, fermentation, filling and bottle cleaning, and packaging; in the smaller breweries communication and decision-making is characterised by frequent, close and informal contacts with the top management, and with brewers;
- *Energy/environmental management schemes* are not implemented in any brewery in the case study;
- *Energy costs and energy consumption:* the energy cost share in the sample ranges from 0.9% to 3% of total turnover; specific energy consumption is between 0.3 MJ_{el}/l and 0.6 MJ_{el}/l for electricity, and between 0.98 MJ_{fuel}/l and 2.3 MJ_{fuel}/l for fuel; annual energy costs per litre beer ranges from _ 0.007 to _ 0.028[2] *Energy consumption* is regularly measured, controlled, and also compared to benchmarks with other breweries; the largest brewery has an online energy controlling and management system in place; energy consumption for steam reduction, hot water, compressed air and cooling is usually metered at the site level, while measurements on the secondary side of air compressors and cooling compressors are not available; electricity consumption tends to be metered in more detail, at least at the level of cost centres;
- *Accountability & incentives*: most breweries allocate energy costs to cost centres, to some extend based on actual measurements, but primarily based on estimated proxies or some fixed shares with allocation adjustments after major investments;
- *Capital budgeting and investment criteria*: specific budgets for investments in energy efficiency do not exist; energy efficiency tends to be a by-product of investments carried out for other reasons; since energy efficiency is rather process integrated, investments in energy efficiency usually have to meet the same investment criteria as other investments, i.e. pay-back times between 3 and 5 years, but exceptions for investments with long lifetimes exist; market risks (declining market, horizontal integration, PET-bottle[3]) prevent smaller breweries to make long-term investments;
- *Purchasing & policy integration*: the technical staff selects the equipment, which, in larger breweries, is purchased through the purchasing department; energy efficiency is routinely included in most breweries in the purchasing and maintenance specification, but energy efficiency is usually only one of many criteria, with quality being most important; life-cycle costing is not routinely applied;
- *Awareness & culture*: most of the interviewees are motivated by environmental concerns and the better performing breweries saw a close and important link between the production of beer as a natural product and the environment, but do not to use environmental performance for marketing purposes; the exchange of information about RUE-measures is very common within the brewery sector;

Universities

Sector overview

During the winter semester of 1998/99, there existed 349 institutions of higher education in Germany including 86 Universitaeten (universities), 7 Gesamthochschulen (polytechnics), 16 Theologische Hochschulen (theological colleges), 6 Paedagogische Hochschulen (educational colleges), 46 Kunsthochschulen (art academies), 152 Fachhochschulen (advanced technical colleges), and 36 Verwaltungsfachhochschulen (administration colleges). Over 98% of the students were enrolled in public institutions. Since the early 1970s the total number of students has grown from 422,000 to now over 1.8 Mio. (Statistisches Bundesamt, 1999 a, b). During the winter semester 1998/1999 about 481,000 people were employed, about 45 % of those were scientific staff including about 37,600 professors. Operating expenses are generally financed through the budgets of the federal states Laender), some by churches or private organisations. For large equipment, new buildings and the extension of buildings for institutions of higher education and their associated hospitals 50% of the investment costs are paid for by the federal budget. *Total expenditures* for all institutions of higher education in 1997 by the federal and state budgets amounted to almost _ 26,000 Mio. In 1997, the investment share was 11.7%. In general, the *funding of institutions of higher education in Germany suffers from tight federal and state budgets*, which cause major challenges for the functioning of the higher education sector (Planungsausschuss, 2000). Many institutions need new equipment for research and teaching, and many buildings need to be refurbished. *Major reforms* provide additional challenges for the higher education sector, such as *increased autonomy* for individual institutions from the state authorities, the introduction of *global budgeting* and *business accounting, new funding schemes, tuition, rankings* and *evaluation, increased competition* with other public universities or with *private universities*, new forms of teaching such as *virtual universities,* or new programme designs including bachelors' and masters' programmes.

Energy consumption

Since data on total or specific energy consumption in the higher education sector in Germany is not available, total *energy consumption* within the German HE sector is estimated to be about 11 TWh (Schleich and Boede, 2000)[4]. This figure corresponds to about 0.4% of final energy consumption in Germany, and is lower than recent estimates would suggest (Winkelmann, 2000; Volkens/Schomaker, 2000).[5] About 40% of energy consumption in universities goes into electricity use, and 60% into heat use. More than 90% of thermal energy use goes into space and process heating, while electricity is primarily used for ventilation and air-conditioning (30-50%), lighting (20-30%), and office equipment (20-30%). Electricity costs account for about 60% of total *energy costs*. Energy costs for the entire higher education sector sum up to around _ 500 Million, which account for about 2% of total expenditures in that sector. The *technical and economic savings potential* in the HE sector is estimated to be high. Analyses show that organisational measures in the public sector may save 5-15%, technical measures to reduce thermal energy consumption by 25-60%, and technical measures to reduce electricity consumption by at least 10 % (Umweltbundesamt, 1999). Similarly, according to a recent study conducted by the Austrian Energy Agency for all Austrian universities (Energieverwertungsagentur, 1999), information and education measures that change users' behaviour can result in 20-30% energy savings without loss of comfort and at low costs.[6] Typical technical measures for the rational use of energy in the higher education sector are listed in Table 3.

Table 3. Selected technical measures for the rational use of energy in universities

Space heating
Programming heating and ventilation controls to match occupancy patterns and/or temperature
Use of Building Energy Management System
Lighting
Replacement of 38mm fluorescents with 26mm
Use of compact fluorescents
Use of photocell, acoustic or movement sensors
Heat generation
Insulation of pipes, valves and flanges
Use of boiler sequencing controls
Replacement of oversized boiler plant
Installation of CHP

Building fabric
Draught proofing of windows and doors
Retrofitting insulation to walls and roofs
Installation of secondary or double glazing on refurbishment
Electrical equipment
Use of high efficiency office equipment
Use of high efficiency motors
Use of variable speed drives in pumps, fans and other applications
Automatic switch off of fans & pumps

This list of measures indicates, that *technical measures for the rational use of energy in the higher education sector are typically cross-cutting*.

Energy management

In six German universities interviews were carried out between Spring and Summer 1999. Some key features of energy management in these universities are as follows:

- *Organisation*: universities are large institutions with complex decision-making structures, where energy consumption is influenced by several institutions, individuals and groups from within and outside the university; the university administration is primarily responsible for measuring and controlling energy consumption and costs, the setting of priorities for investments, purchasing of equipment, space planning, and to a limited extend also for construction planning and maintenance; typically, there is no energy manager; instead a department for technical services is responsible for the supply of heat and electricity services, while a construction department participates in the planning of buildings and is in charge of the buildings maintenance;[7] many universities exhibited a lack of co-ordination, a lack of clear delegation, and a lack of clear responsibilities for energy management;
- *Energy/environmental policy*: formal environmental or energy policies are an exception; no university had a certified environmental management scheme in place; teaching and research are the top priorities;
- *Energy costs and specific energy consumption figures*: the energy cost share in the sample ranged from 1.7% to 2.4% of the budget (including third party funding); specific final thermal energy consumption was between 0.56 GJ_{th}/m^2 and 1.5 GJ_{th}/m^2, while specific final electricity consumption was between 0.28 GJ_{el}/m^2 and 0.66 GJ_{el}/m^2; annual energy costs per student ranged from _ 110 to _ 350;[8]
- *Energy information systems and energy consumption control*: energy consumption is measured and controlled regularly at the level of individual buildings, but no targets exist; buildings energy management systems are usually in place, but mostly only for some buildings, and often outdated; energy costs are paid out of a central budget and unknown to individual departments or institutes;
- *Capital budgeting and investment criteria*: separate budgets for RUE-measures do not exist; typically 6% of the budget for maintenance are required, which is not sufficient; quantity and quality of profitability/risk analyses for RUE-measures vary considerably across universities; for investments, pay-back times of 5 years tend to be required, but they may be longer for equipment with a long lifetime;
- *New build and refurbishment*: for buildings construction and most refurbishment, a state construction agency is responsible for the planning and carrying out of the work, while the influence of the universities is limited; often, prestige and design dominate; co-ordination between planners, various engineering firms and trades is not sufficient;
- *Purchasing & policy integration*: specifications for new equipment are provided by individual departments, and equipment is ordered by central purchasing office, where energy efficiency is taken into account; but usually initial outlays (and not life-cycle costs) are most important; existing laws and guidelines for the integration of environmental performance into the purchasing specifications are not very powerful and usually not enforced;
- *Awareness & culture*: a general lack of awareness for energy performance was prevalent; where educational programs exist, research and teaching staff tend to abstain; support for RUE-measures from the top administration is important, but the personal motivation of those in charge of energy management seems to be crucial for finding and realising RUE potentials; some of the interviewees would like to see universities as being leaders by example (i.e. do what they preach); but the concept of “sustainability” is only starting to enter the curricula.

5. EVIDENCE OF BARRIERS AND POLICY RECOMMENDATIONS

The empirical results have been interpreted in terms of the literature on barriers to energy efficiency, focussing primarily on economic theory (Sorrell *et al.* 2000). The following sections summarise the evidence for the main barriers in the brewery and university sectors in Germany. When interpreting the results, it is important to keep in mind, that barriers can overlap and reinforce each other. Also, the limited number of case studies confines the generalisation of the findings. A detailed exposition of the results on the barriers is beyond the scope of this paper (see Schleich and Boede 2000, and Schleich *et al.* 2000). Instead, summary results of the analysed barriers and possible organisational and sectoral policy measures to overcome those barriers are presented for breweries in Table 4 and for universities in Table 5. The most relevant barriers are printed in bold.