# StromGT: A planning tool for reducing electricity consumption in building automation and control systems

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**Abstract.** Building automation and control systems (BACS) are essential for modern energy-efficient buildings, yet their own electricity consumption is often overlooked. This paper introduces *StromGT*, a free, Excel-based planning tool developed at the Lucerne University of Applied Sciences and Arts. StromGT enables early-stage estimation and optimisation of electricity consumption in BACS and building services. The case studies presented demonstrate the potential to reduce BACS electricity consumption by up to two-thirds.

## 1. Introduction

The electricity consumption of building automation and control systems (BACS) has gained increasing attention over the past decade. Since 2013, the Lucerne University of Applied Sciences and Arts has conducted several research projects funded by the Swiss Federal Office of Energy (SFOE) to quantify and reduce this consumption [1], [2], [3]. These efforts led to the development of StromGT, a practical tool for planners and engineers.

The motivation behind StromGT is to provide a transparent, easy-to-use method for evaluating the electricity demand of BACS during the planning phase — when design decisions have the greatest impact.

## 2. Tool overview

StromGT is an Excel-based tool with embedded Visual Basic (VBA) macros. It is available in German, English, and French, and can be downloaded freely [4]. The tool allows users to:

- Model the electricity consumption of BACS and other building systems.
- Easily identify consumption-relevant devices using the tool's extensive output and sorting options.
- Distinguish between direct and indirect consumption (e.g. direct consumption by a field device, e.g. controller, vs. losses by external power supplies).
- Visualise results in interactive tables and graphs.

The tool supports both new construction and retrofit projects. It is designed to operate with relatively few user inputs: some attributes are optional, and many are dynamically pre-filled with default values by the tool based on other attributes, particularly based on the device type.

The decision to opt for an Excel-based tool rather than an online solution was made for pragmatic reasons. Chief among these were local data storage — eliminating the need for user account management and concerns about data sharing — and the availability of strong in-house VBA programming expertise. Additionally, an online application would have required dedicated hosting, whereas the Excel tool could simply be distributed as a file.

## 3. Methodology

The tool's calculation method is based on the following principles:

- **Device-level modelling**: Each device can have multiple power inputs and two operating states — active and standby. The device attributes are consistent across all types, except for additional attributes specific to lighting systems. For lighting, the tool includes attributes for luminous flux, luminous efficacy, and attenuation levels, along with built-in calculations for redundant values. Attributes common to all types include:
  - Device (unique identifier, amount, description, manufacturer, type designation, URL to the data sheet, local datasheet, types of current outputs)
  - Topology attributes (main supply with attributes "type of current input", "supplying device"; secondary supplies with attributes "type of current inputs", "supplying device(s)"; device type (main type, subtype))
  - Affiliation (BACS vs. non-BACS, list of building services)
  - Time share in active operation
  - Nominal operation point (nominal power, efficiency at nominal power)
  - Internal power consumption in active mode (from main supply, from secondary supplies)
  - Internal power consumption in standby mode (from main supply, from secondary supplies)
- **Power supply topology**: Users define how devices are powered through a supply tree structure. I.e., it is specified which device powers which other device(s).
- **Power losses**: These are dynamically modelled based on product efficiency at nominal load and idle losses. The tool steps through the entire supply tree, from field devices up to the grid connection, to calculate losses.
- **Time share in active operation**: By default, the fraction of time a device spends in the active state is determined by its type. Users can modify these values to better represent specific usage scenarios.
- **Affiliations: BACS vs. non-BACS and list of building services**: These affiliations are automatically supplemented for certain device types and can be overridden by the user.

A comprehensive description of the calculation method is provided in [5], and its implementation as a tool is detailed in [6].

The tool aggregates data by:

- Device type (main and subtypes). Currently, the following main types are preconfigured: power supply, controller, I/O module, input module, output module, network component, operating device/display, sensor, actuator, monitoring, management, lighting: electronic ballast (EB), lighting: bulbs, lighting: luminaire incl. EB, heat pump, air handling unit
- Building service (e.g., heating, lighting)
- BACS relevance (BACS vs. non-BACS)

This structure allows for detailed and flexible analysis and visualisation. It remains, however, the planner's responsibility to use their expertise to optimize BACS electricity consumption without compromising system functionality — this includes applying domain-specific knowledge to select devices that are appropriate and conducive to energy-efficient operation.

## 4. Application scenarios

StromGT is preconfigured for the typical building services: heating, cooling, ventilation, lighting and shading. The tool focuses on BACS but can also cover the full scope of building services, including both BACS devices (e.g., controllers, actuators, sensors) and non-BACS devices (e.g., light bulbs, heat pumps, air handling units). It is up to the planner to decide which devices to include — evaluations of subsystems are supported.

The tool can also be adapted for other services such as access control or security. The default “building service” attribute can be freely configured by the user using free-text input, allowing any type of service to be represented. The same applies to the “device type” attributes (main and sub-type), which can also be defined using free text.

## 5. Case study: Significance of building automation electricity consumption and reduction potential

For a high-rise building in Basel (Roche Building 1)[7] — a building built to the Minergie standard that relies exclusively on groundwater and waste heat for heating and cooling — the relevance of BACS electricity consumption was assessed in comparison to the total electricity consumption of the building services (heating, cooling, ventilation, lighting and shading). For the realised system, the BACS share amounted to 21% (3.6 kWh/m$^2$), meaning that about one-fifth of the total building services electricity consumption (17.1 kWh/m$^2$) was attributable to BACS.

StromGT calculated a possible reduction in the specific annual electricity consumption from 3.6 kWh/m$^2$ to 1.2 kWh/m$^2$ — a two-thirds reduction — by replacing the actual devices with more efficient ones and performing system optimisations (resulting in the “ideal” case).

Figure 1 shows a breakdown of BACS electricity consumption by device type. Device types with high savings potential include “actuator”, “electronic ballast” (lighting), “controller,” and “output module,” as well as “power supplies”: All power supplies together (bar segments in light colors) account for 20% of BACS electricity consumption in the “realised” case (6% in the “ideal” case). In addition to product selection, attention should be paid to the dimensioning of power supplies.

Device type “actuator”: BACS electricity consumption in this category is almost entirely due to heating and cooling valve actuators. Power supply shares account for 72% (realised case). Ventilation damper actuators and shading motors are controlled via 3-point control; standby power consumption is thus avoided, as power is only drawn during movement, and no energy is required to hold the position once it is reached.

Device type “room control/display unit”: Room operation is carried out with energy-autonomous EnOcean control devices, so there is no electricity consumption.

A comprehensive description of the case study is provided in [8].

Figure 2 shows a breakdown of annual electricity consumption by affiliation with BACS and by device type.

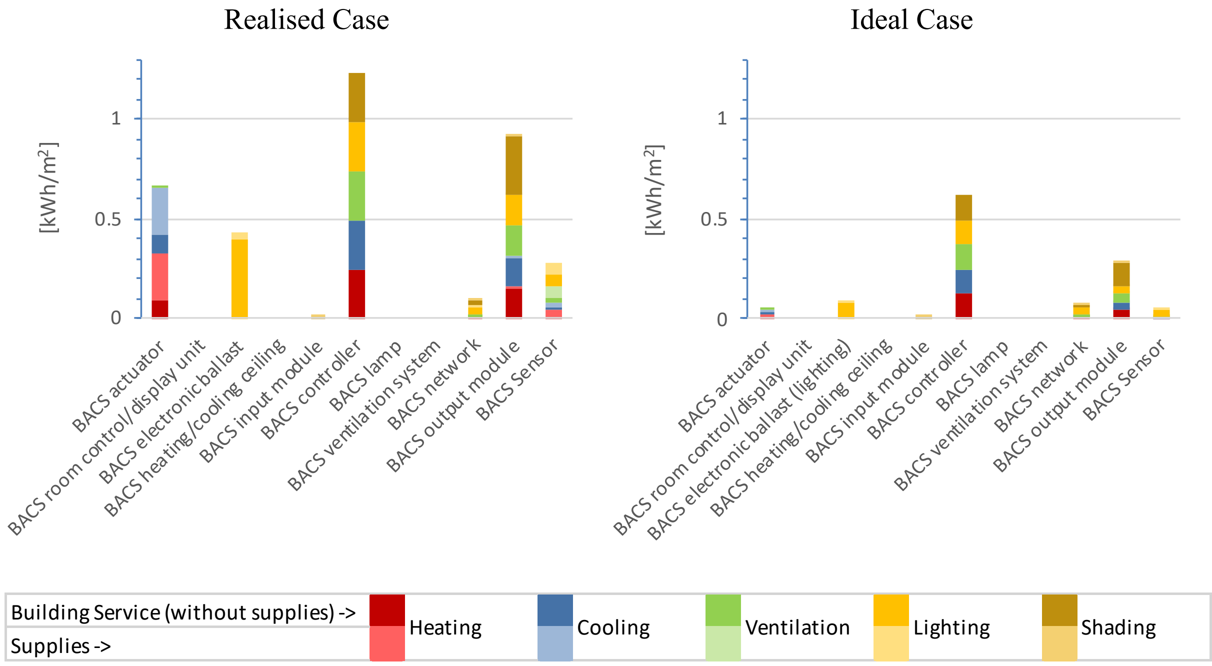


**Figure 1.** BACS annual electricity consumption by device type and building service.

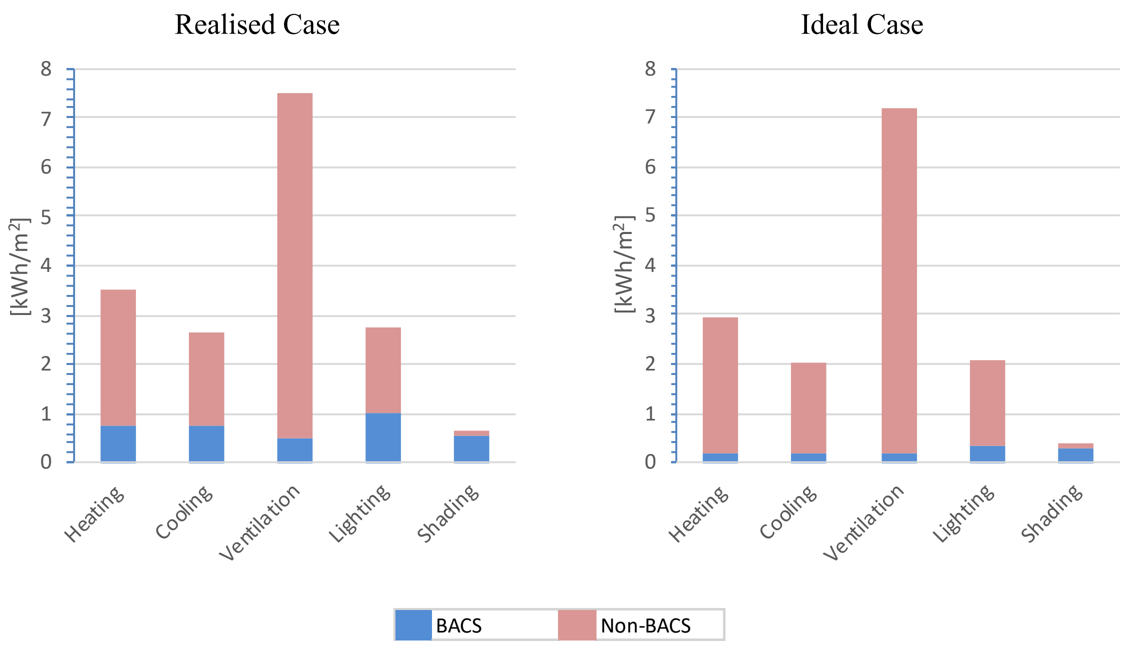


**Figure 2.** BACS annual / non-BACS electricity consumption by building service.

## 6. Summary of cases studies

Lucerne University of Applied Sciences and Arts analysed ten buildings using several early versions of the calculation tool: the high-rise building presented above, five schools, one hotel, two office buildings, and a fictitious office building. The latter was assessed with four variations of BACS. All case studies featured a high level of automation, corresponding to BACS efficiency classes A or B (according to the energy efficiency standard EN 52120).

The BACS annual electricity consumption for room automation was calculated to range between 2 and 5 kWh/m² across all buildings studied.

For three of the buildings — the high-rise presented above, one office building, and one hotel — an "ideal" system was also defined in addition to the realised solution. Table 1 lists the BACS annual electricity consumption for room automation. The corresponding annual savings potential amounted to 2.46 / 1.38 / 1.88 kWh/m², or 68% / 44% / 43%, respectively. Detailed analyses of these cases are provided in [3].

**Table 1.** BACS annual electricity consumption for room automation by building service.

| Building service | High rise "realised" | Office building "realised" | Hotel "realised" | High rise "ideal" | Office building "ideal" | Hotel "ideal" |
|---|---|---|---|---|---|---|
| BACS heating | 0.77 | 0.78 | 0.80 | 0.20 | 0.60 | 0.87 |
| BACS cooling | 0.77 | 0.48 | 0.92 | 0.19 | 0.36 | 0.57 |
| BACS ventilation | 0.49 | 0.47 | 1.87 | 0.18 | 0.38 | 0.59 |
| BACS lighting | 1.03 | 1.18 | 0.52 | 0.35 | 0.31 | 0.29 |
| BACS shading | 0.57 | 0.27 | 0.30 | 0.26 | 0.15 | 0.21 |
| **Total BACS** | **3.64** | **3.17** | **4.41** | **1.18** | **1.79** | **2.53** |

The analyses of the remaining buildings are presented in [1] and [2], focusing on the "realised" scenarios.

Note that we have no knowledge of what other analyses were conducted with our tool. As of June 28, 2025, the StromGT tool has been downloaded approximately 300 times.

## 7. Challenges, Recommendations and Outlook

Despite its relevance, BACS electricity consumption is often neglected due to:

- Lack of client requirements: We are not aware of any building owners who provide planners with specifications or request BACS electricity consumption calculations. However, building owners could specify maximum annual electricity consumption targets for BACS (in kWh/m²), either for the entire system or for individual subsystems of building services. In addition, they could define maximum limits for the combined idle and standby power consumption at multiple levels—such as for the entire BACS, for specific subsystems, or for selected devices — to ensure low annual idle/standby electricity use.
- Absence of regulatory incentives: To our knowledge, there are hardly any consumption recommendations or binding specifications regarding BACS's annual electricity consumption or that of its subsystems. SIA 2056 [9] defines three-tier reference values (low, high, and medium), but it does not require calculations to demonstrate compliance with the selected level. There are also certain specifications for the power consumption of individual devices, such as external power supplies [10].
- Product data availability: Information on typical operational power consumption differentiated by key configurations is often missing. To enable product comparisons across manufacturers, there should be a consensus on measurement conditions.

To address the above challenges, the authors recommend incorporating BACS electricity consumption in building labels (e.g., Minergie, SNBS); standardizing product datasheets with power consumption values that are representative of typical usage scenarios; utilising power properties in classification systems (e.g., ETIM, ECLASS); and creating product databases based on aforementioned classification systems through automated data integration.

Future StromGT developments may include creating a cross-manufacturer product database containing all relevant BACS power consumption values, automating the retrieval of product data via interfaces with classification-based databases, and directly importing product identifiers and supply topology from the BIM model. These enhancements aim to reduce input effort further and improve planning accuracy.

## 8. Conclusion

StromGT empowers planners to identify opportunities for optimising BACS electricity consumption during the design process. For widespread adoption within planning practice, however, several prerequisites remain yet unmet (see Chapter 7).

The case studies mentioned above highlight the significance of BACS electricity consumption and its considerable potential for energy savings through informed planning. Particularly in energy-efficient buildings — as illustrated by the high-rise case study — it is worthwhile to pay close attention to the BACS electricity consumption, given its relatively significant share of overall electricity use.

That said, BACS can yield substantial energy savings by enabling the optimal operation of building services [11] — particularly when its own electricity consumption is minimized.

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