SmartPrio^{GIS}

A concept for recording, holding and evaluating data as a contribution to CO_2 reduction for the Kassel University campus

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Summary

The basic idea of the new SmartPrio^{GIS} concept is to collect building-related data from different formats and from different sources in a structured system. At the beginning of the process, it is important to get a broad overview of the properties and not to collect the best possible level of detail for all potential applications right from the start. By collecting the information with a geo-data referenced application such as ArcGIS from Esri, a quick overview of relevant data is made possible. Due to the successive detailing of the data collection with progressive concretization of measures, significantly fewer human resources are required at the beginning of the process to collect building data. The closer the implementation of energy retrofit measures gets, the more extensive and detailed the available information becomes, making the digital image of the campus increasingly accurate. During the overall process, prioritization options emerge by identifying potential CO_2 savings.

Keywords: concept, energy retrofit, data collection, data management, data evaluation, prioritization, successive detailing, building, university campus, implementation orientation

1. Introduction

As part of the "CampusKassel2030" research project funded by the German Federal Ministry of Economics and Climate Protection, the new SmartPrio^{GIS} methodology for data collection, storage and evaluation is being developed and tested using the University of Kassel campus as an example. With regard to energy refurbishment and efficiency improvement to accelerate the energy transition, the concept is designed to be implementation-oriented and to provide concrete support for the responsible decision-makers in dealing with the properties. Transferability to similar building areas is an important aspect.

The basic idea behind the innovative approach is to reduce the use of resources when collecting data. Neighborhood concepts usually begin with a complete data collection at the start of the project in order to be able to record the variables and boundary conditions for determining the energy balance as comprehensively as possible. This requires a great deal of time and personnel, although the relevance of the results for a longer-term transformation process is comparatively low. Particularly in the case of a university campus, those responsible are familiar with the properties managed and the fundamental aspects of the buildings.

With the SmartPrio^{GIS} concept, an implementation-oriented approach is developed that collects only a basic set of few, but relevant data for all buildings at the beginning of the process. The scope and detail of the database is successively updated as measures are concretized in the course of the process. This means that data collection is largely supported by planning steps that are necessary anyway and does not tie up any additional resources.

This makes the concept fundamentally different from other approaches and projects for collecting and using energy-related data to save energy or increase efficiency. Other projects also use geoinformation systems to collect, manage and apply the data. Examples to be mentioned in this context are:

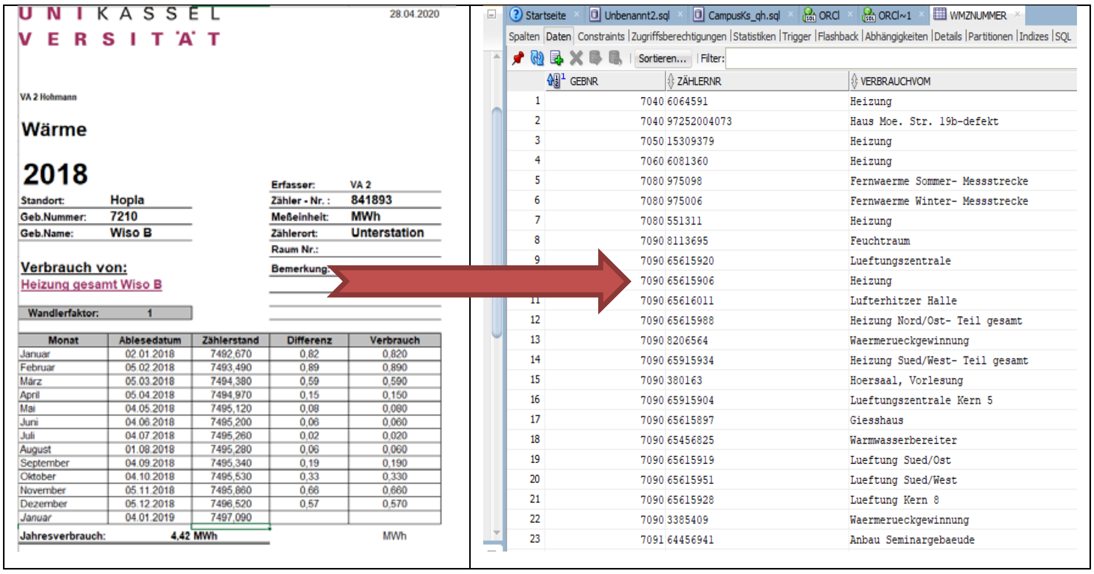
- Wärmeatlas 2.0 - GIS model of the useful energy demand for space heating and hot water in the German building stock [1]

doi:10.18086/eurosun.2022.10.06 Available at http://proceedings.ises.org

- ENA - Energy master planning for grid-connected waste heat utilization; sub-project: GIS-based energy master planning system, stakeholder-specific requirements of municipalities and development of guidelines [2]
- GIS building energy - national database for energy deliveries to buildings [3]

However, the methodology of data collection of the examples mentioned does not follow the new approach described here of collecting a relevant but small amount of data at the beginning of the project by prioritization with as little effort as possible and successively expanding it during the course of the project.

The first task is to collect the data available in various places and in different formats and to structure them in such a way that central access is possible. For this purpose, data sets available as Excel sheets or CVS files, for example, are loaded into a database and further processed by means of SQL commands in order to be able to use and visualize them in ArcGIS. The data originate almost exclusively from the construction department of the University of Kassel or are coordinated with it. Thus, the data quality in terms of goal achievement can be rated as very high. Figure 1 schematically illustrates the described procedure using a concrete example. In the future, consumption data from the building management system (BMS) could be sent directly to an Oracle database to be configured accordingly, which would simplify the process and enable prompt visualizations of measured values and results.


UNIKASSEL VERSITÄT 28.04.2020

VA 2 Hohmann

Wärme

2018

Standort: Hopla
Geb.Nummer: 7210
Geb.Name: Wiso B

Erfasser: VA 2
Zähler - Nr.: 841893
Meßeinheit: MWh
Zählerort: Unterstation
Raum Nr.:
Bemerkung:

Verbrauch von:
Heizung gesamt Wiso B

Wandlerfaktor: 1

Monat	Ablesedatum	Zählerstand	Differenz	Verbrauch
Januar	02.01.2018	7492,670	0,82	0,820
Februar	05.02.2018	7493,490	0,89	0,890
März	05.03.2018	7494,380	0,59	0,590
April	05.04.2018	7494,970	0,15	0,150
Mai	04.05.2018	7495,120	0,08	0,080
Juni	04.06.2018	7495,200	0,06	0,060
Juli	04.07.2018	7495,260	0,02	0,020
August	01.08.2018	7495,280	0,06	0,060
September	04.09.2018	7495,340	0,19	0,190
Oktober	04.10.2018	7495,530	0,33	0,330
November	05.11.2018	7495,860	0,66	0,660
Dezember	05.12.2018	7496,520	0,57	0,570
Januar	04.01.2019	7497,090		

Jahresverbrauch: 4,42 MWh MWh

Startseite | Unbenannt2.sql | CampusKs_qh.sql | ORCl | ORCl~1 | WMZNUMMER

Spalten | Daten | Constraints | Zugriffsberechtigungen | Statistiken | Trigger | Flashback | Abhängigkeiten | Details | Partitionen | Indizes | SQL

Sortieren... Filter:

	GEBNR	ZÄHLERNR	VERBRAUCHVOM
1	7040	6064591	Heizung
2	7040	97252004073	Haus Moe. Str. 19b-defekt
3	7050	15309379	Heizung
4	7060	6081360	Heizung
5	7080	975098	Fernwaerme Sommer- Messstrecke
6	7080	975006	Fernwaerme Winter- Messstrecke
7	7080	551311	Heizung
8	7090	8113695	Feuchtraum
9	7090	65615920	Lueftungszentrale
	7090	65615906	Heizung
11	7090	65616011	Lufterhitzer Halle
12	7090	65615988	Heizung Nord/Ost- Teil gesamt
13	7090	8206564	Waermerueckgewinnung
14	7090	65915934	Heizung Sued/West- Teil gesamt
15	7090	380163	Hoersaal, Vorlesung
16	7090	65915904	Lueftungszentrale Kern 5
17	7090	65615897	Giesshaus
18	7090	65456825	Warmwasserbereiter
19	7090	65615919	Lueftung Sued/Ost
20	7090	65615951	Lueftung Sued/West
21	7090	65615928	Lueftung Kern 8
22	7090	3385409	Waermerueckgewinnung
23	7091	64456941	Anbau Seminargebaeude

Figure 1: Transfer of consumption data from Excel sheets to a database

In addition to the advantages of the methodical approach, the approach of managing the collected data with a geo-data referenced application from the beginning in order to be able to evaluate them within a system for strategic planning, if required, is to be regarded as innovative. Through GIS-based data management, various types of information from different data sources can be summarized, localized and visualized on a building-by-building basis. With the appropriate structuring and processing of the data, it becomes possible to make information available at "one glance" that was previously stored in various places and whose existence was sometimes only known to a small group of people. In addition to the strategic component, the transparency of information and the usability of data within departments and also across divisions are significantly improved.

2. Methodological approach and data collection

The SmartPrio^{GIS} concept is based on a three-level approach, with each level differing in its level of detail, and with more and more concrete information being obtained as the levels are processed.

In line with the research approach, the concept initially refers to a purely energetic view of the refurbishment options and the increase in efficiency. Cost-effectiveness considerations are not included. However, this does not rule out the possibility of further development at a later date. The evaluation criterion is CO_2 emissions, which can be calculated from the consumption for heating the properties and generating hot water as well as the electricity consumption multiplied by the respective emission factor.

The methodological principle is based on the fact that data is successively collected based on a mandatory data set depending on the available information. Ultimately, there should be a high density of information on the buildings at the end of the transformation process. However, the achievement of this optimal data situation for the campus is not bound to a tight time schedule. The information will primarily be obtained in connection with measures that are due to be implemented anyway.

The conceptual approach and the basic technical structure are shown in Figure 2. The continuous georeferenced data management is implemented in the project with the software ArcGIS of the company Esri.

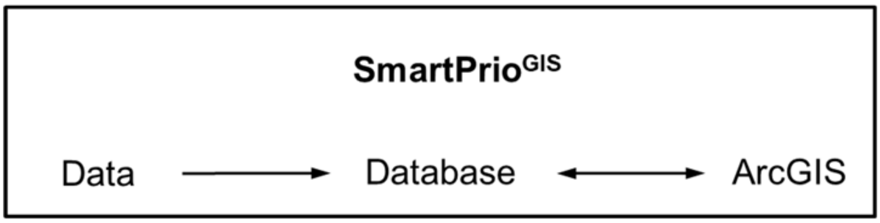


Figure 2: Illustration of the SmartPrio^GIS concept and the basic technical structure

The innovative character consists in the gradual acquisition of data and the successive increase in the level of detail and the scope of data in the course of the processing. At the beginning of the project, only a few data on the individual buildings are available, the so-called basic data. With the help of this basic data, an overview of the building stock should be made possible and thus an energy assessment should be carried out.

It is particularly worth mentioning that the scope of the basic data as well as the type and scope of the data to be collected later were coordinated with the university's building department from the very beginning of the project. This promotes the practicality and applicability of the concept and consistently develops the methodology in an implementation-oriented manner.

Figure 3 shows an example of the evaluation of the final energy consumption of the buildings in comparison. The larger a circle, the greater the final energy consumption for heat generation or power supply. The diagram on the right side of Figure 3 shows the final energy consumption of heat generation for eleven buildings. The buildings are sorted in descending order according to their final energy consumption for heat.

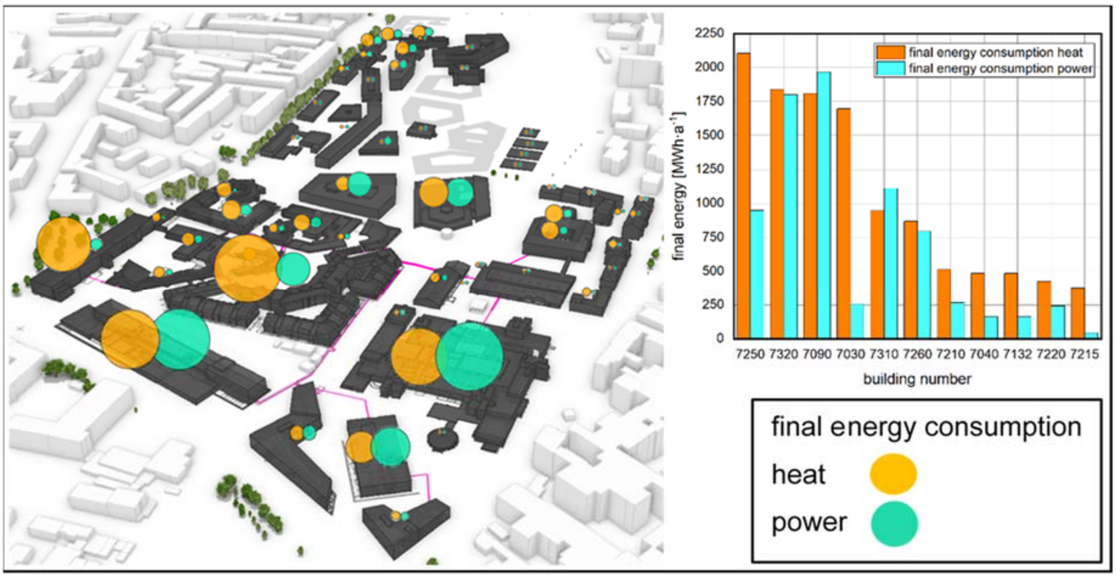


Figure 3: left extract campus overview, right final energy consumption per building – both from ArcGIS

The described methodology and the three-level model of building-related data collection can be extended beyond the energy aspects discussed here to other areas. By considering the idea of transferability, the use of the SmartPrio^{GIS} approach is explicitly connectable beyond the area of the university campus under consideration and offers corresponding development potential.

The concept is presented and described in more detail below. The illustrations refer to the consideration of greenhouse gas emissions via CO_2 equivalents. Of course, other variables such as final energy demand or consumption can also be considered and presented. A distinction is made between expenditures for the provision of heat and electricity, as there are differentiated options for influencing these.

Figure 4 shows the overview and a kind of flowchart for the application of the SmartPrio^{GIS} concept on the three levels.

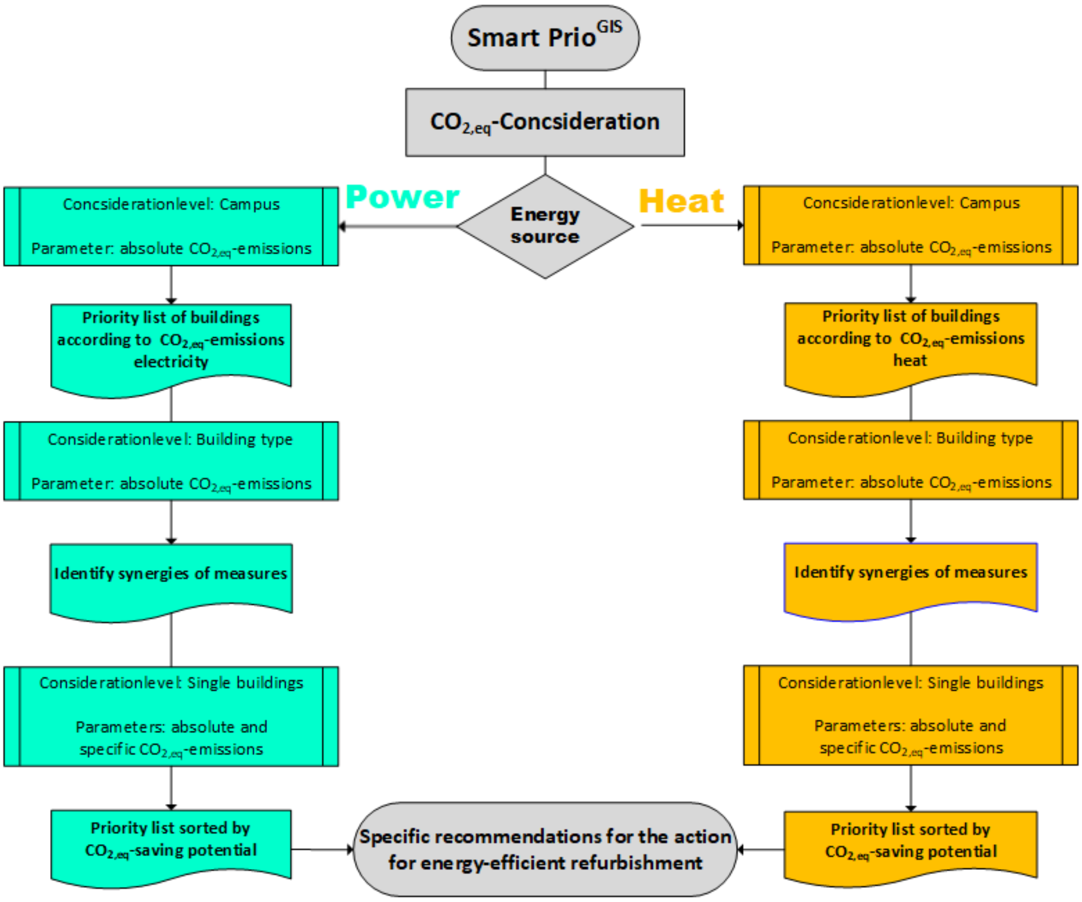


Figure 4: Overview and paths of the SmartPrio^{GIS} concept for the aspects electricity and heat

Consideration level - Campus

The top level of consideration is the campus or area under consideration. Nine baseline data were identified in coordination with the building department and collected for each building within the area of consideration. Specifically, these are

- Building name and number,
- Year of manufacture,
- Construction type,
- Usage,
- Location,

- Area (net floor area),
- Energy consumption in the last three years and
- the main energy sources.

This information as well as the calculated CO_2 emissions can be displayed in the interactive map by clicking on a building.

As a result, at the "building" level of analysis, a table is created differentiating between electricity and heat, in which the buildings are sorted according to the level of equivalent CO_2 emissions. This allows an initial assessment and classification of the buildings and an estimate of their energy quality. The evaluation of CO_2 emissions is analogous to the evaluation of final energy consumption in Figure 3.

In the course of the project, the practical advantages of successive data acquisition and synergy effects from the comprehensive view of the campus became apparent. CAD plans were extracted from the ArcGIS data to support the planning of the university's heating network. On this basis, the heat network was georeferenced as part of an external planning service, and this information was imported into ArcGIS and thus made usable for the project as well as the digital campus image. This generated only a small direct effort, since it was a planning service that was pending anyway. The level of detail of the data and the informative value of the digital campus image could be significantly increased as a result.

Cross evaluations are possible by linking the basic data. The geo-referenced visualization of the buildings and data allows a clear illustration that shows energy facts about the campus at a glance.

Consideration level - building type

The previously collected data is used directly at this observation level or evaluated to identify building types. This allows building clusters of the same age and construction to be formed. As a result, detailed information of individual buildings is derived and transferred under certain conditions and assumptions.

For this purpose, additional data on the building envelope and the systems engineering are recorded and evaluated. Analogous to the building level, the building types are sorted and displayed according to CO_2 emissions. This offers the advantage that critical or energetically unfavorable building types can be quickly identified.

As can be seen in Figure 5, the formation of building clusters also has the advantage that possible synergy effects of renovation or efficiency measures can be derived. In combination with the geo-referenced representation, not only the same building characteristics become visible, but also a possibly given spatial proximity can be recognized directly. From this, in turn, packages of measures can be planned that go beyond dealing with individual buildings.

Figure 5: Excerpt of the paths for the "building type" consideration level

Here, too, as at the "campus" level, the advantage of successive data collection becomes apparent. Thanks to the existing overall view and the exchange with the building department and external service providers, upcoming blower door measurements could be used to couple them with thermographic images on the one hand and to use the data directly on the other. Through clustering, it is also known which buildings have the same construction and thus potentially similar weak points. Coordinated improvement measures can thus be planned and synergy effects exploited.

Consideration level - building

This level has the highest level of detail. The data obtained at the other levels and in the course of the project are supplemented by building-specific information. The focus is initially on the buildings that can be assigned to the critical building types as a result of the clustering. At this point, it is important to emphasize once again that this information is not obtained specifically to improve the data situation. Following the approach of successively obtaining data that are collected anyway, this information can be obtained for different reasons. One reason would be that concrete energy refurbishment measures are pending for a building and for this reason detailed data collection is necessary. The more intensive examination of individual buildings can also take place in connection with student work. For example, bachelor's and master's theses are carried out in the course of the project, the relevant results of which are then added to the digital campus image in ArcGIS.

At the "building" level, findings from more detailed investigations of the building envelope and systems engineering are recorded. In this context, the overall energy balance of the buildings according to DIN V 18599 is a calculation method that produces detailed results. However, determining the energy requirements according to this method for the university buildings, some of which are in mixed use, involves the corresponding effort. Here, in particular, it becomes apparent that it makes sense to not only want to collect this data in order to have a comprehensive data base. The collection of such detailed data can only be efficient and resource-saving if these tasks are pending anyway or if they are processed in the course of parallel projects.

Like the overall energy balance according to DIN V 18599, the creation and evaluation of thermographic images involves considerable effort. This would not be justified just for the sake of the breadth of the data base. However, to collect this information in connection with student work can be understood as a “necessary anyway measure”, which provides the students with very practical and concrete references in addition to the increase in knowledge. For the successive data collection of the digital campus image, the benefits can be seen in Figure 6. In this view, each point on the left side of the image shows a location for which thermography evaluations are available. These can be viewed directly by selecting a point. The right side of Figure 6 shows the pictorial representation and key data, and other relevant information can also be displayed.

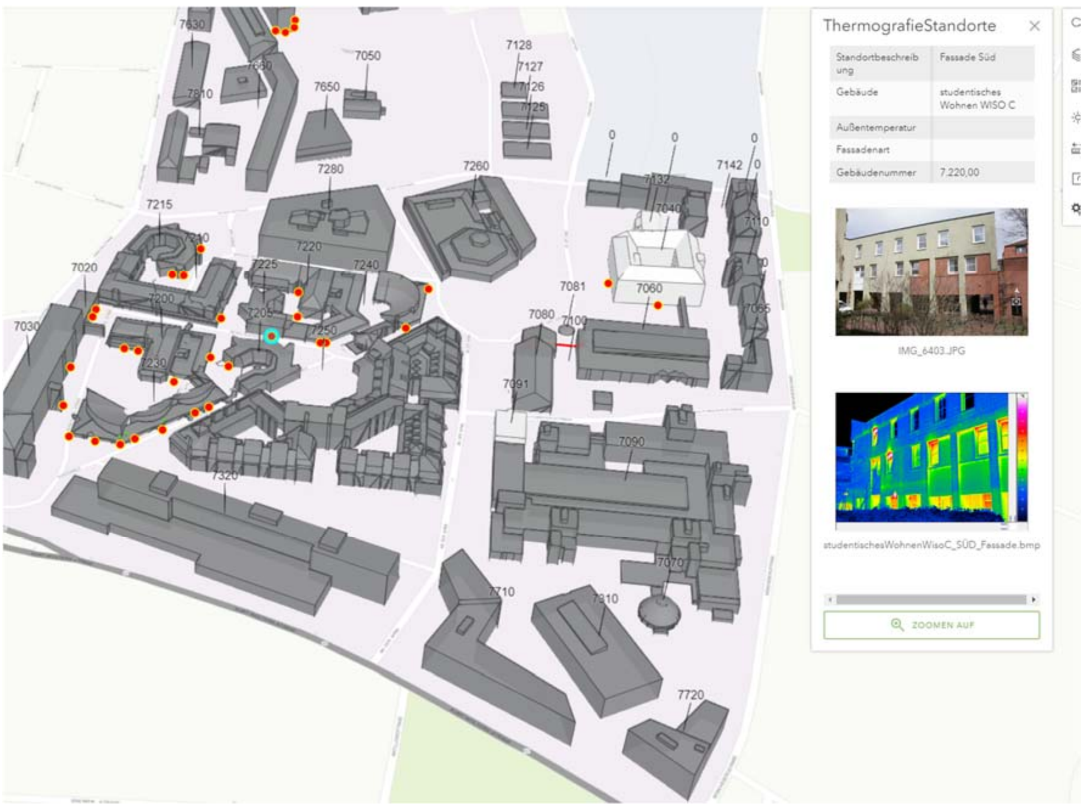


Figure 6: Exemplary representation of thermographic images from student work.

The compiled data and calculation results can be used, for example, to develop renovation measures and quantify savings potential. This can be done for individual buildings as well as for clusters of buildings by means of possible cross-analyses. Of course, the ultimately comprehensive and detailed data at the end of a data collection process also allow statements to be made about the campus balance sheet and savings associated with renovation measures.

3. Procedure using the example

An efficient approach to data collection is to use the smartphone app "Field Maps" from ArcGIS. The browser-based map, which depicts the campus, is used on a mobile basis with the smartphone. This makes it possible to directly record information identified during property inspections and to assign it to a specific location. This means that any data, such as system components (HVAC elements, transfer stations, etc.), thermographs, endoscopies and photos can be georeferenced and assigned to the buildings on the digital map using field maps.

With the help of the online map, in which the own position is displayed, relevant points can be found quickly. Figure 7 shows an example of the procedure for detecting a thermal bridge by means of a thermographic image. A situation (e.g. representation of a thermal bridge, defects, technical faults, etc.) can be evaluated on site and immediately stored digitally in the map as information. Every user of the map thus has direct access to current information.

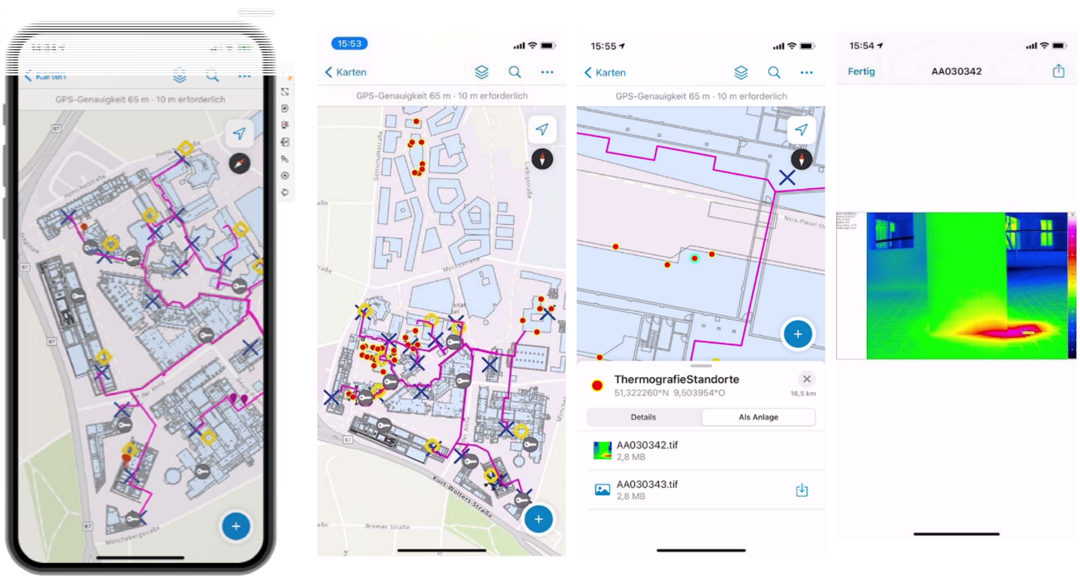


Figure 7: Illustration of the application of the smartphone app "Field Maps" using the example of a thermal bridge

In the future, the information collected in this way need not be limited to energy-related aspects. It is conceivable that the procedure could also be used in other contexts, e.g. for damage reports, for complaint management or for room bookings. For this, it would be necessary to use further functions of the ArcGIS software and to adapt them as required. However, this is easily possible for experienced users, which allows a very individual use of the data and functionalities on the basis of the campus image created.

4. Summary and outlook

The SmartPrio^{GIS} concept developed and available at provides a working basis that can be used and expanded in a variety of ways. In addition to the basic conceptual idea of not having to collect all possible data for a campus at the beginning of a process, but rather to compile this data successively during the course of the process, a resource-saving approach is demonstrated. In conjunction with georeferenced data collection and storage, a digital campus image is created that can be expanded and also used for other subject areas. In this case, only the aspects of energy refurbishment and efficiency improvement are considered. The commercial product ArcGIS from Esri is used as the software for georeferenced data acquisition and storage, since the University of Kassel has a campus license and therefore uses it extensively. The concept can of course also be used in conjunction with other tools.

In the specific case of the application of the SmartPrio^{GIS} concept combined with ArcGIS for the campus of the University of Kassel, it can be stated that the findings to date are very promising. A large amount of data and information is naturally available in the building department, but access is not always possible centrally and across topics. The structured compilation of the data and the central availability of the information on a platform alone, in combination with visualization, offer enormous advantages in terms of meaningfulness and applicability. This could be further optimized so that, ideally, the existing data and their storage location could be found via a central access point (ArcGIS).

At the moment, only a small part of the software's functionalities is used. Above all, there is potential in the area of data evaluation and automated data transfer. In this context, the implementation of a dedicated geodata server could open up further areas of application.

Using functionalities such as "stories" or "dashboards" it is conceivable that the stored data could also be used to inform, sensitize, and activate people for energy-related issues. This could address employees of the University of Kassel as well as students. The use of ArchGIS in various departments would also allow the information already collected about the campus to be used and supplemented in research and teaching.

5. References

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