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Utilization of knowledge systems and bases for selection and evaluation of domestic electrical installations

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Abstract

This article deals with the use of the sophisticated methods for the selection of technical and economic solution of electrical wiring. This solution is based not only on a price but also on many other criteria such as a comfort, service, durability etc. The focus of the work is a treatise on wiring systems from a global perspective, where it is impossible to use a conventional approach for objective evaluation and selection of the appropriate electrical wiring system (because of the complexity of such systems and their interdependencies). In the article are given information of an energy consumption (the total consumption and household consumption), consumption prediction – especially for households. Following is an overview of possible measures for reducing electricity consumption in households. In the part of the article are solved the knowledge, respectively expert systems for use in an electrical engineering – especially for a suitable tool for the selection and evaluation of households wiring electrical system. The result of this work provides a possible solution for a selection of wiring electrical system for households (focusing on the intelligent wiring) – from a technical and economic point of view and with using an innovative approach. The main contribution of this work is a proposal of the main part of the knowledge base. This base could be a basis for knowledge, respectively for an evaluating technical and economical solution of an electrical wiring system – the expert system includes also a feedback function of an effective solution, use value, price etc., which would also serve as a knowledge base.

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1. Introduction

Nowadays, the house is no longer just four walls, one lamp and a television. In a modern house, it is especially about optimizing the comfort of device control and security optimization. There are lots of new systems for security, control and home comfort. There is a problem with a large number of wires, control points and very complicated wiring to achieve customer’s requirements. Companies offer an almost identical product range for intelligent wiring based mostly on three major bus standards - KNX, Nikobus and LON. Basic system requirements include lighting and socket control, visualization, heating, cooling and ventilation control, blinds, awnings, shutters and hinges, windows, doors, gates, power consumption optimization and collaboration with electronic security system and fire alarm. Most companies involved in system wiring offer these features, and they usually differ only in above-standard features, price, etc., but the basic idea remains the same - increasing comfort, safety and energy savings.

Due to the large number of intelligent wiring systems, their possibilities, the types of bus lines, a number of manufacturers, etc., it is necessary to find suitable for the designers or those who are interested in the use of these installations how to choose the type and suitable functional units of the wiring according to predefined parameters. It is necessary to take into account an extensive set of criteria, both from a technical and economic point of view. The economic aspect in electrical and power engineering is very actual today. The use of economic analyses, even simple, is a matter of course without which the technical problem can not lead to the final and optimal solution. Finance happen in the design of electrical installations almost the most important factor. It is necessary to consider not only the investment costs but also due to the constant increase in energy prices to put more emphasis on the operational costs.

Current issue not only in Europe is maximizing energy efficiency while ensuring maximum environmental friendliness. This can be achieved in several ways. One possible way is to concentrate on small customers, whose typical example is households that have shares as a whole on the resulting energy efficiency. In view of these efforts, we offer the use of efficient methods, especially multi-criteria analysis, or other economic tools for evaluating and selecting the optimal wiring solution. This wiring will thus meet not only technical requirements but also economic requirements. Climate change and the increasing lack of resources is a highly debated issue of today. Many countries around the world are dependent on energy imports - in the EU, for example, 50% of currently consumed energy is supplied. By 2030, the amount of imported energy should reach 70% of currently consumed energy. Efficient and sustainable use of energy is a necessity - fully in line with the motto created by the European Commission - "Less is more" [1].

In addition to transport and industry, the other largest appliance of energy is the operation of buildings. Heating, cooling and lighting of residential and non-residential buildings consume approximately 40% of all energy in technologically advanced countries. This is an amount requiring great attention. With regard to the EU and Czech Republic's efforts to reduce energy consumption, it is possible to study electricity savings using system wiring, their optimal design within the technical and economic solution using modern selection methods and subsequent economic and technical evaluation. This opens up the possibility of using knowledge, respectively expert systems for selecting the optimal wiring options for the household sector. In the framework of this study and the effort to make practical use of the system for the selection of household wiring, the analysis and subsequent implementation of the European directives, standards and regulations together with the other international standards should be used in order to help the designers of electrical engineering. Furthermore, this system can serve as the basis for the investor, the owner or as the support for the building energy certificate.

The result in this article should provide comprehensive selection information for home electrical wiring solutions, focusing on system installations, family houses and residential buildings from a technical and economic point of view, using innovative approaches. The aim of this work is to design a knowledge base and the possibility of using knowledge systems for evaluation of the technical solution of the wiring, whose components would also be a feedback function about the effectiveness of the solution, utility value, price, etc., which would serve as a feedback and specifying the basis of the knowledge base.

3. Household electricity consumption

Previously, it was valid that most of the energy consumed in the home for heating and hot water. That still applies in most cases. In recent years, however, the difference between energy consumption for heating and water heating and other energy consumption for household electrical appliances is decreasing. This is partly due to the fact that new or refurbished insulated houses often have half or a third of heat losses, while the efficiency of domestic appliances is growing slowly and, moreover, appliances in households are still increasing significantly. As a result, there is a growing number of households, where the same amount of money as heating is paid per year for electricity. The analysis is processed from [1, 2, 3].

At European level was published Directive 2002/91 / EC of the European Parliament and of the Council on the energy performance of buildings in 2002. The main requirement of the directive is to reduce energy consumption in buildings. A number of European standards have been issued for its implementation, for example EN 15232 Energy performance of buildings - Impact of Building Automation, Controls and Building Management. Building Automation and Control Systems (BACS) can have a significant impact on energy consumption of buildings and their occupants. In recognition of these facts, the European Committee for Standardization issued "EN 15 232:2012 Standard: Energy Performance of Buildings – Impact of Building Automation, Controls, and Building Management" for use in conjunction with the Energy Performance of Buildings Directive (EPBD).

The EN 15 232 standard includes the following main ideas and areas:

- A list of control, automation, and technical management functions that affect the energy performance of buildings.
- A method for defining the minimum requirements for the control, automation, and technical building management functions implemented in different types of buildings.
- Detailed procedures for quantifying the impact these functions have on the energy performance of a building.
- A simplified method to obtain an initial estimate of the impact these functions have on the energy performance of buildings.

On the graph in Figure 1 shows how electricity consumption is copied by economic developments. This trend is also due to the fact that household consumption of electrical appliances is growing with the growth of revenues and, at the same time, their consumption.

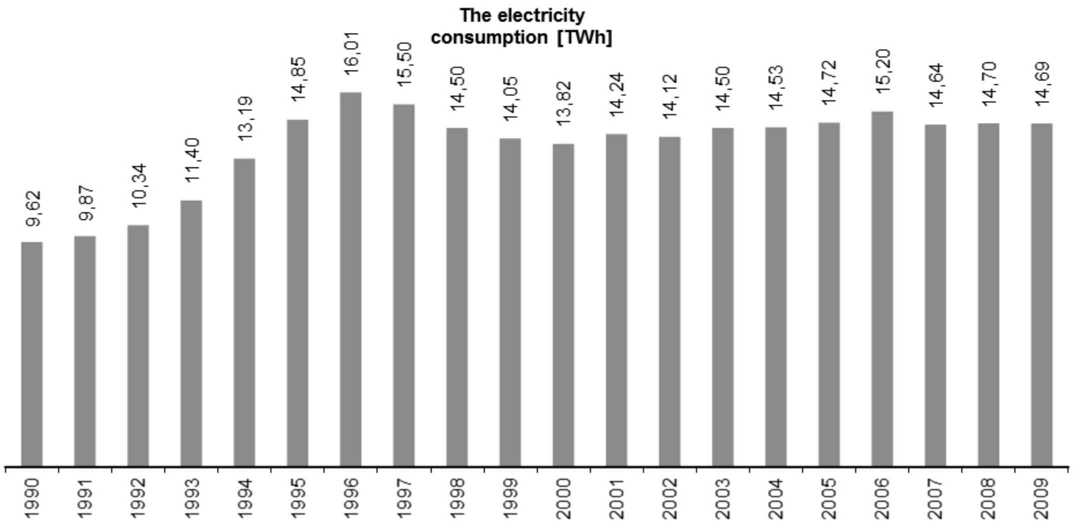

Figure 1. Household electricity consumption – Czech Republic

From Figure 2 shows that household electricity consumption in the EU has a steadily growing trend.

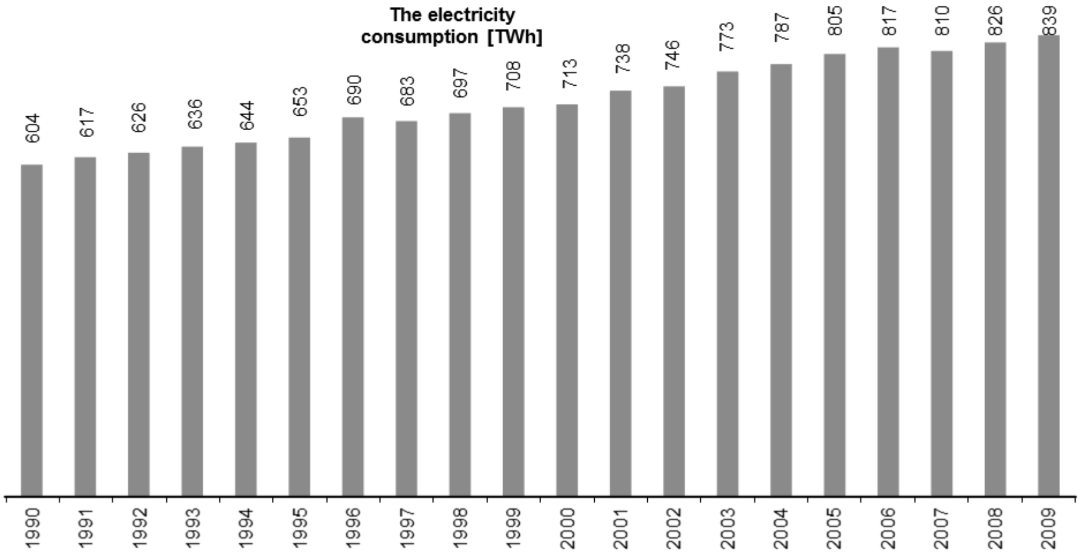

Figure 2. Household electricity consumption – European Union

This graph is defined as the amount of electricity consumed in households. Household consumption refers to all electricity consumption for heating and hot water and all other electrical appliances.

The Joint Research Center of the European Commission published a study according to which, in the period 1999-2004, electricity consumption grew at the same pace as economic growth. This is largely offset by the effect of measures taken to increase energy efficiency. In that period, electricity consumption increased by 11 % in households, by 16 % in the services sector and by less than 10 % in industry.

Growth in household consumption can be explained by the large use of older inefficient appliances, but also by the increase in the number of electrical appliances. Today, many households have two to three televisions, fridges and freezers, and more and more can be found clothes dryer and/or heating, ventilation and air conditioning (HVAC). In addition, the number of houses and large apartments is growing (the residential area is growing). There is an interesting difference between the trend of energy consumption for heating and the consumption of energy for the operation of household appliances. In recent years, there has been a significant tightening of standards for the thermal properties of buildings and consequently a corresponding reduction in energy consumption for the heating of newly built or renovated houses. However, electricity consumption for normal household operation has increased. According to the average values of resources [5, 6, 7], the electricity consumption in the household is separated as follows:

Table 1. Average values for household electricity consumption values.

Heating	Water heating	Another el. appliances
63,4 %	19,8 %	16,8 %

Table 2. Average values for household electricity consumption values – another el. appliances.

Cooling	Washing	Dishwashing	Food preparation	Video system	Audio system	PC system	Lighting	Other
18,0 %	5,2 %	7,8 %	20,7 %	8,3 %	2,8 %	13,7 %	16,6 %	6,9 %

2.1. Intelligent electrical installation

Various concepts and approaches are possible in optimizing the energy efficiency of buildings. In this context, the use of intelligent electrical installation (in other words also system installation) in buildings provides a proven and interesting alternative or complement that can compare cost-benefit ratio. Both the energy and the financial assessment of a similar investment must be done always individually for each building. In calculating energy savings play an important role factors such as building orientation to the cardinal, window size, color interior equipment rooms, the behavior of people in the building and others. This is also followed by a financial analysis of the investment, to which the type of lighting used or the source of heating is also widely spoken [2].

The use of intelligent electrical installation in a currently designed commercial and similar building can be decided quite simply depending on which class is to be classified according to energy performance (in accordance with Directive 2010/31 / EU). It is not desirable to build new objects not only insufficiently heat-insulated but also not equipped with perfect control systems, ensuring a very economical management of energy consumption, thus maximally avoiding unnecessary energy consumption. The current world trend is characterized by the promotion of energy-efficient technologies. The European Standard EN 15 232 has been elaborated in close connection with the European Directive 2002/91 / EC on the energy performance of buildings. The standard specifies methods for assessing the impact of building automation and building management on the energy consumption of buildings.

For the classification were introduced four energy efficiency classes (A to D). Once the building is equipped with automation and control systems, it is assigned to one of these classes. Potential savings of heat and electricity can be calculated for each class according to the type of building and its purpose. Energy class C values are then used as benchmarks for comparing energy efficiency.

In residential buildings, it is necessary first to describe the activities of all the functions used in the building as soon as possible and then decide whether to use any of the control systems. It is not only about the usual functions, including switching and dimming of lighting, including scenes, heating, ventilation and air conditioning control, including time and other programs, control of shading technology, windows and doors, switching of the socket and other power circuits. It is also a collaboration with many other areas of functions. The fact of how many different systems can go so far mostly independently designed and used, it is possible to get at least a rough idea on the basis of the following examples:

- electronic building security system,
- electronic fire system,
- audio and video control system,
- managing remote access,
- measurement of electricity, gas, water, heat, etc., and the transmission of measured data for invoicing,
- heat generation control for heating or cooling,
- sauna and pool technology,
- rainwater management and gardening,
- photovoltaic and other power sources,
- heat pumps,
- access and attendance systems,
- CCTV systems, home telephone and electric porter, etc.

The more demanding the number of these functional areas is required, the simplest the control and the maximal energy efficiency, the more advantageous the use of intelligent electrical installation and partial systems with the possibility of full communication based on open communication protocols (KNX, LON, etc.).

The Institute of Buildings and Energy Systems, part of Biberach's Applied Natural Sciences University, specializing in building automation, conducted a study "The potential for energy savings using modern electrical installations" in 2008. Under the leadership of Prof. Dr. Ing. Martin Becker studied the main literary sources, with a result oriented to the discovery of the potential for energy savings. The study was commissioned by the Central Union of Electrical and Electronic Industry (ZVEI) [4]. Based on this study, the potential for energy savings with modern electrical installations is clearly shown in Figure 3.

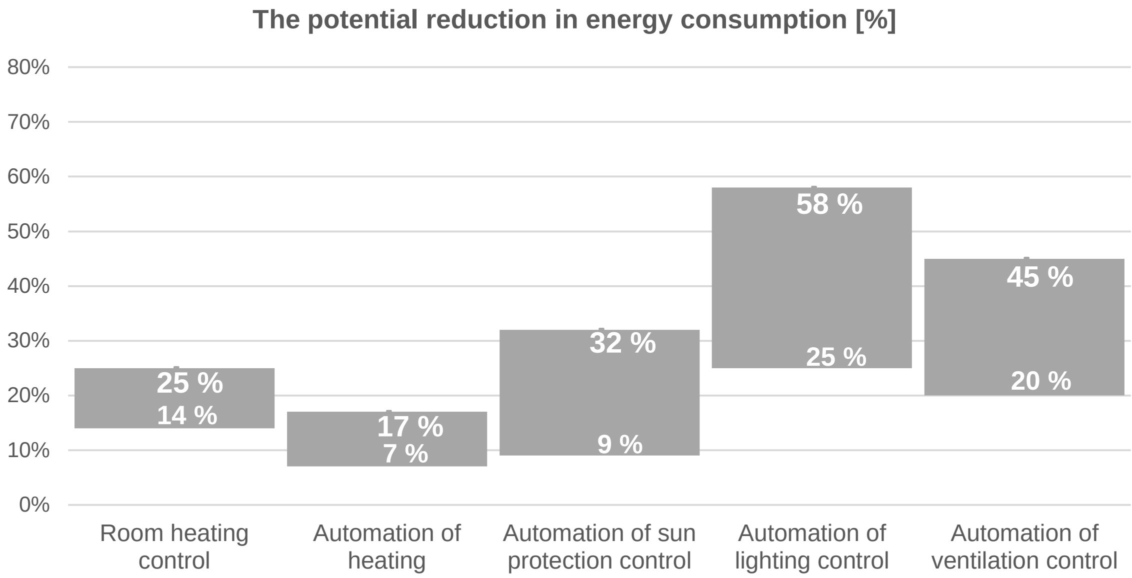

Figure 3. The potential for energy savings with modern electrical installations

Wide dispersion of the values given in certain areas can be attributed to a wide range of factors - applications involving multiple functions, the operational nature of the respective tests, the difference in the definition of different functions, yet the conclusion of the research clearly shows that an intelligent building management can contribute significantly to increasing the energy efficiency of buildings. Overall, the implementation of measures to optimize the management of technology in buildings moving the average value of energy savings in the range of 11 % to 31 %.

The prediction of electricity consumption in the Czech Republic is based primarily on forecasts of macroeconomic and demographic developments and respects the effects of expected savings. In the short and medium term, an increase in the use of electricity is predominantly for heating systems (the effect of tariff policy setting) but also for hot water heating.

According to sources [2, 4, 5, 6] but occurs in the short and medium term, to reduce the specific consumption for heating and hot water, increasing the consumption of the other (with the inclusion providing an increase of efficiency) and a slight increase heating facilities and hot water. Electricity consumption in the household sector (in the Czech Republic) will gradually move closer to the average level of consumption in the EU over the long term. By 2050, it is an increase of 1,5 TWh, or 10 % of consumption in 2014. Stagnation in the long term reflects the expected population decline after 2020. In households will continue to increase the amount and use of electrical appliances, as well as increase their effectiveness. Further significant energy savings for heating are expected. Household consumption is expected to grow by 10,4 % between 2013 and 2040. [2]

2.2. Integration of alternative energy sources and energy storage systems

Another energy saving measure can be the integration of alternative energy sources. Family houses can be equipped with both alternative energy sources and classical ones. Power, consumption and accumulation are controlled by a control unit (CU) that is connected to all power sources, heat sources, appliances and storage capacities via sensors and control elements. CU evaluates and records the received signals from the sensors and, based on this information, regulates the power and appliance settings according to the set parameters.

In most cases, the family house is not equipped with only one source, but it is a combination of more resources that complement each other. For example, a classic combination of sources for hot water heating is a combination of solar panels, a heat pump and a classic boiler. In this case, solar panels are chosen as the primary source, since they produce heat about twelve times cheaper than conventional boilers. In such a case, the control system only draws heat from the solar panels at the time when it is possible. If solar energy is not available, the CU switches to heat recovery from the heat pump, which should be able to meet the required demand. The control unit switches the boiler on when the hot water is unusually high or in the case of extremely low outdoor frosts. The control unit also controls the heat consumption. This is mainly the regulation of the heating in the rooms of the given object or, for example, the regulation of the water heating in the pool. In individual rooms, the required temperature and time are set to avoid unnecessary overheating or under cooling.

A similar situation is with the choice of energy sources. Nowadays, a small photovoltaic power plant on the roof is chosen as a classic power source. This installation can be complemented by a small wind farm and, optionally, a cogeneration unit (CGU) that produces both electricity and heat. Over time, more and more emphasis will be put on family houses with small energy sources.

Some of the elements of electrical installation can be grouped into both energy sources and appliance groups. For example, a heat recovery unit is an electrical energy appliance, but the output is energy in the form of heat, or an air conditioning unit that is used as an electrical appliance but produces cold. The heat recovery unit can, therefore, be evaluated as a source. The division of energy sources and appliances is therefore done in relation to the consumption or generation of electricity.

With the increased use of renewable energy source (RES) is more talk about the accumulation of electrical energy. This is mainly due to the fact that the energy obtained from renewable sources is dependent on conditions that one can not influence. Therefore, in recent years, with the development of renewable energy use, people have begun to have more questions about how to best store energy.

The concept of electrical energy storage can be translated as a storage or supply of electric energy or as a conservation of energy for its later use in appropriate quality and quantity. Currently, the most accumulating storage medium is the lead acid accumulator. Storage systems are irreplaceable from the viewpoint of production and consumption of electrical energy. Electrical energy is a commodity in principle very problematic and any attempt to distribute it confronts the problem of immediate demand and supply. Accumulators or other energy storage are currently under development [8].

The problem of energy storage is currently focused mainly on the solution in the field of elimination of discontinuity of electricity supply from renewable sources and is based on the principles of individual alternative energy sources and on the problems related to the time-varying power of these sources. Developments in the energy storage area are important for two main reasons:

- optimal integration of RES into the grid (classical distribution network),
- preparation for a Smart grids solution.

3. Knowledge system and basis

When exploring other options for selecting electrical installation using a software tool that is equipped with both technical knowledge and basic parameters, conditions and more, it is directly offered the use of knowledge systems. Therefore, the majority of problems solved in this paper focuses on the use of

knowledge systems to create a knowledge base for a software tool that would serve as a user interface for selecting the house installation based on predetermined parameters, conditions and knowledge.
The use of knowledge systems is becoming more and more common in the field of electrical engineering today. A special subgroup, which should be used in our case, ie. “The choice of house wiring based on predefined parameters” and knowledge base associated with system wiring, energy savings, wiring groups according to EN 15 232 and others is a group of knowledge systems. For knowledge systems to solve professional problems, procedures requiring, unlike general, above all specific knowledge, the term “expert systems” is used.

3.1. Representation of knowledge

Knowledge has become a key element of knowledge-based applications, such as expert systems. It is for the creators of the knowledge system to choose the appropriate way of visualizing (capturing, representing) knowledge, the so-called representation diagram. Such a diagram can be imagined as a set of rules and procedures to be followed to capture knowledge. The diagram should be sufficiently comprehensible and versatile for a human. They must be able to capture a wide range of knowledge - from general to more specific. It should also promote easy modularity of knowledge.

Different sources point to a similar division of types of knowledge representation. The basic types of knowledge representation are:

- procedural representation,
- declarative representation,
- schematic representation.

The main element of procedural representation of knowledge is the procedure. Here you can imagine a powerful program code that solves questions such as "How?“ not "What?" In connection with this form of representation, it is possible to speak about so-called rules (productions), which are found, for example, in production systems. It is used to transfer expert knowledge on the computer. It contains various terms and actions that are feasible to meet these conditions. The solved task in the case of procedural representation can be, for example, finding a larger number of two possible ones.
The declarative type of representing knowledge, on the other hand, answers the question "What is to be solved?“ not "How is it to be solved?". Therefore, it is not asked for example how to calculate the largest number, but how the largest number is defined. The expert system has its own procedural and declarative knowledge representation - the facts contained on the basis of facts. These facts are used by rules, for example, to derive other contexts and knowledge. Typical representatives of the declarative type of representing knowledge are logical diagrams (propositional logic, predicate logic of the first and higher order), semantic networks, and status space.
Framework schemes are a combination of procedural and declarative approaches. Declarativeness is based on the way of capturing information about real objects using slots (frame properties) and facets (frame property values). Procedurality is contained in procedures that may be part of a framework structure.
The types of knowledge representation are shown in Figure 4.

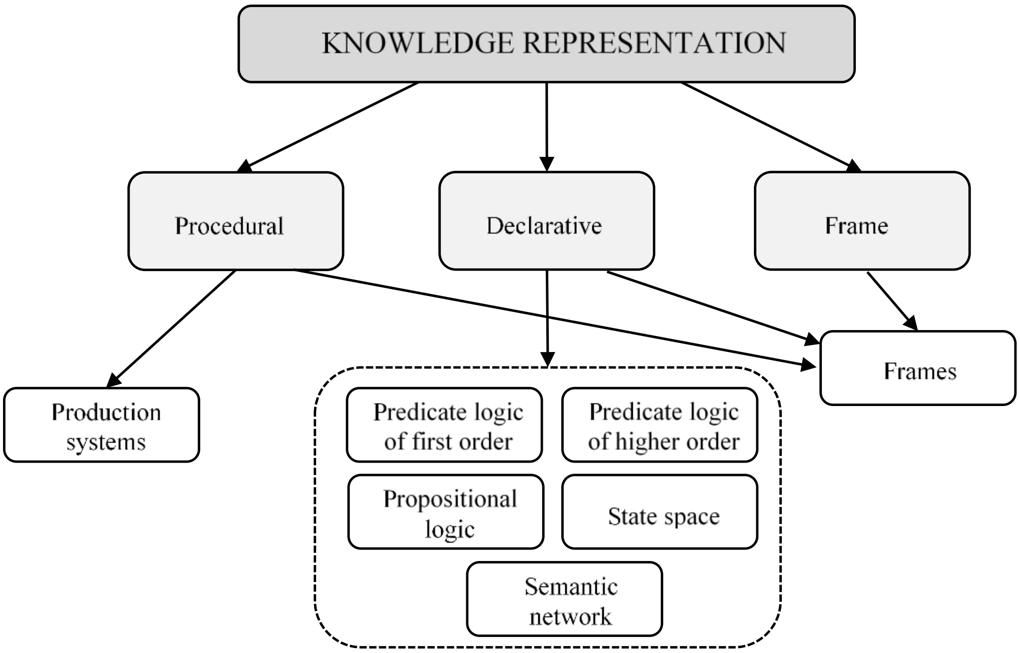

Figure 4. Types of knowledge representation

3.2. Knowledge systems

Knowledge systems respectively expert systems (ES) are defined by the most frequent occurrences in the literature as:

- a system that seeks to solve a problem within the scope of a specific set of assertions or knowledge clusters formulated by experts (experts – from here expert systems) for a specific application area [9];
- a system based on the representation of experts' knowledge that is used to solve problems [9, 10],
- a system of cooperating programs to solve a defined task class, in the most problematic areas the majority of experts [9, 10],
- a system equipped with the knowledge of a specialist in a specific area to the extent that it is able to make decisions by speed and quality equalizing the least average specialist [9, 10].

In each ES, it is possible to distinguish between the three basic components constituting its minimal configuration - the inferential (solving) mechanism, the knowledge base, and the data base (facts). The inferential mechanism (IM) consists of a system of collaborative programs providing the procedural component of the ES activity, knowledge base and facts base (KB and FB) are passive data structures.

3.2.1. The architecture of the knowledge system

The function of the communication module is to ensure interaction between the user and the expert system. The explanatory module explains and justifies the status and progress of the problem, its individual steps, and the results achieved. The results generator compiles partial results into an integral and reasoned whole, without any extra information, in the required form and understandable form [9].

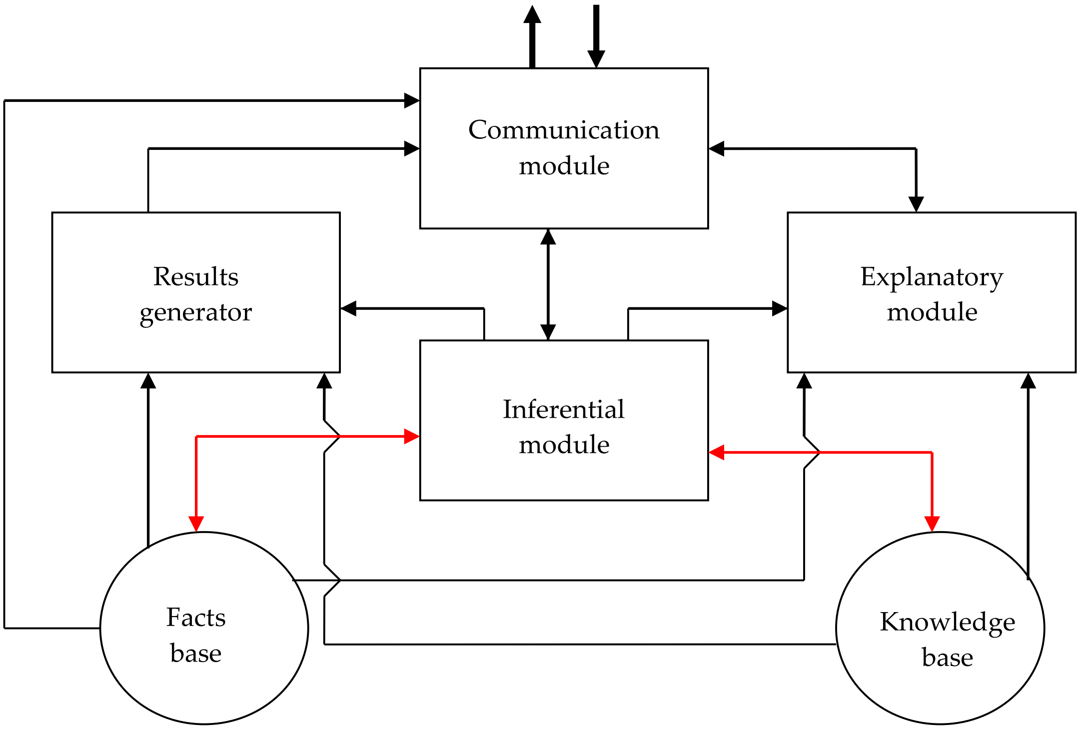

Figure 5. The architecture of the knowledge system

3.2.2. Knowledge base

The knowledge base represents a general model of the area description addressed by the expert system. It is usually made up of rules describing the problem. Experts' knowledge and experience are gathered here. It captures the whole range of knowledge from the most general to the very special, from the well-known to the knowledge that the expert has gained in many years of experience and who only knows that they often help him to solve similar problems.

It turns out that the extent and quality of special, often private, heuristic knowledge differ from the average worker in the problem area. This base is similar to a database. Creating a specialized expert system is a complex and time-consuming activity. One of the important components of the knowledge system is the knowledge base. The basis of this part of the thesis is, therefore, to familiarize itself with ontology, the concept of semantic web and examples of the creation of a knowledge base in the field of electrical wiring and related systems using different means.

3.3. Ontology and modeling of knowledge

During the 1990s, it became clear that the WWW would be a source of extraordinary information. At the same time, however, issues related to the unstructuredness and the unreliability of the information on it have arisen. It was a welcome opportunity for knowledge engineering to get closer to real-world applications. Between the years (approximately) 1996-2002, a whole group of partly related ontological languages was created. This sought to complement the formal semantics to web sites possible applications with web interface.

The concept of ontology can be found both in philosophy and in the area of the semantic web. In the original, the ontology is the doctrine of being. In relation to the semantic web, ontology is understood as a definition of terms and relationships between them. It is used to describe so-called domains of human interest/world. This area then contains the individual classes that are linked by relations. Objects in this domain and their interconnection ontology described using four elements: individuals, classes, attributes and relationships. Sometimes the fifth element is also mentioned - the event. Ontology serves to represent the knowledge base of knowledge or expert applications.

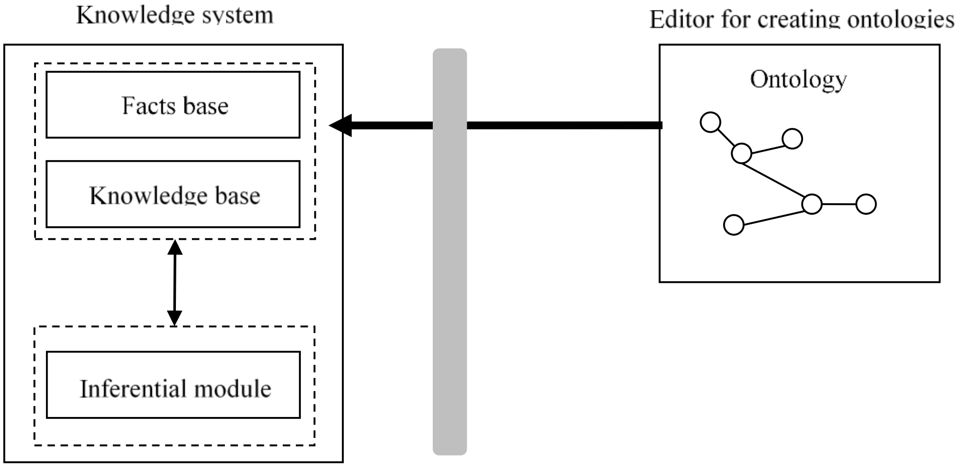

Figure 6. Ontology and knowledge system [10]

Ontologies can be divided according to different aspects, but most often divided according to the source of conceptualization [11]:

- generic ontology (higher order ontology) - the capture of general patterns,
- domain ontology - intended for a specific subject area (most common)
- task ontology (representative ontology or meta ontology) - focused on processes of derivation,
- application ontology - adapted to a specific application (typically including both domain and task part).

From the point of view of knowledge engineering, ontology can be understood as a knowledge structure that is built to:

- sharing information and knowledge among people,
- sharing information and knowledge between machines,
- sharing information and knowledge between people and machines,
- reuse of domain knowledge,
- the use of explicit knowledge that is made available to others,
- separation of domain knowledge from operational (procedural),
- Domain analysis [12].

Ontologies can greatly improve the functioning of the website. In the simplest case, it can be for example search precision - the search engine can focus on the pages corresponding to the given concept (and not ambiguous or even ambiguous keywords). Ontology is one of the most common approaches to recording knowledge.

3.3.1. OWL language

OWL (Ontology Web Language) is a markup language developed by W3C (World Wide Web Consortium) for creating ontologies usable in a semantic web environment. It contains a set of axioms describing classes, properties and relationships between them. Its development and expansion continue to work. [12]

For ontology creation in OWL, one of three options can be used [12]:

- OWL-Lite,
- OWL-DL,

- OWL-Full.

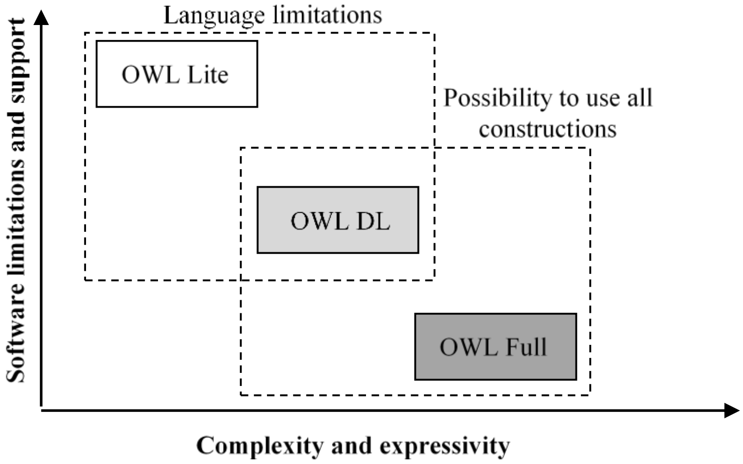

Figure 7. Complexity and expressivity of OWL

In order to choose from the above options, it depends on how ontology and how complex it is to create. If greater expressiveness (= expressive power, the richness of language) is required, we must take into account the available software. Greater expression power requires more capable or more complex software. When all OWL constructions should be used - OWL Full and OWL DL is a good choice. To derive rather OWL DL. Figure 7, which is taken from the source [12], describes the comparison of OWL versions of their complexity and expressiveness.

3.3.2. Ontology in Protégé

Creating OWL ontologies is possible using the open source Protégé editor, which is based on OWL concepts. This platform supports two ways of modeling ontologies, through Protége-Frames and Protégé-OWL editors. It is built on Java, is extensible and provides a plug-and-play environment that provides a flexible foundation for fast prototyping and application development. Ontologies created in Protégé can be exported to RDF, OWL, and XML formats. The basic building blocks of Protégé ontologies are:

- Classes - Classes are the major building blocks of OWL ontology. Classes are interpreted as a set containing individuals. We specify them using formal constructions that specify the exact membership requirements of a particular class. Classes can be taxonomically organized into hierarchies of subclasses and super classes where subclasses specialize their superclasses. In the OWL subclass, it implies the necessary implication, and therefore all instances of the subclass are instances of a superclass without exception.
- Individuals - Individuals represent objects of interest domain. OWL, unlike Protégé, does not assume the uniqueness of the name. For this reason, two different names may refer to the same individual, so it must be explicitly determined whether individuals are identical or different. Individuals can also be used to describe classes, specifically in hasValue restrictions and enumeration classes.
- Properties - Properties are binary relations on individuals that connect two individuals (more precisely, the instance of properties associates two individuals). In descriptive logic, properties are known as a role, and UML and other object-oriented notations are referred to as relationship. Properties represent relationships. The two main types of properties are Object properties and Datatype properties in Protégé. OWL has also a third type of property called Annotation properties, and both of the above-mentioned main types of properties can be marked as annotation properties. As with classes, it is

possible to create their hierarchy in the properties. Properties at a lower level of hierarchy specialize the properties at a higher level above them in a way similar to the superclassing of its subclass. However, under a lower-level property under another property, it is not possible to combine object properties and properties with a data type. Therefore, it is not possible to create an object property that is in the hierarchy under the property with the data type and vice versa. Figure 8, which is taken from the source [12], graphically and clearly shows the basic elements of the ontological model in the OWL language and the Protégé environment.

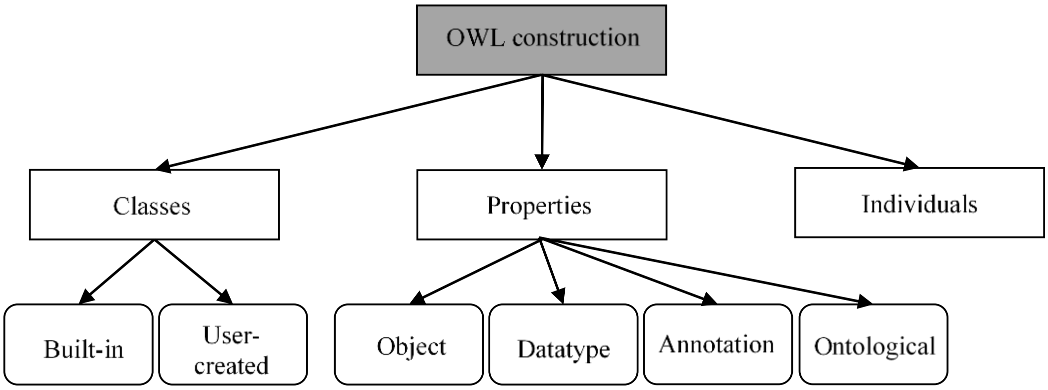

Figure 8. Elements of ontology in Protégé

3.3.2. Modeling in Protégé

The original aim was to facilitate the work of knowledge engineers in the development of knowledge bases. Figure 6-4 shows the connection between the Protect and the knowledge system that contains the knowledge base. Protégé is not an expert system or a program that directly serves to create them but helps to create one of their main parts - the knowledge base. By creating the knowledge base separately from creating a knowledge application, it can be better maintained and managed.

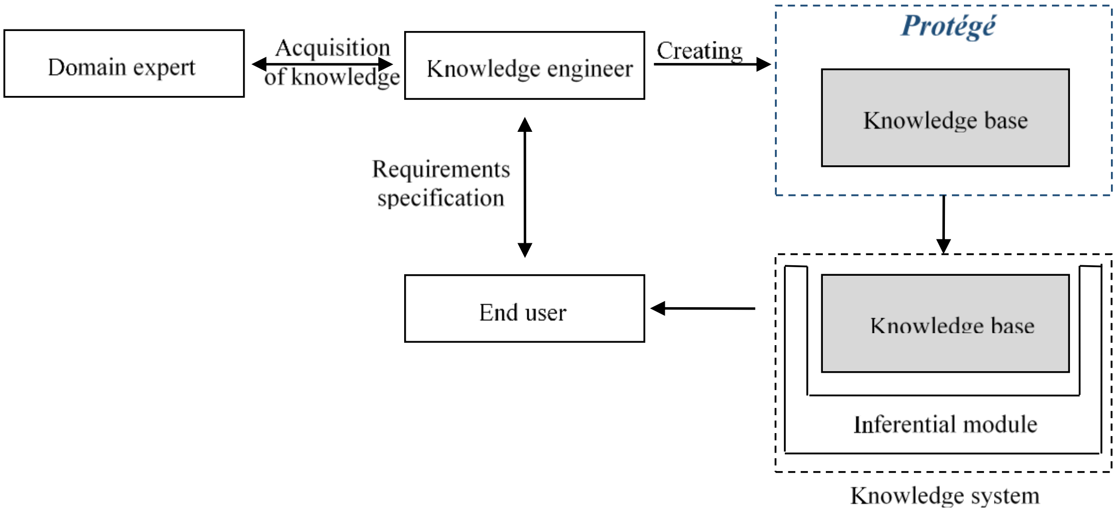

Figure 9. Modeling in Protégé – main idea [13]

4. Knowledge base for household installation

In order to create or at least partially design a knowledge base for household electrical installations, it is necessary to specify and define the concepts of construction and design of buildings. A building is defined as a material object associated with the plot, and this object is the result of a sequence of activities. The sequence of activities from the initial intention to the beginning of use is called a construction or also an investment project abbreviated to the project.

4.1. Designing

Designing is a set of activities in which it is proposed to solve a particular project (in terms of intent) in the various phases of its preparation and implementation. In the area of construction, designing is understood as the creation of project documentation. For each building is always developed project documentation.

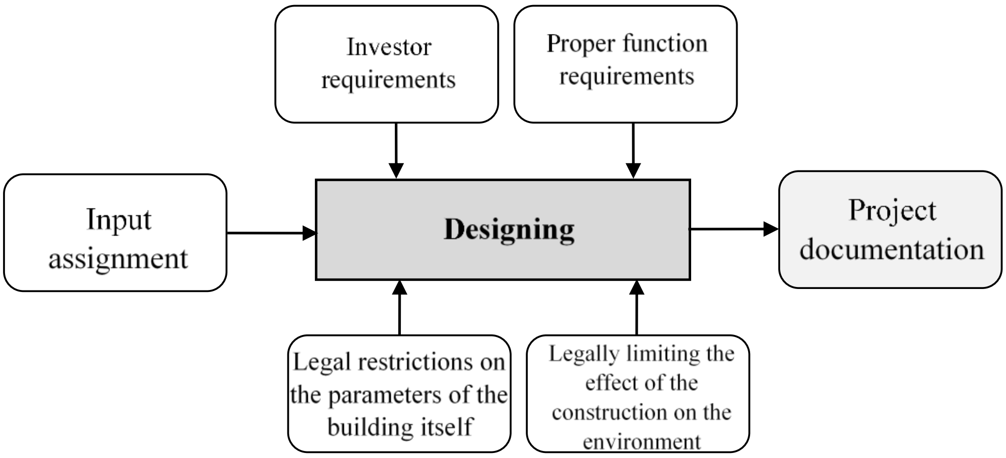

Figure 10. Input and limitation of designing [14]

Designing is a process where a new building is constructed from the sub-elements while adhering to the input and limiting conditions. This is a sequence of activities that create a complete definition of a building from the input. This definition can be considered the Detail Design. Input and limiting conditions can be divided into several groups.

- Investor assignment - for civil buildings, for example, it is the place of construction, the size of the areas and their utilization, the number of floors, the number of people using the individual premises of the building.
- Investor requirements - requirements that specify a technical solution such as technology, type of key equipment, the degree of automation, etc.
- Proper function requirements - Proper construction requires respect for natural and social laws.
- Legally limiting the effect of the construction on the environment - effects of the building on the environment such as noise, air emissions, and sewage. They are mostly limited by legal limits.
- Legal restrictions on the parameters of the building itself - these terms are defined in the laws, decrees and valid standards.

Project activity requires knowledge of methods and procedures for designing the proper construction function and knowledge of legal restrictions for building design. From the formal point of view, it is also necessary to authorize responsible designers with regard to the documentation for administrative management.

4.2. BIM systems

Civil engineering produces works of long-lasting life and high utility value. Therefore, it is necessary to be interested not only in the initial investment in construction but also in the life cycle costs. Three-quarters of the total life-cycle costs of a building fall on the period of use of the building, of which one-third is the cost of management and maintenance. For the successful execution of constructions, it is essential to structure the construction into individual parts, to define individual elements, to describe them and to sort them according to a unique classification. The basic input of the decision and control process is information that relates to the construction as a whole or some of its components.

Information about a particular event or part of a building changes and evolves throughout its life cycle. They need to be incorporated into a structured system to monitor the development of the building over time, optimize the technical and economic characteristics of the building during its lifetime, permanently update the information and generate it immediately.

All these processes can be managed in a uniform and effective way using BIM (Building Information Modeling or Building Information Management), a common IT communication tool for building process participants or other operators. The BIM model can be represented as an information database that can include complete data from the initial design, construction, building management to its demolition. BIM is a working process in which they are among the participants of the construction cycle (architects, planners, contractors, facility managers) creating and sharing information.

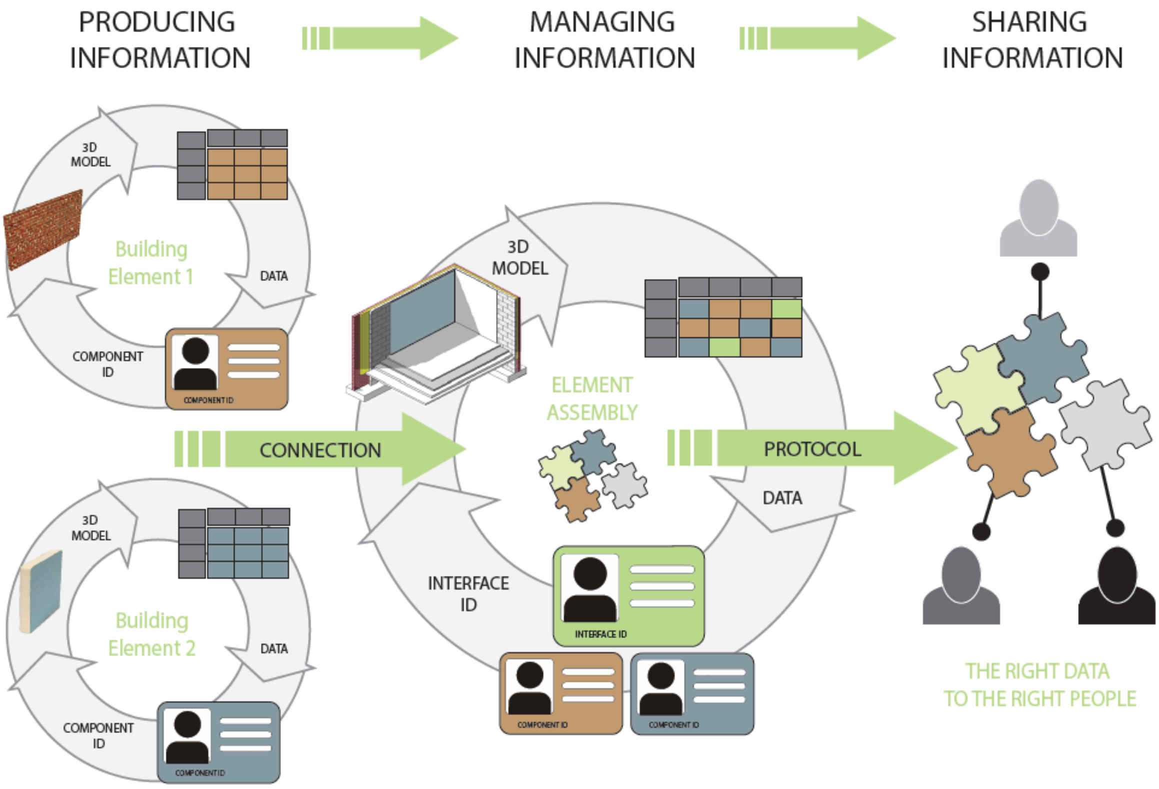

Figure 11. The key of BIM exchanges is the management of information [15]

For the civil engineering, the digitization and implementation of new scientific and technological knowledge are currently a priority. BIM is an option to better define the requirements for the resulting building, to electronically control the course of the building in its individual phases, to make independent assessments easier, to minimize the extra costs of building construction and to ensure better accessibility and more economical operation of buildings.

The general design of the BIM model makes it possible to increase the efficiency of construction products, to improve the quality of the project documentation, to ensure the availability of relevant building information and the equipment and systems used and to meet the energy efficiency requirements of

buildings. In order to remove deficiencies and refine the parameters, BIM systems are tested on existing building orders, but also at universities in the form of final works.
Savings due to the use of the BIM method according to surveys conducted abroad account for 20 % of the total cost of the entire life cycle of the building. With the information model of the construction, it is possible to simulate different situations on the proposed construction, to work with variants to achieve the optimized design result. Using BIM for building new buildings helps to achieve energy savings.
In international (IEC) and European (EN) standards, standards for BIM have already been issued. These standards, in view of the scale of the BIM issue, are largely interfering with the existing system of national regulations. It is, therefore, necessary that the rules for designing and using BIM systems are also embedded in Czech technical standards. Therefore, at the UNMZ, a technical standardization committee for the BIM issue was set up at the end of 2016. Its first is to translate international standards defining parameters in the universal IFC format.

4.3. Ontology for household installation

In the concept of a proposed extension of the natural language query processing system, the knowledge base is a stand-alone module that provides the most comprehensive descriptive information about a specific interest domain in the form of structured data. The basis for ontology development is, as a rule, the list of relevant terms, with consequent differentiation of ontological types, the specification of taxonomy as well as the creation of non-taxonomic relations, attributes and instances.
Although tools for ontology development and maintenance recorded in recent years, great progress (from text editors to graphically oriented interface) provided below the comfort level achieved in object modeling, especially in the area of user interface. Besides the later creation of the discipline, the complicated nature of the logical models seems to play - the extensive axioms can be translated hardly into comprehensible graphical formations and must be edited in a text pseudo code.
To build a functional example of ontology in the field of household installation, the already mentioned Protégé environment was used. The presented example of an ontology is based on defined relationships within the house wiring.
Each ontology concerns a particular domain (problem areas). Ontology modeling concepts that are abstract or concrete, general or specific. On the ontological modeling is difficult to choose a range of ontology that can be implemented and which will also meet the requirements of the target user. The final ontology structure is more or less flat, characterized by one main class with many objects and data properties, where one product card is equivalent to one instance of the main class. In the context of properties of given instances, ontologies may display structured data (containing semantically defined object properties) and text data (in unstructured and therefore semantically unpublished content).
From the point of view of computational processing of native language, data structured is key to achieving relevant results. On the other hand, however, the vast majority of information today is available only in pure text form and without any additional features. Without prior automatic or manual semantic annotation, it is therefore also using technology for processing queries in natural language virtually irrelevant as the results are irrelevant compared using these semantically structured data. Precision semantics is the main advantage of any well-designed ontology because it enables complex and semantic constructions to draw new facts and relationships between individual entities.

4.3.1. Taxonomy

In Figure 12 is shown a basic taxonomy describing several classes arranged in the hierarchy. Almost certainly, we will always find missing instances or classes that would, in our opinion, better capture the situation described.

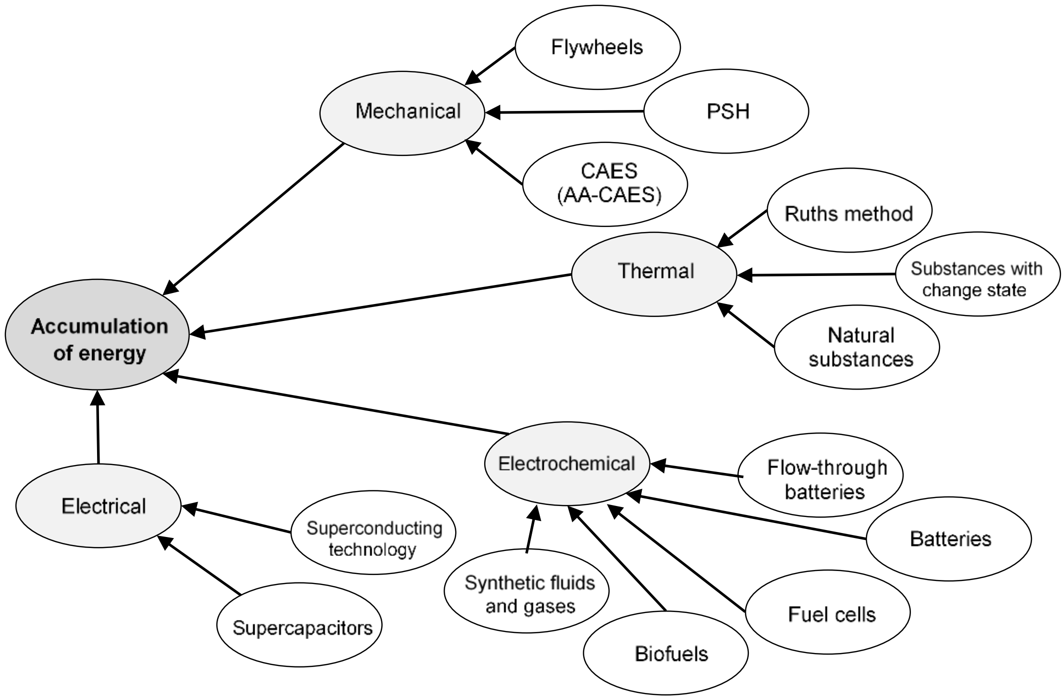

Figure 12. Taxonomy demonstration - Definition of classes and subclasses

Figure 12 shows the *Accumulation of energy* class is the main class, which is divided into four subclasses. These subclasses are then subdivided into other subclasses. Thus described ontology defines the basic relationships between objects. It is necessary to accept that ontology will never be complete because our world and the universe contain so many classes, characteristics and individuals that it is simply not all that can be included in the ontology. This may also be one of the reasons why ontology is divided into domain-oriented (covering only a specific, more limited domain) or generic ontology, which cover very general concepts such as space, time, thing, matter, etc.

4.3.2. Definition of relationships

Individuals need to be defined in order to be more specific. The property creates a relationship - a relationship between individuals. Assigned properties can be divided into four basic categories:

- object properties (creates links between class objects),
- data type (associates individuals with the value of a particular data type),
- annotation (extends information to individual classes or individuals in the form of metadata - comments, explanations),
- ontological (define the interrelationships between ontologies).

The use of the property notion is evident from Figure 13. It is possible to say that each energy accumulation system will have its own manufacturer. It follows that the *Accumulation of energy* class is related to the *AE Producer* class. At the same time, such individuals in the *Accumulation of energy* class as well as in the relevant subclasses such as *Accumulators, Fuel Cells* and others also have a relationship with individuals in the *AE Producer* class.

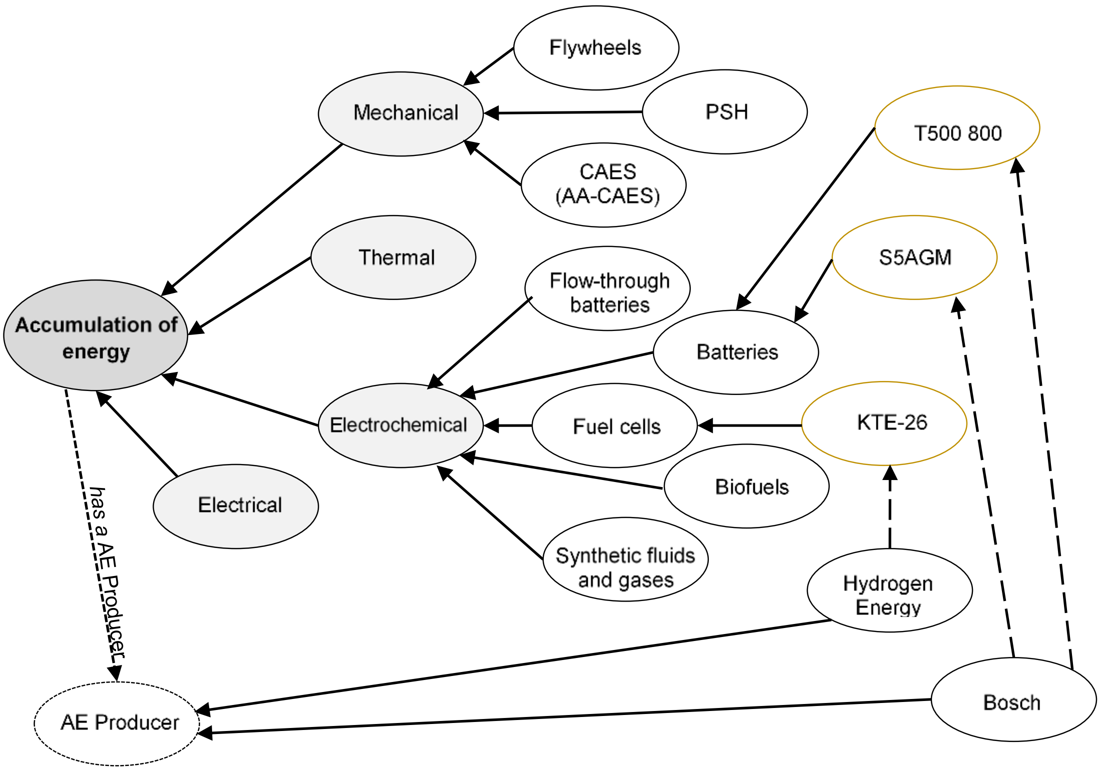

Figure 13. Taxonomy demonstration - Definition of relationships

With regard to the procedures defined in the previous sections of the article, a basic taxonomy for the selection of household electrical installation has been compiled, taking into account the technical possibilities summarized in the theoretical part of the thesis, which deals with the complex analysis of the electrical installation and associated systems.

The assembled semantic network contains a group of defined classes that can be seen as an overview diagram of the key association classes that are directly related to the choice of household installation. From this model, it is possible to create additional sub-models describing in detail specific components, either as other associative networks or as an ontology modeling knowledge related to a given class or production rules of behavior of the given classes.

It is also possible to define instances of given classes as specific objects with defined attribute values. This is the basis for a knowledge engineer who can communicate specific knowledge to each of these classes. The task of the knowledge engineer is also to be able to capture this knowledge with appropriate representation.

It is used associations of types ***is a*** and ***has a*** to build a taxonomy. These association types are used in the context of real simplification and utilization. However, they can not describe all the relationships between the defined classes but can serve as basic information on the procedures for selecting electrical installation and associated systems for a family house.

The semantic network does not form a complete representation of all classes. This network is only a cutout from a complex unit and serves to introduce the initial step in modeling knowledge from the installation for family houses, but also generally for other technical problems or solutions.

In this part of the solution are sought concrete answers to questions such as "What is it?", "What is included?", etc. For example, the question - "What is a battery?" - we can easily find the *Battery* association is a part of an *Electrochemical accumulation* and is part of the *Accumulation of energy* and the

Accumulation of energy is part of the *Energy system* of a family house. A similar process can be continued further define relationships and constraints.

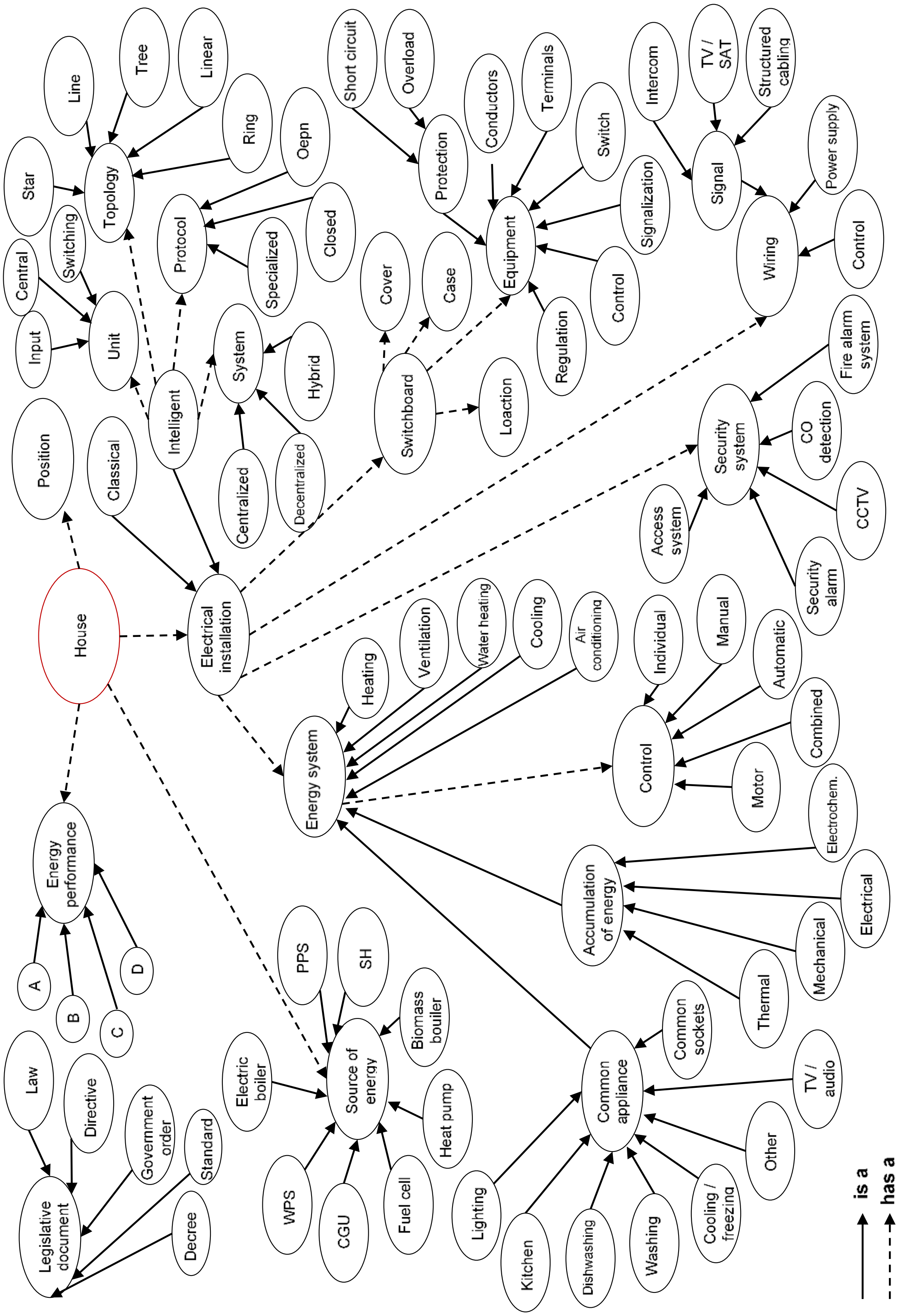

Figure 14. Taxonomy of basic classes for the household installation

4.3.3. Definition of individuals and properties assignment

Figure 15 presents a structure that defines the partial parameters of each type of *Batteries*. This structure shows that for the Battery class, properties that specify properties for specific individuals of the Battery class that works on the electromechanical accumulator system are defined. These attributes are assigned to each individual in the Battery class. Not all of the possible parameters of the batteries, which could be considered important in some cases, are certainly not listed in this example. This is part of the whole design process - continuous development, replenishments and sub-adjustments.

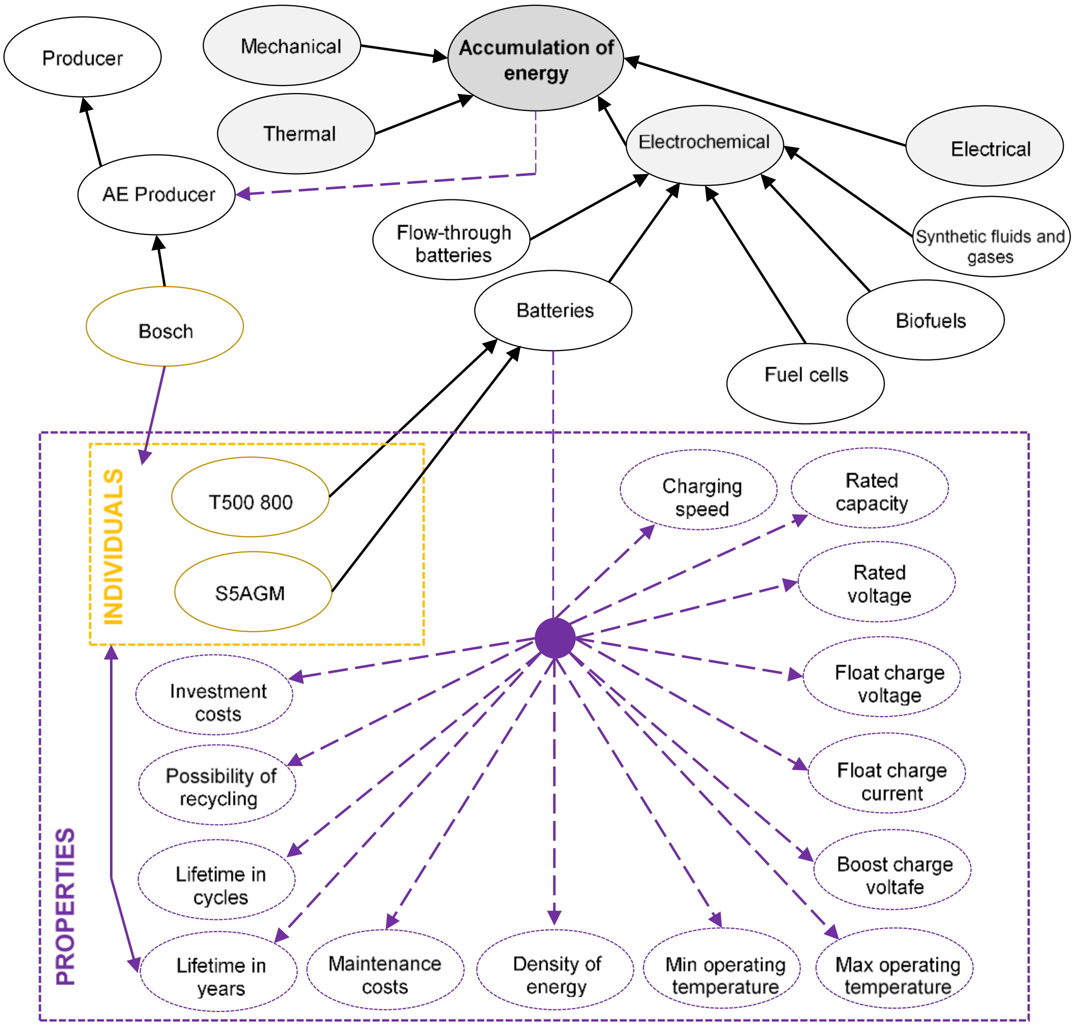

Figure 15. Definition of individuals and properties assignment demonstration

These parameters are crucial for the selection and design of the required energy storage or accumulators in the energy system of the house and in the design compared to the energy performance requirements for buildings, costs etc.

Nowadays, there are many information sources and types of representations that can be used as expert knowledge. Of course, the difference is whether the data will be processed for a normal person interested in the matter only in general or for an expert (for example a designer) who will want to get very detailed information from specific parts. Create a uniform and transparent structure, human-readable and machine-processable, it is not quickly and easily feasible task. All information needs to be transformed into a suitable form, some standardization and integration into the right structures must be done.

The most common and most used information sources are technical data sheets (according to the relevant technical specification standards) in which the producer of the equipment gives basic information about its

properties. For example, in the battery data sheet, their design will be described and the areas of their use will be specified, specifying the specific types of battery. For each battery, the basic operating parameters will be listed in the catalog - rated voltage, rated capacity, operating temperature range, etc.
As can be seen from the above, acquiring information for the knowledge base is a rather complicated and lengthy process. There are many techniques for obtaining input information, but no uniform and optimal approach can be established. However, there are many empirically verified and heuristic principles that can be beneficial to a knowledge engineer. Knowledge can be obtained from experts either directly in a generalized form or by analyzing specific decision situations. However, it is generally advantageous to combine both ways.

5. Conclusions

The current situation in the field of electrical installation and sources of energy is moving towards lowering the cost of energy consumption (or energy in general) and the direction of increasing austerity measures. On the part of the European Union (and not only), it is a constantly visible effort to reduce the energy efficiency of buildings, not only with the use of intelligent electrical installation but also by using alternative energy sources. Thanks to the technical development of intelligent installation, alternative power sources, and the general development of the knowledge of designers and designers involved in designing small units (flats, family houses or apartment buildings), there is a reduction in the price of both electrical installation and more possibility of frequent use of an alternative energy sources.
The possibilities of using knowledge systems have been demonstrated in the description of the household electrical installation. A significant amount of knowledge from the field of knowledge has also been defined. The built-in demonstration base of household installation has shown the possibility of saving knowledge in simple text form. The advantages and disadvantages of this knowledge base have been briefly described.
In the last part of the article, links between ontology and the knowledge base were defined. Simple demonstrations have demonstrated the basic steps to build a knowledge base using simple taxonomic relationships. In order to build a basic sample knowledge base, the problems associated with the use of the Protégé development environment have been described, which enables the creation of basic ontologies and their representation in various formats suitable for machine processing or direct use. Ontologies can greatly assist in the process of converting classification systems, but it is certainly not possible to implement this process through ontology (or other fully automated processes). Ontology, however, can speed up the creation of mapping rules between taxonomies and effectively describe these systems.

Benefits for knowledge engineering:

- Reusability - formal and formal representation of elements and domain relationships makes it easier to share and reuse.
- Search - ontologies are meta data character (meta information) allowing an easy search of large data sources.
- Reliability (authenticity) - Writing formats allow an ontology to automatically check data consistency.

As has been mentioned several times, ontology is a very important tool for describing data, information and knowledge. Application of ontology in data modeling as a tool for describing and cross-transforming data structures is not a miraculous means of eliminating the shortcomings of other similar tools.

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List of acronyms

Acronym	Description
BIM	Building information modeling, Building information management
AA-CAES	Advanced adiabatic compressed air energy storage
AE	Accumulation of energy
CAES	Compressed air energy storage
CGU	Cogeneration unit
CU	Control unit
EN	European standard
EPBD	Energy Performance of Buildings Directive
ES	Expert system
EU	European Union
FB	Facts base
HVAC	Heating, ventilation and air conditioning
IEC	International standard
IFC	Industry foundation classes
IM	Inferential mechanism
ISO	International Organization for Standartization
KB	Knowledge base
KNX	Konnex
LON	Local Operating System
OWL	Ontology Web Language
PPS	Photovoltaic power station
PSH	Pumped-storage hydroelectricity
RDF	Resource Description Framework
RES	Renewable energy sources
SH	Small hydro
UNMZ	Czech Office for Standards, Metrology and Testing
WPS	Wind power station
WWW	World Wide Web
W3C	World Wide Web Consortium
ZVEI	Central Union of Electrical Engineering and Electronics Industry

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