ACADEMIC DIDACTICS AND RESEARCH ASPECTS IN SOLAR ENERGY EDUCATION

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STRESZCZENIE

W artykule przedstawiono propozycje ćwiczeń dla studentów uwzględniające problematykę energii słonecznej. Ćwiczenia przeznaczone są dla studentów kierunków inżynierskich związanych z innymi dziedzinami nauki co wyznaczyło konieczność zastosowania różnych rodzajów oprogramowania użytkowego oraz dostosowanie się do pewnego poziomu ogólności w tej problematyce. Dotyczy to kierunków: ogólno akademickiego - Edukacja techniczno – informatyczna oraz kierunków o profilu praktycznym - Inżynieria bezpieczeństwa i Matematyka. Autorzy starali się wykazać zasadność motywacji w kierunku wykorzystania energii słonecznej wśród studentów innych dyscyplin.

INTRDUCTION

The authors have fund recently that social appreciation for sustainable development encounters barriers that have their origin outside natural resources or technological development. This wide observation indicates definitely the general public as the most obstructive factor. Usually the best practice to counteract against these obstacles is to extend social education starting from early stages at all school levels. This however has been realized for decades and is successful when youth is taken in consideration but becomes ineffective when the same people encounter their professional life. They start their choices directed towards the easiest solutions that require the least effort from them personally or follow some populist behavior usually comfortable in wider social groups and professional relations not concerned about the sustainability but on fast profits or in pursuit of popularity.

One can say that student courses focused on renewables, energy production, environment engineering, low energy buildings, etc. fill the gap between school education and professional involvement in this area. This is obviously right but only partially. These courses gather students that have already been concerned about such problems but the percent of them in the general public is too low to form a sufficient counterpoise to the other group who often have their origin in totally different academic areas such as law, economy, social sciences, art, political science, etc. and simply do not understand the imperative of sustainability. That is why the Faculty of Technology Fundamentals at Lublin University of Technology takes up short courses focused on the mentioned subjects but at the same time underlines their tight connection to the main effects their graduates gain at B.Eng. levels or at M.Sc. levels.

The paper can show this attitude on the basis of the research and didactic process experience realized in two exemplary fields of study such as: “safety engineering” and “education in technology and applied computer science”. Graduates from both fields are recognized as engineers and go, during their first three semesters, among others, through such engineering basics as electrical engineering and thermal dynamics. The effects at the end can be described as follows []:

- Safety engineering (SE) graduates show knowledge on identification, monitoring, design and analysis of safety systems including information and information systems. They are qualified as specialists in safety in many industrial units and institutions. They have certified qualifications of Health and Safety Inspectors, to carry out staff training in safety.

- Education in technology and applied computer science (ETI) graduates show thorough knowledge in named areas related with complex support within pedagogy. They find employment in local industry, IT branch, local civil service, housing office, local district authority, teachers of technology and teachers of informatics at different school levels, i.e.: primary, secondary, vocational.

  The further semesters introduce such subjects as “Selected problems in technology” (devoted to Education students and carried out in English) focused on different energy conversion processes and devices and “Energy security” (devoted to safety students) focused on energy diversification at regional level. These two courses put attention to renewable energy ideas and gaining practice in dedicated user software. Moreover, the classes in limited form without design exercises, but in English are carried out during M.Sc. course in mathematics. These graduates are focused on insurance and banking mathematics. Recently at the Faculty, becoming a mathematician means also gaining basic education in technology and becoming an engineer. That is why the awareness on energy conversion diversity and its mathematical modeling seems one of the most suitable education paths.

SE and ETI students gain their practice in training others (either children or adults) and at the same time they gain possible awareness on energy preservation through the concept of the use of renewable energy sources such as solar energy in particular. Student do their project in couples or in three person groups and through this also learn how to communicate within the range of sustainability but what is extremely important, learn this on the basis on the most modern technology and innovative ideas. Their interest in solar energy is built up taking advantage of their interest in modern software applications, industrial safety and other innovations.

METHODOLOGY OF DEDICATED EXERCISES

The exercises that are dedicated to form and develop solar energy awareness among seemingly disinterested students of various courses have been elaborated using the didactic experience and often by means the method of trials and errors in establishing how far this specialist knowledge can be incorporated in general technology education.

LOW ENERGY BUILDING CONCEPT

This project exercise entitled "Energy in building" has been designed to combine skills in different software applications such as AutoCAD, Excel, ESOP (simplified Polish version Kolektorek) and optionally with some extension with WUFI, Molier or TRNSYS (usually the simplified module COMBISYS). All software is available in educational versions, trial versions or require special approval for educational use. Nevertheless, it is in all cases sufficient for such simple solutions the student choose and/or one month trial license during a course. These restrictions well comply with students' knowledge level in the field of low energy buildings and with time they can devote to perform the exercise. The main attraction to them is the possibility to switch their activity from one user friendly software to another, starting from AutoCad which they already practiced earlier in the course. Moreover, the subject of healthy and energy saving life style that is presented shortly during the first lecture is usually in accordance with their personal knowledge based on internet resources however the positive aspects of the idea of low energy building towards passivity is new to them.

In the sequence of steps students start from making basic projection of one floor building plan and an elevation suitable to present solar PV panels or collectors. It must be mentioned that students are encouraged to adapt their own buildings or flats. This is to give them direct inspiration on how these problems influence their individual life.

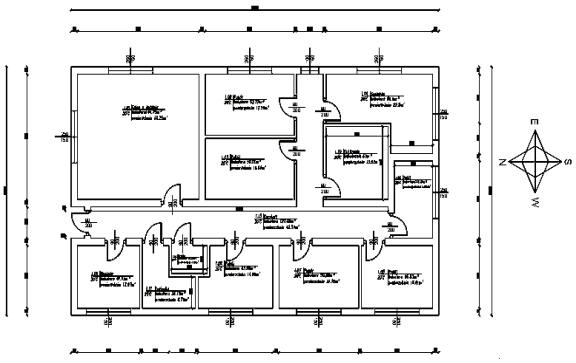

Fig. 1 Standard layout of one floor building and the elements required to proceed with the exercise

The next step is performed in MS Excel in the form of calculation on a spreadsheet. This leads to the result of heat demand simplified calculation for each room optionally using advantageous and disadvantageous heat transfer coefficient values to help them understand the physical difference dimension between good quality materials and low quality ones, different climatic zones, maintenance of established ambient temperature values. The basic heat transfer theory was studied within their previous thermal dynamic course.

Number	Name of the	Wall/ Window	Length	Width	Area	Heat transfer coefficient	Δ t	Power loss Q	Addition	Heat demand
room	room	symbol	[m]	[m]	[m2]	U	oC	[W]	1+d	[W]
1.01	Bedroom	Wall E	4,375	2,7	8,8125	0,3	40	105,75	1	105,75
		Window E	2	1,5	3	2	40	240	1	240
		Wall N	4,45	2,7	12,015	0,3	40	144,18	1,1	158,598
		Floor	4,45	4,375	19,4688	0,3	30	175,21875	1	175,21875
		Ceiling	4,45	4,375	19,4688	0,3	40	233,625	1	233,625
		Qwk=[0,34*(Δt)-9]*Vk								241,801875

Fig.2. Table of simplified heat transfer demand calculation

Beside the procedure presented in Fig.2, the students calculate total value in the building and hot water heat demand dedicated to each group separately. This stage shows also their emotional attitude to the problem of individual choices in buildings and thus the effect of the whole exercise is durable and well memorized. In processes of education in technology any possibility to inspire positive emotional involvement into the acquired knowledge is very precious as the whole areas do not help in this important aspect of education for professional life. This attempt turns out to be true in the three mentioned educational directions.

The next stage is directly connected with solar energy system, usually solar domestic hot water (SDHW). Students follow steps in software available for users in limited versions with some instructions by tutors concentrating their efforts on water demand, covering up of heat demand monthly distributed and emissions reductions which is another emotional step in the procedure especially when dust reduction can be presented. This is very educative also when comparative boilers and fuels can be compared, especially such as: coal, gas, pellets, gasoil.
It is also a kind of general bonus when license conditions allow use German menu, Polish translations and longer time of license validity which differs in time of practice.

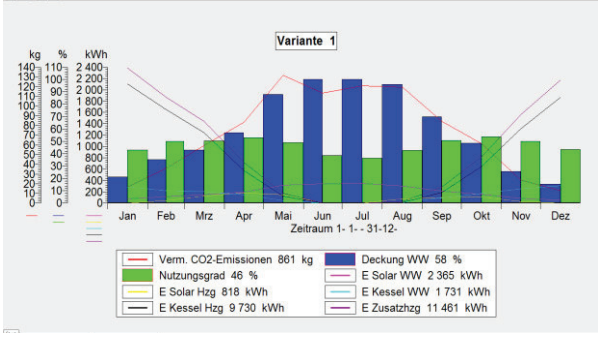

Fig. 3. Optional exemplary variant result from ESOP elaborated by students

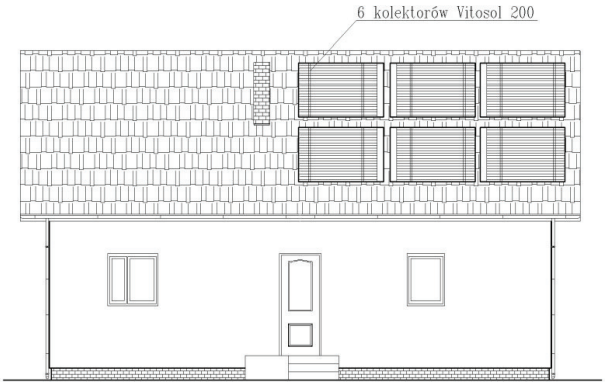

Fig. 4. Final graphic view form, the students complete their exercise with

Didactic processes require students to see and accept important conclusions resulting from their work such as inclusion of renewable energy gain from solar thermal plants in total annual energy use for example. It can be mentioned that in every day practice students take advantage of their exercise and reconsider the use of solar collectors in their house, and often even rely as much as possible on themselves in design and in construction. This feedback from graduates is very optimistic and promising.

Moreover, an optional version of the exercise including WUFI simulation stage can be easily applied and students can easily see if their choice concerning the type of insulation is effective. The final simulation from this light version software that shows heat and humidity transfer throughout the cross section of wall layers can be very suggestive way of motivation towards energy efficient renovations. Nowadays, students are very impressionable to images neglecting in some way process of calculation that seems ineffective to them and the result without an image becomes not convincing and thus - not worth memorizing. These changes in perception refer also to students at engineering courses who previously were supposed to have great imagination and abstractive thinking skills. That is why even the simplest forms of simulation are of substantial importance when motivation towards energy saving problems is induced. Another chance to turn the attention to building environment is the application of Molier graph as some visualization for energy consumption by means of air conditioning systems. ETI and SE students know just basics of humid air treatment and simple examples showing energy demand by cooling the air in rooms is in compliance with what they can be interested in.

The set of optional exercises shown in Figs. 3, 5,6 is useful when teachers want to diversify subsequent year courses which helps students to get used to the routine to rely on their own effort. Cost calculation is usually omitted during the presented exercises intentionally not to make students always grow attached to money.

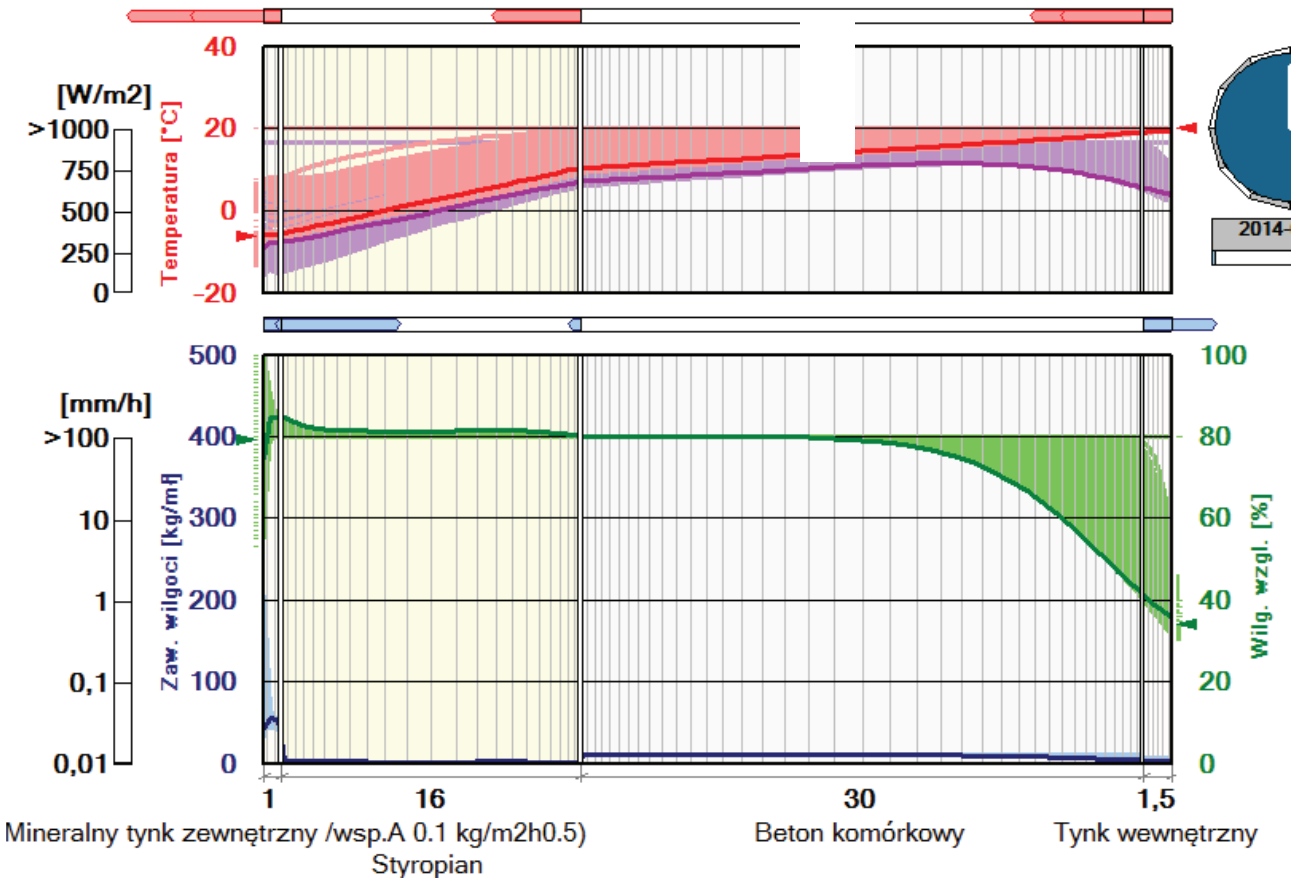

Fig.5. WUFI light simulation example showing how humidity can penetrate wall layers at different ambient temperature

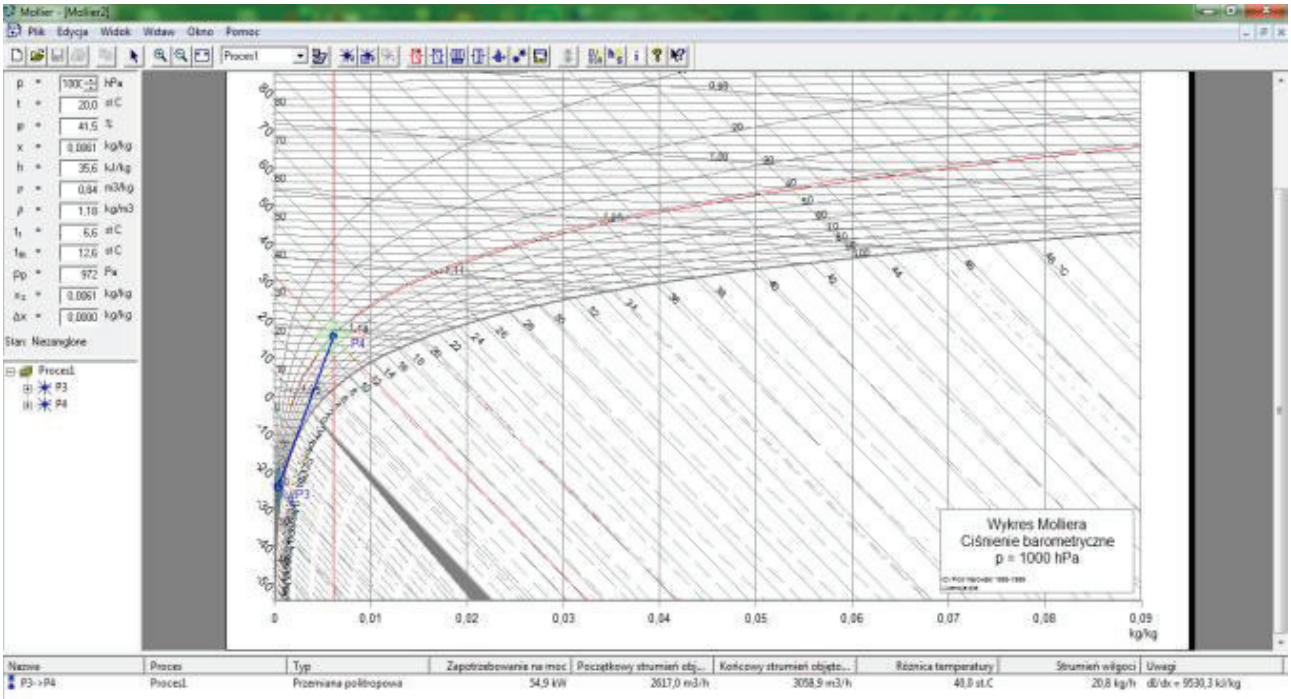

Fig.6. Simple humid air graph showing energy demand changes even in moderate room cooling

SOLAR ENERGY GAIN IN EXERCISE

This simple exercise can help ETI and SE students operate measuring devices in situ using similar methodology as for students at geodetic surveying course. This exercise also helps to understand how important is human care for natural environment and its sustainable use and the pro-ecological awareness increases and the development is performed in agreement with nature. Performing solar measurements in university campus spreads also the idea to the whole university population. To perform this task, a student has to use a pyranometer CM3 Kipp & Zonnen and a multimeter to take current voltage readouts. The pyranometer presented in Fig.7 has a polystyrene foam case and a multimeter is in an anti shock case to ease handy transport and operation. The measurements provide results of instantaneous solar radiation on horizontal surface and as such are not perfectly suitable for professional measurements of solar availability but sufficiently meet the purpose of didactics.

Fig. 8. Practical set of measuring devices in situ (fot.: K. Augustowska)

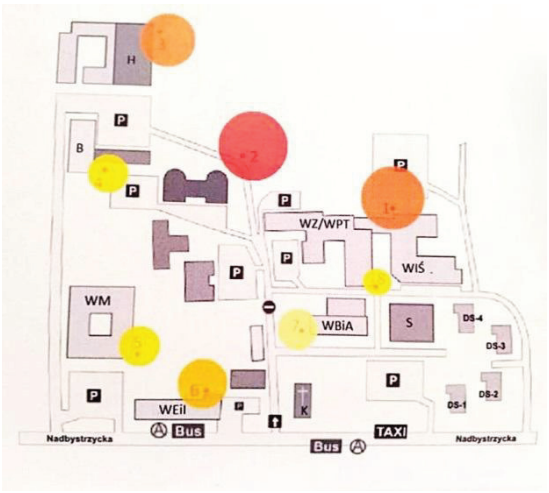

Fig.9. Layout of measuring spots among LTU campus buildings (visualization: K. Augustowska)

This experiment procedure is comparatively time consuming and requires to be performed in two or even more units but through this is suitable as an exercise supplementary in case of student's sick leave or any absence in standard course routine. Results of measurements can be collected in graphs with simplicity of multiplication of readouts by devise constant (Fig.10). Time lapse between measurements in subsequent points were about 3 minutes which indicates how repeatable (different days) substantial differences can occur even in short distance when the directly close surrounding is different (illuminated walls, green tree area, shaded walls) without visible obstacles to direct beam.

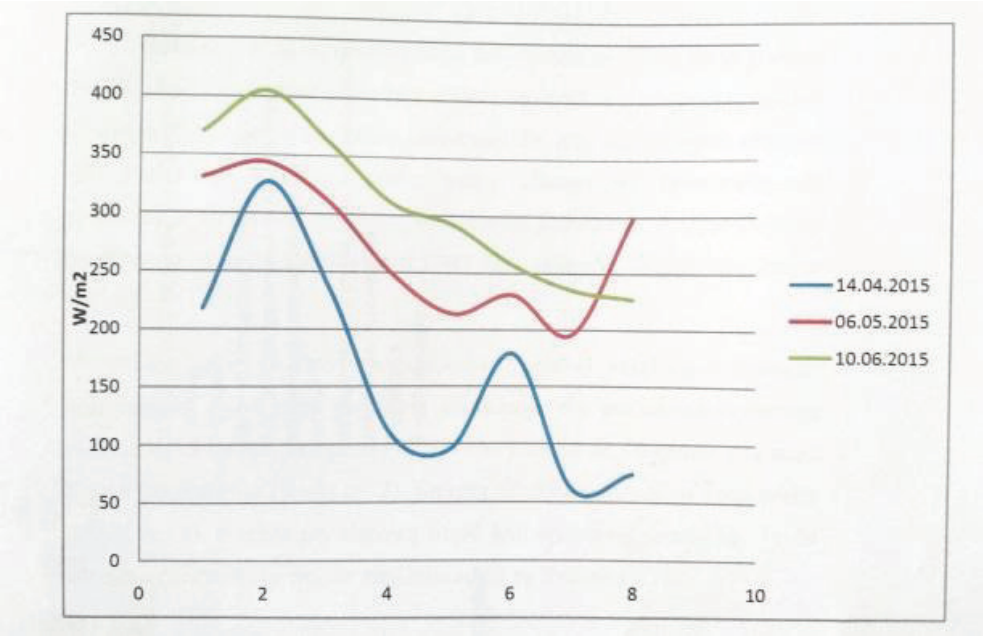

Fig. 10. Graphical presentation of solar energy measurements (W/m^2) in horizontal plane in selected locations within 150 m^2 of Lublin University of Technology campus

PROGNOSIS EXERCISE

Students calculate predictions on the basis of the real data sets available currently thorough the Internet and apply selected equations, usually by means of Excel. Usually the logarithmic trend line establishes dynamic increase during the first years - real data years and in calculated trend years. Then stabilization of the curve is visible which indicates in this case that the area of installed solar thermal collectors yearly can keep approaching close to/revolving around $350x10^3$ sq.m. within 2035. Some other trials as power regression or proportional are visibly too optimistic from the point of view of students and then they attempt trials to supply reasonable justification beside calculation. They usually point out such factors as the necessity of modernization of worn out systems, saturation of the market, possible weather disadvantageous influence occurred occasionally etc. Anyway, writing so, the students have to do some additional information research and this is beneficial. The example in Fig. 11 shows a relevant graph.

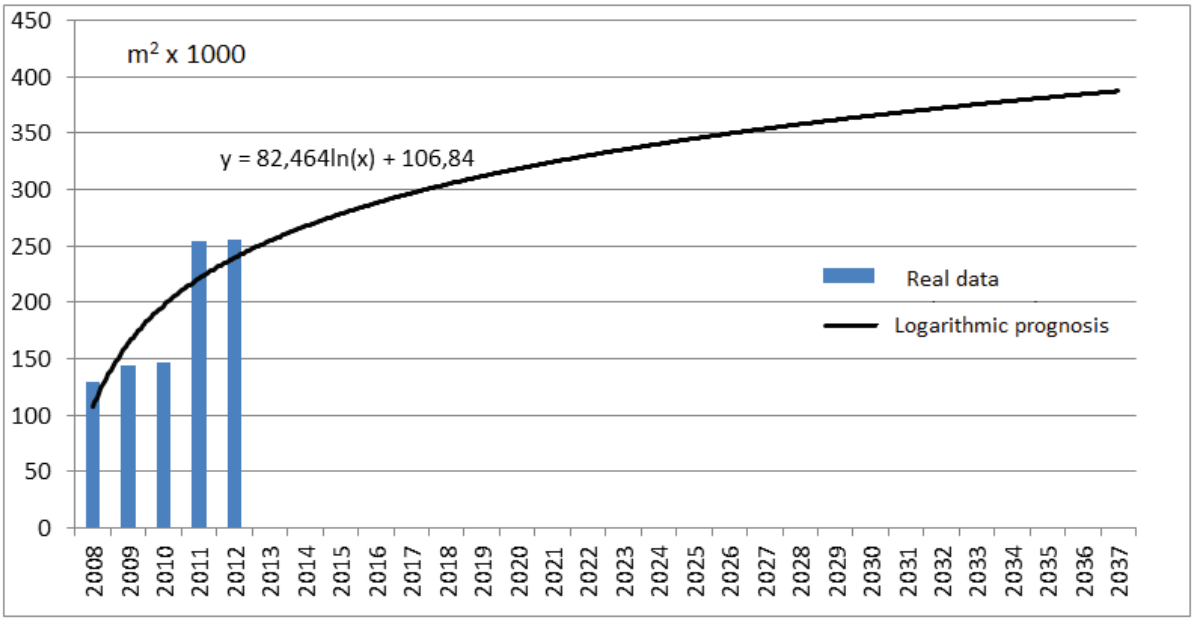

Fig.11. Predictions for solar thermal collectors installed area

CONCLUSIONS

The presented examples are limited to some final results general conclusion of successful application can be formulated only because teachers had multiple occasions to talk to their graduates who reported proudly their involvement in renewable energy promotion and even their own application in private real estates. The authors are convinced by their own experience that continuous didactics of this type consequently repeated in subsequent years can be effective at least at regional level of applications. They even propose similar simple didactic applications to other university faculties such as law, economy, social sciences, commerce, journalism, etc. to steadily work out the influence outside regional universities.

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