OCCUPATIONAL HEALTH AND SAFETY RISKS DURING THE CONSTRUCTION OF SOLAR PV SYSTEMS AND SUGGESTING TRAINING TOPICS

Balázs Zákányi
associate professor, University of Miskolc,
Faculty of Earth and Environmental Sciences and Engineering
3515 Miskolc, Miskolc-Egyetemváros, e-mail: balazs.zakanyi@uni-miskolc.hu

Ákos Olajos
student of Occupational Safety and Health Engineering,
Faculty of Earth and Environmental Engineering
3515 Miskolc, Miskolc-Egyetemváros, e-mail: akos.olajos@student.uni-miskolc.hu

Renáta Zákányi Mészáros
senior research fellow, University of Miskolc, Research Institute of Applied Earth Sciences,
Chamber of Engineers of Borsod-Abaúj-Zemplén County Work Safety Group Chairman
3515 Miskolc, Miskolc-Egyetemváros, e-mail: afkzmr@uni-miskolc.hu

Abstract
The installation of solar PV systems has led to a competitive market situation in recent years. Solar panels are being installed on a wide variety of sites and buildings. Companies are competing with each other to see who can do the job at a better price and who can do it in sometimes extreme conditions. Our work focuses on the dangers at height and how to avoid them. Workers, because of their lack of training, can often find themselves in situations that should result in a suspension from work by law or regulation, but without this knowledge, they can perform tasks that seriously endanger their health or their lives. Because the installation of solar PV systems is a relatively new industry, no two roofs are the same, and no two designs are the same. Thus, it is often only during installation that it becomes apparent that the work would require alpine engineering expertise, but employers, prioritising cost-effectiveness, fail to take this into account. This in turn puts the worker at risk, who is not aware of all the risk factors. We present the dangers of working at height with solar panels and propose a general training material that would make this field safer and, in so doing, significantly reduce the risks.

Keywords: *solar panel, alpine technology, occupational health and safety education*

1. Introduction

We use a wide range of technologies to generate electricity in Hungary today, the most important of which are nuclear (37%), hydrocarbon (29%), coal (14%) and renewables (7%). These do not cover our energy needs, so we need to import 13% of our energy, but this has significant costs. In order to achieve a stable economy, we are moving towards self-sufficiency in energy production, which is one of the reasons for the increased demand for clean energy in recent years, including the inexhaustible solar energy. The generation of electricity from solar radiation is possible with advanced solutions that have taken a century of experience to develop and spread (Lawson, 2020; Internet_1).

Due to the increased demand for solar PV systems, industries have emerged to serve the target audience. As demand grows, so does the industry, employing more and more workers. The demand for raw materials, manufacturing, transportation and of course construction has increased. The installation of systems has resulted in a competitive market. Solar panels are being installed on a wide variety of sites and buildings. Companies are competing with each other to see who can do the job at a better price and who can do it in sometimes extreme conditions.

The works pose a number of risks to workers, as in most cases the work is carried out at height, installing live equipment, exposing themselves to extreme weather conditions from which escape is difficult. From the point of view of occupational safety, we are talking about a significantly dangerous and complex activity, despite the fact that in Hungary today, no professional qualification is required to work as an assembler of solar systems.

We want to focus our work on the dangers at height and how to avoid them. Workers, because of their lack of training, can often find themselves in situations that should result in the suspension of work by law or legislation, but without this knowledge, they can also perform tasks that seriously endanger their health or their lives. Because the installation of solar PV systems is a relatively new industry, no two roofs are the same, and no two designs are the same. Thus, it is often only during installation that it becomes apparent that the work would require alpine engineering expertise, but employers, prioritising cost-effectiveness, fail to take this into account. This in turn puts the worker at risk, who is not aware of all the risk factors.

We would like to present the dangers of working at height with solar panels and propose a general educational material that could be used to make this area safer. By anticipating this, the risks could be significantly reduced through the use of alpine engineering skills.

2. The spread and development of solar systems

The French physicist Alexandre Edmond Becquerel discovered the photovoltaic effect in 1839 and built the photovoltaic cell in his father's laboratory that same year (Váradi, 2014).

In 1860, English-born electrical engineer Willoughby Smith began experimenting with photovoltaic technology. He was conducting experiments with submarine cables when he discovered that the selenium used for these cables behaved differently during the day than at night (Váradi, 2014).

The first modern solar cell was made in 1885 by American inventor Charles Fritts in New York. He coated a slab with a layer of selenium and a semi-transparent gold film, which generated electricity in response to sunlight. Although its efficiency was barely 1%, it paved the way for the future of one of the most important techniques used to generate electricity today, the solar cell (Váradi, 2014).

In 1888, the physicists Heinrich Hertz, Wihlem Hallwachs and Alexander Stoletov independently found that negative charge is released from negatively charged metal plates when exposed to ultraviolet radiation. These were the basis for the first solar cells as we know them today (Váradi, 2014).

Einstein also worked on photons from the sun and found that photons coming in shorter wavelengths produced a significantly better photovoltaic effect. He was awarded the 1921 Nobel Prize in Physics for his explanation of the photoelectric effect (1905).

More and more physicists began to work on early solar systems as a result of these discoveries, but this process was hampered by the two world wars. Other research took over and until the 1950s almost no progress was made in this field (Váradi, 2014; Boxwell, 2021).

It was Russell Ohl who registered the patent for the first modern semiconductor solar cell, which he created while researching transistors, leading Bell Laboratories engineers to introduce the first efficient silicon semiconductor solar cell in 1954. However, it gained widespread attention when the US Navy used solar cells for its satellites in 1958 to provide a different power supply than before (Váradi, 2014).

The development of solar cells for residential use was launched when the US National Science Foundation set up a division to research and develop solar cells. The real breakthrough came in 1973 during the oil crisis. It became clear that fossil fuels could not be considered as the sole, primary source of energy. Several oil companies saw the potential of solar energy and began to invest heavily in it. Thanks to these investments, more and more professionals have been trained to make this branch of energy production more efficient. From the 1980s onwards, the residential market also began to be supplied with solar installations. Demand began to spread in many directions, offering a solution in all areas, even where the utilities had not yet been installed. Many farms in Europe have installed systems and have chosen this solution for their daytime energy needs. In the 2000s, a number of studies on the lifetime and efficiency of the cells were carried out, so that the payback period became clearer, which pushed the growing industry in an even more positive direction.

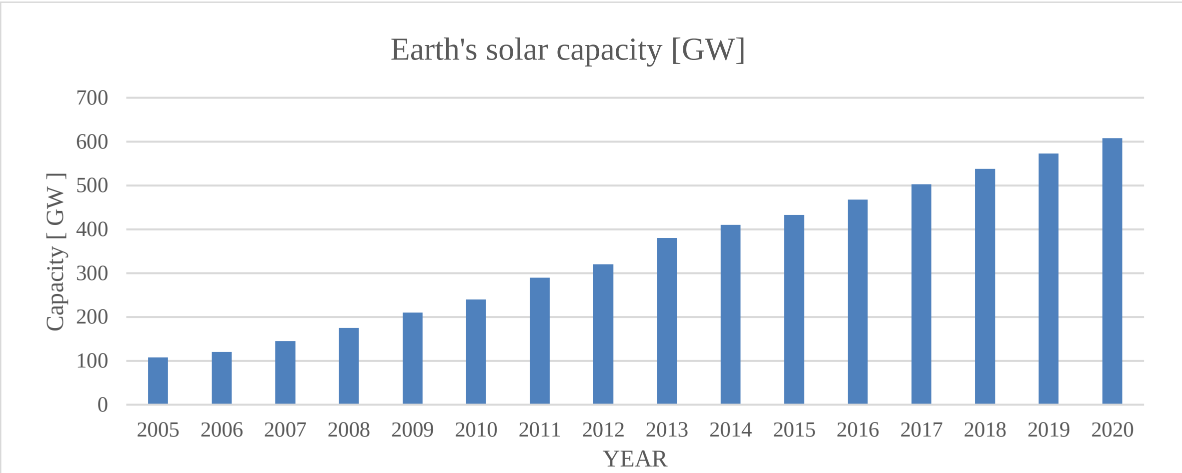

Figure 1. *Earth's solar capacity [GW]*

The graph above illustrates that by the end of 2020, the Earth's solar capacity will have exceeded 600 GW, placing it third on the list of renewable energy sources. Hydropower remains in first place and wind power in second. However, it is clear that solar is the dominant energy source of our time and its growth shows no sign of stopping (Internet 1 and 2)

2.1. Increasing use of solar energy in Hungary

In Hungary, the installation of solar systems started in the early 1990s, but it was far from being a widespread investment. The building materials were expensive to purchase and the payback period was not favourable. In 1997, Dunasolar Solar PV Manufacturing Ltd. started solar panel production in the country, bringing it into the focus and within reach of companies. Not only in production, but also in professional representation. The Hungarian Solar Energy Society was founded, which brought together professionals who wanted to work in this field and also represented its interests.

It was mainly businesses with higher energy needs that invested in retrofitting, but as the technology became more widespread, the demand grew and more and more companies started to invest. One after another, companies were set up whose main profile was the professional installation of solar panels, and whose employees were employed exclusively in this field (Farkas, 2003).

In recent years, several large-scale solar systems have been installed in the country:

- In 2015, the solar power plant on the 30-hectare site of Mátra Power Plant Ltd. will have a capacity of about 18 MW.
- The state's 10 MW solar power plant in Pécs was inaugurated in 2016.
- In 2020-2020, EON will install a 12 MW solar PV system on the roof of the Győr Logistics Centre. This is a unique investment, as there has never been a roof of this size in Europe (Internet_1).]

In addition to the industrial scale, a number of 500 KW parks have been established to supply energy to towns and cities. Of course, investments have also been made at the residential level. Attention has also been paid to the supply of domestic consumption, including the installation of so-called Household-Scale Small Generating Stations (HMPPs), which is growing in popularity almost by the day. The market has tried to meet the increased demand. Hundreds of orders have been placed with various companies for CCGT systems ranging from 2 kW to 50 kW (Inernet_1 and 3).

Figure 2 illustrates how the amount of electricity generated by photovoltaic systems in Hungary has increased.

As previously described, systems were installed before 2010, but only then did they start to become significant. From 2010, there was a slow increase until 2014, when the economic recovery meant that the price of solar systems became more affordable and a wider range of people could afford them. The rate of growth is clearly visible, with the penetration of CCS systems contributing significantly. In 2020, we have reached 3058 MW, of which almost 50% is CCS (Internet_1 and 2).

2.2. Number of workers involved in the construction of solar PV systems

As a consequence of the increase in solar capacity in Hungary, as described above, more and more companies and thus more workers are installing solar panels. In Hungary, the number of companies involved in the installation of solar systems is over 1 000, and this number is increasing year on year (Internet_4).

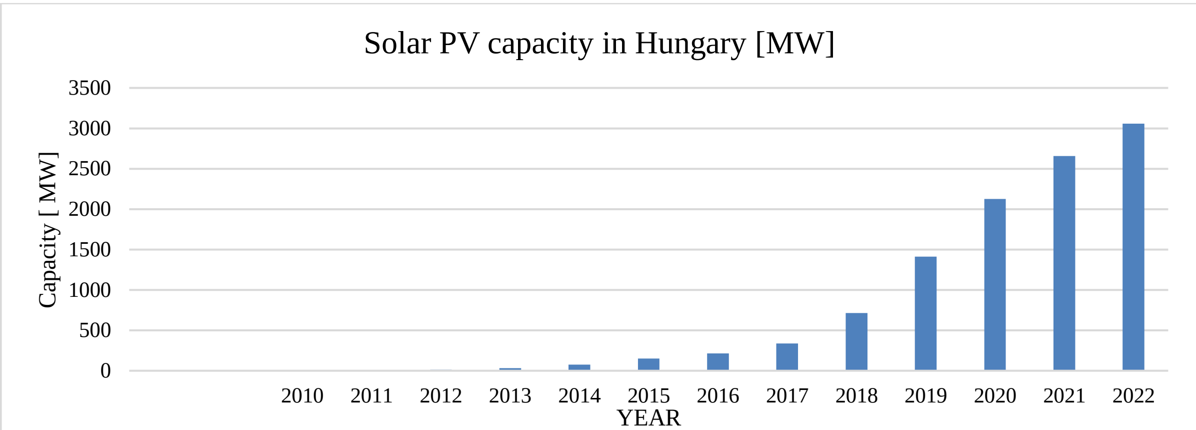

Figure 2. *Solar PV capacity in Hungary [MW]*

We have tried to gather information on the number of workers on the construction sites, but unfortunately we have not been able to find such data. We contacted several statistical companies, but none of them could provide us with accurate data. Our research led us to the conclusion that workers are registered for different jobs. Some companies only occasionally undertake this activity and there is also a huge turnover.

The number and skills of workers is therefore constantly changing. One recruitment agency told us that they regularly hire out workers to build solar systems. Some of these workers are employed for 1-1 weeks, while others spend months on this type of work. The companies that hire the workers do not expect the people they are looking for to have any professional qualifications. In our discussions with solar companies, we found that the situation is similar everywhere, without exception. Despite higher wages, they suffer from a constant shortage of staff. Constant travelling, bad weather and unpleasant, inadequate workplace ergonomics lead them to look for another form of livelihood within a few months (sometimes a week or two) (Internet_4).

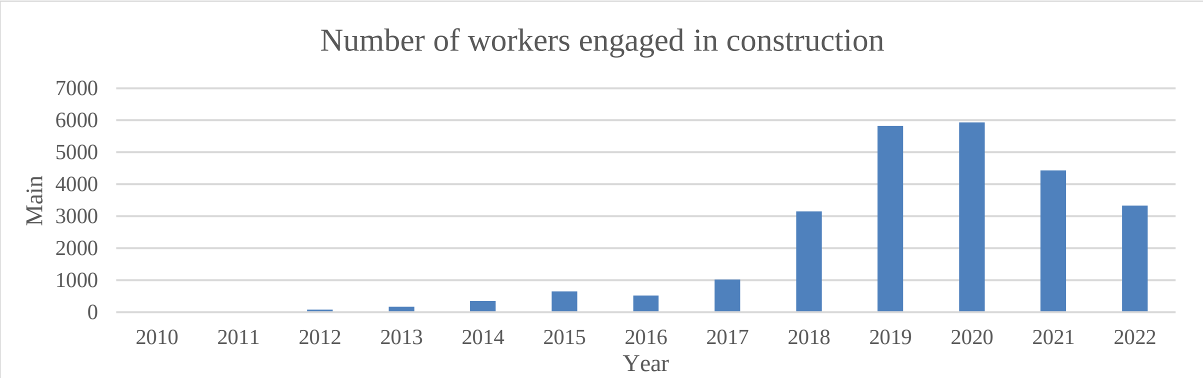

Figure 3. *Number of workers engaged in construction*

Since we wanted to show the number of people at risk from this activity, we could only produce a diagram by doing a calculation. We would like to note that the results in Figure 3 are only approximations and not official data. In discussions with some construction site managers, foremen and solar installers, we have found that about 10 workers can acquire 100 kW in 1 month with an 8-hour work schedule. Of course, this is heavily influenced by the weather and the location of the installation. On a complicated, complex roof, they cannot install the panels nearly as efficiently as they can with a ground-mounted system. For this reason, we take an annual average. For 10 people, this is 1200 kW, which means that 1 person installs on average 120 kW per year. In Hungary, taking into account the annual capacity of completed systems, a simple division can be used to calculate approximately how many people have been installing solar panels per year in recent years. The years 2019 and 2020 stand out, which was surprising at first glance, but can be justified, as these are the years in which the majority of solar parks were built (e.g. Győr Audi, 500 kW park). During this period, we did not find any companies whose main profile was solar panel construction, so it is possible that some workers were doing 1-2 installations during the whole year, in addition to other types of work. In the last 2 years, the role of Household-Scale Small Heating Installations (hereafter HMKE) systems has become much more important, which we estimate to be around 3,000 active workers. This number is of course not equal to the number of people who make their living from solar PV systems, as they are the ones who specifically do the assembly work.

Based on our approach, we are talking about 3,000 people who are affected by the subject of our work, because they are the ones who one day are on the roof of a family house, the next day on the ground, and the third day they might be on a 15 m high roof. They are constantly risking their lives because of these extreme situations, lacking the necessary experience and expertise. And their numbers increase in proportion to our energy needs (Internet_4).

3. Rules for the construction of solar systems

Construction usually takes place in different locations, so there are many regulations to take into account. Installations can be carried out on the ground and high up on the roofs of buildings, which makes this activity highly dangerous. Ground-mounted activity is not relevant to my topic and therefore the risks of this activity will not be addressed.

3.1. Legal basis

Articles XII and XVII of the Fundamental Law of Hungary state the right to work and give freedom of choice of profession. Closely linked to this is the provision in Article XVII, which is the most important for us, that workers have the right to safe and healthy work. Compliance with this right is in the common interest of both employer and employee. In our experience, skilled workers on construction sites are not sufficiently aware of the meaning of this. They are not properly informed about what they can and cannot do.

Act XCIII of 1993 on Occupational Safety and Health and the related Implementing Decree 5/1993 (XII.26.) of the Ministry of Labour and Social Affairs regulates the requirements, basic personal and material conditions of safe and healthy work. It also specifies aspects of the prevention of occupational accidents and describes the responsibilities of the state, the employer and the employee in relation to occupational safety and health.

Decree 65.1999. (XII.22.) of the Ministry of Economic Affairs and Labour on the minimum safety and health protection requirements for personal protective equipment for workers at work, which is in force from 27.07.2021. The regulation covers all employers who employ workers for organised work. The employer must take into account the tasks assigned to the employee and provide personal protective equipment to perform them. It also lays down the health and safety requirements for personal protective equipment.

Joint Decree 4/2002 (II. 20.) SZCsM-EüM on the minimum occupational safety and health requirements to be implemented at the construction workplace and during construction processes. In order to avoid accidents during construction work, the legislation provides for the designation of coordinators and the definition of their responsibilities. It provides for the preparation of construction design documentation and its content requirements, as well as the responsibilities of the contractor, technical manager and builder during the work. The worker must be informed of the risks involved in the work in order to avoid them.

10/2016 (IV.5.) NGM Decree on the minimum level of safety and health requirements for work equipment and its use. Chapter 5 of this regulation deals with "The precise definition of the additional requirements for work equipment and its use for temporary work at a height", where it lists the general rules for work at height, and thus also applies to the construction of solar panels on roofs. Work at a height is defined as work at a height where temporary work is carried out and the necessary safe and ergonomic conditions cannot be provided, and therefore the worker must be provided with equipment that allows him to carry out the work safely. The solution may be collective (scaffolding) or individual protective equipment (body harness) to protect the worker from falling. The regulation sets out in detail the rules on collective protection, such as the requirements for scaffolding, the positioning and fixing of ladders for access.

Decree 11/2003 (IX. 12.) of the Ministry of Agriculture, Forestry, Environment and Water Management on the safety rules for industrial alpine technology activities, which describes when we can talk about alpine technology and who exactly is covered by the decree. Here we are talking about a specific sector where the activity is subject to an educational qualification. It defines the conditions and means of work for the employer. It also lays down requirements for the use of personal protective equipment. The definition of rope techniques, descenders and belaying points is also set out in detail.

3.2. Personnel conditions of the assemblers during the works

The installation of solar systems, as a job, requires only training and does not require a professional education, so the personal conditions are equivalent to those of any skilled worker in the construction industry, as defined in Article 49 of the Labour Protection Act:

- who has the right physiological effects to do the job,
- you do not endanger your health in the course of your work,
- the worker's reproductive capacity is not at risk,
- before starting work, you have a medical examination to determine your fitness for work,
- your own safety and the safety of others is not at risk.

Under these conditions, anyone can participate and work on the projects.

4. Roof structure types and hazards

The basic function of the roof structure is to drain rainwater and protect the building. Its design must take into account the risks posed by the weather (snow load, wind) and the possibilities for people to stay on the roof. In recent years, roof ladders and anchorage points have been installed on most new buildings. In older buildings this is very rare and often structures are encountered which are not only difficult to transport but cannot even support the weight of the average person. The concept of roof structures includes the structure supporting the roof with its different layers and the shells and roof slabs (Kelényi and Kiss, 1978; Zádor, 1984; Kószó, 2005).

Roof structures can be grouped in many different ways according to their needs and design, but the most important for my thesis is the degree of slope, shape and roof sheathing material (Kelényi and Kiss, 1978; Zádor, 1984).

They can be divided into 4 different groups according to the degree of slope:

- flap supports - angle of inclination: $x \leq 5°$,
- low inclination - inclination angle: $5° < x \leq 16°$,
- central inclination - inclination angle: $16° < x \leq 45°$
- minor inclination - inclination angle: $45° < x$ (Kószó, 2005).

By roof shape:

- storytelling,
- tent roof,
- winner,
- half-roof,
- antifoam roof,
- oromorphic container roof,

- thin container roof,
- common container (Kószó, 2005).

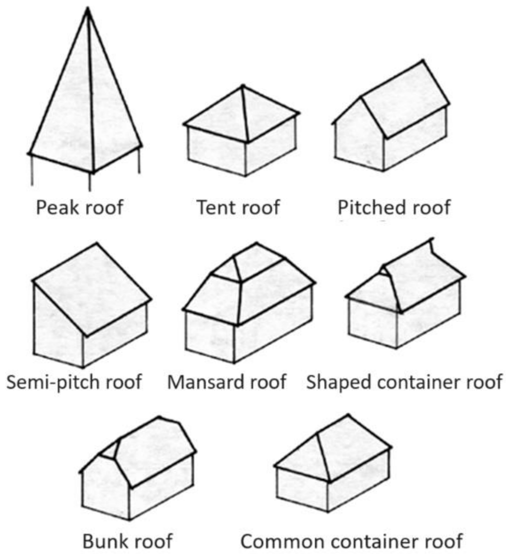

Figure 4. *Roof shapes*

Based on the material of the shell:

-scaled coverings (slate, corrugated slate, tile, shingle),
-chalk cover (straw, reed),
-flat sheet coverings (bituminous shingles, plastic sheet),
-waveplates (plastic, glass, metal),
-plates (plastic, glass, metal) (Kószó, 2005).

4.1. Characteristics and hazards of flat roofs

The spread of flat roofs is common in the country. It is most common in large-scale factories, apartment buildings and halls, but is also becoming more common in detached houses. Angle of inclination: X ≤ 50, which means that the risk of falling is limited to the edges. Heights range from 10 m to 50-60 m. By law, when working on a roof level below 200 m, if the place of work is more than 2 m from the edge of the level difference, a 2 m boundary line is sufficient. If work is carried out within the 2 m danger zone, collective or individual protective equipment must be used to prevent falls. In terms of their cladding, they may be bituminous, shingle, metal or glass. The supporting structure is secured by weighting, since this is the only way to ensure the integrity of the insulation against rainwater. This type of roof is characterised by very large systems, which require several tonnes of material to be moved by hand over the surface, so that a large number of workers are working on the roof. In most cases, the concrete elements used for weighting are lifted by cranes, while they are removed by hand. However, if the desired deployment on the roof is not possible due to the load capacity, the lifting is also done manually with smaller weights (Kószó, 2005).

Dangers: the main danger is the edge of the roof, where it is strictly forbidden to go out without insurance. If the slab cannot support the weighting stones on the pallet, the stones are lifted one by one by hoisting, which poses an increased risk. However, these roofs have considerable ceiling engineering and openings. These are identified as a hazard during construction as there is also a risk of falling through the openings. These openings are almost flush with the roof during strong sunlight, so their delineation and attention-grabbing marking is extremely important (Kószó, 2005).

4.2. Features and hazards of pitched roofs

The spread of pitched roofs is typically much less than that of flat roofs. Pitch angles $5° < X \leq 16°$ so that transport on the roof shell is also possible. Collective protection against falling should be provided and personal protective equipment should be provided for those working on the edge. Typically, this method is used to cover detached houses. They are similar to the previous one in terms of their cladding, with the difference that in some cases a tile roofing version is already encountered. Since the main task is to drain rainwater, tiled roofs are already prepared with solar panel supports, making the construction easier to carry out and eliminating the risk of soaking (Kószó, 2005).

Dangers: due to the greater angle of inclination, a trip or slip can have serious consequences, and therefore requires increased attention from the worker. The low angle of inclination is not a flat roof. The roof surface may also have overlights, smoke vents, ventilation ducts, which can lead to a fall, and these should always be marked (Kószó, 2005).

4.3. Characteristics and hazards of medium pitched roofs

The most common roof type in our country. Its pitch is between 16° and 45°. In terms of cladding, all types of solutions are available (sheet, tile, shingle, plastic, glass). In terms of roof shapes, you can find pitched, gable, semi-pitched and container roofs. For these types (above 200 m), the law requires the use of fall protection where the working height exceeds 2 m (Kelényi and Kiss, 1978; Zádor, 1984; Kószó, 2005).

Dangers: due to the large pitch angle, free access to the roof is no longer possible. The risks vary depending on the type of roofing. In the case of tile roofing, there is a risk of unstable, unsecured surfaces that can shift and fall. Fixed tiles are also available, but they are not nearly able to support the weight of a person, and are the only protection against falling. The surface of the tiles can be of various types, but they are typically flat and free of handholds, so there is a significant risk of slipping. When securing damaged slab surfaces with ropes or slings, it should be borne in mind that the edges of the slab may cut the securing devices and cause a fall. In the case of slate roofs, there is also a flat surface where securing is problematic. These roof surfaces are at the greatest risk of collapse, as they are not nearly as load-bearing as tile or sheet roofing. It is very rare to find a trade where work is carried out on this surface, but in terms of solar panel installation, it is every day that we find a site where work is carried out on a slate roof (Kelényi and Kiss, 1978; Zádor, 1984; Kószó, 2005).

4.4. Characteristics and hazards of pitched roofs

Pitched roofs are roofs with a pitch angle of more than 450. The most common types of roof covering are slate, shingle, slate roofing, but tile roofing is also possible. Roof types are: turret roof, hipped roof, gable roof and, in rare cases, gable and semi-gable roofs. By law, at least two people must work together at the same time. When working, the roof structure must be checked and a fixed working seat must be used on the surface. In the case of securing ropes, the anchorage points must be selected in such a way that they can withstand the load on them in the event of a fall (Kelényi and Kiss, 1978; Zádor, 1984; Kószó, 2005).

Dangers: because of its steepness, this type is the most dangerous, with the highest risk of falling. Weather conditions have a significant impact on the work, with a high risk of slipping in rainy or freezing weather. In the case of safety nets and scaffolding, there is also a risk of falling over. Escape from the roof surface can take considerable time. Manual handling of material (which is always done when installing solar panels) is extremely cumbersome, as the workers have to use their hands to move the material (Kelényi and Kiss, 1978; Zádor, 1984; Kószó, 2005).

Figure 5 shows the implementation of a solar PV system in a school in Budapest. The building is interesting because its inclination angle is 55°. Due to a rubber mat track, the building plinth cannot be supported by a tripod. There is a break under the solar panels, below which a steeper roof continues, making the construction of a protective net extremely costly. An interesting feature of the roof is that the tiles are fixed due to the steepness, so it was not possible to move or lift them. Installation was only possible with the help of ropes. The person in the picture is secured to the profile of the solar panel by means of a Y-cantle.

Figure 5. *20.09. 2022 Budapest III. district*

5. Training material needed to work safely

To work safely, it is essential to have training that workers can receive before starting work.

In Figure 6 we have tried to illustrate the steps of what we consider to be the educational material. In this way, workers could learn step by step the necessary skills to prevent accidents. It is also mutually beneficial for employers, as they can safely undertake more complex and dangerous work at a minimum cost, thus not only improving conditions but also creating a competitive position for their company compared to those who do not take advantage of this opportunity.

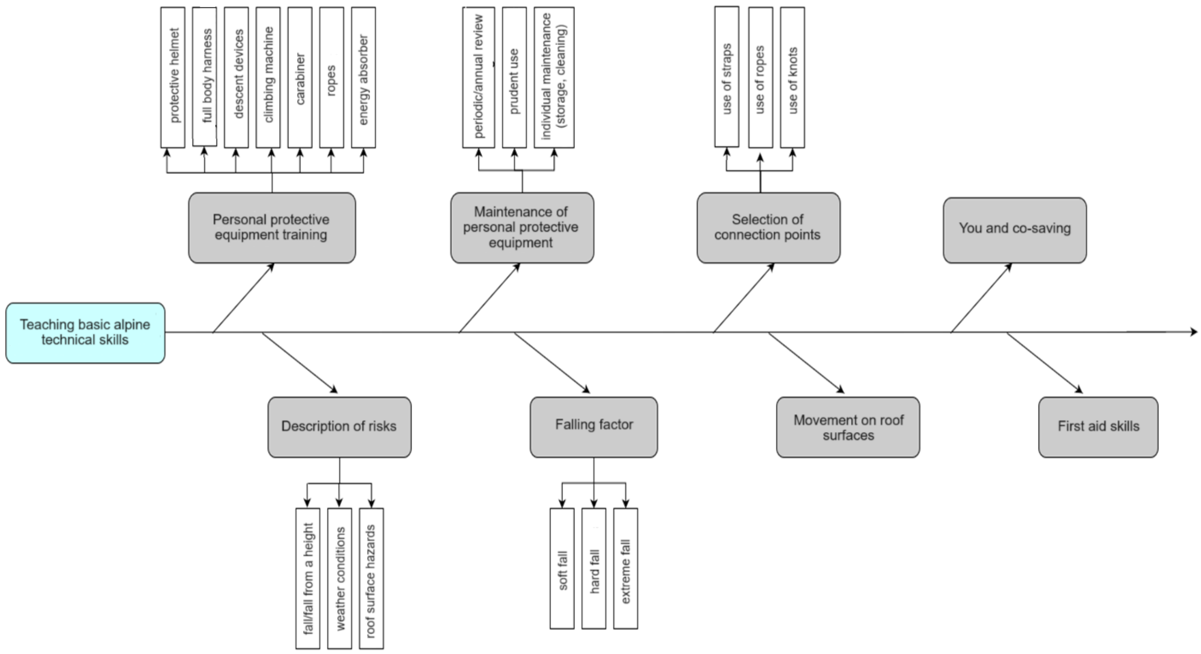

Figure 6. *Education flowchart proposal*

We believe that the presentation and practice of the training material should be carried out in conjunction with the annual OSH training. The training should be given by a person with a degree in occupational safety and health who has the necessary expertise in alpine technology, as without it he or she would not have the necessary skills.

6. Summary

In the course of our work, we presented the spread of solar systems in Hungary and their effects and risks for workers. In the last 10 years, more and more companies have been established whose main activity is the construction of solar systems. As this number has increased, so has the number of workers who risk their lives and work at heights every day.

Roof surfaces can be diverse and therefore have different hazards. We have drawn the reader's attention to the fact that, although there are many rules for working at height, in some cases, without the necessary skills, it is easy for a worker to endanger his or her life.

Currently, in our country, no professional qualification is required for employees working on the construction of solar systems, so these activities can be carried out without the necessary expertise.

In our research, we found that teachers of workplace rules are not sufficiently aware of the dangers of this area and how to deal with them. There are several situations that can arise that, without sufficient expertise, the risk assessor will not recognise.

Industrial alpine technology has many potentials that could prevent accidents if mastered and used. By attending a training course (repeated every year) and learning what they have heard, workers would be able to recognise and deal with work hazards safely and carry out their work. Thus reducing the number of accidents at height.

7. Acknowledgements

The research was carried out in the framework of the GINOP-2.3.2-15-2016- 00010 "Development of enhanced engineering methods with the aim at utilization of subterranean energy resources" project of the Research Institute of Applied Earth Sciences of the University of Miskolc in the framework of the Széchenyi 2020 Plan, funded by the European Union, co-financed by the European Structural and Investment Funds.

References

[1] Lawrence, L. (2020). *Solar power for beginners*. pp. 1-86.

[2] Internet_1: **https://bestsolar.hu/napelem-telepites-maganszemelyeknek/** (Accessed: 10.08.2023)

[3] Varadi, P. F. (2014). *Sun above the horizon: Meteoric rise of the solar industry*. CRC Press. ISBN: 978-981-4463-80-5 **https://doi.org/10.1201/b17086** (Accessed: 10.08.2023)

[4] Boxwell, M. (2021). *The Solar Electricity Handbook*. 2021 Edition, Greenstream Publishing. ISBN: 978190767076

[5] Internet_2: **https://www.tisztaenergiak.hu/naperomu/** (Accessed: 10.08.2023)

[6] Farkas, I. (2003). *Napenergia a mezőgazdaságban*. Mezőgazda Lap- és Könyvkiadó Kft. ISBN 9789639358911, pp 1-318.

[7] Internet_3: **https://napelemrendszer.info/napelem-inverter.html** (Accessed: 10.08.2023)

[8] Internet_4: **https://www.ksh.hu/munkaero** (Accessed: 10.08.2023)

[9] Kelényi, Gy., Kiss, I. (1978). *Építészeti stílusok*. Móra Ferenc Ifjúsági Könyvkiadó, Bubapest. ISBN 963-11-1123-7, pp. 1-63.

[10] Zádor, A. (1984). *Építészeti szakszótár*. Corvina Könyvkiadó, Budapest. ISBN 963-13-1794-3, pp. 1-125.

[11] Kószó, J. (2005). *Háztetők*. Szukits, Szeged. ISBN: 9634971139, pp.1-298.