PARTICIPATION OF CONSTRUCTION CLUSTER „DUNDJER" IN THE DUAL EDUCATION SYSTEM IN THE FIELD OF SOLAR ENERGY APPLICATION[1]

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UDK: 374.7:620.92
DOI: 10.14415/konferencijaGFS2018.051

Summary: *A survey among members of the Construction Cluster Dundjer from Niš, showed that more than 50 % of employers have a problem to find skilled workers with specific skills among own workers and also on the work market. They stated also that they would rather invest in education of their emploees improving in this way loyalty of own workers than to educate unemployed workers from the scratch. The need for additional education, not being part of system of formal education and prevailing of practical nature is especially noticed in the field of energy efficiency, ecological building, and solar energy. These three fields are recognized as very prosperitive and promissing in construction sector. It has to be realized by establishing close relations with educational and R/D institutions, and by forming dual education system. As a result, this would improve production processess and procedures using reserach results and improved competences of workers in the field of solar energy.*

Keywords: *Solar Energy, Dual Education, Corporative Education, Energy Efficiency, Smart House*

1. INTRODUCTION

There are more and more examples that students who complete high school, even students who complete college, do not know how to do what they have completed, and that employers want to receive those who have practical knowledge. Businesses are

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faced with great problems to reach professional and qualified staff, since students after completing secondary vocational school, as well as students after graduating from faculties, do not have functional, usable, and applicable knowledge that could immediately be included in the working process. Techniques and technologies in today's society are rapidly progressing, schools and faculties simply cannot follow these changes, so it is imperative that this part of professional, practical education must be transferred to companies, because it is in the interest of both economy, science, and students, because dual education brings work immediately.

The topic of the project is development of the methodology and practical training plan for the three companies, members of the Construction Cluster Dundjer, in the dual education system in the field of energy efficiency, ecology, and solar energy. By making a survey among cluster members, 50 percent of employers find it difficult to find workers with the necessary skills both among their employees and among the unemployed at the labor market. In addition, employers emphasized that they would rather invest in the practical training of existing employees, which would increase their commitment to companies, than to educate some unemployed, from the beginning, without any experience. The need for additional training for employees, which are not part of the formal education system, but practical training, has been recognized in the field of energy efficiency, ecology, and solar energy. These three areas are seen as prosperous in the construction sector, where it is possible to connect the economy with the scientific and educational institutions and development institutions, by establishing dual education in order to improve production processes and procedures through the implementation of scientific achievements and improving the competencies of employees. This paper deals with design with curriculum in the field of solar energy application for dual/corporate education in construction industry.

For this purpose, it is necessary to create an individual plan and program of practical training tailored to each specific company and its capacities and needs in the field of solar energy. The best experts in these areas will be engaged in the implementation of these plans. For the end of the project, a workshop is planned through which the results and dissemination of the project will be presented.

2. PROJECT ACTIVITIES

Within the project, the following activities will be carried out:

1. Conducting survey among companies within the cluster about their needs for practical training in the field of solar energy,
2. Development of a plan and methodology for practical teaching for ABR,
3. Development of a plan and methodology for practical teaching for Deltaelektronik,
4. Development of a plan and methodology for practical teaching for Kapaparojekt.

3. EDUCATIONAL PLAN AND PROGRAM

Profession: Technician of Solar Energy (TSE)

The following subjects are provided:

SE-1. Introduction to Solar Energy;
SE-2. Methods for Calculation of Solar Capacity of Specific Micro-location with Application of Convenient Software
SE-3. Solar Cells and Panels - Theory and Available Technologies
SE-4. Connecting Panels in Solar Energy Systems
SE-5. Solar DC/AC Inverters – Methods of Connection in Bigger Systems (Solar Plants)
SE-6. Contemporary Legal Frames, National and International Contracts (Solar oriented FIDIC), New Demands in Production and Application of Solar Energy. .

The contents of seminars SE-1, SE-2, and SE-3 are taken from available literature and publications, mainly of first author. The key practical seminars are composed in collaboration with known German firm SMA, based on trainings delivered to members of Construction Cluster on workshops and seminars (in Niš and Sofia, Bulgaria), and also on trainings offered by SMA Solar Academy (see [4]). The contents of seminar blocks SE-4 and SE-5 (SE-5.1. only), as very important, will be presented in continuation.

SE-4. Connecting Panels in Solar Energy Systems

This block contains the following seminars:

SE-4.1. PV Systems up to 30 kW (Residential Systems for Private Applications)
SE-4.2. PV Systems up to 250 kW (Commercial Applications)
SE-4.3. Visualization and Control of PV Systems
SE-4.4. Service and Maintenance of PV Systems with a Decentralized System Structure
SE-4.5. Designing of PV Plants with the Sunny Tripower 60 Inverter and the Medium Voltage Station
SE-4.6. Designing of Large-scale PV Plants with Sunny Central Inverters and the Medium Voltage Power Station

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SE-4.1. PV Systems up to 30 kW (Residential Systems for Private Applications)

This seminar gives overview of palette of products solutions (mainly of SMA firm) for installation of PV systems for self-consumption-optimized PV systems in the private application segment with an output of up to 30 kW. The starting point is discussion (brain-storming) about the possible reasons end customers might want to install a PV system and looks into possible ways of reducing household energy costs. In addition to inverters, the participants will of course also become familiar with power electronics close to the module. The communication and monitoring services and self-consumption optimization systems are also covered. One pilot system would enable system planning and dimensioning possible. The selection process for choosing just the right products for intended application is included. In the final part, the students will consolidate the skills that have learned in a workshop on system design.
This seminar is part of block of courses on residential and commercial PV plants solutions. This block consists of four seminars, SE-4.1., SE-4.2., SE-4.3., SE-4.4. All

seminars can be visited as stand-alone trainings, but if one would like an even deeper and more encompassing understanding, attending the entire block is recommended.
Target group: Installer, solar technology specialist, technical system planner, electrically qualified person.
Requirements: Basic knowledge of solar power systems, PC skills, Internet-enabled terminal (the lecturing is of BYOD – Bring Your Own Device type).

SE-4.2. PV Systems up to 250 kW (Commercial Applications)

This seminar gives an overview of product solutions for the installation of self-consumption-optimized PV systems in the commercial application segment with an output between 30 and 250 kW. In addition to inverters, the electronics supporting solar panels will be also considered. For systems of given size the added value analysis of an electric storage solution will be performed and aspects regarding its use in the commercial domain discussed, regarding its use in the commercial domain. Using a sample system design, the participants will learn what makes system planning and dimensioning possible. The selection of the right products and elements for own intended application will be performed. The consolidation of the skills one has learned in a workshop on system design will be done on the final.
This seminar is part of block of courses on residential and commercial PV plants solutions. This block consists of four seminars, SE-4.1., SE-4.2., SE-4.3., and SE-4.4. All seminars can be visited as stand-alone trainings, but if one would like an even deeper and more encompassing understanding, attending the entire block is recommended.
Target group: Installer, solar technology specialist, technical system planner, electrically qualified person
Requirements: Basic knowledge of solar power systems, PC skills, Internet-enabled terminal (the lecturing is of BYOD – Bring Your Own Device type, participants require W-LAN Access).

SE-4.3. Visualization and Control of PV Systems

This seminar gives the overview of different options available for visualization and control of PV systems. In addition to analysis of interfaces for communication and data loggers (SMA), an introduction to on-line service will be presented. The theoretical knowledge presented will be practically applied by accompanied workshop. Pilot systems, designed by small training groups, are configured so that they send the data to (SMA) monitoring system. The possibilities of manufacturer-neutral system communication using the Modbus Protocol will be also taken in consideration. For provided system size, the added value of an electric storage solution and clarifying aspects regarding its use in the commercial domain will be also explained. Using a sample system design, the participants will learn what makes system planning and dimensioning possible. The selection just the right elements and products for intended system design is important task to be learned. The consolidation the skills learned in a workshop on system design is provided on final.
This seminar is part of block of courses on residential and commercial PV plants solutions. The block consists of four seminars, SE-4.1., SE-4.2., SE-4.3., and SE-4.4. All

seminars can be visited as stand-alone trainings, but if one would like an even deeper and more encompassing understanding, attending the entire block is recommended.
Target group: Installer, solar technology specialist, technical system planner, electrically qualified person.
Requirements: Knowledge of solar power systems and components (SMA), PC skills, Internet-enabled terminal with a WEB browser (IE, Firefox, Safari) for the workshop on system communication.

SE-4.4. Service and Maintenance of PV Systems with a Decentralized System Structure

Only PV systems that work reliably and fault-free guarantee maximum yields over the long term. The participants of this seminar should help to their customers to achieve this by regular maintenance and prescribed measurements, service and a customer-specific PV system monitoring concept. This seminar qualifies the participants to undertake maintenance on PV systems with decentralized inverters and battery-storage systems, and perform a targeted analysis of anomalies. The key topics covered by this seminar are basic knowledge on photovoltaics, PV plants (fields), inverters, battery systems, and other components of PV systems. Based on this knowledge, the participants learn how to professionally examine PV systems, how to proceed provided and emergency measurements, and how to use them for problem solution and quality check and assessment. The suggestions how to prepare corresponding paper works (documentations) and how to obtain maintenance by proper PV systems monitoring are also delivered. Optimization of PV systems by modernization and upgrading by up-to-date elements will be explained. By number of practical exercises the measurements and assessments of pilot systems will be presented. The communications of systems with localization of possible errors and proposal for fixing of system malfunctions are parts of this seminar. Content of this seminar is given by following units:

- Safety in handling inverters and PV systems
- Basics of photovoltaics
- PV system components and their functions
- Installation and commissioning
- Relevant European standards
- PV system monitoring
- Troubleshooting and rectifying errors
- Practical exercises

Target group: Service technicians, solar technology specialists, installers, experts.
Requirements:

- Basics of electrical engineering
- Participation in practical exercises exclusively for persons qualified in electrical engineering (written proof must be furnished in the seminar)
- Knowledge of SMA system technology
- PC skills
- The internet-enabled terminal is needed for the workshop on system planning (participants require W-LAN access)

This seminar is part of block of courses on residential and commercial PV plants solutions. The block consists of four seminars, SE-4.1., SE-4.2., SE-4.3., and SE-4.4. Both seminars can be visited as stand-alone trainings, but if one would like an even deeper and more encompassing understanding, attending the entire block is recommended.
Target group: Installer, solar technology specialist, technical system planner, electrically qualified person
Requirements: Knowledge of solar power systems and components (SMA), PC skills, please bring an Internet-enabled terminal with a WEB browser (IE, Firefox, Safari) with you for the workshop on system communication.

SE-4.5. Designing of PV Plants with the Sunny Tripower 60 Inverter and the Medium Voltage Station

The planning and design of large-scale PV plants is getting more and more attractive due to many advantages this technology offers. This technical seminar enables the participants to design up-to-date decentralized large-scale PV plants connected to the medium-voltage grid. The illustration of this solution is given by presentation of SMA inverter Sunny Tripower 60. The main topics of seminar are topology, functions, protection and dimensioning the inverter, and medium-voltage station (by SMA). The seminar covers also design of PV plants using up-to-date software (Sunny Design) and configuration of medium-voltage station with advance specified system demands. In general, this course contains the following units:

- Concepts of large-scale PV plants
- Main components of decentralized large-scale PV plants
- Topology and main features of the Sunny Tripower 60 (SMA)inverter
- Function, components and main features of DC combiner boxes
- Functions and main features of Inverter Manager and I/O Box (SMA)
- Commissioning of Sunny Tripower 60 inverters (SMA) using the LCS tool software
- Main features, components and configuration of the Medium Voltage Station
- Designing of PV plants using the software Sunny Design (SMA).

This seminar is part of block of courses on residential and commercial PV plants solutions. The block consists of two seminars, SE-4.5. and SE-4.6. All seminars can be visited as stand-alone trainings, but if one would like an even deeper and more encompassing understanding, attending the entire block is recommended.
Target group: Renewable energy professionals.
Requirements: Previous knowledge of PV modules, PV inverters, medium-voltage transformers, AC voltage, AC current, active and reactive power, Ethernet, and Modbus. Because this seminar includes lessons and workshops with software, laptop computer and a pocket calculator are necessary for course attending.

SE-4.6. Designing of Large-scale PV Plants with Sunny Central Inverters and the Medium Voltage Power Station

The planning of centralized large-scale PV plants has become much easier because of turnkey solutions by SMA. This technical seminar qualifies you to design modern

centralized large-scale PV plants connected to the medium-voltage grid using the successful SMA solution: The Medium Voltage Power Station. The main topics are the topology, functions and protections of the Medium Voltage Power Station, including the designing of PV plants using the latest version of the SMA software Sunny Design and the configuration of the Medium Voltage Power Station according to specific project requirements. The units that be presented are:

- Main components of centralized large-scale PV plants
- Topology and main features of the Sunny Central 500-1000 CP XT inverters (CPE)
- Function and components of the Sunny String Monitor, SMA String Monitor and SMA String Combiner
- Function, components and main features of the Medium Voltage Power Station (SMA)
- Designing of PV plants using the SMA software Sunny Design.

This seminar is part of block of courses on residential and commercial PV plants solutions. The block consists of two seminars, SE-4.5. and SE-4.6. All seminars can be visited as stand-alone trainings, but if one would like an even deeper and more encompassing understanding, attending the entire block is recommended.
Target group: Renewable energy professionals
Requirements: Successful participation in seminar "Designing of PV plants with the Sunny Tripower 60 inverter and the Medium Voltage Station." Laptop PC and a pocket calculator are needed for participants, because this seminar includes lessons, workshops with software and a visit to the Sunny Central factory (SMA).

The second block of courses to be presented is

SE-5. Solar DC/AC Converters – Methods of Connections in Systems (Solar Plants)

This block of lectures contains the following seminars:

SE-5.1. Storage Systems in the Smart Home (SMA)
SE-5.2. Designing of Off-Greed Hybrid energy Systems with Sunny Island Battery Inverters (SMA) and the Multicluster Box
SE-5.3. Commissioning of Off-Greed Hybrid Energy Systems with Sunny Island Battery Inverters and the Multicluster Box
SE-5.4. Designing of Hybrid Energy Systems with the Fuel Save Controller (SMA)
SE-5.5. Commissioning of Hybrid Energy Systems with the Fuel Save Controller (SMA)
SE-5.6. Webinar on Sunny Tripower Core1 (SMA) – Functions, Design, Installation, and Commissioning
SE-5.7. Webinar on Utility Solar Solutions – Portfolio and Opportunities.

SE-5.1. Storage Systems in the Smart Home (SMA solution)

Due to standing rising prices of energy, PV plants with battery storage systems are more and more attractive for private households. This kind of solution allows maximum independence accordingly a significant reduction of electricity costs. This seminar gives the knowledge about planning and designing future-proof and sustainable solutions with

flexible and integrated storage solutions (mainly products of SMA). Key aspects of the seminar are application scenarios for different systems, battery expertise and criteria for battery selection, tips on designing and integrating PV storage solutions into the smart homes (SMA Smart Home solution), i.e. plant monitoring, visualization of energy flows and optimization of self-consumption via load shifting. This seminar is part of block of trainings on off-grid systems and storage solutions which consists of three seminars SE-5.1, SE-5.2 and SE-5.3. All noted seminars can be participated as stand-alone trainings, but in order to have an even deeper and more encompassing understanding, attending the entire block is recommending. Content of seminar is:

- Flexible and integrated storage solutions for new and existing PV plants - Flexible Storage System and SMA Integrated Storage System,
- Battery concepts, requirements for installation, commissioning and maintenance,
- Designing PV plants with battery storage systems,
- Integration into the Smart Home: Plant monitoring, energy monitoring, and energy management with the Sunny Home Manager and controllable devices.

Target group: Installer, solar technology specialist, technical system planner, electrically qualified person.
Requirements: Basic knowledge of solar power systems, PC skills (Internet-enabled terminal is needed – BYOD lectures (Bring Your Own Devices), participants require W-LAN access).
Contents of seminars SE-5.2. - SE-5.7. could be found in Project report (in Serbian), on the site www.dundjer.co.rs , and in [4].

4. FINAL PROJECT BENEFICIARIES

Final direct project beneficiaries are 3 companies, members of Construction Cluster Dundjer, and its emplyees, as well as representatives of scientific-research institutions and the entire local community. The employees will receive elaborated practical training plans, based on which they will later continue to work in the company, because companies prefer to invest in their employees, through training in the workplace, profiling according to their business process, but to re-qualify someone from the labor market.

5. THE IMPACT OF THE PROJECT ON LOCAL / REGIONAL DEVELOPMENT

Businessmen gain on the quality of the existing workforce and thus raise their competitiveness and do not have to look beyond the required profile of their company. Representatives of the scientific and research institutions promote the cooperation of science and economy, and the local community receives skilled workers, who are fully in line with the needs of the market. The impact of the project on local / regional development is above all in raising awareness both among business people and the local community about the needs and benefits of dual education as the only possible model that can keep up with the development of technologies in the world. The bulky, sluggish,

and inert educational system can not cope with advanced technologies, so that it alone can provide theoretical knowledge, which is often obsolete and outdated itself. It is therefore necessary to cooperate with the economy as a clasp with new technologies and upgrading the school system. The additional facts for project influence are:

• The installation of solar panels makes a significant positive feature of the building when issuing an energy passport for the building;
• Step towards achieving Agenda 20-20-20;
• Leads to the optimization of the ultimate price of the property, given all the advantages mentioned above.
• The impact of the project on the economic strength of the construction cluster itself is obvious, because the economic strengthening of cluster members and the cluster itself becomes economically strong.
• Entrepreneurs, strengthening ties with scientific and educational institutions, have a backward impact on the creation of state policy development and the promotion of entrepreneurial education, which should create a base for future experts who will be competitive both on the domestic and foreign labor market. There is absolute replicability of the effects of the project due to its very wide application in the construction sector, as well as in other industries. The project results could be simply replicated on other cities and municipalities, which also face the working power deficit, especially in skilled workers, supported in this way by dual/corporate practical trainings.

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UČEŠĆE GRADJEVINSKOG KLASTERA „DUNDJER" U SISTEMU DUALNOG OBRAZOVANJA U OBLASTI KORIŠĆENJA SOLARNE ENERGIJE

Rezime: *Pravljenjem ankete medju članicama klastera Dundjer iz Niša, ustanovljeno je da više od 50 odsto poslodavaca ima problem da nadje radnike sa potrebnim veštinama*

kako medju svojim zaposlenim tako i medju nezaposlenim na birou rada.Osim toga, poslodavci su istakli da bi radije ulagali u praktično obrazovanje postojećih zaposlenih, čime bi im povećali privrženost firmi, nego da od početka edukuju nekog nezaposlenog radnika, bez ikakvog iskustva. Potreba za dodatnim obukama zaposlenih, koje nisu deo formalnog sistema obrazovanja, već su pretežno praktične obuke, uočena je naročito u oblasti energetske efikasnosti, ekološke gradnje i korišćenja solarne energije. Ove tri oblasti su prepoznate kao prosperitetne u gradjevinskom sektoru, gde se može izvršiti povezivanje privrede sa naučno-obrazovnim i razvojnim institucijama, uspostavljanjem dualnog obrazovanja radi unapredjivanja proizvodnih procesa i procedura kroz implementaciju naučnih dostignuća i unapredjenje kompetencija zaposlenih. U tu svrhu bilo je potrebno napraviti pojedinačni plan i program praktičnih obuka prilagodjen svakoj konkretnoj firmi i njenim kapacitetima i potrebama u navedenim oblastima, u ovom slučaju u oblasti korišćenja solarne energije. U ovom radu dat je prikaz projektovanja metodologije i plana praktične obuke za tri kompanije, članice klastera Dundjer, u sistemu dualnog obrazovanja iz oblasti primene solarne energije.

Ključne reči: *Solarna energije, dualno obrazovanje, korporacijsko obrazovanje, energetska efikasnost, pametna kuća*