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Quality, Productivity and Performance Relationship in Renewable Energy Systems

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Abstract **– In this study, Quality, Productivity and Performance Relationship in renewable energy systems are examined in terms of Standards and Quality Management, Process Approach and System, Resource Management and installation. This study initially focuses on the concepts of quality, productivity, performance, skill, effort, education continuity, consistence and sustainability, and the relations between them. Then, providing examples from renewable energy systems, process, process management and the importance of process approach is discussed. In this study, the role of adopting the process approach in increasing the performance, productivity and effectiveness and the needed processes for a management system are emphasized. The effect of human source on processes, the role of technical staff in the process, employment of technical and vocational schools in the sector are dealt with. Then, factors causing performance losses and energy feasibility in renewable energy sources and uncertainties are dwelled on. In the study, handling the processes within the frame of respect towards humans, other entities, living beings and environment, the efficient and effective use of finite natural resources without harming the environment, spreading the understanding of using the resources to meet the needs without wasting them, raising ecological consciousness and sensitivity are focused on and the need for handling environment, energy and quality concepts together for the purpose of fostering quality life and environmental conscience are emphasized. Finally, electricity need, production and diversification are dwelled on.**

Keywords **– Quality, Productivity, Performance, Renewable Energy, Solar Energy**

I. INTRODUCTION

The secret key word that opens the door of information society, education, development and competition is "quality". Since 1980's, with the increasing influence of globalization, quality has become a popular concept and a desired component in all areas of life such as education, health and security[1].

Quality is not a feature with a definite meaning. Maybe it is a concept that incorporates several features. People's power to purchase their endless needs, fashion, traditions and life styles affect quality. The reason why quality is defined in different and various ways is the fact that quality is a versatile and multi-dimensional concept. All definitions are expressions of different points of view on quality [2].

Eight dimensions of product quality management defined by David A. Garvin[3] are performance, features, reliability, conformance to standards, durability, serviceability, aesthetics or style and perceived quality.

Performance refers to a product's primary operating characteristics. This dimension of quality involves measurable attributes, so brands can usually be ranked objectively on individual aspects of performance. Overall performance rankings, however, are more difficult to develop, especially when they involve benefits that not every consumer needs. Performance is often a source of contention between customers and suppliers, particularly when products are not adequately defined within specifications. The performance of a product often influences the profitability or reputation of the end user. As such, many contracts or specifications include damages related to inadequate performance. The question of whether performance differences are quality differences may depend on circumstantial preferences-but preferences based on functional requirements, not taste. Some performance standards are based on subjective preferences, but the preferences are so universal that they have the force of an objective standard [4].

Productivity and Performance are the terms employed as the strategy behind the development in improving the determinant of success. Benchmarks are those said to gauge future performance and relative effectiveness which are said to have standard setters.

Productivity is a workflow process that gives output qualitatively measured in terms of profit and benefit. Performance is totally dependent on independent workforce measured quantitatively and also the important part to know is productivity is directly proportional to performance where each person brings to the table a different knowledge of the process, as well as individual experiences.

Skills and talents are valuable capitals. Along with skills, increasing the performance and maintaining it can only be realized through effort, diligence and hard work. These can be reinforced through education. Receiving education starting from early ages is important in terms of continuation, stability and sustainability. Human constantly develops and changes sociologically, culturally and biologically and shows interest in every new and different thing.It is a necessity of human-centered understanding to achieve maximum productivity through evaluating the human resource in the best way possible and enabling him/her to reach the highest performance in accordance with his/her skills and talents. The personnel affecting the favorability of the product should be competent in terms of proper education, skills and experience.

There are many studies on education and training. An article by R. Akdağ[5] is on "Investment on Human and Emotional Intelligence", the role of education on the development of a country is studied by Z. B. Ünal, Z. Öndoğan, O. Pamuk[6]. Vocational and technical training are of particular importance in countries that are

economically strong. Countries, relevant institutions and organizations make action plans for developing education and also update or revise them. One of the main purposes of vocational and technical education is to meet the need for the qualified personnel. Vocational Higher Schools hold a very important place in meeting these needs.[7]. Related to the subject, quality in technicians' training is studied by İ. İçöz [8] and total quality management in technicians' training is also studied by M. Küçük[2].

II. System Designing Process

Renewable energy (Solar, Wind, Geothermal, biomass/biogas, hydrogen, tidal, hydroelectric, etc) systems and technologies concern and contain several issues, systems and fields such as machinery, material development, construction, electrics, electronics, computers, control and automation. For instance, a wind turbine consists of several components such as rotor, generator, spiral gear box, power distribution unit, shaft, control unit, measurement devices, blade and tower. In the same way, solar photovoltaic power system and hybrid systems consist of several components as well. In order for the system to function properly, several necessary operations and the interaction of operations must be determined and managed accordingly.

The operation or group of operations manage for the purpose of changing input into output can be interpreted as process. Defining processes, the interaction of processes with one another, the management of processes for producing the desired output, determining, applying and controlling the connections, combinations and interactions between processes within the system of processes are called the process approach.

Process performance and constant improvement of processes (Kaizen of Processes) through measuring activities is also of great importance in terms of sustainability and continuity. PDCA (Plan Do, Check, Act)methodology is a handy tool that can be applied to all processes. This tool is used in accordance with a policy suitable for the purpose (quality, environment, energy, work safety etc.) Plan: Form the necessary processes

Do: Apply the processes

Check: Measure the processes, monitor and report the results

Act: Review so as to improve the process performance constantly and take precautions as taking precautions is easier than correcting errors and it also costs less.

Achieving perfection is aimed by repeating the cycle continuously. Hence, standardizing the actions, improving and developing the achieved standards can be ensured. Being used in management systems such as PDCA cycle and Kaizen (continuous improvement),ISO 9001, ISO 14001, ISO 50001, OHSAS 18001 etc., process management is considered important in terms of continuity, sustainability, effectiveness and productivity.

Adopting a system is a strategically decision. Designing, applying, realizing and sustaining the system is influenced by conditions such as the environment, changes in the environment, risks imposed by the environment, changing needs, products and services; processes, organizational structures, the size of the institute or the organization, etc. Adopting process approach while establishing, improving and sustaining a management system has an important role in increasing the performance, productivity and effectiveness. The processes needed for a management system includes processes concerning management operations (responsibilities), supplying/managing the sources, manufacturing the product/realizing the service, assessment, analysis and improvement. It is human who establishes, manages, applies, controls, monitors, reviews, improves and develops the system. A process or a system can be directly or indirectly influenced by the person doing any of the tasks. Thus, the personnel carrying out the tasks affecting conditions of the product must be competent in terms of proper training, education, skill and experience. Processes require several technical tasks to be performed properly. The competent and proper use of resources influences the productivity and performance of the processes in a positive way.

The most important existence, value and source in the nature is human. Human is the source that influences the result the most. Competent, crafty technical personnel who have received sufficient technical and practical training to carry out the tasks required by the sector are needed. These personnel are available in vocational and technical schools and colleges raising technical employees. Especially those who receive training and graduate from such programs as mechanical technology, electrical technology, electrical device technology, electronic technology, computer technology, mechatronics, control and automation technology etc. adapt to the sector more easily. After receiving adequate training in installation of energy systems, the technical personnel trained in these programs can meet the needs of the sector and competently work in fields such as set-up, maintenance, assembling, disassembling, repairs, measurement control, checkup, experiments, testing etc. There is also a study as to the importance of intermediate staff in electric energy systems sector, the missions they can assume and the quality of contributions to be made by vocational schools in employing them efficiently and effectively [9]. Monitoring the employee's performance, as well as choosing the right technical employee, exposing him/her to vocational training, employing him/her in the proper position, is also of great importance.

Humans (employees, workers), established system, the material used, the machinery and equipment used, environmental factors and factors as such can result in loss or reduction in the performance. For stability, continuity and sustainability, it is essential to determine and monitor the influence of all factors, to take protective and precautionary actions, to make and review enhancement and improvements continuously. When it comes to the issue of wind-power among renewable energy sources, doing an energy feasibility study of wind power stations is vital for the applicability, cost forecasts, production calculations and supplying funds. In the measurements and calculations during energy feasibility processes, devices and methods must be used in accordance with international quality

standards (WMO, IEC, MEASNET, ISO, FGW). The technical personnel and engineering team to take part in the process must also do their work in compliance with national and international calculation standards. When these measurements are made and studies are done utilizing devices and methods suitable for the qualities of the project, the uncertainties in energy calculations are minimized and cash flow calculations along with financial calculations are based on a dependable foundation. For the financial forecasts to be realized and economic performance to be sustained, it is necessary to make the project design of the plant according to some productivity criteria, to implement the set-up sticking to the project and to record processes while strictly inspecting them. In the same way, the operation of the plant must be maintained at a certain quality standard in order to produce the amount of energy forecast in the feasibility plan. The precautionary maintenance procedures of the wind turbines-expected to function for 20 years - must be carried out without any delays, production statistics must be monitored carefully and the improving maintenance of the turbines experiencing a decrease in performance or malfunctioning frequently must be done on time.

For a wind plant's economic value to be maximized, qualified personnel must be employed in measurement, feasibility, engineering, construction, set-up and operation processes, all the tasks must be carried out according to quality standards and all the processes must be recorded by independent inspectors. Only through this way can wind plants turn into sustainable businesses, create employment and contribute to economy.

In the same way, degradation in solar photovoltaic modules and decrease in performance and productivity as a result of this degradation can be given as an example. Degradation is a result of a combination of factors such as high temperature, humidity, thermal cycle, exposition to ultraviolet lights and high voltage. It is important to consider which condition or conditions have led to the degradation and to carry out protective and precautionary activities. Real implementation tests and standard PV module tests based on accelerated (aging) simulation tests have been developed and still continue to be developed. Thus, defining and evaluating the uncertainties influencing the results are important in terms of forecasting the deviations in the production expectations and play an important role in assessing the cost, finance and production income of the project(feasibility-profitability report). It is possible to monitor, identify and consider the visible and invisible costs even in the design phase by making work measurement with simulation system and to do the work faster and more effectively, thereby achieving higher productivity, by using a work study that contains a method study and a time study. Making the product-production design, plans, analysis, checks, inspections and reviews, developing production and operation system, standardizing all of the processes starting from design and planning and reaching higher levels of standards by constantly improving these standards contribute to performance and productivity. Adopting this understanding as work culture saves institutions, systems and employees from cumbersomeness and monotony.

On the other hand, it is not only a conscientious and moral responsibility to take these processes into consideration within a framework of respect to humans, other living beings and environment but an obligation we have for future generations. Products and activities affect the environment not only on a local scale but a global one as well. Therefore, it is essential that natural resources be used effectively and efficiently. The resources are not infinite. They are limited and scarce. "Scarce" does not mean "deficient". They are sufficient for everyone. If one walk of life uses or spends it more than the others, the others have to spend less and have to share what is left. Spreading the understanding of meeting needs without wasting resources, raising ecological awareness together with quality life must be handled as a policy. It is vital that environment, energy and quality policies be discussed and evaluated together.

Immigration to the cities has led to the increase in need for electricity and its production due to reasons such as rapid increase in city populations, the increase in electrical household appliances etc. Electricity production with lower and more reasonable costs brings about various practices every day. On the other hand, the replacement of coal-carbon based inefficient conventional plants with efficient facilities and clean energy power plants is encouraged for the purpose of decreasing the use of resources contributing to global warming. In recent years, especially in some particular European countries and in the US, encouragement and support mechanisms have been increasingly utilized in order to improve and support the widespread use of renewable energy. Power plants with higher productivity and lower emissions are gaining importance. Cost element in establishing renewable energy systems makes the transition to these systems harder and delays it in countries with lower national income, purchasing power and lower household incomes. In the transition process, hybrid systems can accompany network connected systems. At the same time, the integration of systems and smart systems highlight energy management and productivity. Concerning energy, which is an essential factor for sustainable growth and development, countries are gravitated towards energy diversification so as to decrease their energy dependence and gain energy independence.

III. Case Study

As is known, one of the most important factors affecting the energy harvest expected in photovoltaic energy systems is that the system is set up in the proper angle of repose and orientation. In a study we carried for the 1kWp photovoltaic system scenario symbolically designed in İzmir within this scope, the best panel inclination angle is established to be 34^o and the best panel orientation was established to be 0^o (due South). On the grounds of these findings, the energy productions expected in inaccurate angle and orientation scenarios are calculated and these scenario results are compared with the best possible case.

Within the scope of this study, the angles of repose and orientations of the photovoltaic panels in the system are presented comparatively. A comparative study is carried out on the effects of changes in situations on efficiency and performance.

Table 1:The comparison of different angle and orientation scenarios for a photovoltaic system designed in the location of İzmir

		Monthly Energy Production kWh													
Inc. (°)	Orient (°)	J	F	M	A	May	J	Jul	A	S	O	N	D	Tot.	Decr %
34	0	92,00	92,80	140,00	142,00	159,00	162,00	158,00	158,00	152,00	137,00	104,00	83,00	1.580,00	
34	180	19,00	20,90	55,10	88,60	129,00	147,00	134,00	105,00	62,10	28,30	18,60	16,70	824,00	-47,85
34	90	52,10	61,60	106,00	121,00	149,00	158,00	150,00	137,00	115,00	90,80	59,50	45,30	1.250,00	-20,89
34	-90	52,50	61,80	107,00	122,00	150,00	159,00	152,00	139,00	116,00	91,40	59,90	45,20	1.250,00	-20,89
20	0	80,10	84,70	134,00	143,00	166,00	174,00	168,00	162,00	147,00	125,00	91,00	71,40	1.550,00	-1,90
20	180	23,90	38,60	83,70	112,00	149,00	165,00	155,00	130,00	93,90	58,50	27,30	19,00	1.060,00	-32,91
20	90	53,80	64,00	111,00	128,00	158,00	170,00	161,00	147,00	122,00	95,00	61,40	46,40	1.320,00	-16,46
20	-90	54,10	64,20	111,00	129,00	159,00	170,00	162,00	148,00	123,00	95,40	61,70	46,40	1.320,00	-16,46
0	0	55,00	65,80	115,00	133,00	165,00	178,00	169,00	154,00	128,00	98,10	62,90	47,30	1.370,00	-13,29

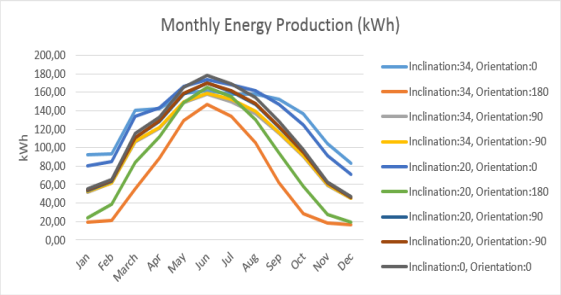

Fig. 1: A comparative graphic of different angle and orientation scenarios for the photovoltaic system designed in the location of İzmir

In the 1kWp FV system designed in İzmir location, firstly the situation in the optimal inclination (34°) and orientation (due South) is examined. As a result of this examination, the annual energy harvest of the 1kWp system is calculated as 1580Wh/year. Then, the same system is handled for different situations and the results are compared. For instance, an energy reduction of 47,85% is detected between the best possible situation -the optimum angle and due South orientation- and the scenario designed with the optimum angle and North orientation. The figures related to all of the examined cases are presented in Table 1.

IV. Results

Productivity and Performance are the terms employed as the strategy behind the development in improving the determinant of success.

Skills and talents are valuable capitals. Increasing and sustaining the performance along with skills can be possible through effort, diligence and hard work. These can be enhanced through education. It is important for the individual to receive education starting from early ages in terms of continuity, stability and sustainability in life. Making use of the human source in the best way possible and attaining maximum productivity by employing every person in a position fitting his/her skills thereby helping him/her reach the peak performance is a requirement of a human oriented understanding.

Defining processes, the interaction of processes with one another, the management of processes for producing the desired output, determining, applying and controlling the connections, combinations and interactions between processes within the system of processes are called the process approach.

Adopting process approach plays an important role in increasing the performance, efficiency and effectiveness.

Process performance and constant improvement of processes (Kaizen of Processes) through measuring activities is also of great importance in terms of sustainability and continuity. PDCA (Plan, Do, Check, Act)methodology is a handy tool that can be applied to all processes. If this tool is used in accordance with a policy suitable for the purpose (quality, environment, energy, work safety etc.), it can reveal its true effect. The personnel carrying out the tasks affecting conditions of the product must be competent in terms of proper training, education, skill and experience.

Now that products and activities affect the environment not only on a local scale but a global one as well, it is important to discuss and evaluate environment, energy and quality policies together.

The emergence of different practices in electricity production every passing day, the replacement of coal-carbon based inefficient conventional plants with efficient facilities and clean energy power plants for the purpose of decreasing the use of resources contributing to global warming put forward hybrid systems, the integration of systems and smart systems, which require energy management and productivity.

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AUTHOR'S PROFILE

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He was born in 1962 in Samsun. He graduated from Samsun Namık Kemal High School in 1979. After completing the Department of Mechanical Engineering at Yıldız University, Faculty of Engineering in 1984, he worked as an engineer in private sector 1984-1986. In 1990, he started her graduate education at 9 Eylül University Engineering Faculty, Mechanics Engineering and in 1994 he started her doctorate education at 9 Eylül University Engineering Faculty, Mechanics Engineering. He worked between 2000-2009 as a lecturer at Ege University. Since 2009, he has been working as a assoc. prof. dr in Vocational High School at Ege University.