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We know that sun is responsible for life on earth and is ready to contribute and at service permanently to support the life on earth. Renewable energies as sun, wind energy and bioenergy were available before, is available today and will be available for ever in the future.

Energy production and consumption based on coal reserves during the industrial revolution was the initiator of the energy problems on earth. After 1950s, following the Great London Smog during which about 4500 citizens died in London, petroleum became the preferred fuel with less damage to environment. After the petroleum crisis in 1970, energy savings became an issue together with the waste heat from nuclear reactors designed for nuclear weapon material production facilities. The dream of nuclear waste heat power plants as a solution to energy problem was over after 1978. There were no nuclear waste heat power plants ordered in USA for the last 35 years and 100 of them which was ordered between 1973-1978 were cancelled after 1978.

Beginning with late 1970s, we see early industrialized countries initiating energy technology development efforts under OECD IEA Technology Agreements on energy efficiency, clean coal technologies, safe nuclear power plants and renewable energy technologies.

Energy end use efficiency became the main pathway to a sustainable energy future. The problem faced was the dislocation of inefficient and polluting energy conversion and end use technologies from industrialized countries with higher environmental standards to developing countries with lower environmental standards.

With the UNFCCC, United Nations Framework for Climate Change Convention, clean coal technologies became obsolete technologies which could survive only with harmful subsidies. The efforts to develop safe nuclear power plants could not be realized and the support for research has almost diminished without any results and benefits for the future.

German and British environmental economists working on environmental externalities have calculated the social costs which damages the human health and the natural environment. Internalization of external costs of conventional energy production and consumption technologies became the main reason for the industrial countries converting from unsustainable and polluting conventional technologies to renewable energy technologies. The transition started in USA (1980) and Germany (1993). After Obama administration took over in USA, wind turbine on shore, PV on roof installations, led lighting and electrical vehicles has ended up with a clean energy revolution which is declared in 2013 by USA DOE (Department of Energy) Secretary. Naturally the first step was energy end use efficiency in transportation, industry and buildings to reduce the size of the problem.

Today renewable energy technologies are available in markets in modest capital costs working with free, renewable, always available renewable energy resources. The cost of electricity production from renewable energy is now about 3-5 dollar sent / kWh. The global installed capacity reached to 450 GW for wind and to 250 GW for PV. As a result, global demand for petroleum and coal is becoming lower for each day. For conventional fuels, the prices increase as there is more demand; renewable energy becomes cheaper as more people use it.

In any community, defining problems correctly and finding solutions that can be implemented requires the participation of the stakeholders with their information, expectation and demands in the decision making process. Community power is emerging for the 100% renewable energy communities with the participation and ownership of the local stakeholders.

Renewable energy as a high entropy fuel is available globally and locally in lower quality. That's why we can consider it as people's energy. Always available for people nest to their houses, businesses, and living space, sun never denies its light and heat to human beings.

Finally in cooperation with energy end use efficiency, symphony of renewable energies provides a permanent solution for long lasting energy problems of the earth. The distributed and intermittent nature of renewable energy generation requires smart grids and renewable energy storage facilities to supply 100% of the energy demand. This is how we can make the solution independent from the problem; renewable energy independent from the fossil fuels and nuclear waste heat. It is clear that we should define the problem and the solution and separate them from each other and decide about where to go.

For any energy resources to be a solution, first criteria are sufficient resources; the second criteria are the availability of the technologies using this resource; the third criteria are that the cost should be more favorable and competitive with other alternatives; and the forth criteria is the existence of the local and global decision makers who are on the solution side.

Energy decision support tools need to be used for local communities and countries for planning the future of the community energy systems with the renewable energy technologies of the future.

Transition to ecological and democratic societies using 100% Renewable Community Power is important, but today more important is "how to speed up the global transition to 100% Renewable Energy?" which will be the main concern of IRENEC 2017 which will take place in Istanbul on 18-20 May 2017.

Tanay Sıdkı Uyar

Conference Chair, IRENEC 2016

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(EUROSOLAR Turkey)

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Efficient Use of Energy to Achieve Global Warming Targets

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ABSTRACT. Energy is one of the major inputs that play an important role in the social and economic development of societies. Depletion of the fossil fuels which provide most of the world's energy demand, increase in the consumption in industrial processes, the rise in the concentration of greenhouse gases in the atmosphere to dangerous levels to human health as a result of the destruction of the ozone layer, have put energy production and efficient use of energy among the most challenging topics today.

Crises in sharing the energy sources, steadily increasing environmental consciousness, increasing World population and the economic competition is forcing people to utilize the facilities they have more rationally. The energy sector must be kept under control, observed and planned carefully for the future especially in developing countries; migration to large cities, the altering and improving life standards and the development in many industries has increased the demand for energy rapidly and continuously. On the other hand energy has become the main issue in almost all engineering applications in the world today due to its steadily increasing price and its unpredictability.

The key issue to a sustainable development is the balance between the supply and demand of energy, keeping the environment clean, healthy and pollutant free. This topic is very important for Turkey, who is in the process of becoming a member to EU and a co-signer of the KYOTO protocol. Turkey imports more than half of her energy although she has a variety of primary sources. The difference between supply and demand is expected to reach 200 million TOE by 2020.

Energy efficiency is "a low hanging fruit" on the "energy tree" which can help address a number of objectives at the same time and at a low or negative cost, such as security of supply, environmental impacts, competitiveness, balance of trade, investment requirements, social implications and others.

This paper has been prepared to illustrate the energy efficiency measures and methods utilized in the industry, presenting the outcome of an energy analysis for the consumption for processes, heating and conditioning of production areas and office space heating of a pharmaceutical plant.

The influence of the building sector on global warming and ozone layer depletion has also been investigated. Approaches and actions taken by the European Union and Turkey as a candidate country to EU are discussed. A brief presentation of a software developed in Turkey, is introduced to assess the energy performance of a building.

Keywords: Energy, Efficiency, Energy Performance of Buildings, Energy Performance Software, Modeling

1 INTRODUCTION

Energy is one of the major inputs that play an important role in the social and economic development of societies. Depletion of the fossil fuels which provide most of the world's energy demand, increase in the consumption in industrial processes, raising the concentration of greenhouse gases in the atmosphere to dangerous levels to human health by destroying the ozone layer, have put energy production and efficient use of energy among the most challenging topics today.

The hole discovered in the ozone layer, in 1986 resulted in the banning of chlorofluorocarbons and were replaced by hydro chlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) which are not as effective. Today however we know that they have greenhouse effect as well. Climate change has been the focus of environmental protection and sustainability initiatives since 1990 as one of the major problems of our age. Environmental issues have attracted the attention of not only scientists but all kind of groups from the society.

Concerns regarding the environment and the sustainable development expressions in the activity report of the United Nations in 1987 have found ground in several countries around the World and have initiated environmental rallies. European Union countries, USA, Australia and Canada and especially England have supported sustainable development policies by passing laws. As a result nations have found themselves in a discussion platform related to social, ecological, economic and cultural sustainability in addition to their development models and issues. United Nations Framework Convention on Climate Change (UNFCCC),has been made effective on March 21, 1994 to prevent the manmade dangerous influence on climate systems and the greenhouse gas accumulation in the atmosphere. As a first step to limit greenhouse gases on an international level which has the power to apply worldwide sanctions, was arranged in Kyoto, Japan on December 11, 1197, the KYOTO Protocol and made effective on February 16, 2005. 191 countries have signed the protocol as of September 2011.

COP21 (Conference of the Parties) or CMP11 (Meeting of the Parties), was held in Paris between November 30 – December 11, 2015 with the participation of 196 countries. This was the 21st meeting since the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and eleventh between the parties of the 1997 Kyoto Protocol. The 5th evaluation report issued after the Intergovermental Panel on Climate Change (IPCC) in 2014 states that the greenhouse gases emitted since 1870 must be kept under 2 900 Gigaton to keep the average global temperature increase below 2ºC [1]. The aim of the Paris summit was to reach an international consensus to describe the measures after 2020 and agree on a treaty not to exceed the 2ºC limit.

2 ROAD MAPS AND LEGASLATION

There has been a great increase in the number of laws issued in Europe related to energy and the environment. This number has tripled in the last twenty years. An important portion of them is related to building services and HVAC systems. The term HVAC can be perceived differently in different countries. In cold climates it is understood as heating, cooling and ventilation, whereas in the Mediterranean countries for example as only cooling and ventilation.

The selection and design of an HVAC system depends on several parameters, such as, how the building is used (residence, commercial, office, industrial, etc.), the budget, primary energy source and price, duration of the utilization of the spaces, hygienic properties, etc. The relation between the different factors should be studied carefully to find the ideal solution. Usually there are more than one alternative. A residential building can be designed with individual heating/cooling, all air heating/cooling, combi boilers, split air conditioner or central heating/cooling. The building may have several systems operating together. An industrial facility can utilize fan coil systems for theating and cooling the offices and an air system for the production halls. We should not forget the alternative renewable energy systems (heat pumps, solar collectors, PV panels, etc.) [2, 3].

2.1 Energy Balances

Although Turkey has several energy sources, she imports more than half of her energy production. In 2006 the total energy production was 31,7 million TOE and the consumption 101,7 million TOE [4]. The energy deficiency was 570 million TOE. Predictions indicate that this figure will exceed 200 million TOE by 2020. Import of oil, gas and coal will continue to cover the energy demand in the future.

The primary energy consumption profile of Turkey indicates that the share of buildings is 26%, the industry 27%, power plants 24%, transportation 14%, agriculture 2% and other 4%. The fuels consumed are 32.5% oil, 28.2% coal (including lignites), 28.9% natural gas, 8.1% wood and 5.1% hydraulic [5, 6].

Combustion of fossil fuels has an important role in the utilization of the energy sources. A slight increase in the combustion efficiency would result in extreme savings. The energy production methods used today have several inconveniences very well known to everybody. They rely on limited resources (fossil fuels), pollute the environment (air and water pollution, waste storage) and enhance greenhouse effect.

Combustion of fossil fuels results in the liberation of carbon in the form of carbon dioxide. This gas is known to be one of the major greenhouse gases created by humans. Today we are experiencing climate changes in the form of draughts, floods, extreme temperatures, diminishing corals and melting of ice blocks in the arctic region. Therefore we are forced to give up on fossil fuels, switch to renewable sources and reduce the liberation of carbon dioxide.

Energy supply of Turkey, according to 2012 figures depends on, 30.7% coal (14.8% lignite), 25.3% oil, 4% hydraulic, 30.9% natural gas, 6.3% solar, geothermal, wind and other renewables, 2.8% non-commercial sources like wood, animal and plant waste [6]. 72% of Turkey's energy consumption depends on imports.

2.2 European Union

The EU countries have acted with responsibility although their share in the global greenhouse gas emission is only 10%, and have accepted as a policy to bring the levels to 85 – 90% of the 1990 level by 2050. We can summarize this with the 20 – 20 – 20 target of EU. They have achieved the 2012 target and are aiming to beat the 2020 goal. They have prepared a road map (March 8, 2011) to establish a carbon economy and determined the key elements by 2050.

Member states have been promoting renewable energies and energy efficiency in their individual state policies since a long time. They have also been playing a pioneer position in the international arena. The reflection of these policies has led to the establishment of zero energy buildings. These buildings have no net energy consumption and do not produce carbon dioxide. According to EU targets, public buildings by 2018/2019 and all other buildings by 2020/2021 should be zero or near zero buildings.

The EU has issued the Energy Performance for Buildings Directive, EPBD, (2002/91/EC), to serve the purpose. This directive can be considered as a progression of the previous directives, Hot Water Boiler Directive (92/42/EEC), Construction Materials Directive (89/106/EEC) and SAVE Directive (93/76/EEC) which aims on energy efficiency to reduce carbon dioxide emission.

Energy performance criteria for buildings have existed since the 1970 oil crisis. These initiatives have started as pilot projects; high performance buildings have been designed, built and used. Successful applications have been adopted by construction companies due to the interest they have attracted. Within the years they have been converted into standard applications. The process has ended up in the release of national standards and regulations. Figure 1 illustrates the process for Germany. Other countries have shown similar developments. The top line demonstrates the minimum requirement for the "Wärmeschutzverordnung", insulation regulation (TSE 825 for Turkey) and the "Energieeinsparverordnung", Energy Efficiency Regulation (BEP for Turkey) for Germany. The bottom line indicates the level for pilot projects. The intermediate area accounts for the variation of the average level of performance in construction practice. The bottom right corner shows the energy plus buildings becoming more and more popular recently.

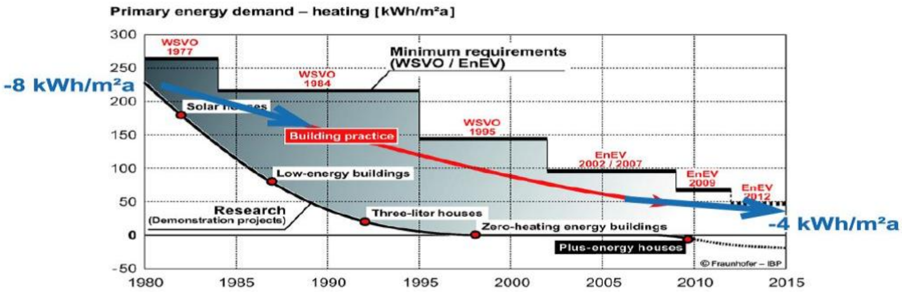

Fig. 1. Development of Energy Efficiency of Buildings in Germany [7]

A revision has become necessary within the years to account for the encountered difficulties. This revision was issued on July 9, 2010. Accordingly, the member states were forced to issue laws, regulations, legislations, etc. by July 9, 2012. The directive also requires the states to ensure that all new buildings built after 2020 to be nearly net energy buildings, nnZEB and public buildings after 2018. The member states should also issue national plans for:

- A definition to give an approximate annual kWh/m^2 primary energy consumption value that takes into account local, national and regional elements. Factors for the calculation of primary energy can be based on from national or European standards.
- Intermediate targets for 2015.
- Financial and political benefits for nearly net zero energy buildings.

The 2010 revision of the EPBD requires states to determine the energy demand of buildings using the cost – optimal concept. Moreover calculations should be made with comparable methodologies. Cost – optimal level is defined as the level accounting for the minimum cost for the life cycle of the building. The level is established considering investment, maintenance, operation costs and energy saving projects. Economic life of the building can vary and should be defined by each state. Comparable methodologies can be guided by

- Defining reference buildings
- Defining energy efficiency measures
- Assessing the real and primary energy demand of the reference building
- Calculating the application cost of these measures

We have to be careful with the cost effective economic and cost – optimal concepts. An energy efficiency project is economic if the cost of the application is lower than the profit during the life cycle (net present value is positive). The cost – optimal solution is the one that maximizes the net present value. The calculation becomes complicated compared to a simple insulation thickness problem when the whole building is considered. The optimum should be selected among several points as depicted in Figure 2.

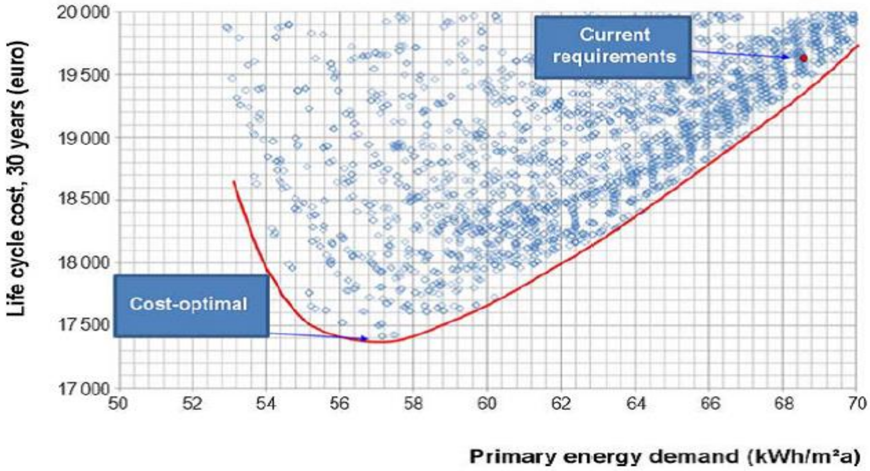

Fig. 2. Cost – Optimal Point for a Specified Country [8].

The definition of the reference building is critical. Differences for the buildings with respect to their function, location, indoor and outdoor temperatures should be considered. 9 different reference buildings should be defined at least (one new and two existing family houses, complexes and office buildings). In addition reference buildings should be considered or the following cases:

- Different private houses
- Apartments and block complexes
- Office buildings
- Education complexes
- Hospitals
- Hotels and restaurants
- Sport complexes
- Shopping centers
- Other

The new directive also brings the necessity to maintain and control the sustainability of the energy efficiency levels. A high performance building can suffer from negligence through the years.

2.3 Turkey

The Ministry of Environment and City Planning has been working on the subject for several years. The legislation is summarized chronologically.

- May 2, 2007 Energy Efficiency Law, No. 5627
- October 9, 2008 Heat Insulation Regulation, No. 27019

- October 25, 2008 Regulation for the Efficient Use of Energy Sources and Energy, No. 27035
- December 5, 2008 Energy Performance of Buildings Regulation, No. 27075
- February 6, 2009 Principles and Procedures for the Delegation, Certification, Reports and Projects covered by the Energy Efficiency Law, No. 5627, No. 27133

Turkey has been performed better in the subject and has passed the Energy Efficiency Law in 2007 and the related by – laws and regulations in the following couple of years. One of the milestones is the revision in the Thermal Insulatıon Regulation, TS 825 in 2008. This regulation is now under development to include cooling as well as heating.

3 ENERGY EFFICIENCY IN BUILDINGS

The purpose of the Energy Performance of Buildings Directive is to establish the rules during the assessment of the energy consumption of a building taking into account climatic data, indoor environment, local conditions and cost effectiveness, classify the building with respect to primary energy use and carbon dioxide emission, define minimum energy criteria for new and heavily renovated building, evaluation of renewable energy applications, control of heating and cooling systems, limiting greenhouse gas emissions and procedures for environmental protection.

It covers the principles and procedures to be applied to existing and new buildings including residences, offices and service complexes to cover the mechanical installation, lighting, electrical installation, electric consuming equipment, energy performance calculations, energy certification, independent, approved bodies to issue certificates and control buildings, investigate to guide the national energy policies and acquisition of related data.

3.1 Energy Certificate

An energy certificate is issued valid for 10 years for every building over 1 000 m^2 floor area. The certificate shows the following information and a sample is depicted in Figure 3.

- Energy demand of the building
- Insulation characteristics
- Efficiency of heating and cooling systems
- Energy consumption for heating, cooling, ventilation and domestic hot water (kWh/year)
- Primary energy consumption for each fuel used (kWh/year)
- Classification of the primary energy consumption between A and G
- Greenhouse gas emission for unit area (kg CO_2/m^2-year)
- Classification of greenhouse gas emission between A and G
- Energy consumption for lighting

- Energy class of the building with respect to primary energy consumption Certificates are being issued since January 1, 2011.

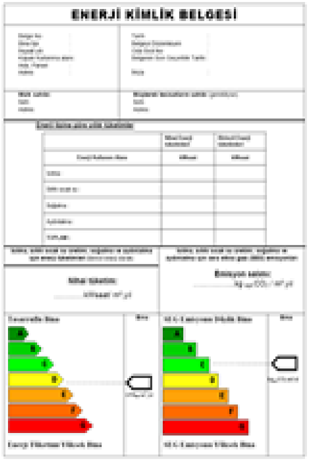

Fig. 3. Energy Class Certificate

3.2 BEP – TR Software

This is the energy performance evaluation software to assess the energy consumption of the building and issue the Energy Class Certificate shown in Figure 5. A calculation methodology had been issued as a part of the Energy Performance of Buildings Directive, date: 07.12.2010 number 27778. BEP – TR is the internet based software of this methodology. BEP – TR is a modular software composed of the following components referring to the standards mentioned on the side.

- Geometry and Material Properties
- Net Energy: ISO 13790
- Lighting: EN 15193 (Pre-standard)
- Solar Gains: EN ISO 13790:2004, EN ISO 13790:2008, EN ISO 15255:2007, EN ISO 13792:2005, Ashrae Fundamentals:2009
- Internal Loads: EN 15316, EN15241,EN 15243, EN 15193, Ashrae:2009
- Mechanical Installations: DIN V 18599:2007

It has four main modules. The first one establishes the geometry of the building, material properties, zones and the heat loss and gain of the structure on an hourly basis. The geometry is defined in a hierarchic flow associated with the component properties. It also provides the opportunity to read data from CAD software.

Properties of the building elements can also be introduced in a hierarchic pattern. Objects holding the geometry together (building, floors, zones, rooms, walls, windows, etc.) have been defined relative to each other. The drawing can be performed using a Professional CAD program or an existing CAD software output can be adopted. Curved contours are taken as polygons having 15º increments. Properties of the materials are given at every related step.

The second module, net energy demand of the building involves several parameters both active and passive. It is based on ISO 13790 standard. The building is broken up into zones and typical zone relations are defined as depicted in Figure 4. Heat storage characteristics of the materials are also considered during the calculations. The components of the structure are interrelated on an unsteady basis using an electrical network analogy.

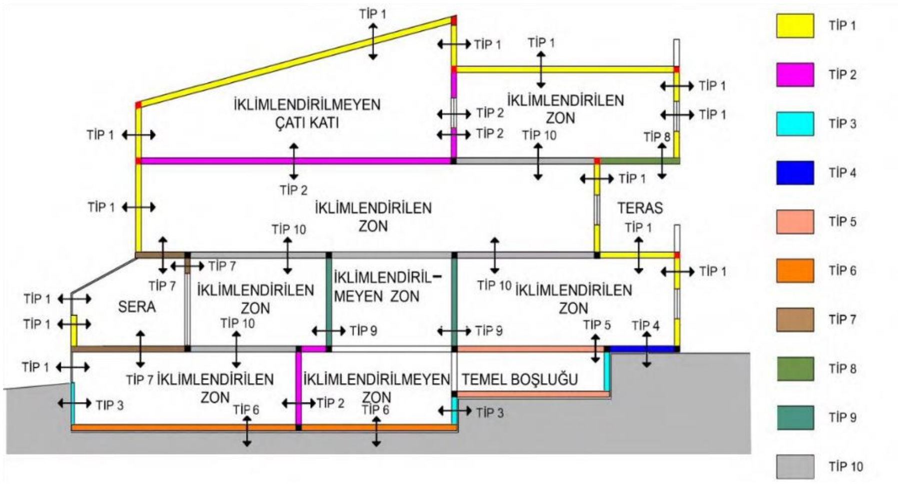

Fig. 4. Characteristic Relations between Zones

Heat storage characteristics of the materials are also considered during the calculations. The components of the structure are interrelated on an unsteady basis using an electrical network analogy as illustrated in Figure 5.

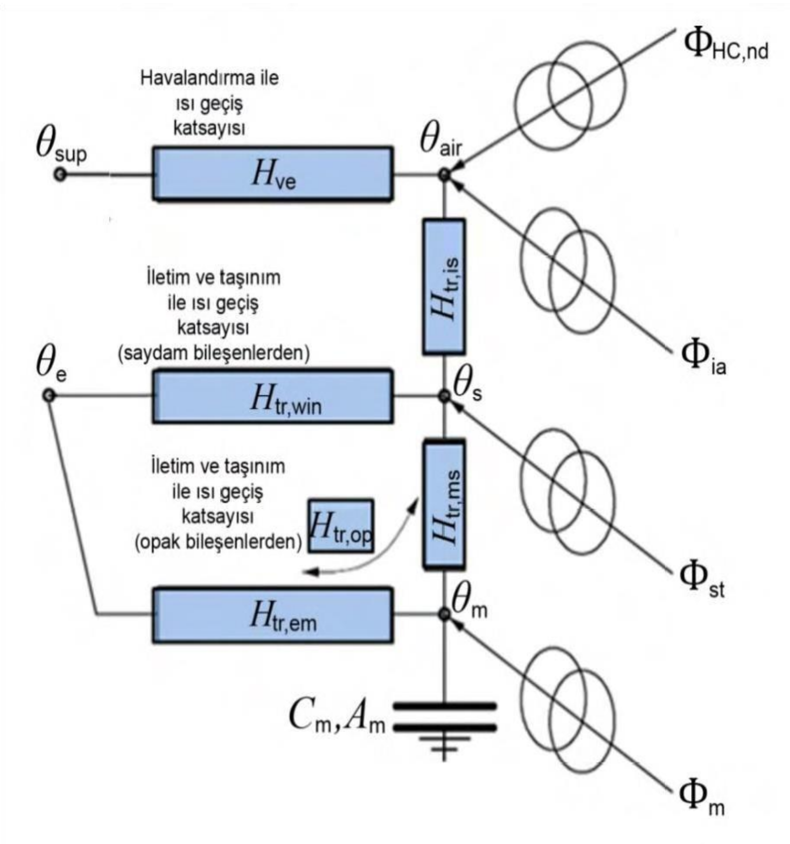

Fig. 5. Electrical Network Analogy for the Calculations [9]

The third module handles the lighting and the last one the mechanical system serving the building. The system has heating, cooling, ventilation, domestic hot water, cogeneration and photovoltaic elements as shown in Figure 8.

The lighting module uses a new methodology based on measurements and equations taken from the literature. Several new lighting alternatives have been included. Moreover, the height of the lighting fixtures and the color of the walls and ceiling have also been included to the calculations.

The net energy demand for the heating and cooling equipment to cover the overall building is transferred from the net energy module. The energy consumption of the auxiliary elements, like pumps, fans, etc. are calculated and added. Control system losses and consumption are considered.

The net energy flow of the building is assessed by including renewables like heat pumps, solar collectors, photovoltaic panels, cogeneration, etc. This consumption is compared with the results of the reference building to determine the energy class of the building. A match results with Class C.

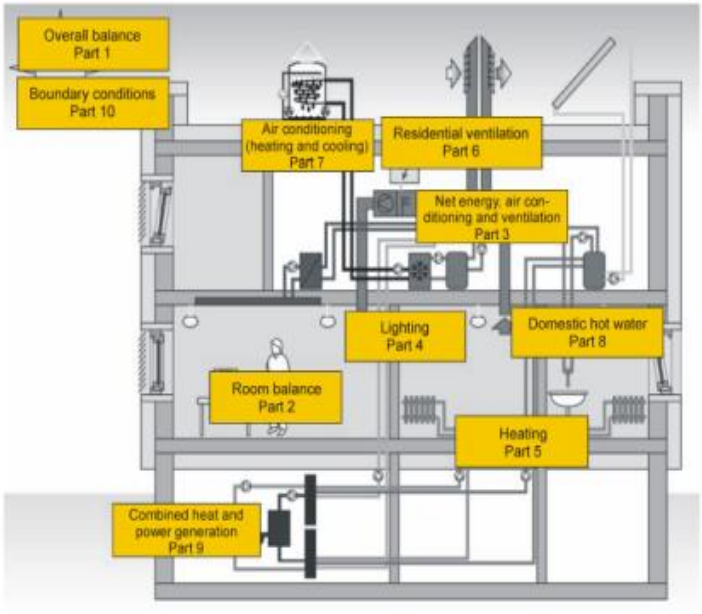

Fig. 6. Components of the Mechanical System [9]

Climatic conditions from different stations have been added to the tables in addition to the city centers. Also, the "bin data" for the evaluation of heat pumps have been included in the form of tables for city centers as well as smaller settlings, based on 1°C temperature classes. For the methodology to work for heat pumps, they have to be tested in accordance with the standard TS EN 14511.

Finally XML address tables have been established to aid software developers. A data dictionary has been prepared to introduce the terminology.

4 ENERGY EFFICIENCY IN THE INDUSTRY

Table 1 shows that the share of the energy demand for the industrial sector has increased from 21% in 1970 to 29% in 1998. Oil is the most important primary energy source with a share of 35.5% [10].

Table 1. Energy Consumption of Different Sectors (%)

	1990	%	1995	%	2000	%	2005	%	2006	%	2009	%
Industry	14542	35	17372	35	24501	40	28282	39	30974	40	25966	32
Buildings	15358	37	17596	35	20058	33	23013	32	23726	31	29466	37
Transport	8723	21	11066	22	12008	20	13849	19	14884	19	15916	20

Agricul-ture	1956	5	2556	5	3073	5	3359	5	3610	5	5073	6
Other	1031	2	1386	3	1915	3	3296	5	4163	5	4153	5
TOTAL	**41610**	**100**	**49976**	**100**	**61555**	**100**	**71799**	**100**	**77357**	**100**	**80574**	**100**

If we follow the energy prices in the world and Turkey, we see that the price of a barrel of oil was $3 in 1970. After the raise by the OPEC countries in 1973, it became $12, the Iran revolution, $28 and the Iran-Iraq war $34. Dropping to $16 later showed a sharp peak again when Iraq invaded Kuwait, $40. Today it is around $30. Gasoline sells for around $1.5 per liter.

The above picture indicates that, more than a half of the energy used by the industrial sector is imported and its price fluctuates drastically according to socio-political reasons. To reduce the foreign dependence of our energy character, alternatives such as;

- Utilizing new energy sources (Solar, wind, biogas, wastes, etc.)
- Applying new technologies (energy storage, hybrid systems, fluidized bed power plants, heat pumps, etc.)

could be considered. But we should not forget that, the most effective means is to reduce the amount of energy used and energy savings. In fact, when we remember the environmental impact (CO2 and greenhouse gases) of the problem, we will deduce that the best solution is the rational use of energy.

4.1 Planning energy savings in the industry

The first step towards the energy analysis of a facility is to establish the energy balance. Points of energy consumption, their energy demand and the load variations have to be assessed carefully. The distribution of the energy bought from the market (like electricity), the efficiencies at the consumption points and the losses are determined. Not only the momentary values, but also the daily, weekly and annual variations have to be considered. From the data, information like the average energy consumption, deviation from these values and the energy per product can be calculated.

In the second stage, energy rejected from each point is recorded. The waste is than compared with the energy demand of other points to find possible utilization. The synchronization of the available energy and the need is also very important; energy storage should also be considered if possible.

During the third stage, the technology needed to accomplish the energy transfer is investigated; relevant methods and equipment are selected. Feasibility studies are carried out and the return periods are calculated.

The last period of the process is to follow up the performance of the improvements. This stage is also very important because it is the dissemination of the gathered information and the experience to parties of interest.

There are several important elements related to the rational use of energy in industrial facilities.

- Electrical energy savings
- Thermal energy savings
- Mechanical energy savings
- Process energy savings
- Reclamation of materials
- Fresh water supply

4.2 Energy analysis of an industrıal facility

The measurement parameters and measurement points have been established. 9 energy zones have been chosen; the zones are summarized in Table 2. Steam flow rates and temperatures have been used to assess the energy consumption of the processes. Temperatures were recorded continuously and the steam flow rates in groups to minimize the number of flow meters. Temperatures and production programs were used to determine the operation periods.

Table 2. Energy Zones for Steam Consumption

Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Energy Zones	Boiler House	Pen. Process	Pen.Space Heating	• Office Heating • Old Office Building • Solids Manufacturing	Non-Pen. Process Liquids Manufacturing Solids Manufacturing	Non-pen. Space Heating	Ceph. Space Heating	Ceph. Process	Diessel Room + Distillation

Steam flow rates measured using 22 orifice plates and 5 flow meters. Two electronic flow meters were mounted on the 2 main steam lines and recorded continuously. The meters were calibrated at the beginning and end of the measurement periods. Temperatures were measured with J and T type thermocouples and recorded by 12 data loggers. The measurements were taken every 20-30 minutes. Data was processed with Excel-Macros. Flue gas analysis and fuel meter readings were also recorded regularly. Winter measurements were taken in February and March, summer readings in August and September. Production was 8 hours a day.

Tables 3 and 4 summarize the results of the measurements both for winter and summer. The total steam production calculated from the fuel meter readings have been distributed among the two major lines according to the measurements recorded by the flow meters. This consumption was then distributed among the various processes and equipment. The actual reading from the flow meters, the real values (Values of Fuel meters) and the total found as a result of the redistribution were compared for checking. It can be observed that the difference between the values is well within the error limits typical for such on-site studies. Sankey Diagrams were prepared to illustrate the share of each process or unit group in the total energy consumption.

Table 3. Distribution of Steam Consumption between Processes and Heating in the Winter (Production, Night, Weekend)

	Production			**Night**			**Weekend**		
	(%)	**Heating and Ventilation (%)**		**(%)**	**Heating and Ventilation (%)**		**(%)**	**Heating and Ventilation (%)**	
		Process Area	**Office**		**Process Area**	**Office**		**Process Area**	**Office**
Line-1	19.1	11.0	12.3	10.4	14.5	20.0	13.4	9.7	18.8
Line-2	14.1	42.2	1.4	8.5	45.4	1.6	13.7	42.6	1.6
Total	33.2	53.2	13.7	18.9	59.9	21.6	27.1	52.3	20.4

Table 4. Distribution of Steam Consumption between Processes and Heating in the Summer (Production, Night, Weekend)

	Production			**Night**			**Weekend**		
	(%)	**Heating and Ventilation (%)**		**(%)**	**Heating and Ventilation (%)**		**(%)**	**Heating and Ventilation (%)**	
		Process Area	**Office**		**Process Area**	**Office**		**Process Area**	**Office**
Line-1	25.3	5.5	0.2	40.4	1.7	0.0	38.8	0.9	0.4
Line-2	30.2	38.8	0.0	22.1	35.7	0.0	26.6	34.4	0.0
Total	55.5	44.3	0.2	62.5	37.4	0.0	65.4	35.3	0.4

The final distribution of the total steam consumption between the various processes and heating in winter and summer respectively are summarized in Tables 5 and 6 for production, night and weekend operations. The share of heating has been given for the production areas and the offices separately. It can be observed that, roughly 30% of the total consumption is consumed for the processes, 50% for heating and conditioning of the production areas and 20% for office space heating in the winter. In the summer roughly 55% of the total consumption is consumed for the processes, 45% for heating and conditioning of the production areas. Office space heating isn't applicable during the summer. Only domestic hot water is consumed but the relative share is negligible.

5 CONCLUSION

The influence of the industrial and building sectors on global warming and ozone layer depletion has been investigated. There are several measures that can be applied in industrial facilities to use energy more efficiently. The key is an effective energy analysis which considers the dynamic nature of the processes. Approaches and actions for improving the energy performance of buildings, taken by the European Union and Turkey as a candidate country to EU have been discussed. The evaluation should be based on a common methodology, defining reference buildings with cost optimal solutions. A brief presentation of software developed in Turkey has been introduced to assess the energy performance of a building.

It is not possible to achieve the global warming prevention targets without the efficient use of energy. We have already consumed two thirds of the allowed carbon emission declared at the Intergovermental Panel on Climate Change (IPCC) as of 2011. To stay below the safe 2ºC limit, investments and financial supports should be channeled to low carbon electricity, energy savings and its efficient use.

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Decentralized Grid Control

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ABSTRACT. In the near future decentralized small generators must provide grid control. This contribution presents solutions to replace rotating masses for momentary reserve and providing primary reserve power with battery storages. It is proposed to use the intermediate voltage capacitors in power converters to provide energy for the virtual inertia. Decentralized converters must be able to provide power of 5 W and energy of 50 Ws per installed kW of power in the worst case, which can easily be handled by typical battery inverters. Providing primary control power with batteries is limited by the capacity of the battery. Losses and imprecise frequency measurements may soon lead to a depleted or full storage. It is possible to reduce this issue by making use of several parameters of freedom.

Keywords: Grid control, virtual inertia, primary control, power converter, smart grid

1 INTRODUCTION

An electric power supply with 100% renewable energies will be based on decentralized small generators and less large power plants. At certain times, renewable energy sources contribute already up to 80% to the power consumption in Germany and soon shares of 100% for longer periods are expected **Error! Reference source not found.**]. Thus, the decentralized small generators must provide grid control. This contribution presents solutions to replace rotating masses for momentary reserve and providing primary reserve power with fluctuating generation as well as with battery storages.

1.1 Providing Virtual Inertia

Most power provided by decentralized renewable energy generators is provided by electronic power converters without rotating inertia. Fortunately, Germany's grid is part of the ENTSO-E, European Network of Transmission System Operators for Electricity, and today the missing inertia can be compensated by the other members, which have less renewable energies **Error! Reference source not found.**]. However, in future, this instantaneous reaction on load steps must be covered by the feed-in inverters **Error! Reference source not found.**] **Error! Reference source not found.**] **Error! Reference source not found.**]. These solutions are either costly or not sufficient. Therefore, here a solution for inverters (like e.g. used in Battery storages or PV systems) is investigated. It is proposed to use the intermediate voltage capacitors in the inverters, because they can react much faster than the battery itself. In addition, this concept can be applied to further inverters and even converters of loads, e.g. for LED lamps.

In this chapter, only the instantaneous reaction is considered, while the following primary control is taken over by a further control (see below). To get the power and energy requirements, the methodology and data of reference **Error! Reference source not found.**] is used: a worst case event of a lack of 3 GW power in the ENTSO-E grid is assumed. This requires 372 MW in the German grid. Assuming the primary control taking over with a linear increase within 20 s **Error! Reference source not found.**], this requires energy of 3720 MWs. Relating this to the peak demand of 80 GW leads to 4.6 W/kW, rounded up to 5 W/kW. Concluding, additional power of 5 W and energy of 50 Ws per installed kW power capacity is needed to cover one event.

Typically, the size of a capacitor relates to its maximum energy content. To determine the interdependence, the capacity, rated voltage, diameter and height of 190 electrolytic capacitors are collected from the website of an electronic components distributor **Error! Reference source not found.**]. Rated energy and volume are calculate from this data and shown in **Error! Reference source not found.**a. In real circuits, not the maximum rated energy capability Emax can be used, because the capacitor is discharged from the maximum voltage Umax only by a voltage difference □U. Then the usable energy Euse is:

$$E_{use} = E_{max} \cdot [1 - (1-\square U/U_{max})^2] \qquad (1)$$

This equation is used to illustrate in **Error! Reference source not found.**b (orange trace), which Emax is necessary, if the required energy of 50 Ws is stored. As mentioned before, this relates to an installed power of 1 kW. The blue curve relates to an extrapolation of the volume using the fit function in **Error! Reference source not found.**a.

It can be shown that the maximum voltage has no influence on the capacitor size and can thus be freely selected. Only the relative voltage difference, which can be considered as relative voltage ripple, determines the size. If a DC link capacitor is used, the ripple should remain below 10%, requiring least 300 Ws (e.g. 3800 µF/400V), resulting in a capacitor volume of about 100 cm³ (e.g. 4 cm diameter and 8 cm height). A size of this order of magnitude can typically be found in 1 kW single phase converters. The considered voltage step is relevant only for the worst case of an extreme power loss event.

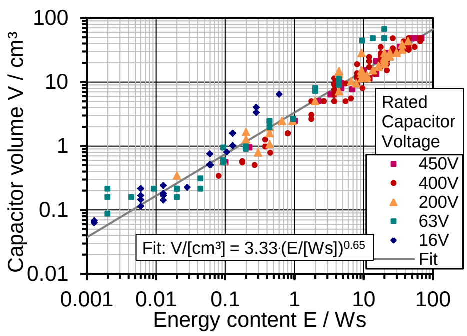
During daily operation, frequency fluctuations are much smaller and thus the expected voltage fluctuations on the capacitor are much smaller. Replacing a virtual inertia, the required control power □P is dependent on the time derivative of the frequency deviation □f from the nominal frequency f0 (50Hz):

$$\frac{\Delta P\ (t)}{P_0} = T_a \cdot \frac{d}{dt} \frac{\Delta f\ (t)}{f_0} \qquad (2)$$

P0 is the nominal power of the system (in this case the rated power of the inverter). Ta is a time constant. In the European power grid this time constant equals typically Ta = 20 s. □P is the power, which would be drawn from the grid by the power inverter in addition to the regular power. **Error! Reference source not found.**a shows the measured frequency (orange) for one hour on 8.Feb.2014. It is filtered to achieve reasonable results (red). The required additional power (blue) is only a very fraction of the rated power. Compared to the 100 Hz ripple on the capacitor, the additional ripple is an order of magnitude smaller and has thus no influence on the deterioration of the device. The power is used to charge and de-charge a capacitor with maximum energy content of 300 Ws, which relates to charging directly the DC-link capacitor (see above). From this the capacitor voltage can be calculated. The voltage variation □Uc is proportional to the integral of the current and thus approximately to the power. Thus, the integral compensates the time derivation df/dt leading to the following equation for the voltage variation □Uc:

$$\frac{\Delta U_c(t)}{U_0} = T_a \cdot \frac{1}{2} \cdot \frac{P_0}{E_0} \cdot \frac{\Delta f}{f} \qquad (3)$$

This equation is applied to the measured frequency in **Error! Reference source not found.**b (blue curve). The voltage variation during the investigated time remains between +3.4% and -3.4%. This is a quite small value, which can be handled easily by power electronics.



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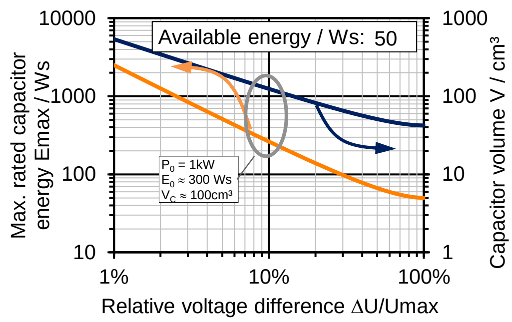

Fig. 1. Volume size of electrolytic capacitors. a) Various electrolytic capacitors, data from **Error! Reference source not found.**]. b) Needed capacitor energy and volume size to store 50 Ws.

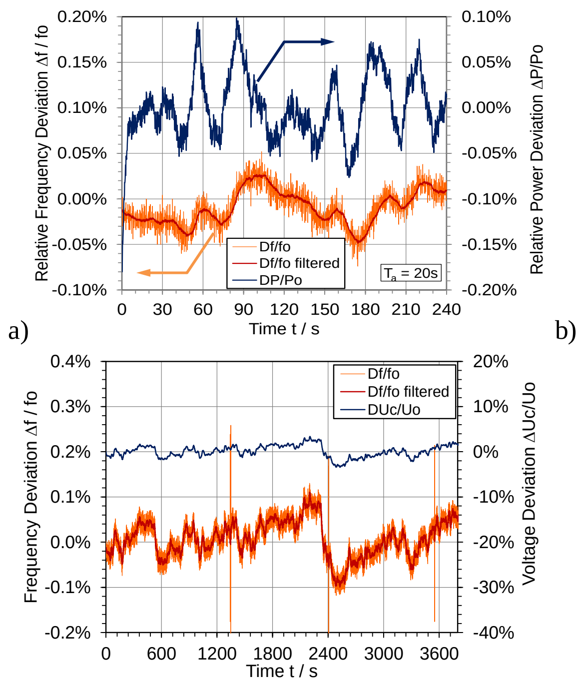

Fig. 2. Measured frequency and calculated values on a capacitor with 300 Ws.
a) Additional power flow. b) Voltage fluctuation,

2 PRIMARY CONTROL POWER

Providing primary control power with batteries is limited by the capacity of the battery. Positive and negative control power must compensate each other over time to maintain the state of charge. However, losses and imprecise frequency measurements may soon lead to a depleted or full storage. It is possible to reduce this issue by maing use of several parameters of freedom. In addition, buying or selling additional energy

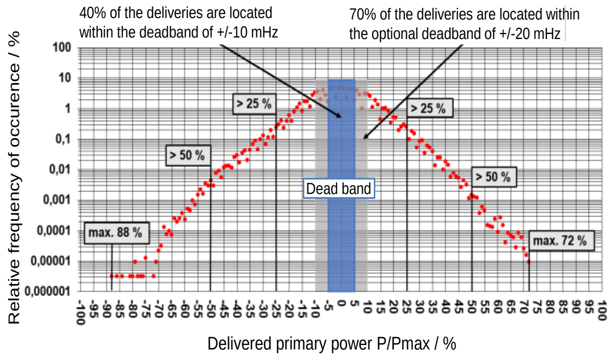

Fig. 3. Frequency of occurrence of Primary Control Power in 2013 **Error! Reference source not found.**].

To provide primary control power in the ENTSO-E European grid, a system must at any time be able to feed-in or absorb power proportional to the deviation of the grid frequency from the nominal frequency between +/-0.2 Hz **Error! Reference source not found.**]. In a worst case, a deviation of +/-50 mHz may last for 30 min. In addition, at any time an amount of energy must be preserved to cover a worst case event (near blackout event). This corresponds to providing two times 15 min the full power. These two conditions determine the minimum size of the battery.

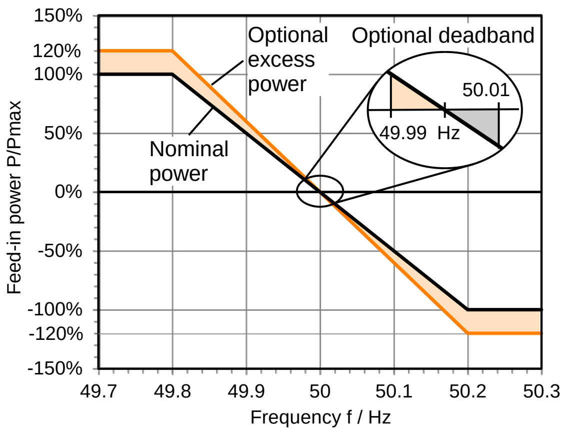

Fig.4. Degrees of freedom of the power delivery curve. According to **Error! Reference source not found.**].

Theoretically, positive and negative frequency deviations should average to zero and charging and discharging of the battery should compensate each other. For the further investigations the measured grid frequency with a resolution of 1 s for the year 2013 is used. Further actual frequency data is available at]. **Error! Reference source not**

found. shows the occurrence of positive and negative frequency deviations. The curve looks rather symmetrical. In addition it shows that more than 40% of the time the grid frequency remains within a dead band (see below) and 70% in an extended dead band, which includes the measurement uncertainty of the frequency **Error! Reference source not found.**].

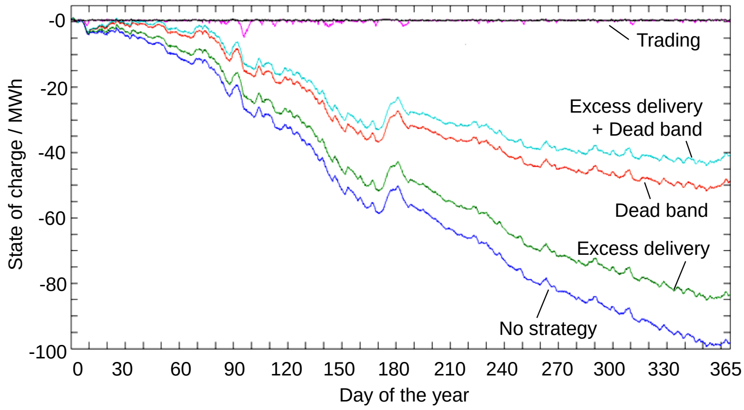

Fig. 5. Effect of applying degrees of freedom for a battery storage with 1 MW rated Primary Control Power **Error! Reference source not found.**].

However, an offset may appear due to imprecise measurements and losses of the battery. Then, the state of charge of the battery quickly exceeds any limits.
(blue, "no strategy") shows the simulated state of charge of a battery with an assumed round trip efficiency of 80% and a rated Primary Control Power of 1 MW. At the end of the year a lack of energy corresponding to a delivery of 100 h full power can be observed, which is beyond any technical realization. To avoid this, the following degrees of freedom are allowed **Error! Reference source not found.**]: 20% optional excess power delivery during normal operation and optional operation in a dead band between +/-10 mH (both illustrated in **Error! Reference source not found.**). In addition, a delay of the reaction and using a gradient of up to 30 s is possible.

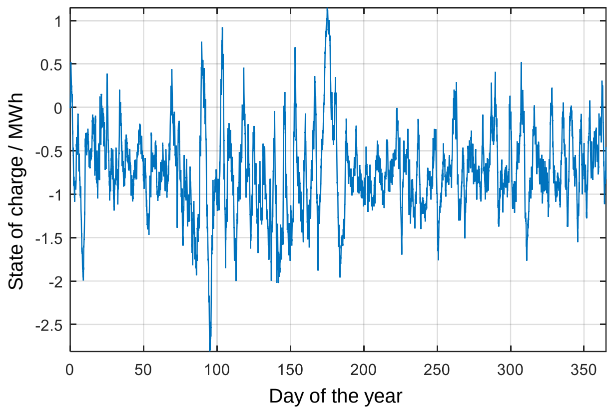

Fig. 6. Calculated battery state of charge with frequency compensation using only a running average with an averaging length of one day for a battery storage with 1 MW rated Primary Control Power.

The effects of an optional excess power delivery and optional operation in the dead band are simulated and shown in

. Clearly, the use of the dead band has a much larger effect. Combining both methods reduces the lack of energy to 40 MWh. Further details are available in **Error! Reference source not found.**]. To compensate the remaining energy, it is possible to trade energy at the stock exchange market **Error! Reference source not found.**]. In addition, the frequency measurement is defined with a precision of +/-10 mH which can be considered as additional degree of freedom. Especially systematic errors in the frequency measurement will lead to a fast runaway of the state of charge. Such errors can be compensated by averaging the measured values and subtracting this value as systematic error. To consider long term effect, a running average can be used, e.g. with an averaging length of one day. **Error! Reference source not found.** shows the effect of applying this method. The state of charge remains within a range of -2.5 MWh to +1 MWh. Such a value is close to a possible realization.

3 CONCLUSION

Virtual inertia can be provided by intermediate voltage capacitors in battery inverters without additional impact on the hardware. Providing primary control power with batteries requires the use of available degrees of freedom. Especially a suitable operation in the dead band and compensation of systematic frequency errors give good results.

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PV Integration in Diesel Grids – Fuel Saving Technologies

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ABSTRACT. This Article show fuel saving potentials of PV introduced in diesel grids. First a literature review is done, for existing PV diesel systems without batteries, with real measured data of fuel saving potentials and simulation results to get fuel saving values of different strategies. In a second step we show fuel saving potentials of battery less PV integration in a case study, for a Greek island (5.9 MW peak load), Egyptian industry site (420 kW peak load) and a small village in a rural region of Nepal (79 kW peak load). Further we present results of fuel saving potentials with small battery systems just used as spinning reserve but with grid building ability.

Keywords: Renewable energy, off- grid, PV- diesel systems, fuel saving

1 INTRODUCTION

Integrating standard grid connected PV systems into diesel grids without battery storage is possible to a certain share of around 8% of yearly energy or around 10 to 20% PV share of peak load without grid stability problems. With new commercially available fuel savers controller (FSC) higher shares can be realized. Our grid studies even show that under certain circumstances like fast PV inverter reaction times grid frequency gets more stable because of smoothening out load changes with excess PV power. General rising fuel prices, cutting off subsidies for conventional fuels due to countries running out of money, and low prices for grid connected PV systems reduces the return of invest for battery less PV diesel systems to a few years. This is very attractive for investors. Technically PV diesel systems are divided into low penetration, medium penetration and high penetration systems, in low penetration systems grid connected PV systems up to a share of 50% spontaneous penetration (= P(t)renewable power / P(t)load power) may be integrated without specific control action. In medium penetration systems, a control mechanism is needed (e.g. commercial FS) to prevent diesel generator operating in a state lower than ~30% of its nominal power. In high penetration systems some kind of storage is often used to enable the switching off of single gensets. [2]

2 STABILITY OF PV- DIESEL SYSTEMS WITH FUEL SAFE CONTROLERS

In PV- diesel systems the task of the FSC is to prevent the diesel system running below the diesels minimum power (often 30% - 50% of nominal power) in cases of low load and high PV power. To prevent these situations when too much PV is available, the fuel save controller controls the PV available power down until the diesel runs again in its allowed power range. This is necessary because if the diesel generator is running long time in low load (below diesel minimum load) irreversible damage because of incomplete fuel burning may occur.

To show influence of FS to grid stability in diesel grids with a high share of PV we performed some simulation studies for a PV-diesel grid in Haiti. The diesel generator has a nominal power of 490kVA and PV plant of 270kW peak. The simulations are done in DigSILEND® Power Factory®. Most difficult thing is to parametrize the diesel generator as often only view information of the field system is available. With our parametrization we can see one important thing is the time of reaction of the PV inverter to external signal from FSC. In cases of very fast reaction time PV integration in diesel grids may have positive influence on frequency because in cases of excess PV energy during lunch time it may smooth out load changes, frequency gets more stable.

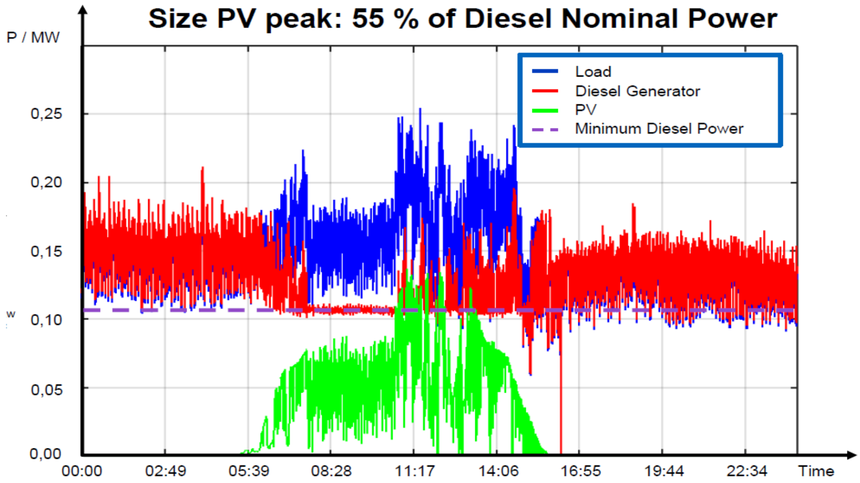

Fig. 1. Figure 7 PV- diesel system with FSC, during lunch time PV power is curtailed to avoid diesel running below minimum diesel power. PV power supplies significant share of load

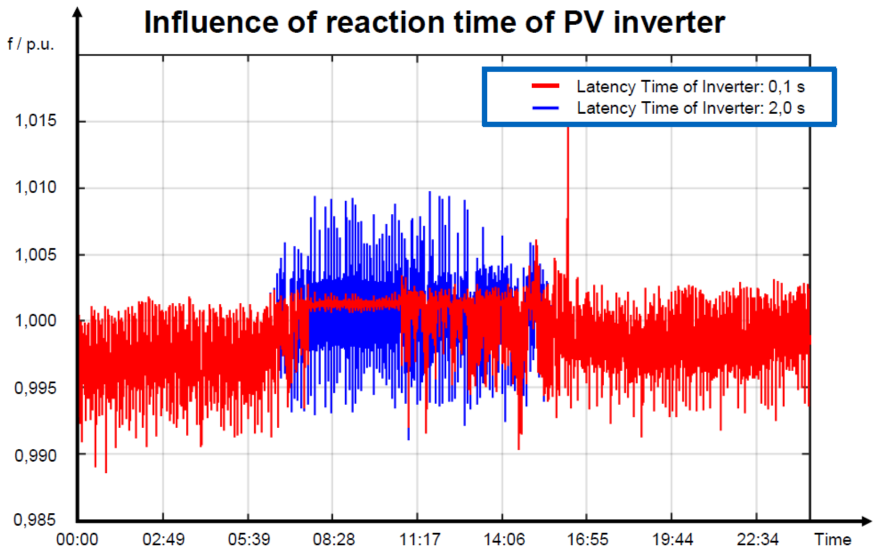

Fig. 2. Fast reaction times of PV inverter may improve frequency variations in PV- diesel systems

3 FUEL SAVING DATA OF EXISTING BATTERYLESS PV DIESEL SYSTEMS IN LITERATURE

Literature for only a few batteryless PV diesel systems like in Araras, Amazonas region of Brazil [3] and in Nemiha Valley, British Columbia, Canada [4] is available. Some information are also available for the systems of Marbel Bar, Nullagine and Kings Canion in Australia, but fuel saving potential is not explicit assignable.

The Araras system is a low penetrating system with daily load profile ~25kW day and an evening peak up to an hourly mean value of 43kW. Average load is 27 kW. The system consists of three 60kVA (54kW) diesels and one 12,5 kW rated [3] PV generator. Yearly energy share of PV is around 8,3 % and annual fuel saving is given by 5,5 % and 315 kg/kW [3]. Calculated in liters (L) with 0,85 kg/L (DIN 590) we get 4632 L saved diesel.

The system in Nemiha Valley is a medium penetrating system, average load is 29 kW and peak load is 75 kW. Three 95 kW diesel gensets are available.[4] For not operating one diesel genset below 30% of nominal load some “noncritical loads (…) were left on all times, effectively acting as a dump load.”[4] For optimization one 30 kW diesel genset was bought to have the possibility to switch off noncritical loads (dump loads). “During weekday nights and on roughly every second weekend, the 30 kW genset is manually selected as the main generation unit.”[4] Further several distributed PV generators in sum 27,36 kW are integrated. In case of instantaneous penetration of greater than ~100% one 18 kW dump load starts and causes a frequency fall leading to a stop of PV inverters power delivery. Yearly fuel saving is ~25% or 26000 L per year in total. The 26000 L are split to 11130 L for energy efficiency by load control, 9000 L by introducing 30kW Generator and manual Generator control and 5900 L through PV Generator.[4] We calculated roughly 5,7 % savings through PV, 10,7% with energy efficiency/ Load control and 8,6 % fuel saving with generator management. Instead of switching of the PV inverter through dump load frequency impulse a continuous power reduction of the inverters e.g. with actual FS can increase PV usage by 10%.

4 CASE STUDY OF FUEL SAVING POTENTIAL IN BATERIELESS PV DIESEL SYSTEMS

To show fuel saving potential a simulation environment was build up and a comparing study of fuel saving potential with PV integration of different penetration levels and used technology is done. The simulation environment is build up in Matlab®. Diesel, PV and system controller models are integrated. The PV model is developed by Fraunhofer ISE according to [6], monocrystalline standard module parameters are used. Radiation data are from Meteonorm® software. For diesel model the polyfit function of Matlab® is used to fit datasheet values of fuel consumption. To avoid wrong fuel consumption calculations [4] because of no values in low states of operation < 25% of nominal power the diesel is always operated in higher states of nominal power. The system control model cares for:

Generator management: Starts most efficient diesel combination to serve the load within the diesel generators operating borders of 30% to 85% of nominal power.

Fuel save controller: The fuel saver defines the maximum possible PV power usage while maintaining the spinning reserve of diesel gensets. To prevent that diesel power falls under 30%, PV power must be reduced.

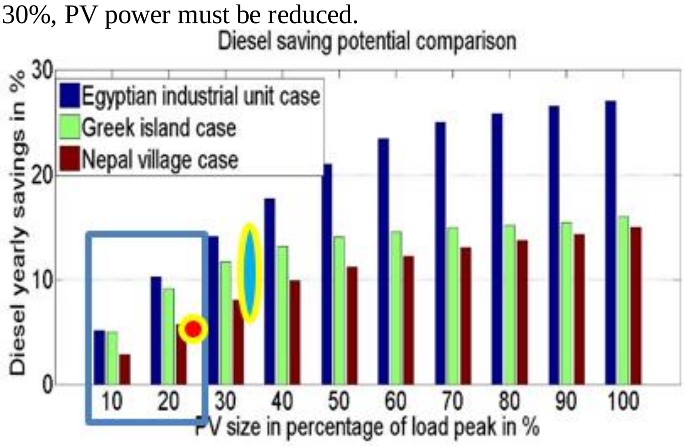

Fig. 3. Fuel saving potentials of different PV generator sizes. (Load peak Egyptian Industrie 420 kW, Greek island 5.9 MW, Nepal village 79 kW.) The blue square shows fuel saving possible without FSC. Red dot is fuel saving of Araras village and blue oval fuel saving of Nemiha Vally literature case.

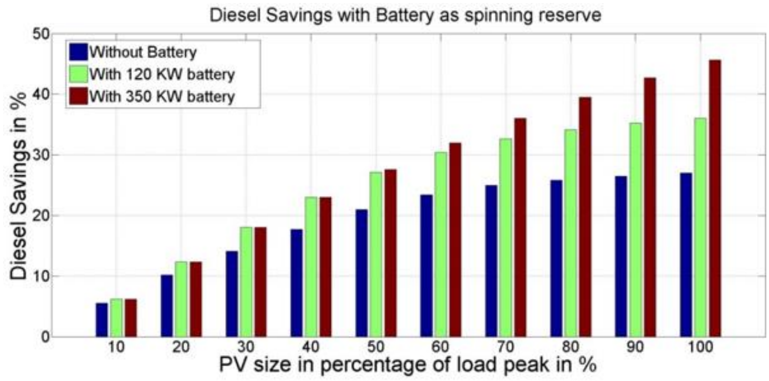

Fig. 4. With small battery system, with just enough energy to start generators significant additional fuel saving is possible.

The simulated systems are a 5,9 MW peak load Greek island and small Village in Nepal of 79 kW peak load. The simulated PV share is given in percentage of peak load, diesel generators are defined by load data of the Greek island (multiple generator set) or chosen by load profile in the Nepal case (1*80 kW). For a reasonable share of PV there are big fuel saving potentials up to 15%. Lower diesel savings in the village in Nepal supposed to be caused by the load profile with a high peak in the evening through the use of light. The reference diesel consumption in the Greek island case is already an optimized result by using always the diesel combination with the best efficiency according to the hourly load. A more simple way very often used in the field is just to switch on from biggest to smallest. The optimized strategy saves 17% of diesel with 3525 million liters (ML) instead of 4253 ML in basic operation mode! In the Egyptian system we have the highest fuel with up to 30% without battery. This is because the load profile suits perfect to PV! With a battery system significant additional fuel saving is possible, more than 50%.

5 CONCLUSIONS

In this article we give different examples of fuel saving potentials, of course these potentials varying from site to site and depending on specific load profiles. Generally energy efficiency is the most important thing in island systems, but not always influenceable by the power plant operator. Thus the first step could be generator management with shown fuel saving potential of 17% in our case study. Better suiting diesel gensets to avoid dump loads and to operate in better efficiencies also offer great potential e.g. 20% in [4]. In a second step PV integration without additional control is possible, offering fuel saving potential around 10% in the considered field study [3] and our simulation. With integrated fuel save controller potential up to 30% and even higher may be possible. Different diesel generator techniques like variable speed generators offer additional fuel saving, especially if gensets often run in part load. Last but not least small battery systems with only enough storing capacity to bypass the time till the start and synchronization of diesel generators may save more than 50% in the Egyptian case study.

6 OUTLOOK

In new simulations we will show fuel saving potential of diesel gensets running in cylinder cut off mode. Actually we develop a load management system, this will be tested in a 15 kW and 60 kW laboratory systems. A field test is planned.

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The Paris Agreement and the Future Role of Bioenergy

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1 INTRODUCTION

The climate conference in Paris (COP 21) created a framework for the climate policy of the next decades. The representatives of 195 countries decided upon new targets and a dynamic procedure to reach these targets. The target was formulated as to limit the temperature rise well below 2°C as compared to preindustrial levels and to pursue efforts to limit the temperature to below 1.5°C in this century.

As a consequence of this target setting article 4 of the agreement says: "to achieve a balance between anthropogenic emissions by sources and removals by sinks of GHG in the second half of this century." And it is further stated: "developed countries taking the lead … in absolute emissions reduction targets"[1].

From this can be concluded: fossil fuels should be more or less deleted from the energy system by the middle of this century and this replacement of fossil fuels should start now.

This ambitious target has to be seen in connection with the ongoing increase of the CO2 concentration in the atmosphere. A CO_2 level of 420ppm is seen as an upper threshold. If this level will be exceeded it will become almost impossible to comply with the targets of the Paris Agreement.

Around 1980 the CO_2 concentration was well below 350 ppm and fifty years earlier, around 1930 it was below 300ppm. But in the last 30 years this concentration started to grow rapidly and reached the critical level of 400ppm the first time in 2015. At present the CO_2 concentration is growing with 2ppm per year. Within one decade the critical threshold to limit global warming would be crossed, if mankind does not start to reduce CO_2emissions!

The Paris Agreement and its fast implementation can be seen as the last chance to keep global warming below 2°C. This opportunity can only by seized if the transition of the energy systems to 100% renewables starts now!

2 PARIS and THE FUTURE ENERGY SYSTEM

A glance on the global energy system illustrates the challenge that the societies are facing. In the year 2013 the global primary demand for energy was 567 EJ and 463EJ were coming from fossil fuels, that is 81.7%. The contribution of bioenergy was

10.1%, from other renewables (hydro, wind, solar, geothermal) 3.5% and 4.7% came from nuclear [2].

According to COP 21 the use of fossil fuels should peak within the next few years and then continuously decline. Table 1 gives an overview how this decline of fossil fuels should look like if a linear reduction path is assumed until 2050. The annual reduction of fossil fuel should be in the size of 13.4 EJ!

Table 1. Global use of fossil fuels as primary energy, reduction targets derived from the Paris Agreement [2]

	EJ
2010,	427
2013	463
2035 reduction target	242
2050 reduction target	40

As a consequence of Paris the world needs an ambitious exit strategy for fossil fuels that should start immediately. On the other hand the global population is growing, the demand for heat, for power, for transport services will grow too! But this demand for additional for energy must not be satisfied by fossil fuels. After Paris the key strategy for the future energy systems: better efficiency and more renewable energies.

Better efficiency concerns the conversion of primary energy to final energy - for instance in the power sector huge savings are possible – but also the improved efficiency in all devices and systems using energy. It might be possible to reach a growing final energy supply with a declining primary energy offer. By 2013 the supply of 567 EJ primary energy was converted to 382 EJ final energy, the conversion losses being in the size of 185 EJ! Therefore improved efficiency and energy saving are important pillars of the energy transition.

The other key strategy is the boost of renewable energies. By 2013 the contribution of renewables was as follows:

Table 2. global contribution of renewablesto the primary energy supply, 2013, EJ

	EJ	%
Bioenergy	57.6	74
Hydro	13.6	17
Wind, solar, geoth., oth.	6.7	9
TOTAL	77.9	100

Table 1 and 2 explain the huge task that has to be performed. Within 35 years the use of fossil fuels should go down more than 400 EJ and at the same time the supply of final energy might still grow! Renewables and better efficiency should fill the gap. As an intermediate step - the year 2035 - is analysed more in detail.

3 THE YEAR 2035 – A FIRST MILESTONE FOR THE TRANSITION

The year 2035 can be seen as an important milestone in this transition to a climate neutral, fossil free energy system. The use of fossil fuels should be halved by then; it is assumed here that the final demand of energy due to economic and population growth is still growing by 10% from 382 EJ to 420 EJ, although the efficiency is being improved strongly. The evolution of the system until 2035 under these conditions is presented in table 3:

Table 3. global final energy, EJ, 2013, 2035, [2]

	2013	2035
Fossil and nuclear	310	155
Renewables	78	265
TOTAL	382	420

The contribution from renewables to the final energy demand should grow from 78 to 265EJ within the coming 20 years. This is the logic consequence of the decisions in COP 21. A more than 3-fold increase of all renewables is needed. But big difference in the growth rate will occur between the technologies.

Table 4. global contribution of renewablesto the final energy supply, 2013, EJ

	2013	2035	Annual growth
	EJ	EJ	%
Bioenergy	57.6	122	3.4
Hydro	13.6	23	2.3
Wind, solar, geother., others	6.7	120	13.8
TOTAL	77.9	265	5.7

Table 4 gives an impression on the needed changes. It is based on detailed studies of WBA on the potential of biomass and other renewable technologies. The key message of this analysis can be summarized as follows:

The contribution of bioenergy to final energy demand should be more than doubled from 2013 to 2035 and the contribution of wind and solar should be increased 18 fold during this period. Wind, solar and geothermal should grow with an annual rate of 13.8% and contribute a similar quantity to the final supply as bioenergy by 2035. If these milestones could be reached the world would stay on the road of the Paris Agreement. Bioenergy should grow with 3.4% annually and contribute almost one third to the final energy.

Whereas wind, solar and hydro deliver final energy as electricity or heat, one part of biomass has to be converted from primary energy to final energy. Therefore, it is simpler to describe the contribution of biomass as primary energy. Based on default values it can be concluded biomass should contribute around 140 EJ primary energy to the system by 2035 as compared to 57 EJ in 2013. Bioenergy will have to play a key role in the transition to a climate neutral energy system.

4 THE ROLE OF BIOENERGY

Biomass is the biological matter from living organisms. The green plants capture carbon from the atmosphere through photosynthesis and release it back by decay or use. Every year, plants convert 4.500 EJ of solar energy and 125 Giga Tons of carbon from the atmosphere into biomass: eight times as much as the global energy need. Microorganisms break down most of the plant biomass to $CO2$ and water as part of the natural carbon cycle, while the rest of the energy can be used to satisfy human needs for food, feed, different material purposes and energy.

Biomass for energy comes from three main sources as is shown in table 5: agriculture, forestry and waste.

Table 5. origin of biomass for energy

Main sector	Sub sector	Examples
Agriculture	Dedicated crops -main product	Crops for biofuels, energy grass, short rotation forests, other dedicated crops for energy
	By-products and residues	Herbaceous by-products: straw cereals, rice, cornstalk, bagasse, empty fruit bunch from oil palm, Woody biomass: pruning and regenerating orchards, vineyards, olive plantation, oil palm plantations, Other forms: processing residues such as kernels, sunflower shells, rice husks, manure from animal production
Forestry	Main product	Stems, wood fuel from forests or trees outside forests, from landscape cleaning

	By-product	Residues of forest harvest (branches, tops) residues of wood industry (bark, saw dust, other wood pieces, black liquor, wood chips, recycled)
Organic Waste		MSW (Municipal Solid Waste), food waste, waste from the food industries, sewage

At present the main part of bioenergy comes in the form of firewood direct from the forests or as by-products from the forest and wood industry. In developing countries in Asia, Africa wood fuel for cooking plays an overruling role, in developed countries modern forms of biomass such as chips, pellets, transport fuels and biogas are growing. Table 6 informs about the origin of biomass for energy in 2012 and the estimation of WBA for the year 2035

Table 6. global contribution of biomass for energy EJ [3]

Main sector	2012	2035
Agriculture	5.6	69
Forestry	48.9	65
Organic Waste	1.7	6
TOTAL	56.2	140

A growing part of biomass goes to conversion plants that transform biomass to heat, electricity or biofuels. A broad range of different technologies is in use for this conversion of biomass to energy such as modern combustion, gasification, fermentation, esterification, anaerobic digestion to mention the more important ones.

Biomass for energy offers various benefits such as a supply of the markets for heat, electricity and transport fuels; it is stored solar energy and reduces the cost of energy storage; it creates new jobs during the construction and operation of bioenergy plants, it allows the productive use of land not needed for food supply, it improves energy security.

More than 75% of the biomass is used for heating purposes, a rather small share goes for transport fuels and electricity. Also in the future the main role of biomass is seen in the heating sector followed by transport fuels and electricity.

Sustainability of bioenergy is an important issue. The basic rule: not more biomass should be used in a region than is being produced by plants; the fertility of the soil has to be maintained. Biomass for bioenergy has to be seen as part of a sustainable agriculture and forestry in a region. No specific policies on agriculture and forestry for energy are needed but a national policy that maintains the sustainability of the agriculture and forest sector independent on the end use of the products.

5 DRIVERS OF BIOENERGY: CARBON TAX; INFORMATION

A general answer for many questions concerning the transformation to a fossil free energy system would be the phasing out of all subsidies for fossil fuels and nuclear energy and the implementation of a general tax on fossil $C0_2$ emissions. Such a step would encourage the growth of bioenergy and other renewables but also incentivise all efforts for better efficiency without any administrative burden. This proposal has also to be seen under the aspect that the low oil prices in the year 2015 and 2016 hinder the reduction of fossil fuel emissions and thus accelerate climate change. The Agreement of Paris and the current oil glut offer a window of opportunity to go for general carbon taxes in Europe. The global institutions such as the World Bank, the UN and the IMF encourage and should more encourage the national states to take this step, even if a common global or European solution is not yet feasible.

Other important drivers for a fast deployment of bioenergy are: education, training, know how transfer, demonstration projects, financial support and a better support of the regional agriculture and forestry.

6 CONCLUSIONS

The climate conference in Paris (COP 21) created a framework for the climate policy of the next decades. The representatives of 195 countries decided upon new targets and a dynamic procedure to reach these targets.

These targets can be reached if all renewable energies are pushed in all countries of the globe. In this context the growing contribution of Bioenergy to the global energy system is of specific importance:

- Bioenergy is the most important renewable energy source and has the potential to more than double its contribution to the energy supply by 2035!
- In all countries with a high share of renewable energies today bioenergy plays a key role. These examples show that a replacement of fossil fuels without bioenergy is not possible.
- Biomass is stored solar energy; it can contribute essentially to solve the storage problem in winter months.

Technologies and potential for a further development are available.

The future contribution of biomass to energy depends highly on reliable, stable government policies – carbon taxes should become a key instrument in the promotion of renewables, in particular of bioenergy.

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Developing Bankable Biomass-To- Energy Projects Across Africa

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ABSTRACT. For most countries in Africa at least 50% (and for some about 90%) of the energy used comes from various forms of biomass. However, the conversion of biomass to energy (usually as heat energy) is mostly very inefficient, with conversion efficiencies of under 20% being usual. Government and non-government agencies in all of these countries are aware of far more efficient ways to convert the main forms of biomass to energy, and also of other mature bioenergy technologies that can use the available forms of biomass not presently utilised.

The growing concern about the world's high levels of greenhouse gas (GHG) emissions has resulted in availability of significant funding for projects including the efficient conversion of biomass to energy. The opportunity is there for African countries reliant on biomass for much of their energy to access this funding, both for improving efficiency, and for the technologies that can use currently unutilised forms of biomass and wastes.

Countries with high biomass use for energy usually have very low net CO_2 emissions. For example in Sudan the population of about 34 million is estimated to produce only about 0.3 tonnes of CO_2 per person. In Sudan biomass provides over 50% of the energy needs. However, more efficient use of biomass, and use of presently unutilised municipal wastes for energy, has the potential to reduce deforestation while providing significant baseload electricity, plus industrial heat and transport fuels.

African countries could utilise biomass more efficiency and source it more sustainably, and introduce modern technologies to utilise the presently unutilised biomass and municipal waste streams. The results would be reduced import of fossil fuels, reduced GHG emissions, and more jobs, but the obstacle is the high capital costs.

To successfully access the capital needed for these projects requires submissions containing the sort of project feasibility and analysis detail and informed and holistic planning that the major sources of funding require. This paper will give details on how such bankable projects can be developed, what sorts of detailed information the funding agencies require, and what are the sorts of projects that tick all the boxes.

Keywords: bankable projects, biomass, biowastes, bioenergy

1 INTRODUCTION

The African countries in aggregate contribute relatively little to the world's CO2 emissions, and over 80% of those emissions come from South Africa, Nigeria, Egypt, Morocco, Algeria and Libya. However, despite the fact about half the countries have per capita CO2 emissions from fossil fuel use of under 0.2 tons, all African countries developed their lists of formal actions (known as intended nationally-determined contributions or INDCs) that itemize the various ways they will each reduce in some ways their individual GHG emissions. Many of these involve some change in electricity production toward greater use of renewable energy technologies. In some cases they are planning to roll out installations of solar photo-voltaic (PV) panels at household and at industrial scale, or to build large groups of wind turbines connected into their grids. However, the cost of these measures will be very great compared to their real impact on existing GHG emission. Generation of electricity from either wind or solar usually cannot fully displace present fossil-fuelled forms of electricity production, and if these intermittent sources of renewable electricity are installed at a significant scale they may greatly complicate the management of the national grids. Some countries will be able to manage this fort of intermittent but quite predictable supply better than others, and those countries with a major fraction of electricity supply sourced from generation systems that can be varied very rapidly, such as hydro dams or geothermal power plants, would appear to be much better placed.

As with hydro dams and geothermal installations, biomass via a number of technologies can provide on-demand electricity, and so can be used to displace or fully substitute for electricity from fossil-fuelled sources over the whole range of scale. Examples of the bioenergy technologies, and forms of biomass used as feedstock, include furnaces fuelled by sugar cane bagasse or other agricultural residues, anaerobic digesters using slaughterhouse wastes, or aquatic weed, food wastes, animal manures or city sewage as feedstock's, and gas engines fuelled by the flammable gas produced in landfills. Another fuel that is usually between 50% and 70% biomass is the non-recyclable combustible fraction of municipal solid waste, and this can be used as a fuel in specially designed high temperature furnaces producing steam that spins turbines coupled to generators.

The development of modern highly efficient bioenergy technologies can significantly reduce demand for the traditional biomass fuels of wood and charcoal, the unsustainable sourcing of which is responsible for serious deforestation in many African countries. In some cases, along with the generation of the supply of alternative biomass forms for cooking and industrial heat, there are plans for sourcing the wood and charcoal from planted forests instead of from native woodlands and forests area. The regrowth of native forest areas as well as the sequestration of atmospheric carbon by actively growing and managed younger forests will allow some additional revenue from this extra carbon storage.

2 PRODUCING BANKABLE PROJECTS

As with larger scale of development of any other form of renewable energy, the development of any of the modern bioenergy technologies requires significant capital funding. Of all forms of energy, it is heat that is cheapest to produce, whether from shallow or deep geothermal sources, from solar radiation, or from biomass. The capital cost of a more technically advanced, high efficiency biomass-to-heat system is usually from US$300,000-500,000 per MW of thermal output capacity (not including costs of buildings, civil works, roading and heat reticulation piping), and so the cost of a plant producing 30 MW of heat energy will cost from about $9 million. If the heat was previously being produced by use of oil, natural gas or coal, then revenues from sale of avoided-GHG-emission certificates may add to the revenue from sale of heat, and even without this is quite frequent that the due to savings in cost of fossil fuels alone the plant can be paid off within a few years.

The value of electricity and heat produced are also critical to the economics of other biomass and waste-fuelled combined heat and power (CHP) plants. The capital cost of CHP systems using solid biomass may be from US$4 million/MW-e capacity and up. To build a larger waste-to-energy (WtE) plant on a greenfield site will cost upwards of US$5.5 million/MW-e capacity. A larger anaerobic digester producing electricity and heat from the biogas produced will cost US$6-8 million per MW-e output capacity, or more depending on feedstocks, gas quality and other factors. Projects involving biomass and waste to energy may involve overall costs of the order of $10 million for a city anaerobic digester to produce 1 MW-e from sewage, up to $250 million for a 50 MW-e WtE plant converting 300,000 tonnes a year of sorted MSW into 50 MW-e and 100 MW-th.

The development of submissions seeking funding for biomass to energy projects must include the full information needed by the identified funding agency. This is not just information about the possible environmental and social benefits, but also detail on all the quantifiable environmental data, including specifics on GHG emissions avoided, the pathways for qualifying for internationally-recognised third party certification of this, as well as information on impacts on water, soil and air. In most cases, assuming competent management, the installation of modern bioenergy technologies will have overwhelmingly positive impacts, and water, air and soils around the plant site will be measurably improved. Appropriate monitoring and testing protocols have to be costed into the overall project to quantify this.

To develop a project funding submission for a waste-to-energy plant for example, the proponents must go through a long series of steps to build up the detail required. Some of the critical steps include: identification of the basic need and benefit details, a pre-feasibility study, a business plan, identification of the logistical issues, development of the legal aspects, negotiating waste supply and pricing and heat/power off-take agreements, and setting up the legal structures.

It is instructive to learn how projects of this general have already been developed and what the process and pitfalls were. While there have been many mid-size to large-scale anaerobic digestion systems installed in African countries and elsewhere, there are very few large WtE plants (one in Durban and planning for others), and it may be necessary to look further-afield at examples recently installed or in planning in China, India, Malaysia and Indonesia. Large-scale landfill gas extraction systems are relatively common, though in Africa the landfill construction is often not of the necessary standard for this; and the main city landfill for Addis Ababa is relevant in its present upgrading on a new site.

The issues of income to a project from environmental benefits that are generated may be critical for gaining funding for a project. An example is the possible upgrading of the sewage treatment of Khartoum from the present large settling ponds. It is obvious that the present system results in free release of very large amounts of methane, and is the cause of potential health impacts due to methane drift and pollution of ground water supplies, as well as the source of offensive odour and insect-borne diseases affecting surrounding residential areas. Large-scale anaerobic treatment of this sewage resource will turn captured methane into electricity, while producing a high-nutrient fertiliser by-product for agriculture plus effluent water quality that is suitable for irrigation. This site is only one of many similar ones across Africa. A place that can provide all such projects with the essential data on engineering, technical issues, costs and management issues, is the new sewage treatment system in Qatar.

The development of projects to utilise agricultural residues also can draw on data from existing installations. For example, the Kenana sugar mill in Sudan has a 60 MW-e capacity co-generation plant which supplies all process heat and steam for sugar production that is fuelled by sugar cane bagasse produced at the mill. It provides the example of the economic outcome when the base elements required for such projects are clearly present. These are: 1) that there is a clear need for heat and steam (and possibly electricity), that presently may be coming from increasingly expensive, often imported fossil fuels, or unsustainably sourced wood. 2) that there is a potential fuel available in large volumes that is a residue of the process, and may presently involve a cost of management and disposal, and 3) that the economics show that the savings due to using the residue as a fuel will mean the capital cost of the necessary plant will be paid back within some acceptable period. In the case of a commercial operation like this any funding amount being applied for would usually be as a concessional loan, or a grant making up less than half of the capital cost and provided on the basis of the real environmental benefits that are demonstrated.

3 CONCLUSION

The development of larger-scale bioenergy projects and for submissions for funding for these projects is a complex process, involving much time and drawing on information from government department personnel, researchers and environmental scientists, engineers, lawyers, and even politicians. Information also has to come from managers of the state or national water and power systems, managers of waste streams, suppliers of transport logistics, road construction contractors, and city planners. The people developing the project may call on original equipment manufacturers or importers, organisations that deal in third party certification of ‘carbon credits’, or who manage their sale, and testing laboratories for all the necessary issues of complying with standards of emissions into water and air, or of residues including of material that must be dealt with in secure landfill.

This paper's author is presently involved in development of a number of projects in Sudan, of small, medium and large-scale biogas systems and a large scale waste-to-energy plant. Her presentation draws on this experience in project development in Sudan, as well as technical knowledge gained from work with UNESCO, from working with the NGOs Practical Action and Agricultural Technology Transfer Systems in Sudan, and from work with the World Bioenergy Association. The content of this IRENEC presentation also draws on a UN-ESCWA (Economic and Social Commission for Western Asia) workshop: Regional Training on Renewable Energy projects development, finance and business planning, held in Rabat, Morocco, over 3 & 4 May.

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Benefits of Renewable Energy and Analysis of Solar Power Plants in Turkey

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ABSTRACT. Fossil-based energy sources of our world are rapidly running out. Majority of the developed countries are all in huge effort to find an alternative and endless solution for this problem. It is ineluctable to lean renewable energy sources to meet the energy demand which is increasing by the growing population and urbanization of the World.

It is known that electric production obtained from Solar Power Plants (SPP) is so expensive and difficult. This study has been done for proving against that.

Keywords: Key Words: Solar Power Plant, Multi Criteria Decision-Making, Histogram Method.

1 INTRODUCTION

In order to guarantee our today and future, we must to give the necessary support renewable energy sources. Nowadays on a worldwide scale the percentage of the use of renewable energy sources is only about 10%. In 2050s if the percentage cannot raise up to about 40%, huge energy crisis will occur [1]. Solar energy has been used for thousands of years. As early as the seventh century B.C., people discovered that a piece of glass could focus sunlight to make fire [2]. However, nowadays World's actual electricity production acquired from solar energy is quite limited.

In this study, 1 MW Solar Power Plant (SPP) institutions have been examined to encourage the investors and to guide the person or institution to be willing to invest in the field of solar energy.

2 ENERGY SOURCES

Rapidly rising world population has led to the increase the need for energy and urbanization. Despite the reduction of energy resources, the rapidly rising demand for energy is the most important reason to require orientation to alternative energy sources.

2.1 Primary Energy Sources in Turkey

When the energy sources in Turkey [3] are evaluated, as shown in Figure 1, this land is very poor in fossil-based energy sources. But Turkey has more advantages than most developed countries in terms of usability of the solar energy which is endless, renewable and harmless energy source.

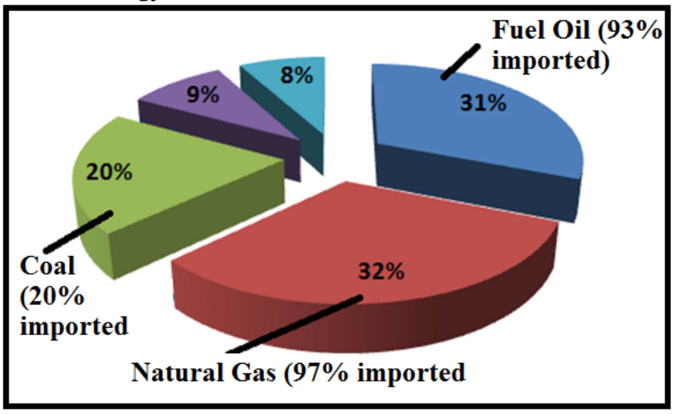

Fig. 1. Energy Importation of Turkey

2.2 Electricity Generation and Aims of Turkey

As Figure 2, Turkey's largest source of electricity is power plants burning natural gas. Producing the State's electricity need by using renewable energy sources, reduces environmental harm which fossil fuels such as natural gas can cause and decreases our reliance of imported fuels. Nowadays the electricity generated by renewable energy sources in Turkey is 5,86% rate. The aim of the Turkish government on this issue is to raise the percentage to 30% in 2023 [4]. With this optimistic forecast, depending on the destination of SPP is expected to reach a capacity of 5000-6000 MW by 2023. This is hopeful case, and a good investment opportunity. The success of this aim can be achived by giving importance to this area by government and individual entrepreneurs.

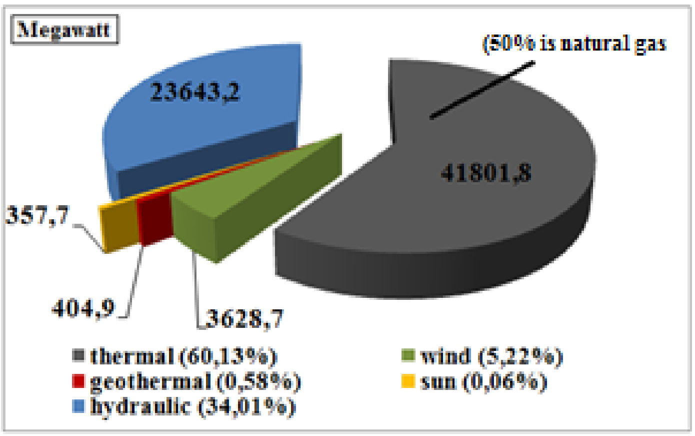

Fig. 2. Electricity Generations by Sources [3]

2.3 Comparison of Solar Energy Capacity of Turkey and Germany

Turkey's annual average sunshine rate is approximately 1.7 times larger than Germany. But productionof electricity by using the solar energy sources of Turkey is approximately 110 times smaller than Germany. Turkey’s [5] and Germany’s [6] production of electricity from solar energy is seen in Figure 3.

Fig. 3. Comparison of Capacity and Numbers of SPP

3 APPLICATON

This chapter is prepared for the purpose of a reference to investors who want to make a profit, people who wants to reduce its dependence on foreign energy resources of the country and environmentalists who want to reduce damage to the environment of the fuel. In this chapter which location would be the most efficient for a SPP 1 MW, set-up and maintenance costs and income / expenditure balance will be evaluated.

3.1 Multi Criteria Decision-Making about Location of SPP

There are many factors that affect facility location SPP. These factors are within the numeric and non-numeric variables. In this method, specific data is digitized and assigned relative to all variable rates. When the average duration of sunshine are evaluated, of which is shown by Figure 4, the red colors, are best suited to the installation of SPP.

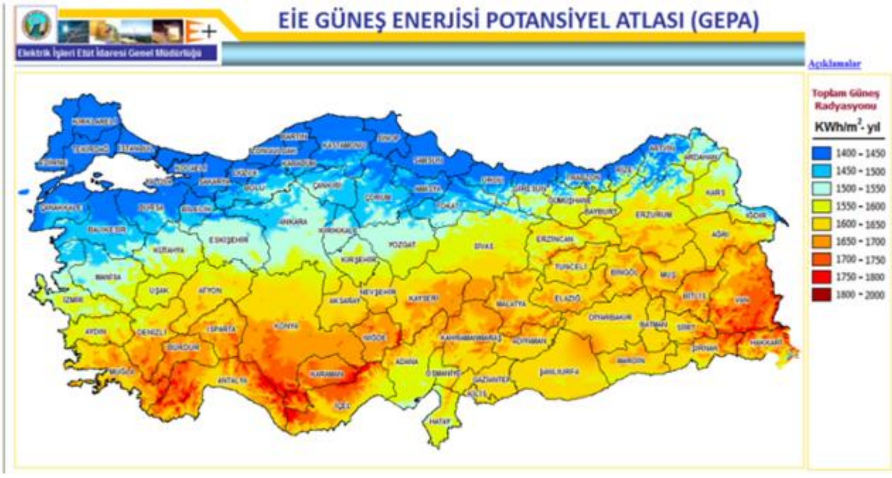

Fig. 4. Turkey's Solar Map [7]

For this sample, firstly 13 provinces were selected. These 13 provinces were evaluated according to selected five criteria in Table 1. These five variables can vary within the scope of the person who will make the investment preferences and priorities.

Table 1. Evaluation of SPP Location

VARIABLES →		Electricty generation capacity[6]		Land prices[7] (m^2)		Possibility of terrorist acts	Degree of earthquake generation[8]		Distance of SPP industry zones	
Sıra	Province	Electricity (kWh/Yıl)	relative rate (%)	Price of m^2 (TL)	relative rate (%)	relative rate (%)	Eartquake zones	relative rate (%)	Distance	relative rate (%)
1	Van	26.900	69	16	62,5	10	1st degree	20	too far	60
2	Malatya	26.300	63	23	43,2	48	2nd degree	40	far	70
3	İstanbul	21.700	17	161	6,2	54	1st degree	20	too close	100
4	Kayseri	26.300	63	22	45,4	52	3rd degree	60	close	90
5	Antalya	26.800	68	55	18,2	55	2nd degree	40	Yakın	90
6	Konya	26.500	65	21	47,6	74	5th degree	100	too close	100
7	Aksaray	26.000	60	19	52,6	72	4th degree	80	far	90
8	Kocaeli	21.800	18	96	10,4	65	1st degree	20	too close	100
9	Burdur	26.200	62	28	35,7	68	1st degree	20	far	70
10	Nevşehir	26.000	60	18	55,5	67	3rd degree	60	close	90
11	Adana	26.000	60	35	28,5	35	3rd degree	60	close	90
12	Denizli	26.200	62	40	25	60	1st degree	20	far	70
13	Sinop	22.400	24	28	35,7	72	3rd degree	60	too far	60

Using the data in Table 1, the histogram graph is plotted in Figure 5 and is determined as the facility location of Konya SPP. Konya Karapinar District, located in the Solar Industry Specialization area. There is no need to purchase any land in this area because of the treasury land can be allocated to the SPP investors. Therefore, Karapinar District is preferred in Konya. For this reason, approximately $ 50,000, the land purchase price will be saved.

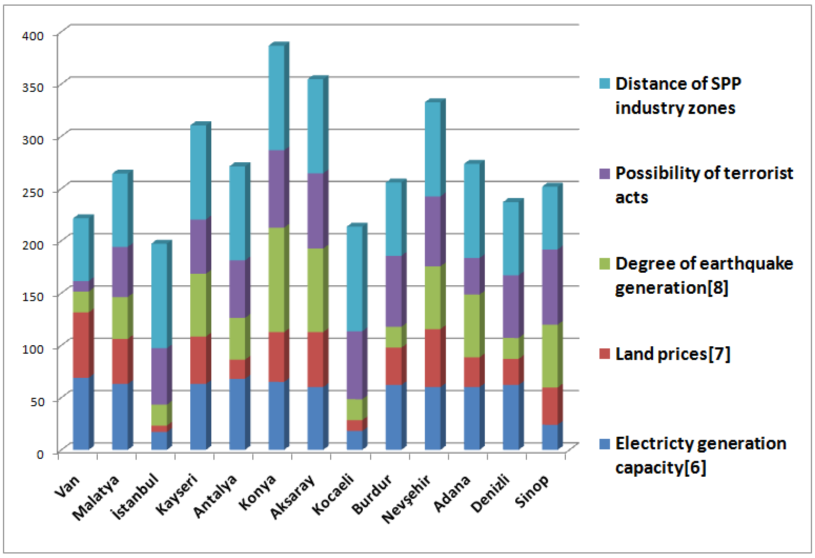

Fig. 5. Histogram for Location Selection

3.2 SPP Incentives and Cost Calculations

In Turkey, maximum installed capacity of a SPP that does not require licensing is up to 1 MW. SPP over this value has to be the incorporation and get licensing requirements.

3.3 The Solar Energy Incentive Amount In Turkey

The positive developments have been since 2011.For example, government gives fixed price electricity purchase guarantee to solar based electricity production and thanks to the legislation arrangements done by government solar energy technology has started to improve. In addition, individuals and companies in their homes, work places, in every type of business and the facilities they have, they can produce electricity with solar energy up to 1 MW without any legislation. Besides surplus they have can be sold to the distribution company in exchange for specified fees. Purchase price of $ 13.3 cents per KWh of electricity produced by the SPP and it is guaranteed by the state and purchase time is fixed price for 10 years [10].

Operating and Investment Expenses.

These costs are calculated for a SPP installation of 1 MW that will not require a license requirement. For this calculation, installation expenses of investment and annual operating expenses after installation were taken into account.

The installation expenses in Table 2 are TEDAŞ project, SPP official application fee, taxes and charges, machinery, equipment, earthmoving and the wire fence expenses around the land.

Table 2. Operating and Investment Expenses

OPERATION AND INVESTMENT COSTS		
OPERATION EXPENSES (ANNUALLY)	Personnel expenses	$15.000
	Maintenance and Repair expenses	$10.000
	Insurance expenses	$2.000
	Other expenses	$2.000
	Annual land rental fee	$1.150
	Total Operating Expenses	**$30.150**
INVESTMENT COSTS	Application fees, project fees, Taxes and Charges	$52.000
	SPP Investment Cost	$950.000
	VAT	$0
	Total Investment Expenses	**$1.002.000**

Income and expenditure balance

In this section, according to installation and operating cost in Table 3, income and expenditure balance is calculated.

According to monthly average radiation values of Karapinar district, as shown Figure 6, monthly earnings of the investment are calculated in Table 3. The 15% loss, for reasons such as cloud density was evaluated for the possibility of not fully achieved by duration of average sunlight values.

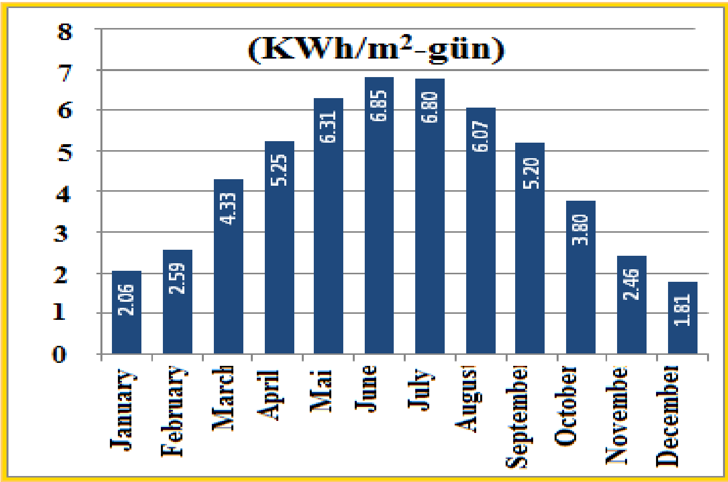

Fig. 6. Karapinar Global Radiation Values [7]

According to Figure 6 and Table 3, the duration of the investment pays off (1) is 6,5 years.

$$\text{Pay off time}=\frac{\textit{Total Investment Expenses}}{\textit{Total Income} - \textit{Total Operating Epenses}} \qquad (1)$$

Table 3. Benefits by Months

MONTHS	Daily Radiation Values	DAYS	Monthly kW	NET kW (%15 loss)	INCOME
JANUARY	2,05	31	25.420	22.878,0	$3.042,77
FEBRUARY	2,59	28	29.008	26.107,2	$3.472,26
MARCH	4,33	31	53.692	48.322,8	$6.426,93
APRIL	5,25	30	63.000	56.700,0	$7.541,10
MAY	6,31	31	78.244	70.419,6	$9.365,81
JUNE	6,85	30	82.200	73.980,0	$9.839,34
JULY	6,80	31	84.320	75.888,0	$10.093,10
AUGUST	6,07	31	75.268	67.741,2	$9.009,58
SEPTEMBER	5,20	30	62.400	56.160,0	$7.469,28
OCTOBER	3,80	31	47.120	42.408,0	$5.640,26
NOVEMBER	2,46	30	29.520	26.568,0	$3.533,54
DECEMBER	1,81	31	22.444	20.199,6	$2.686,55
TOTAL INCOME	4,22	365	652.636	587.372,4	$78.120,53
A) MONTHLY AVERAGE INCOMES (TOTAL INCOME/12)					$6.510,04
B) MONTHLY AVERAGE EXPENSES (TOTAL OUTGOING/12)					$1.458,33
MONTHLY AVERAGE NET EARNINGS (A-B)					$5.051,71

Credit support within the scope renewable energy systems, are provided by the World Bank and the International Bank for Reconstruction and Development. May 9, 2014 on the World Bank Group Board of Executive Directors confirmed project of Turkey's Renewable Energy Integration. US $ 300 million for the project is given by (IBRD) International Bank for Reconstruction and Development and 50 million US $ are given by the Clean Technology Fund of (CTF) [11]. The project is being implemented by TEIAS under the Treasury guarantee. These loans application and pre-approval process are done by local banks in Turkey.

Banks also give credit to the most 80% of the SPP investors. In this context, minimum capital amount for this investment must be $200,000.

4 CONCLUSION

The aim of the Turkish government about energy production with renewable energy sources is to raise the percentage to 30% in 2023. By achieving this goal; **annual 21 billion cubic meters of natural gas** will be imported less and **47 million tons of carbon dioxide emissions** will be produced less. [12] Additionally the energy addiction of Turkey from foreign countries will decrease, and investors who invested to this area will be satisfied.

Consequently, everyone should perform their own responsibility as to preferring renewable energy resources in energy generation and not wasting generated energy. In this respect, it should be benefited from solar energy, which has endless source, at maximum rate. Therefore, everyone at least is able to build a unlicenced SPP, if he/ she cannot afford this, they can generate their electricity by installing solar panels on their roof. But still cannot afford, without wasting they are able to prevent not only their own but also state’s economy from suffering.

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Contribution of Clustering Approach to Obtain Competitive Advantage: A Field Example OSTIM Renewable Energy and Environment Cluster

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ABSTRACT. This article is related with Energy Economics. Renewable energy share is increasing day to day in Turkey and worldwide. The sustainable and feasible renewable energy equipment provisioning is a very important issue both in investment and operation periods. The development of renewable energy industry should be supported in terms of economic and social progress. The clustering approach has been used and supported by governmental policies for rapid development and competitiveness of industrial sectors. The clustering is based on synergy economy, dynamic relationship and networking among cluster member companies, universities, governmental and non-governmental organizations. The clustering improves productivity, efficiency and innovation. By the way it provides high quality job, local / regional development and international level competitiveness power. One of the successful clustering has been carried out by The Renewable Energy and Environmental Technology Cluster at Middle East Industry Trade Center Organized Industrial Zone (OSTIM) in Turkey. The clustering impact of The Renewable Energy and Environmental Technology Cluster was reviewed. The cluster employee profile is significantly higher than Turkey's average.

Keywords: Key word: Cluster, Clustering, Renewable energy, energy economy

1 INTRODUCTION

The development potential of renewable energy is closely associated with the strengthening of the companies working on renewable energy equipment design, production and services. The sustainability and healthy development of the industry can be obtained by plenty number of the companies that have worldwide competitive advantage. The fast and economical procurement of renewable energy equipment is one of the most important issues in sustainable growth. These equipment and services should be obtained economically and quickly in both periods the installation phase and operation phase. It may cause serious problems that may arise in any of these issues. This problem may be in the form of economic and reputational loss. The production of energy with planned quality and quantity depend upon these equipment quality, service quality and operating properly.

The clustering is one method to get competitive advantage at certain industries. The clustering approach are used and supported with government grants at more than 75 countries [1]. The clustering is based on close cooperation of companies working on similar or complementary industries at the same geographical regions. Thus a social community can be created and economical synergy may arise. The close relationship also established with university, government and civil institutions. The clustering initiatives are trying to strengthen with various policies and supports by governments. The companies which are members of cluster are more productive, efficient and competitive than those outside the cluster [2]. In order to get these advantages, the following items should be realized. The strong cooperation among members, to create a social community, governments grants, strong and stable leadership, tight collaboration with universities and other institutions. In Turkey, The Ministry of Economy has supported clustering by Improving International Competitiveness program. The incentives are included the needs analysis, training, consulting, purchasing committee, employment of cluster coordinator. 161 projects with 3727 companies are supported by government incentives according to February 2016 data. [3].

2 WHAT IS CLUSTERING

There are many definitions of clustering. According to Porter's [2]; ‘’ Clusters are geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs such as components, machinery, services, and providers of specialized infrastructure. Another definition from Morosini [4]; An industrial cluster is a socioeconomic entity characterized by a social community of people and a population of economic agents localized in close proximity in a specific geographic region. Some other definitions are emphasized conscious and continuous cooperation among cluster companies, universities and governmental institution. In the many of the clustering definitions, the main component of clustering is stated that geographical concentration, social community creation, corporation, face to face communication. These items play a key role to obtain clustering benefit. The clustering improves productivity, efficiency, expertise, knowledge creation and innovation. So a strong clustering provides sustainable competitiveness power for cluster members in short time. The clustering provides high quality job and improved expertise by cooperation with universities and other institutions.

3 WHAT IS NOT CLUSTER

An industrial site, an organized industrial zone, science or technology park, a consortium of firms, producer cooperatives, trade and professional associations are not a cluster. However, it can be a basis to provide potential to develop an important element in a cluster or clusters. This structure may provide the physical closeness but it is only one component of clustering. The social entity creation, tight cooperation with each other and local institution, knowledge creation, networking required for developing cluster.

4 OSTIM RENEWABLE ENERGY AND ENVIRONMENTAL CLUSTER

One of the most successful clusters are carried out Middle East Industry Trade Center Organized Industrial Zone (OSTIM) in Turkey. There are six clusters in OSTIM [5]. The public grants are benefiting at various projects. The Renewable Energy and Environmental Technology Cluster [6] is one of the successful cluster in OSTIM. The Renewable Energy and Environmental Technology Cluster achievement reached by the clustering approach is examined in this article. This cluster has carried out many issues such as strong cooperation among members, stable and strong leadership by industrial zone administration, obtaining government grants, tight collaboration with universities. Thus Renewable Energy and Environmental Technology Cluster achieved very important competitive power in short time period. The government grants and cooperation with universities were played the key role to improve cluster. The projects carried out together with universities and other institutions led to the implementation of new technologies. The cooperation with local and foreign institutions and organizations has been provided to gain a global vision of the cluster. The mutual trust improved into the cluster made it possible to produce collaborations and advanced knowledge creation. The employment of high qualified persons according to industry average has provided to obtain the competitiveness and is continuing to play a key role. The employee qualifications of The Renewable Energy Cluster have examined comparatively with the average of Turkey. The cluster employees profile is given at Table 1 with comparison of Turkey's small medium enterprises (SME) employees average profile [7].

Table 1. The Renewable Energy Cluster Employee Profile at OSTİM

Cluster Name	**Renewable Energy Cluster**	**Turkey Average* for SME's**
Number of company	69	
Total employees	514	
Number of University graduate employees	282	
number of engineers	115	
bilingual employees	167	

(Total employees/ number of Company)		**3**
University graduate employees %	55	
Engineers %	22	
Bilingual employees %	**32**	**8**

As it is seen at Table 1, the average number of employee and bilingual employee percentages at the cluster are 3 and 4 times higher than average Turkey SMEs respectively. This shows that cluster provides high quality jobs by attracting high profile labor. Additionally, the example of activities will be given carried out by the clustering approach

5 CONCLUSION

The renewable energy is an important sector at Turkey. The local industry availability will be provided significant support at the sector both economic and strategic level. The clustering may provide sustainable competitive power in short time period. OSTIM Renewable Energy and Environmental Technology Cluster achieve significant success at this sector. By conducting clustering approach high quality job, sustainable competitiveness power has been achieved. This success has been strengthened local and regional development efforts. In summary, the contribution of clustering approach to the developments in the renewable energy sector was investigated by the example of the Renewable Energy and Environmental Technology Cluster at OSTIM.

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Performance Analysis of Grid Connected 250 kWp Dicle University Solar Power Plant in Diyarbakır/Turkey and Comparison with Simulation Results at Winter Conditions

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ABSTRACT. In this study, performance analysis of 250 kWp solar power plant maintained in Dicle University was determined for 2015-2016 winter season. Data of energy production in December, January and February were recorded by monitoring and data logger system and evaluated according to performance criteria in IEC 61724 standards. The solar power plant was simulated under the same conditions by using PVsyst V6.39 software. In the study calculated performance parameters, data of energy production amounts, global irradiation, temperature, wind speed, solar sun shine duration were examined and measurement results were compared with simulation results.

Keywords: Solar Power Plant, Solar Energy, Performance Analysis, PVsyst Simulation

1 INTRODUCTION

Nowadays technology is developing rapidly, so this leads to requirement of more energy amounts. Currently about 76% of the world's energy demand is supplied from fossil fuels [1]. However, it is seen that fossil fuels pollute the environment and be exhausted in the near future. Thus, clean energy sources slowly began to take its place.

Sun is an enormous energy source and provides majority of renewable energy. In solar mapping research made by Renewable Energy General Directorate it is seen that Turkey especially, Southeastern Anatolia region has an important solar energy power potential. According to this research the Southeastern Anatolia Region is the richest region in Turkey with average annual solar radiation 1460 kWh/m^2-year and 2993 hours/year average duration of sunshine data.

In order to perform reliable analysis for electric power generation from solar energy, receiving the data accurately from solar power plants during operation has a great importance. Analysis of the data obtained from plants that is operating under actual atmospheric conditions will give information about energy obtained and plant performance. By the help of this data to obtain the design criteria of solar plants for a specific region will be possible. For this reason, performance analysis of 250 kWp solar power plant established in Dicle University was investigated for the winter period 2015-2016. The data required for analysis were obtained from the solar power plant and Meteorological Measurements Station in Dicle University.

In this study, the solar power plant was simulated in order to measure data, design PV system and analyze PV system operation by using the PVsyst V6.39 software. Simulation results were compared with energy production data of the solar power plant measured in December, January and February. The production values of the plant for three months were compared with global solar irradiation and sunshine duration values. Also performance parameters defined in IEC 61724 standards were calculated and compared with the simulation values.

2 SYSTEM'S TECHINAL DESCRIPTION

Dicle University Solar Power Plant is a project supported by Karacadag Development Agency and is carried out by Dicle University Engineering Faculty. The project began in 2014 but initiation of energy production was in 2015. The plant is located at latitude $37^0$54'N, longitude $40^0$16'E. Plant power is 250 kWp. Solar power plant ambient air temperature varies between 31,1°C and -1,7 °C during year.

Viessmann Vitovolt 300 P250 polycrystalline modules are used in the plant. In this system, 1000 PV modules which form 250 kWp are placed by an inclination angle of 30 degrees and facing of zero degre azimuth to south. In addition, each module has 60 solar cells.

In the plant a unit of 10 kW ABB PVI-10-TL-OUTD, and 8 units of 30 kW ABB TRIO-27.6-TL OUTD outdoor type inverters are used. The inverters have two MPPT inputs. Also plant is made of 8 units of 30 kW and one unit of 10 kW strings. There are six arrays in each 30 kW string. Three arrays of one unit is connected to an input of MPPT. There are two arrays in each 10 kW string. Each of these arrays are connected to separate inputs MPPT. In each array, 20-modules are connected in series. In addition, low voltage of the inverter output is converted to high voltage and connected to power grid by three-phase 630 kVA, 0,4/34,5 kV dry-type transformer. Dicle University Solar Power Plant's general connection configuration is shown in Figure 1.

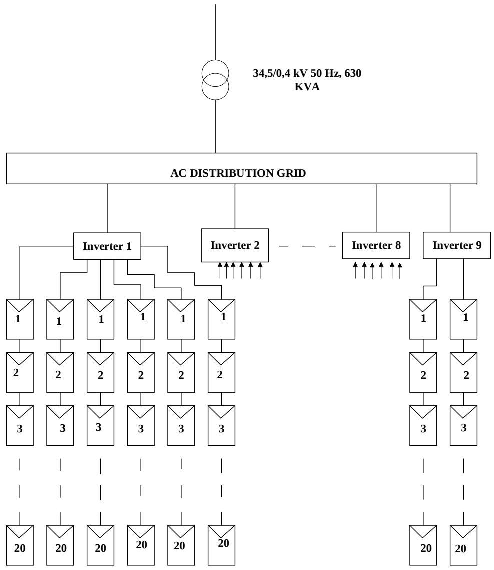


Fig. 1. Configuration of Dicle University Solar Power Plant

PVsyst is a modeling and simulation program used for analysis of PV technology. PVsyst uses important parameters such as inclination degree, meteorologic data, technical specification of system components such as PV panels and inverters. PVsyst gives results in terms of efficiency, losses of PV power, performance ratio, the capacity factor and 3D drawings [2-4].

In this study, the meteorologic data was taken from the solar measurement stations located on the roof of Dicle University Science and Technology Research Center building. Solar measuring stations can measure and record eight different type of data such as global radiation, sunshine duration, temperature, humidity, wind speed, and wind direction. For this purpose, a pyranometer, sensors related to wind and temperature and data logger were used in the solar measurement station. Total global irradiance, sunshine duration, and temperature were measured in every 10 minutes and given in terms of, W/m^2, hour and degrees of Celsius respectively. These measured data were recorded by LoggerNet program. The average monthly temperature, total sunshine duration, average global radiation and wind speed average values taken from the measuring station for the winter period, are given in Table 1.

Table 1. Measured meteorological data for winter period.

DATE	Average temperature ^{0}C	Total sunshine duration	Average Wind Speed (m/sec)	Global radiation (kWh / m^2-day)
December (2015)	5.35	223.21	0.97	1.43

January (2016)	1.69	119.74	1.22	1.1
February (2016)	8.68	170.56	1.06	1.74

In this power plant ten different types of parameters such as PV power, PV energy, produced energy, dc power, current, frequency, inverter temperature was measured and recorded. Measured data were recorded in every 5 minutes which can also be accessed by using Aurora Vision monitoring program.

3 PERFORMANCE ANALYSIS

Performance analysis of the plant was computed according to IEC 61724 standard parameters [5]. According to IEC 61724 standard energy and performance values of the system should be monitored for a certain period (τ). Analysis of the obtained data can be evaluated daily, monthly, or annually by using following definitions and formulas [5], [6].

Reference yield (Y_R) is defined as the ratio of incident total power irradiation (H_t) to reference irradiation G (1 kW/m^2) and given as [5], [6]:

$$Y_R = \frac{H_t(kWh/m^2)}{G(kW/m^2)} \quad (1)$$

Final yield (YF) is the ratio of the produced energy in a certain period (day/month/year) to installed power of the plant and is expressed as below equation [5], [6]:

$$Y_F = \frac{E_{Use,PV}}{P_0} \quad (2)$$

Where $E_{Use,PV}$ defines the produced energy and P_0 is the rated power. Performance ratio can be defined as below equation [7].

$$PR = \frac{\sum_i EN_{AC\_i}}{\sum_i [P_{STC}(\frac{G_{POA_i}}{G_{STC}})]} \quad (3)$$

Where EN_{AC} defines measured AC electrical generation (kW), P_{STC} summation of installed modules' power rating from flash test data (kW), G_{POA} measured plane of array (POA) irradiance (kW/m^2) and G_{STC} irradiance at standard test conditions (1000 W/m^2). This parameter is used to compute the performance and long-term variations. Also capacity factor (CF) is defined as total produced energy during a year to annually PV module potential energy which is given as:

$$CF = \frac{E_{AC,a}}{8760 \times P_{PV,rated}} \quad (4)$$

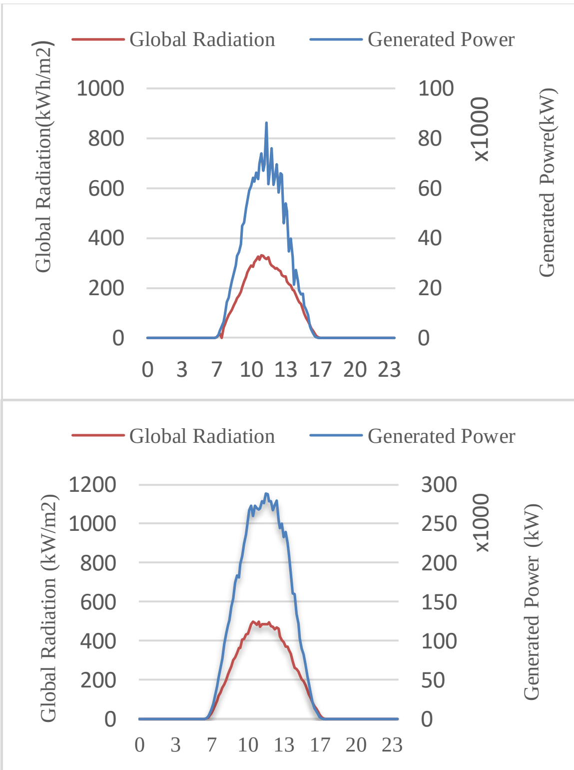
In this equation $E_{AC,a}$, P_{PV}, and 8760 coefficient expresses total produced energy in a year, total energy amount in kWh, and hour amount of a year respectively. Also the yield of the investigated system can be defined in the equation below:

$$\eta_{sys,m} = \frac{E_{AC}}{H_t \times A_a} \tag{5}$$

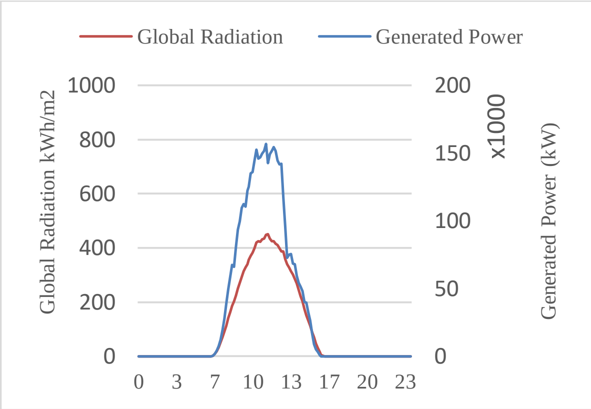
Here E_{AC} is produce AC power by system, H_t is the incident irradiation, and A_a is the system planar area.

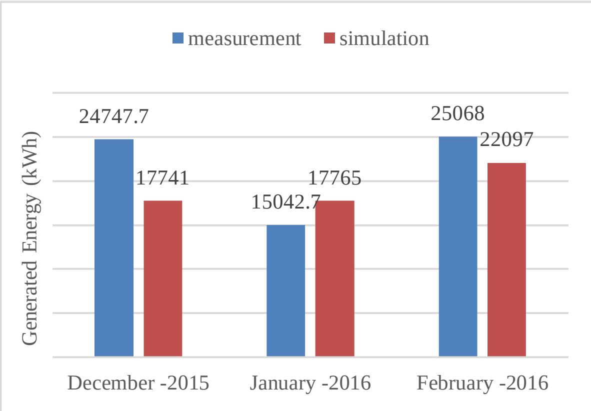
4 RESULTS

Daily average produced energy values and measured global irradiation amounts of the plant gained in December, January, and February are shown in Figure 2. Due to investigation of the data it was seen that maximum power obtained in February was 288,894.1 kW at 11:40 pm and the maximum value of the global irradiation reached in February was 18,470.4 kW/m^2.



a) December b) Januray





c) February d) Generated Energy in three months.

Fig. 2. Average daily solar energy production and measured global irradiation amounts and generated energy values of the plant for December, January, and February.

Produced energy amount by the plant in winter period and simulation results are shown in Figure 2.d. Maximum energy obtained in February was 25,068 kWh in winter period.

Measured and simulated performance parameters in December, January and February are given in Table 2. Average of system yield was 0,876 for this period.

Table 2. Measurement and simulated performance parameters of Dicle University Solar Power Plant.

	December (2015)		January (2016)		February (2016)	
	Measurement	Simulation	Measurement	Simulation	Measurement	Simulation
Yr (kWh/kW)	1,43	2.45	1,1	2.39	1,74	3.64
Yf (kWh/kWp)	3.2	2.18	1.94	2.14	3.45	3.2
PR	0,90	0.894	0,86	0.878	0,85	0.888

CF	0.012	0.0078	0.0072	0.0075	0.013	0.01
η	0.91	0.972	0.87	0.971	0.85	0.974

Comparison of Dicle University Solar Power Plant performance with the other solar power plants maintained in several countries [5], [8]–[10] is shown in Table 3.

Table 3. Comparison of solar power plant performance ratio for different countries.

Country	Authors	Plant PowerkWp	December	January	February
India	Sharma at all [5]	190	0,72	0,64	0,73
Pakistan	Buhari at all [8]	178.08	0,65	0,68	0,7
Italy	Aste at all [9]	11.250	0.72	0.69	0.72
Canada	Panchula at all [10]	20 000	0,7	0.86	0.82
Turkey	This paper	250	0,9	0,86	0,85

It can be seen from Table 3 that; performance ratio of Dicle University solar power plant is higher than the others.

5 DISCUSSION

In this study the energy producing data of Dicle University solar power plant for 2015-2016 winter season and its simulation results were investigated and performance parameters were obtained. As the lowest value of the measured energy production of solar power plants occur in winter, produced energy and performance values remain minimum during this time. At least these minimum values must be achieved are for the loads fed only from solar energy. Therefore, analysis of a solar power plant performance in winter conditions is very important.

Additionally, it was observed that there were some differences between the simulation results and real values obtained from the plant. Real values were found higher than the simulation results. The PV modules provide maximum efficiency in first years of establishment. This may be one of the reasons of high measured values. Also diversification of climate may lead to these high values.

Some various studies about performance of solar power plants has been performed by different researchers in several countries [7-10]. The result of our study showed that performance ratio of Dicle University Solar Power Plant is more efficient than others.

Turkey suitable for utilizing solar energy power systems due to its has abundant solar energy resources. Yearly average total solar radiation is highest in Southern Anatolia Region in Turkey. Our findings arise from great potential of global irradiation and sunshine duration levels of Southern Anatolian Region of Turkey.

The usage of solar energy resources will be an alternative to the conventional energy in the near future. So increasing the efficiency of renewable energy products is very important.

6 Acknowledgments:

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Control Techniques for Oscillating Wave Energy Converter

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ABSTRACT. With the advance of technology, the need for energy increases every day. The ever increasing demand for energy and also the serious level of environmental issues force energy research towards environmentally friendly renewable energy sources. The main sources of renewable energy are listed as solar, wind and wave energy. Among those, the solar and wind are already being utilised with some capacity. The only potentially good source left to explore is the wave energy. The presented work provides details on potential of wave energy and importance of control application in energy extraction from waves. The presented work focuses on modelling, simulation and control of a typical heaving wave energy converter. In this study, the heaving wave energy converter is modelled and simulation studies have been performed for phase and latching control. It has been shown that phase control performs better than latching control in all regular sea states. It has been also shown that latching control becomes a difficult control approach especially in irregular waves. For comparison of phase and latching controls only the regular waves are used. The phase control itself is also tested with the irregular waves. The results of the simulation studies are also presented in plots showing comparative study on the performance of phase and the latching control techniques.

Keywords: Renewable energy, wave energy, wave energy converter, wave power, control

1 INTRODUCTION

With the advance of technology in our daily life, the need for energy increases every day. The increasing demand for higher energy and also the environmental concerns lead to environmental friendly energy sources. The main environmental friendly sources of energy are wind, solar and wave energy. These renewable energy sources are mostly utilised or the related technology has reached to a certain level of capacity for wind and solar systems.

Wind energy, solar energy and wave energy are showed as main alternative energy sources. Wind and solar energy sources are turned into active energy production sources. In Turkey, at the end of 2014; 3630 MW electricity was produced by wind and 70 MW by solar energy. There are more power sites planned for near future installations [1].

However, the developments for wave power systems seem to be slower in development relative to the other two environmental friendly energy sources. It is also very important to point out that the energy potential for wave energy is very high and globally widely distributed. The increasing number of research papers in the area also indicates that there is an increasing interest in the research topic. An early assessment, in 1973, was made as the global wave power potential to be in the order of 1-10 TW [2]. Most of the wave energy is washed ashore and this huge potential of renewable energy sources is dissipated. A typical wave can transport its energy hundreds of kilometres with no or almost little loss across oceans. There is limited amount of work done to extract energy from waves although there are some recent efforts with reasonable levels of success [3]. Wave energy is accepted as a concentrated form of wind energy which is generated by solar energy [4]. The amount of energy transferred and, hence, the size of the resulting waves depends on wind speed, the length of time for which the wind blows and the distance over which it blows (the "fetch") [5]. The wind- wave interactions is extensively explained by Mastanbroek [6].

The energy potential analysis of waves reveals that the most energetic ones are observed far from the shoreline. As the waves travel to shoreline they appear to lose their energy. Therefore, depending on the location of the wave energy converter (WEC) relative to shoreline, there are three defined categories namely as, shoreline, near-shore and off-shore systems. The energy potential for waves are calculated using wave frequency (ω_f) and significant wave height (H_s). As increasing wave height increases wave energy, offshore devices receiving the highest waves also have the highest energy capture potential.

2 Energy extractıon from waves

From 1970s onwards there has been many studies reported on development of WECs and it appears that from the 6 degree of freedom (Figure 1), only pitch, surge and heave motions are directly coupled to the incident waves. Therefore, it is obvious that almost all research in this area focuses on these modes of motion [7].

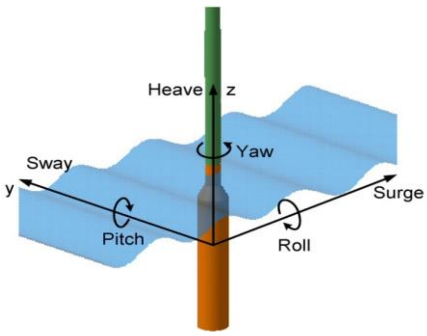

Fig. 1. Six-Degree of Freedom motion of floating object

Another main issue is that of the six fundamental solid body motion modes, only heave, surge, and pitch are directly coupled to the waves [7]. It was also reported [7] that power, which can be extracted from a motion mode anti-symmetric with respect to the waves, is twice as great as that to be had from a symmetric mode, such as heaving. This is one of the reasons why pitch or surge mode of motion is more suitable for wave energy research where power capture capabilities are potentially higher. However, it is the coupling effects between these two modes that make the behaviour of a pitching and surging device a complicated one. The question is that the power capture performances of these devices are dependent on their resonance with the incident waves. Especially in irregular wave conditions, it is necessary to maintain resonance in both modes to maximize power capture. In these seas, the resonance is named as quasi resonance [7] where the resonance is suggested to be aperiodic as opposed to that of regular waves where it is assumed to be periodic [7].

3 IMPORTANCE OF CONTROL IN ENERGY CONVERSION

The oceans have a great wave energy potential. However, the irregular nature of ocean waves and complexity of wave-WEC interaction makes the issue a challenging one. Although, control techniques appear to improve the wave power extraction potential, understanding of the overall issue still remains to be weak. One of the challenges in offshore systems is to apply the control techniques to WECs. The control strategies for oscillating types mainly aim keeping the WECs at resonance by adjusting the WEC natural frequency to match the incident wave frequency. It was mentioned in literature that there are two main control strategies, namely as latching control and phase control.

3.1 Latching Control

In latching control technique, instead of trying to match the wave and WEC frequencies by parameter adjustment, the motion of the WEC is interrupted by stopping it and extending the oscillation period of the WEC to match the wave period [8]. The action of stopping the motion of WEC is achieved by applying brake on the guide of the motion axis. However, to apply latching it is necessary to have WECs natural period shorter than the wave period.

3.2 Phase Control

Phase control strategy is based on resonance phenomena in which the maximum amplitude of motion of WEC can be achieved when natural frequency of the WEC and the frequency of waves are matched. The fixed settings for system parameters restrict the power capture performance of the system, resulting in inefficient power capture performance. If the WEC properties can be adjusted to match wave frequency to achieve resonance, then the energy extraction performance can be improved. The phase control approach can theoretically be implemented either by adjusting mass or the stiffness properties of the WEC, known as slow and fast tuning, respectively.

4 WEC model

As illustrated in Figure 2, the time-domain model of the point-absorber WEC system [9] consists of two parts that run in consecutive steps. In the wave force pre-processing part of the simulation, the time-series wave elevation data is processed to yield the time-series wave force signal, and the time-series wave frequency signal is also estimated. The power conversion part is, on the other hand, based on a MATLAB/SIMULINKTM [10] model, where the wave force is used to excite the WEC model and the displacement (x) and velocity (v) signals are calculated. These signals, along with k_{pto} and b_{pto}, are then used in PTO where the instantaneous power (P_{ins}), moving average power (P_{ma}) and the controlled force (H) are calculated. The tuner block in Figure 2 uses the estimated wave frequency signal and generates the optimum PTO settings (k_{pto}, b_{pto}) using the ideal point-absorber WEC theory.

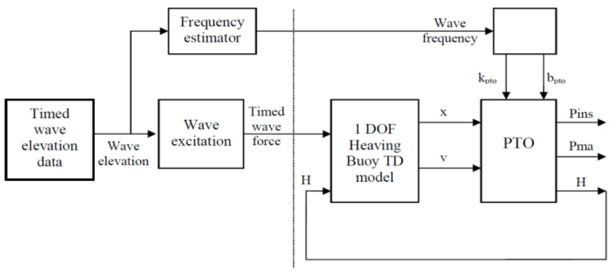

Fig. 2. Overall model of the point-absorber WEC system

The equation of motion in the time domain for a single translation mode, or degree of freedom, subject to wave effects can be expressed in the form

$$m_{dry}\ddot{x}(t) = F(t) \quad (1)$$

in which $x(t)$ is the position of the body at time t, m_{dry} represents the inertial mass of the body, and $F(t)$ is the total force on the body. Eq. (1) can be expressed below

$$(m_{dry} + a)\ddot{x}(t) + bxdot(t) + cx(t) + \int_{-\infty}^{t} K_R + (t-\tau)xdot(\tau)d\tau = \int_{-\infty}^{+\infty} K_E(t-\tau)\zeta(\tau)d\tau - H(t) \quad (2)$$

With zero initial conditions (i.e. at ‘rest’), it can also be shown [8 and 11] that the Laplace transform of equation (2) can take the form

$$[(m_{dry}+a)s^2+bs+c]X(s)+\frac{B_R(s)}{A_R(s)}sX(s)=\frac{B_E(s)}{A_E(s)}Z(s)-H(s) \quad (3)$$

where $X(s)$, $Z(s)$ and $H(s)$ are the Laplace transforms of $x(t)$, $\zeta(t)$ and $H(t)$ respectively.

The adaptive controller used in tuning the system is based on the dominant wave frequency. It uses this information for determination of the tuning parameters in order to keep the WEC in resonance. Therefore, the second set of calculations for the Part 1 simulations are estimation of the dominant wave frequency in the wave elevation data. For this purpose, the Discrete Fourier Transform (DFT) is used in estimating the dominant frequency as a time series.

In the second stage of the simulation, the computed wave force and other necessary parameters are stored in the workspace, before subsequently being utilised to drive the SIMULINKTM model of the WEC.

The inputs to the 1-degree-of-freedom time-domain SIMULINKTM model of the WEC block are the wave force, F (F), and the power take-off force, H (H), and the outputs are the state variables, i.e., the heave displacement, x (x), and the heave velocity, v (v).

The input to the tuner block is an estimate of the sea wave frequency ω_{est} (omega_info), so that the optimum power take-off parameters k_{pto} (kpto) and b_{pto} (bpto) can be calculated using the equations [8]:

$$k_{pto}=m\omega_{est}^2-k_{net} \quad (4)$$

$$b_{pto}=b\omega_{est}^3 \quad (5)$$

where the coefficient b (b) is given by

$$b=\frac{b_{rad\_nom}}{\omega_{nom}^3} \quad (6)$$

and where b_{rad_nom} is the radiation damping coefficient at the nominal wave frequency

$$b_{pto}=\frac{b_{rad\_nom}}{\omega_{nom}^3}\omega_{est}^3 \quad (7)$$

It is clear that if the estimated wave frequency is close to the nominal frequency then, it can be assumed that $\omega_{est}=\omega_{nom}$ and hence b_{pto} will simply be equal to b_{rad} (assuming also that $b_{loss}=0$) [8]. Therefore, equation 7 can be rewritten as follows,

$$b_{pto}=b_{rad\_nom} \quad (8a)$$

Alternatively, if $b_{loss}\neq 0$ then,

$$b_{pto} = (b_{rad\_nom} + b_{loss}) \tag{8b}$$

The inputs to the PTO block are the heave displacement, x (x), and heave velocity, v (v), fed back from the 1-degree-of-freedom WEC block, and the power take-off stiffness, k_{pto} (kpto), and damping coefficient, b_{pto} (bpto), from the PTO tuner block. The outputs are the PTO force, H (H), the instantaneous power, P_{ins} (Pins), and a second-order moving-average power, P_{ma} (Pma).

The PTO force, or control force, is defined as

$$H = k_{pto}x + b_{pto}v \tag{9}$$

and the instantaneous power converted is defined as

$$P_{ins} = b_{pto}v^2 \tag{10}$$

A moving average value of the PTO power is also computed in the 'moving average power blocks'. The moving average (P_{ma}) is defined as follows,

$$P_{ma} = \frac{1}{\int_{t_n}^{t_m} dt}\left(\int_{t_n}^{t_m} P_{ins}(t)dt\right) = \frac{1}{T_d}\int_{t_n}^{t_m} P_{ins}(t)dt \tag{11}$$

where $P_{ins}(t)$ and $T_d = t_m - t_n$, are the instantaneous power at time t and the moving average window length, where the latter is defined as the difference between the window start time (t_n) and end time (t_m). This function averages the input signal $(P_{ins}(t))$ over a time period T_d (typically 20 seconds) and yields a fast-acting smooth estimate of the moving-average mean power.

Another parameter computed for analysis is the nominal power, which is computed for each time data sampling point, i.e.

$$P_{nominal}(t_n) = \frac{1}{t_n}\int_{0}^{t_n} P_{inst}(t)dt \tag{12}$$

where $P_{ins}(t)$ and t_n are the instantaneous power and the time for which average power capture is calculated, respectively. Therefore, the average power $P_{nominal}(t)$ parameter indicates the average captured power at time t.

5 RESULTS

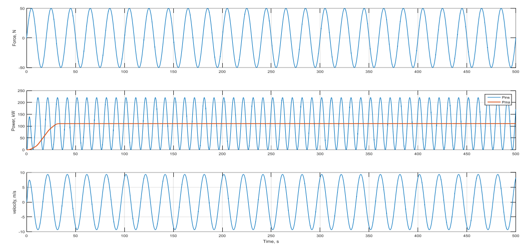

Fig. 3. Default performance parameters of WEC

With fixed tuning settings (stiffness 1,58 kN/m, damping 2,51 kNs/m), for heaving WEC in regular waves the results are given in Figure 3. The captured moving average power for fixed control parameters is about 110 kW.

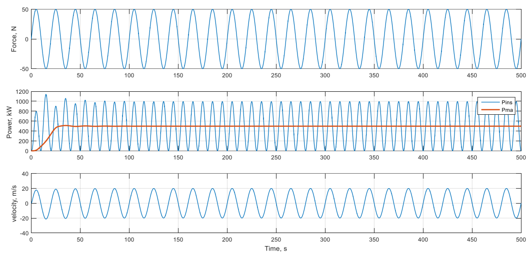

Fig. 4. Performance parameters of WEC controlled by phase control technique

Phase control technique was also applied to WEC for regular waves. The results are shown in Figure 4. The natural frequency of the WEC is tuned to match the estimated wave frequency. As a result of the tuning, the capture power of the device increases. It was seen that moving average power capture results for WEC is increased from 110 kW to 497kW by phase control.

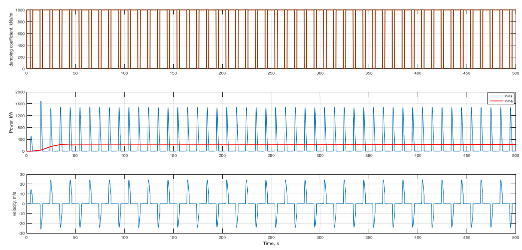

Fig. 5. Performance parameters of WEC controlled by latching control technique

Another technique, latching control, was applied to WEC in regular waves. Latching control technique is based on applying brake on the motion of the WEC to match the periods of the WEC and the waves. The period of wave is estimated and the oscillation period of WEC is extended by applying a brake. The brake time is calculated and the damping coefficient was maximized to generate the braking effect. It can be seen in Figure 5 that the moving average power is about 214 kW.

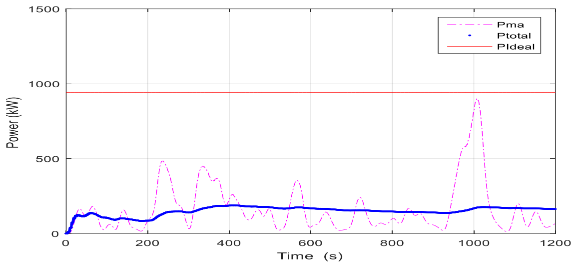

Fig. 6. Performance parameters of WEC controlled by constant dominant omega phase control technique for irregular waves

Figure 6 shows the results of the simulation for irregular waves with fixed tuner settings. The dominant frequency of whole dataset was estimated and the parameters were adjusted according to this dominant frequency. Ideal power is calculated as 942kw but the captured power is calculated is as low as 163kW.

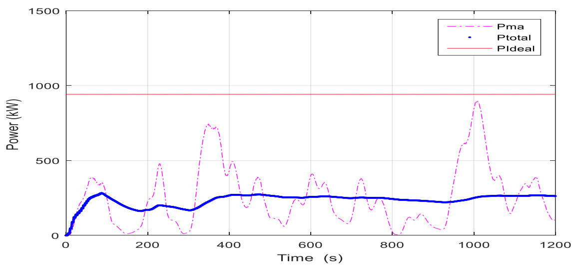

Fig. 7. Performance parameters of WEC controlled by sliding DFT phase control technique for irregular waves

In Figure 7, as a part of the irregular wave simulations, the frequency estimation of irregular waves is done with sliding DFT technique. The captured total power was increased to 262kW. The sliding DFT technique is successful for estimation of dominant frequency for significant waves. As a result, the power capture efficiency of WEC is increased compared to the results for the fixed tuning settings based technique.

6 CONCLUSION

In this paper, latching and phase control techniques studied for an oscillating type wave energy converter using a MATLAB/SIMULINK^{TM} model. The moving average power values are achievedas shown in figures. Although both approaches aim at achieving resonance phenomena, it appears that phase control is better at achieving the desired resonance compared to latching control in regular waves.

The study also contains the different phase control techniques for irregular waves. Both constant omega and sliding DFT techniques are applied. The sliding DFT technique seems to be more efficient and effective in achieving the desired resonance. It is also very much clear that the power capture performance of WEC systems depend on the type of control approach selected. In regular seas, the use of sliding DFT based phase tuning technique seems to improve the power capture performance in the order of 4 to 5 times. Considering that the same system is used in both cases, the importance of control techniques and related research on the topic becomes far more clear. Therefore, it is obvious that there is a clear need for research on WEC control techniques and related studies.

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The Techno-Economic Comparison of Solar Power Generation Methods for Turkish Republic of North Cyprus

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ABSTRACT.

The objective of this work is to examine and compare the techno-economic and environmental feasibility of 40MW photovoltaic (PV) power plant and 40MW parabolic trough (PT) power plant to be installed in two different cities, namely Nicosia and Famagusta in Turkish Republic of Northern Cyprus (TRNC). The need for using solar power technology around the world is also emphasized. Long term solar radiation and sunshine data for Nicosia and Famagusta are considered and analyzed to assess the distribution of solar radiation, sunshine duration, and air temperature. In addition, these two different technologies with same rated power of 40MW will be compared with the performance of the proposed Solar Power Plant at Bari, Italy. The project viability analysis is performed using System Advisor Model (SAM) through Annual Energy Production and economic parameters for both cities. It is found that for the two cities; Nicosia and Famagusta, considered through this study, the investment is feasible for both 40MW PV power plant and 40MW PT power plant. From the techno-economic analysis of these two different solar power technologies having same rated power and under the same environmental conditions, PT plants produce more energy than PV plant. It is also seen that if a PT plant is installed near an existing steam turbine power plant, the steam from the PT system can be used to run this turbine which makes it more feasible to invest. The high temperatures that are used to produce steam for the turbines in the PT plant system can be supplemented with a secondary plant based on natural gas or other biofuels and can be used as backup. Although the initial investment of PT plant is higher, it has higher economic return and occupies smaller area compared to PV plant of the same capacity.

Keywords: Solar Power, Photovoltaic Plant, Parabolic Trough plant, Techno-Economic Analysis

1 INTRODUCTION

Renewable energy (solar, wind, tidal, hydroelectricity, geothermal, biomass, etc.) production represents a minor part of the total world energy consumption, although an upward increase is being witnessed daily in this aspect of energy. Due to climate change, caused by greenhouse gases (GHG), and other harmful emissions resulted from fossil fuel combustion, many countries nowadays are subsidizing solar energy utilization and enforcing strict rules on emissions for reducing the dependence on fossil fuels. Expectations are that renewable energy will play a major role by the end of this century [1].

Human energy consumption is estimated to be 50TWh ($50x10^9$ kwh) per day and majority of this energy is extracted from the combustion of fossil fuels which also releases unwanted gases, CO_2, NO_2, SO_2, etc. into the atmosphere. In 2005, the world oil consumption was equal to 85 million barrels per day and is growing at an alarming rate [2]. Biggest portion of this growth is associated with the economies in developing countries. Based on the information of World Economic Outlook 2010 (WEO) published by International Monetary Fund (IMF), in 2009 world economy decreased by 0.6% [3]. This was as a result of international economic crisis that year, and there was a global recession of -3.2%. IMF estimates that during the period 2010-2015 the average growth could be 4.6% for world economy, 2.5% for developed economies and 6.7% for emergent economies [3]. Thus, in most of the countries in which energy consumption is strongly related with economy, it is expected that energy consumption will grow again. World energy consumption will increase by a factor of 20 if all 9 billion people in the developing countries consume the same per capita amount of energy as the 6.9 billion people currently in the developed countries. The United States Department of Energy (U.S. DOE) estimates that by 2025 the most useful fossil fuel will continue to be coal, but on the other hand renewable energies will exceed natural gas production in subsequent years [4].

2 ENERGY USE AND SOLAR POTENTIAL IN NORTHERN CYPRUS

Nearly half of the fossil fuel imported (44%) into TRNC is used for electricity generation in thermal power plants, which is a very expensive way to generate electricity. It is well known that increase in electricity consumption has gone parallel with population and economic growth in general. According to the electricity board of TRNC, KIB-TEK, the total number of the residential customers was 120,119 and the total number consumer (in different tariffs) was 155,318 in 2014 [5]. In TRNC, the winter peak on 9th January 2013 was 257MW and the summer peak, on 15th August 2013 was 259MW, whereas on 20th January 2014, winter peak was 218MW and at summer peak on 25th August 2014 was 279MW [6].

Renewable energy resources in TRNC are mainly solar energy. Solar irradiation in Cyprus (a typical example of an island in the Mediterranean Sun Belt) is one of the highest in Europe, with more than 300 days of the year considered as having sunny weather and an annual irradiation of around 2,000kWh/m2 on a tilted surface of 27.58o [7]. A 1.2 megawatts solar photovoltaic plant has been in active use since May 2011 [15] in Cyprus and it is still in use till date. However, as there is not any law to promote the use of renewable energy sources in TRNC, there are only few private PV system installations. The solar energy input is particularly high at areas where the dry summer is well pronounced, lasting from April to October. [7]

In the lowlands the daily sunshine duration varies from 5.5 hours in winter to about 12.5 hours in summer. The mean daily global solar radiation varies from 2.3 kWh/m2 in the cloudiest months of the year December and January to about 7.2 kWh/m2 in July. The average solar irradiation received in TRNC (35°N, 33°E) [8] during winter is estimated to be 60 kWh/m2 (per month) in the months of December and January. During the summer the estimated solar irradiance is said to be 240 kWh/m2 (per month) in the month of June and July [9]. The country itself has a population of about 320,475 over 3355 square kilometers (1295 sq. mi). The annual solar irradiation at Bari (Italy) is 1600 kW/hm2. [10]

3 METEOROLOGICAL CONDITIONS FOR NORTHERN CYPRUS

Annual average value of the solar radiation for Nicosia is 5.20 kWh/m^2/day and for Famagusta is of 5.18 kWh/m^2/day [11] (Table 1). The lowest and highest temperatures and sunny hours are given in table 2 [12].

Table 1. long-term annual values of global solar radiation on horizontal surface and sunshine duration for the two sites in trnc.

Cities	Latitude (deg.)	Longitude (deg.)	Altitude (m)	Sunshine (hours/day)	Annual average Insolation (kWh/m^2/day)
Nicosia	35.20	33.3	224	12.14	5.20
Famagusta	35.10	33.9	225	12.13	5.18

Table 2. long-term monthly lowest and highest values of sunny hours and temperatures for the two sites in trnc

City	Lowest monthly sun hours	Highest monthly sun hours	Min. average temp.	Max. Average temp.
Nicosia	January…140 hrs	July…377 hrs	January…5ºC	July…37ºC
Famagusta	January…150 hrs	July…376 hrs	January…7ºC	July….32ºC

4 METHODOLOGY

The technical and financial analysis of the proposed plants will be carried out using System Advisor Model [13]. Furthermore, the techno-economic analysis for the proposed solar power plants for BARI-ITALY will be used as a reference and for comparison. Cost figures of BARI, especially those related for the installation, operation and maintenance of the PT plant will be used with minor adjustments where necessary. The investment, operation and maintenance cost figures of the PV Plant will also be obtained through local installers.

The software that was used for simulation in this work is SYSTEM ADVISOR MODEL (SAM). It is a performance and financial model designed to facilitate decision making for people involved in the renewable energy research. The model calculates the cost of generating electricity based on information provided about a project's location, installation and operating costs, type of financing, applicable tax credits, incentives and system specifications. SAM reports performance and financial metrics in the form of tables and graphs. It calculates a system's total electricity production in kilowatt-hours for the first year based on hourly weather data for a particular location, and physical specifications of the power system components. It then calculates the total production for subsequent years based on an annual degradation factor, and annual cash flows based on financial and economic inputs to determine the levelized cost of energy and other economic metrics.

The modeled PT thermal power plant (a Concentrated Solar Power, CSP system) field layout is shown in fig1. It can be observed that the power block (turbines, steam generator, condenser and tanks) is in central position while the solar field is constituted by 3 areas: 2 of them containing 33 Solar Collector Assembly (SCA) and the third one containing 70 SCA. The SCAs are parallel-connected. Each SCA is constituted by 6 series-connected collectors (in a U form) and each collector is 100m long and has a span of 5.76 m. Then, one SCA is 600m long (occupying 300 m long and 17.28 wide area) while the distance between two SCA is equal to 2 times the span of a collector (distance between two collectors ıs approximately 6.81m).

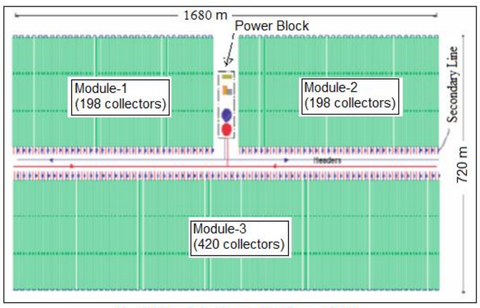

Fig. 4.1 Parabolic Trough Plant Layout [10]

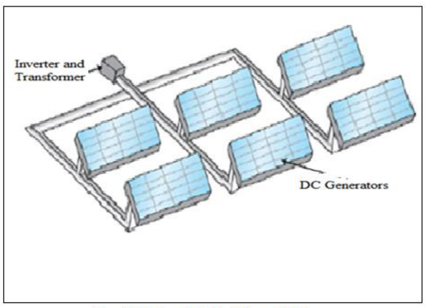

Fig. 4.2 Photovoltaic Plant Layout [10]

Figure 2 shows the layout of the PV plant. 20 series-connected PV modules of 250Wp rated power constitute a single array. One hundred arrays are connected to the

DC side of each 500- kWp inverter. Two inverters are linked to a 1MW LV/MV transformer in a single MV/LV cabin. Finally, 40 MV lines are collected in a single HV/MV cabin which allows injecting the AC electrical energy into the grid. Table 3 resumes the parameters of the PV plant and Table 4 for PT plant at Bari, Italy.

The electrical rated power of the CSP in this case study is 40MW, while the efficiency of the thermal cycle is equal to 42.3%. The total energy produced by the PV plant is 56GWh/year, while PT plant produces 168 GWh/year. This great difference of the produced energy is due to the fact that CSP has the storage system constituted by the hot tank, which allows producing the same amount of energy also when the radiation is low or at night. The thermal storage system of CSP is its strength with respect to other renewable energy sources without storage which have the weakness of the unpredictability of the produced energy.

Table 3. Parameters of the Proposed PV plant at Bari [10]

S/N	DESCRIPTION	VALUES
1	Number of mono-crystalline PV modules @ (250wp)	160,000
2	PV module Efficiency in Standard Test Conditions (STC)	17%
3	Losses of the BOS	12.5%
4	Number of 500-kWp inverters	80
5	Number of MV/LV cabins	8
6	Number of HV/MV cabins	1
7	Area needed for 1MWp	1.5×10^4 m^2
8	Total area	60×10^4 m^2
9	Total electrical rated power	40MWp
10	Yearly solar equivalent hours	1600 hrs/year
11	Yearly produced energy, net	56GWh/year

Both plants (CSP and PV) show degradation in the energy performance during the whole life-cycle; for both of them the degradation can be estimated in 0.5% to 1% of the capacity for each year. For PV plant the ordinary annual maintenance costs are taken as 1% of the initial investment, around 750 k€ per year, while for PT plant, the annual maintenance costs are taken as 2%, due to the major complexity of the plant, around 2,600 k€ per year. Investment related parameters for the PV and CSP plants installations in NC are given in table 5 and Table 6 respectively.

Table 4. Parameters of the proposed parabolic trough plant at Bari-Italy [10]

S/N	DESCRIPTION	VALUES
1	Number of the collectors	816
2	Area of each collector	551.47 m^2
3	Total collector area	45 x 10^4 m^2
4	Distance between collectors	12/ m
5	Annual solar hours	1600 hrs/year
6	Peak solar radiation intensity	900 W/m2
7	Mean collector efficiency for year (depending on the annual direct radiation)	0.67
8	Peak thermal collection efficiency	0.79
9	Peak thermal power of the solar field (with radiation of 900W/m^2 and efficiency of the collector equal to 0.79)	320 $MW_{p,t}$
10	Annual heat collected with radiation of 1000W/m^2 and efficiency of the collector equal to 0.67)	482 GWh
11	Solar field area	90 ha
12	Temperature of the hot tank	550 °C
13	Temperature of the cold tank	290 °C
14	Storage capacity	3.000 MWh
15	Rated electrical power	40 MWe
16	Thermo-electrical efficiency in rated electrical	0.423
17	Losses of BOS	17.5%
18	Produced energy for year	168 GWh/year
19	Load factor (ratio between produced energy and energy obtained if the CSP works in the rated conditions during the whole year)	0.48

Table 5. Investments for PV plant

PV plant			
Rated power	40,000	KWp,e	
Costs item	Unit cost	Size/quantity	Total Cost (€)

PV modules	1.20€/Wp	40MWp	48,000,000
Inverters	151.00€/kWp	40MWp	6,040,000
Cabin MV/LV	150,000.00€/cabin	8,00	1,200,000
Cabin HV/LV	180,000.00€/cabin	1,00	180,000
Other electrical components	179,00€/kWp	40.000kWp	7,160,000
Other (design cost, purchase of the land)	162,00€/kWp	40.000,00	6,480,000
Taxes (in %)	10.00%		
Taxes (in €)	6,906,000.00		
TOTAL (in €)	75,966,000.00		
Cost/unit	€/kWp		1,899

Table 6. Investments for the Parabolic Trough Plant

CSP plant			
Rated power	40.000		KWe
Cost item	Cost/unit	Size/quantity	Total Costs (€)
SCA	97.20€/m2	45 x 10^4 m^2	47,727,968
Hot and cold tanks	8.70€/kWht	3,000MWh	26,100,000
Hp and Lp turbines	650.00€/KWe	40 MW	26,000,000
Steam generator	124.00€/kWhe	40 MW	4,960,000
Other (design cost, purchase of the land)	270.00€/kWhe	40 MW	10,.800,000
Other thermal and electrical components	248.76€/kWhe	40 MW	9,950,538
Taxes (in %)			10.00%
Taxes (in €)			12,553,850.69
TOTAL(in €)			138,092,357.61
Cost/unit	€/kWe		3,452

Power generation from renewable sources includes the use of recent technologies, and then projects become expensive. Therefore, governments need to create economic incentives to enable the development of new power generation plants. Sometimes the incentives are linked to the initial investments as co-financing, whereas other times they are linked to the produced energy. This last solution is more interesting because it encourages the plant manager to manage the plant optimally. Usually two types of economic benefits can be achieved; government support in form of feed-in tariffs and the commercial benefit related to selling of the produced energy to the local energy utility company.

It can be noted that the total economic incentive for the PT plant is equal to three times that related to the PV plant with the same rated power. Moreover, the incentive for the PV plant is limited to 20 years, while the incentive for the PT plant continues until 25 years. Then larger initial investments of the PT plant (Table 7) are annually compensated with larger total incentives as shown below.

Table 7. Summary of PV and PT Plant Investment at Bari [10]

DESCRIPTION	PV	CSP
Rated power (kW)	40,000	40,000
Equivalent yearly operation hours (h)	1,600	4,200
Yearly produced Energy (MWh)	56,000	168,000
Feed-in Tariff (€/MWh) (incentive)	240	270
Total Period of feed-in tariff (years)	20	25
Energy sale price (€/MWh)	90	90
Yearly government incentive (€) (A)	13,440,000	45,360,000
Yearly selling of the produced Energy (€) (B)	5,040,000	15,120,000
Yearly total incentive (A+B)	**18,480,000**	**60,480,000**

5 RESULTS AND DISCUSSIONS

All the calculations will be shortened into a table.

5.1 Techno-Analysis of Proposed Solar Plants

In this section the techno- analysis of a proposed solar power plant installation in Nicosia and Famagusta are presented. The SAM model used for the analysis can only estimate annual solar energy generation for cities in United States. It is found that Sacramento city located in California has similar annual solar radiation with Famagusta and Lubbock city in Texas has similar annual solar radiation with Nicosia. These two cities are used for simulation to this work. Table 8 shows and compares five cities with their annual solar radiation in horizontal surface and at inclined surface calculated using solar electricity handbook. [14].

Table 8. Annual Solar Radiation for some cities in USA, Italy and North Cyprus

Cities	**On Horizontal surface (KWh/m^2)**	**On Inclined surface (KWh/m^2) angle (from horizontal)**
Sacramento, California, USA	1838	2055 at 38°
Lubbock, Texas, USA	1832	2027 at 34°
Bari, Italy	1509	1653 at 41°
Nicosia, North Cyprus	1878	2038 at 35°
Famagusta, North Cyprus	1800	1933 at 34°

Table 9. Mathematical model result summary of PT Plant

	Nicosia	**Famagusta**
Annual Solar Radiation	$1878kWh/m^2$	$1800\ kWh/m^2$
Collected heat energy (87.5% performance factor)	65.7GWh/year	63.0GWh/year
Peak Solar Radiation	$900W/m^2$	$900W/m^2$
Peak heat collection by the solar field	$320MW_{p,t}$	$320MW_{p,t}$
Annual heat collected (67% efficiency)	566GWh	543 GWh
Thermo-electrical conversion (42.3% efficiency)	239GWh	230GWh
Net electrical energy produced yearly (17.5% efficiency)	197GWh/year	189GWh/year

All values from PV plant at Bari were considered as a reference for installation of 40MW plant in Nicosia and Famagusta except for annual solar hours and annual energy production.

With the stored energy, the system will continuously operate about 19.6 hr at the rated capacity. To have the system running at the rated capacity for 24 hours, the storage capacity must be increased by about 35% to 2000 MWh. Storage size of larger than 1440 MWh cannot be charged on daily basis, even in summer periods. However, this large size will allow for heat losses, inefficiencies in heat transfer and especially for those periods when power may not be produced due to other reasons including maintenance and feed in problems.

Further increase in storage capacity may give advantage during the long cloudy hours. In this work, storage capacity is taken as 3000 MWh. This enables the system to continue production at rated capacity for a continuous period of 26 hours when sun is not available.

All values simulated in SAM for both 40MW PT plant and 40MW PV plant for Nicosia and Famagusta have the same parameters with 40MW PT plant and 40MW PV plant at Bari, Italy. However, the annual solar radiations are taken as 1832KWh/m^2 and 1838KWh/m^2 for Famagusta and Nicosia respectively. Table 10 and 11 compares Solar Power Plants in Bari, Nicosia and Famagusta.

Table 10. Comparison of Photovoltaic Power Plant in Bari, Nicosia and Famagusta

Cities	Solar Annual Radiation (kWh/m^2)	Yearly Produced Energy (GWh/yr)	Initial Invest-ment (1000 €)	Econom-ic Life (years)	SPP (years)	Unit Cost (€/kW$_p$)	Unit Sale Price €/MWh	State Incentives Yearly (1000 €)
Bari	1600	56	75,966	25	9	1,899	90	3,440
Nicosia	1832	71	65,415	23	8.5	1,551	120	0
Famagusta	1838	66	66,429	25	9	1,649	120	0

Table 11. Comparison of Parabolic Trough Power Plant in Bari, Nicosia and Famagusta

Cities	Solar Annual Radiation (kWh/m^2)	Yearly Produced Energy (GWh/yr)	Initial Investment (1000 €)	Economic Life (years)	SPP (years)	Unit Cost (€/kW$_p$)	Annual Heat Collected (GWh/yr)	Unit Sale Price €/MWh	State Incentives Yearly (1000 €)
Bari	1600	168	138,092	25	7	3,452	482	90	45,360
Nicosia	1832	190	121,519	20	6.5	3,068	566	120	0
Famagusta	1838	180	124,584	25	7	3,145	543	120	0

Summary of the financial indicators, Net Present Value (NPV), Internal Rate of Return (IRR), Simple Payback Period (SPP), Economic Life Cycle of the system, Annual Energy, Total Investment Costs, for PT plant and PV plant in both cities (Nicosia and Famagusta) are discussed. Evaluation of the results presented in Table 9 and 10 are done in the coming sections with graphical demonstration of the simulation results.

5.2 Energy Production

The amount of energy delivered to the utility at each city of NC annually by 40 MW PT and PV plant is calculated by the SAM simulator program and the results are presented in Fig 5.1. The program considers inputs such as solar radiation, mean temperature and sun tracking settings while determining produced energy. It is found that the highest energy production is obtained at Nicosia power plant with both PT and PV plants. The amount of energy produced by the PT plant and PV plant in Nicosia are equal to 190,000MWh/year and 71,428MWh/year, respectively. However, at Famagusta the energy production values for the PT and PV plants are 180,865MWh/year and 66,563MWh/year, respectively. As expected, for annual energy production, there is a difference of 10%-15% against 40MW PT plant and 40MW PV plant at Bari, Italy to 40MW PT and 40MW PV plant in Nicosia and Famagusta.

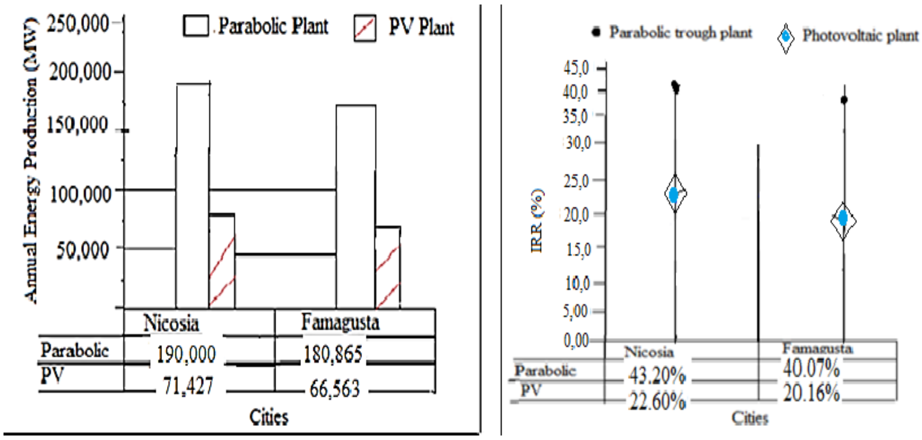

Fig. 3. Annual Energy Production for Nicosia and Famagusta and Internal Rate of Return of each solar power plants

5.3 Financial Analysis

The economic feasibility analysis can be carried out by the SAM simulator software, which is capable of calculating a large valuable number of financial indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), Simple Payback Period (SPP), Economic Life Cycle of the system, Annual Energy, Total Investment Costs, After Cash Flow, etc. However, to conduct such an analysis, initial costs, periodic costs and financial parameters that are given in section 4, should be taken into account as input to the software. Some of these economic indicators, which are presented in Table 10 and 11, are discussed below to determine profitability of 40 MW PT plant and 40MW PV plant investments at two different cities of TRNC. Fig.4 shows IRR representing the true interest yield provided by the project equity over its life. All IRR values are over discount rate which shows economic feasibility of 40MWp PT plant and PV power plant investments in TRNC.

Simple Payback Period (SPP) represents the length of time that it takes the project to recoup its own initial cost, out of the cash receipts. SPP of these investments vary between 6.5 and 7 years which are short periods compared to the life duration (25 years) of the project. The SPP obtained at Nicosia for PT plant and PV plant are 6.5 and 7 years respectively. However, same values of SPP are seen at Famagusta, which are 8.5 and 9 years with PT plant and PV plant respectively, as shown in Fig.5.

The averages are 6.5 and 7 years with PT and PV plant respectively. It shows that both PV and PT installations in both cities are feasible.

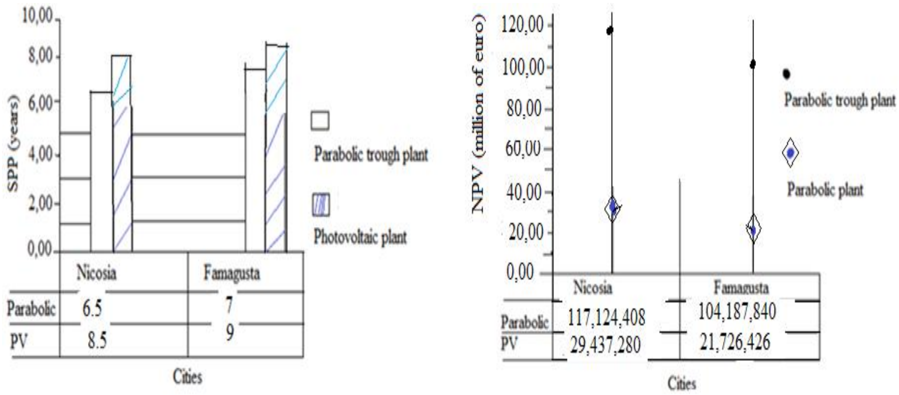

Fig. 4. SPP at two cities for different solar power plants (left). NPV for two different solar power plants at two cities (right).

Fig. 6 presents Net Present Value (NPV) of the projects, PT plants and PV plants at two different cities, Nicosia and Famagusta. Net Present Value (NPV) of the project refers to the value of all future cash flows, discounted at the discount rate. As all NPVs are positive, installations at the two cities, Nicosia and Famagusta are profitable. According to Fig.6, Nicosia is the most profitable city for both PT plant and PV plant.

U.S dollar values produced by SAM were converted to EURO at a rate of 0.8Euros =1.0 Dollars

6 CONLUSION

Over the last eight years, electricity consumption has been increasing in TRNC and this demand nearly doubled after 2004 due to the construction of new houses and holiday resorts. However, TRNC is dependent on imported fossil fuels. As an alternative and sustainable energy source to fossil fuel fired thermal power stations, solar energy is the most suitable local energy source due to the climatic conditions of TRNC.

This work examines two sites; one inland and one shore, for the PT plant and PV plant implementation in TRNC. Techno-economic and environmental feasibility of 40MW PT plant and 40MW PV-grid connected power plant is carried out using System Advisory Model (SAM) version 4.0 software. Two cities, Nicosia and Famagusta are selected as candidate sites for such an installation. References were made based on the proposed solar power plants parameters at Bari, Italy for the installation of 40MW PT plant study and 40MW PV plants Nicosia and Famagusta. The PV module selected for the 40MW PV plants is 250Wp with inverter capacity 5000Wac. The long-term meteorological parameters obtained from NASA shows that PT plants and PV power plants can have a major impact on the future energy mix of TRNC due to high solar radiation and long sunny hours.

The simulation results show that Nicosia has an annual energy production capacity, 196,262MWh/year and 71,427MWh/year with PT plant and PV plant, respectively. For Famagusta plants annual energy production are 180,865MWh/year and 666,563MWh/year with PT plant and PV plant respectively.

The study pointed out that both of the two sites in TRNC are profitable for implementing PT plant and PV power plant. Power plants in Nicosia have higher profitability than power plants in Famagusta. In addition, it is observed that the use of solar power plants reduces large amounts of CO_2 emissions to the environment thereby making the environment cleaner. Therefore, for the same rated power and under the same environmental conditions, PT plant produces more energy than PV plant. This implies that the economic return of PT plant is greater. Moreover, the area occupied by PT plant is smaller than that occupied by PV plant. Nevertheless, the initial investment required to install the PT plant is much higher than the PV plant. The maintenance costs of PT are also much higher than that of PV plant. Furthermore, for the PT plant, cooling water is required for condensing the steam. As usual, there are advantages and disadvantages for each technology. Then, it is not possible to say a-priori that one technology is better than the other one. This work has highlighted some of the main issues that are needed to take into account before to decide which solar power technology is the better one for a specific case.

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Permaculture: A Holistic Science to Design Sustainable Human Settlements

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ABSTRACT. Permaculture is an ethics-based design science to design sustainable human settlements. Initially developed as a collection of sustainable agriculture technics, it has soon become to cover all disciplines related to the human culture. The word ‘permaculture’ is created by its founder Bill Mollison as a new word from the combination of ‘permanence’ and ‘culture’. Being a wild life expert and an academician on environmental sciences Bill Mollison and his colleague David Holmgren developed the concept towards the end of 1970s in Australia. Permaculture currently has more than two million practitioners all around the world. Covering many different disciplines like architecture, engineering, finance, arts, mathematics, physics, botanic, zoology, etc. and dealing with all aspects of a human settlement like land, buildings, earth works, water, soil, energy, climate, waste, food production, plant systems, animal systems, access road, social networks, communities, etc. permaculture provides a holistic approach to solve existing problems which endanger the human race, and calls for urgent action due to the severity of these problems. During all their activities Permaculture practitioners follow an ethical approach. Anchored in the central concept of ‘life ethic’ which means to respect and care for all existence just because they exist, permaculture ethics is formulated under three main principles: In all actions (1) care for earth, (2) care for people, (3) limit consumption and return any surplus to (1) and (2). This ethics requires a redefinition of fundamental needs of a human being. Learning from nature by proper observation, Permaculture replicates existing sustainable natural ecological systems to speed it up with human intelligence and technology and creates designs for sustainable human settlements which can vary in size from a small house with a garden, up to a village, a town, a city or a very large landscape that can be as big as a country.

The aim of the paper is to explain the contribution of Permaculture to the sustainable design of human settlements. Starting with the brief analysis and definition of the major problems which impact the continuation of human race on earth; the holistic, solution-oriented approach of Permaculture will be described; major concepts and techniques of Permaculture design will be briefly explained.

Keywords: Permaculture, Sustainability, Energy Efficiency

1 INTRODUCTION

Permaculture is an ethics-based design science to design sustainable human settlements. Initially developed as a collection of sustainable agriculture technics, it has soon become to cover all disciplines related to the human culture. The word 'permaculture' is created by its founder Bill Mollison as a new word from the combination of 'permanence' and 'culture'. Being a wild life expert and an academician on environmental sciences Bill Mollison and his colleague David Holmgren developed the concept towards the end of 1970s in Australia. Permaculture currently has more than two million practitioners all around the world.

The aim of the paper is to explain the contribution of Permaculture to the sustainable design of human settlements. Starting with the brief analysis and definition of the major problems which impact the continuation of human race on earth; the holistic, solution-oriented approach of Permaculture will be described; major concepts and techniques of Permaculture design will be briefly explained.

2 SCOPE OF PERMACULTURE

The concept of 'Permaculture' is still fairly new to our country in spite of the recent increase of its awareness among the environment-friendly people. The term 'Permaculture' was coined by Bill Mollison, a wild life expert and an academician specializing in environmental sciences, biogeography and social psychology, when he was professor at the University of Tasmania together with his graduate student David Holmgren; and it is an interdisciplinary scientific design system.

In the beginning, 'Permaculture' was a contraction of 'Permanent Agriculture', a design science covering sustainable agriculture applications. In time it has expanded into all areas of human activity and now the term refers to 'Permanent Culture', since it is impossible to have any sustainable agricultural activity that is not based on a sustainable culture.

After writing the book 'Permaculture One' [1] with David Holmgren, Bill Mollison parted ways with Holmgren, left the university and founded Australian Permaculture Research Institute. After this he has dedicated his entire energy to propagating Permaculture system, principles and strategies across the world. In addition to writing the books 'Permaculture Two' [2], 'Introduction to Permaculture' [3] (translated in Turkish [4]), and 'Permaculture: A Designer's Handbook' [5]; he has educated thousands of students via the courses he gave, applied countless projects in many parts of the world, founded institutes and communities. He has given conferences on sustainability all over the world. Due to the solutions and suggestions to social and environmental issues that he has developed throughout his life, Mollison was awarded Right Livelihood Award, also known as alternative Nobel Prize, in addition to many other prizes and honors. The term 'Permaculture' has copyright by Bill Mollison and the use rights are awarded to the Permaculture designers and trainers who have completed the two-week Permaculture Design Course and obtained the respective certificate. Mollison still lives on his farm in Tasmania and continues to spread out Permaculture.

Covering many different disciplines like architecture, engineering, finance, arts, mathematics, physics, botanic, biology, zoology, forestry, agriculture, etc. and dealing with all aspects of a human settlement like land, buildings, earth works, water, soil, energy, climate, waste, food production, plant systems, animal systems, access road, social networks, communities, etc. permaculture provides a holistic approach to solve existing problems which endanger the human race, and calls for urgent action due to the severity of these problems.

2.1 Major Problems Impacting the Continuation of Human Race on Earth

Permaculture is mainly concerned with the continuation of human race on planet earth. From the perspective of Permaculture there are three major problems endangering the human race. With an exponentially increasing degree of importance the first problem is defined as pollution. The second is deforestation. Finally the third and the most serious one is loss of soil, in terms of both quantity and quality.

Unfortunately, the conventional agriculture techniques that have been applied since more than five thousand years are the main reason of soil degradation and erosion. Conventional agriculture decreases the fertility of soil, in addition to being one of the reasons for erosion, deforestation, and pollution. We lose the most fertile layers of our land by using nonrenewable resources, deep tillage, wrong hoeing, wrong watering, and use of chemical fertilizers, insecticides and herbicides. According to Bill Mollison, “If an evil genius worked for years, he could not find anything as destructive as conventional agriculture.” Permaculture teaches us the things that can be achieved through natural farming techniques instead of conventional agriculture.

2.2 Approach of Permaculture

Learning from nature by proper observation, Permaculture replicates existing sustainable natural ecological systems to speed it up with human intelligence and technology and creates designs for sustainable human settlements which can vary in size from a small house with a garden, up to a village, a town, a city or a very large landscape that can be as big as a country.

In Permaculture design, each element must serve multiple functions and each function must be supported by multiple elements. Our purpose is to create a sustainable ecosystem, of which we can be a part. In order for a system to be sustainable, it should internally generate the energy it shall need for its survival and upkeep throughout its lifetime and for its recycling at the end of its life. We can design a sustainable ecosystem that will feed, fertilize, care for and protect itself by combining related plant and animal systems in an appropriate location and appropriate conditions. When it is done following the patterns existing in nature, this design will result in a decreasing amount of effort and a reduced need of external energy over time, and in a few years will become sustainable in its natural flow without the need for our intervention.

3 PERMACULTURE ETHICS

During all their activities Permaculture practitioners follows an ethical approach. Anchored in the central concept of 'life ethic' which means to respect and care for all existence just because they exist, permaculture ethics is formulated under three main principles: In all actions (1) care for earth, (2) care for people, (3) limit consumption and return any surplus to (1) and (2). This ethics requires a redefinition of fundamental needs of a human being.

Permaculture states that each person has a right to access clean air and water, healthy and nourishing food; a reasonably sized shelter that will cool itself in hot weather and heat itself in cold weather; the ability to socialize in a society of harmonious relationships; and to realize his/her own potential. Unfortunately, the huge majority of people in our world today are far from achieving these basic needs. If India and China had achieved the 'democracy' of the North West, we would need 5-6 additional worlds to meet the needs defined according the current system of consumption. In this rate, most of us will be extinct within a very short time frame. We need to become aware of this urgent situation and relinquish the idea of domination over the world. We are not superior to other life forms! If we can internalize this truth and teach it to our children, we will realize that everything we do to other living creatures, we also do to ourselves. The generation that grasps this notion will not knowingly harm or destroy any living creature. Everything, every life in nature has a function and a reason for existence.

4 CONCLUSION

Permaculture design includes many different techniques that can be applied in large landscapes, cities, residential areas, common areas, schools and homes. Applying the permaculture technics, we can easily achieve solutions that will decrease our energy consumptions. What is important is not the amount of water we have but the number of times we can recycle and reuse this water. In schools and houses the grey waste water can be reused in gardens, rain water can be collected, compost can be made using food waste and soil development can be observed. We know that nothing is waste or garbage in the nature. Why not feed compost worms in addition to cats, dogs or fish as house pets?

In one conversation, Bill Mollison stated: "We all need to figure out a way to understand the nature. If we don't figure out, we will not understand. If we don't understand we may lose it. Those of us here agree that we are losing the nature and we know that we will miss it." Our land and our resources are dwindling while the human population is increasing at an ever-faster pace. Our children will one day ask us "Mother, Father, what did you do to prevent this?" No matter where we are, we urgently need to take action.

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Evaluation of The Natural Assets and Natural Resources Law and Renewable Energy Law of Turkey, In Respect of Ecological Law

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ABSTRACT. It is now beyond dispute that the renewable energy systems have the potential to fully replace the fossil based energy systems. It is also clear that fossil based energy systems damage ecosystems and constitute the most important reason of climate change. What is important is to determine the prospective and required nature of the law regulating the relation between the renewable energy systems and ecosystems.

Despite being contrary to the Constitution of Turkey and the international conventions to which Turkey is a party, a part of Turkish judicial system consisting of laws and secondary legal norms that are easily amended upon the political will covers regulations disregarding biological diversity, ecosystems, and environmental, historical, archaeological and cultural values. Therefore, the administration and the investors usually face off with ecosystem supporters both in de facto and de jure.

This study presents the important bases of Turkish judicial system at the level of laws, in respect of ecosystem, environment and energy law and the conflicting aspects of these; and also determines the measures to protect the environment and the ecosystems, and to prevent the possible conflicts between the ecosystem supporters and investors of renewable energy resources. Consequently, mitigation and even the prevention of the effects of the climate change, in short building a future depends on the collaboration of ecosystem supporters and renewable energy investors.

Keywords: Ecological Law, Environmental Law, Renewable Energy, ecosystem.

1 INTRODUCTION AND COMPARISON OF THE ECOLOGICAL LAW AND ENVIRONMENTAL LAW

This study aims to evaluate the law relating to natural resources, and current electricity generation systems in Turkey as well as the “Renewable Energy Law”, which is the main topic of the conference, in respect of “ecological law”. This evaluation will be made on the basis of Turkish Judicial System. At this point, it is crucial to note that evaluating the subject just in terms of the present judicial structure, apart from “production-consumption-population” systems will be rather deficient. It would be right to make this evaluation by also considering the localisation of the production models in Turkey, normalization of the consumption system in line with the actual needs, and a right population policy. However, because of the limitations with regard to time and the subject, the matter will be evaluated only from a legal perspective.

First of all, we will shortly compare the definitions of "ecological law" and "environmental law" that is commonly used nowadays, and explain why we prefer to use the term "ecological law".

Ecological Law;

primarily accepts the human as a component of the ecosystem. It is an ecosystem-based, namely life-based judicial system that prioritizes the maintenance, renewal and improvement of the ecosystems on the basis of the sustainable life principle, and that addresses all related economic, social, cultural and legal acts and actions from this perspective.

Environmental Law;

is a human-based judicial system that focuses on the living and non-living things around humans and their protection on the basis of the sustainable development principle and that addresses all related economic, social, cultural and legal acts and actions from this perspective.

It is a concept that points to legal measures aiming an effective and overall environmental protection (e.g. Environmental Laws and By-laws) [1].

As can be understood from the definitions, in fact these two concepts are different. Today, ecological law is not used commonly. However, it is not easy to explain biological diversity and natural assets such as soil, water, forest, pasture, sea, in short, the law on ecosystems through the legal arrangements of the Environmental Law, aiming to protect the environment. Indeed, environmental law is the law aiming to prevent environmental pollution. Likewise, Environment Law of Turkey essentially aims to prevent environmental pollution and at the same time, to protect and promote the nature/ecosystem at a minimum. One of the two main practices based on the Environment Law of Turkey is the Environmental Impact Assessment, which is almost completely founded on the prevention of pollution. Second main practice is the Environment Plans, which are mostly founded on the protection and utilisation of natural assets.

The concept of "environmental law", which is based on humans and sustainable development and which primarily aims to prevent pollution is used commonly, but despite this we will instead use the concept of "ecological law/eco-law", which is more comprehensive and which is based on ecosystem/life. Similarly, for the thinkers and activists of this field, we will prefer to use the concept of "ecosystem supporters" instead of "environmentalist".

Firstly, international conventions transposed as required by the Constitution, laws of Turkey and last paragraph of the Article 90 of the Constitution will be evaluated with an ecological law perspective and those mainly focusing on environmental law will be addressed, when necessary.

2 ELECTRICITY ENERGY GENERATION SYSTEMS AND THE STATE OF PLAY IN TURKEY

According to the fuel type, electricity energy generation systems can be grouped mainly under three headings as:

1. Fossil Based Systems: Coal - Oil- Natural Gas – Shale Gas
2. Renewable Energy Systems: Sun – Wind – Hydraulic – Geothermal – Biomass – Biogas – Wave – Tidal
3. Nuclear Energy Systems: Fission System– Fusion System

According to their fuel types, energy generation systems applied in Turkey are as follows:

FOSSIL BASED ELECTRICITY GENERATION: 70% (c.a.30% coal, 40% natural gas)

RENEWABLE ENERGY BASED ELECTRICITY GENERATION: 30%

Renewable energy based electricity generation is “mostly based on Hydroelectric Power Plants (HPPs)” and the respective share of Wind Power Plants (WPPs) is about 5%. Despite there are different classifications of HPPs as with reservoir and with regulator, it is known that the number of run-of-the-river HPPs may exceed 1600 and approximately 450 of them are active. In other words, many rivers in Turkey now run through pipes. Consequently, due to the high number of “fossil based plants” and HPPs, there are serious problems with regard to “renewable energy”, “clean energy”, “ecosystem damage” and “environmental pollution”. These all are covered under the “ecological law” and “environmental law”.

3 LEGAL ARRANGEMENTS IN TURKISH JUDICIAL SYSTEM CONCERNING THE NATURAL ASSETS/NATURAL RESOURCES AND ECOLOGICAL LAW/ENVIRONMENTAL LAW

Legal Arrangements under the Constitution of the Republic of Turkey

Main legal arrangements in the Constitution of Turkey in this regards are as follows:

Article 43: Utilisation of the Coasts,

Article 44: Land Ownership,

Article 45: Protection of Agriculture, Animal Husbandry, and Persons Engaged in These Activities,

Article 56: Health Services and Protection of the Environment,

Article 63: Protection of Historical, Cultural and Natural Assets,

Article 90/last paragraph: Ratification of International Treaties,

Article 166: Planning,

Article 168: Exploration and Exploitation of Natural Resources,

Article 169: Protection and Development of Forests.

Related parts of these articles are as follows:

3.1 Utilisation of the Coasts

Article 43 **-** The coasts are under the authority and disposal of the State.

In the utilization of sea coasts, lake shores or river banks, and of the coastal strip along the sea and lakes, public interest shall be taken into consideration with priority.

3.2 Land Ownership

Article 44 **-** The State shall take the necessary measures to maintain and develop efficient land cultivation, to prevent its loss through erosion.

3.3 Protection of Agriculture, Animal Husbandry, and Persons Engaged in These Activities

Article 45 **-** The State … to prevent improper use and destruction of agricultural land, pasture s and pastures …

3.4 Health Services and Protection of the Environment

Article 56 **-** Everyone has the right to live in a healthy and balanced environment.

It is the duty of the State and citizens to improve the natural environment, to protect the environmental health and to prevent environmental pollution.

3.5 Protection of Historical, Cultural and Natural Assets

Article 63 – The State shall ensure the protection of the historical, cultural and natural assets and wealth, and shall take supportive and promotive measures towards that end.

3.6 Ratification of International Treaties

Article 90 **-** International agreements duly put into effect have the force of law. No appeal to the Constitutional Court shall be made with regard to these agreements, on the grounds that they are unconstitutional. In the case of a conflict between international agreements, duly put into effect, concerning fundamental rights and freedoms and the laws due to differences in provisions on the same matter, the provisions of international agreements shall prevail.

3.7 Planning

Article 166 **-** Planning the economic, social and cultural development, in particular the rapid, balanced and harmonious development of industry and agriculture throughout the country and the efficient use of national resources by taking inventory of and evaluating them, and the establishment of the necessary organization for this purpose are the duties of the State.

3.8 Exploration and Exploitation of Natural Resources

Article 168 **-** Natural wealth and resources shall be under the authority and at the disposal of the State. The right to explore and exploit these belongs to the State. The State may delegate this right to persons or corporate bodies for a certain period.

3.9 Protection and Development of Forests

Article 169 **-** The State shall enact the necessary legislation and take the measures required for the protection and extension of forests. Burnt forest areas shall be reafforested; other agricultural and stockbreeding activities shall not be allowed in such areas. All forests shall be under the care and supervision of the State.

The ownership of state forests shall not be transferred. State forests shall be managed and exploited by the State in accordance with the law. Ownership of these forests shall not be acquired by prescription, nor shall servitude other than that in the public interest be imposed in respect of such forests.

Acts and actions that might damage forests shall not be permitted.

As it is seen in the above given articles of the Constitution, Article 43 concerns "coast ecosystem"; Article 44, "soil ecosystem"; Article 45, "soil and pasture ecosystem"; Article 63, "natural assets /biological diversity", Article 169, "forest ecosystem"; and they all form a basis for the ECOLOGICAL LAW. Moreover, Article 56 of the Constitution partially concerns "environmental protection" and partially "environmental pollution" and forms a basis for the "TURKISH ENVIRONMENTAL LAW". Considering that the Constitution of the Republic of Turkey dates back to 1982, first Environment Law of Turkey to 1983, and first By-Law on the Environmental Impact Assessment to 1993; and that the environmental awareness and movement gained momentum after these dates; it is understandable that the concepts of "ecosystem" and "ecological law" have not gained a place in the judicial system.

In the Constitution of Turkey, there is no legal arrangement, directly addressing energy. However, Article 168 stipulating that natural wealth (natural assets) and (natural) resources shall be under the authority and at the disposal of the State is important in this regard. Remarkable point here is that the natural assets and resources are not owned by the State, but they are under the authority and at the disposal of the State. Here, the constitutional system preferred sovereignty law with a public view, instead of the usual property law. This preference is suitable, in respect of the "Civil Law". Accordingly, natural assets such as forests, pasture, mountains, fresh and salty waters, flora and fauna, i.e. the biological diversity; and also all the natural resources related to renewable energy such as especially ground waters, mineral waters, geothermal waters, mines, hydraulics and wind are under the authority and at the disposal of the State. This matter is regulated at the Constitutional level clearly in Article 43 only for coasts but it is regulated at the level of laws for other natural assets, mines and miscellaneous energy law (Article 4 of Law No. 3213 on Mining, Article 4 of the

Law No. 5686 on Geothermal Resources and Natural Mineral Water, Article 1 of the Law No. 167 on Groundwater, and Article 3 of the Petroleum Law No. 6491 include arrangements in this regard).

Article 166 on planning is important as it displays the balance relation between the development and the nature, by pointing to planning and balance. Main axis of the ecological law's effort to protect the ecosystems has been founded by the raise of awareness regarding the "superior public interest and superior ecosystem interest" with the "basin-based and cumulative" assessment following the application of Article 166.

4 INTERNATIONAL CONVENTIONS ON ECOLOGICAL LAW AND ENVIRONMENTAL LAW, TO WHICH THE REPUBLIC OF TURKEY IS A PARTY

Among the international conventions, those such as the "Convention on Wetlands of International Importance especially as Waterfowl Habitat", "Convention Concerning the Protection of the World Cultural and Natural Heritage", "Convention on International Trade in Endangered Species of Wild Fauna and Flora / CITES", "Convention on the Conservation of European Wildlife and Natural Habitats", "Convention on Biological Diversity", "European Landscape Convention" and "International Convention for the Protection of Birds" are mainly conventions founded on the "protection of the ecosystem and/or natural assets", i.e. the ecological law. As understood from their names, others are mainly conventions founded on the "prevention of pollution", i.e. the "environmental law".

Regardless of its type, conventions ratified duly in accordance with the last paragraph of the Article 90 of the Constitution are considered at the level of "law" in the domestic law. Moreover, in line with the last paragraph of the Article 90 of the Constitution, in the case of a conflict between international conventions on fundamental rights and freedoms (which covers Articles 12-74 of the Constitution) and the legal arrangements under the domestic law, the provisions of international conventions shall prevail. Therefore, conventions protecting the ecosystem and preventing the environmental pollution are very important in the Turkish constitutional law system. However, it cannot be asserted that the executive and administrative organs do act sensitively in this regard. Approach of the jurisdiction system towards the matter is not at a required level yet.

5 LEGAL ARRANGEMENTS AT THE LEVEL OF LAW IN TURKISH JUDICIAL SYSTEM, CONCERNING ECOLOGICAL LAW AND ENVIRONMENTAL LAW

Law No. 2863 on the Conservation of Cultural and Natural Property (1983)

Law No. 2872 on Environment (1983)

Law No. 2873 on National Parks (1983)

Coastal Law No. 3621 (1990)

Law No. 4122 National Afforestation and Erosion Control Mobilization (1995)

Law No. 4342 on Pastures (1998)

Law No. 5403 on Soil Preservation and Land Utilization (2005)

Law No. 5312 on the Law Pertaining to Principles of Emergency Response and Compensation for Damages in Pollution of Marine Environment by Oil and Other Harmful Substances (2005)

Forest Law No. 6831 (1956)

Among these laws, "Law on Environment" is mostly and Law No. 5312 on the Law Pertaining to Principles of Emergency Response and Compensation for Damages in Pollution of Marine Environment by Oil and Other Harmful Substances is mainly founded on the "environmental pollution and protection of the environment /environmental law" while the others are mainly founded on the protection ecosystem and/or natural assets, i.e. "ecological law". Although they seem to regulate ecosystems, above-given laws also include arrangements damaging the ecosystems.

For example;

Although Law No. 2873 on National Parks totally aims to protect the ecosystem, Article 8 of the Law allowing the allocation of land for tourism investments for an unlimited period of time, and Article 11 stipulating "exploration and operation permits or concessions to be issued for the areas subject to the provision herein in accordance with the provisions of the applicable laws concerning mines and oil may be granted by the Council of Ministers provided that the applicable provisions of the Law No 2863 for the Protection of Cultural and Natural Assets are reserved" contradict with the purpose of the Law and the Constitution.

Although Law No. 4342 on Pastures was enacted for the determination, land registration and protection of pastures, Article 14 titled "change in the purpose of allocation" which was amended many times to the detriment of pastures and which introduces a permission system for investments for mines, oil, natural gas and tourism, any kind of energy investments and zoning activities for an unlimited period of time is totally in contradiction with the purpose of the Law.

Although Law No. 5403 on Soil Preservation and Land Utilization aims to protect and develop the agricultural land, Article 13 titled "agricultural lands other than agricultural purposes", which introduces a permission system for investments for mines, oil, natural gas and tourism, any kind of energy investments, any investments approved on the basis of public benefit, and zoning activities for an unlimited period of time is totally in contradiction with the purpose of the Law.

Article 16 and 17 of the Forest Law No. 6831 which zones the forests for the construction of any investments for tourism, industry, transport, energy and zoning activities, and particularly mining are in great contradiction especially with the Article 169 of the Constitution.

Moreover, there are legal arrangements concerning the environmental protection and pollution under the criminal law.

5.1 Legal Arrangements under the Criminal Law

Provisions of the Criminal Code No. 5237

Offenses against Environment

- Article 181 Intentional pollution of environment
- Article 182 Pollution of environment by negligence
- Article 183 Causing Noise
- Article 184 Pollution caused by constructions

Offenses Causing General Risk

- Article 172 Spread out of radiation
- Article 173 Causing explosion by atomic energy
- Article 174 Storage or delivery of hazardous substances without permission

Provisions of the Misdemeanours Law No. 5326

- Article 41 Pollution of Environment

Penal Provisions of the Law No. 2872 on Environment, Article 20-27

Penal Provisions of the Law No. 2863 on the Conservation of Cultural and Natural Property, Article 65-74

It is seen that especially in the recent years, these provisions have not been applied, even at least as deterrents.

Legal Arrangements at the Level of Law in Turkish Judicial System, Concerning Energy Law

Law No. 6446 on Electricity Market (2013)

Law No. 5346 on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy (2005)

Law No. 4628 on the Organization and Duties of the Energy Market Regulatory Authority (2001)

Law No. 3154 on the Organization and Duties of the Ministry of Energy and Natural Resources (1985)

Law No. 5627 on energy Efficiency (2007)

Law No. 3213 on Mining (1985)

Law No. 5686 on Geothermal Resources and Mineral Waters (2007)

Law No. 167 Groundwater (1960)

Law No. 6491 on Petroleum (2013)

Law No. 5015 on Petroleum Market (2003)

Law No. 4646 on Natural Gas Market (2001)

Law No. 5307 on Liquefied Petroleum Gas (LPG) Market (2005)

Law No. 5710 on Construction and Operation of Nuclear Power Plants and the Sale of Energy Generated From Those Plants (2007)

Law No. 2690 Law on Turkish Atomic Energy Authority (1982)

Law No. 3096 on Assignment of Enterprises other than Turkish Electricity Administration to Produce, Transmit, Distribute and Trade Electricity (1984)

Law No. 3996 on Implementing Investments and Services within the Framework of the Build-Operate-Transfer Model (1984)

Law No. 4283 on the Construction and Operation of Electric Power Plants and Sale of Energy through the Build-Operate Model dated (1997)

Under this topic, it will be focused firstly on Electricity Market Law. Setting aside the exaggerated incentive provisions in the Article 25, and Provisional Articles 2, 4, and 5 of this Law, land allocation for mining activities and renewable energy investments in forests, pastures and all areas under the authority and disposal of the State, for an unlimited period of time is a point of departure for the ecosystem supporters.

First two paragraphs of the Article 8 of the Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy are the repetition of especially, paragraphs 2 and 3 of the Provisional Article 4 of the Electricity Market Law. In other words, land allocation is allowed in forests, pastures and all areas under the authority and disposal of the State for mining activities and renewable energy investments, for an unlimited period of time. Moreover, paragraph 5 of the same Article stipulates "Permission may be granted for the establishment of electrical energy production facilities based on Renewable Energy Resources in national parks, nature parks, nature monumental and nature preservation sites, preservation forests, wildlife promotion sites, and special environmental preservation site provided that an affirmative opinion of the Ministry, or of the regional conservatory board in the case of natural conservation areas, is obtained". This practice hinders the renewable energy's feature to protect the ecosystems; and therefore, is unacceptable for the ecosystem supporters.

Article 7 of the Mining Law can be summarized as "where there is mining, there exists no rule". Other details will not be addressed as they are beside the point.

6 CONCLUSION, EVALUATION AND SUGGESTIONS

It is unquestionable that this quick evaluation made within a limited period of time and at the level of laws at a minimum can be elaborated with secondary legal norms. We want to re-underline our awareness that correct results cannot be obtained by excluding the failures in the production system, defects in the consumption habits, and matters concerning population policies. As the matter is addressed only on the basis of its legal aspect and at a level of certain norm, evaluation and suggestions have been made unavoidably from this aspect and for that level.

7 EVALUATION AND SUGGESTIONS

1. International conventions on ecosystems and the environmental protection, which were transposed and become a part of the domestic law in accordance with the Article 90 of the Constitution; and which prevail in case of any conflict with the domestic law cover detailed arrangements for the protection of ecosystems and prevention of environmental pollution. However, in practice they are not applied at a sufficient level.

2. Moreover, laws and secondary legislation on mining, energy, forests, pastures and agricultural land include arrangements that promote the damage to ecosystems and pollution. Current law and the related secondary legislation "allow any kind of mining and energy investments at anywhere", which is inacceptable.
3. This structure in Turkish judicial system makes the administration and the investors usually face off with ecosystem supporters both in de facto and de jure.

4. Renewable energy is an energy model supported by the ecosystem supporters. However, maintenance of this support depends mostly on the viewpoints of the renewable energy investors to the ecosystem.
5. At first, run-of-the river and small-reservoir hydroelectric plants were supported as renewable energy models, in comparison to big dams but, in practice it all turned out to be a devastation of ecosystem. This has led to the emergence of the "clean energy" concept. Now, HPPs are no more advocated, and they result in numerous cases and public reaction.
6. These developments necessitate renewable energy investors to plan their investments by taking into account not only the energy legislation but also the legislation on the protection of ecosystem and environment.
7. As the legislation especially on the environmental impact assessment is not based on a study at strategic scale and does not cover a basin-based, spatiotemporal cumulative assessment, the practices in this regard do not yield positive results. Therefore, in having the environmental impact assessment reports prepared, renewable energy investors should attach importance to the fact that these reports include a basin-based, spatiotemporal cumulative assessment, and respect and comply with the regional Environment Plans.
8. Collaboration of ecosystem supporters and renewable energy investors is a must to mitigate and even eliminate the effects of climate change, and accordingly to build a future.

This will be the last suggestion and closing remarks of the presentation.

Thank you.

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A Sustainable Power Generation Infrastructure Model for Turkey

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ABSTRACT. The Turkish electricity sector gained a huge transformation from a state controlled structure towards a liberal sector structure, in its rally which started back in 1984 with the law Nr. 3096 giving TEIAS the right to outsource power investment services to private investors in form of B.O.O./B.O.T. contracts. Followed by the adaptation to the EU legal frame work, such as the Electricity Market Law Nr. 4628 (2001, amended by the Law Nr. K6446 in 2013), the Gas Market Law Nr. 4646 (2001) and the Minerals Law Nr. 5177 (1985, amendment in 2004). The countries power generation fleet turned from 100% state owned to 25% state owned and 75% private owned entities. The installed power capacity and annual energy consumption increased from 6.64 GW and 26.5 TWh p.a. to 74 GW and 270 TWh p.a. (as of 12/2015). A growth of ten times the beginning value within 30 years. But still with its 3347 kWh per capita consumption the country is far behind Germany's 7081 kWh per capita level and provides an ongoing market opportunity for investors and technology providers. The global economic challenges triggered in 2008 didn't harm yet the Turkish economy in form of a recession but provided a slowdown in its power consumption growth to a level of 4-5% p.a. instead of its 7-8% levels of the former years. It is expected that the installed capacity will increase to a level of above 100 GW by 2023, which means new investments of more than 32 GW in total. When considering the decommissioning requirement of the aged and the in the merit order losing power stations, the new capacity investment requirement enlarges. This remarkable 'new capacity & investment requirement' gives the country the possibility to structure a new electricity master plan to suit its market needs, within an economically viable and technically sound manner. At this point it needs to be emphasized that the further change will be associated with a rough technical rally (recorded already by the blackouts in 2012, 2014 and 2015). Due to its quasi island transmission grid with limited approval to export (400 MW) and import (550 MW) power capacities from its neighbors of the ENTSO-E network, as well as limited utilization possibilities of the export and import capacities with its southern neighbors and when considering its fully liberal power market set up [which follows primarily the guideline "Laissez-nous faire"[1] ("Let them do, let them pass")], plus the government target to lower the countries account deficit by promoting especially river type hydro, wind and solar power; the system operator (TEIAS) will have restless days and nights. This paper proposes a humble solution to this 'bridge country' seated between Europe and Asia, phasing typical difficulties in managing all its potentials while growing consistently.

Keywords: Power Generation, Sustainable, Master Plan, Energy, Infrastructure, Electricity,Organized Electricity Generation Zone

1 SNAP SHOT OF TURKEY'S PRESENT POWER INFRASTRUCTURE, MARKET AND ENERGY POLICY

The installed power generation capacity of Turkey has reached a level of 74 GW shared by 29.2% steam coal & lignite thermal, 30.9% gas fuelled thermal, 34.0% hydro, 5.2% wind, 0.6% geothermal and 0.1% solar power. The contribution to the total in 2014 generated electrical energy of 258 TWh has been: 29.6% steam coal & lignite thermal, 48.1% gas fuelled thermal, 16.1% hydro [2], 5.2% wind, 0.6% geothermal and 0.1% solar power.

The Governments capacity growth plan (2014 – 2023) covering thermal and renewable energy sources, plus the two nuclear power plants (4x 1.2 GW each) for 2023 is 110 GW.

Further, with its huge enlargement potential in wind power (to grow from 3.6 to max. 48.0 GW), solar power (from 0.09 GWp to 0.6 GWp and later on to theoretical max. 56.0 GWp), run off the river power (from 7.0 to theoretical max. 14.5 GW) installed capacity levels, the related technologies create a serious threat to the transmission grid stability of Turkey, due to their generation fluctuations. Especially when considering the very limited possibility to export power to its ENTO-E neighbors Greece and Bulgaria (with a maximum allowed transfer of 550 MW), the balancing prospect doesn't look bride. Whereas, it's southern neighbors don't provide enough synchronous sources, as well. So, Turkey has to establish a self-sufficient power generation and transmission system.

1.1 Renewable Energy Source's Contribution to Consumption

The main renewable sources (wind, hydro, geothermal and solar) contribute by 20.9% to the total annual generation, whereby the less predictable ones among those provide the following contribution; (a) Wind power with an installed capacity of 3.6 GW (5.2% of installed cap.) a generation of 8.4 TWh (3.4% of annual consumption), (b) Dam type hydro power with an installed capacity of 16,6 GW (23.9.0% of installed cap.) a generation of 28.6 TWh (11.4% of annual consumption) and (c) River/RoR type hydro power with an installed cap. of 7.0 GW (10.2% of installed cap.) a generation of 11,85 TWh (4.7% of annual consumption).[3] See; Table 3 and Table 4.

All these renewables create serious grid management burdens, due to their hourly, daily and seasonally generation fluctuations. Managing such a market under a perfect 'market storm' conditions (triggered by high natural gas prices, a wet winter and the TL/$ devaluation), in a playground of to some degree manipulated prices (by politically routable players). Further, renewables which are selling power via the 'Renewable Energy Resources Support Mechanism' (RERSM) and related price are 'exempted from the obligation to generate the power' within the day ahead market. They don't have to manage the market (capacity) imbalance either. The burden (or from another perspective ‘the opportunity’ to serve) is shifted to other technology players.

1.2 Increase Potential in Operational Challenges of TEIAS

TEIAS and any power generator connected to its grid have to fulfill the grid code guidelines which are (a) HV Grid Voltage Range 340 V – 420 V and Nominal 380 kV and (b) Frequency Range 50.5 Hz - 51.5 Hz and a duration of 1 minute; 49 Hz - 50.5 Hz Permanently; 48.5 Hz - 49 Hz and a duration of 1 hour, 48 Hz - 48.5 Hz. duration of 20 minutes. If not the system protection relays would force the system breakers to cut the power connection in order to protect the system from severe deviations.

The operational challenge of TEIAS within its quasi-island type transmission network will further increase in the next decade, the more of Turkey’s renewable energy sourced power investment potentials get connected. Hydro, wind and solar energy resources provide the major portion of those newcomers. The country has a maximum 38 GW (eq. to 130 TWh/a) economical hydro, 48 GW wind capacity to install, 1527 kWh/m²-year of average Global Solar Radiation, 31.5 GW theoretical geothermal energy potential, 8.6 MTOE biomass, 1.5-2 MTOE biogas investments potential.

1.3 Market Balance and Financial Settlement Center’s and The Dispatch Center’s Challenges

The civil servant controlled Market Balance and Financial Settlement Centre (MBFSC or PMUM in Turkish), under pressure of strict instructions to utilize low cost day ahead market sources (without overseeing the weak flexibility of the generation fleet and the transmission capacities), cannot manage a countries power fleet which is getting more and more complex and volatile due to its infusion of none reliable renewable energy sources. Further, ‘Being limited in export and/or importing power capacities’ creates a great grid management challenge. Despite to the European grid (which has integrity, high wheeling capacities between countries in a wide geography from east to west and north to south) encapsulating a time zone width of 3 hours, the Turkish power grid, located within a onehour time zone, shows rather features of typical islands, as proven by the latest power blackout on March 30th, 2015. The entire country was shut down for 10 - 20 hours varying province based and the cost was an economical loss of estimated 2 billion US$. If this happens today, can you imagine what could happen in the future if the projected not easy to predict renewables come online without a major plan how to manage the system. Especially when considering the lag of flexible power generation technologies, which were kicked out of the market due to high gas prices and manipulated power tariffs.

2 ENTSO-E AND OTHER POWER IMPORT/EXPORT POSSIBILITIES OF TURKEY:

In its north Turkey is connected to the ENTSO-E transmission network via Greece and Bulgaria. In its south it's connected to other transmission networks such as Georgia, Armenia, Azerbaijan (incl. Nakhichevan), Iran, Iraq and Syria.

2.1 ENTSO-E and Other Power Import/Export Possibilities of Turkey:

ENTSO-E, the European Network of Transmission System Operators, represents 41 electricity transmission system operators (TSO) from 34 countries across Europe. ENTSO-E is one of the largest AS synchronous grids in the world.

15 April 2015 ENTSO-E's Continental Europe grid, extended to Turkey by adding TEIAS into the system via its interconnection to Greece and Bulgaria. The parties jointly gained the possibility to export (400 MW equal to 0.6% of the installed capacity of Turkey) from and import (550 MW equal to 0.8% of the installed capacity of Turkey) power to Turkey. The export and import capacities allowed by the ENTSO-E are way too low to support Turkey's renewable energy sourced power generation fluctuations by providing a push and call facility. It strongly is recommended that Turkey finds a national solution for its hassle.

Looking at Europe, thanks to its huge installed generation capacities of 1.1 TW to suit Europe's total consumption of 3116 TWh (2012, excl. Turkey [4]), equipped with large power transmission networks and cross border wheeling capacities. Whereas France, Germany, Switzerland, Czech Republic, Spain, Norway, Sweden, Bulgaria, Romania, Netherlands and Poland were in 2014 the champions in exporting power, to their neighbors. The champs in importing power were Italy, Denmark and Austria. Whereby the total cross border electrical energy wheeling reached 464.3 TWh (2014, incl. Turkey).

2.2 Southern Neighbours Based Import/Export Possibilities of Turkey:

Turkey's total cross border theoretical maximum net transfer capacity to its southern neighbors is 4.24 GVA (which is 3.4 GW and equal to 4.6% of installed generation capacity) only. This limits the cross border loading and unloading (push and call) possibility of the unpredictable WPP and RoR/HEPP's hydro generation capacities. Due to other technical restrictions the under Graph 6 given net transfer capacities are only useful within certain fractions. When we look at the present power market sizes of Turkey's neighbors and their economic growth figures, an extensional use of their transmission - generation – consumption ('TGC') system, to provide a complementary solution (technical and commercial optimization) to Turkey's hassle, doesn't seem to be possible in the mid-term.

2.3 Congestion Management

Market integration requires solutions to identify and effectively manage network congestion. Network congestion occurs when electricity is unable to flow where it is needed due to physical (e.g. not enough capacity) or contractual (all available capacity has been reserved) issues. Part of the solution to congestion is often investment, yet appropriate rules for determining the amount of available capacity at a border, and making that capacity available on a non-discriminatory basis is also vital.

Turkey will have it very difficult to solve its power wheeling congestion by utilizing the cross border net transfer capacities via its ENTSO-E or Southern Neighbor's grids, hence all these countries have their own power market features in terms of RES subventions (as the case is for the ENTSO-E countries), or other technical and financial features (like Georgia trying to develop its +6 GW RoR-HEPP potential), or Iran and Iraq trying to market its gas fuelled CCGT power potentials. Turkey is again in the middle of the crossroads of variety (some may call it dissimilarity) and change. Under these conditions 'flexibility' and a 'low cost' base becomes a need.

3 THE IDEA OF 'DOMESTIC LIGNITE BASED POWER TO SOLVE DEPENDENCY'

The government's obsession in promoting lignite fuelled power plants to reduce the dependence on foreign sourced natural gas, disregarding and even preventing the advantage of clean steam coal fuelled high efficiency USC-PC power technologies is expected to collapse, especially after the recent law change related to the coal mining sector triggered after the mine accident in Soma region, escalating the lignite production cost by 20 to 30 US$ per ton, while adapting the health and safety standards of the Turkish mining sector to international standards level. Due to the poor proximate features of the domestic lignite's, such fuel based power plants aren't able to compete against the cleaner coal based high efficiency power technologies.

4 SOLUTION

Having read enough on the burden, the problems and the challenge caused by the renewables; let's come to the solution to the technical and commercials matters. VUCA (Volatility, Uncertainty, Complexity, Ambiguity) has become the new normal in markets, which require the right vision for proper handling.

4.1 High Efficiency Thermal Power Plant Technologies Provide Solutions

When we look at the entire picture of TEIAS's challenges (which is expected to grow in the next years) the solution to: (a) to provide low cost power to support the fairly high priced renewables becomes USC-PC coal fuelled thermal power plants (with >43% plant net efficiency) and (b) to manage the fluctuating loads of the renewables becomes the flexible CCGT (with >61% plant net efficiency) and CCGE (with >50% plant net efficiency) technologies.

It is important to mention at this point that cleaner coal USC-PC and/or USC-CFB technologies providing 43 - 46% plant net efficiencies compared to the world average of 36%. Each 1% plant efficiency increase would reduce 3% CO2 Emissions. Replacing inefficient coal power with cleaner coal power would reduce 2.0 Gt/yr CO2, which could make the climate change fear story irrelevant.

4.2 Organized Electricity Generation Zones for Solving Structural Challenges

VUCA has become since the last 2 decades the normal of doing business in the emerging markets and even in some developed markets, as well. The herein described power sector image of Turkey calls for 'planning' and 'regulating' properly its liberal electricity market, the entire chain from power generation to transmission and distribution. The aim of Organized Electricity Generation Zones ('OEGZ') is to avoid all the above mentioned obstacles caused due to; transmission network transfer capacity limits, other technical matters, regulatory matters, legal matters, public acceptance matters; and to harmonize the interests of confronting stakeholders. OEGZ's is the Authors humble solution to the VUCA situation in Turkey.

The idea of bringing up the OEGZ solution to structural challenges is in some way an analogy of Turkey's quite successful 'Organized Industrial Zones' ('OIZ') Law Nr. 5590 dated back in 1973, whereas the first Turkish OIZ was established in 1961 in Bursa city with a World Bank credit. The OIZ law helped Turkey to establish as of today 256 OIZ's spread around the country, filled with industrial facilities providing jobs, revenue and profit to the country. [5]

The main targets of OIZ's are (a) to discipline the industry, (b) to contribute to the planned development of the industry in harmony to its neighboring city and region, (c) to encourage investors, (d) to bring together complementary industries so that their products and by products can be utilized and optimized to each other, (e) to ensure efficient production and increase profit, (f) dissemination in the less developed provinces, (g) to discipline the use of agricultural lands, (h) to insure establishment of healthy, inexpensive, reliable industrial infrastructure together with common social facilities, (i) to prevent environmental pollution by the joint waste treatment plants (incl. solid waste- and waste water treatment plants), (j) to ensure the management of such bodies under the guideline of the relevant laws and regulations.

When it comes to the OEGZ structure the following topics can be added to such list: (k) By planning OEGZ's at the seashore the sea water originated cooling water to assure low condensation temperatures (insuring best plant efficiency, thus low fuel consumption and lowest possible emissions. Further with this technology wasting of valuable ground water at wet cooling towers is prevented as well), (l) the access to the sea will insure easy transportation to the site (of heavy equipment, fuel (cleaner coal, LNG, CNG), limestone, chemicals, ammonia, oil etc.) and easy deportation of by products (such as ash, gypsum etc.), (m) the availability of seawater secures an endless process & potting water source thanks to the desalination technology, (n) to secure low cost base load power generation (essential for funding the expensive renewable energy sourced power fleet), (o) to secure flexible power generation (able to cope with the fluctuating generation of the renewables), (p) establish a low loss 800 kV DC power transmission backbone (q) Common HVAC/HVDC Switchyard (380kV AC to 800kV DC). The most important complementing item to this list would be the following which is item (r) the cumulative and consolidated environmental impact assessment at the very beginning. [6]Such method is expected to provide relief to the main concerns of the Turkish people. OEGZ's would be proposed to be subject to the 'LCP Directive' and 'Best Available Technology' criteria under a strict predefined scheme of cumulative emission calculations.

Based on a recent study which was performed for a landmark in the west coast of the Marmara Sea the cumulative emissions were calculated to suite the LCP Directive with a total capacity of up to 15 GW's and based on coal fuelled thermal power plants seated side by side. The report was made by an independent environmental consulting firm in order to countercheck the EIA permits given by the MoEU. The numeric results did prove that people's concerns related to the present project pipeline for a total capacity of 10 GW are unjustifiable. Let's imagine the area would be designed as an OEGZ, it is expected that the amount of concerned people would drop tremendously.

When it comes to planning an OEGZ master plan, then we are talking about the base load generation and flexible load generation of Turkey's upcoming 50 years of power requirement. As per TUIK (Turkish Statistical Institute) the present population of 77.6 million citizens will rise to a peak of 93.5 million by 2050 and then decline to a level of 89.1 by 2075. i

Further assuming that Turkish Citizen's power consumption is expected to reach a level of 7000 kWh per capita the following power loads could be expected by the year 2065: (a) Base load demand 40 GW, (b) medium load demand 60 GW and (c) peak load demand of 80 GW. Based on these assumptions and projections a master plan covering five individual Organized Electricity Generation Zones (OEGZ), each sized for catering 10 GW seems to be a good plan to start with. Maybe at this point we shall remember the guideline "Plans are Nothing. Planning is Everything." - D. Eisenhower.

The graph below demonstrates a very simply schemata how the individual power plants could be seated within a 10 GW sized OEGZ, all having access to sea for cooling, material and equipment handling, as well as centrally designed waste treatment (fluids and solids) facilities.

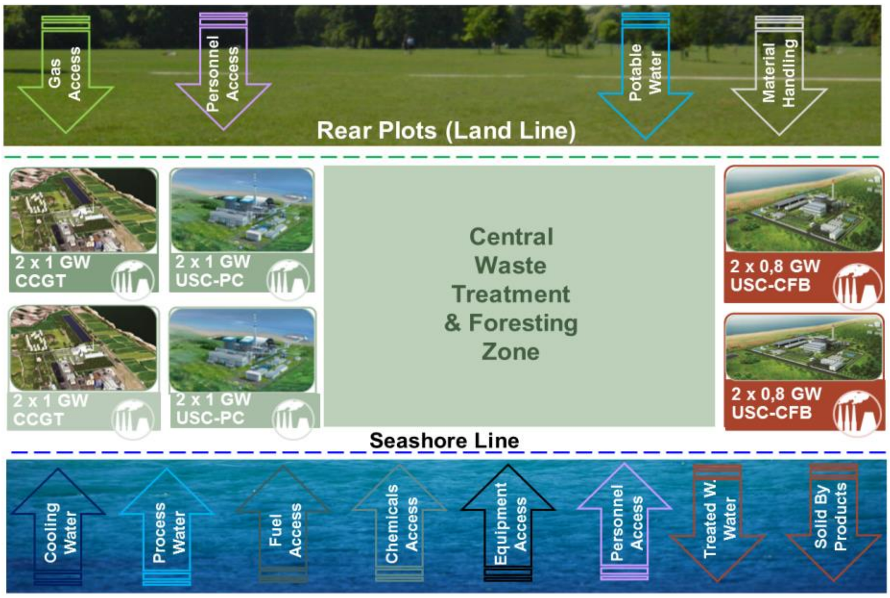

Fig. 1. 10 GW Size OEGZ Schemata

5 REFERENCE

1. Le Gendre (1681) "Laissez-nous faire" ("Let us be," literally "Let us do").
2. Turkey is poor in water sources for power generation, thus the utilization factors (of the extensive size installed hydro capacities) were this year within an annual average of 19.5%, equal to 1710 full load operating hours, whereas 2014 was a dry year. In general the average projected annual full load operating hours for dam type HEPP's is around 3500 hours only.
3. EMRA (2014). Data given as of 31.12.2014.
4. E.I.A. (2012). U.S. Energy Information Administration
5. Historically the idea of industrial zones goes back to 1885 where in a US-American report this need is addressed. The first OIZ was constructed though in 1899 in Great Britain in Manchester named as the 'Trafford Park'. Later in 1905 and 1909 "Central Manufacturing" and "Clearing" named OIZ's were established in Chicago.
6. The intent here is perform a full environmental impact assessment report at the very beginning of even without having any firm IPP that would join the OEGZ. The cumulative impact of the entire 10 GW sized OEGZ, would be calculated, checked and permitted by the MoEU.

Turkey's Renewable Future: Alternative Power Supply Scenarios for Turkey until 2030

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ABSTRACT. Turkey's energy market is going through a rapid change. Throughout the last decade, power demand has grown by 70% [1]. This is a trend that is expected to continue. The Turkish government has articulated an energy future that would involve rapid expansion of coal-fired generation, to meet the needs of a growing economy and reduce the country's dependence on imported gas. This strategy is likely to result in a further push for Turkey's rapidly increasing GHG emissions (Between 1990 and 2012, country's emissions from public electricity and heat production increased by 286% [2]). Against this backdrop, WWF-Turkey commissioned Bloomberg New Energy Finance (BNEF) to evaluate if a renewables-based alternative strategy could be just as cost-effective as the current coal dominated strategy of Turkey, to meet increasing power demand [3]

Keywords: Energy policy, role of renewables, electricity supply scenarios

1 METHODS

According to Turkey's official power demand projections, until 2030, power demand is expected to increase by 1.5 times. A more "realistic" power demand forecast for Turkey until 2030 constitutes the basis of BNEF's analysis. In an effort to analyze the power generation alternatives to meet demand, three scenarios were formulated.

The first of these scenarios, "Official Plans Scenario" is based on the official targets for increase in power demand, the installed capacity targets for coal, nuclear and renewable energy sources for 2023 and the official predictions up to 2030. The second scenario, dubbed "Business-As-Usual Scenario" makes mainstream projections about how power demand and supply will evolve in Turkey by 2030 on the basis of the current conditions of the electricity market and sector, existing policy outlook and capacity pipeline. The third scenario, named as "Renewables Development Pathway (RDP) Scenario", depicts an alternative, where wind and solar energy are prioritized and by 2030, they take on the dominant role that is now played by natural gas in Turkey's power sector.

After analyzing the power generation mix and required installed capacity additions under each scenario, BNEF run a cost analysis (capital expenditure + O&M costs + fuels costs) to see the total costs (both nominal and discounted) associated to each scenario from 2014 to 2030. This is accompanied by the comparison of carbon emissions of each scenario, and an analysis on what the cost of compliance with EU ETS and Industrial Emissions Directive after year 2020 would be under three scenarios. The analysis is followed by policy recommendations of WWF-Turkey.

2 RESULTS

BNEF analysis argues that official power demand growth forecast until 2030 is likely to be too high at on average 5.25% per year. Turkey is expected to follow the same path as comparable European countries in enjoying robust GDP growth but with a declining power intensity, ultimately stabilising power demand per capita. Power demand is forecasted to grow by about 93% between 2013 and 2030, significantly less than the doubling expected under the official plan.

BNEF analysis proposes two options for meeting this higher power demand. The Business-As-Usual Scenario is a coal-led strategy derived from current policies, much like the official plan but with more realistic assumptions for power demand and nuclear and renewables build-out. According to the analysis, it would leave fossil-fuel generation at 60% of the total electricity supply in 2030, and push power sector emissions up by 98%.

Renewables Development Pathway, on the other hand, concentrates on expanding wind, solar and hydro, rather than coal capacity. The analysis reveal that such an alternative would benefit from projected sharp reductions in levelised cost of electricity per MWh from the first two renewable power technologies. Under this scenarios, by 2030, Turkey can meet 47% of its power demand from renewables (21% hydro + 26% non-hydro). Emissions in 2030 would be anchored near current levels.

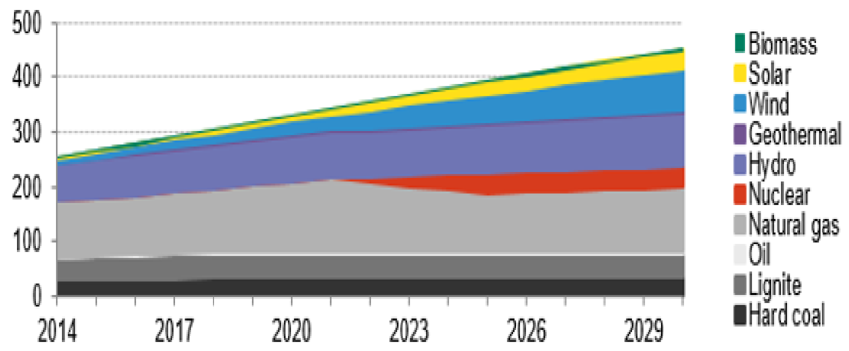

Fig. 1. : Power Generation Mix under BAU Scenario (2014-2030) (TWh)

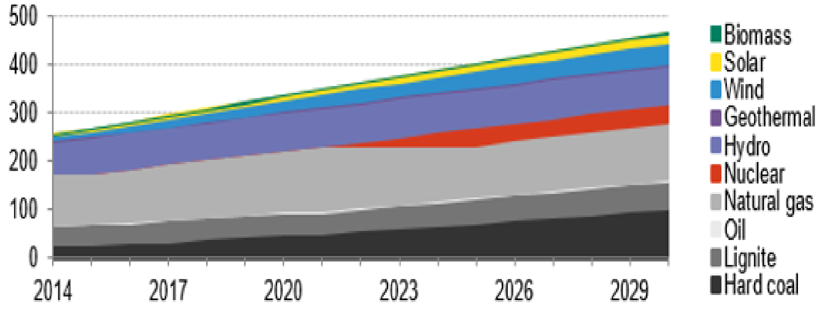

Fig. 2. : Power Generation Mix under RDP Scenario (2014-2030) (TWh)

BNEF estimates that the total generation cost to Turkey until 2030 of both options – business-as-usual and Renewables Development Pathway – would be around $40 bn (nominal terms). This would include the upfront capital cost of building new capacity and the cost of running the fleet of plants, including the bill for fuel feedstock.

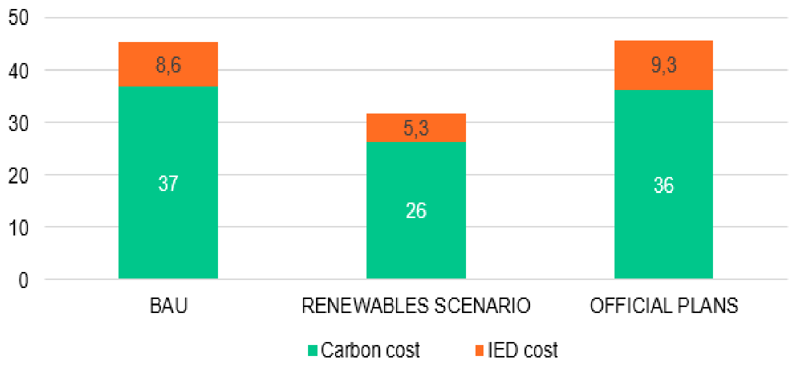

Fig. 3. Annual sum of capital and operating expenditures (including fuel use) 2014-30 ($bn)

The analysis further concludes that under a renewable based strategy, cost of complying with the EU Emission Trading Scheme and the Industrial Emissions Directive between 2020 and 2030 is 13 billion US $ less than the coal-led strategy.

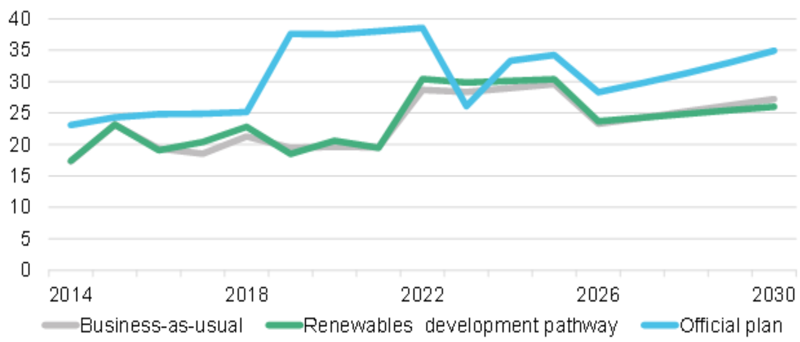

Fig. 4. Environmental Taxes (Based upon the assumption that relevant EU legislation will be applied in Turkey from 2020 onwards)

3 CONCLUSION

Building on BNEF analysis, WWF-Turkey's recommendations for more sustainable power generation in Turkey are as follows:

- In order to meet the twin goals of satisfying rising electricity demand and decreasing fuel import dependency, **renewable energy needs to become an integral part of energy supply security strategy**.
- **Turkey must update its renewable energy target in power generation.** In accordance with BNEF analysis, the new target should be "50% renewable energy by 2030".
- **Support schemes for renewable energy technologies need to be improved:** Feed-in tariff regimes for especially wind and solar need to be rendered more effective. The changes could provide a more favorable investment environment.
- F**ossil fuel subsidies – especially for coal – need to be phased out:** According to International Money Fund (IMF), Turkey's coal subsidies amount to 0.66% of the country's annual GDP and 1.9% of government revenues [4]. Phasing out these subsidies could reveal the real cost of fossil fuels and create much needed funds for energy efficiency and renewable energy projects.
- **Finance of renewable energy projects needs to be prioritized:** Climate negotiations under the UNFCCC framework can potentially render some fossil fuel power generation assets "stranded assets" in the medium term. This necessitates the initiation of a vast transition to renewable energy resources and determination of finance priorities accordingly.
- **Renewable energy should be an integral part of industrial policies:** BNEF analysis suggests that, under the Renewables Development Pathway scenario, if 50% of the envisaged renewable capacity investment can be spent on domestic goods and services, Turkey could decrease the impact of power generation related

imports on its trade balance. Positive impacts on parameters such as employment, export, GDP etc. could reinforce this impact. Turkey's Renewable Energy Resources Support Mechanism (YEKDEM) provides additional support for use of domestic content in renewables projects. This is a positive step that needs to be transformed into a strategic priority for Turkish industrial plans.

- **Thermal power plants should be subject to robust environmental impact assessment processes:** Electricity Market Law no.6446 provided exemption from environmental legislation to those power generation assets that are owned by EÜAŞ or which are in the privatization process. This clause was revoked by a recent decision of the Constitutional Court. In line with this decision, no thermal power plant should be exempt from environmental legislation. On the other hand, new legislation and tools such as EU ETS and Industrial Emissions Directive, which would help internalize the externalities of energy projects need to be introduced.
- The economic lifetime of a coal power plant is around 40 years. The decisions taken today are likely to lock in the Turkish economy and society to an expensive high-carbon and fossil fuel dominated future until mid-century. In light of the decreasing costs and environmental, social and economic advantages, renewable energy resources should be given the priority in the electricity supply security strategy of Turkey.

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At Eti Krom Ferrochrome Furnaces We Have Recovered Useful Energy

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ABSTRACT. In almost all metallurgical operations, such as arc or reduction furnaces, most of the energy that goes into the process escapes in the flue gas and is wasted. At Eti Krom Inc.'s ferrochrome production plant, we implemented a project that recovered useful energy. The system consists mainly of a waste-heat boiler, a filter bag station, a fan and a clean-gas stack. Recovered heat from the flue gas can produce more than 30 tons per hour of steam, which is fed into a system to drive a steam turbine to generate 5.5 MWe of electrical power, which is then either directed back to the plant or sent to the national grid. The dedusting portion of this project is as important as the power generation. We estimate to reduce the overall CO2 emission by 25,000 tons per annum.

1 INTRODUCTION

Eti Krom, established in 1936 as a state- owned enterprise, is located 55 km from the city of Elazig in the eastern part of Turkey. After undergoing privatization in 2004, Eti Krom became a subsidiary of YILDIRIM Group, a Turkish industrial conglomerate headquartered in Istanbul. Eti Krom is the largest chrome ore and ferrochrome (FeCr) producer in Turkey. FeCr is an alloy of chromium and iron containing between 50% and 70% chromium. Ferrochrome is produced by electric arc furnaces melting chrome ore as shown in Figures 1 and 2. Ferrochrome production is essentially a carbothermic reduction operation taking place at high temperatures. Chrome ore (an oxide of chromium and iron) is reduced by the carbon in coke to form the iron-chromium alloy as shown in Figures 3a and 3b. The heat for this reaction comes from the electric arc formed between the tips of the three electrodes at the bottom of the furnace and the furnace hearth. This arc creates temperatures between 2,500°C and 3,000°C, and in the process of smelting, large amounts of electricity are consumed.

As a producer of high-carbon ferro-chrome, Eti Krom operates a total of four submerged arc furnaces, two of which have nominal power of 17 MVA each, and the other two with nominal power of 30 MVA each, providing annual capa-city of 150,000 metric tons (mt) of high carbon ferrochrome. High-carbon ferro-chrome is an important ingredient of stainless steel production.

In almost all metallurgical operations, such as arc or reduction furnaces, most of the energy that goes into the process escapes in the flue gas (stack gas) and is wasted. With the ever-increasing cost of electrical power, not to mention its scarcity, it is imperative nowadays to capture this wasted energy and recycle it back to the metallurgical operation. At the Eti Krom high-carbon ferrochrome production plant, they have been working with SMS SIEMAG AG on a project to implement an energy recovery system. The system consists mainly of a waste- heat boiler, a filter bag station, a fan and a clean-gas stack. Recovered heat from the flue gas can produce more than 30 tons per hour of steam, which is then fed into a system to drive a steam turbine to generate 5.5 MWe of electrical power, which is then either directed back to the plant or sent to the national grid.

Fig. 1. - Tapping process and electrodes of submerged arc furnace

Fig. 2. a, b- Ferrochrome alloy (FeCr), Ferrochrome pieces in bulk

This project is regarded as a pioneering effort in the field of ferrochrome production. This environmentally friendly system at Eti Krom was implemented in the beginning of 2016. This is a new addition to the overall sustainability of the largest ferrochrome operation in Turkey.

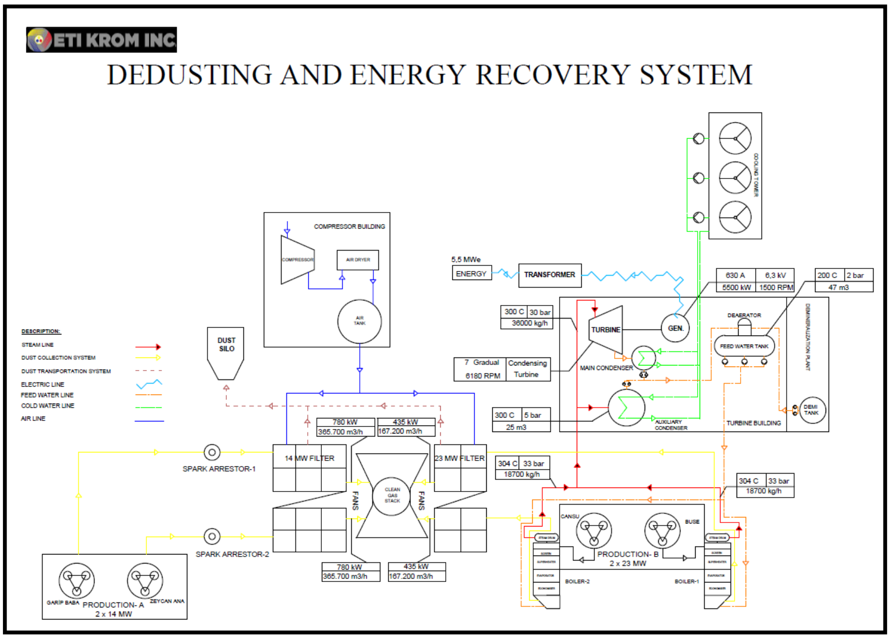

Fig. 3. - Waste heat energy recovery and dedusting project flow chart

Waste gas heat recovery and cleaning will be applied to two newer 30-MVA ferrochrome furnaces, and waste gas cleaning to the two 17-MVA furnaces. The heat energy from the hot waste gas ranging from approximately 600°C at the gas stack down to 200°C at the bag filter plant will be recovered by evaporative cooling and transformed into steam, which is then used for electric power generation. The system applied to the newer arc furnaces is designed for a temperature of 200°C at the bag filter plant where the bag filters cannot withstand temperatures higher than 200°C. The dedusting plant serves all the arc furnaces to ensure that hot, dust-laden flue gas is cleaned by the bag filter plant and the resulting emissions are well below international standards. Figure 4 shows the flow chart of this process.

2 THE WASTE HEAT BOILER

The boiler system is composed of an economizer, evaporator, super heater, screen, steam drum and blowdown tank. Inlet temperature of the flue gas into the boiler (steam generator) is approximately 600°C and the outlet temperature is approximately 200°C or less. The process that takes place inside the boiler can be described as an evaporative cooling system, which employs water's large enthalpy of vaporization. Flue gas temperature can be reduced significantly through the phase transition of liquid water to water vapor (evaporation), which can cool air using much less energy than refrigeration. A simple example of natural evaporative cooling is perspiration, which cools the body.

An economizer, in simple terms, is a heat exchanger. In the system, there are three economizer sections that preheat water from the feed water tank. The economizer sections prevent flooding of the boiler with liquid water that is too cold. Water entering the evaporator is heated sufficiently to ensure that the evaporator pipes are not damaged by temperature extremes. In the evaporator section of the boiler, water in the liquid state is converted into a gaseous or vapor state. The evaporator heats water that drops from the steam drum to gen-erate saturated steam that is then sent to the superheater. The superheater serves to raise the temperature of the saturated steam to superheated steam; superheated steam is defined as steam that is heated above the boiling point at a given pressure. Moreover, superheated steam is a dry gas that can be used to drive turbines.

Boiler feed water usually contains two harmful dissolved gases: oxygen and carbon dioxide. If the dissolved gases are not removed before entering the boiler, they will be liberated by heat and may cause severe corrosion in the boiler, steam lines, condensate lines and heat transfer equipment, which can be very costly to repair. A deaerator in the system removes the dissolved oxygen and carbon dioxide mechanically. The deaerator is a pressurized tank, designed to heat water to the temperature of saturated steam at the pressure level inside the deaerator. The deaerator provides an effective means for recovery of heat from exhaust or flash steam. It also provides a location for returning condensate and accepts condensate first to reduce excessive makeup water. In this case, water from the demineralized water system is sent to the feed water tank with two bar at 30°C, which in turn feeds the boilers by pumps.

3 POWER GENERATION SYSTEM

The power generation system consists of the steam turbine package (turbine, gear box, generator) and the turbine condenser directly attached to the turbine. The steam turbine package includes the condenser turbine, gear box, a generator and a condenser provided by M+M Turbinen-Technik GmbH. This steam turbine is able to generate 5.5 MWe of electrical energy. The package is a compact unit and fits on a turbine table. A special spring system is installed between the turbine table and the ground.

The steam turbine is a mechanical device that converts thermal energy in pressurized steam into useful mechanical work; this mechanical force is then converted into rotational force, which is then converted to electricity. An impeller in the turbine is connected to an electrical generator that utilizes the spinning motion of the impeller to generate electricity.

A gearbox, to reduce rotation speed, is located between the turbine and electric generator. The power from the rotation of the turbine is transferred to the generator through the main shaft and the gearbox, which allows optimum adjustment of turbine speed to the particular operating conditions. The generator connected to the turbine produces electricity by turning a copper circuit inside of a magnetic field, and the turning of the copper inside the magnetic field generates electricity. The electricity generated in the circuit is then fed to the electrical substation, which sends the power to the ferrochrome production plant or the national grid.

After the steam leaves the exhaust section of the turbine, it enters a condenser where it is cooled to its liquid state. The process of condensing the steam creates a vacuum, which draws in more steam from the turbine. The water is returned to the boiler, reheated and used again, whereas the auxiliary condenser functions as a safety valve that reduces steam pressure to an operational level and then sends the condensed water back to the feed water tank. The last condenser is a gland steam condenser that maintains a constant vacuum for the steam seal exhaust header and condensates steam from the steam seals so that it can be reused within the plant cycle.

4 FLUE GAS CLEANING SYSTEM

The dedusting system (bag filter house) is located outside the arc furnaces. Flue gas is introduced through the boiler and then the bag filter house for the newer furnaces in order to reduce the temperature of the gas from 600°C to 200°C. However, the flue gas is introduced through the bag filter house for the existing furnaces because the temperature is below 200°C. Therefore, both flue gas streams from the new and older furnaces go to the filter baghouse to optimize the dedusting process. Before entering the bag filter house, a spark arrestor isolates and separates coarse dust and burning particles in the flue gas. During the filtering process, the dust-laden gases flow from the outside into the filter bag; thus, dust is retained in the bag outside. Fans push the clean gas through the clean gas stack into the atmosphere, and the collected dust is transported by chain conveyors to a dust silo, from where it is discharged into a truck that disposes of the dust at a landfill site in compliance with environmental regulations.

5 AUTOMATION AND CONTROL

The basic automation system consists primarily of two components: a PLC (Programmable Logic Controller) and an HMI (Human Machine Interface). The HMI, through the Supervisory Control and Data Acquisition (SCADA) system, enables the operators in the main control room to control and monitor the entire production process.

6 CONCLUSION

In order to achieve long-standing, profitable and sustainable growth, priority is given to energy efficient, cost- effective and environmentally friendly projects. They have objectives to improve the environmental profile of their mining and ferrochrome operations. Focusing on efficiency and cost reduction in their operations will reduce energy and water consumption, which will eventually minimize waste and reduce greenhouse gas emissions that contribute to global climate change. This system will reduce 25.000 mt of CO_2 emissions per year. As a result, their ferrochrome operation’s carbon footprint will be significantly reduced.

Switch from Gas to Biomass in DH: Success Story of Lithuania

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Abstract. For Lithuania, dependence on imported fossil fuels from Russia was an economic and political challenge. At the same time, indigenous biomass resources were and still are abundant. From 2000 to 2015 biomass use in DH sector increased form 2 % to 61 % - the share of biomass used in DH first time exceeded the share of imported gas. Lithuania has already reached the targets of the EU Directive regarding the Incentives for Consumption of Renewable Energy Resources for Lithuania to increase this rate to 23 percent until 2020. The main reason for this growth is enormous renewable energy resources in Lithuania (for example, forests cover ~ 33.2 percent of Lithuania (2,2 M ha)), also the price of using biomass for heating is up to 3 times lower than price of natural gas). The amount of biomass per capita in Lithuania is one of the highest in the European Union and it is estimated that in 2020 Lithuania will take the lead in the EU according to the quantity of available biomass for energy needs.

1 ARTICLE

Heating has always been one of the most important and problematic global issues for people living in the altitudes like Lithuania. Over a span of 6 to 7 month a year, when the temperature at night time drops below 0˚C (and sometimes even below -30˚C), only a well prepared person (family, community, city, nation) can survive and develop the country.

Lithuania is an unitary parliamentary republic with a population of around 3 million people only. It is a part of the so-called “Nordic Baltic” region of Europe, occupying the area of 65.300 sq. kilometers with the capital of Vilnius (est. 1323, population- 543.000). The first written mention of Lithuania is found in a medieval German manuscript the “Annals of Quedlinburg” dated 9th of March, 1009. The country has a great history: in the 15-18th centuries The Grand Duchy of Lithuania was part of the Polish-Lithuanian Commonwealth, ruling the territory from the Baltic to the Black sea.

Lithuania was part of the Soviet Union (1940-1990), and since the country got back its independence on 11th of March 1990 the issues of energy supply and security have become of major importance. The energy system during the Soviet times was developed in the same way as in all the other Republics of the Soviet Union: the electricity supply system was based on large generators, including nuclear (Lithuania had two nuclear blocks at Ignalina NPP, 1600MW each), the heating of the cities was based on heat generation from gas and supplied through well developed, but poorly maintained district heating systems. Also, all the gas supply was designed only by the pipe-line from Russia, and all the electricity system was connected only with the neighboring Byelorussia and Latvia (in so called BRELL ring, there was no connection to the West). Therefore, the transformation of such “inheritance” was inevitable, the question was only how to get out of this situation.

We can discuss endlessly about models and reforms, when you look back, having all the necessary information, knowing “mistakes”, “advantages” and different aspects of one way or another. But I would like to leave this for others, instead introducing you shortly to a reformed energy system of Lithuania, focusing on the main topic – development of Biomass energy in District Heating systems of Lithuania.

At present Lithuania is a country, where final electricity consumption is about 10 TWh annually, the heating requires around 20 TWh, and liquid fuels for transport another 20 TWh. Ignalina NPP was closed (in 2009), but it still requires a lot of man power, investment and public money spent on the process of closing and on insuring its safety. Local generation of electricity is still based on improved gas-using technology, but with around 15% of market share of renewables (wind, hydro and around 2,5% of biomass electricity). But the electricity grid already has a connection to Sweden (NordBalt, 700 MW), and a connection to Poland (LitPolLink, 500 MW) completed, so Lithuania will become a part of a new – Baltic electricity ring. Of course, the consumption of electricity dropped significantly from 1990, because of the transformation of the industry (there are not any larger ineffective old style plants and factories), also because of the growing effectiveness of the electricity consumption.

When we come to the heating issue in Lithuania, we need to understand, that the prevailing heating model in the cities (including smaller towns and even bigger villages in the countryside) is district heating, as it was developed during the Soviet regime. 55% of heat consumers are served by district heating companies. For this purpose, we have 2683 km of DH pipes in Lithuania, 478 boiler houses with installed capacity of 8200 MW, and 1530 MW of biomass boiler houses among them. 41 municipals and 12 private companies are involved in the process of heat production and supply to the consumers, 7 private companies are involved in heat generation only as independent heat producers. Up to 10 TWh of heat is produced annually and supplied to consumers, with average losses in the grid of around 15%. (Another 7-9 TWh is produced and consumed in private houses and other premises not connected to DH). DH model is a really effective, clean and consumer-friendly for heating buildings, but only in the way, when such heat is cheap or - to put it better - affordable. And this was the major problem as well as an opportunity for the development of biomass energy in Lithuania.

After Lithuania became a member state (MS) of the European Union (EU) in 2004, the main and only natural gas supplier Gasprom from Russia started to increase prices on gas. This process is clearly visible in the figure No.1 below.

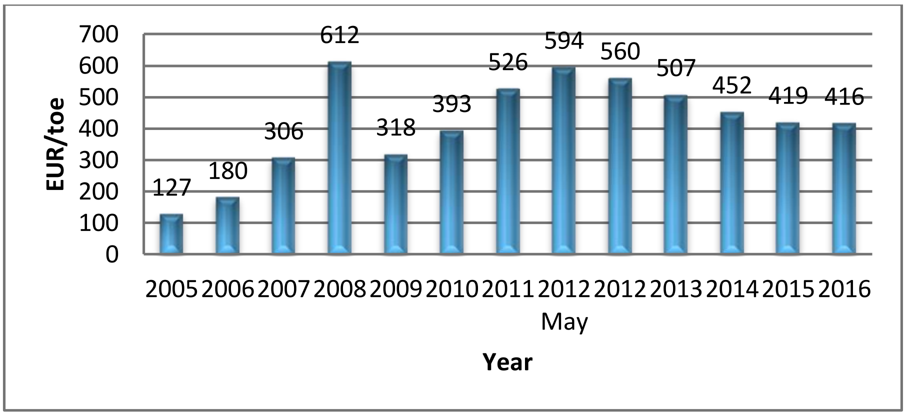

Fig. 1. The dynamic of natural gas price (including transportation and capacity fee) without VAT.

The peak of gas prices was reached in 2008 and 2012, when DH companies had to pay for natural gas over 2050 Lt/toe (593 EUR/toe), including transmission and distribution fees.

Lithuania became a MS of the EU, paying the highest price for imported gas. This price became recognized as "political" price, having nothing in common with the market situation. After some Gasprom disputes and even stopping of gas delivery to Ukraine, Lithuania started to feel also insecurity of gas supply, and high prices on gas deepened the misbalance of international trade. Gas supply and "political" price regulation by Gasprom also caused the first and only fail of attempt to join EUR zone by Lithuania in 2008, as the criteria of sustainable and agreed inflation rate was not met because of the sharp price increase on gas, and consequently - on heat.

Lithuania started several international legal cases against Gasprom regarding the regulation of gas prices, and has already won one of them. Also, a LNG terminal (with the very symbolic name "Independence") was built and started to operate in 2014.

Price increase for heat consumers is indicated in figure No.2.

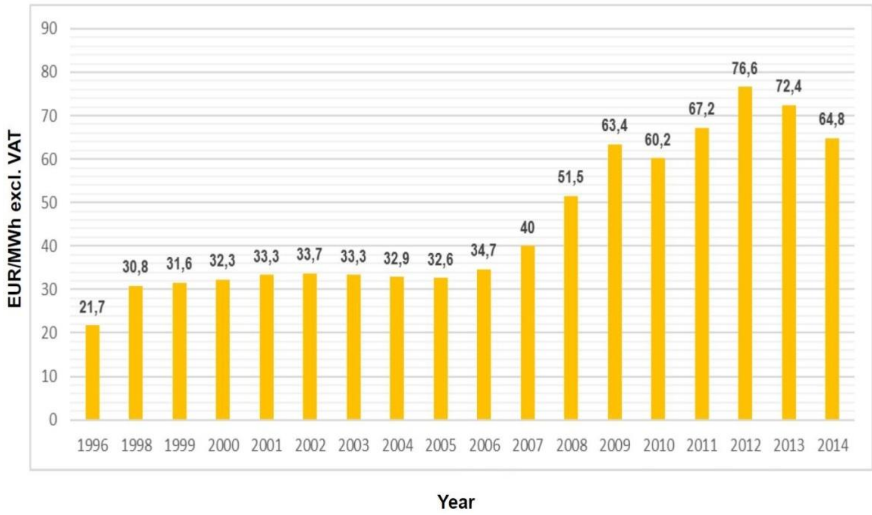

Fig. 2. Average district heat prices (excluded VAT) in year 1996, 1998–2014.

The opportunity to use biomass for the production of heat in Lithuania was also known before the independence. For instance, in 1988 a biomass boiler was installed in a regional town Birzai. However, the process gained momentum since the restoration of the independence, in cooperation with Nordic countries and using the funds of assistance programs for Lithuania (Phare, etc.). The number of biomass boiler houses (using mainly chipped wood and forest logging residues) and the amount of their installed power started to grow rapidly. But still – huge work to be done was visible ahead: in 2004 (the Year, when Lithuania entered the EU) less than 10% of heat in DH was produced from biomass.

The process of transition from gas to biomass was accelerated when foreign energy companies (e.g. Dalkia from France, Fortum from Finland) entered DH market in Lithuania. They brought clear vision of transformation of DH and relationships to Western (Scandinavian) technology companies.

Local business also discovered the sector interesting for investments. At that time specialized biomass production and supply companies were established. Their main areas of activities were collection, processing, storage and delivery, ensuring a continuous supply of biomass to boiler houses. It is important to note that the emerging biomass energy industry addressed not only the heat supply issue, but also the ecological problem: wood industry, sawmills had accumulated vast amounts of unused wood waste and residues, which caused a big headache for managers of those companies. Development of Biomass energy proposed a comprehensive acceptable solution – using such waste as fuel, and replacing imported fossil fuels. The first local companies, producers of biomass energy equipment – boilers and complete boiler houses – were also created at that time.

It became clear that this situation requires a new approach to biomass resources and biomass production processes of various related institutions: The Ministries of

Economy, Energy, Agriculture and Environment, state-owned forest enterprises, private foresters, energy companies, and, of course, municipalities. There was a need for a systematic, science-based approach to biomass resources and their exploitation prospects, which had to be reflected in the legislative system. On 4th of June 2003 creation process of biomass energy association started, with the final formation and incorporation at the end of 2004. In addition to commercial issues important for companies it began to build its approach to the biomass energy perspective. Some of the most important prospective tasks included development of the biomass energy market, researches on biomass resources, development of the association membership covering the entire biomass energy chain, building cooperation and partnership relationships in Lithuania and with foreign partners, interception and dissemination of foreign experience in Lithuania. Also the number of activities and methods of operation have been confirmed as to be used: organizing conferences and seminars, writing articles in magazines and newspapers, giving interviews and participating in public discussions, taking part in decision making process as experts, promoting biomass energy in public events, initiating scientific research studies, disseminating the best practices and examples, etc.

The activity of Lithuanian biomass energy association Litbioma was started in 2004. Following its goals, Litbioma created a wide network of relationships nationally and internationally, acting as a “think tank”, generating visions and ideas, gathering and disseminating information, and as lobbying organization. Litbioma became a member of AEBIOM in 2006, and joined WBA in 2015. We are also members of World Energy Council Lithuanian committee, Lithuanian confederation of industrialists, Lithuanian confederation of renewable energy resources, European pellet council. Litbioma has entered into partnership with Directorate general of state forests and Lithuanian association of forest owners, Lithuanian District heating association, Operator of the Lithuanian energy exchange BALTPOOL. We have also a partnership agreement with UABIO- Bioenergy association in Ukraine. In this way Litbioma is in position to participate constantly in the flow of information, related to biomass energy industry worldwide. The number of members of the association has also been growing, reaching 57 companies by 2014, covering all the spheres of the biomass energy (R&D, biomass mobilization and production, equipment production). Companies, producing energy from biomass, are united in Lithuanian district heating association, which is a partner organization, as mentioned above.

Estimation of biomass potential in Lithuania became the core issue for Litbioma. Only sustainable use of biomass and scientifically proven resources served as a serious argument in discussion whether biomass energy has limits of its development and where they are. The number of research studies, initiated by Litbioma with the involvement of Lithuanian forest institute, Directorate general of state forest and private forest owners’ organizations gave a possibility to protect the increasing consumption of wood for biomass energy. The work was finalized in 2013, after the “Assessment of biomass potential in Lithuania, price forecast for biomass, assessment of social benefits of using biomass, and proposals of state interventions for the development of the use of biomass” (auth. M. Nagevičius) was successfully introduced to all the participants of the market and politicians. It clearly showed, that we have in Lithuania more than enough woody biomass (1,5 M toe annually), with additional reserves, coming from municipal waste, agricultural sector and peat, as a local fuel in total- 2,2 M toe annually. The fact, that Lithuanian state forests were recognized as the best protected in the world in 2012 in accordance with Yale University, issuing Environmental Performance Index on annual basis, showed to all of us, that Lithuania is also on the right way in developing the state forestry for the needs of biomass energy. The market indicated this positive trend much earlier: from the beginning of fast biomass energy development in 2004, biomass remained up to 3 times cheaper, despite the deep fluctuation of the gas price in Lithuania (Figure No.3)

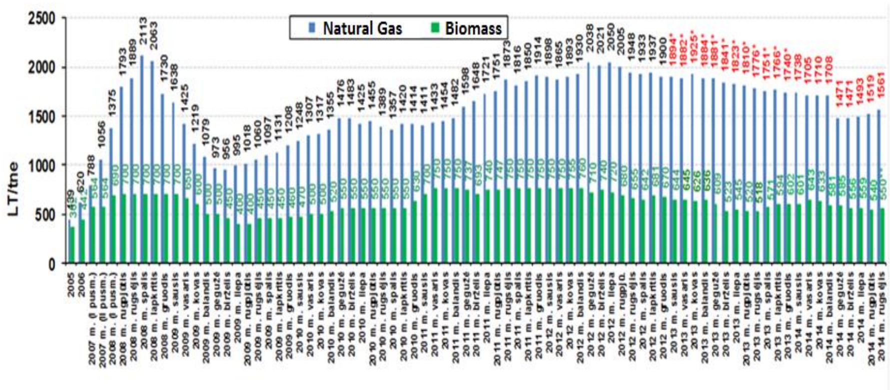

Fig. 3. The comparison of natural gas and biomass price (including transportation and capacity fee) without VAT.

The next very important part of the work for Litbioma was active participation in creation of Lithuanian national energy strategy (a law from 2007) and in the process of creation on Renewable energy law and related documents (2009-2011). For the first time the potential of biomass energy was evaluated and stated in legal acts of the highest importance!

In the beginning of 2014, after 10 years of active development, Litbioma came to conclusion, that switch from gas to biomass energy in DH became a success story and very positive example of modernisation of the country. Almost 49% of heat in DH systems of Lithuania was produced from biomass in 2014, for the first time overcoming imported gas, and 61% was reached for biomass in the heating season of 2015-2016 (Figure No.4).

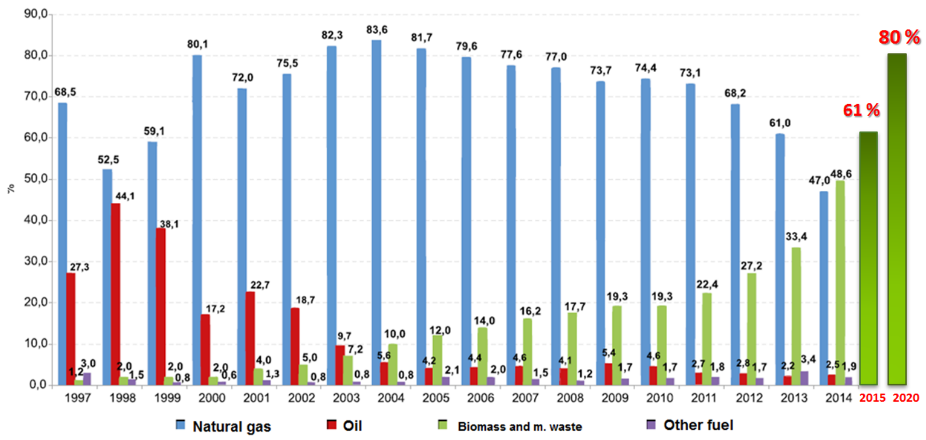

Fig. 4. Years 2015-2016 finalizing the transition from gas to biomass in DH of Lithuania.

Practically all the cities, towns and bigger villages have now biomass district heating, capable to cover base load and supply heat and hot water. It is very often, that biomass energy covers 100% of necessary heat (in smaller towns). Practically, only in the capital of Lithuania Vilnius this type of transition is still in progress. A new biomass powered CHP, with WtE block built in addition, will finish this switch from gas to biomass in Lithuania in 2017. This impressive and large energy unit will be able to produce 400GWh of electricity (3,7% consumption of Lithuania), will supply to DH grid in Vilnius 1.240 GWh of heat (delivering up to 50 % of Vilnius need), and will reduce the emission of CO2 by 230.000t annually. Together with the existing capacities of biomass boiler houses and CHP in Vilnius it will be enough to cover even more than base load, and only peaks during very cold days will require a little help of gas generators. After this is done, biomass heat in Lithuanian DH will reach not less than 80% of market share. The work will be finished!

Biomass energy also found its place in industry. Wood processing industry traditionally used to be the “ice-breaker” of the process (what is obvious having in mind the main raw material they have to deal with). But we are proud, that cheap and clean heat and steam from biomass is liked by others, like milk and fish industry, paper and tobacco plants, even chemical industry. 1.300GWh of heat was produced from cheap and local biomass in industrial companies in Year 2015.This significantly increased compatibility of Lithuanian producers due to cost-effective and clean biomass energy applications in theirs factories and plants.

Biomass industry of Lithuania has grown itself as well during the last decade. More than 6500 people are employed in technological companies and production and supply of biomass. The export of technological equipment reached 50 M EUR in 2015, but is expected to grow up to 300 M EUR in 2020. The average salary is 50% higher in this sphere of Lithuanian economy, comparing to the average.

As a result, this transition from imported fossil fuel-gas to local biomass offered to Lithuania lower prices of heat to consumers and lower emissions of CO2. Number of jobs increased significantly, and R&D, cooperation of science and business, development of technologies took place in large scale. Biomass energy helped to improve social and economic situation in rural regions, also offering in some cases solutions for better land use. It also improved foreign trade balance of the state, finally - increased energy independence and environmental situation.

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Present Developments and Potential of Biomass to Energy in Australia

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Abstract. Australia has several real advantages in reaching a high potential for the development of biomass to energy. These include that, of the population of about 24 million, about 80% live in either the six major greater city areas or in about eleven secondary urban concentrations. Almost all of the urban areas with larger populations are along the coast close to deepwater shipping ports. Due to this concentration of population the supply of fuels, electricity and industrial heat is simplified, and the waste streams are generated within a relatively small area for aggregation, collection and potential processing.

As a first world country the demand in Australia for energy, water and other resources, is relatively high per capita, and production of wastes per capita or per household is also relatively high. Presently about 20 million tonnes a year of municipal solid wastes goes to landfills, with over 10 million tonnes being combustible [6].

The other advantage for Australia is that there is a significant production of all forms of economically available biomass, even though much of this is presently unutilised. In many areas the biomass is simply burned or allowed to rot, due to there being no existing market. While much of this is woody biomass from plantation forestry, between five and ten million tonnes of straw is burned each year in the fields, and many millions more ones of urban wood waste and organic processing waste are unutilised with much of this going to landfills [6].

While much of this presently unutilised biomass could be converted into electricity, industrial heat and transport biofuels, the forestry and agriculture sectors of the country have a clear capacity to produce significantly more biomass if the necessary market signals are there. The estimate is that current biomass and waste could provide over 17% of the country's present base electricity demand or about 5000 MW-e. Other estimates suggest that a figure of about 25% or 7500 MW-e is currently feasible [5,6]. The heat produced at the hundred or more combined heat and power plants of various capacities would be used for industrial purposes, as is done at similar scale of plants in central and northern Europe, India, Brazil and elsewhere.

While biomass was always a source of energy using older less efficient conversion systems, the development of biomass and waste to energy using modern highly efficient systems has already commenced and this paper will provide examples.

Keywords: Australia, biomass, waste streams, infrastructure

1 INTRODUCTION

The high level of reliance in Australia for energy from fossil fuels is well-known. This use of fossil fuels for electricity, industrial heat and transport, coupled with the long transport distances and the relatively inefficient building design, together result in a per capital emission of greenhouse gases (GHG) of about 24 tonnes (some estimates for GHG emissions/capita are as high as 30 tonnes).

This situation has developed since about 1945 when the population of Australia grew very quickly because of a high birth rate and a strong immigration policy. At the same time homes in Australian cities were converting from the fuels of wood or town gas (produced from gasification of coal) for cooking and heating water, to electricity. The electricity was generated by large centralised condensing coal-fired plants. While almost all towns and cities prior to the Second World War had their own separate electricity generators and reticulation of power to households, the state electricity boards progressively took these over and connected all towns to the centralised supply via networks of high tension power lines (usually of about 110,000 volts).

From about 2000 two things have been working together to drive the movement away from use of electricity and gas by households and industry. One is the falling costs of solar photovoltaic (PV) panels for households and institutions (with an enthusiastic adoption helped by some years of high feed-in tariffs). The second is the sharply rising cost of natural gas and electricity. The rising costs are due to several factors, but the reality is that the cost to the Australian consumer of the fossil sources of energy is now steadily trending up.

2 THE SCOPE FOR ENERGY FROM BIOMASS IN AUSTRALIA

While the high costs of electricity from solar PV panels and from wind are either subsidised or subject to feed-in tariffs, and the general public is generally ignorant of the complexity of how the national grid can cope with every larger input from these two sources of intermittent electricity, it is biomass and waste that are now beginning to be appreciated for their ability to provide dispatchable power and on-demand industrial heat, as well as transport biofuels. This is reflected by a falling away of investment in wind turbines, and a hold on installation of several larger solar energy plants.

In 2014 while the electricity from wind was about 9800 gigawatt-hours (GWh) and from solar PV systems of under 100 kW was 4834 GWh, the electricity production from biomass-fuelled plants was about 2400 GWh. This supply of bioelectricity in 2014 was only about 1% of total electricity demand. In that year, the combined renewable sources including large hydro were supplying about 13.5% of demand [2].

Up to half of the capacity of bioenergy plants producing this electricity was found in industries that required large volumes of steam or large amounts of heat. These were mainly in the pulp and paper sector and in the sugar production sector. Overall, there were 139 plants in 2014 producing electricity at capacities of 100 kW-e up to 70 MW, with the greatest number being smaller capacity plants fuelled by biogas from landfill sites, from anaerobic digesters at sewage treatment, or from anaerobic digestion of animal manures [2]. However, by 2016 the number of larger biomass to electricity plants now in development or planning is rapidly increasing as several federal and state government stimulus packages and availability of special funding come on line. When these are being commissioned by 2018 the amount of energy from biomass may be up to triple the 2014 output.

Industry and local government are playing a role in this also as they are seeing that the bioenergy technologies allow industry waste streams to be converted into energy from industry, while keeping the 'energy money' circulating within the local or regional economy, and generating permanent jobs.

Of course, as in other countries, by far the greatest amount of energy produced from biomass is as heat. On the basis of overall energy consumption in Australia provided from renewable energy sources, biomass is the clear leader and it is in the supply of heat from biomass for industry, commerce, institutions and households that the greatest potential for development exists. This is as use of combustible processing residues to fuel industrial boilers, through expansion of the pellet production from both wood and straw for fuelling small household heating systems, and by use of woodchip and other woody residues for medium to larger industry or institutional heating demands.

Australia's good transport infrastructure (mainly using road transport but with some regions well served by train lines) means that biomass can readily be aggregated in larger volumes. As an example of how this works in practice, Australia currently exports about 6 million bone-dry tonnes of woodchip from up to eight deepwater ports, which are located in five of the six states. This export woodchip is usually produced at the export sites from roundwood brought in by trucks carrying loads of up to 50 tonnes from up to 200 kilometers away.

2.1 Examples of biomass to energy technologies currently in use

Australia is utilising many of the bioenergy technologies currently regarded as being mature elsewhere in the world. These include

- Bubbling fluidised bed furnaces fuelled by diverse forms of biomass including grape marc, paper recycling waste and plastics, and coffee grounds.
- Conventional furnaces producing heat and steam. These furnaces are fuelled by biomass including macadamia nut shells, almond shells, olive pits, or high moisture content wood waste. Some of these have an organic rankin cycle (ORC) turbine/generator attached
- Anaerobic digestors producing biogas to fuel gas engine-driven generators at up to an aggregate of 10 MW-e

- Gasification systems are in use in several sites. One is a 50 MW-e capacity system using sorted municipal wastes. Another site at a retrofitted Sydney office building has a pair of Volter 50 kW-e gasifiers utilising wood chip and dry paper waste.
- Another form of gasifier uses sawdust as the feedstock to produce a gas used for firing bricks on a large scale
- Pellet production and small pellet fuelled heating systems. Production of domestic quality white wood pellets has jumped from about 5000 t/yr in 2012 to about 130,000 t/yr in 2015 (this includes 100,000 t presently being exported).

2.2 Examples Of Bioenergy Plants In Planning And Development

The new plants in development around Australia reflect the sort of stimulus this sector ahs received over the last two years. These plants are often larger, use technologies and fuels novel to Australia, and almost always are designed to make best use of heat produced. They include;

- a 150 MW-e circulating fluidised bed (CFB) plant being converted from a fuel of remediated coal mine tailings to being fuelled by sorted municipal wastes and urban woody waste
- a bioethanol and co-generation plant that has the potential to also produce pellets
- a 20 MW-e straw-fuelled plant that is modelled on similar plants in Spain
- a bioethanol plant with output capacity of 110 million litres a year
- new state-of-the-art anaerobic digesters utilising wastes from one of Australia's largest beef abbattoirs and from a major egg production facility, to produce heat and electricity to cut energy costs by up to 50%
- multiple on-site anaerobic digesters converting manure slurry from piggeries in heat and electricity

A number of bioenergy technologies are not yet implemented at commercial scale yet in Australia despite their potential. These include production of pyrolysis oil and torrefied or steam-exploded pellets, or of cellulosic ethanol. Another technology that is yet to attract the necessary major investment is waste-to-energy processing by high temperature furnaces, or production of synthetic fuels from waste via any of the gasification pathways.

3 CONCLUSION

Australia has the potential to be producing up to 30% of final energy from biomass by 2030. The realisation of this potential is now underway with focused supportive policies in three states and at federal government level. It is being facilitated by the need to update ageing power generation infrastructure and by Australia's need to develop on-demand or base-load sources of renewable energy to reduce emissions in line with international commitments. Finally there is a growing recognition that energy from biomass is more than cost-competitive with other renewable energy sources and can play an important role in reducing emissions of GHGs while generating jobs and helping farmers and the rural sector generally adapt their practices to reduce the risks to production that accompany a changing climate.

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Solar Energy and Evaluation of Its Applicabilty in the Southeastern Anatolia Region

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ABSTRACT. One of the main problems of Turkey is the dependency to energy sources from outside of Turkey to generate the electricity. Therefore, all renewable energy sources such as hydro, wind, solar and geothermal should be used to decrease this dependency in the country. Although many investments have been done by private sectors to use wind energy for this purpose in the last decade, this is not possible to say similar things for the solar energy. However, many stimulus packages have been presented by government of Turkey to increase investments to the solar energy and photovoltaic (PV) systems are expected to grow dramatically in the next years. The Southeastern Anatolia Region of Turkey has many advantages for solar energy to generate electricity because of its geographical location. In this paper, the potential of electricity generation by using solar energy in the Southeastern Anatolia Region is evaluated in the aspects of available areas for photovoltaic power plants in the region, solar irradiance values and sunshine durations.

Keywords: Renewable energy sources, solar energy, Southeastern Anatolia Region.

1 INTRODUCTION

Renewable energy sources such as hydro, biomass, wind, solarand geothermal are very important to generate electricity for countries. This situation is more critical for some countries had dependency to energy sources from outside to generate their electricity like Turkey. Therefore all renewable energy sources mentioned before should be used to decrease this dependency in the country. Solar energy is a durable energy source and offers environmentally clean option compared to other energy sources. In addition, solar energy has enormous potential without negative effects of conventional energy sources. The Southeastern Anatolia Region of Turkey has many advantages for the solar energy to generate electricity because of its geographical location. However, hydro sources are also very important to generate electricity not only for the region, but also for the country.

Sunbelt countries based within 45° of the Equator have an advantage to the use solar energy effectively as shown in Fig.1 [1]. Solar energy potential of this region changes between 3.5 and 7 kWh/m^2 day and sunshine duration reaches up to 3500 hours per year [2].

Fig. 1. Sunbelt Countries in the World [1].

Although Turkey is one of the sunbelt countries, the installed power capacity of the PV power plants was only 20MW in the country at the end of the year 2014 [3]. However, the installed capacity has just reached to 358 MW in recent months, dramatically [4].

Turkey has a bigger solar electricity generation potential to use solar PV compared to European Union (EU) member countries and also other European countries except for Portugal and Spain as shown in Fig 2 [5]. In addition, the maximum potentials of most of these countries are less than minimum potential of Turkey.

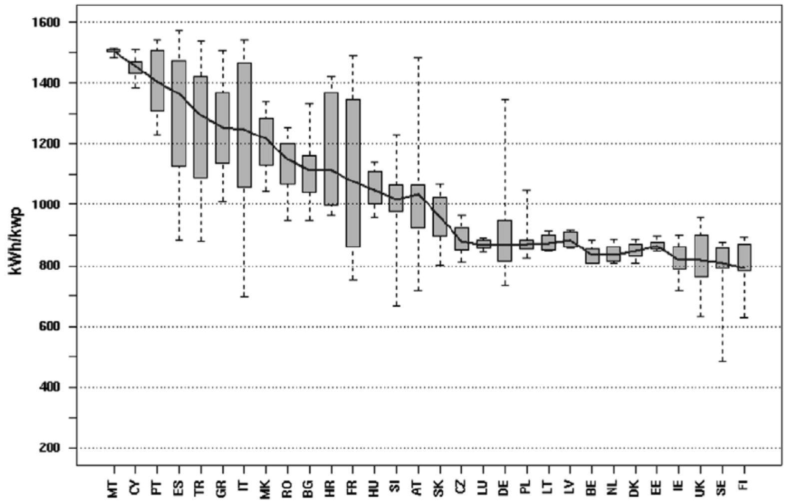

Fig. 2. Yearly Sum of the Electricity Generated by a Typical 1 kWp PV System in the European Countries [5].

The total installed solar collector area in Turkey was calculated as almost 18 640 000 m^2 in 2012. The annual production of planar solar collectors was calculated as 1 164 000 m^2, while that of vacuum-tube collectors was 57 600 m^2. All of the vacuum-tube collectors and 50% of the planar collectors produced in the country are known as used in Turkey and thermal energy generated by using these collectors is almost 768 000 TOE (Tonnes of Oil Equivalent) in 2012. The use of the thermal energy produced in 2012 was calculated as 500 000 TOE in the homes and 268 000 TOE for the industrial purposes [6]. Some factors of effecting solar irradiation and their effects are given in Table 1 [2].

Table 1. Some Factors of Effecting Solar Irradiation [2].

COMPONENT	EFFECTS
Earth-Sun Distance	The annual change of 3.5%
Clouds	The dominant factor task
Water Vapor	Selective absorber
Air Pollution	50% reduction of the direct radiation
Forest Fires	Regional effects
Volcanic Ashes	Global annual impact
Location	The position of the sun
Time of Day and Seasons	The position of the sun

PV solar cells contain semiconductors that convert sunlight coming to the surface directly into the direct current (DC) electricity as one of the cleanest renewable energy systems. However, solar radiation and sunshine duration values are very important for solar power plants use PV solar cells [7]. It has been presented that the total annual average sunshine duration is 2737 hours and the total solar energy is 1527 kWh/m2 per year according to the Solar Energy Map (SEM) of Turkey prepared by the General Directorate of Renewable Energy. License applications was started to Republic of Turkey Energy Market Regulatory Authority (EMRA) for the licensed generation of electricity limited with 600 MW capacity totally by using solar energy in 2013. This capacity will be increased to minimum 3000 MW in 2023 by the target of Republic of Turkey Ministry of Energy and Natural Resources [6].

Average sunshine duration of the Southeastern Anatolia Region is 3016 hours per year and solar power is used generally for thermal energy to heat water in this region. In this study, potential of the Southeastern Anatolia Region for the PV power plants is aimed to present.

2 DETERMINATION OF THE SOLAR ENERGY POTENTIAL OF THE SOUTHEASTERN ANATOLIA REGION AND COMPARISON

The solar energy map of Turkey is shown in Fig. 3 [8]. As it can be seen in Fig. 3, total solar radiation values per year in regions that have yellow and red colors are between 1600 kwh/m^2 and 1800 kwh/m^2 and these values are quite good to take advantage of the solar energy. Solar potential of Turkey is quite suitable even with the lowest value 1400 kwh/m^2 compared to Germany which is one of the leading countries in generating electricity by using solar energy with 1300 kWh/m^2 per year value. Monthly average solar energy potential derived from the SEM and annual solar energy distribution of Turkey are given in Table 2 and Table 3, respectively [9, 10].

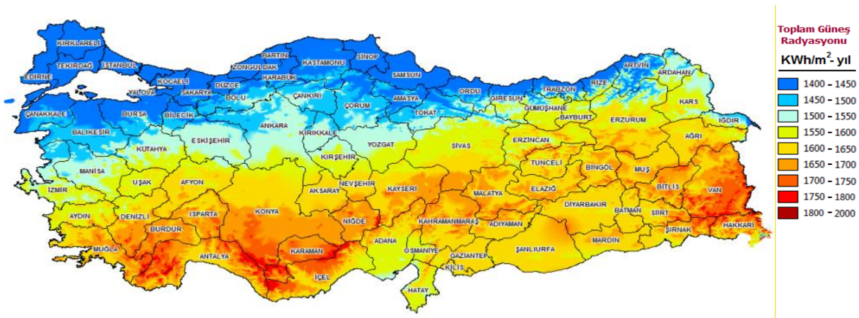

Fig. 3. Turkey Global Solar Radiation Distribution Map [8].

Table 2. Turkey's Monthly Average Solar Potential.

MONTHS	MONTHLY TOTAL SOLAR ENERGY (kcal/cm²month - kwh/m²month)		SUNSHINE DURATION (hours/months)
JANUARY	4.77	55.49	127.41
FEBRUARY	6.02	70	146.16
MARCH	10.32	119.97	194.37
APRIL	12.72	147.9	223.8
MAY	16.37	190.34	282.1
JUNE	16.95	197.1	324.3
JULY	17.33	201.5	350.61
AUGUST	15.49	180.11	331.7
SEPTEMBER	12.41	144.3	276.9
OCTOBER	9.22	107.26	212.97
NOVEMBER	5.52	64.2	154.5
DECEMBER	4.24	49.29	116.25
TOTAL	**131.36**	**1527.46**	**2741.07**
AVERAGE	**0.35**	**4.18**	**7.509**

Table 3. Turkey's Annual Total Solar Energy Potential Distribution by Region [9,10].

AREA	TOTAL SOLAR ENERGY (kWh/m²-year)	SUNSHINE DURATION (hours/years)
Southeastern Anatolia Region	1491.2kWh/m²	3015.8 hours
TheMediterraneanRegion	1452.7 kWh/m²	2923.2hours
AegeanRegion	1406.6 kWh/m²	2726.1 hours
Central Anatolia Region	1432.6 kWh/m²	2711.5 hours
East Anatolia Region	1398.4 kWh/m²	2692.5hours
Marmara Region	1144.2 kWh/m²	2525.7 hours
Black Searegion	1086.3kWh/m²	1965.9 hours

The total average sunshine duration in Turkey is 2741 hours and the country is one of the most available countries to use solar energy to generate electricity. The Southeastern Anatolia Region has the biggest solar potential as it can be seen in Table 3 and this regionis followed by the Mediterranean Region. In addition, The Southeastern Anatolia Region also has the highest potential in terms of daily and total solar energy value as shown in Fig. 4 [8].

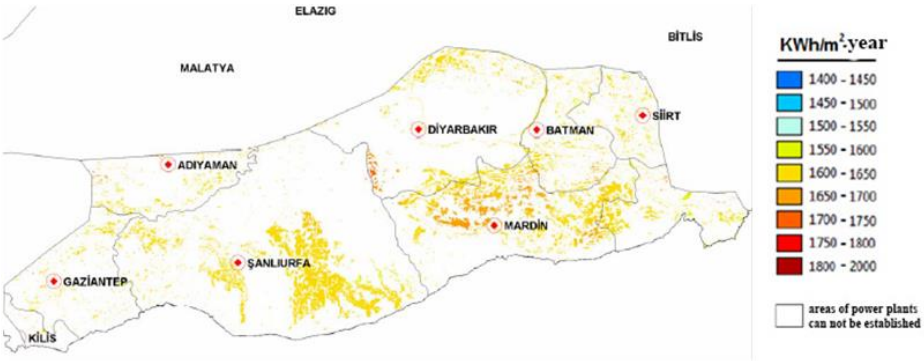

Fig. 4. Global Solar Radiation of the Southeastern Anatolia Region [8].

Besides the region's solar potential, sunshine duration of the application area is also important. Sunshine duration of the Southeastern Anatolia Region is 3016 hours as the highest sunshine duration in the country as given in Table 3. The Southeastern Anatolia Region has a high altitude with a hard and cold climate condition and this region takes the highest solar radiation compared to other regions in winter. Because, airborne water vapor condenses in the form of rain and snow and the atmosphere is clear. Therefore, preventing effects of the solar radiation are the minimum levels [11].

3 RESULTS AND DISCUSSION

The Southeastern Anatolia Region of Turkey has many advantages for the solar energy to generate electricity because of its geographical location. The region has high sunshine duration and solar radiation values. The average daily sunshine duration of the Southeastern Anatolia Region is 8.6 hours. Therefore, it can be said that investments should be focused to the region. Although some legal arrangements made to increase investments to the solar energy, there are also some shortcomings and these problems should be solved as soon as possible. In addition, the special stimulus packages should be presented for the Southeastern Anatolia Region.

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Comparison Of Renewable Energy Potential In Relation To Renewable Energy Policy In Ecowas Countries

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ABSTRACT.

The members of ECOWAS (Economic Community of West African States) have most of its rural and even urban population lacking proper access to constant electricity which is hampering its socio-economic development. ECOWAS member states are also experiencing rapidly rising growth energy demand due to growing population and industrialisation. ECOWAS, in dealing with these challenges recognizes the global paradigm shift from conventional energy to renewable energy sources. Therefore, many member countries are enforcing policies to improve their energy generation especially as regards to renewable energy production.

The objectıve of this paper is to investigate the renewable energy potential and of four member countries of ECOWAS; Nigeria, Ghana, Mali and Senegal. The paper considers five renewable resources Solar, Wind, Biomass, Hydro and Geothermal. The paper compares the resources potential with the renewable energy policies that each of this countries has put in place to ascertain if these policies focus on improving the country's most promising resources. Nigeria has huge Hydro, Wind, Biomass and solar potential and also has major policies to support growth of its potential. However, direct policy focus should be made to Hydro resources as it shows the most promise for Nigeria. Ghana has good Wind, Biomass and solar potential but limited Hydro resource potential. Ghana policies also seem to be focused on its potential strengths as well. Mali, like Ghana also have good Wind, Biomass and solar potentials but are also limited in their Hydro resource potential. However, Mali seem to be lacking in policies to directly improve this resource. Senegal has fantastic Solar and Wind resource potential but are infinitely limited in their Hydro potential. Senegal has good policies to improve rural electrification however policies to properly harness their enormous wind potential is lacking. While no country amongst the ECOWAS countries considered have any policy to improve the utilisation of their geothermal resources, the study shows that Nıgeria and Senegal show the most promise in development of this resource.

Keywords: Renewable energy, Renewable energy potential, Energy policies.

1 INTRODUCTION

ECOWAS consist of 15 member states all of which a located in the western sub region of Africa. With the population of just over 335 million ECOWAS with Nigeria providing more than half of the entire population. Over the last 3 years the macroeconomic prospects of ECOWS has grown by 5.7% in 2013, 6.0 % in 2014 and in 2015 it grew by 5.0% [1].

Many countries in ECOWAS have large potential for both renewable and non-renewable energy sources like hydro, solar, biomass, geothermal, wind, coal, natural gas and crude oil. However, a large majority the region suffers from a huge gap in their energy demand as compared to their energy generation. For many years, virtually all of the ECOWAS member states suffered from power shortages, which has obstructed their socio-economic development. This situation has not improved mainly due to antiquated infrastructure, inadequate skilled manpower, and lack in required funding to satisfy the constant rise in energy demand [2]. Traditional biomass contributes more than 75% of the primary energy consumption within the West Africa sub-region. However, it is used in usually non-sustainable way. The energy sector is also characterized by large oil imports, even in Nigeria, which is the leading exporter of crude oil in Africa. This dependence in foreign oil exposes their energy sector to the constant price fluctuations for countries without fossil fuel reserves and for countries with fossil fuel like Nigeria it reduces their earnings [3]. This issues have created a scenario where this ECOWAS states have less than 10% of their rural population not able to access electricity [4].

This problem compelled many ECOWAS states to embrace their Renewable Energy Sources (RES) with active Renewable Energy Policies (REP). In 2014,13 Member States have adopted a REP, 13 Member States had a renewable energy target in place, and all 15 Member States had at least one policy or one target at the national level, promoting renewable energy technology developments [5].

The objective of this paper is to investigate the renewable energy potential and of four member countries of ECOWAS; Nigeria, Ghana, Mali and Senegal. The paper considers five renewable resources Solar, Wind, Biomass, Hydro and Geothermal. The paper compares the resources potential with the renewable energy policies that each of this countries has put in place to ascertain if these policies focus on improving the country's most promising resources. Ultimately, giving recommendation to the best policies based on the RES potential of four member states Nigeria, Ghana, Mali and Senegal.

2 RENEWABLE ENERGY Potentials

The amount natural energy flows through the earth's ecosystem can supply all for humanity's energy needs, energy from the Sun and wind exceeds current energy use by a lot. As of 2002 natural energy exceeded 425 EJ. However, the theoretical maximums renewable energy is not equivalent to the technical maximums because the technical minimums are limited to technology used to extracted it. However as Renewable energy technology improves this technical maximum will improve.

2.1 Nigeria's Renewable Potential

Nigeria has an estimated an annual average of daily solar radiation to vary from as high as $7KW/m^2$ /day in the northern regions to as low as $3.5KW/m^2$ /day in the south, and an annual average daily sunshine hours to vary from as high as greater than 8hrs/day in the northern border regions to as low as less than 6hrs/day in the coastal regions of south [7]. There is a seasonal component to solar irradiation in Nigeria with dry seasons having greater peaks that the raining seasons.

The metrological data of the mean wind speeds across the country the divided the into 6 geographical zones of Nigeria; North-west, North-east, North-central, South-west, South-east and South-south. Nigeria has maximum mean wind speed 3.9m/s and minimum mean wind speed 1.9m/s at the height of 10 meters [8].

Hydro generation accounts for 30% of Nigeria's power generation. However, Nigeria still has a lot of Hydro-electric potential. Nigeria has a Small Hydro Power Economic feasible potential of about 498.MW. Nigeria has the potential of creating about 199 Large, medium or small scale dams which can produce a gross total of 14,750MW [9]. Nigeria is currently under utilizing it hydro potential only using about 14% of its potential.

Nigeria produces about $2.01*10^{18}$ J of biomass energy annually. In 2010, Nigeria produced an estimated total of energy of 1,958.94PJ from agricultural crop, 54.6PJ from residues from perennial plantation residue and an estimated 186.33GJ of municipal solid waste was produced as well [10]. While biomass is being used for cooking and heat it is currently not being used to produce electricity in Nigeria.

Fig. 1. Geothermal spots in Nigeria

Nigeria has over 30 potential geothermal spots within the borders of the country as seen in Figure 1. Majority of which range between $21mW/m^2$ and $30mW/m^2$. Nigeria also has potential geothermal location off the shore of the country [11]. Nigeria doesn't use geothermal energy for electricity generation.

2.2 Ghana's Renewable Potential

The average solar irradiation in Ghana ranges between 3.5kWh/m^2 and 6.5 kWh/m^2, with regions of the country having varying solar intensities. The highest solar irradiation is experienced in Northern and the least in the western regions [12].

Ghana's has a technical wind power potential estimated to be more than 5,000 MW. Average wind speeds are 6.4-7.5 metres per second (m/s), Overall, the most promising areas for deployment of wind power plants are along the mountains in the south-eastern part of the country and by the coastal areas of the east of Ghana. About 200-400 MW of onshore wind power could be established there with wind speeds in excess of 8 m/s [13].

Ghana has an estimated total biomass of wood fuel at 813–850 million tonnes, wood processing residue is 1 million tonnes/year, and agricultural residues is 1 million tonnes/year. From 2004 to 2009, consumption of wood fuels and charcoal was about 340,380,760.3 tonnes. Agricultural and forest wastes, animal wastes, sawdusts, agricultural crops constitute the major sources of biomass supply in Ghana

Hydropower potential of Ghana is estimated to be about 2,420 MW, though the hydropower contribution to electricity generation is 1180MW being generated from two hydro power stations. Ghana also has a small hydro potential 17.42MW of small hydro from a potential 69 sites.

Ghana from has 4 potentıal spots for geothermal energy which is one of the least amongst the ECOWAS countries wıth its minimum range between 1-10 mw/m^2 and the highest geothermal heat energy in Ghana is 31-40mw/m^2 as shown in Figure 2 [11].

Fig. 2. Geothermal spots in Ghana

2.3 Mali's Renewable Potential

Mali's average daily solar radiation for the period to between 5kWh/m^2/day and 6.5kWh/m^2/day. Mali's solar potential increases from south to the northern part of the country. Mali also daily sun lighting duration of 7-10 hours. [15]

The annual mean simulated wind speeds for the regions in mail at height of 50 meters above the surface ranged between 1.5 m/s -6.5m/s, most of the country however has wind speeds greater the 4.0 m/s [15].

Mali has a Small Hydro Power feasible potential of about 115 MW in about 30 locations around the country. Mali has a total hydro-electric potentıal of about 1,150 MW must of this potential can be harnessed along the river Niger and Senegal [9].

Mali has about eight (8) potential geothermal spots within its borders one of which has the potential to produce 91-100mW/m^2. The rest of the locations have a potential to produces between 31-60mW/m^2[11], as seen in figure 3.

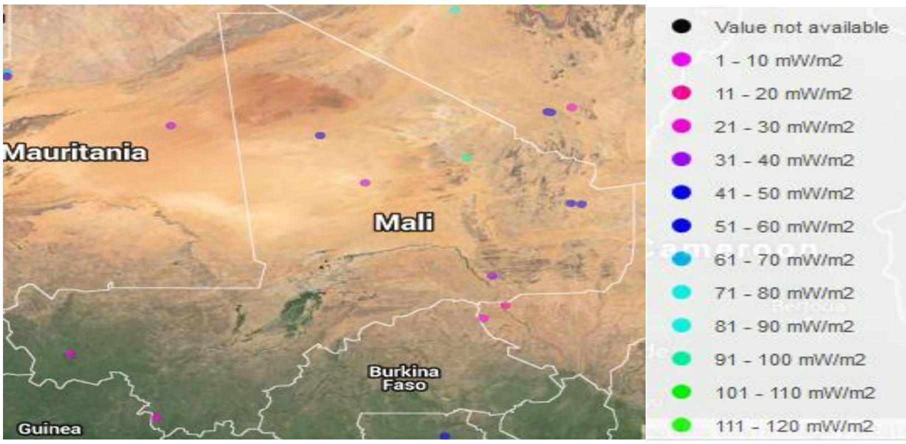

Fig. 3. Geothermal spots in Mali

About 60% of Mali's land is either desert or very dry. However, Mali still has abundant biomass about 33 million hectares with a standing volume of 520 million cubic metres of fuel wood, and a weighted productivity in the entire country of about 0.86 cubic metres/ha/year, several million tonnes of agricultural residue and plant waste and about 2,000 hectares of Jatropha plantations for sustainable bio-fuel production [16].

2.4 Senegal's Renewable Potential

Senegal is a fairly sunny country and has an average solar horizontal irradiation range between 2075 kWh/m2 and 2200 kWh/m2. The northern region of a Senegal has a mean global solar radiation of 5.8kW/m2/day and to a lesser extent the southern region of the country mean global solar radiation as 403kW/m2/day [17].

Senegal has poor potential for wind energy because of very low wind speed and constant sudden oscillations in peak making it very unpredictable [17]. However, there have been very impressive wind speeds in certain regions in Senegal. Where the least mean speeds at 20 meter height was 4.10m/s and could get as high as 4.36m/s at 12 meter height [18].

The total potential for large hydropower in Senegal is estimated to be approximately 1 400 MW on the Senegal and Gambia Rivers. Senegal no known potential for small hydro [9].

Senegal has about twenty (20) potential geothermal spots within its borders many of which have the potential to produce 51-60mW/m^2. The rest of the locations have a potential to produces between 31-60mW/m^2[11], as seen in figure 4.

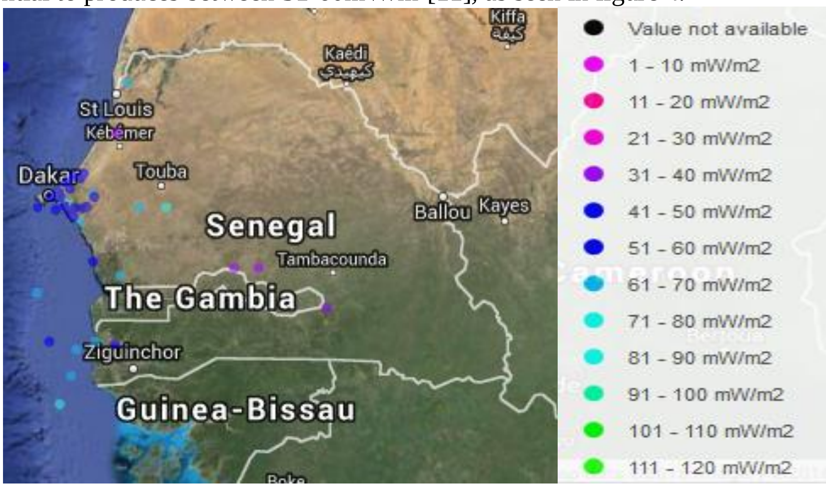

Fig. 4. Geothermal spots in Senegal

3 RENEWABLE ENEGY POLICIES

ECOWAS has developed a comprehensive action plan as regards the whole region. The ECOWAS Renewable Energy policy (EREP) outlines the cumulative objectives of all the ECOWAS states, which are; increase the share of renewable energy in the overall electricity mix, including large hydro, to 35% by 2020 and 48% by 2030. ECOWAS also intends for Member States to develop their National Renewable Energy Policy and Action Plan (NREP)

3.1 Renewable Energy policies in Nigeria

Nigeria has 3 major policies for renewable energy for electricity generation Nigeria Renewable Energy Master Plan (NREMP), Multi-Year Tariff Order (MYTO) and Nigeria Feed-on Tariff for Renewable Energy sourced electricity(RNSE).

NREMP has set installed capacity targets by 2025 to increase small-hydro by 1400MW; increase Solar PV to 500MW; Biomass-based power plants by 385MW and raise wind to 40MW. MTYO II assures that renewable energy provides assured fixed tariffs commensurate to market prices and RNSE orders distribution companies to purchase 50% of electricity from renewable sources

3.2 Renewable Energy policies in Ghana

Ghana has established 4 major renewable energy support policies Renewable Energy Services Programme (RESPRO), Renewable Energy Act 2011, Feed-in tariff for electricity generated from renewable energy sources, and Net Metering Code.

RESPRO is meant support rural electrification programme by providing solar home appliances to over 2000 households by providing solar streetlight, solar powered water pumps, refrigeration for clinics as well school lighting systems. Feed-in tariff for electricity generated from renewable energy establishes feed-in tariff rates for electricity generated from wind, solar, biomass, and small-hydro. Net metering code supports facility owners supply energy to the grid owners are credited for electricity the facility supplies to the grid, and this credit is set off against electricity purchased from the Distribution Utility. For only renewable energy generators with capacity up to 200 kW will be able to benefit from the net metering support. Renewable Energy Act 2011 provides for the development, management, utilisation, sustainability and adequate supply of renewable energy generation for heat and power.

3.3 Renewable Energy policies in Senegal

Senegal has established 2 major renewable energy support policies Renewable Energy. Renewable Energy Law and Program for the promotion of renewable energies, rural electrification and sustainable supply in domestic fuel (PERACOD)

PERACOD targets electricity grid expansion and increased electrification rates from 16% in 2007 to 60% by 2022. PERACOD supports small-scale and individual rural electrification initiatives by subsidizing up to 80% of initial investment, with a major focus on Solar Home Systems.

3.4 Renewable Energy policies in Mali

Mali has established 1 major renewable energy support policies which is the National Strategy for the Development of Renewable Energy

National Strategy for the Development of Renewable Energy main objective is to promote the widespread use of renewable energy technologies and equipment to increase the share of renewable energies in national electricity generation up to 10%. However, Mali unlike the rest of the studied ECOWAS states does not have a direct master plan.

4 CONCLUSION

Nigeria has huge Hydro, Wind, Biomass and solar potential and also has major policies to support growth of its potential. Nigeria is currently on track in terms of policies, directing its emphasis mostly on improving Hydro by 1400MW. However, more great emphasis should be but on wind energy in Nigeria. direct policy focus should be made to Hydro resources as it shows the most promise for Nigeria.

Ghana has good Wind, Biomass and solar potential but limited Hydro resource potential. Ghana policies also seem to be focused on its solar and wind potential which is only correct considering the have low Hydro potential. Nevertheless, Ghana would do well by increasing it focus on biomass energy.

Mali, like Ghana also have good Wind, Biomass and solar potentials but are also limited in their Hydro resource potential. However, Mali seem to be lacking in policies to directly improve this resource. It is important for Mali to join the rest of the ECOWAS countries to develop a Renewable Energy Master plan. I will be of great advantage to them to see to improve on their Wind, Solar and Biomass Energy as there is where they shoe the greatest potential.

Senegal has very good Solar and Wind resource potential but are infinitely limited in their Hydro potential. Senegal has good policies to improve rural electrification however policies to properly harness their enormous wind potential is lacking.

While no country amongst the ECOWAS countries considered have any policy to improve the utilisation of their geothermal resources, the study shows that Nıgeria and Senegal show the most promise in development of this resource.

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Predictive Analytics for Wind Farms – Project Experience with Intelligent IT Solutions for Optimization of Plant Efficiency and Availability

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ABSTRACT.

As a wind generator's performance is highly dependent on the current wind speed, inefficiencies are not always visible from SCADA data. Often component degradation or failure remain undetected and negatively affect electricity generation or plant availability. As maintenance is complex and costly due to the nacelle's altitude and the distance between wind park and operation center, reliable information at an early stage about component condition and performance would be very beneficial. To identify inefficiencies, derogation or impending defects, SCADA measurements should be continuously analyzed and compared with a theoretical calculated value that takes into account the current environmental conditions.

For thermal power plants numerous different IT tools are available, which are successfully used since many years to detect such situations. Their potential for use in the wind power sector have been investigated, tried and tested. It was found that statistical calculation methods for process performance monitoring and early damage-detection fit best to the requirements of the wind sector. These methods and their application to wind data will be demonstrated within this paper.

Keywords: Wind Power, Predictive Analytics, Optimization of Efficiency and Availability

1 BOUNDARY CONDITIONS OF THE POWER PLANT OPERATION

The objective of a continuous monitoring of the power plant operation is not just to improve the plant efficiency and the availability. At the same time, the maintenance costs are to be decreased, and the available human resources are to be deployed efficiently. To be able to derive this information, a very large amount of data from the operation of the plant is required for evaluation.

In thermal power generation plants, a large amount of analog and binary process data is usually available in the DCS (Distributed-Control-System). The cycle rates are often in the minute range, but also go down to one second. They are read out and transferred via interfaces to special applications at the level of technical operation management systems (Fig. 1).

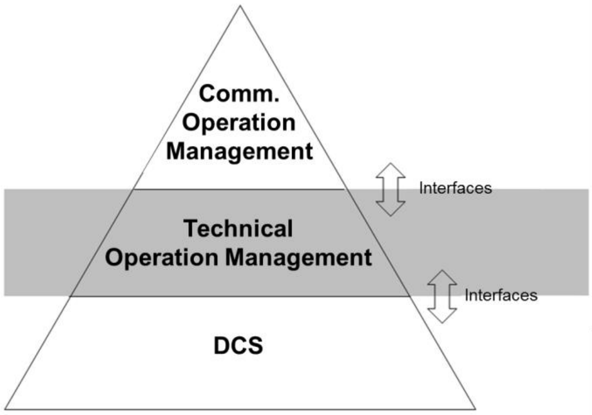

Fig. 1. Structure of the levels of the technical IT in thermal power plants

The processing is effected promptly, however, in contrast to the DCS, not necessarily real-time. The interfaces supplied by the manufacturer of the DCS usually follow international standards (e.g. OPC) and are non-reactive. Thus they decouple the data transfer both regarding the technical responsibility (which on the part of the DCS lies with the supplier and for the technical operation management systems with the operator) and regarding the "transfer of ownership" of the data which the operator assumes this way and autonomously stores as well as further processes without any retroactive effect on the DCS.

For wind energy plants, the situation is not that homogeneous. The range reaches from plants that provide very few analog measured values in cycle rates of mostly 10 minutes right up to (mostly newer) plants and SCADA systems respectively that provide two-digit numbers of analog values per wind energy plant with cycle rates of down to one second. Concerning messages, the scope depends on the respective manufacturer and plant type. The access privileges to the plant data have to be clarified with the supplier on a case-by-case basis.

Prerequisite for the procedures described in what follows is the provision of the required data. For plants that supply no or only a few data it may therefore be necessary to retrofit with an appropriate interface.

The data provided by the SCADA system of the wind farm are sufficient for many evaluations. Additional instrumentation e.g. with sensors of a vibration monitoring is only required for the procedures described below if these are to be systematically monitored and evaluated.

1.1 Structural Environment

The local, organizational, and IT-technical structures in the fields of thermal and wind energy generation plants diverge significantly. A thermal power plant is a confined space where both the operating staff and the IT technology are located. Owner, operator, and operation manager often belong to the same company or group.

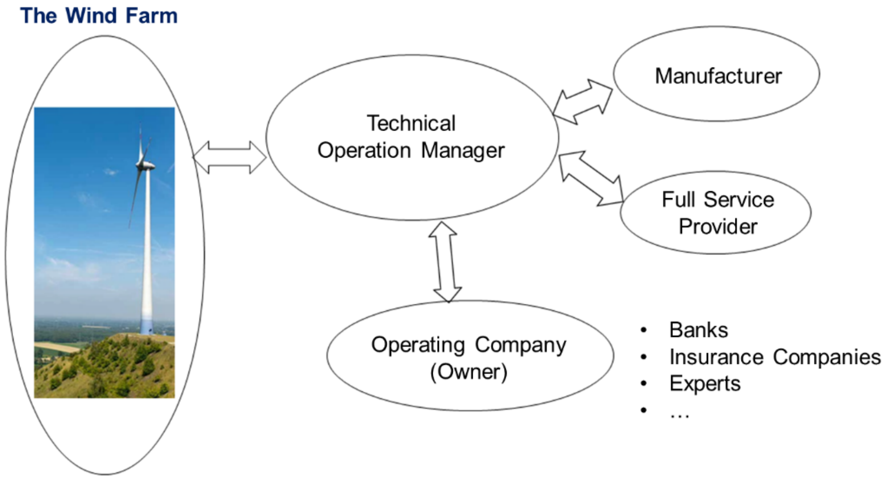

Fig. 2. Operating structures of a wind farm

The situation of operating wind farms is completely different: the wind energy plants and the "control room" are geographically distributed, the distribution in terms of companies and functions is dispersed, and the technology is heterogeneous. The operator of a wind farm often contracts the operation management out to a dedicated operation manager. The operation management of wind energy plants is usually effected from far away with only occasional on-site operations by staff. At the same time, full-service contracts for wind farms exist in many cases where the manufacturer (or a specialized full-service provider) ensures availabilities of the wind energy plants either in terms of time or energy. The task of the operation management is to coordinate these full-service contracts with the activities that concern the other parts of the wind farm.

Under the given boundary conditions, particularly in the case of availabilities ensured by contract, the question arises in which places the energy output can be further improved.

On the one hand, most of the full-service contracts refer to a guaranteed availability in terms of time. Underperformances in terms of energy are not covered here. Detecting these early on and increasing the efficiency is thus a priority for the operator and operation manager respectively.

On the other hand, also the remaining non-availabilities of typically 2 up to 3 percent as well as the times excluded from the availability calculation in the contract represent a potential for improvement. In this context it is important that maintenance-relevant information is reported and used efficiently in time and regardless of subjective valuations in order to systematically increase the availability with little human resources.

1.2 Improving the Efficiency

Prerequisite for improving the efficiency is to promptly know the current active power of the energy generation plant and to identify sources of possible losses. Based on such an analysis, deviations from a reference mode of operation are detected promptly, and appropriate measures are assessed regarding their economic efficiency (lost generation). The execution of such an analysis only using the operating data provided in the SCADA system, however, is made difficult in daily operations due to the vast amount of data. Deriving the important key figures for the process and the main components is not continuously possible without the support by appropriate IT systems. Only by means of an automated data analysis can the flood of data be condensed into information on the condition of the process and the plant, and the operation management staff be supported in fulfilling their tasks.

1.3 Reducing Downtimes

Maintenance is another effective parameter for optimizing the value chain. An optimization at that point, however, must consider the plant availability to be achieved and the costs of unplanned shutdowns. Therefore an increasingly important task will be to intelligently combine reactive, preventive, and condition-based maintenance for minimizing the overall costs. Here the significance of condition-based maintenance is going to increase. This assumes that changes in the condition of a component are detected early on and reliably. A quantitative analysis of the trend is then the basis for selecting the appropriate measure and determining the optimal time for executing it in terms of costs. This task, too, cannot be carried out continuously in daily operations without the support by suitable IT systems. Only by means of specialized IT tools can all the main components be continuously assessed efficiently and only on the basis of the operating data of the SCADA system. This applies even more as due to the varying ambient conditions the change of an individual measured value does not necessarily indicate changes in the plant condition. Thus mostly the actual component condition can only be derived from the interaction of several measured values.

1.4 Utilizing Resources Efficiently

A number of experienced staff members have developed a “procedural feeling“ for such coherences. Based on their occupation they know which combinations of measured values are normal and which ones are unusual. These skills, however, are not evenly distributed among all experts. Moreover, in times of demographic change and at the same time decreasing human resources there is the risk that when such knowledge carriers leave the company, the valuable know-how will get lost and often can only be restored in the medium term. Here, too, the practical knowledge can be quantified by using IT tools for data analysis. This way the "best practice" will be fixed in an IT system, independent of the experience of individuals. Then it can be further developed in a continuous improvement process, not just site-related but company-wide.

Regardless of whether the necessity for optimizing the value chain in energy generation is considered in terms of improving the efficiency, of condition-based maintenance, or of the efficient deployment of human resources: in each case the use of IT systems for continuous data analysis is essential for condensing the complexity of the data into information on the basis of which efficient work is possible.

2 METHODS OF DATA ANALYSIS FOR PROCESS QUALITY MONITORING AND THE EARLY DETECION OF DAMAGES

The analysis of the requirements for optimizing the value chain shows that the data analysis of in-service measurements has to cover various ranges of tasks. An essential goal is to identify the quality of processes or the condition of components early and reliably. For this, normalized key figures have to be defined that depend only on the condition, but not on the current operating and ambient conditions.

A good example of this is the monitoring of the active power of a generator for assessing the current plant performance. The active power is not directly suitable as a key figure for monitoring the plant performance as it strongly depends on external influencing variables (Fig. 3a) like e.g. speed and direction of the wind as well as air pressure and temperature. An operation-related reference value has to be consulted in order to enable a continuous monitoring and assessment of the active power in spite of this at all times. This reference value is not a constant but depends on the influencing variables mentioned above. As the corresponding manufacturer information on such a reference value is often unavailable or does not consider all relevant influencing variables sufficiently accurately or for the entire, actually occurring value range, it has to be determined by means of suitable models. Such a reference value specifies the active power to be expected under the current operating conditions at a good plant condition (Fig. 3b). A deviation between the measured actual value (blue) and a reference value determined for the current boundary conditions (orange) can now be used as a measure for performance. In a next step, this so-called key performance indicator (KPI, Fig. 3c) can be monitored reliably – i.e. with a low proneness to false alarms – for critical changes by means of statistical methods (Fig. 3d). A similar situation exists regarding almost all key variables of the wind energy plants, from the described example of the active power of a generator via oil or bearing temperatures right up to the bearing vibration.

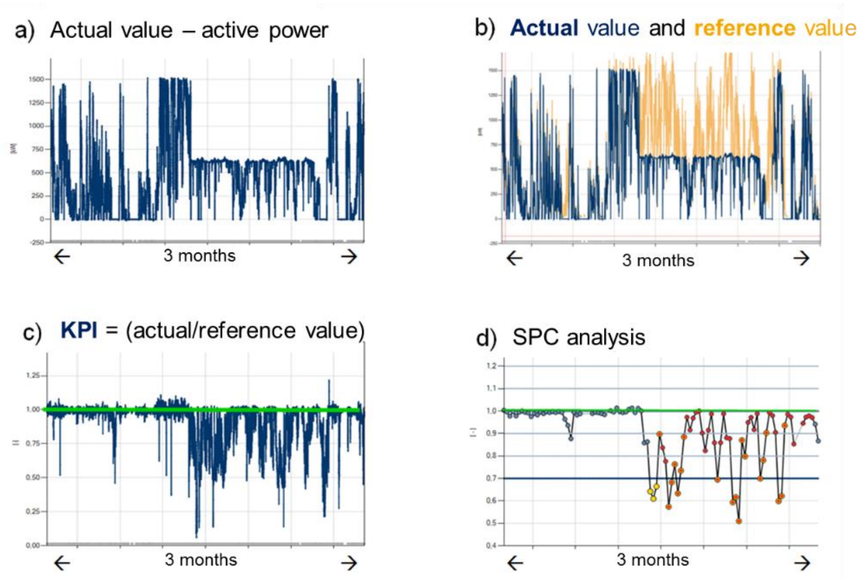

Fig. 3. Detection of critical process changes by analyzing existing operating data

Determination of Reference Values

Thus an IT system for the continuous analysis of operating data must contain a tool by means of which the reference value for important process variables can be determined depending on the current operating situation.

Other than in the conventional process quality monitoring of thermal power plants, however, typical measured quantities of wind energy plants are not subject to the modelling with physical basic equations that can be carried out e.g. by means of appropriate thermodynamic cycle calculation programs (Fig. 4a).

Therefore a system for the condition and process quality monitoring of wind energy plants has to work with models that can preferably be derived directly from the measured plant data. Data-based models on the basis of e.g. neural networks or similar models can be applied for this (Fig. 4b). The advantage of data-based models is that they can also be created without detailed knowledge about the internal physical coherences and can thus be put to versatile uses.

For creating the model, historical data records are "learned" e.g. by an artificial neural network over a defined time range. Here it is crucial that the selected data records show the behavior of the unaffected component and that they contain the target variable (e.g. the vibration amplitude of a bearing) as well as all important influencing variables (e.g. rotation speed and bearing temperature). The trained network can then be systematically accessed to provide a reference value in line with the current mode of operation (Fig. 4c). The reference value thus retrieved corresponds to the historical value of the unaffected component.

The data-based modelling with neural networks thus allows to reconstruct the reference value in line with the current mode of operation from historical data. The procedure has long been tried and tested and provides reliable results for all operating conditions that occurred during the learning phase. New operating conditions can be learned subsequently as required without great effort.

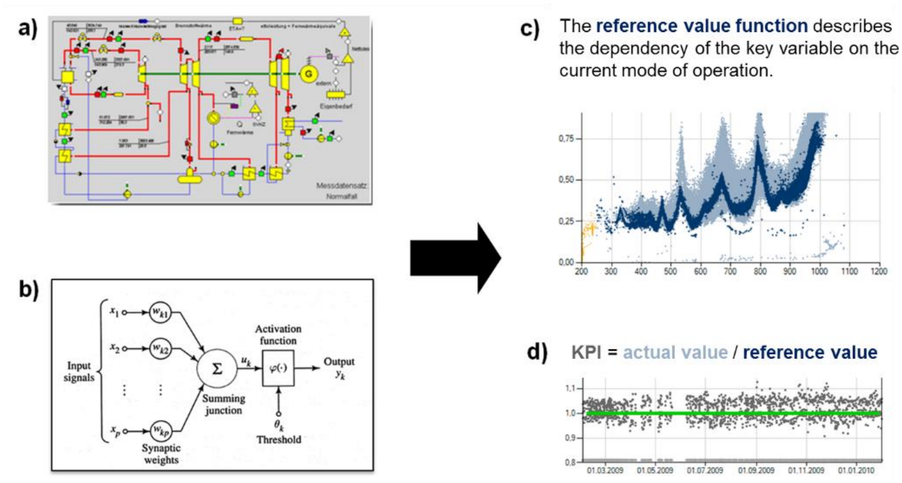

Fig. 4. Physical (a) and data-based (b) models for determining the reference value function (c), KPI noise among other things due to measurement uncertainties and model errors (d)

2.1 "Key Performance" Indicators

In the process quality and condition monitoring of wind energy plants, data-based models on the basis of neural networks provide the reference values of key variables that can be compared to the current value. As key performance indicator (KPI), the deviation is then suitable for assessing the process or a component as it only depends on the process quality and the condition of the monitored component respectively and is no longer superimposed by external influencing variables. As in a continuous (online) monitoring of the wind energy plant the KPIs have to be derived from operating data, they are, however, subject to a certain extent of fluctuations due to the measurement uncertainty. In practical application, smaller model imprecisions, just like transient processes, lead to further fluctuations of the KPIs (Fig. 4d). In spite of this, it is necessary to detect significant changes in the condition automatedly as early as possible in order to relieve the expert staff from regularly analyzing the KPIs manually. On the other hand, the acceptance of the system will suffer if changes are signaled due to such fluctuations without an actual cause to be substantiated in the component or in the process.

2.2 Statistical Data Analysis

The third component of an advanced system for the continuous process quality monitoring and early detection of damages from in-service measurements therefore consists in methods that analyze the behavior of the condition online and automatedly.

Such a tool has to reproduce the engineering work of analyzing time series and – similar to the experienced engineer looking at a measured value chronology, but automatically – detect significant trends and patterns or sudden leaps in the monitored key figure.

With statistical process control (SPC), such a tool is available. The chronological sequence of KPIs can be evaluated online by means of SPC. So-called control charts are an important element of statistical process control and have been in use as tools for quality assurance in manufacturing for many years. Control charts are diagrams that illustrate the chronological sequence of characteristic process parameters/KPIs.

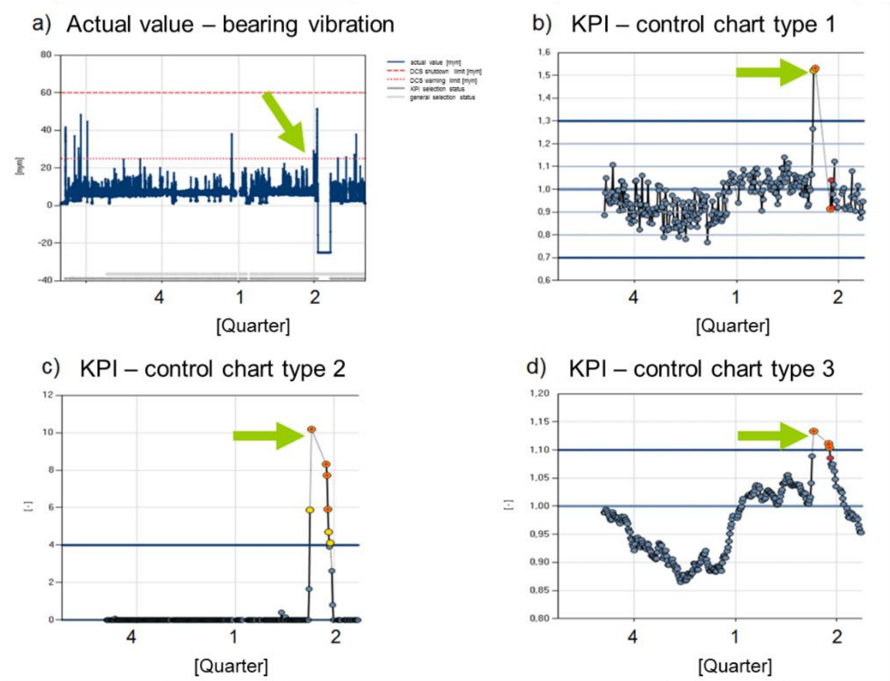

Fig. 5. Actual value (a) of a bearing vibration, various SPC analyses of the corresponding KPI (b-d)

Fig. 5 shows various control chart types. In diagram a) the monitored actual value (blue) and, in addition, two constant limit values (red) are recorded. It becomes clear that a direct monitoring of the measured value with constant limit values is unrewarding as the strong fluctuations due to the operation either lead to multiple false alarms, or no alarms will be triggered at all. Thus in diagram b) no longer the original actual value is monitored, but the corresponding normalized KPI is assessed by means of SPC. If the value of the KPI is within the limits (dark blue) and shows no statistically significant distribution patterns (like e.g. many values in the upper third, increased scatter, frozen measured value, etc.), then it is blue; otherwise it is shown in red. The lower diagrams c) and d) show the results of further statistical analyses. Also for these analyses applies: if the value of the analysis is below the displayed limit values, the process and component respectively is unsuspicious; if it is above, this will be classified as a significant change. Usually in the case of online systems an action will only be triggered if various analyses show abnormalities simultaneously. This point in time is marked by a green arrow in the diagrams.

The SPC procedure is particularly suitable for the automatic monitoring of the KPIs owing to its high sensitivity and, at the same time, low proneness to false alarms. The continuous monitoring of the KPI behaviors by means of SPC significantly contributes to the timely detection of impending damages or problems. "Overlooking" critical changes can be largely ruled out when the system autonomously notifies the respective experts by e-mail in the event of detected abnormalities.

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3 USING THE DATA ANALYSIS AT THE WIND FARM

With wind energy plants increasing more and more in size, the mechanical requirements and loads and thus the failure probability of wind energy plants are rising. Thus the optimization of the technical operation management and condition-based maintenance is increasingly gaining in importance.

The current operating condition of individual components of a wind energy plant can be recorded metrologically. These measured values are condensed online into standardized key figures. The mode of operation of the plant and the component condition are assessed quantitatively and objectively. This way, transparency is gained, which facilitates a continuous improvement process and provides an additional benefit for a predictive projection of the condition.

The illustrations of the three examples of application shown below have a virtually identical structure. They were calculated subsequently on the basis of historical data. Firstly, in each case a characteristic measured value (dark blue) of the considered component or the process is shown in a diagram, top left, which strongly correlates with the component condition. The diagram also contains a statement on the represented measured quantity and the monitoring period. Next to it, the results of individual SPC methods are listed. If the value of the KPI is within the limits (light blue) and does not show any statistically significant distribution patterns, it is dark blue, otherwise it is shown in red. A green arrow marks the time of the alarming.

The following examples show the application of data-based models – neural networks were used for determining the KPIs in this specific case – for assessing the condition.

3.1 Condition Monitoring Using the Example of a Main Bearing Temperature

The first example shows the monitoring of the main bearing temperature of a wind energy plant over a period of several years (January 2011 – July 2013). The trend graph of the main bearing temperature allows to detect both the load dependence and a seasonal effect (Fig. 6, l, top). A change in the process is hard to detect only by observing the behavior of the main bearing temperature. The SPC recalculation detects that the behavior of the main bearing temperature has noticeably changed after the half-yearly maintenance (end of May 2013).

Thus immediately after a maintenance activity, the system provides important details on whether measures like e.g. alignment work on the power train have had a positive or also negative effect on the performance of a plant.

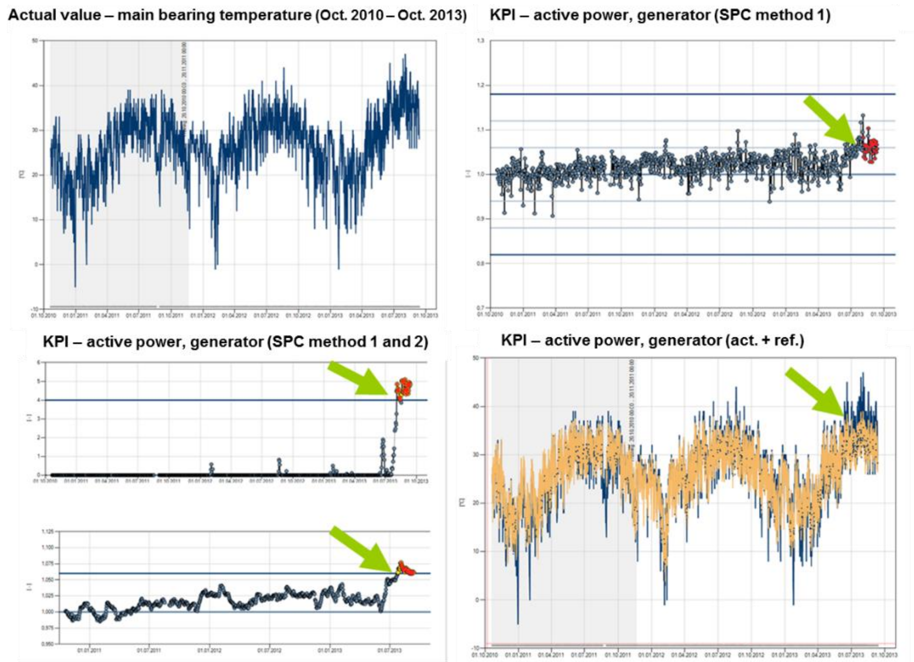

Fig. 6. Main bearing temperature – increase after half-yearly maintenance

3.2 Condition Monitoring Using the Example of a Gear Bearing Temperature

Fig. 7 shows the successful application of SPC using the example of a gear bearing temperature. Due to increasing wear of the force fit surfaces in bearings and decreasing lubrication qualities, the gear bearing temperature continuously increased over a longer period of time (Fig. 7, l, top). Warning limits and shutdown limits are stored in the controller of the wind energy plant for the monitoring of the individual bearing temperatures. A violation of the shutdown limit leads to unplanned shutdowns (controller-operated shutdowns) and thus to undesired losses of generation.

The wind energy plant was kept in operation until the planned half-yearly maintenance (end of May 2013). However, the gear bearing temperature violated the shutdown limit (100°C) prior to the half-yearly maintenance, which led to downtimes. The SPC recalculation detects the increase in the gear bearing temperature early on and indicates it (see arrow) as early as many months before the shutdown is triggered. In addition, during this time it is possible to use a trend projection to determine the so-called critical remaining time in which the component can still be operated without failure. The SPC trend module predicts – at a constant increase – a violation of the limit value for February 16, 2013 (Fig. 7, bottom right). This information supports the timely scheduling of the required maintenance measures.

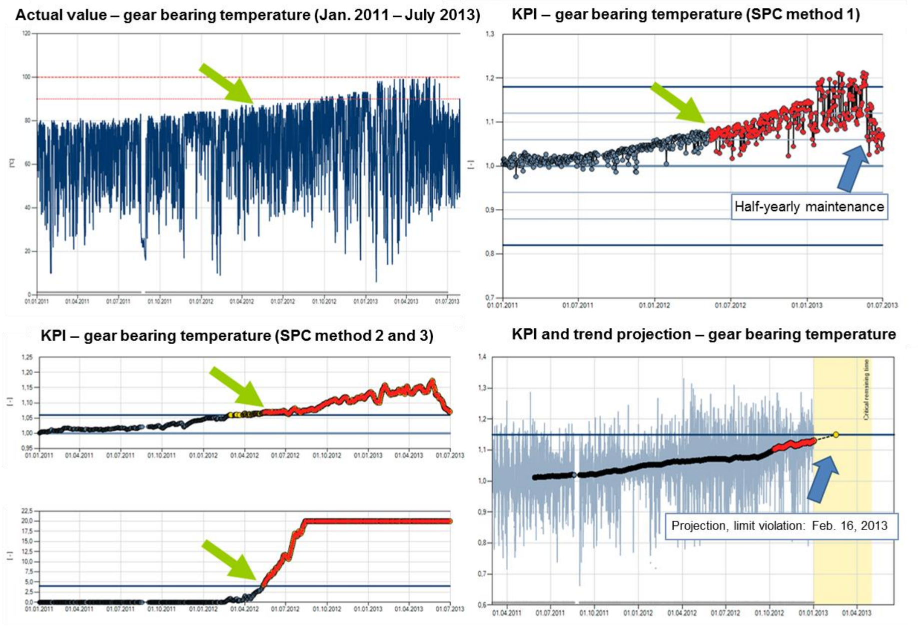

Fig. 7. Gear bearing temperature – long-term trend

3.3 Condition Monitoring Using the Example of Performance Monitoring

The monitoring of the active power of the generator is an important topic due to the necessity to estimate the energy output. The next example shows how the performance characteristics of the wind energy plant is monitored by means of SPC in order to detect deviations from the regular behavior. It illustrates a throttling procedure initiated after a bearing damage. The generator output was throttled to 600 kW over a period of six weeks. Subsequently, the bearing was replaced on days with little wind. In this case, SPC detects the throttling of the plant immediately and generates a message. Furthermore, the calculated reference value describes the possible performance behavior (Fig. 8 and l, orange). This behavior of the reference value is used for calculating the lost generation. For the throttling procedure illustrated below, a cumulated lost generation of ca. 500 MWh was calculated.

On the one hand, the procedure provides an early alarm in the event of reduced generation, and on the other hand – if the cause cannot be remedied in the short term – it allows to calculate the reduced generation. In doing so, only operating signals of the wind energy plant itself are used for the calculation. It is not necessary to draw on generation data of adjacent machines or comparison figures across the country.

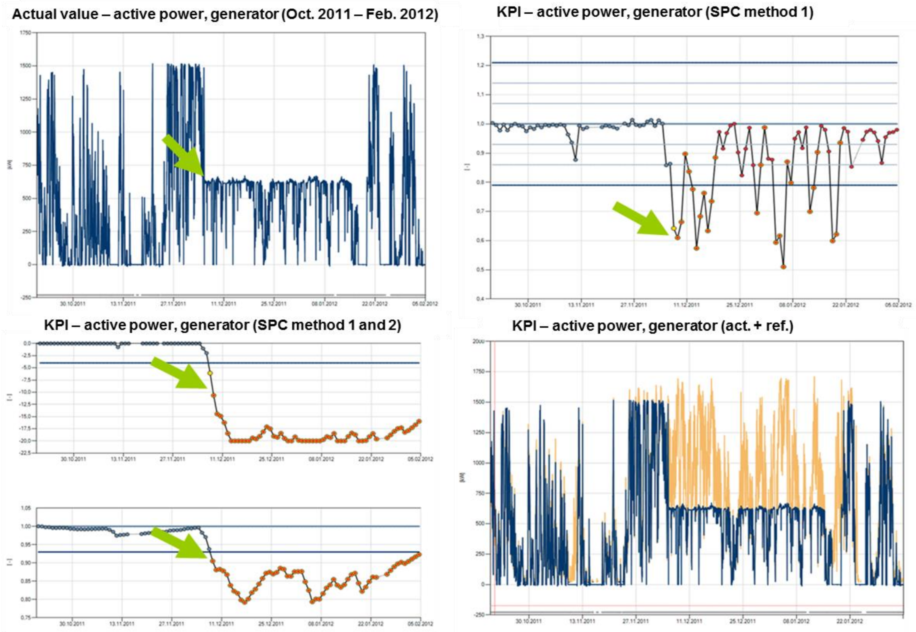

Fig. 8. Active power of a generator – throttling the active power to 600 kW

4 USING THE DATA ANALYSIS AT THE WIND FARM

Advanced systems for the continuous process quality monitoring and early detection of damages calculate key performance indicators for the condition of the process or of individual components from the comparison of in-service measurements with reference values for the "good" plant condition that result from a data-based modelling. The additional application of statistical procedures allows to evaluate the time series of the KPIs automatedly and to detect changes early and reliably. Here the flood of data from modern SCADA systems is condensed into information without burdening the operating staff with extensive evaluations. The examples have shown that this generates operational benefit owing to an increased transparency of the plant operation, support of condition-based maintenance, and the protection of know-how in times of demographic change.

The systems available today indicate early, reliably, and partly automated that significant changes in the condition of a component or of the process have taken place.

When such a change has been detected and indicated, mostly a first analysis of the causes can take place by way of a detailed analysis of the key figures. In many cases a final analysis of the cause by an experienced authorized person will still be required, possibly on site.

The SPC procedure thus promptly provides valuable condition-based data that exert a significant influence on the plant operation and help to systematically schedule and determine inspections and maintenance. If the causes cannot be remedied in the short term, SPC individually calculates the resulting reductions in generation for the affected wind energy plant. In negotiations with manufacturers and service providers concerning required maintenance measures, this information provides the basis for prioritizing those tasks with the greatest economic effects. In any case an SPC-based process quality monitoring supports the operation managers in increasing the plant efficiency of each individual wind energy plant and thus improving the profitability of the wind farm.