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# Planet Earth Capacity Factor AND New Look Criteria _ A

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*Abstract*— The paper presents the study, Erturan, Cekirge and Thorsen [1], that is introducing facts and capacity of continuously changing and evolving situation in the environment. In this paper [1], it is presented facts and indicators of the Planet Earth capacity factor considering questions of existing human activities' safety and sustainability. These questions can be extended for advancing and developing our home planet without encountering a dilemma and future generations and civilization developments' sufferings because of our movements. In order to get positive answers to these questions, we definitely need to improve our technological skills. It might be an appropriate explanation to understand our current timeline. As the 2020 COVID-19 pandemic demonstrates, nature can quickly become a formidable foe—particularly if humans are caught unprepared. Although Earth's ideal conditions have provided humans with a perfect environment to thrive socially and economically, her natural resources are not limitless and her natural balances are delicate. It is critical to begin developing solar technology to meet the human race's energy needs. The human race currently meets its energy needs mainly through fossil fuels. But not only are fossil fuel reserves limited but also excessive reliance on fossil fuels can cause long-term environmental damage. On the other hand, solar energy is bountiful, free and clean. As such, solar energy is a great alternative source of energy that will ensure that future generations enjoy a hospitable planet and healthy and economically stable living conditions. Planet Earth supports our current lifestyles, but there are obvious indications of unusual changes in her cycles. Only recently have we begun to consider plans regarding Earth's capacity; historically, we have mostly considered local environmental factors. Unfortunately, the time for only thinking of local factors has passed – we must consider the planet's capacity for continued human survival in order to create a sustainable lifestyle. As humans, we believe that we live in some sort of "infinite time spiral" – that is, we believe that the human race will live forever – but this is simply illusionary cortical brain activity. The mitigation measures are also presented by [1].

*Keywords—CSP, Solar Desalination, TES, Thermal Energy Storage, SiC, DSG*

## I. FACTS AND INDICATIONS

The questions such as; "Are the current human activities being safe and sustainable?"; "Are the next generations will not suffer because of our civilization developments acts?" and "Can we progress and develop in our home planet without facing the dilemma?" The current Earth's commercial activity developments require a new act policy. Developing awareness will start asking the proper questions, learning and not to be afraid from facts however, planet Earth that we living on is supporting and caring our lifestyle but there are obvious indications to unusual changes in her cycle. Until today we have hardly considered in our act plans to put into planet Earth capacity factor, it is mostly considered local environmental factors. As a human nature we think that we live in infinitive time spiral, but this is only illusionary cortical brain activity. Here, the facts will be considered to explain how we come to this critical and dynamic effect point and what may be faced in the future. Incising human population and consuming habit requires knowledge to manage our new age civilization requirements. It is needed to change our habits and to keep our technologies effective and sustainable to an unknown destiny. "Facts and Indications" are against our civilization sustainable development ability. The following question to shape a reality modeling must be asked: Are the existing human civilization technologies models flexible? If a simplification answer is depending decision maker's corollary benefits. Then; "Are the current lifestyle and commercial developments sustainable and extensible for the future generations?"

The existing human civilization models and outputs within the dynamic effect reality are needed to be diagnosed. Furthermore, the following question must be answered: "Whether the current lifestyle and business developments are sustainable!" This study paper is about where is the critical line stands and to acting responsively and collectively to new models. Facts forcing mother Earth to revise her cycle into destructive period. Having hopes for the future depends on breaking the old walls and involved in the new age sustainable styles, time to start to look new criteria. Indications and facts which planet Earth is facing are listed. From all over the planet many scientific studies have already published. The listed indications and facts are real and calculated by many reliable scientists. Controversial discussions will continue and the issue is not "who is right or wrong" and the interest is to show you the dynamic indications and facts' effects, and use all symptoms to create extensive integrated cover to the awareness of our planet Earth. When the mathematical algorithm is determining the facts under the dynamic inputs to planet Earth, the indications are increasing and getting complicated.

**Facts:** Carbon Fuels Use and Extreme Foot Print, Changing the Planet Earth Surface, Polluting the Oceans, Polluting the Soil, Mass agricultural and Livestock Activities, Increasing Human Population

**Indications:** Extreme Climatic Weather Conditions, Changes in Magnetic Fields, Changes of the World Axis, Extinctions of the Species, Atmospheric Abnormal, Ocean Currents Abnormal.

The work of valuable scientists' indications and facts data are not at for the sustainable future. We definitely need to stretch our technological abilities accordingly. It may be an appropriate explanation for understanding our current timeline. "If a cup is fully full then even one drops a water will spill over the cup, so it does not matter how big is the cup or how tiny is the drop." We don't own the planet Earth has been here over 4.3 billion years and she will be here after us. If we want to continue our civilization and plan to universal journeys, we must respect the planet Earth and start to prepare new look criteria for a sustainable future.

## II. SEARCHING AND DEVELOPING NEW LOOK CRITERIA

Proposed design configuration next-gen CSP tower systems are the combined Brayton Cycle + Rankine Cycle + TES + Thermal Water Desalination systems integration. Kreith and Goswami [2], Boerema et al. [3], Law et al.[4] and [4]. Our teams build and operated Greenway CSP tower plant, NREL-GREENWAY [5] and all the relevant data is from Greenway CSP tower plant. The field capacity 5 MWt. System layout DSG (direct steam generator), 10 MWt/h single tank sensible TES, 1 MWe steam turbine, 510 Intelligent wireless heliostats. Greenway CSP plant had operated 8 years. The smart plant operation system developed and tested during that time. The plant operating control system philosophy on real time data sharing based and interactive operating software is synchronized within dynamic solar energy input configurations.

One off the most efficient and multipurpose solar energy field is CSP tower systems. CSP tower with thermal energy storage design has the ability to use the super steam in any industrial applications. Such as; baseload electrical plants, hybrids to any carbon base energy plant, thermal water desalination and most practically anywhere steam form used. We will share our real time CSP tower experience to explore to highly efficient combined cycle system configurations. Acceptance and attentions will occur within low LCOE. Our current studies show that, we are able to produce steam cost 0.002 US $/kWh.

Commonly, steam turbines (Rankine Cycle), are used for electricity production in the Concentrated Solar Power (CSP) plant therefore efficiencies are limited. Electricity generation will be done with both gas turbine and steam turbine through this uniquely designed CSP-Tower plant. Combination in the gas turbine (Brayton Cycle) and steam turbine (Rankine Cycle) will increase field efficiency. Also, when the sun does not shine, the thermal energy storage system provides steam to the turbine to produce electricity. If two CSP-Tower plants, that are having the same number of heliostat and location are compared in terms of efficiency and electricity production, it is seen that this unique facility reaches the target cost. Another significant point is reduction of carbon emission for the design of CSP-Tower facility. In gas turbines, the air from the compressor is directly burned. However, air came from the compressor is heated in SiC (silicon carbide) air cavity receiver to higher temperature and taken to the combustion chamber in this design facility. In this way, it is possible to heat air with reduced consumption of natural gas. Thus, the gas turbine system consumes minimum fuel just to balance system and releases lower greenhouse gases. Concentrated solar energy technology is developing rapidly. However, in order to be expand this technology in electricity generation, it is necessary to develop high efficiency and low-cost systems. The purpose of this study is to demonstrate the reduction of the price below 5 US ¢/kWhe. It is also very important to present novel ideas while reaching the targeted cost. There are critical success factors for the target. One of the most critical success factors is the development of systems which are available and compatible with the grid system. These requirements will be achieved through the integration of energy storage systems. In the paper, it will be presented that the implementation of the design of the thermal energy storage for increasing availability in the concentrated solar energy systems. Therefore, existing uncertainties preventing the implementation of these systems in a large scale will be overcome. The pilot application will be developed that concentrated solar power system based on direct steam generation will be supported by innovative thermal energy storage system. This paper's aims will be at an example for commercial applications. Another critical success factor is high efficiency of CSP plants. In conventional CSP technologies, limited efficiencies are achieved with a single turbine cycle. This causes low efficiency in CSP plants. Within the scope of the paper, it is aimed to increase the efficiency by using both gas turbine and steam turbine cycles. When the success factors are discussed for the targeted price, it will ensure that future designs by the experts in the field will utilize combined steam turbine and gas turbine cycles. Both thermal energy storage and higher efficiency will help to achieve the paper's goals, an acceptable cost and efficiency. Thermal desalination is superior to this and other methods of desalination for a number of reason, first, unlike these plants that burn fossil fuels and other un-renewable energy sources to run the plant, a thermal desalination plant runs entirely on solar energy and the steam that it generates during the desalination process, Further, a thermal desalination plant can operate and produce water far more cheaply than the current technology. Thus, a thermal desalination plant provides the environmental benefit of a reduced the carbon footprint, lessens the United States' dependence on foreign fossil fuels, and provides water to the American public at lower costs.

Widespread commercialization of the thermal desalination process also addresses a critical, life-and-death issue namely, the scarcity of fresh water in various parts of the country. Indeed, the growth of the U.S. population, coupled with lengthy droughts, has created significant fresh water shortages in certain states. These shortages have not storage. The fresh water that is output of the desalination unit will be for public utilization. The brine (excessively salty water) that is output of the desalination unit will be processed for to obtain precious minerals with Zero Liquid Discharge (ZLD) technologies and the goal to cost is with less
than 1 $/m^3$.

It is evident that future energy sources will be renewable systems and especially CSP tower design for central generation of electric power. The production cost of this energy is the essential to utilization and expansion of the CSP as a dependable energy source. In addition, reduction of carbon emissions will have a positive environmental impact while addressing the unrelenting need for electric power and thermal desalination.

## III. TECHNICAL DESCRIPTION, DESIGN, INNOVATION, AND IMPACT

### *A. System description*

• Heated air through SIC air cavity tube receiver to 715 ºC and 13 bar will be sent to the First Turbine (Brayton Cycle).
• To higher efficiency and balancing the system conditions some limited natural gas may be in complimentary use.
• Hot air (545 ºC) from output of the turbine (Brayton Cycle) will be the source to heat exchanger to steam production. Steam from output of the heat exchanger will be supplied to the single tank sensible Thermal Energy Storage (TES) for its charging and Second Turbine (Rankine Cycle) for to generate electricity.
• While charging Thermal Energy Storage, required steam for steam turbine (Rankine Cycle) will be running the turbine for to generate electricity.
• During the peak hour extra heat will be used to charge the TES
• Thus, when the sun shines, electricity production will be done together with First Turbine (Brayton Cycle) and Second Turbine (Rankine Cycle), and also the thermal storage system will be charged.
• When the sun does not shine, the thermal storage system will discharge and only the Second Turbine (Rankine Cycle) will produce electricity. While TES charging the Rankine Cycle efficiency will be limited with in turbine capacity.
•Thermal desalination unit will be charged from steam turbine exhaust heat and necessary heat balance will be regulated from TES within the sprinkle steam reduction method.

• Thus, the total efficiency of the plant can reach for 65 %.

### *B. Heliostat Field*

• 1500 heliostats each heliostat 16m$^2$ total field 24,000 m$^2$. Average thermal capacity 10 MWth/h, Peak times capacity 12.8 MWth/h (annual hours 3000 MWth/h/y);
• Main achievement is heliostat production cost less than 100 USD/m2, including simple site assembly and erections designs including;
• Smart and independent heliostats system within wireless communications, autonomic calibrations; automated interactive heliostat field control management by using auxiliary software data transfer is within the wireless communication. (Auxiliary system configurations including; weather station system, motion control PCB, automated calibration system, cloud detection system, thermal cameras, and wireless communication system;
• The production hours and the power are calculated for the field designed using design data; and
• The seasonal average thermal energy production graph was created by taking into consideration the design data and seasonal working hours.

### *C. Air Cavity Receiver*

Although Silicon Carbide (SiC) ceramics have been considered for CSP receiver tubes by the CSP industry in the past, there is reluctance on the part of the commercial CSP industry, central layer of its product, using micron sized SiC fibers dispersed within a SiC matrix, Krenkel [7]. This composite layer surrounds an inner monolithic layer providing fluid containment and the state of being airtight and not brittle and exhibit a stress strain behavior similar to ductile metals, with a graceful failure mode when overloaded. Testing large SiC CMC components (Channel Boxes for Boiling Water Reactors as examples) have demonstrated an extraordinary tolerance to mechanical shock. Thermal shock testing TRIPLEX clad from 1000 ºC to room temperature has also demonstrated robust behavior. In addition, independent tests by the Karlsruhe Institute of Technology in Germany demonstrated robust performance under thermal shock from 2000 ºC to room temperature. With high temperature, high solar radiation emissivity and light design, the receiver will ensure that the field reaches the desired yield.

### *D. Thermal Energy Storage (TES)*

TES, system the proposed paper's project will implement the design and pilot scale application of the thermal energy storage system to increase availability in the concentrated solar energy systems. One of the most important constraints in solar energy applications is that there are none available and compatible with the grid system. Therefore, existing uncertainties prevent the implementation of these systems on a large scale. The pilot application will be developed that concentrated solar power system based on direct steam generation will be supported by innovative thermal energy storage based on steam generation and this paper's project will be an example for commercial applications. Concentrated solar energy technology is developing rapidly; however, in order to be more used this technology in electricity generation, it has become necessary to develop high efficiency and low-cost systems. One of the most important features is the development of systems which are availability and compatibility to the grid system. It is possible only through integration of energy storage systems.

CSP tower energy systems can reach higher temperatures and increase total energy conversion significantly. In these systems, thermal energy storage has been made by the use of molten salt systems. Therefore, the stored CSP tower energy systems can reach higher temperatures and increase total energy conversion significantly. In sensory heat is transferred from the molten salt that is circulated between tower and the cold and hot tank to the primary flow through heat exchangers to produce steam. In this type of storage systems, there still remain serious problems in operation due to molten salt circulation.

The proposed paper's project is aimed at a facility that can be an alternative to these systems that are commercially operated but cannot be competitive in the electricity market due to the high cost of operation and investment. In addition to this, it is aimed to develop a novel and innovative design based on sensible heat storage and to perform the performance measurement with the facility to be installed in the real conditions. The proposed sensible single tank heat storage system consists of the combination of evaporator and two super heater units. Hot steam produced by super heaters 545 $^{o}$C. Low cost filling material will be used as heat storage medium because the evaporator can operate at 290 $^{o}$C a lower temperature. System is durable and no maintenance required. The desired pressured fluid comes to super heaters from steam drum. When the desired steam is obtained from evaporator section, the steam will be transferred to the super steam production storage with valve control mechanisms. Because of the high temperatures in this unit, molten salt and/or special fillers are used as heat storage medium. In the detailed engineering design work done, it is intended that both evaporator and hot steam storage units are suitable, efficient and low-cost operations to the conditions of steam turbine in CSP-tower field. This makes it easier for the operator who operates more economically and smoothly whole system. According to these features, a heat storage system based on high temperature and direct steam production will be designed. in addition, a storage system will be designed which does not currently exist commercially and cannot be found a similar example in the scientific literature. In this regard, concentrated solar energy technology also complies with the development of innovative industrial applications and the development of high temperature thermal storage system, Cekirge, Erturan, Thorsen et al. [8].

### *E. The Thermal Desalination System*

The desalination unit has been in the commercial market for decades; we will plug and run the system end of the Rankine cycle turbine as a condenser unit, Delyannis [9], Khawaji [10], Al-Shammiri and Safar [11], Warsinger [12] Crittenden et al. [13] and [14] and Cekirge, Erturan, Thorsen et al. [15]. A "Multi-Effect Plate Evaporator (MEP)" is considered, and the MEP desalination process consists of a series of evaporation and condensation chambers known as effects. Each effect is fitted with heat transfer, and in the plate channels of an effect, seawater on one side is heated up and partially evaporated to distillate vapor, which is used in the next effect; on the other side, the distillate vapor from the previous effect is condensed, giving up its latent heat, into pure distillate. By maintaining a partial pressure difference across the effects, the process is able to yield maximum efficiency from available low-grade thermal energy sources. The brine that is output from the desalination unit will be processed to obtain precious minerals with Zero Liquid Discharge (ZLD) technologies. The fresh water output from the desalination unit will be for public consumption and utilization. The fresh water output from the desalination unit will be for public consumption and utilization.

### *F. Feasibility*

Detailed feasibility studies were made for the proposed CSP facility within the scope of the paper's project. In particular, if the field is built in East Cost, the operation hours there will be over 3000 available solar hours per year. The number of heliostats to be used for the corresponding CSP field is 1500 heliostats when looking at the DNI data in the relevant area; and this will correspond to 24000 m$^2$. Also, the height of the tower is 50 m. In electricity generation, both gas turbine, steam turbine and thermal desalination unit will be used and the overall efficiency is aimed to be 65 % and 6 MWe will be generated; 4.5 MWe from the gas turbine and 1.5 MWe from the steam turbine. In addition, in addition, the storage of thermal energy will begin when the production of steam is peaking and electricity generation from the steam turbine will continue through thermal energy storage when the sun does not shine. When all these design data and perfect field design are taken into account, the scenario for reaching the target cost has been created.

## III. CONCLUSIONS

The impacts are:

1) High efficient and low-cost renewable power plant design.
2) Multipurpose combine cycle philosophy.
3) Old fashion proven low-cost TES design.
4) Reduction of the carbon emissions.
5) To achieve the highest efficiency rate in the simplicity.
6) The overall plant efficiency is aimed to be 65%.
7) The impact will be revolutionary.

The beneficial impacts of CSP technology cannot be underestimated. Currently, Earth's fossil fuel reserves are being depleted and burning fossil fuels poses environmental challenges. Considering the limits of the human population and its consumption habits requires management of the demands of a modern civilization. The existing habits of mankind are needed to change; and must keep our technologies effective and sustainable to navigate an unknown future. The next stage of human civilization must look for new ways to develop into a higher-tolerance species. We must teach our citizens how to live on this planet through a new age perspective. These requirements are a part of this new "Planet Earth User

Guide.” This user guide may help us understand the current situation of our planet and the forces leading Earth into a destructive cycle. Having hopes for the future depends on changing old habits and evolving into species that survives sustainably in the new age. This situation is now more critical and demonstrative if the 2020 COVID-19 pandemic is considered. Solar energy is free, bountiful and clean. Transitioning to solar energy will offer a clean alternative energy source, and it is the essential part of the "Planet Earth User Guide.”

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