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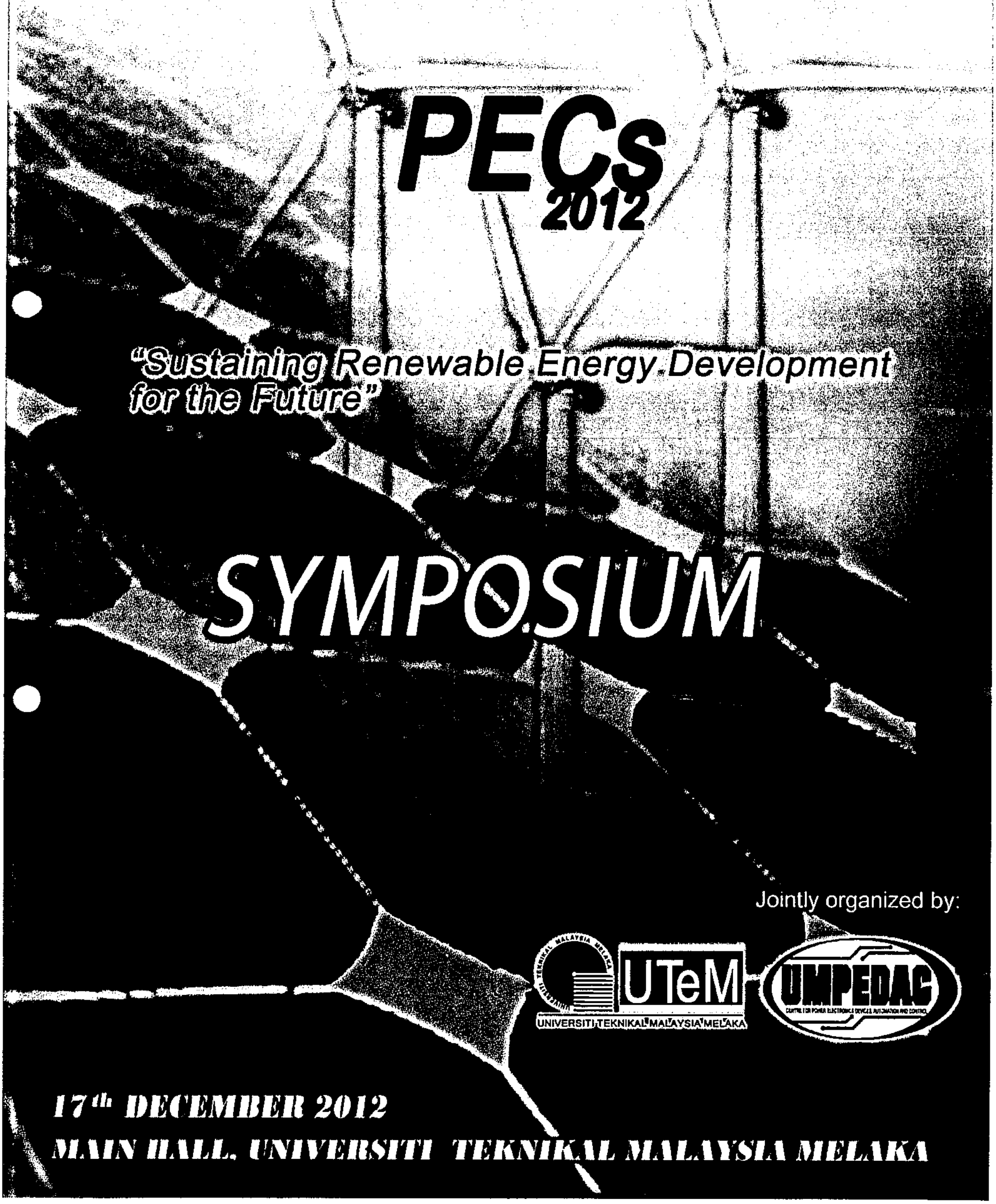

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CONCENTRATING SOLAR POWER (CSP) IN MALAYSIA ENVIRONMENT : A REVIEW

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Abstract - **Malaysia has abundant of solar energy with magnitude of approximately 4.21–5.56 kWhm^{-2} for average daily solar irradiations and the sunshine duration is more than 2,200 hours per year. However, until now Malaysia is only focusing on Photovoltaic (PV) panel to generate electricity, while harnessing solar energy by using Concentrating Solar power (CSP) has not been given adequate consideration by the government. This paper reviews the CSP technology and the potential of developing CSP plant in Malaysia environment by considering the Direct Normal Irradiance (DNI) and a few geographical aspects.**

Keywords – **Photovoltaic (PV); Concentrating Solar Power (CSP); Direct Normal Irradiance (DNI).**

V. INTRODUCTION

In the beginning of twenty first century, world is confronted with global climate change and increasing of oil prices. Across the world, protests and demonstrations have erupted against governments for the surge in fuel pump prices, which is also sparking general inflation in the price of food, electricity and other commodities.

Oil provides 40 to 43 percent of all energy used by the world. Oil and coal each account for 40 percent of global warming emissions from fossil fuels worldwide. According to the World Bank in 2008, Malaysia is a high energy user. Each Malaysian used 2,693kg of oil. In comparison, each Indonesian used only 870kg, Filipino 455kg and Chinese, 1,598kg and in terms of electricity use, each Malaysian used an average of 3,667kWh (kilowatt hours) in 2008 [1].

By looking at the scenario, Malaysia government has started a few initiatives to tackle the problem. In April 2009, the Ministry of Energy, Green Technology and Water was established in a cabinet reshuffle to replace the Ministry of Energy, Water and Communications and The National Green Technology Policy was launched by the Prime Minister of Malaysia in 24 July 2009, some of the objectives of the policy are to reduces the energy usage rate and at the same time increase economic growth, Facilitate the growth of the green technology industry and enhance its contribution to the national economy and Increase national capability and capacity for innovation in green technology development.

Concentrating Solar Power (CSP) is one of a green technology or Renewable energy technology that can become main source of electricity in future. The technologies are clean, reliable and environmentally friendly. Malaysia government should move a step forward to look into this technology and then consider CSP as one of the capable technology for generating electricity rather than solar PV, Biomass, Mini Hydro and Biogas.

VI. SOLAR ENERGY

Malaysia and many countries all over the world are now focusing more on green technology and the renewable energy. According to the 2011 projection by International Energy Agency, Renewable energy which is solar power generators may produce most of the world's electricity within 50 years, dramatically reducing the emissions of greenhouse gases that harm the environment. Of all sources of renewable energy, solar energy is by far the most abundant [2].

Under the Energy Entry Point Programmed [3], the target for Malaysia to build solar power capacity is up to 1.25 GW by 2020. Compared to Germany in the middle of 2012 the solar power capacities reach 20,000 MW or 20 GW and currently no other countries on earth producing solar power plants with a capacity like German.

Malaysia has abundant sunshine and solar radiation. On average, Malaysia receives about 6 hours of sunshine every day. The annual average daily solar irradiations for Malaysia have a magnitude of 4.21–5.56 kWhm^{-2}, and the sunshine duration is more than 2,200 hours per year [4] meaning that Malaysia has a rich supply of sunlight than German and should be aggressively tapping solar power.

It is estimated that the earth receives approximately 1000W/m^2 amount of solar irradiation in a day [5] and by harnessing the solar energy from eight different solar power plant sites throughout the world, the energy generated from these plants has the capability to supply more than enough electricity to satisfy the present global energy utilization [6]. These sites are located in the deserts in Southwest Asia, China, Australia, Southern South America, United States and Mexico.

There are two ways to extract electricity from solar radiation, which are Photovoltaic: The direct conversion of sunlight to electricity and CSP which uses heat to generate electricity. In contrast to photovoltaic, CSP technologies do not produce electricity directly through solar radiation, but use concentrated solar energy to indirectly generate heat and power.

CSP is a promising technology for power. No fossil fuel is used in this technology; therefore no greenhouse gases are emitted [7]. Important features of most solar thermal technologies are their capacity for bulk power generation and their viability in a wide range of plant sizes from a few kilowatts to several hundreds of megawatts [8].

V. CONCENTRATING SOLAR POWER (CSP) TECHNOLOGY

CSP is also referred to as concentrating solar thermal power, represents a powerful, clean, endless, and reliable source of energy. Concentrating solar power plants produce no Carbon Dioxide (CO_2), thus reducing carbon emissions from electricity generation by approximately 272.2 kg per megawatt-hour [9].

Four types of solar concentrators are in common use, parabolic trough, parabolic dishes, central receivers and Fresnel lenses. Linear concentrator systems collect the sun's energy using long rectangular, curved (U-shaped) mirrors. The mirrors are tilted toward the sun, focusing sunlight on tubes (or receivers) that run the length of the mirrors.

There are two major types of linear concentrator systems which are parabolic trough systems and linear Fresnel reflector systems.

A. Parabolic Trough Concentrator

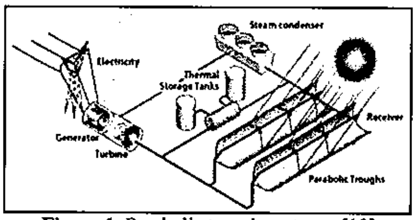

Figure 1. Parabolic trough systems. [10]

A parabolic trough concentrates incoming solar radiation onto a line running the length of the trough. A tube (receiver) carrying heat transfer fluid is placed along this line, absorbing concentrated solar radiation and heating the fluid inside. The trough must be tracked about one axis, because the surface area of the receiver tube is small compared to the trough capture area, temperatures up to 400°C can be reached without major heat loss.

B. Fresnel reflector systems

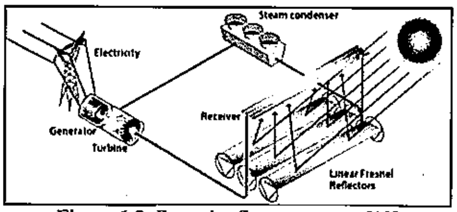

Figure 1.2. Fresnel reflector systems [10]

A Fresnel lens concentrator uses refraction rather than reflection to concentrate the solar energy incident on the lens surface to a point. Usually molded out of inexpensive plastic, these lenses are used in photovoltaic concentrators. Their use is not to increase the temperature but not enable the use of smaller, higher efficiency photovoltaic cells. As with parabolic dishes, point focus Fresnel lenses must track the sun about two axes [8].

C. Central Receiver Systems

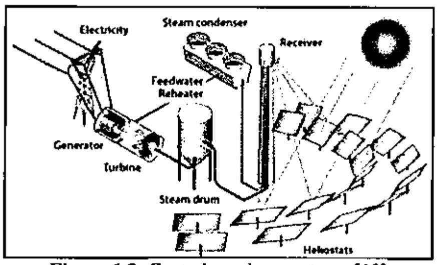

Figure 1.3. Central receiver systems [10]

A central receiver system consists of a large field of independently movable flat mirrors (heliostats) and a receiver located at the top of a tower. Each heliostat moves about two axes, throughout the day to keep the sun's image reflected onto the receiver at the top of the tower. The receiver, typically a vertical bundle of tubes is heated by the reflected insolation, thereby heating the heat transfer fluid passing through the tubes.

D. Parabolic Dish

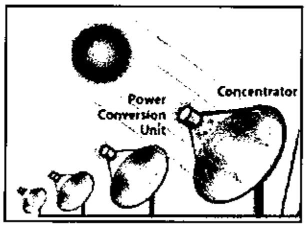

Figure 1.4. Parabolic trough systems.[10]

Parabolic dish concentrators are made from reflecting mirrors. They have a stirling engine that are situated at the focal point of the dish reflector. The solar radiation is concentrated onto a receiver at the focal point and absorbs the heat and then heat up the gas to generate electricity

V. COMPARISON OF CSP TECHNOLOGY

All of the CSP technologies have an advantage of generating clean energy with no fuel cost. The only impact concentrating solar power plants have on the environment is land use. To be able generating high electrical energy, more land is needed for the plant. Although the amount of land a CSP plant occupies is larger than that of a fossil fuel plant, both types of plants use about the same amount of land because fossil fuel plants are additional land for mining and exploration as well as road building to reach the mine [11].

Each of CSP technology has its own value proposition and therefore different deployment optima. Table 1 show that parabolic dish has the highest efficiency, 18-25% but its hybrid operation is still in the R&D phase. Solar tower efficiency is the second highest which is around 14-17% and have the highest operating temperature of High Temperature Fluid (HTF) 1000°c. The efficiency and the operating temperature HTF of Linear Fresnel is the lowest among other CSP but the cost for linear Fresnel are cheaper than the others CSP systems. Parabolic Trough efficiency is 10-15%. But, parabolic trough has the advantages of lowest material demand; good land-use factor, modularity, thermal storage, etc. make parabolic trough the most popular CSP option. [7].

Table 1. Different CSP Technologies [7, 12]

Technology	Temperature	Hybrid operation	Cost (S/Kw)	Efficiency
Parabolic Trough	400°C	Possible	4,156	10-15%
Solar Tower	1000°C	Possible	4,500	14-17%
Parabolic Dish	750°C	Still in R&D phase	6,000	18-25%
Linear Fresnel	270°C	Possible	2,200	9-15%

Changes in global renewable energy markets, investments, industries and policies have been so rapid in recent years. The cost for producing electricity from renewable resources has traditionally higher than producing electricity from coal or natural gas. However, as renewable technologies attain commercial viability and enter the mainstream market, their price per kilowatt hour is usually decline.

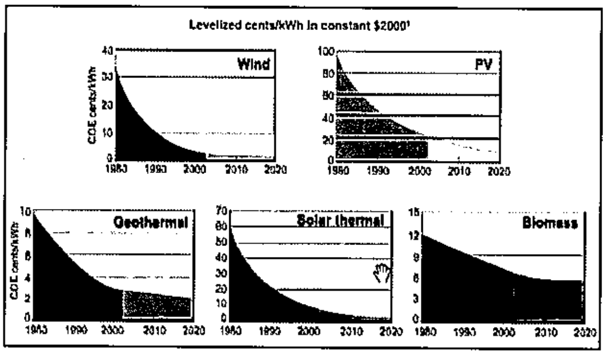

Figure 1.5 Renewable Energy Cost Trends
Source: NREL Energy Analysis Office
(https://tdksc.ksc.nasa.gov/servlet/dm.web.Fetch/TEERMShahRenewableEnergyOverview.pdf?gid=102614)

The renewable technologies, PV have historically shown a large proportion of cost reductions. Cost reductions in solar PV in particular meant high growth rates in manufacturing. Cost reductions in wind turbines, Geothermal, CSP and biomass technologies also contributed to growth. The dramatic reductions in PV costs can become a real challenge for the growing market of CSP. However compared to PV, CSP technologies are economically competitive. To some extent, market size can be compared with PV technologies [13]. In general, CSP solutions are considered to be environmentally friendly. Mirrors or concentrator do not require much maintenance, no greenhouse gas emissions and production of mirrors when compared to PV cells is less energy, intensive and more environmentally friendly [14].

V. CONCENTRATING SOLAR POWER AND ITS ISSUE IN MALAYSIA ENVIRONMENT

CSP technology requires Direct Normal Irradiance (DNI) of at least 1900-2000 kWh/m2/year in order to be economically feasible. Basically locations that have been primarily targeted as suitable for CSP solutions are those with high sun exposure and low cloud coverage, such as southern states of the United States, Mexico, Mediterranean sea region, Middle East, south Africa, parts of China, Pakistan, India, Australia and parts of South America [8].

By referring Figure 1.6, Malaysia and other countries in tropical region are not in the high insolation zone or at the area with excellent resource of solar radiation. The DNI for Malaysia are below than 1900 kWh/m^2/y. In most tropical regions, clouds reduce the annual production of CSP Plants to such an extent that they probably never will become viable [15]. Because of this problem, it is difficult for the countries at the tropical region including Malaysia to develop their own CSP plant.

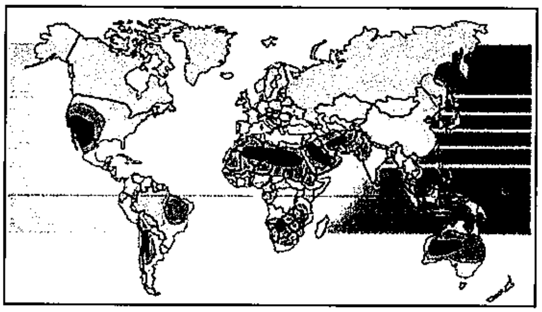

Figure 1.6 Geographical Ranges for CSP Plant
Source: CSP Global Market Initiative.
Key: Dark orange = excellent resource; pale yellow = adequate resource; green = insufficient resource.

Due to climate condition, it is usually believed that the CSP systems cannot be used in the tropics with relatively high diffuse fraction of global radiation. However, there is no systematic study on this issue [16]. From Figure 1.6, Malaysia and other countries at the tropical region still have an adequate solar resource to develop CSP plant and most world regions except Canada, Japan, Russia and South Korea have significant potential areas for CSP [17], meaning that Malaysia still have a potential to develop its own CSP Plant.

Solar energy is available over the entire globe and only the size of the collector field needs to be increase [18], or else the new design of CSP technology should be produced to provide the same amount of heat or electricity as in the region area with excellent resource of solar energy.

Among available technologies for energy production from solar source, CSP could give a significant contribution to develop a more sustainable energy system [19] and many calculation have shown that CSP is more cost effective than PV not only in sunbelt [20]. But in Malaysia, power generation from solar energy is monopolized by PV solar and it is proven when Malaysia FIT scheme is limited for only four sources of renewable energy which are solar PV, Biomass, Mini Hydro and Biogas.

VI. GLOBAL DEVELOPMENT OF CSP PLANT

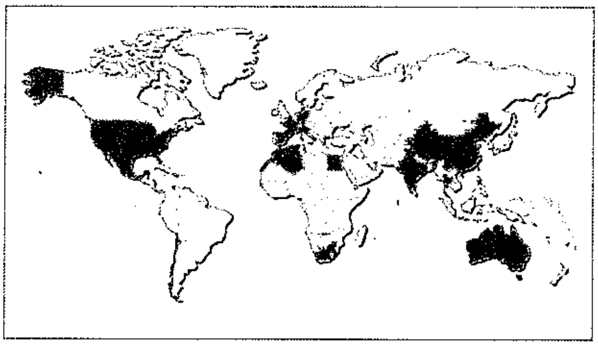

Figure 1.6 CSP project by country
Source: National laboratory of U.S Department of Energy

It is observed that most of the CSP potential studies were mainly focused on application in dry arid areas of mid-latitude zones [14] and from Figure 1.6, mostly the CSP plant are located in area with excellent solar resource with DNI higher than 1900 kWh/m2/year.

German located in area with DNI 902 kWh/m^2/year which is much lower than Malaysia. However in December 2008, German has launched their CSP plant at Jülich, Rhineland. They are using Tower system with capacity of 1.5MW.

Thailand a tropical country with Direct Normal Irradiance in ranges of 1350–1400 kWh/m^2/year become first country in Southeast Asian that have the their own CSP plant. On January 25, 2012, Thailand's first Concentrating Solar power Plant called TSE1 supplied 5 MW of electrical power to Thailand's public power network for the first time.

CSP in German and Thailand proves that CSP plant can work even at regions with DNI lower than 1900 kWh/m2/year.

VII. CONCLUSIONS

Since Malaysia is in the tropical regions with its own characteristics, such as wind speed, rapid change of clouds, rain, thunder storm and humidity level. These will affect the performance of the CSP system. An innovative development and research of CSP should be carried out in Malaysia environment with detail consideration both on the technical and economic aspects.

The research could give big impact not only for Malaysia but for others who want to understand and explore on CSP technology.

Thailand as a nearest neighboring country with Malaysia has started their CSP Plant with the capacity of 5MW in 2012 and will increase the capacity to 135MW in the next five years. Malaysia should take serious consideration by looking at the CSP progress in Thailand and start to look into CSP technologies as one of the promising renewable energy for Malaysia future.

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