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Fully solar powered airport: A case study of Cochin International airport

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ABSTRACT

The contribution of aviation industry towards green house gas emission is getting attention all over the world. The carbon footprint of airport can be reduced by substituting the conventional source of energy with solar PV based power generation. The mandatory vast and free space areas around runways can be utilised for utility scale solar PV power plants. The present research aims to analyze the operational performance of 12 MWp solar powered airport commissioned by Cochin International Airport Limited (CIAL), India based on first year operational data. The performance of the plant is also simulated using most popular PV simulation softwares – PVSyst and SolarGis, by accurately giving the plant specification. The average performance ratio (PR) of the plant is 86.56% and corresponding capacity utilisation factor (CUF) is 20.12% with final yield of 1984.1 h. The performance parameters obtained through the software was found to be in close match with the measured values. The economic and environmental analyses of the solar powered Cochin airports confirms its effectiveness in reducing the carbon footprint, leading to virtually zero emission, clean and green sustainable airport.

1. Introduction

Greenhouse gases and its impact is a big concern all over the world. It is estimated that the increase in the atmospheric concentration of carbon dioxide was 40% during the last 250 years, i.e from 280 ppm in 1750 to 400 ppm in 2015. Since its beginning, aviation industry has been contributing to green house gases emission. At present, the exhaust gas from aviation contributes to 3.5% of global emissions and its share is expected to double in the coming fifteen years (Editorial, 2004). India, being a tropical country with latitude lying between 7° and 37° is blessed with enough solar irradiation and sunny days (1600–2000 kWh/m^2 & 250–300 sunny days). Government of India (GoI) is obliged to reduce its greenhouse gas emissions under the Conference of the Parties (COP), in Paris, France. Aviation industry is constituted by airports, aircrafts and related utilities such as taxi, flight food. Airports act as an interface between landside access to airspace and airside access to the ground (Stevens, 2006). Recently, it can be seen that airports are evolving into a transport cum infrastructure hub which caters the commercial, industrial, business of aviation industry. As a result, the area around many of the international airports is developing into a city and is better described as Airport Metropolis (Weisbrod et al., 1993). So the ecological impact during the construction and operation of airport will increase in future.

Vast and flat land area is necessary for an airport. An area of 810 ha was acquired for the construction of Cochin Airport in 1999 (Wikipedia, 2016). Major portion of this land was reclaimed from marshy and paddy fields, which in turn affect the biological balance. Large air conditioned buildings such as terminals, hangers, multi-story car parks, office and/or retail space, freight and logistics areas, hotels are constructed on these land (Rowlings and Walker, 2008). Also vast and free spaces/areas are reserved around the runway for proper flight takeoff and landing. It also referred as sound buffer zone as it helps to reduce noise pollution. The energy consumption of a large airport is equivalent to that of a city of 100,000 peoples. Based on the energy analysis of the 14 biggest airports in Greek, it has been concluded that the average heating energy requirement is around 68 kWh/m^2 and the average energy use for lighting and motion is 172 kWh/m^2. Thus the total use energy is about 240 kWh/m^2 (Koroneos et al., 2010).

On an average, the daily electrical energy requirement of Cochin Airport is around 50,000 units (Cochin International Airport Limited,

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2016). The energy bills paid by the airport authority are always huge amount. Also all the airports including Cochin Airport are dependent on electricity generated from conventional energy sources such as coal, natural gas, hydro etc. So airports are causing environmental pollution from the period of its construction (Koa et al., 2017).

Air transport is becoming popular among public due to shorter travel time and reduced airfare. So the need of the hour is to transform the airports into sustainable and environmental friendly. Kılkış (2014) presented a roadmap and assessment methodology to make the future airports and terminal buildings truly sustainable. Liu (2014) reviewed the methods of selection, quantification, evaluation and weighting of the basic indicators and their aggregation. An effective framework has been developed that can be used to rank various renewable energy systems (RES). Kılkış and Kılkış (2016) analysed large airports in terms of services and quality, energy consumption and generation, carbon dioxide emissions and mitigation planning, environmental management and biodiversity and atmosphere and low emission transport. The ecological impact of airport can be reduced to a great extent by consuming energy generated from renewable sources. Rubeis et al. (2016) studied the historical data related to electric power, thermal energy and fuel consumption in Leonardo da Vinci International Airport of Rome. Based on study, smart solutions are proposed for load management such as finding an optimum point between production and consumption, the safety and reliability of innovative load management systems. Rowlings and Walker (2008) presented a variety of sustainable energy options that are suitable for airport facilities. It was found that solar and cogeneration has the most potential benefit for an Airport. Somcharoenwattanaa et al. (2011) presented the analysis of a new 52.5 MWe CHP plant at the Bangkok Suvarnabhumi airport. Presented the analysis of a new 52.5 MWe CHP plant at the Bangkok Suvarnabhumi airport and concluded that the primary energy consumption reduced to 24%, achieving 27% decrease in CO_2 emissions. Falvo et al. (2015) presented the analysis of a 25.3 MWe CHP plant at the Rome Airport, which was used as a way to heat the airport buildings. Tapping of wind energy is suitable in certain airports due to the availability of large unoccupied areas. Gran Canaria Airport or Burlington International Airport have installed wind turbines in their premises. However, location of wind mill near the airport is not advisable as the turbine is regarded as a physical barrier and may cause a possible interference to the radio navigation systems. The other renewable energy sources such as biomass, geothermal are site dependent and may not be suitable for airports in general. Koroneos et al. (2010) developed an optimization model to determine the optimum share of renewable energy sources in various end-uses such as heating, cooling, and lighting. In the case conducted for new airport of Thessaloniki, it was found that solar collectors could provide 2% of the heating energy requirement while the contribution from biomass systems could reach a level of 8% of total energy needs. The renewable fraction should be decided in such a way that the sustainability indicator of the system is high.

The vast and flat land plots as well as tall and large buildings with spacious roof area are favourable for solar PV based power generation (Ruther and Braun, 2009). Since Cochin airport lies at low latitudes, it has an advantage of the sun always high in the sky. Though airport regulatory bodies instructs “object free” and “controlled activity” areas around runways, those regulations do not restricts installation of ground-level devices such as solar panel. Wybo (2013) addressed the safety concerns related to the implementation of large-scale PV systems in airport locations such reflectivity of panels and its potential effect on pilots, electric shock hazard, birds nesting in the PV system etc. This paper suggests developing an integrated open circuit detecting electronic system and a frangible support structure. Compared to other electricity generation technologies, solar PV is having lowest Green House Gases (GHG) emission. Airports can be characterised by expanses of land covered in pavement based surfaces such as runways, roads, car parks, walkways etc. These dark surfaces often lead to urban heat island effect, thereby escalating the HVAC load especially during summer. Since PV output will be more during summer, the increase in load can be compensated. The HVAC loads in airport buildings and solar power production profiles are often synchronised. Moreover, PV system requires less maintenance, have life up to 25 years and can be recycled. The key issue in developing large-scale PV systems is that it requires large, flat plot which is secured against vandalism, thieves and existing power lines. Ruther and Braun (2009) assessed the reduction in energy demand at the Florianopolis International Airport, Brazil with the use of building-integrated photovoltaic (BIPV) systems and found that the entire electric power consumption of the airport complex can be met with the integration of PV systems during warm climates, in line with the concept of a zero-energy building (ZEB).

Kumar and Sudhakar (2015) evaluated the performance of 10 MWp grid connected solar PV system in Ramagundam, India from the measured onsite values. It was found that the plant was having an average performance ratio (PR) of 86.12%, Capacity Utilisation Factor (CUF) of 17.68% and the annual energy generation was 15,798.19 MWh during the observed period. Also the plant performance was predicted using PV simulation softwares, PVSyst and SolarGIS. The plant was operating at values closer to the predicted values from PV simulation softwares.

Sundaram and Babu (2015) computed the performance of 5 MWp grid connected photovoltaic plant in Sivagangai district, India using real annual data from the site. Also RETScreen software was used to compare the real performance with simulated output. The average daily final yield and overall system efficiency was found to be 4.810 h/day and 5.08% respectively. The performance of present system is compared with other grid connected systems installed in different parts of India. Padmavathi and Daniel (2013) analysed the performance of a 3 MW grid connected SPV plant in Karnataka, India using monitored data for year 2011. The plant was having good value of Capacity Utilisation Factor (CUF) but the value varied with peak load. Goura (2015) elaborated the design of 1 MW grid tied solar PV plant and analysed its performance after monitoring the plant for one year. The performance ratio of plant was found to be 77%. Verma and Singhal (2015) studied various parameters that affect the performance of SPV plant and suggested the methods to optimize the power generation. A case study of 20 MW Solar PV Project in Gujarat, India was discussed in order to analyze and quantify the losses that can occur in a grid connected PV system. The variation in losses measured from actual site and that predicted by PVSyst software was negligible. Sidi et al. (2016) analysed and compared the performance of two PV arrays of different PV technology (a-Si & μa-Si) installed in 15 MWp solar PV plant in Nouakchott, Mauritiana. Sukumaran and Sudhakar (2017) estimated the performance of 2 MWp grid connected solar power plant in Raja Bhoja International Airport.

The suitable renewable energy source to meet the energy requirement of an airport is found to be solar through extensive literature survey. However there is very much scare literature on performance of such solar powered airport. This study is aimed to fulfil the research gap in analyzing the prospects of commissioning solar plant in airport. The paper aims to analyze the on field performance of 12 MWp solar power plant installed at Cochin Airport based on actual monitored data (Sept 2015–Sept 2016) and performance indices like PR, CUF, array and reference yield, energy efficiency. The objective is also to provide an insight to the environmental and economic benefits of solar powered airport.