Renewable and Sustainable Energy Reviews 76 (2017) 391–406

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

A review on state of art development of model predictive control for renewable energy applications

W. Razia Sultana[a], Sarat Kumar Sahoo[a,*], Sukruedee Sukchai[b], S. Yamuna[a], D. Venkatesh[a]

[a] School of Electrical Engineering, VIT University, Vellore, Tamil Nadu, India
[b] School of Renewable Energy Technology (SERT), Naresuan University, Phitsanulok 65000, Thailand

ARTICLE INFO

Keywords:
Model predictive control
Photovoltaic systems
Wind energy systems
Grid connected systems
Stand-alone applications

ABSTRACT

Renewable energy sector is undergoing rapid expansion as the global focus is shifting towards cleaner, reliable and sustainable resources. As the new installation of these resources are well underway, there is tremendous potential for exploring these to more advanced control algorithms. Model predictive control is gaining immense popularity because of its flexible controllability, its ability to be used in any of application irrespective of its field as well as the availability of fast processors. This paper presents a systematic review on Photo-voltaic (PV) and wind energy systems controlled by Model predictive control approach. The work presented here will help the researchers to further explore the flexibility of this controller for design, analysis and implementation in renewable energy systems.

1. Introduction

The world is undergoing remarkable development recently and is moving towards green energy technologies, far from fossil fuels. Even though a majority of the countries have started using renewable energy extensively, there is still having a long way to go to utilize this energy to satisfy their daily energy demands. Though the government is concentrating on all forms of renewable energy only wind and solar hold a special place mainly because they are hassle-free. Reasons for the optimistic development of the global renewable energy markets are certainly its financial benefits, uncertain worldwide oil and gas supply, and the urgent need to go for pollution-free technologies in order to reduce the change in climatic conditions and air pollution [1].

Solar energy is inexpensive and its acceptance seems irresistible. The price of PV panels has declined 99% over the last four decades and has dropped by three fourths, helping global PV installations grow 50% per year. Fig. 1 shows the new solar and wind energy installations from the year 2000–2015 and forecasted new installations up to the year 2019.

The world wind power capacity had an increase of more than 20% a year over the past 10 year span. This is because of many credible features such as its declining price and by public policies supporting its expansion [2].

China, the world's prime producer of carbon emissions has projected to install a total of 120 GW of wind power, 43 GW of solar and 320 GW of hydropower at the end of this year. It has targeted at least 20 GW of new wind power installations and 15 GW of additional solar PV capacity next year. Fig. 2 shows the global new installation for the years 2000–2015 and the forecasted installations from 2015 to 2019. Fig. 3 shows the total cumulative capacity for the top 10 countries.

According to data by the International Renewable Energy Agency (IRENA), employment in the wind energy sector is raised to a whopping 23%, having crossed a 1 million jobs milestone in this year, up from 834,000 in last year. The nation to lead in this arena was China with more than 500,000 jobs. The other countries to follow it were US and Brazil. The world-wide wind capacity has attained reached 392′927 MW by the end of June 2015, out of which 21′678 MW were added in the first six months of 2015. Fig. 4 shows total solar cumulative installed capacity of top 10country in 2014 and 2019. All wind turbines installed worldwide by mid-2015 can generate 4% of the world's electricity demand. The global wind capacity grew by 5.8% within six months [3].

Since the growth in the renewable energy sector is inevitable with the global focus shifting towards it, with all the preplanned new installations, it is the responsibility of all us to utilize this energy to a maximum possible extent with an ultimate efficacy. In recent times, developments in power electronics and semiconductor technology have led to several advancements in power electronic conversion systems [4]. The evolution of the fast processors have also played a major role in it

* Corresponding author.
E-mail addresses: raziafriendly@gmail.com (W.R. Sultana), sksahoo@vit.ac.in (S.K. Sahoo), sukruedeen@nu.ac.th (S. Sukchai), yamuna.ksrm@gmail.com (S. Yamuna), venkatesh.dandi209@gmail.com (D. Venkatesh).

http://dx.doi.org/10.1016/j.rser.2017.03.058
Received 30 January 2016; Received in revised form 1 March 2017; Accepted 8 March 2017
1364-0321/

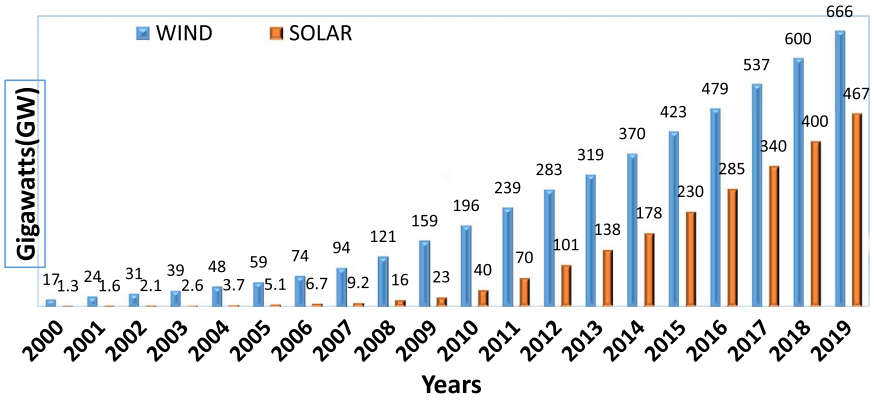

Fig. 1. : Global Cumulative Installation 2000–2019.

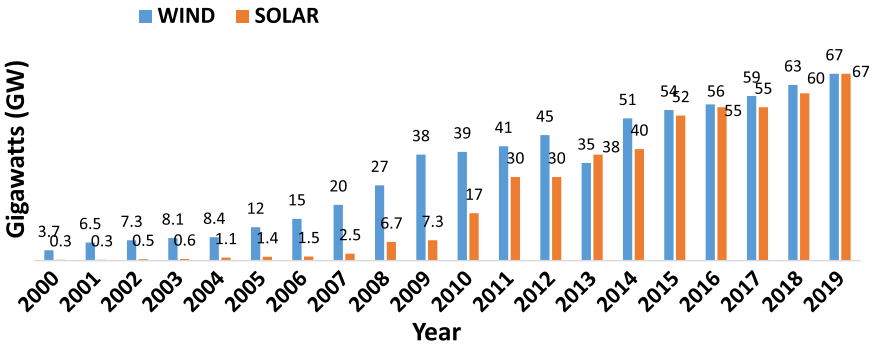

Fig. 2. : Annual New Installations 2000–2019.

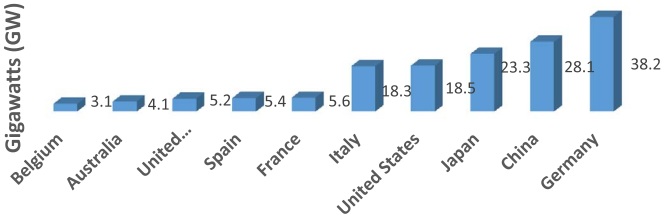

Fig. 3. : Total cumulative capacity by country (top 10) in 2014.

by paving a way for executing many advance, complex and sophisticated control techniques to the converters within a fraction of second. One of these techniques which is gaining huge popularity in recent years in the field of power conversion is the Model Predictive Control algorithm (MPC). The main objective of this review is to present a systematic review on MPC controlled PV and wind energy systems. The focus of this work is to provide an in-depth review on MPC controlled converters with renewable energy source and its applications. The objective or the control law of the any MPC based control is defined in the cost function. Therefore the control variable and the cost function of each predictive controller is described for each renewable energy application. These descriptions are tabulated for the ease in understanding. The main applications of the MPC controlled renewable energy system is to either be used as a standalone application or to be connected to the grid. Thus, the work presented here will help the researchers to further explore the flexibility of MPC controller for design, analysis and implementation in renewable energy power conversion systems.

2. Motivation and research background

Even though the idea of MPC was developed in 1970 in process control industry, the interest in it has reached its pinnacle only in recent days. Its gaining popularity is because of the availability of fast processor which has the ability to implement many complex problems in a fraction of seconds. The main advantages of the MPC controlled

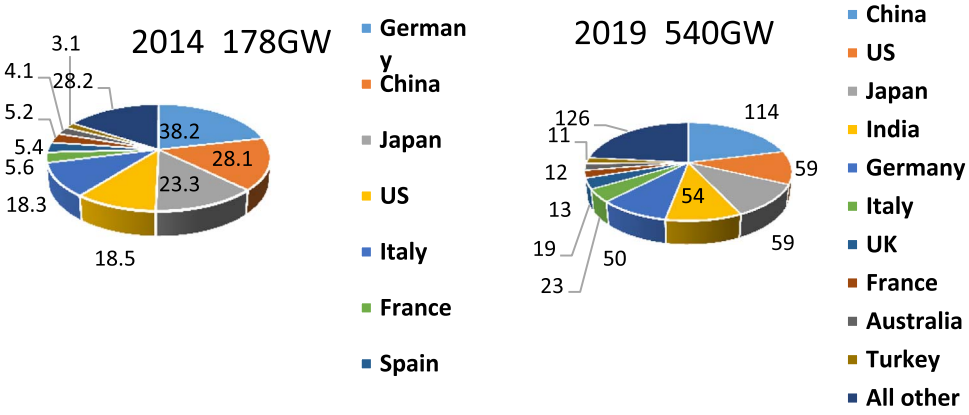

Fig. 4. : Total PV Cumulative Installed Capacity by Country (top 10) in 2014 and 2019.