20 Years of Photovoltaic Cables – what have we learned to prepare for the future?

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ABSTRACT

Investment in the electric generation system continues, with greater fractions than ever (27% in 2022) being derived from renewable sources. The years since 2016 have seen significant growth (70-80 GW pa) in the solar arena, which has a heavy reliance on cable systems to both connect the panels and export the power to the grid. As the size and power of the PV arrays grow, longer and longer lengths of PV cables are required for them to operate reliably in some really challenging environmental conditions. This paper details the evolution in cable designs that have supported PV and identifies the future trends that will need to be addressed in the manufacturing and standardisation space.

KEYWORDS

Reliability, Photovoltaic Cables, Renewable, Longevity

INTRODUCTION

Large changes are occurring in the renewable technologies arena [1,2,3]. Along with wind (offshore and onshore), solar capacity is growing considerably (15% pa in 2021) with application in utility (57%), commercial (27%) and residential (16%) installations in 2021. The key elements of solar farms are photovoltaic (PV) panels and arrays, inverters and PV cables used for connections. In addition, there are export cables for the wider grid. As the size and power of the PV farms grow, longer and longer lengths of PV cables are required for them to operate reliably in some really challenging conditions. Even current solar farm designs require a lot of cables and connectors — a 1MW module will require approximately 7 km of PV cable currently operating at a direct current (DC) voltage of 1.5kV. With solar farms being key parts of the electric infrastructure, they must operate for a long time, with an expected period of use under normal conditions anticipated to be at least 25 years. This is a challenge as the PV cables must withstand the combined effect of:

- DC voltages from the panels
- Impact of direct sunlight
- Wide ambient temperature fluctuations
- High conductor temperatures from the array output
- Abuse from wildlife and floods

This paper reviews the evolution of the designs and materials used in meeting the various needs of PV cables and suggests a number of the challenges that need to be addressed as the use of PV cables increases. It also looks at the emerging challenges in this space.

RENEWABLES

Conventional energy resources (oil, coal, natural gas) are finite and contribute to carbon emissions to various extents. Thus, there is great interest in alternative sources of energy for the future. Renewable energy sources (biofuels, hydro, solar and wind) continue to expand their role in the electricity generation mix [1], contributing 1%, 15%, 4% and 7% respectively of the global electric energy mix (Figure 1).

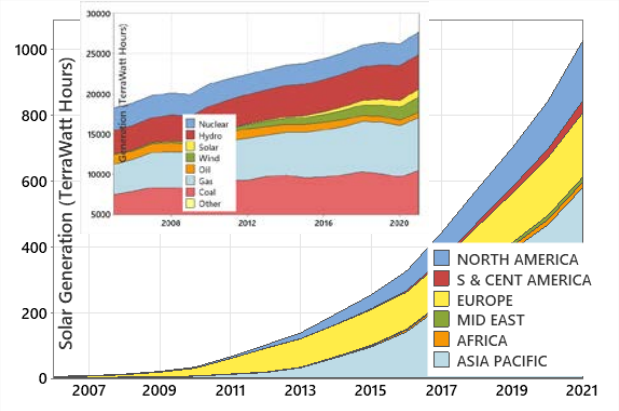

Figure 1. Growth of the PV application and context (inset) with fuel sources for electricity generation [1]

Solar energy is an abundant resource, and the converted energy can be considered to have a limited impact on pollution. Solar or PV-based generation offers long-term growth of approximately 50% per annum, with the Asia Pacific region having the largest installed capacity in 2021 (Figure 1). To achieve the goals of reduced carbon emissions in international climate accords (such as the Paris Agreement), the proportion of renewables will need to increase 2.5 times from today to 2050 [2].

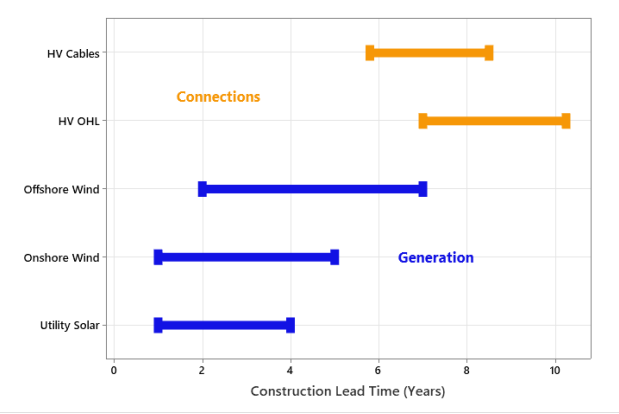

Figure 2. Estimated range of construction lead times for critical elements of renewable generation [2]

Even though there is a clear impetus for the installation of renewables, there are considerable lead times (years) both for generation and the grid elements (Figure 2). In fact, solar is the technology that can be most rapidly implemented. The current estimated operating lifetime of a solar plant is 25 years [13]; coal and nuclear plants have lifetimes of 50 and 60 years respectively.