

"Analysis, assessment, challenges, and enhancements of TOPCon(Tunnel oxide passivated contact) modules and uncertainties of its system's operation yield evaluations and projections"

Synopsis:

In the past two years, advanced solar PV modules track has continued to be exciting, in order to seize the opportunity of technology iteration and adapt to market development, many old and rookie photovoltaic companies are embarking on production line technology transformation and product iteration, in this process, n-TOPCon technology took the lead in breaking through.

Out of these various high efficiency solar Modules, tunnel oxide passivated contact (TOPCon) solar modules are gaining more interests due to possessing various advantages such as availability of raw material, easy process sequence, high efficiency potential etc. In order to further increase solar PV module efficiency, better reliability and reduce project LCOE, a large number of PV manufacturing companies have been devoted to a variety of low-cost and high-efficiency crystalline Si solar modules. In first part this article presents about, the module structures of tunnel oxide passivated contact, its characteristics, degradation evaluation process, performance of bifacial, CTM (Cell to module) losses, Production difficulties of packaging TOPCon cells and efficiency progresses in small scale production line or are promising in mass production are presented. Both the industrialization status and future development of this high efficiency TOPCon solar modules, the progress will be obtained by the researchers in various aspects to improve the TOPCon modules efficiency, current status of commercialization and finally future scopes of improvements with possible challenges.

In 2023, companies have accelerated the pace of TOPCon cells and modules manufacturing. the national TOPCon layout capacity has exceeded 3GW at china. In addition to the full expansion of existing industry leading companies, more crossovers, rookies and other leading companies in the manufacturing process have joined this field. As the main representative of new photovoltaic technology, TOPCon photovoltaic modules have been cultivated in the market for one year, and downstream customers have a full understanding of their cost performance. As a result, the second section of this research explains TOPCon PV Module used ground mount grid connected system in the range of 50MWp estimate analysis of Levelized Cost of Energy (LCOE) and its field of uncertainties of several technical aspects of PV system yield prediction and assessment based on solar resource, TOPCon module properties, system output and performance—including long term effects.

System testing looks at the performance of the complete conversion chain of a PV system. This conversion chain includes many aspects PV module DC output such as the bifaciality factor, albedo considerations, solar irradiation parameters, and the efficiencies of auxiliary equipment, including inverters and transformers. This comprehensive approach leads to a more robust understanding of the overall system performance, enabling more accurate yield projections and assessments.

In summary, this article provides a multifaceted exploration of the analysis, challenges, and enhancements surrounding TOPCon solar modules, as well as the uncertainties inherent in evaluating and projecting their system operation yields. It combines technical intricacies with practical considerations, offering valuable insights into the dynamic landscape of advanced PV technologies and their role in shaping the future of sustainable energy production.

Key Words: TOPCO_n, PV modules, bifaciality factor, albedo, Solar irradiation, LCOE, Bifacial, CTM losses, Grid connected.