# Theoretical Efficiency Limits for Alternative Solar Cell Device Concepts

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As the demand for renewable energy sources is increasing, many alternative concepts have been explored to enrich the prospects. In the solar cell field, multi carrier generation, spectrum manipulation, thermo-photoelectric cells, hot carrier, intermediate band, and many other techniques have been studied as new concepts. In this work, the theoretical limits of multi-carrier generation and multi-interface pre spectrum divided solar cells' efficiencies are analyzed and discussed in detail.

The solar cell market is dominated by single p-n junction devices such as Si, CdTe, and CIGS cells. The theoretical efficiency of such devices is well set by a recent version of the neat Shockley-Queisser (SQ) model. In this model, the single junction cell efficiency depends on the energy gap and cannot exceed 33%. Practically and in support for SQ model, the best lab efficiency is 25% for Si solar cell and it has not changed much since the early 1990s. The alternative device concepts should be able to surpass this limit. For example, a 43% efficient triple junction cell has already been realized.

Based on the analysis, more than 80% efficiencies are possible; however, such high efficiencies are achievable only in ideal cases. So, some of the technical and practical difficulties are addressed and discussed. The analysis is based on the classical transport approach and assuming the measured 1.5 AM solar radiation spectrum. We used the reference National Renewable Energy Lab (NREL) measurements. For multi- carrier generation, no distinction is made between multi-exciton generation and carrier multiplications, as the multiplication is assumed ideal as Heaviside step function of the ratio of photon energy over energy gap, where the multiplication happens, is ignored.