Assessing Possibilities & Limits for Solar Cells

David Cahen and Lee Barnea
the Weizmann Institute of Science, Rehovot 76100 ISRAEL

We show how two, seemingly simple, criteria can serve to gauge

- in how far significant progress is possible for different types of solar cells and
- if basic bounds may limit such progress.

The criteria are the ratio of

- the efficiency of the best commercially available module to that of the best laboratory cell, **BCM/BLC**, and
- the ratio of the open circuit voltage of this same best laboratory cell to the band-gap or effective optical absorption edge of the absorbing part of the cell, $\mathbf{V_{OC}/E_G}$.

BCM/BLC reflects to some extent manufacturing maturity of the cell type, shown by the significantly higher value for CdTe than for CIGS, or for the single-, compared to the multi-junction a-Si modules, with the ratios for the dye and organic systems much lower still. The ratio for the highly developed Si cells does, though, show what can be expected. Naturally, an additional ratio is that of the best laboratory cell to the Shockley-Queisser (SQ) efficiency, but that is a number, which reflects academic ability rather than industrial promise.

V_{OC}/E_G expresses a limit that is to some extent related to the SQ limit, but, for example the relatively low value for dye- and organic cells may well indicate basic limitations for such cells, which I will consider as well in this lecture.

The significant difference in V_{OC}/E_G between CdTe and CIGS cells may reflect the difference in grain boundary chemistry and physics of these polycrystalline thin film systems, while the low value for a-Si likely expresses (also) the importance of the a-Si tail states.

The need to identify and define basic limitations, beyond that given by SQ, and to distinguish such limitations from lack of development effort and of maturity is becoming critical for the further development of solar cells, especially for newer types, be they inorganic (classical) ones or unconventional ones. The BCM/BLC and V_{OC}/E_G criteria can play an important role in putting order in the enormous parameter space that we face in making our choices for the future.