HANWHA Q CELLS — CELL MIXING

CELL PRODUCT "BINNING"

It is normal to sort solar cells into 0.2 % efficiency "bins". As an example a 1920 bin typically has cells with efficiencies of between 19.2 % and 19.4 %. Within a single production run there could be 10 or more of these 0.2 % bins. This wide range is mainly due to differences within the silicon wafers, as such the range for monocrystalline is much tighter than for polycrystalline for this reason. Sorting into these bins makes the conversion from cells to modules more controlled and predictable, but it increases logistic complexity and makes the usage of rare border cell classes more difficult. To resolve these issues Hanwha Q CELLS developed a strategy for intelligent mixing of different cell classes into one module. Whilst there are potential losses for the module manufacture from mixing cells, there are also benefits. Mixing cells allows the number of module power classes to be reduced which adds flexibility to the manufacturing processes so much so as to overcome minor losses.

CELL MIXING – RISKS

Since 2013 Hanwha Q CELLS has employed the mixing of multiple cell efficiency bins within a single module. From extensive testing it was shown that mixing cells with a maximum efficiency range of 1.6 % does not effect the module power by more than 1 % and has no impact on reliability. The potential risk of lower power modules comes from differences in the I_{mpp} between the cells – I_{mpp} is the current of the cells when operating at the maximum power point. The relationship between the deviations in Impp and the power loss is shown below. Small differences, eg. < 7.5 %, result in a power loss of around or less than 1 %, however with greater differences the loss grows quickly.

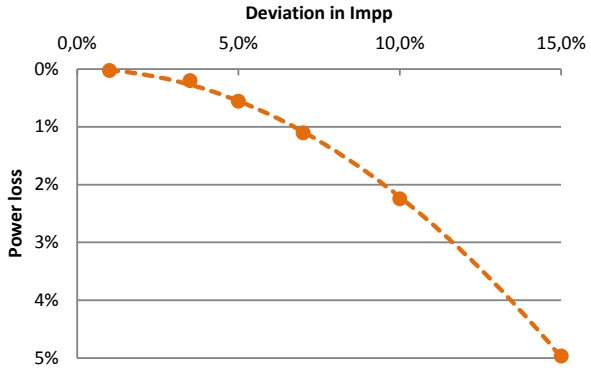

Figure 1: Module power loss vs. I_{mpp} Deviation between the cells.

Any power loss resulting from cell mixing is accounted for is accounted for when measuring the power of the module, and does not lead to future degradation. Thus ensuring no losses are passed on to the end customer.

CELL MIXING – MODULE TO CELL LINES

As Hanwha Q CELLS has grown, combined onsite cell and module manufacturing has been employed. Combined production greatly increases the flexibility of the manufacturing site to respond to customer demands. In the past cells had to be resorted prior to module production in order to produce optimally mixed modules. This process required additional handling of the cells, which are fragile, and can lead to breakage. Utilising combined cell and module production mixing within the cell production. This removes the double handling and ensures no damage is done to the cells, providing module production with specially sorted boxes to produce select module powers.

ELECTROLUMINESCENT TESTING (EL)

100 % EL testing is utilised in all Hanwha Q CELLS production lines to identify any potentially issues and sorted out damaged modules from the production. This process is effectively the cells working in reverse, taking in electricity and producing light, but only in the infrared portion of the spectrum. The brightness of the cells in the EL picture is therefore proportional to the efficiency of the cells. So it is clear to see from looking at EL pictures if a module was made with mixed cells.

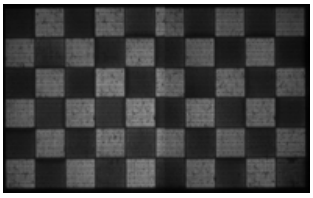

Figure 2: Regular Module Line Mixing

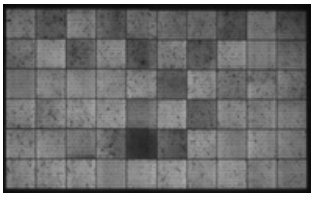

Figure 3: Asymmetric Cell Line Mixing

MODULE HEATING

During operation modules normally heat up, the normal operating cell temperature (NOCT) is typically around 45°C. Deviations in I_{mpp} can result in temperature differences between different cells within the module. Through a series of tests and the evaluation of physical processes it has been shown that there will not be more than a few degrees difference between cell temperatures during normal operation for even the most extreme cell mixing. As such these minor temperature differences from cell mixing have no effect on module performance or reliability.

Every cell from Hanwha Q CELLS is inspected for hotspots using infrared cameras during cell production, with effected cells being removed during sorting. Sorting out these cells ensures no overheating of the modules, however mixing different cell efficiencies within one module has no effect on the risk of hotspots.

LOW-LIGHT BEHAVIOUR

Cells from a single production, despite differing efficiencies, will all show the same relative behaviour at differing intensities of light. Also the mixing of these cells together will have no effect on this behaviour. As such mixed modules will have the same low light behaviour as their unmixed counterparts.

SUMMARY

By mixing cell classes in one module, it is possible to more flexibly respond to market requirements. It has been shown that mixing has no influence on the output quality and therefore on the specification or the durability of Hanwha Q CELLS PV modules. Only through EL imaging is it possible to identify whether different cell classes were use in the construction of a single module. Moreover, as described in this paper, this mixing does not affect the operation of a module in performance, yield or reliability.

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