BOS COST SAVINGS
NEEDS AND POTENTIAL FOR LARGE SCALE GROUND BASED PV SYSTEMS UNTIL 2010

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ABSTRACT: More and more large scale ground based systems were implemented with thin-film modules in the past years in Germany. Based on module pricing thin film modules appear to be very attractive for this type of application. However there are quite significant differences in balance-of-system (BOS) costs within different c-Si and thin film (TF) module types, which have a high impact on total system costs. The BOS cost portion is significantly higher for systems with TF modules compared to c-Si modules. Existing c-Si modules and BOS components were developed and optimized to achieve cost savings in the past decades already a lot. TF modules as well as the related BOS components are at the very beginning of this development so the cost saving potential – especially for BOS costs is considered to be significantly higher for TF module based systems. Since a 6.5% degression in the feed-in tariff is required in the German EEG for ground based systems a high cost reduction pressure is imposed on total system costs. The results of BOS cost savings achieved already will be demonstrated for a sample thin-film module.

Keywords: Cost reduction, large grid connected PV systems, Thin Film

1 INTRODUCTION

More and more thin-film (TF) modules are going to be used in large scale ground based PV systems – mainly due to high costs of crystalline modules. However, the lower efficiency of the TF modules along with their lower system operating voltage cause significantly higher balance-of-system (BOS) cost. Namely the costs for the supporting structures, DC cabling and inverters (power conditioning units – PCU) are higher than for c-Si modules. Even within the "family" of the TF modules significant variations in BOS costs can be observed [1]. An sample for the different costs between a c-Si modules and two types of TF modules is given in Tab. 1 below.

	c-Si	TF1	TF2
Substructure	0	217	332
DC-Cabling	0	24	117
Inverter & Grid Connection	0	170	170
Fencing, Cable Conduits, etc.	0	16	12
Total	0	427	631

Table 1: BOS cost differences (in €/kWp) between c-Si and TF modules

As Tab. 1 indicates there can be "penalty" of around 400 – 600 €/kWp between the BOS costs for the different technologies. It should also be noted that and additional cost disadvantage for TF exists because of higher land lease in terms of €/kWp because of the lower module efficiency.

In order to compete on the total system costs the TF modules costs must compensate at least these higher BOS costs.

As a result of these higher BOS costs and lower module costs the share of BOS costs is significantly higher for TF systems (see Fig. 1). The importance of the BOS cost saving potential – in particular for TF modules – can be seen easily: 49% of the total costs are BOS costs for systems with thin film modules whereas only 27% BOS costs are reported for plants with crystalline modules.

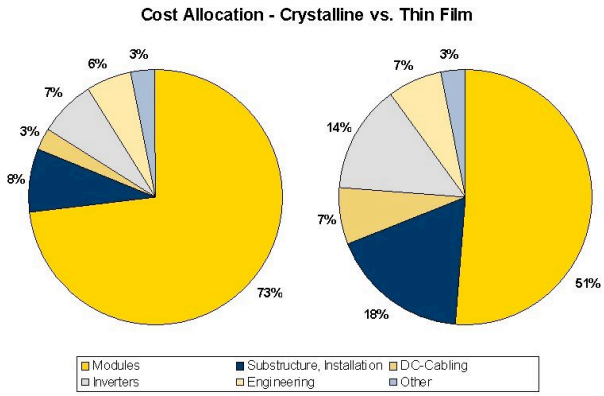

Figure 1: Cost breakdown for large scale ground based PV system with c-Si and TF modules.

To give an example: If the costs for supporting structures can be reduced by 20% for both module types then the savings on the total system level are 3.6% (20% x 18%) for TF modules but only 1.6% for c-Si module (20% x 8%). This leads to the conclusion that the cost saving potential inherently is higher for TF systems than for c-Si systems.

In Germany the EEG law asks for a reduction in feed-in tariff by 6.5% annually for ground based systems (whereas the reduction for roof-top systems is 5% annually). Given this one can easily calculate the cost reductions needed on system level in order to allow an investor for an installation in 2010 to achieve the same return on investment he would get for an installation in 2005. Tab. 2 presents a rough calculation of the price reductions needed (compared to starting year 2005).

	2006	2007	2008	2009	2010
Ground-based	-295	-575	-835	-1080	-1300
Roof-top	-235	-465	-680	-885	-1080

Table 2: Required price reductions compared to 2005 price basis.

Please note that this calculation does not reflect

potential changes in interest rates or tax effects – of the interest rates are rising the price reductions needed might even be higher than presented in the Tab. 2.

However it becomes obvious that the total system prices for large scale ground based systems must be reduced by 1,300€/kWp in 2010 compared to 2005 prices. And these price reductions can not only be achieved by lower modules costs but only if the BOS costs are reduced significantly also.

2 BOS COST SAVING POTENTIAL BY 2010

2.1 Areas for BOS cost savings

We analyzed the different BOS cost components having in mind module modifications that can help to reduce the BOS costs as well as new designs or improvements of BOS components. In detail we made the following assumptions:

Supporting Structures: We expect a cost decrease due to increased module efficiencies. We assumed a 15% increase for module efficiency for c-Si and a 25% increase for TF. Another cost saving we expect from optimized designs which will result e.g. in material savings (i.e. less kg/Wp) but will also adopt the design to the specific module characteristics (e.g. for frameless modules, which to our understanding, will become more and more popular for large scale systems): We anticipate also savings due to economies of scale. However we believe that these savings will be compensated by price increases for steel, etc…) so we do not expect additional cost savings.

DC-Cabling: Here we expect cost savings due to module efficiency increase since less cable material and connections are needed per kWp. We also believe that significant cost savings can be achieved by higher system operation voltages (up to 1.000Vdc) because of an increase of the number of modules in series and consequently a reduction of the number of strings and costly field boxes for string monitoring. Here clearly TF modules which are limited in most cases to 450-600Vdc at the moment have a higher cost saving potential than c-Si modules which are widely available for 1,000Vdc systems voltage already. New designs and modifications such as the usage of pre-fabricated dc cables will also result in significant cost savings. Another approach – especially to allow TF modules to be operated at higher voltages might be by grounding the (-) pole of the array [2].

Power Conditioning Units/Inverters: Also for the PCUs the step to 1.000Vdc system voltage would decrease the inverter costs for TF plants significantly whereas this system voltage is already a standard for c-Si modules. Cost savings result mainly from the lower currents which reduce the costs of switching devices, IGBTs, etc… in the inverter. As a windfall profit the inverter efficiency will increase. Improved module insulation by appropriate edge sealing and backside foils or glass along with grounding of the (-) pole would allow also for thin film modules to use inverters up to the 1 MW range and therefore to achieve a cost reduction due to economy of scale of the inverter.

Another cost saving results from the reduced number of buildings needed to host the inverters: For 8 low voltage inverters with 125kVA each we need 2 inverter buildings whereas two 500kVA inverters only require a single building.

Other cost factors such as module packing, installation process, project management, standardized blocks for large scale plants will also cut down the BOS costs.

2.2 Estimate of BOS cost saving potential

Based on the assumptions described above and the current costs of BOS components we tried to estimate the cost saving potentials for the BOS components for both modules types.

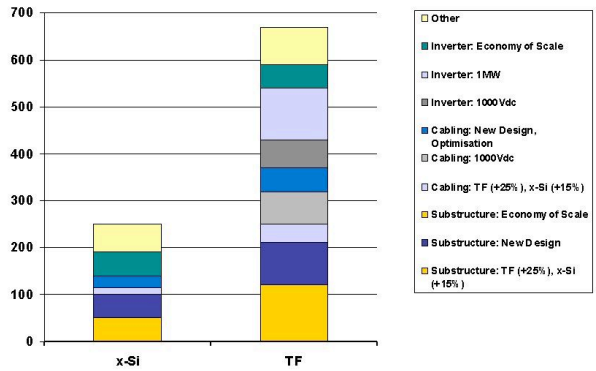

Figure 2: BOS cost saving potential in €/kWp for c-Si and TF modules

Based on these calculations we arrive at the following conclusions:

The BOS cost saving potential for TF (650€/kWp) is significantly higher than for c-Si (250€/kWp). Some of the reasons are that any cost saving measure will favour TF systems because of their higher BOS cost percentage of total systems costs in general but also the higher efficiency increase expected for TF (and therefore higher savings in area related costs) as well as the fact that 1,000Vdc along with the capability to implement 1 MWp inverters exists already for c-Si systems.

It should also be noted that many efforts were undertaken already in the past 15 years to optimize BOS components towards the needs and properties of c-Si modules so further cost reduction potential is limited. TF module technology and appropriate BOS components however are still at the very beginning, so relatively big advantages can be achieved with limited efforts and time.

On the other side if a total of 1,300€kWp savings are required by 2010 compared to 2005 then c-Si module prices must be reduced by around 1,050€/kWp whereas the TF module prices must "only" decrease by 650€/kWp.

3 BOS COST SAVING ACHIEVEMENTS BY 2006

As mentioned above we have identified some BOS components where significant cost savings can be achieved. In the following sections a description of some modifications and the related cost savings which were realized for a specific TF module (double glass, frameless, 1,000Vdc system operating voltage) since 2005 is given.

3.1 Supporting Structure

The 2005 design with 2 modules in landscape format above each other was changed to 4 modules in landscape format (see Fig. 3 and 4) by design modifications and optimizations. Cost savings (without any "wind fall profits" due to higher module efficiency) are around 60€/kWp. Because of increased material costs for aluminium and steel the cost savings were lower than expected.

Figure 3: Supporting structure design 2005 (2 modules in landscape format above each other)

Figure 4: Supporting structure design 2006 (4 modules in landscape format above each other)

3.2 DC Cabling

Although the modules would have allowed for 1,000Vdc voltage we were limited to 900Vdc only in 2006 since the max. input voltage of the inverter did not allow for higher voltages. However the increase of PV system voltage from 600Vdc to 900Vdc already resulted in cost savings of 60€/kWp.

By using pre-fabricated DC cables for the string wiring (see Fig. 6) compared to the string wiring design using field junction boxes (see Fig. 5) from c-Si plants cost savings of 80€/kWp could be realized, whereas our initial expectations were around 50€/kWp.

Figure 5: Field junction boxes for parallel connection of PV strings (as they are typical for c-Si plants)

Figure 6: New, prefabricated DC cables for string-cabling.

3.3 Power Conditioning Unit/Inverters

The use of "standard" design inverters reduced the costs by approx. 60€/kWp compared to low voltage inverters and by another 120€/kWp due to the 1 MWp inverter blocs (economy of scale) and savings in inverter periphery (buildings, etc…).

3.4 Other costs

Due to more efficient project management and economy of scale effects with increased average system size cost reductions of around 40€/kWp could be already achieved.

3.5 Summary of cost savings by 2006

In total the cost savings on BOS side were slightly above 350€/kWp as illustrated in Fig. 7. It is worth being noted that within only one year of in-depth investigations and design modifications as well as optimization work and intensive discussions and collaborations with BOS suppliers significant cost reductions could be achieved already. In fact most of the not efficiency (or area) related

cost savings identified for 2010 (see Fig. 2) for this specific thin film module were already achieved.

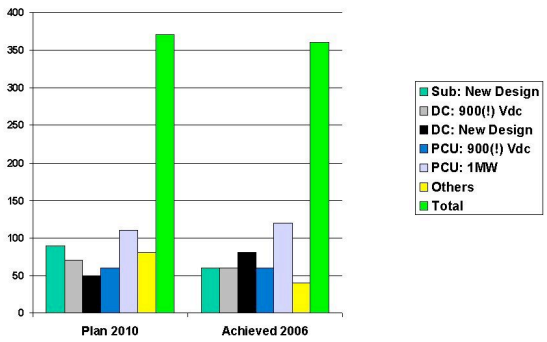

Figure 7: Summary of the planned and achieved BOS cost savings.

4 CONCLUSIONS AND OUTLOOK

The cost saving potential on BOS level for large scale ground based systems for "typical" c-Si modules as well as a thin-film modules was identified. Since the BOS costs represents a higher portion of total system costs with TF systems compared to c-Si systems and because BOS technology for TF systems is in the very beginning of the improvement phase the BOS cost reductions for TF systems will be significantly higher than for c-Si systems.

On the other side, the German EEG asks for significant cost reductions via reduced feed-in tariffs depending on the year of plant implementation. It can be expected that more and more market introduction schemes will adopt similar measures soon. This causes an significant pressure for cost savings on system level – especially for ground based systems in Germany, where price reductions of 1,300€/kWp are required by 2010 (this is about 1/3 of the current system costs for ground based systems).

As we demonstrated for a specific thin film module type we could achieve by technical design optimizations in both the module area (due to higher system operating voltages because of improved module sealing) and the BOS system technology cost savings of 350€/kWp already. With further cost savings due to improved module efficiency or other design modifications such as module size increase, etc… we are confident that BOS cost savings of at least 650€/kWp are achievable by 2010 the latest. The cost savings may be slightly different for other thin-film module types – however we believe that significant BOS cost savings are possible for any thin-film module.

For c-Si modules we believe that the BOS cost saving potential is significantly lower in terms of €/kWp because of two reasons: First, the BOS cost portion is lower than for thin-film systems and second, a lot of cost saving potential of c-Si systems was exploited already in the past 15 years.

Since the BOS cost saving potential is significantly lower for c-Si modules (250€/kWp) compared to thin-film modules (650€/kWp) the module costs must be reduced by 1.050€/kWp for c-Si modules and (only) by 650€/kWp for thin-film modules compared to 2005 prices in order to keep c-Si modules competitive for large scale ground based systems in Germany.

The 6.5% degression of feed-in tariff for ground based PV systems in Germany imposes a tough cost pressure on module and BOS components manufacturers as well as system designers and installers to reduce the total system costs. This results in a high innovation rate – some of the recent developments won't have happened without this price pressure. On the other side we believe that those manufacturers and system designers/installers who are successful in this market segments will become some of the most competitive companies within the PV industry.

5 REFERENCES

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