The South African REIPPPP program – focus on details to continue and increase its success

by Ronald Lange

The South African REIPPPP program is a success. To continue this success a continuous attention to the details is necessary. Focussing on the PV programs and more on the PV modules, this detail is the formulation of the local content.

The South African Renewable Energy Independent Power Producers Procurement or REIPPPP program, launched in August 2011, kick-started in its first 3 rounds a 1.4 GW PV industry with the first 75 MW project connected to the grid ahead of schedule [1]. The South African government has been able to generate the necessary business environment and confidence to invest in the long-term PV projects. This is no sinecure in the global PV industry that is aggrieved with changing (government) regulations and investors making significant losses. The confidence in the South African market is also reflected in the significant reduction of the tariffs in the subsequent rounds of the REIPPPP program. The continuation of the REIPPPP program is given by the plan to provide an additional 400 MW per year till the year 2020 with an increasing amount of a local manufacturing content [1, 2]. In this article, a proposal is made about the local content regulation and the local South African PV industry, focused on the local manufacturing of PV modules and their components.

The REIPPPP aims at both generating cost efficient electricity as well as further development and strengthening of the local manufacturing sector. In the tender process, the cost efficiency part has a weight of 70% [3]. This high value drove the goal of a cost efficient electricity generation successfully home. The PV electricity price decreased significantly from R2,65/kWh in round 1 to R1,65/kWh for round 2 to a capped price of R1,40/kWh for round 3.

The local economic development requirement has a weight of the remaining 30% and the scorecard is composed of various aspects like job creation, value of local content spend, socio-economic developments and others [3]. For the PV module manufacturing, the value of local content spend is most important. The local content value for PV has been set at a threshold of 35% for round 1 and 2 and 45% for round 3. The targets for round 1, 2 and 3 have been formulated as 50, 60 and 65%, respectively. The aim for subsequent REIPPPP rounds is to steadily increase both the threshold and target values.

The formulation of local content percentage is valid for the complete PV installation. For large multi-megawatt field installations, a PV installation consists mainly of the PV modules, the mounting construction, DC to AC inverters and cabling, with the necessary civil works playing a significant role. The value of the local content spend is depicted in Table 1 [3, 4]. Based on these figures, no need exists to use locally manufactured PV modules for round 1 and round 2. Evaluating round 1 and round 2 results in the use of a minor 5% of locally produced PV modules. Increase of the local content threshold to 45% for round 3 does not necessarily result in a use of locally manufactured PV modules.

The local content regulation in the REIPPPP

The local content is defined as shown in Fig. 1 and resulted in a 5% market share of locally produced PV modules. The application of this formula will lead at some point to a scenario where the local PV module production has to step up from 5 to 100% contribution. With the announced annual rounds of 400 MW this exceeds the current production capacity. No development to meet this production capacity is expected to happen. In addition, the current existing local manufacturers will face an abrupt demand change that is extremely challenging to manage. To circumvent this scenario and to continue the success of the program for the local PV industry, a slight adaptation of the local content regulation is proposed (Fig. 1) [5]. The advantage of this is a gradually increased production capacity, which will result in a healthy and sustainable local PV module production industry.

An additional advantage is that local PV module manufacturing is guaranteed. Using the word “laminated”, no assembly (lmc – laminate to module conversion) or import scenario is possible. Currently, the local content regulation allows a 5 – 10% local content due to a mark-up by importing PV modules. This import scenario does not result in a local production, not in job creation and does not lead to an added value. An assembly (lmc) scenario leads to a 10 – 15% local content and results in an intrinsic and no value adding 5 – 8% cost increase of the PV modules with a limited local production.

The intrinsic cost increase of an lmc assembly compared to a cmc manufacturing results from the adaptation of the production process in factory 1 and mainly from the additional packaging of the laminates in factory 1 as well as the double handling steps in factory 2. A PV module produced in an lmc process undergoes 2 additional sun simulations, one additional EL test and one additional packaging step (Fig. 2).

Why local PV module manufacturing?

A 50 MW PV module manufacturing plant will create about 150 to 250 jobs. Depending on the automation of the production line, a minimum of about 20 operators per production shift will run a semi-automated line whereas around 50 operators per shift will run a line without an automated tabber/stinger. The question can be asked why local PV module manufacturing is of importance. The installation of the modules will create more jobs. The answer is that local and sustainable PV module manufacturing ensures the development of a local raw material industry and that a local production increases the product know-how, which avoids the import of inferior products.
The development of a local raw material industry is waiting. All raw materials except the PV cell can in potential already be produced in South Africa using existing production facilities and equipment. The solar glass as well as the aluminium frames are already produced locally. The use of existing extruder equipment in e.g. the packaging industry could supply the encapsulant (EVA) as well as the components for the backsheet. The backsheet can subsequently be made locally as well as the copper-based cell and string connectors or ribbons. The expertise and equipment to produce flexible DC cabling for the junction box (and also for the PV field) is available as well as the technology and equipment to injection mould and assemble the actual junction box. The local production and supply of the raw materials needed for the PV module production is contingent on demand from local PV manufacturers which is in turn dependent on demand for locally manufactured PV modules. Meeting the demand for the requisite raw materials will commence immediately on the demand arising given that the productive capacity and technology already exists.

**Does a local South African manufactured module causes an increase of the electricity price?**

The solar PV costs per kWh generated, the so-called technical kWh costs of a PV installation, can be calculated with the input of the component costs, the sun hours as well as the depreciation period. Assuming a relative high cost of R20/Wp for the installed PV installation, an average South African solar radiation value of 2000 kWh/m²/y, a constant power output over a relative short depreciation period of 20 years, results in a technical kWh price of R0,50/kWh [6]. Assuming a 10% higher PV module cost, the installation costs will be R22/Wp and the resulting technical kWh price will be R0,525/kWh. In comparison the REIPPP tariffs are: R2,65/kWh, R1,65/kWh and capped R1,40/kWh for round 1, 2 and 3, respectively. Please note that statutory, legal, regulatory and other compliance costs need to be added to the technical prices when strictly referencing against the REIPPP tariffs. Although this is a simplistic calculation, it is obvious that there is some scope for increased PV module prices without any effect on the output cost of electricity. The R0,025/Wp based on the estimated 10% price increase of PV modules would probably be easily absorbed in the value chain of the PV Installation.

**Why 40% locally laminated?**

A limitation using local manufactured modules is necessary to create the necessary competition, to stimulate export and more important, to drive the local market. The combined production capacity of the three existing PV module manufacturers is assumed to be about 150 MW. Adding 100 MW for 2 announced newcomers, a total PV module capacity of about 250 MW could exist. In the REIPPP program an annual capacity of 400 MW till 2020 is stated and 40% of these 400 MW is 160 MW per year. The five local PV module manufacturers have access to these 160 MW, which leads theoretically to 32 MW for each manufacturer. These 32 MW will most probably cover the necessary production capacity utilisation, which leads to a healthy company finance structure. Note that the 32 MW are not a given, which provides the necessary national competition. The 40% will allow imported products, providing international competition and will prevent non-realistic high module costs. However, the most important and exciting outcome of defining the limitation around 40% is that the combined local PV module manufacturers have a spare capacity of 90 MW [7]. Since this spare capacity is needed to provide the necessary operating margins, the development of a private industrial, commercial and residential South African PV market will be strongly pushed and the REIPPP program fulfils its aim as the enabler of the local South African PV manufacturing industry.

**PV module production process and raw materials [9]**

A diagram of a crystalline silicon based PV module is given in Fig. 4. The PV cells are connected in series by soldering copper-based ribbons and subsequently embedded in a rubber-like encapsulant. This has a thickness of 0.4 – 0.5 mm and is based on a 72:28 co-polymer of ethylene and vinyl acetate (EVA), acts both as a “glue” to hold the complete module together and as a decoupling agent for the mechanical forces applied to the module. The front glass, with a thickness of 3.2 mm and tempered, is a highly transparent glass with a minimum amount of ferric iron, is an important component due to its longevity as well as the mechanical stiffness. The back sheet is a cost-optimised layer of environmental stable plastic foils with a thickness of 0.4 – 0.6mm and a poly(ethylene terephthalate) or PET core layer of about 50 – 150 μm. This layer is used as the electrical insulation. The junction-box acts as the power plug and includes the bypass diodes, as well as connector plugs.
that are important to minimise power losses. Finally, the aluminium frame contributes to the PV module’s stiffness and facilitates mounting.

The manufacturing process is shown in Fig. 5 and consists of the three main processing steps of electrical cell connection, encapsulation and sun simulation. The cell connection is performed by a tabbing and stringing process and determines the electrical output of the PV module. A non-optimal soldering process increases the resistance of the connection and results in a decrease of the power output. The encapsulation or lamination process combines the different layers of the module and determines its quality and life time. An optimal lamination process results in well-defined interfaces between the different materials. In both the tabbing/stringing as well as in the lamination process a careful management of the coefficient of thermal expansion (CTE) of the different materials is of utmost importance. A non-optimal cooling process in the lamination step induces stresses that eventually lead to de-lamination. The final sun simulation determines the power output and hence the economic value of the module. Solar spectrum match, pulse (or flash) stability as well as light uniformity are key to reliable values. Overrating the PV module power output will result in a bad reputation and hence business loss for the PV module manufacturer whereas an underrating will decrease the margins.

The main quality tests performed are the permanent visual checks, control of the electrical cell connection (dark current test), electrical performance of the cell grid (EL testing), lamination step (adhesion measurements and x-linking density if using EVA), junction box and frame mounting (wet leakage and ground continuity) and finally an EL and HiPot test to exclude post-lamination processing defects and to guarantee an electrically safe product.

The module manufacturing process is generally called a cell-to-module-conversion or cmc process. Alternatively, a laminate-to-module-conversion or LMC process is used (Fig. 2). In this LMC process, the PV module producer purchases a laminate and basically assembles this laminate to a module by mounting the junction box and the frame. Various reasons for the existence of this Lmc process can be given from quality and minimizing risks aspects seen by an investor, to fulfilling a minimum of regulatory requirements with securing a maximum of the production value chain “in-house” by a Tier 1 PV module manufacturer. The economic disadvantage of the LMC process is that the LMC process intrinsically increases the costs compared to a cmc process, due to an adaptation in the production process and mainly double handling. In the LMC process the electrical cell connection, EL testing, lamination and sun simulation is performed in factory 1, followed by packing and shipment of the laminates. In factory 2, an income control is performed which in general includes a visual control, sun simulation and EL testing of the laminate. After this income control the junction box is placed and the module is framed. The module is EL and HiPot tested and undergoes a final sun simulation before packing and shipment. The intrinsic cost increase results from the adaptation of the production process in factory 1 caused by the sun simulation of a laminate instead of a module and mainly from the additional packaging of the laminates in factory 1 as well as the double handling steps in factory 2. A PV module produced in an lmc process undergoes 2 additional sun simulations, 1 additional EL test and 1 additional packaging step, leading to an intrinsic and no value adding 5 to 8% price increase.

For completeness, it is mentioned that various thin film technologies exist to produce PV modules. Thin film technologies apply the electrical cell grid in several production steps direct on the glass substrate or superstrate. The initial investment in this production equipment is significant. The manufacturing process starting from the glass substrate or superstrate is basically similar to the crystalline silicon based PV modules starting from the lamination step. Due to the vulnerability of the unprotected electrical cell grid that is deposited on the glass, the further processing of the PV module is mostly performed in the same factory.

In summary, the PV module production process is thoroughly known and high quality PV modules can be produced locally in a certified production environment. A module assembly or laminate-to-module-conversion (lmc) intrinsically increases the cost price of a PV module without adding value. Hence, a module manufacturing or cell-to-module-conversion (cmc) process is favoured.

The commercial and business environment of a local PV module manufacturer

A typical local PV module manufacturer starts with a PV module capacity of about 30 – 60 MW per year. This local manufacturer
purchases the PV cells from significant larger PV cell producers and supplies the local installation industry and mainly large EPC companies. This section discusses this structure from the perspective of the local PV module manufacturers.

The crystalline silicon based PV module is a commodity product. Its design and technology is hardly changed in the last 30 years. The poly-silicon and hence PV cell prices significantly decreased since 2008/2009 [8]. The result is that the necessary optimisations in the module manufacturing process are basically completed. Hence, limited opportunities for further cost reductions exist in the current PV module technology. This would indicate that PV module prices are unlikely to significantly decline further in the near and medium term.

As in every commodity business, the PV module manufacturers have to focus on their core business and to manage their production, purchasing and logistics processes to perfection. This means that to produce in a commodity business, a production capacity utilisation of about 80% is required to cover fixed costs and the balance is needed to provide operating margins. An advantage of recently started manufacturers is the access to the latest technology is hardly changed in the last 30 years. The poly-silicon and hence PV cell prices significantly decreased since 2008/2009 [8]. The result is that the necessary optimisations in the module manufacturing process are basically completed. Hence, limited opportunities for further cost reductions exist in the current PV module technology. This would indicate that PV module prices are unlikely to significantly decline further in the near and medium term.

In summary, a PV module can be regarded as a commodity. A new and relatively small PV module manufacturer faces decreased margins due to economy of scale penalties, particularly in purchasing power. The small manufacturers do not have inherently higher production costs. Smaller PV module manufacturers lack the capital for a backward or forward integration and have to focus on an optimized production of the PV modules. A production capacity utilisation of about 80% is required. Market entrance is hampered by both the perceived risk to investors towards a new producer as well as the slightly higher priced PV modules.

References

[3] RFP volume 5 economic development requirements 2011.08.03.
[7] 400 – 160 = 90 MW

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