Statics – a missing link in PV projects

In general mounting components play a minor role across the PV sector as a whole. Most of the focus is on PV modules, electricity and annual yield. Compared to the key role of these components, this is somehow astonishing. Additionally, there are daring improvements, for flat-roofs for example, where there has been far reaching development over the past five years.

As the development of new components for pitched roofs has slowed down, the amount of damaged installations has increased. This leads on directly to the root cause and certainly won't be found in the lack of proper components.

Apart from inappropriate installation, in some cases, the lack of proper calculation of the measurements of the mounting components can be easily identified as the reason. There are a couple of reasons which explain this problem. One is historic, the German DIN, where only the calculation of fixations per m² was required. The result did not tell the installer precisely where to position them. Another one is that most planners and installers seemed to operate well estimating the type of fixation, rail and layout, based on their experience.

Today both EUROCODE and its national annexes and US Building Code require a detailed calculation of statics, but a huge number of planners are still estimating – which is a horrendous conception, as they are responsible for repair and indemnity.

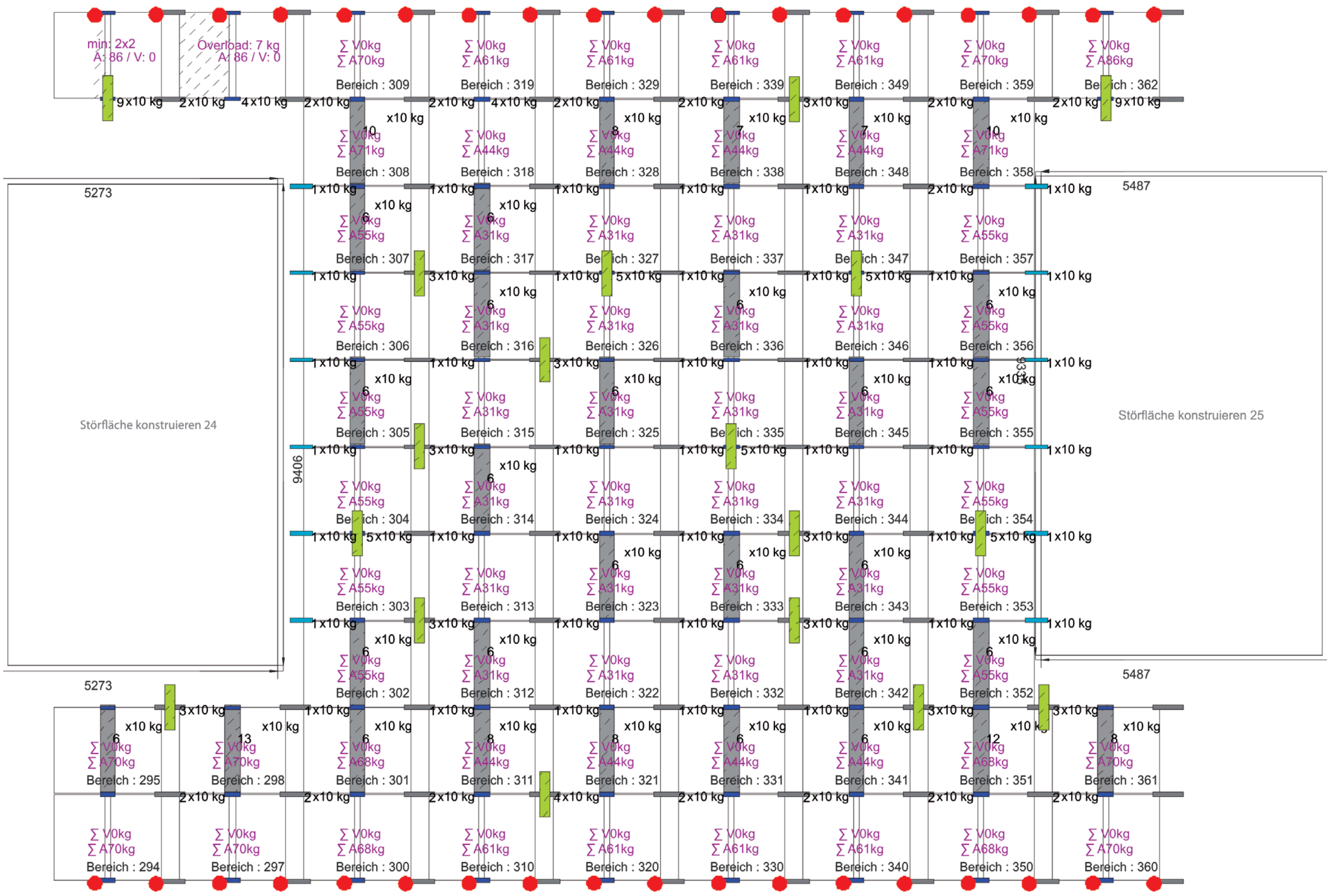
Keeping the residential sector in mind, having to repair just a small number of defected installations, could possibly financially ruin an installer. Imagine this on a commercial scale, with aerodynamic systems; each storm would be a nightmare for every installer.

As an installer or planner is not usually a structural engineer and as changes in project design need to happen quickly, reliable software and transparent visualisation, together with extensive project reports, are essential. The goal has to be to serve these demands as a kind of by-product of the regular project design process.

So, what does software need to take into account?

Some software vendors follow a generalisation approach, where rows are regarded as a static unity. Nature shows us that this is not accurate and thus not safe enough.

The only serious approach is to take each individual roof installation. The wind and snow forces have their effects on the modules, as individual parts of the installation. Depending on the location of a module on the roof, the forces will be



different. EUROCODE and US Building code define how these roof-zones need to be calculated, according to the dimension of the building, roof type and pitch of roof.

These forces need to be calculated, according to the project location and the national codes applicable to the project location.

The model takes in to consideration that the modules transfer these forces to mid- and end-clamps. The clamps transfer these forces to the module rails and then they are sent to either fixations or to cross-brace-connectors, when a cross-bracing mounting layout is in use. Then the cross-brace-connectors transfer the forces to the base rails, which then transfer these to the fixations. On pitched roofs the fixations are the last calculation point. The total result shows if the roof structure s capable of supporting all loads.

The verification for each component has to be done taking in to account it's position in the installation. The result of these calculations needs to lead to either the positioning or number of components or to the indication and visualisation of overload of single components. This gives the user the opportunity to change components, change layout or general design. In the end the installer or planner needs to have an 'all green' plan of the actual project.

On pitched roofs, a detailed calculation and visualisation for single layered projects or smaller projects might be a task for software, which can be run locally on a computer.

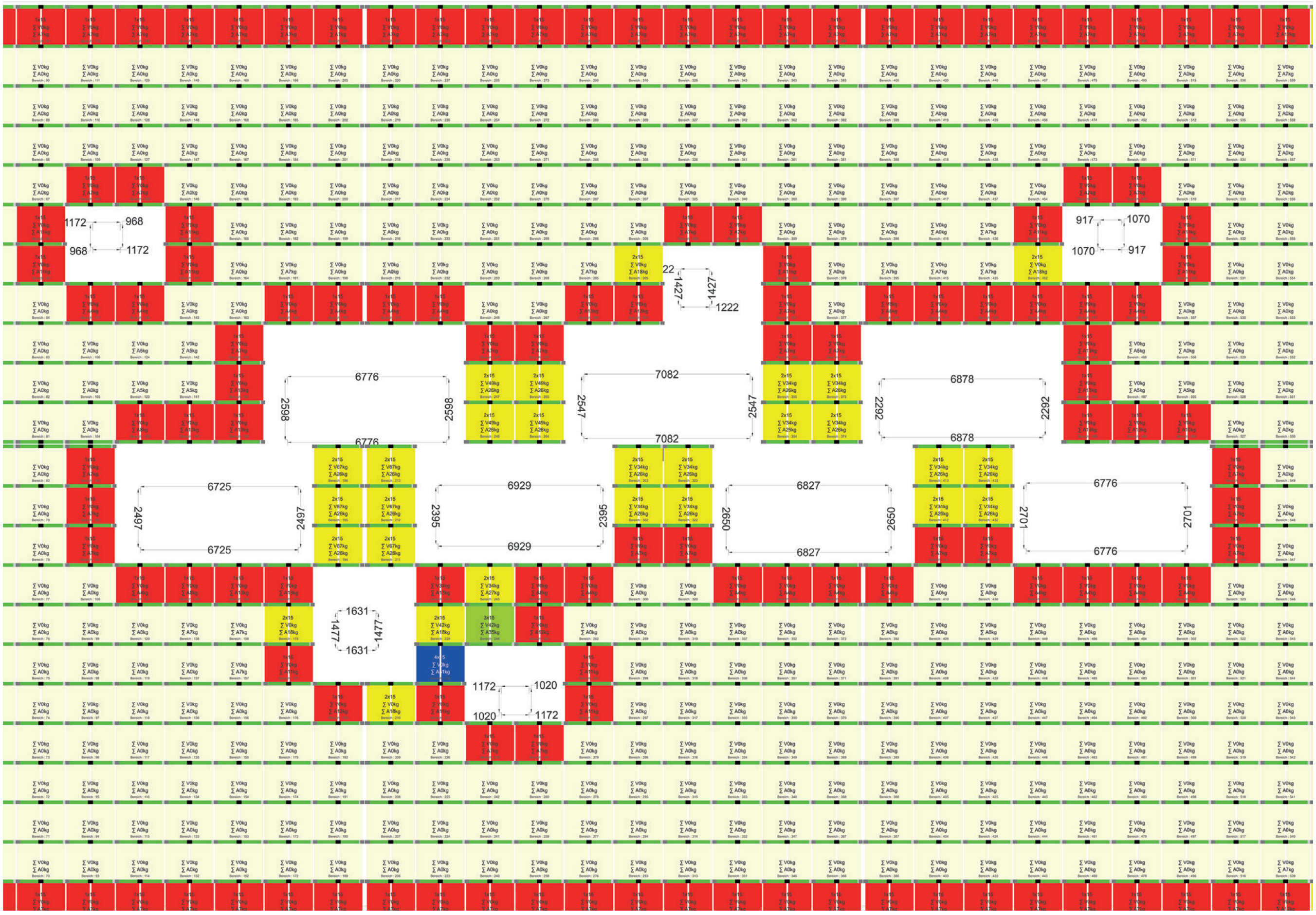
Larger projects and cross-braced layout lead to a significant higher amount of calculations, which should be done by up-to-date web technology topologies, as in this case the calculations will take on a multi-core server. Here, multi-threaded calculations on 48 or more processors will give results in a fraction of a second.

In contrast to mounting components for pitched roofs, where a physically penetrating connection is present, aerodynamic systems for flat-roofs are an example of innovation inside photovoltaics. Actually, it is the only installation on flat-roofs, without any penetration. Here, just putting ballast inside the mounting structure will prevent the installation from shifting or uplifting and flying off the roof.

Several institutes have wind tunnels where it's possible to measure the properties and behaviour when wind is applied. The results give amount of ballast, depending on project location, building dimensions, module location and number of modules connected to each other. Some years ago, the results defined just a few roof zones, where today the demands, due to higher needs, have compelled these institutes to find more differentiating approaches. More roof zones and the distribution of ballast to modules, which technically would not need any.

So, besides the high accuracy in calculating ballast for these installations – in order to prevent installations from sliding or from flying off the roof – today, the level of complexity has reached a level, where manual calculations, even using pre-scripted Excel, are impossible for a practical use.

The Austrian company Levasoft, with offices in Klagenfurt, offers the Solar.Pro. Tool and uses a unique approach to design



and calculate aerodynamic systems. Linear algebra with a highly efficient solver, run on a dedicated 48 core machine. A solver is a piece of mathematical software, which 'solves' a mathematical problem. General solvers typically use an architecture to decouple a problem's definition from the strategy used to solve it. (Wikipedia).

The linear equation is filled with constraints, parameters and demands. The mathematical content of this equation is then sent to the solver. Multi-million options, where ballast and what type of ballast needs to be placed in which specific locations are arise easily – even with smaller project sizes. Parallel calculation on 48 cores is done in just seconds.

A great benefit of this approach is that it also gives the user the option to include economic factors. How expensive is a ballast tray, purchased, shipped, brought on the roof, placed and filled with ballast? How about total costs, when different types of ballast are used, such as stones and different sizes of ballast-trays? Even physical fixations, their costs and static properties can used as a part of the linear equation. For example, in California, they have to be part, due to seismic reasons.

Another reason forcing a differentiated approach to calculation can be found on modern roofs. Calculation results of some wind-tunnel certificates, older than five years, will prompt the designer and installer to put more than 200KG ballast on each corner of a generator field. On many modern roofs this is just not possible. The building itself often has either a low total load reserve, a low point load reserve or its isolation is too soft to bear loads higher than 60 Kilo Pascal.

So, it can be regarded as an absolute matter of course, that planners should experience the proper, fast and differentiated calculation of statics as kind of by-product of their regular design-process.

Furthermore, meaningful operation and display of results should be implicit. The display of results needs to be transparent, because understanding a result automatically leads to proper installation and an adequate handling of changes, applied to either improve the installation or to just make it happen.

Solar.Pro.Tool offers all the points mentioned above. In addition, all calculation results can be part of the project report, just by pressing a button and by selecting the desired option. The fullest detail of structural properties and the calculation results are mandatory to put the planner, the installer and the customer in the best position, when it comes to reliability.

Public buildings are a special case. Here, before contract and build – in some areas, after the installation is complete – an independent structural engineer needs to re-calculate the installation, in order to give official approval. Having a highly detailed and meaningful project report will speed up the approval time and will also reduce costs.

The summary of all points – laid out above – leads us to say guessing times are over. PV projects nowadays are demanding the extensive calculation of statics, in order to meet required standards, to remain competitive and to be reliable. This can only be achieved by using a software, which is capable of giving statics as a by-product during the design process and which delivers almost any kind of output, transparency and detail.

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