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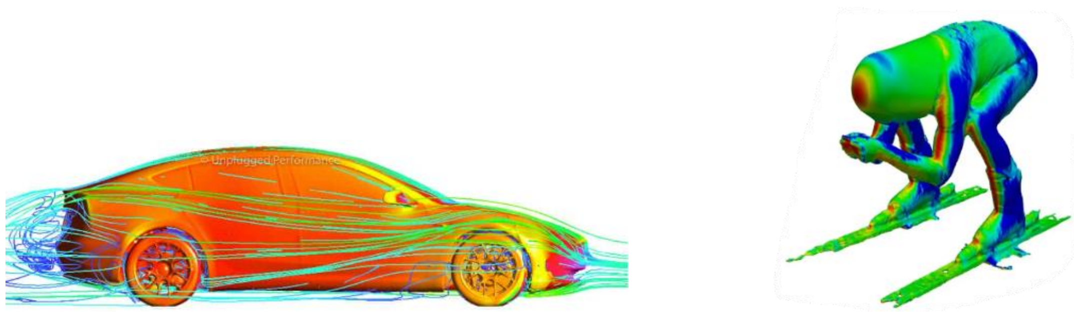
WIND DEFLECTION

BACKGROUND



Air flow visualizations from CFD analysis of automobile and alpine ski racer

Practical experience with wind forces provides a basic understanding of what makes an object more or less aerodynamic. The smooth contours of automobiles, the curve of airplane wings, and the tuck of bicyclists and skiers help these objects move through the air with less resistance. This improvement in aerodynamic performance is measured as a reduction in the pressure coefficient, a dimensionless number which describes the relative pressures around an object. The pressure coefficient is independent of body size – a fact that enables scale models to be tested in a wind tunnel[1].

For many commercial rooftop PV systems, pressure coefficients measured during wind tunnel testing, along with other parameters, determine how much resisting force is necessary to secure a PV array to a building. There is a strong incentive to minimize the amount of ballast

[1] As scale reduction becomes too large, it's impossible to fabricate and instrument the model because the feature sizes are too small. Scales between 1:15 and 1:40 are typically used for solar arrays.

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and/or roof anchors needed to achieve the lowest installed cost, i.e. the structural system (racking plus modules) should be as aerodynamic as possible.

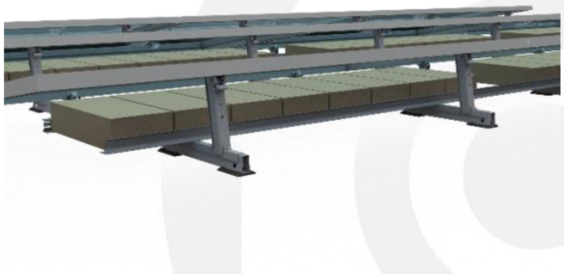
PROS AND CONS OF WIND DEFLECTION

Mounting system vendors strive to minimize the number of components in their products to keep total part cost as low as possible thus maintaining market competitiveness. Excluding wind deflectors is consistent with this hardware focused approach. However, for single tilt systems, it also results in significantly higher wind uplift forces. **Deflector-less rooftop racking products must employ more ballast and roof anchors than deflected systems. A well-designed deflector can reduce lift forces by a factor of 2x to 3x.**

A true 'systems' design process considers installation labor plus the cost of all items required to build a PV structure even if not sold by the racking vendor, e.g. ballast blocks, roof anchors and associated hardware. **While omitting deflectors reduces the 'base' racking hardware cost and some installation labor, the large increase of required ballast and anchor quantities and all the labor to install them results in higher total installed cost.**

PanelClaw has pressure coefficients for two, single tilt versions of its clawFRplus product including a fully commercialized, deflected system and an experimental version without deflectors. Both data sets come from the same 3rd party expert which enables a direct comparison without concern for methodology differences affecting the analysis.

Deflected clawFRplus System



Deflector-less clawFRplus System

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In the highest-pressure wind zone (near north roof corners), the deflector-less system's lift coefficients are 2.3X larger than the deflected system. In the lowest pressure zone (roof interior), the deflector-less system's coefficients are nearly 3X larger. In fact, many of the pressure coefficients for the deflector-less system match up quite well with coefficients found in ASCE 7-16 and 7-22[2]. This similarity is not surprising because the ASCE coefficients are based on many studies of rooftop mounting systems without wind deflectors generally matching the shape, size and height off the roof of solutions found on the market today.

At the risk of stating the obvious, PV arrays without a wind deflector will undoubtedly require more ballast and/or roof anchors to meet the ASCE 7 and International Building Code requirements. **If you are using or evaluating one of these products and find the vendor's calculation tools specifying similar ballasting and anchor counts to a wind deflected system, such as clawFR or clawFRplus, ask the vendor to justify the design. Better yet, ask a 3rd party expert to review and validate it or avoid it altogether.**

DEFLECTOR DESIGN PRINCIPLES

One way to minimize uplift forces is to completely block wind ingress beneath the modules, but this solution drives up component counts (cost) and causes another problem - increased module operating temperature. System designs that impede natural air flow to such an extent that it causes elevated temperatures beneath the module are unacceptable due to the resulting production losses.

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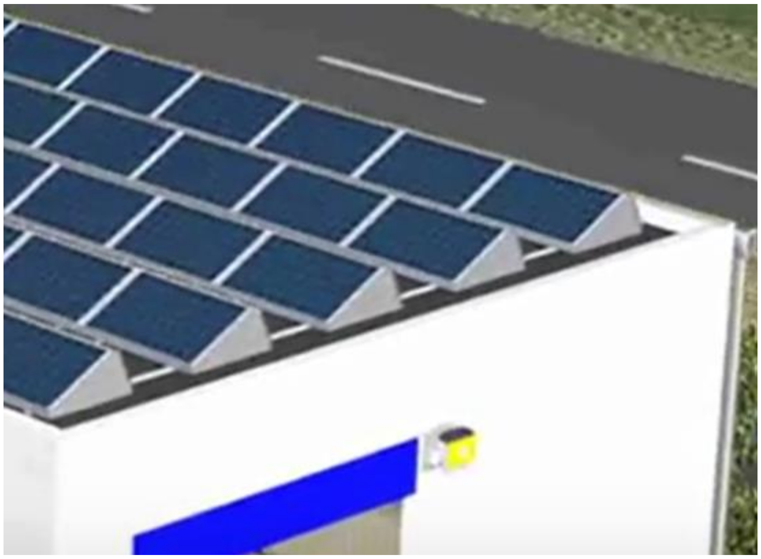
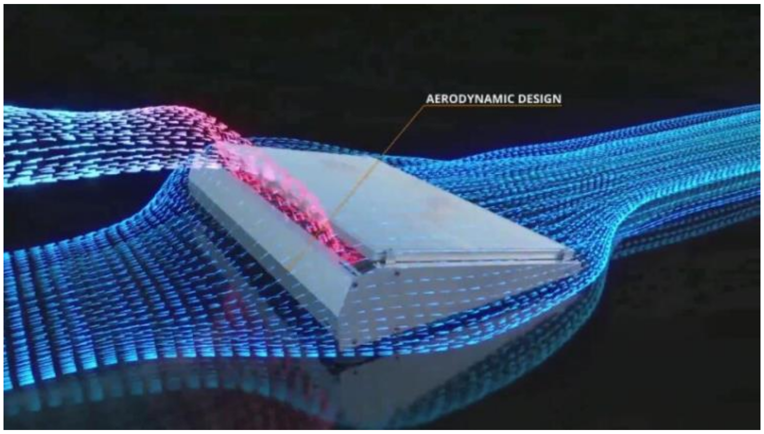
[2] ASCE 7-22 C29.4.3 Rooftop Solar Panels for Buildings of All Heights with Flat Roofs or Gable or Hip Roofs with Slopes Less Than 7 Degrees



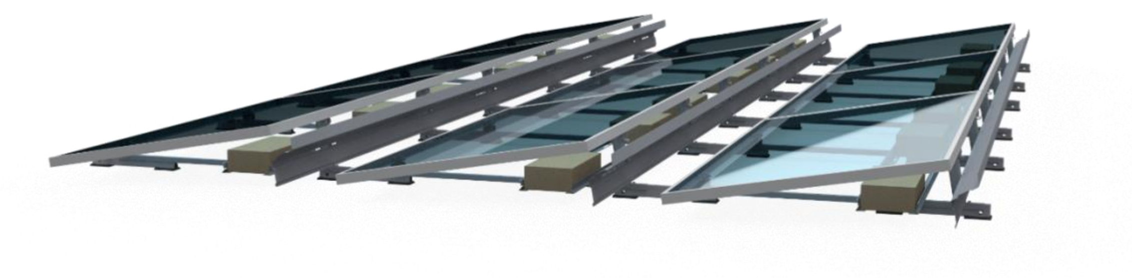
Enclosed system design example

In the video linked below, notice the gap between the top edge of the deflector and the high side module edge which serves to equalize pressure above and below the module thus reducing net uplift forces. All gaps between module, deflector and roof are important.



Video demonstration of air flow with equalizing deflector

The clawFR and clawFRplus system designs have a large gap between the top edge of the deflector and the module frame, as shown in the image below.



clawFRplus System

CONCLUSION

This article discusses several key principles important to solar structures for low slope (a.k.a. flat) commercial roofs. Some vendors offer mounting solutions with wind deflectors and others have deflector-less solutions. **First-hand experience with aerodynamics and real-world measurements in boundary layer wind tunnels proves that deflected systems have much lower pressure coefficients and therefore require significantly less ballast and/or anchors to resist wind loads.**

Be wary of racking vendors offering products without deflectors whose design calculations yield similar or lower ballast requirements than vendors with deflected products of similar geometry. PanelClaw's clawFR and clawFRplus systems use wind deflection to deliver the lowest cost, safe and secure installations.