Solar panels with sun position tracking system

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Abstract. This article presents the development of an automated system that includes a set of solar panels, which with the help of special drives and software orientates the position for maximum power generation. The development of drives is based on Dynamo software and Revit. The problem was posed to address the issue of global warming and reduce fuel consumption for electricity generation. Principle of operation of solar panels.

1. Theoretical statement of the question
Since the industrial revolution, the development of civilization was accompanied by the rapid development of machines and mechanisms, in parallel with which there was an increase in their energy consumption. The classic source of energy is fossil fuels. But such energy is generated with the release of harmful substances. In particular, a huge amount of carbon dioxide is released, which is the main cause of global warming. Therefore, at the moment, there is an acute problem of finding alternative energy sources. One of the directions in alternative energy is solar energy, that is, the production of electrical or thermal energy from solar energy.

Now technologies that consume solar energy are developing at a high speed. Such technologies include devices for generating photovoltaic - solar panels, which are associations of photovoltaic converters (photocells) - semiconductor devices that directly convert solar energy into direct current. In construction, this technology can be applied in the form of facade panels with solar panels. This design has already been implemented. But it does not use the full potential of solar energy. For maximum efficiency of the solar panels, it is necessary that the sun's rays are directed perpendicular to the surface of the panel.

2. Panel Design
Dimensions and shape. One of the main modern trends in architecture is bionics, which involves the use of complex curved shapes. Therefore, the panel is designed in the form of an equilateral triangle, because this shape allows you to repeat any curved surface.

The size of the side of the triangle is 3 m. The mass is calculated in proportion to the KSM-190 solar panel and is equal to 179.3 kg.

Two types of panels are being designed - with two movable vertices and with one movable vertex.

Telescopic lifts with a section in the form of a pipe are responsible for lifting the peaks. Section sizes were selected in the SCAD software and computer complex. Loads are collected according to the code of rules 20.13330.2016 “Loads and impacts”. The section is selected as a hollow thin-walled pipe with a wall thickness of 3.5 mm
Creating a model. Create an adaptive type model family in the template. In the properties of the grid, assign a type - triangles are flat. We set the parameter $a$, which will be the base of the triangle. Assign the size of the horizontal grid put two points at the vertices 2, 3 and set the offset to them. Then we connect the base points with the corresponding displaced points, put the points on these lines and give them a normalized curve parameter. We connect points 2 and 3, then put a point in the middle of the segment and connect it with vertex 1. Put a point on the straight line and set a normalized curve parameter for it and create a panel with telescopic racks in shape. The model of simple panel is on figure 1.

![Figure 1. Model of front panel.](image)

Building a wall. For example, take a wall with a small radius of curvature oriented to the east. To do this, create a shape-generating element and divide it into rectangles, into the nodes of which facade panels will be inserted. Scripting in the Dynamo visual programming platform, which comes in addition to Revit. You must specify the location of each panel on the wall and adjust the scale of the model points.

Figures 2-4 depict nodes for determining the coordinates of panel nodes, scaling them, and selecting one specific point from the set.

![Figure 2. Nodes for panel edge coordinates searching.](image)
In order to more correctly build the model, it is necessary to leave one of the three points of the panel in order to build a vector normal to the panel plane.

Setting the conditional sun, it is necessary to bind its model to the script responsible for the rotation of the panels under the beam perpendicular. It is also necessary to specify the nodes along which the angles between the normal vector to the solar panel and the sunbeam vector will be located. These nodes are on figures 5-6.

Figure 3. Nodes for scaling of model

Figure 4. Nodes for edge selecting.

Figure 5. Nodes for sun parameters.
Using this script, facade panels were designed that will generate a significant part of the electricity consumed by the building or structure. The use of this type of panels can increase the amount of generated electricity by 17%.

Figure 6. Nodes for searching of angles between vectors.

Figure 7. Nodes for angle listing.
So, the process of designing the facade panel was considered. It is clearly shown how modern technology, namely the use of parametric design, can accelerate the work of an architect and engineer. Equally important is the fact that this script can be applied to other types of panels by minor changes. This is one of the most important aspects of parametrics - it is not just the model of the object itself that is being built, but the logic of its construction. It is important to separately identify the degree of angles in degrees in the form of a leaf list. For this, a separate block of nodes is allocated, where the entire possible leaf corner is calculated between the sun and the panels which can be noticed at fig 7. Setting conditions, we refer to Vladivostok, where the height of the solstice above the horizon on the day of the summer solstice is 70 °, and the winter - 23.5 °. Therefore, the angle of inclination of the panel must be within the same limits. The conditions are presented in figure 8.

![Diagram](image_url)

**Figure 8.** Nodes under conditions for Vladivostok.

Using the node algorithm from the Dynamo software and the visualization part of the Revit software, we will reproduce the operation of the mechanisms for solar panels. The movement of the panels from 9 am to 1 pm with an interval of one and a half hours is shown in figure 9.
3. Conclusion
Using this script, facade panels were designed that will generate a significant part of the electricity consumed by the building or structure. The use of this type of panels can increase the amount of generated electricity by 17%.

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