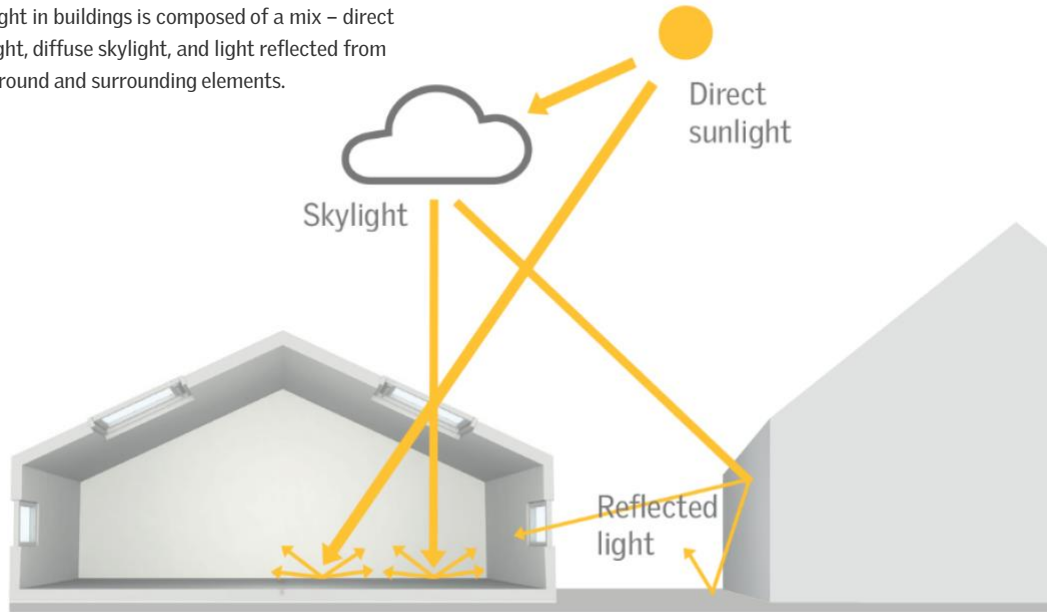


How to evaluate daylight

Daylight in buildings

Daylight in buildings is composed of a mix – direct sunlight, diffuse skylight, and light reflected from the ground and surrounding elements.



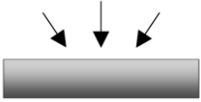
Direct sunlight is characterised by very high intensity and constant movement. The illuminance produced on the surface of the earth may exceed 100 000 lux. The brightness of direct sunlight varies by season, time of day, location and sky conditions. In a sunny climate, thoughtful architectural design is required, with careful management of allowance, diffusing, shading and reflecting.

Skylight is characterised by sunlight scattered by the atmosphere and clouds, resulting in soft, diffuse light. The illuminance level produced by an overcast sky may reach 10 000 lux in the winter and as high as around 30 000 lux on a bright overcast day in the summer. In a cloudy climate, the diffuse sky is often the main source of useful daylight.

Reflected light is characterised by light (sunlight and skylight) that is reflected from the ground: terrain, trees, vegetation, neighbouring buildings etc. The surface reflectance of the surroundings will influence the total amount of reflected light reaching the building facade. In some dense building situations, the light reflected from the ground and surroundings can be a major contributory part of daylight provisions indoors

How to evaluate daylight





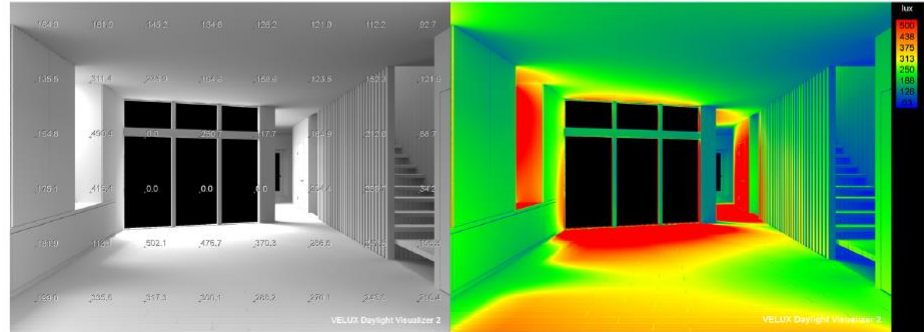
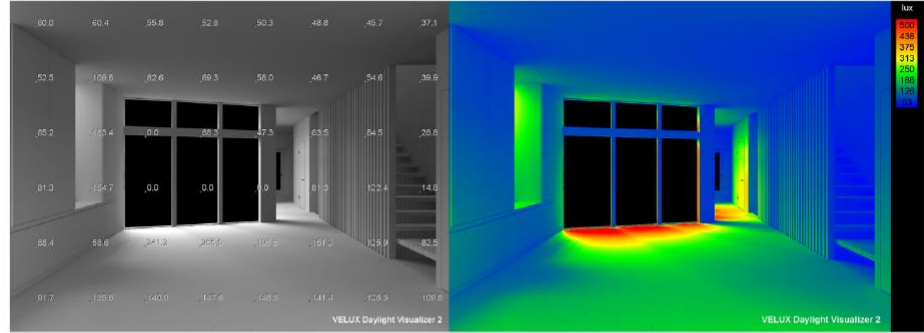
Illuminance

Illuminance is the measure of the amount of light received on a surface.

It is typically expressed in lux (lm/m²).

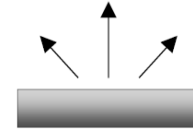
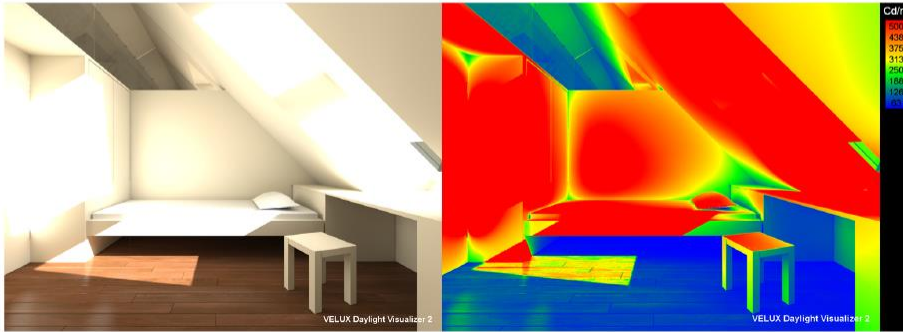
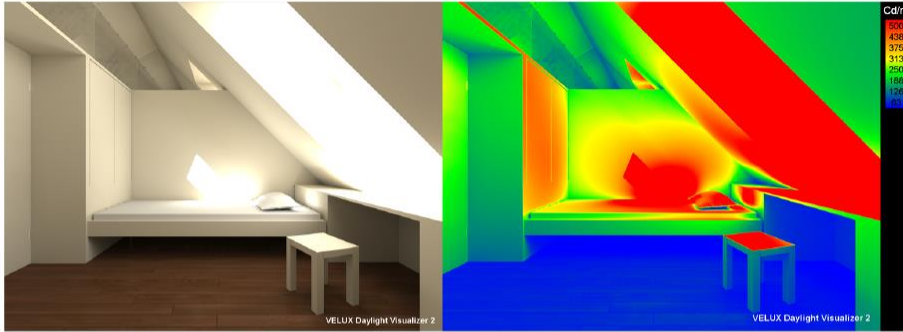
It is the measure of light currently used by most performance indicators to determine daylight availability in the interior.

Typical illuminance values:	
Direct sunlight	100000 lux
Diffuse skylight	3000 – 18000 lux
Minimum levels for tasks and activities:	
Residential rooms	200 – 500 lux
Classrooms (general)	300 – 500 lux
Workspace lighting	200 – 500 lux



How to evaluate daylight





Luminance

Luminance is the measure of the amount of light reflected or emitted from a surface.

It is typically expressed in cd/m^2 .

It is the measure of light used to evaluate visual comfort and glare in the interior.

Typical luminance values	
Solar disk at noon	1 600 000 000 cm/m^2
Solar disk at horizon	600 000 cm/m^2
Frosted bulb (60W)	120 000 cm/m^2
T8 cool white fluorescent	11 000 cd/m^2
Average clear sky	8 000 cm/m^2
Average cloudy sky	2 000 cd/m^2

How to evaluate daylight



Daylight measuring devices



Illuminance levels can be measured with a luxmeter (shown below) or predicted through the use of computer simulations with recognised and validated software (e.g. VELUX Daylight Visualizer).

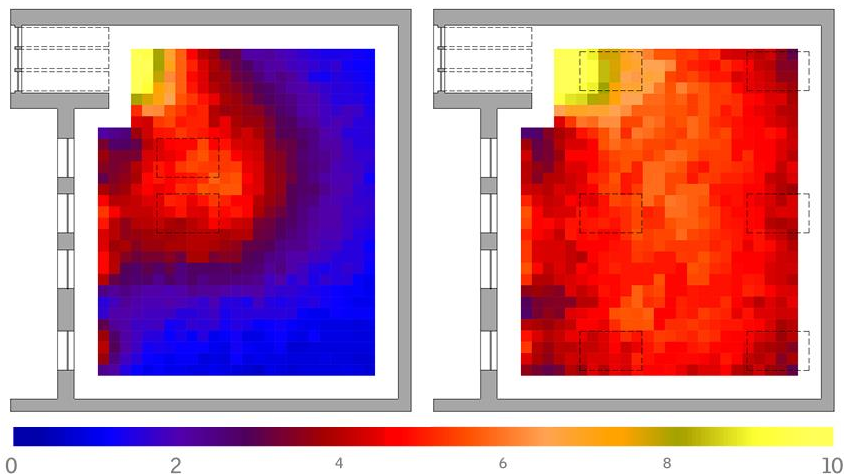


Luminance levels can be measured with a luminance meter (shown below), through the use of high dynamic range (HDR) imaging techniques together with digital camera and luminance mapping software (e.g. Photolux) or through the use of computer simulations with recognised and validated software (e.g. VELUX Daylight Visualizer).



How to evaluate daylight





Average DF	2.75%	Average DF	5.06%
Median DF	2.30%	Median DF	4.09%
Uniformity Dmin/Dav	0.15	Uniformity Dmin/Dav	0.49

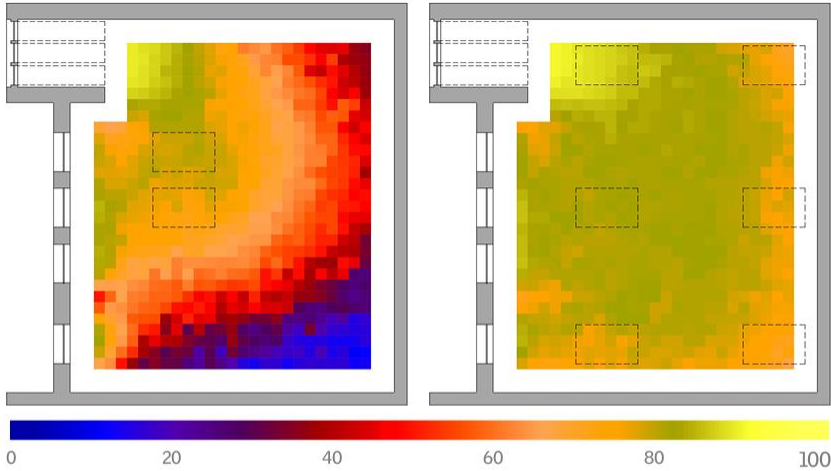
Performance indicator

Daylight factor (DF) is a daylight availability metric that expresses the amount of daylight available inside a room (on a work plane) compared to the amount of unobstructed daylight available outside under overcast sky conditions.

The higher the DF, the more daylight is available in the room. Rooms with an average DF of 2% or more can be considered daylit, but electric lighting may still be needed to perform visual tasks. A room will appear strongly daylit when the average DF is 5% or more, in which case electric lighting will most likely not be used during daytime (CIBSE, 2002).

How to evaluate daylight





Average DA ₃₀₀	59%	Average DA ₃₀₀	82%
Mean DA ₃₀₀	63%	Mean DA ₃₀₀	82%
Uniformity D _{min} /D _{av}	0.14	Uniformity D _{min} /D _{av}	0.83

Daylight Autonomy

Daylight autonomy (DA) is a daylight availability metric that corresponds to the percentage of the occupied time when the target illuminance at a point in a space is met by daylight (Reinhart, 2001).

A target illuminance of 300 lux and a threshold DA of 50%, meaning 50% of the time daylight levels are above the target illuminance, are values that are currently promoted in the Illuminating Engineering Society of North America (IESNA, 2013), see section 1.9.4.

How to evaluate daylight



Simulation tool Daylight Visualizer

Users can perform quick comparisons between different scenarios such as window layout, pane properties, room surfaces, sky conditions, locations, orientations and more.

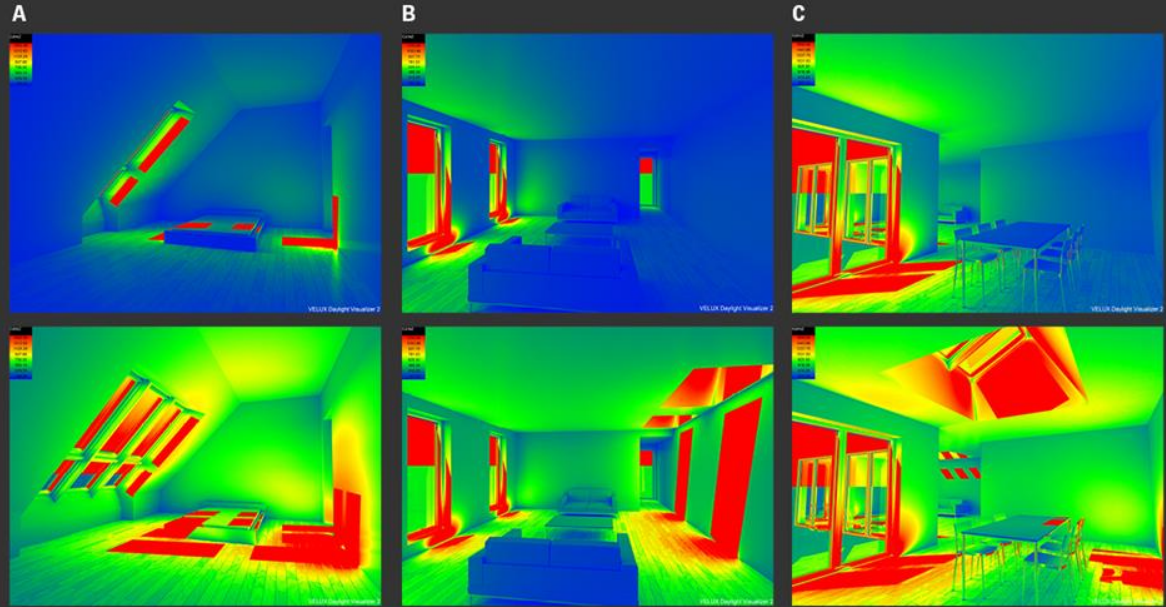


How to evaluate daylight



Simulation tool Daylight Visualizer

Users can perform quick comparisons between different scenarios such as window layout, pane properties, room surfaces, sky conditions, locations, orientations and more.



How to evaluate daylight



VELUX Daylight Visualizer rendering.



A picture from the house after construction.



Simulation tool
Daylight Visualizer

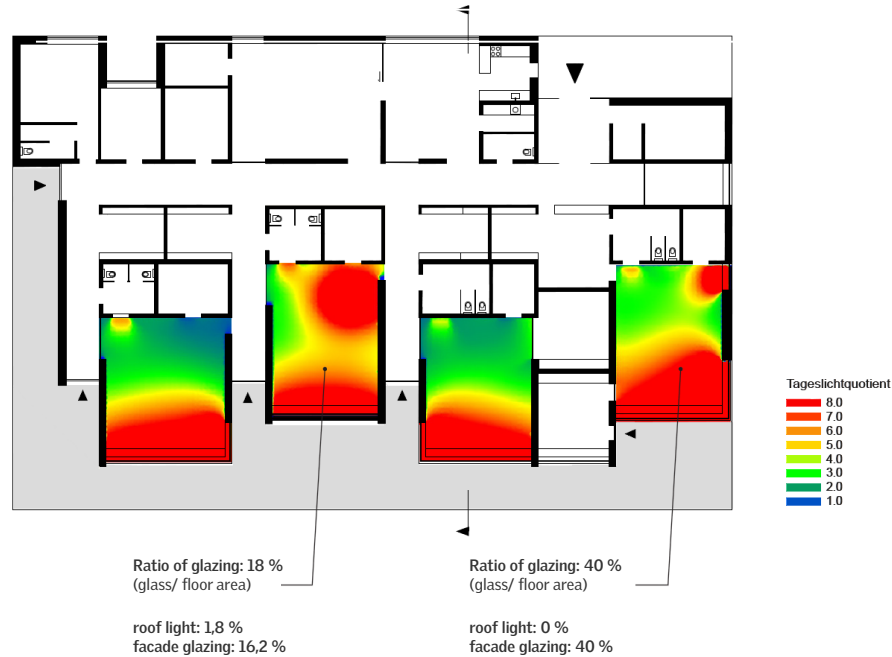
How to evaluate daylight



Simulation tool Daylight Visualizer

Bigger ratio of glazing does not automatically mean good daylight distribution in a room.

In this particular case, a combination of windows that provide a view out and a top light result in a better daylight performance in one of the group rooms, than it does with the double size of glazing area in the facade.



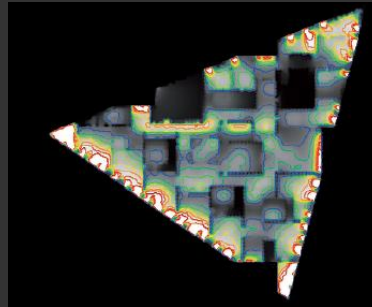
Kindergarten Neufeld, SOLID architecture, Austria
© SOLID architecture

How to evaluate daylight



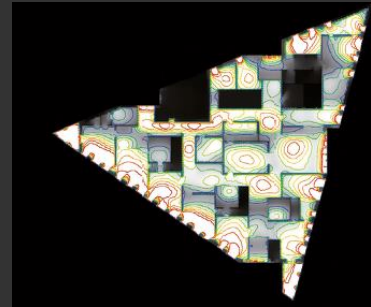
Simulation tool Daylight Visualizer

Design optimizations, Solhuset Kindergarten, Denmark



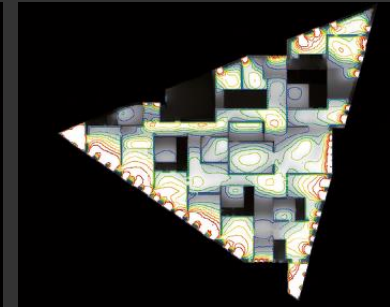
Initial design

The daylight conditions in the initial design are evaluated using the daylight factor (DF) performance indicator. The simulation shows the areas of the building where the light levels are not sufficient, such as the gymnastic room located in the central part and the dining room facing east (e.g. 5% DF instead of 2% DF). By contrast, it shows high light levels in certain areas which could be used better if re-distributed.



Revised design

A revised window layout is proposed based on the findings made in the first evaluation, aiming to reach adequate light levels in the central parts of the building. This new model also included angle openings of the window linings. The light levels obtained in the central part of the building and the dining room are much higher than in the previous model, ensuring that all the activity rooms have sufficient daylight.



Final design

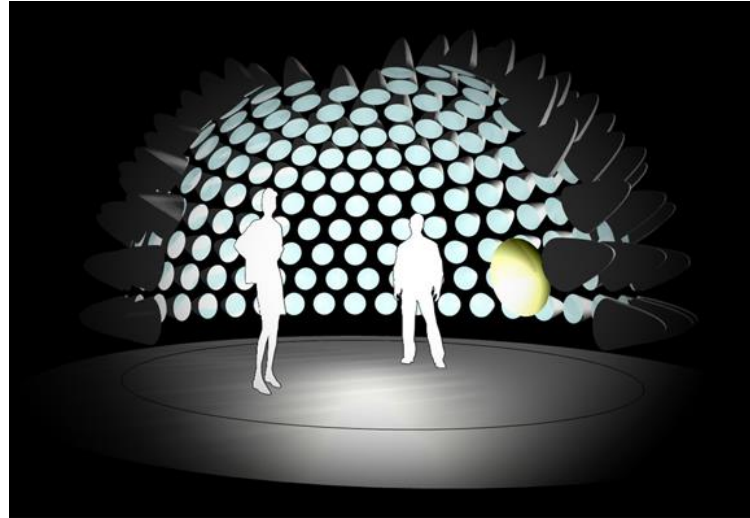
According to the architect, the number of windows and size of the window linings opening has been optimized in the final design to promote a more rational solution in terms of ceiling construction, while keeping a generous and good distribution of daylight inside the rooms. The daylight factor simulation of the final design shows a significant improvement over the results obtained with the initial design.

How to evaluate daylight



Artificial sky/ sun evaluation with physical models

Artificial sky accurately simulates external natural lighting conditions; those arising from the sun, sky and clouds and the reflections from the ground and nearby structures. It can do so for all weather conditions, seasons and locations.

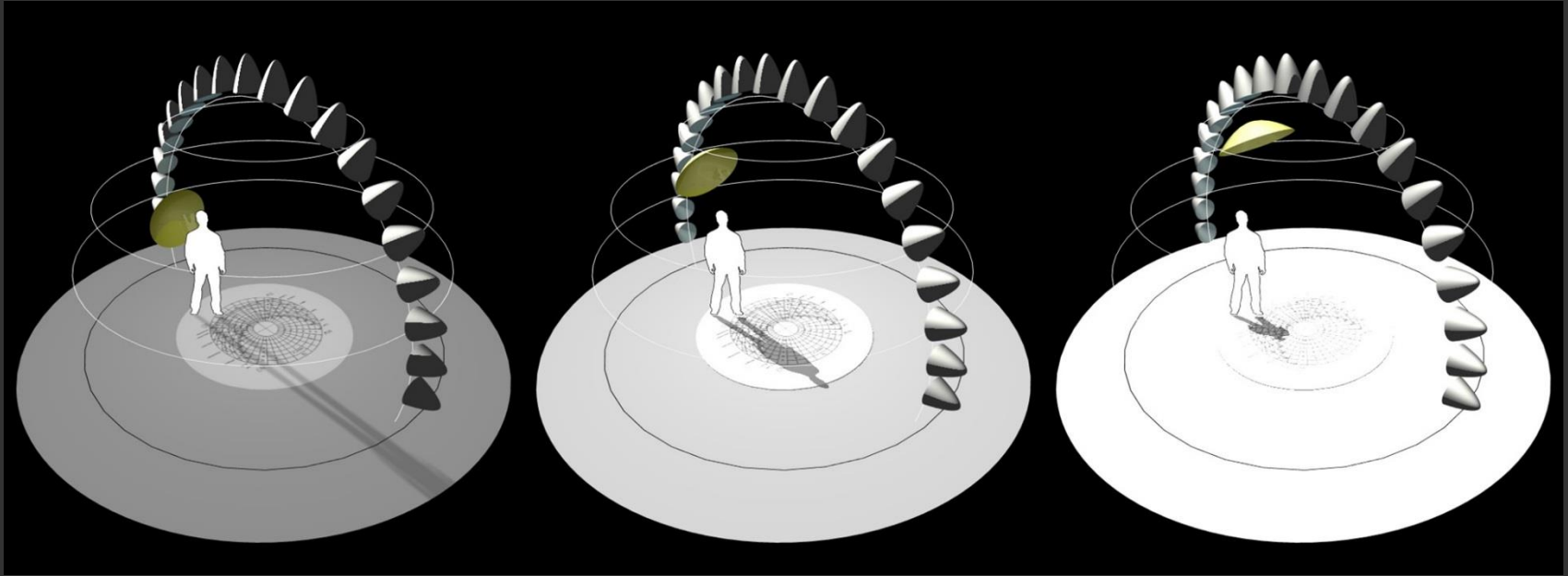


Artificial sky
© Danube University Krems



How to evaluate daylight





Artificial sky
© Danube University Krems

How to evaluate daylight



Artificial sky/sun evaluation with physical models



Model under artificial sky



Daylight in a model under artificial sky



Daylight visualizer rendering



Daylight in actual house

How to evaluate daylight





ReThink
Daylight

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