INSULATION POWER

Materials for Lessons on Mathematics and Energy Saving Literacy for grades 10-12

APEC-Tsukuba, 2017
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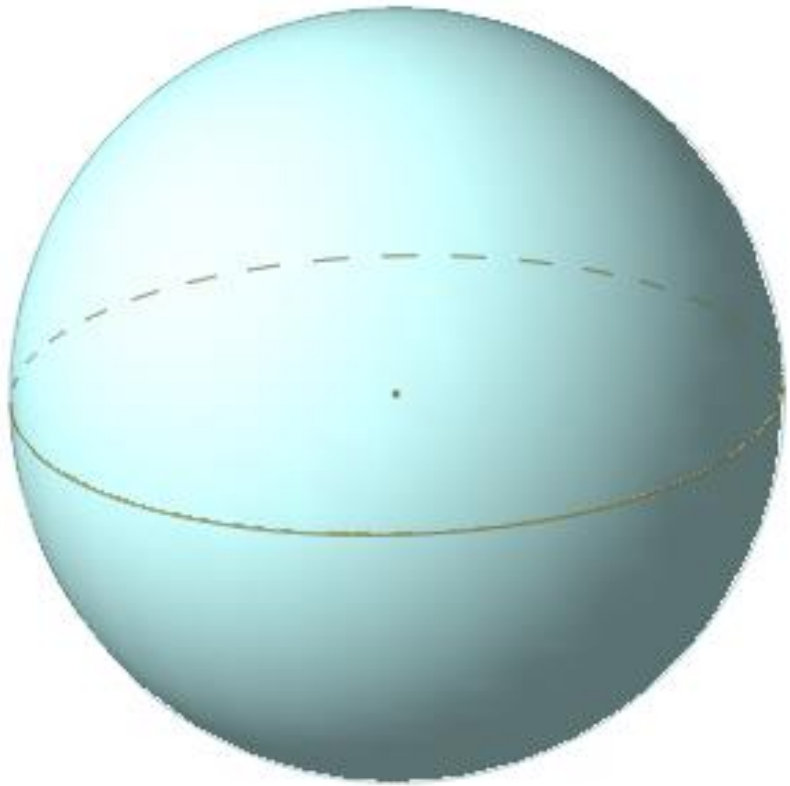
A piece of mathematics



The area equals

$$S = 4\pi R^2$$

A piece of mathematics

The total power of emission (output) equals

$$W = \sigma S T^4 = 4\pi R^2 \sigma T^4.$$

With

$$R = 6,95 \cdot 10^8 m,\ \sigma = 5,67 \cdot 10^{-8},\ T = 6000 K$$

we get:

$$W = 4 \cdot 3,14 \cdot 6,95^2 \cdot 10^{16} \cdot 5,67 \cdot 10^{-8} \cdot 6^3 \cdot 10^{12} =$$

$$= 4,46 \cdot 10^{26}.$$

A piece of mathematics

Assumed that the emission spreads uniformly in all directions (isotropicly) at the distance $d = 1,49 \cdot 10^{11}\, m$ from Sun to Earth we obtain the *specific insulation power* or the *Sun Constant:*

$$C = \frac{W}{4\pi d^2} = \frac{4,46 \cdot 10^{26}}{4 \cdot 3,14 \cdot 1,49^2 \cdot 10^{22}} \approx 1,6 \frac{kWt}{m^2},$$

which characterizes the flow of the sun energy through the unit of the surface near Earth in vacuum.

What follows from the fact the Earth has ‘Shape of a Tangerine’ and atmosphere?

The insulation is weakening when going through the air. The Air Mass coefficient is different for different areas and depends on the latitude:

$$k \approx k_0 \cos\lambda,$$

where $k_0 \approx 0,58$ is the coefficient for uppermost possible insulation in tropic areas.

For Moscow:

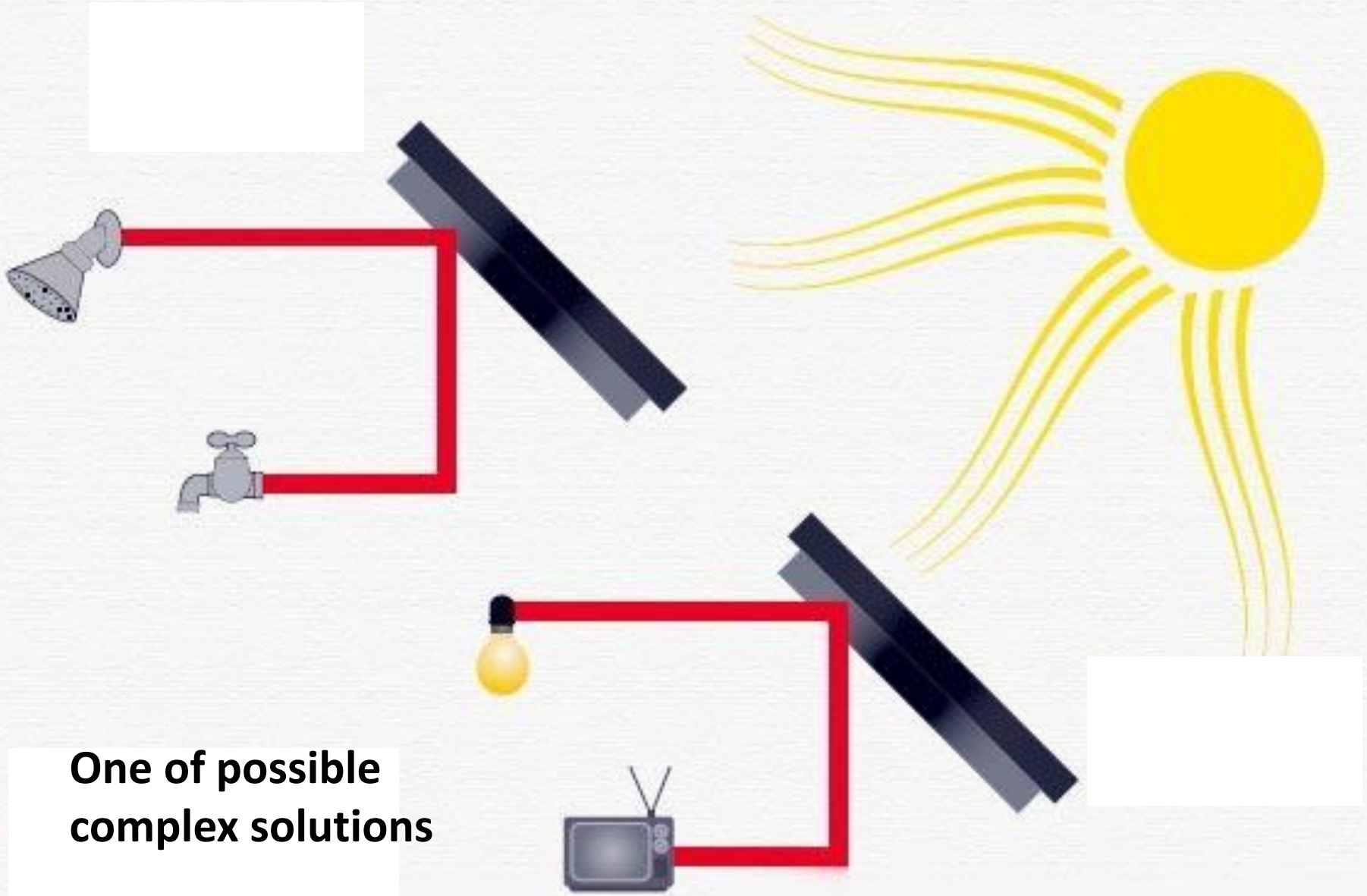
$$\lambda = 56°; \quad C \approx 1,6 \cdot 0,58 \cdot \cos 56° \approx 517 Wt/m^2.$$

Despite the fact some models can be useful, all models are wrong

All calculations are rough and averaged. We didn't take into account many effects:

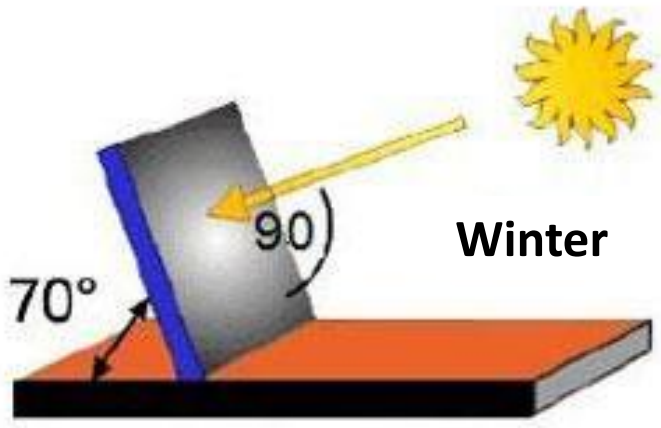
1. Pollution
2. Weather
3. Season
4. Earth axe's bias
5. Think what else can be you can only imagine
6. Think what else you can't even imagine

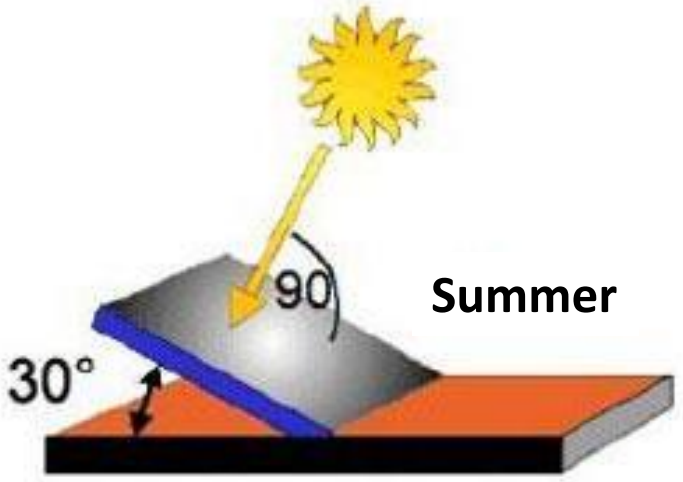

Потребитель
12В
Контроллер
Солнечные
батареи
преобразователь
аккум.
батареи
Потребитель
220В



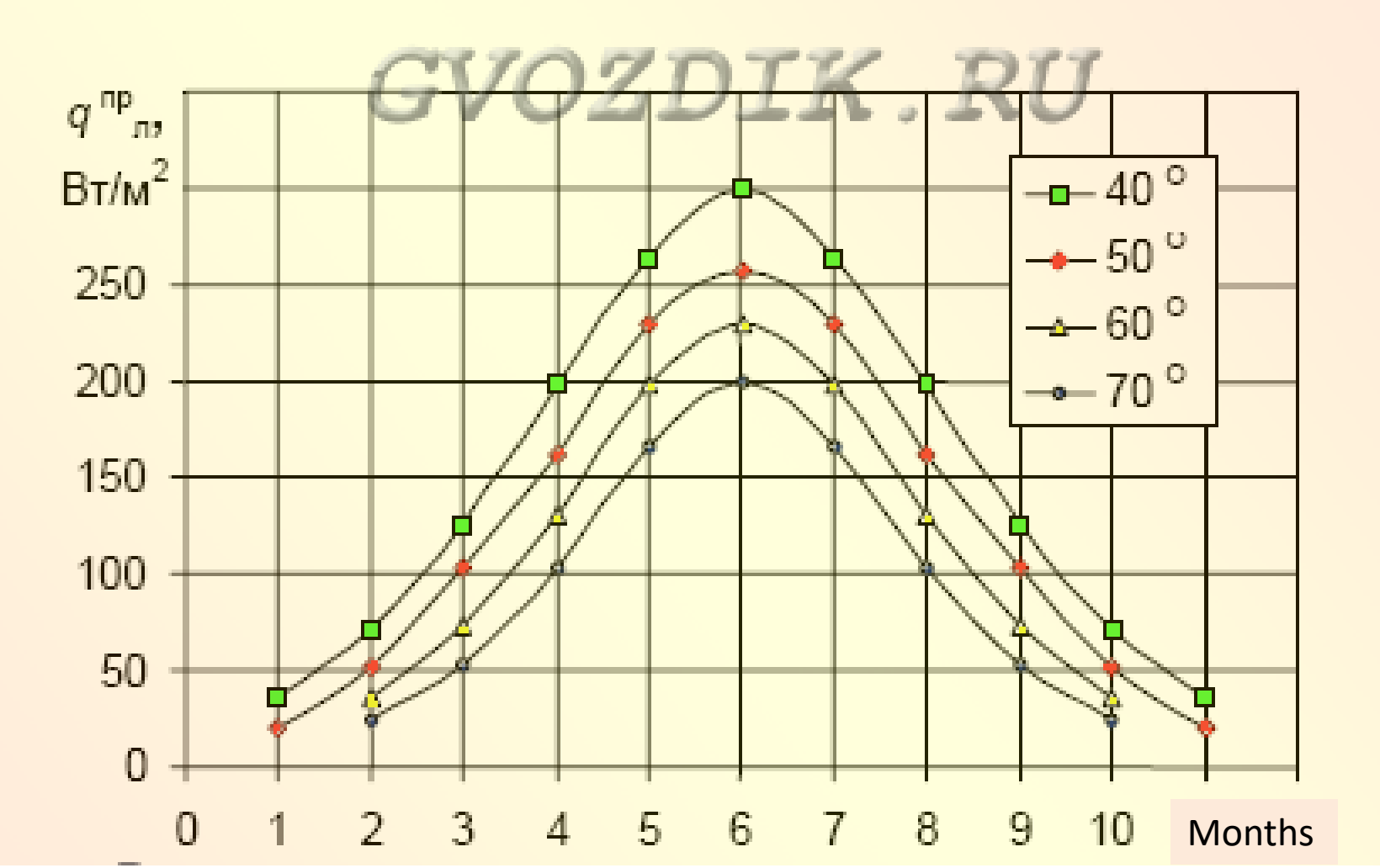
One of possible complex solutions

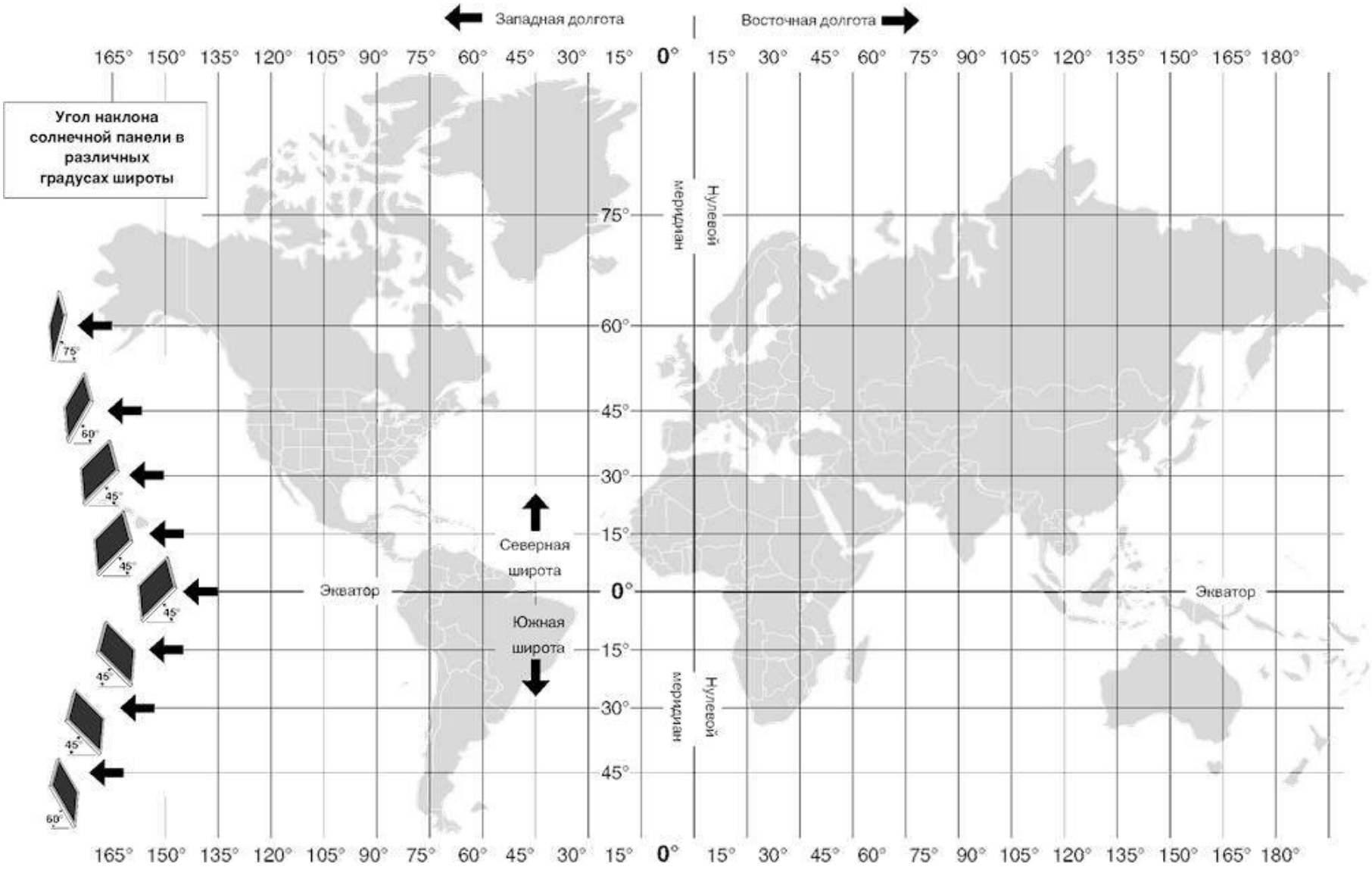
At least we can change the angle in order to catch sunrays better



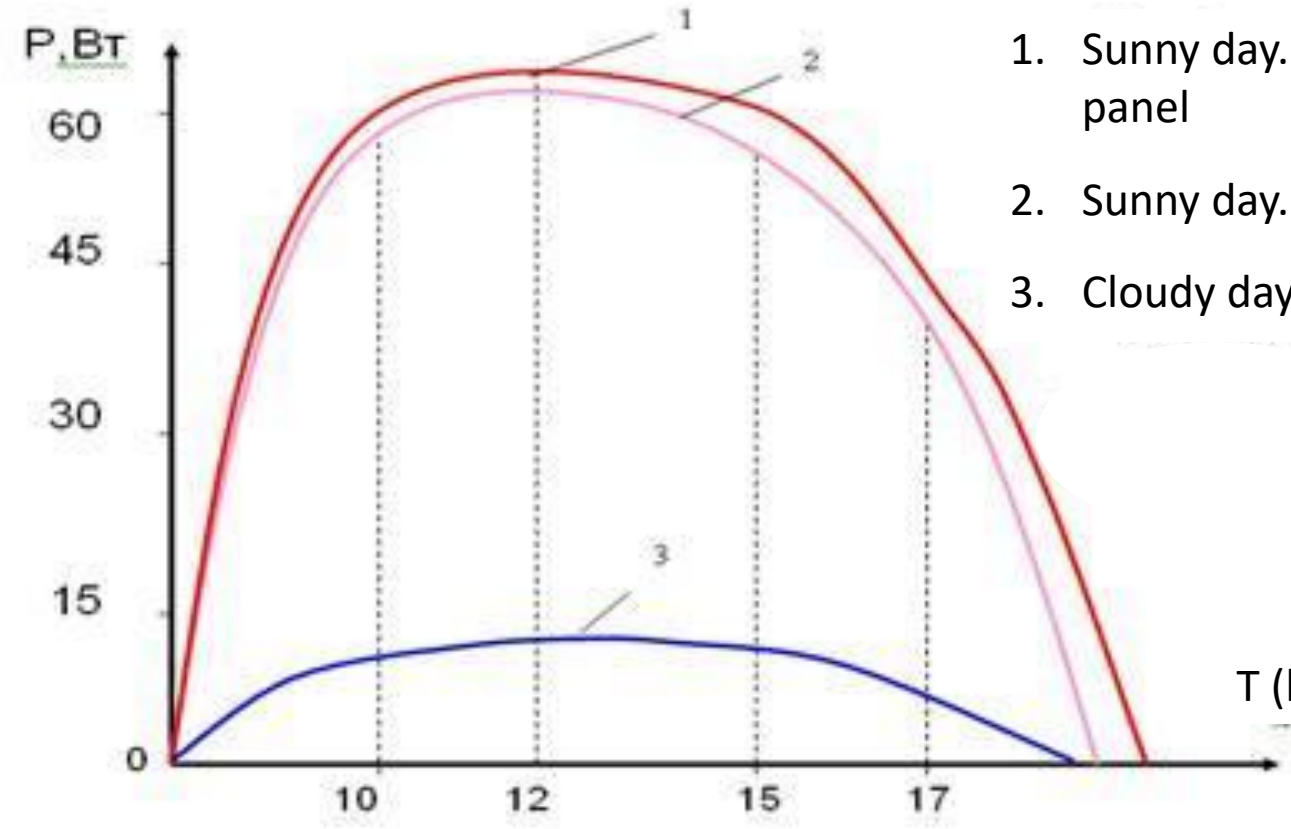


Insulation density distribution by seasons



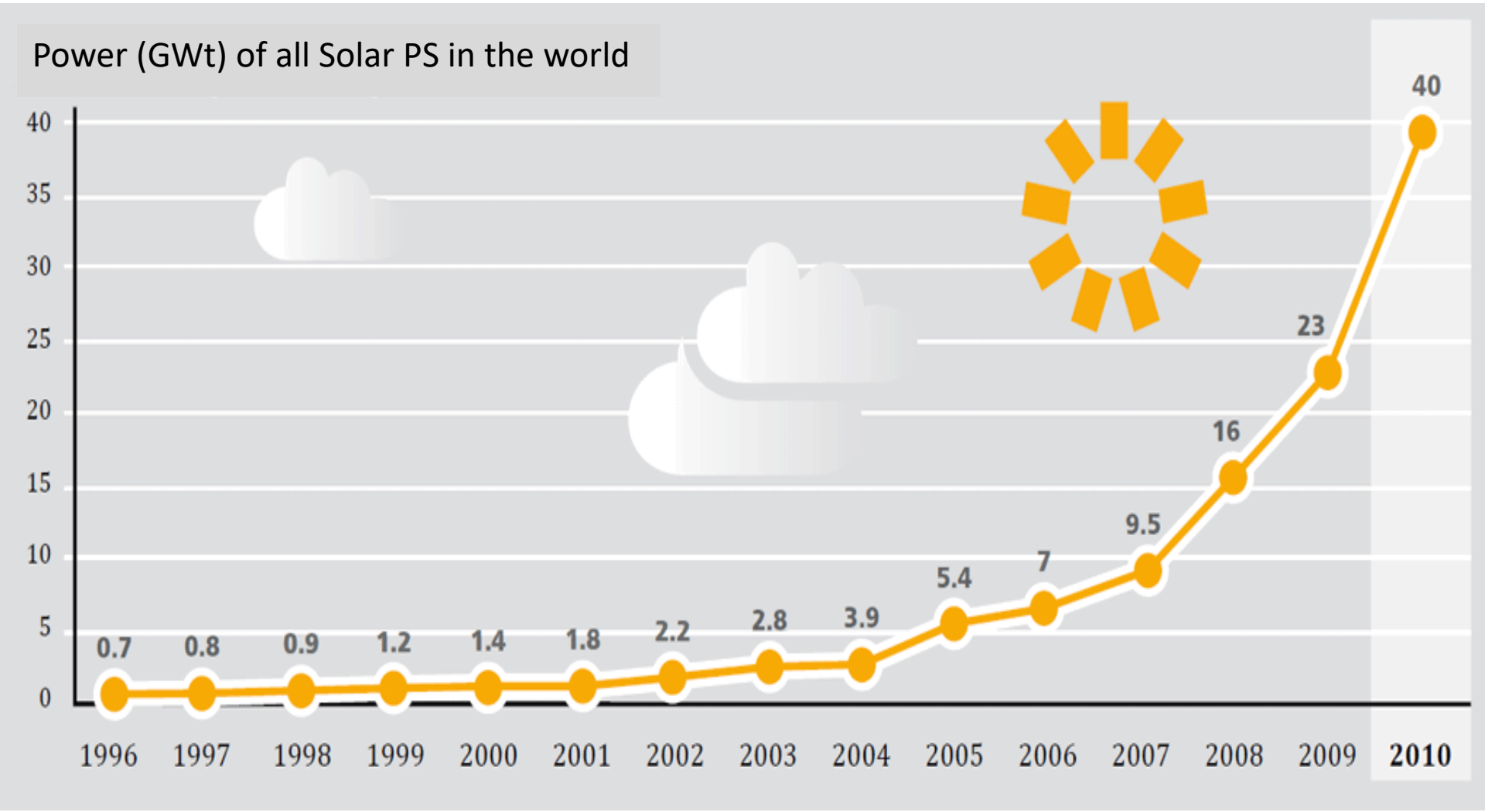

Западная долгота
Восточная долгота
165° 150° 135° 120° 105° 90° 75° 60° 45° 30° 15° 0° 15° 30° 45° 60° 75° 90° 105° 120° 135° 150° 165° 180°
Угол наклона солнечной панели в различных градусах широты
75°
60°
45°
30°
15°
0°
Нулевой меридиан
Северная широта
Южная широта
Экватор
Экватор
75°
60°
45°
45°
45°
45°
60°

Power – time relation for sunny and cloudy days



1. Sunny day. Oriented panel
2. Sunny day. Static panel
3. Cloudy day. Static panel

Development



Coefficient of efficiency

$CE_{SP} \approx 10-11\%$ (compare: $CE_{ICE} \approx 30\%$)

Theoretically can be increased to 22%. Engineers work hard on it.

So now if you have a house with the roof $200\ m^2$ tiled with solar panels you can theoretically obtain some about $12000Wt = 12kWt$ in ideal conditions.

In reality three – four times less. But this is a breakthrough in energy technologies.