SOLAR THERMAL COLLECTORS

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CARA ACADEMY

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The lecture focuses on the use of solar thermal collectors as an efficient way to harvest heat from the sun. It explains their operating principle, control, and how they combine with other heat sources in buildings. It shows practical installation examples and emphasizes quality materials, proper design, long service life, recyclability, and their contribution to energy self-sufficiency and climate-change adaptation.

.SUMMARY

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Motivation

- Solar thermal collectors convert solar radiation into heat with much higher efficiency than photovoltaics.
- They are suitable for heating domestic hot water, pools, and supporting low-temperature space heating.
- When properly sized, they can cover up to 50% of annual energy use for water heating.
- They reduce the load on the main heat source (e.g., biomass, heat pump) and protect the roof from overheating.
- The technology is proven, with long service life (collectors 40+ years; other components 10–12 years).

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Principle of operation

- The collector transfers heat via a non-freezing heat-transfer fluid to a heat exchanger in the storage tank.
- The system operates together with another heat source (boiler, heat pump, electric heater).
- Electronic control runs the pump based on the temperature difference between the collector and the tank.
- Once the set temperature is reached, the system switches off automatically—no risk of overheating or damage.
- Quality collectors are maintenance-free, resistant to high temperatures, and have zero fire risk.

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Application in practice

- Optimal yield: 1–1.2 MWh of heat per year from one 2 m² collector.
- For single-family homes: roughly 1 collector per 100 L of storage; tank volume = twice the daily hot-water use.
- Flat-plate collectors are more durable than evacuated tubes—less failure-prone, more resistant to snow and frost.
- Collectors can be installed vertically or horizontally, on pitched or flat roofs, or on façades.
- Key factors: robust anchoring, structural assessment, and roof pre-provisioning already during building design.

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Adaptation to climate change

- Collectors reduce building overheating—removing heat from the roof to the tank, thus cooling the environment.
- They are highly resistant to extremes (e.g., hail—tempered 4 mm glass).
- Made mainly from recyclable materials (metal, glass, mineral insulation) within the EU.
- They support local energy self-sufficiency and reduce the carbon footprint.
- They represent a long-term, reliable solution for sustainable buildings resilient to climate extremes.

.TRANSCRIPTION OF THE RECORDING

MOTIVATION

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Hi Miro, I came to tell you about solar thermal collectors—what they're used for and in which cases they are or aren't suitable.

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I approached it from the angle of why it's appropriate to install collectors: solar thermal has a substantially higher efficiency of converting solar radiation when used to heat media like domestic hot water, pools, and other loads, compared for example with photovoltaics. As you can see, the limiting temperature up to which that efficiency stays high is around seventy degrees Celsius. They can also be used to some extent for seasonal support of a low-temperature heating system. If we take an optimally sized solar thermal system for DHW heating, we can save about fifty percent of the energy the building spends annually on DHW. Solar thermal collectors are an ideal way to support biomass, since you can practically shut the biomass boiler down for half the year and the solar thermal system will cover the heat demand during the summer season. Another important aspect is the shading of the roof from solar radiation, which is

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beneficial especially in the summer months when the roof doesn't overheat. A great thing about solar thermal collectors is that you don't have to install the optimal system size right at the start—if you're financially constrained or for other reasons, you can expand the solar thermal system gradually. That's used mainly on larger installations.

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It's a proven technology that has worked for decades, and it's important to choose a technology supplier who guarantees the quality and long service life of the components. For your reference, the service life of quality solar collectors is on the order of forty years or more. That applies to the supporting structures the collectors sit on and to the metallic pipework. The service life of other components—such as storage tanks, pumps, or electronic controllers—runs around ten years or more, which is comparable to other components used in heating technology. And a key component is the solar heat-transfer fluid; it's replaced every eight to twelve years depending on how the solar system is used outside the summer period. We talked about service life. I'd also stress that there are different collector suppliers on our market—some higher quality, some lower.

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In our case we can guarantee the quality with a 12-year warranty, while the actual service life is of course much longer. If we compare solar thermal collectors with photovoltaics, we can extract more heat from a given roof area. So if you used a PV system to heat a medium, doing it with solar thermal collectors would yield roughly three times more heat than with PV. The collectors are very easy to recycle, since they're made of metals, glass, and mineral insulation. There's a minimal share of elements that are problematic to recycle. Most—or all—of the components are manufactured in Europe, which you can't say about photovoltaics. Likewise, in terms of legislation and permitting, it's simpler than PV. Regarding fire risk, the risk is zero with solar thermal collectors. In principle, a solar

PRINCIPLE OF FUNCTION

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thermal collector is a heat source; heat is then carried by a heat-transfer fluid that must be both antifreeze and non-toxic, and with the help of a pump it's delivered to a heat exchanger. The exchanger can be integrated directly into a storage tank—whether a domestic hot water tank or a heating water tank—or designed so that the exchanger is outside the tank body, in which case we talk about an external heat exchanger. In any case—whether the sun is shining or not—you always have hot water or heat, because the solar thermal system cooperates with an additional heat source such as a boiler, heat pump, electric heater, or district heating.

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Briefly on the control principle of the solar system: there's electronics that read the collector temperature (the heat source) and the temperature of the load, evaluate the temperature difference, and if that difference is sufficient, the pump turns on. If the difference decreases, the pump slows down; if it's insufficient, it simply turns off. We see the same thing in the next diagram. One of the functions is maximum temperature protection. That means no matter how hot the collectors get, once the temperature you set in the tank—say sixty degrees Celsius—is reached, the controller stops transferring heat from the collectors and they no longer heat the tank. This can mean that if the household is on vacation, the solar collector may overheat somewhat, which is absolutely no problem for quality collectors. I want to emphasize—there's a notion among the lay public

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that if you have solar thermal collectors, you have to cool them or they'll be damaged. This is not true: if the collectors are quality-made, they can withstand high stagnation temperatures and no such problem occurs.

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Let me say this—what you just said puts me in that category. I always thought when you wrote about the maximum temperature, you meant the maximum temperature of the collector, meaning it must be cooled during vacation time to prevent damage. And you're saying the opposite: if I set the maximum temperature in the tank, the collector itself won't be damaged even though its temperature—since the pump is off and no heat is being transferred to the tank—rises. So the collector literally doesn't care how hot the roof gets—what the temperature on it is. Right?

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That's right. If you have quality collectors, it doesn't bother them at all. If you invest in cheaper technology with less durability, then it can be a problem, so—

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The basic rule is: choose quality components that aren't bothered by high temperature.

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A solar thermal system lives its own life, and its control and operation don't have to tie into how the rest of the DHW heating system works—that is, the backup/boost system. You can have a building where a heat source has been heating DHW for years or decades, and you decide to add a solar thermal system. You don't need to interfere with the existing control system or DHW circulation. You simply add a solar thermal system and it will preheat the cold water; the final boost takes place in the existing system. In other words, the control system and other parts don't necessarily have to be interconnected.

APPLICATIONS

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In terms of the optimal number of collectors, we distinguish three types of systems: undersized, optimally sized, and oversized. As you can see in the graph on the left, increasing the number of collectors doesn't automatically increase the amount of energy saved per year. For a maximally optimal system, from one collector of two square meters you can harvest about 1.0 to 1.2 megawatt-hours of heat annually. If for some reason you decide to install more collectors—say because the price is favorable—don't expect a linear increase. You'll cover the spring and autumn periods, but in summer you'll have a certain heat surplus you can't use. Conversely, if we go down in collector count—say roof area is limited and you'd like forty collectors but the roof allows maybe

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twenty—it's no problem for the system, because fewer collectors will run at a lower temperature, since they can't heat the load fully over the day. However, a lower operating temperature for collectors also means higher conversion efficiency of solar radiation, so it will operate more efficiently. Looking at larger installations such as on an apartment building, a rule of thumb for sizing is: if you have a daily demand of 4,000 liters, then—if roof area allows—it's suitable to install forty collectors of two square meters each. The annual savings of such a system are around forty megawatt-hours. From that, based on your energy price, you can calculate the financial savings and then the payback. For single-family houses we size as follows: take the number of occupants and determine daily DHW demand. We multiply that

daily demand by two to get the optimal size of the solar-heated storage tank. For a four-person household, for example, daily consumption may be around 160 liters; times two, rounded, gives a ~300-liter tank, and for every 100 liters we add one collector of two square meters. That's a fairly large tank volume, so homeowners may be surprised why we install such a large tank. It's because it covers two days of demand: some water in the upper part was heated yesterday for today. And for the solar system we also need a kind of "empty battery," meaning the bottom part is cold and we charge it with solar for the next day. On the technologies available on our market, you'll encounter so-called flat-plate collectors and also tubular/evacuated-tube collectors. If you want technology with long service life, I'd definitely consider flat-plate collectors. Evacuated-tube

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collectors have been a boom of the last twenty to thirty years. They were presented as a hi-tech new product—something progressive—however, practice has shown that in our climate they tend to be failure-prone. For example, if gaps between collectors fill with snow in winter, which melts during the day and freezes at night, cracking can occur. Likewise, the vacuum that provides insulation in those collectors isn't as durable as it should be. As I said, if we want something that lasts for decades, let's focus on flat-plate thermal collectors. For architects it's useful to note what shapes are available. They're made either vertical—which is the most common installation since the cost of the support structure relative to installed area is lower—or, if for aesthetic or functional reasons you need horizontal collectors, those are available too,

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as you can see in the images.

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Let me ask: when I look at a collector, not every collector can be rotated horizontally or vertically depending on the orientation of the tubes inside, right? Meaning I need to know in advance whether I'll install it horizontally or vertically and order that type accordingly?

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Exactly—you buy a collector intended to be installed either strictly vertically or strictly horizontally.

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So it's not something we decide later on site how to mount it?

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That's not possible.

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Options for placing collectors on a building—roof, façade, or flat roof. For larger installations, collectors usually end up on the flat roof. There we consider how many collectors we need to place and whether there's enough space. In critical cases where we need to fit as many collectors as possible, an indicative figure: if we place two-square-meter collectors at a thirty-degree tilt, the minimum aisle or gap between the first and second rows should be at least one meter. Then, with the sun at a forty-five-degree elevation, it strikes all rows of collectors without self-shading. This is an extreme when roof space is scarce. If we have ample roof space, we try to increase the spacing—and that depends on whether we want to capture the low winter sun as well, or we're satisfied with strong spring, summer, and autumn

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sun. On pitched roofs we mount collectors either above the roof covering or integrate them into the roof skin. Most commonly they are mounted above the covering; on the left you can see various mounting brackets for different roof coverings.

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If the roof pitch is low, we can increase the collector tilt to raise energy yield. From an aesthetic standpoint that can be a problem, so we don't always use it and sometimes we sacrifice the extra yield to preserve the building's appearance. The key issue when mounting collectors on flat roofs is the method of safe, solid anchoring. Ideally, the load-spreading structure can be anchored directly into the roof structure, giving safe, rigid fixation. If that's not possible, we must rely on ballast. The amount and distribution of ballast on the roof must come from a structural assessment. In other words, you need a structural report; whether it's 100, 200, or 300 kilograms per collector is determined by the structural engineer. Here you see an example of a simple steel base frame. That's the ideal

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case when we got onto the roof in time and could anchor firmly into the reinforced concrete.

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Another anchoring option: again anchored into the solid part of the roof, with the load-spreading structure made of lighter cold-formed steel sections. In this case we had to bridge a roof that didn't have sufficient load-bearing capacity, so massive heavy steel profiles were used. And one more shot of the same installation. Collectors can be placed not only on the flat roof surface but also on the building façade.

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Let me ask one thing: on that façade it was always at a tilt. Would you recommend installing a thermal collector strictly vertical on a wall, or not?

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If there are aesthetic reasons for it, it's possible.

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So for purely aesthetic reasons—purely aesthetic?

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For purely aesthetic reasons, it's possible. We sacrifice some energy yield because the tilt won't be optimal, but technically it's feasible.

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When designing a new building, it's advisable to bear in mind that in the future some roof-mounted solar-harvesting technology may be added. It's good to have anchoring points already prepared during construction, so that later a load-spreading structure can be installed for either thermal collectors or another technology. That way we avoid additional drilling into the roof and compromising waterproofing five or ten years later.

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I think this is a very important point: the architect should really plan for the roof to serve other purposes—like cooling the urban environment via a green roof or producing energy from the sun. Even if it's not yet clear whether it will be PV or what ratio between PV and thermal—if such a system is chosen—one thing should be respected: some form of energy production will go on the roof. So prepare the roof in advance—even if installation happens again in five or ten years—so you don't have to drill through the waterproofing and anchor into the roof later; have it ready.

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You're right, although it's often done exactly the way you said it shouldn't be—most buildings still aren't pre-prepared. Another part of the pre-preparation can be creating sufficiently wide entries/openings for bulky tanks and other components necessary for the solar system to function. We also need to ensure the floor area has sufficient load-bearing capacity. And we'll need to create a route for the solar piping from the roof to the technical room.

ADAPTATION TO CLIMATE CHANGE

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ZIn terms of contribution to climate resilience, we're talking about a technology with long service life if you choose the right components. Compared with photovoltaics, it can harvest three times as much heat from a given roof area—

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So that's my note on the contribution to resilience.

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I'd say the word "resilience" is very important here. It's longevity—that forty years surprised even me. That's one type of resilience, but there's also resilience to extreme weather, which is one of the hallmarks of climate change—for example hailstorms. From what I know, flat-plate collectors are incomparably more resistant to this phenomenon than, say, tube collectors—by the very nature of their design, especially when they're well made. Right?

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That’s right. The key factor is the glass thickness. In our case we use 4-millimeter glass. It’s tempered glass with high strength. Many competitors, even in Western Europe, use thinner glass. So it’s happened more than once that after a severe storm with very large hail, the collectors were about the only thing on the roof (and greenhouses, etc.) left undamaged.

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There’s another point—the energy savings on building cooling. I like this point almost philosophically, in that a thermal collector actually transfers energy from point A (the roof) to point B (the storage tank). In that sense, it acts like a cooler: it removes energy from where we don’t want it—the roof—and moves it to where we do want it. So, logically, it takes away energy that would otherwise overheat the roof.

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Exactly—and if collector placement is chosen well, you can significantly reduce sun exposure on the areas you don’t want over-insolated.

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And not to mention—you said at the beginning of the presentation—that most components are made locally; by locally I mean Europe, yes?

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Yes—metals, glass, and some—

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So, recyclable materials?

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Exactly.

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And made locally, then.

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Exactly.

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Good—so now we have a situation where the architect, designer, or investor has decided to go for solar thermal collectors. What’s their step one? What should they do? Because there were several issues—for example, structural engineering—where advice is needed. What should be step one?

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It’s very simple. Most designers who design heating systems don’t do solar thermal system projects on an assembly line—it may be five percent of their total work. So you should turn to experts who do this essentially full-time. I’m not saying they have

to be designers; consultants will do. They'll direct you on what the solar system should look like in terms of size and what you can use it for.

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Thank you very much for coming.

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Thank you, too.