

# **Solixi products, hard- and software and services**

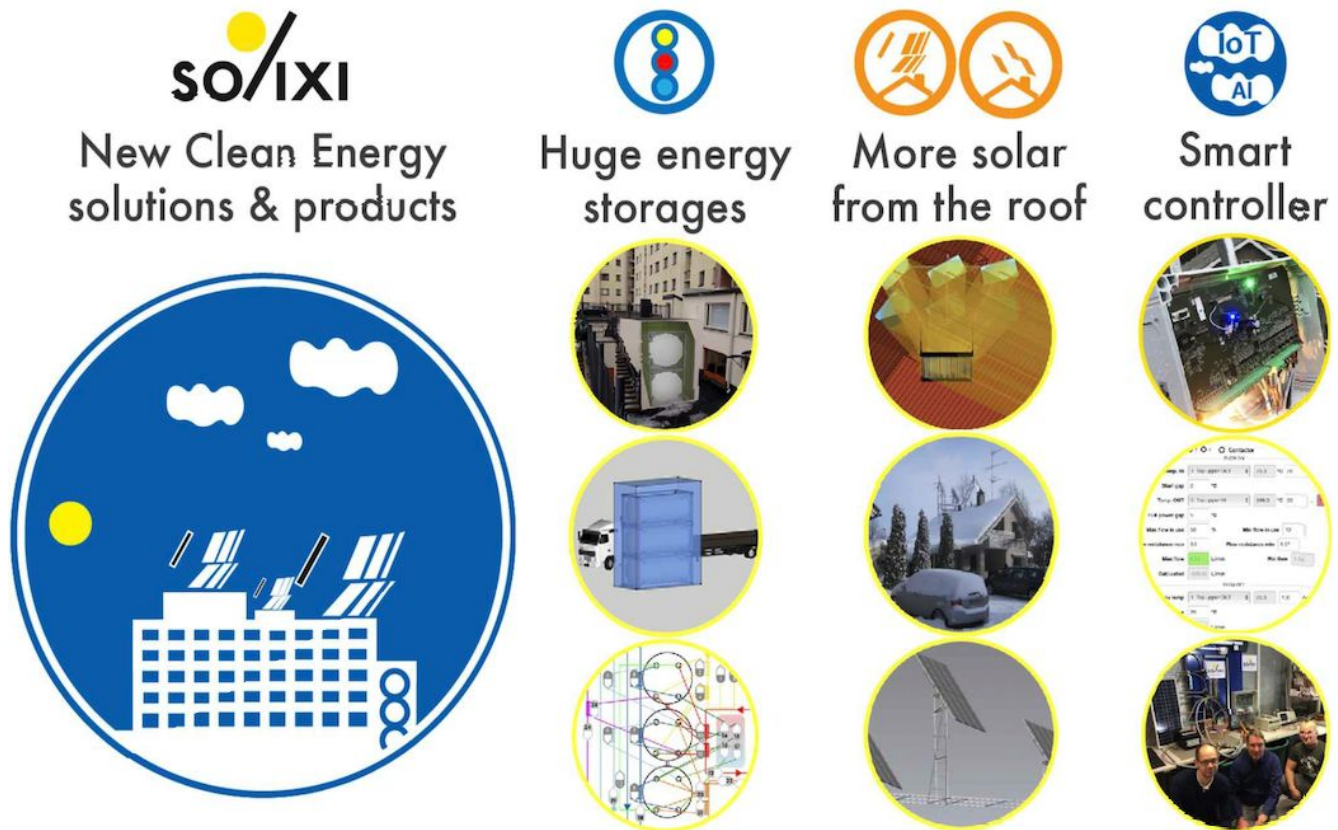
## **List of innovations, description, prototypes, images and TRL Technology Readiness Level**

Excellence - Implementation - Risks

## **Index**

- 1.1. Technical summary**
- 1.2 Innovativeness, the technological challenge**
- 1.3. Solixi Water Boiler**
- 1.4. Solixi Solar Concentrator**
- 1.5. Solixi Controller**
- 1.6. Solixi Solar Tracker Frame**
- 1.7. Solixi Thermal Collector**
- 1.8. Solixi Water Pumps, temperature sensors, secured heat circles**
- 1.9. Solixi manifolds and flexible hoses, installation**
- 1.10. Solixi Electric Resistor**
- 1.11. Solixi Heat Pump**
- 1.12. Air-to-Water heat pumps**
- 1.13. Geothermal Energy as seasonal storage**
- 1.14. Heat recovery, heat removal**
- 1.20. Solixi web calculator**
- 1.21. Solixi Control, security**
- 1.22. Steps planned to take Solixi system to the market, Serial production, Risks**

## 1.1. Technical summary



Energy system designer Solixi has created technologies that improve the performance of a building and city energy system; heating, cooling, energy storage and efficiency. It stabilizes the grid. It enables a profitable 100% emission free energy business.

**Technology and products** are simple, scalable and compatible. Solixi provides a fully emission-free energy system;

The large **MWh capacity Water Boilers** and tank containers and **TWh capacity thermal soil heat storages** simultaneously store cold and hot and give a 100 and 1.000.000 fold improvement in the storage capacity with increased volumes.

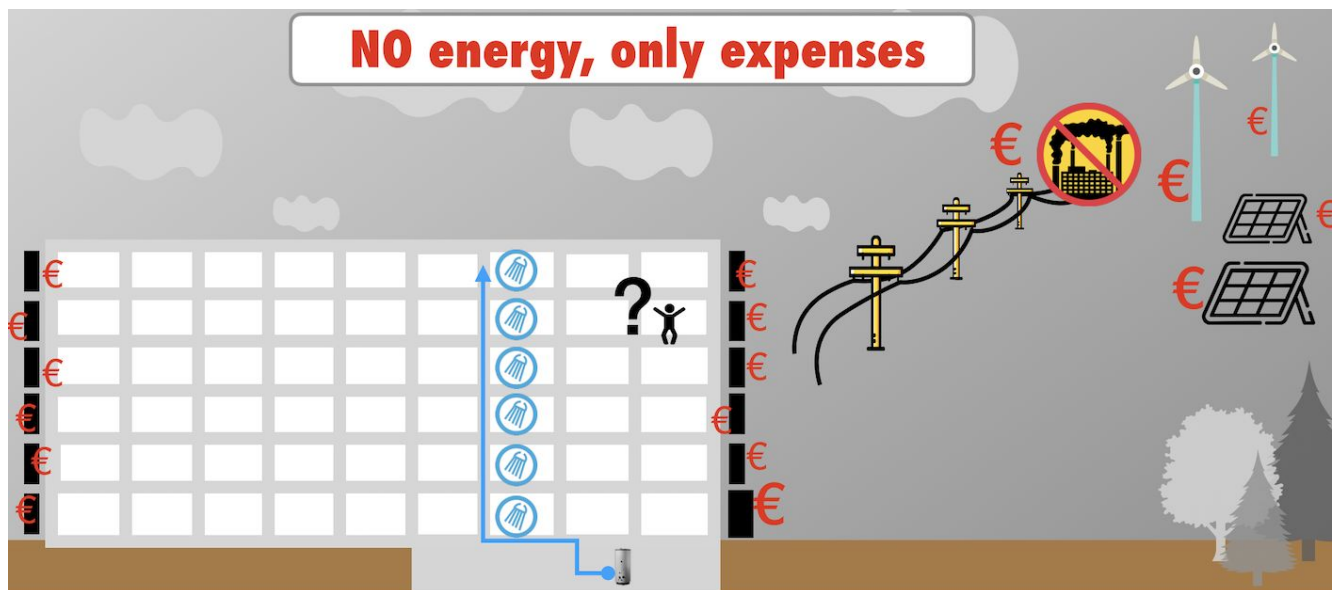
Solixi storage prices are only 3-15€/kWh compared to regular water boiler and electricity storage capacity prices 100-500€/kWh.

**Solar Concentrators** produce hot water and orientate rooftop solar collectors and mirrors towards the sun, enabling hot temperatures all day long during all seasons. Significant increase of energy production regardless of roof shape and orientation.

All solutions are steered by **AI & IoT Controllers**, which closely monitor timing, temperatures, weather and price of electricity and integrate electric resistors, heat pumps, heat recovery, cooling and other devices. Easy to connect to different Smart Cities solutions.

Strategy is to innovate, develop, [patent](#), license and bring to market products that enable a zero-emission infrastructure & cities.

## 1.1. Innovativeness, the technological challenge

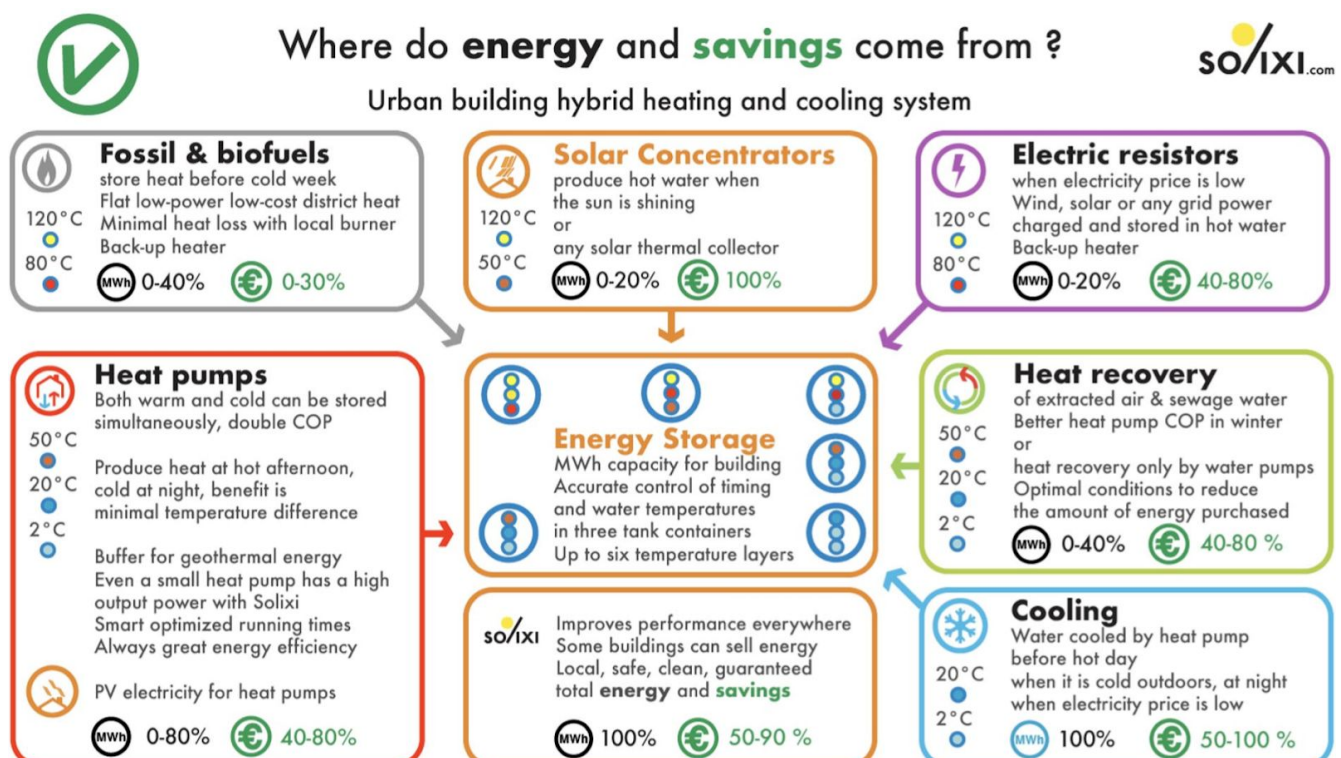


The key challenge and problem is (Image above); How to secure energy when the wind and solar power supply is low and consumption high? How to replace the control power that was previously obtained by burning fossil fuels and is no longer an option? How to get production to meet consumption? How to do it profitably? How to ensure the functioning of society and stop emissions in a few decades?

**These issues are key IF funding criteria.**

100% clean and sustainable urban heating and cooling has not yet been accomplished in any city.

Solixi has everything cities and societies need, a system level solution:



## Technological innovativeness

The solution is a hybrid system. In the table above, the total energy (MWh) is up to 220% and 100% is enough, so the most suitable options for each building can be selected (1.2.). When the system is smartly optimized with Solixi Controller, total annual savings are 50-90%.

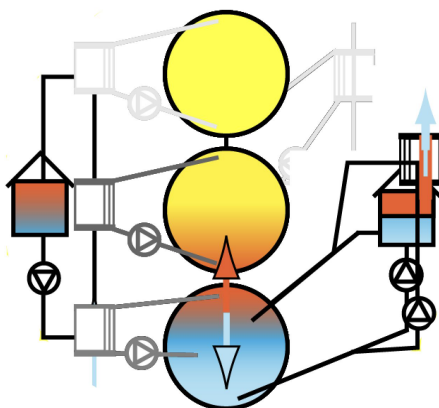
[5:20 min video to get a quick overview of the Solixi's Urban Building Energy Solution, click here.](#)

If a city has a district heating network, emissions, costs and emissions can be further reduced. Solixi's thermal soil heat storage eliminates seasonal variations with its terawatt-hour capacity.

[5:00 min video to get a quick overview of the Solixi's solution for cities \(case Helsinki\), click here.](#)

In the centre there is a huge water boiler, a **thermal energy storage** (1.3.). The water is heated and/or cooled by various devices like heat pumps and electric resistors that will change electricity (solar and wind) to thermal energy.

The old-school way is to heat water by **fossil fuels**, that can be at least partly replaced by **biofuels**. This is an option also in Solixi's solution, although it should be minimized. The widespread use of biofuels is not environmentally friendly. The old-school cooling method is an **air-to-air heat pump** and low energy efficiency in the middle of a hot day.



It is simple to heat water by rooftop thermal **solar collectors**. Unfortunately, the sun usually shines when the need for heating is minimal. Sun radiation is mainly heat and the efficiency is high. The energy yield and water temperatures will increase significantly by **Solixi's Solar Concentrators** (1.4.). Even weeks (months) of sunshine and thermal energy is stored in a large water tank (and soil). The rotating mirrors in the Solar Concentrator frame can be changed to PV panels, the result is **Solixi Solar Tracker** (1.6.). It enables efficient electricity generation from almost anywhere on the roof all day long.

**Electric resistors** (1.10.) easily heat water to hot temperatures. These are an obvious part of the system and are used when electricity price is low or even negative. Solixi has created an electric resistor that fits

perfectly into the system.

**Heat pump** is the most efficient method to convert electricity to heat. Heat pump is not an energy source as the sun is and the outcome is always both warm/hot and cold. Usually the other is wasted and removed. This does not have to be the case with Solixi, both can be stored and used when needed. All water heat pumps, old and new, are compatible with Solixi; Air-to-Water, Water-to-Water and Geothermal Heat Pumps. They all benefit from Solixi because runtime and temperatures can be optimized. Solixi has designed a heat pump that fits perfectly into the system. It dramatically lowers the cost of investment and brings more flexibility and new features that further improve efficiency (1.11.).

**Heat recovery** (1.14.) reduces the need for external energy. Huge water volumes and accurate control of timing and temperatures make the Solixi system very simple and affordable. Solixi can design and manufacture heat exchangers that fits perfectly into the system.

**Air conditioning and cooling** is vital because heat waves intensify. Solixi can store huge amounts of cold water to be used during the hottest moments of the day and secure affordable cooling.

**Solixi improves the performance of all these functions.** Each unit has optimum operating temperatures. All of them can be optimized at the same time, as the Solixi water boiler can have up to six temperature layers. All

sectors are compatible with water boiler equipment already on the market. An old and small water boiler can be replaced with Solixi's big water boiler and continue to use equipment that has already been installed. These devices can also be replaced with better ones made to work as part of the Solixi system.

**Hybrid systems are complex.** Manual adjustment is not an option as conditions are constantly changing. **IoT & AI controller** (1.5.) make the Solixi solar concentrator and the large Solixi boiler to work. It orientates the mirrors and optimizes charging and discharging, dozens of water pumps and flow rates. Heat circles are automatized. **Solixi controller integrates devices to function as a system;**

**The Solixi system as a whole is the most important innovation.** Several pilots in Finland and China, prototypes and large R&D team. Dozens of images and drawings are included in the details below.

## Three core innovations, protected by [patents](#)

and [products lines](#). **Technology Readiness Level is depending on the model;**

1.3. [Solixi Water Boiler](#), TRL 6-7

1.4. [Solixi Solar Concentrator](#), TRL 6-7

1.5. [Solixi Controller](#), TRL 6-7

## Add-ons:

Innovations accelerate the development of other products and solutions. **Solixi has innovated a lot of improvements and useful devices.** Some of these are already tested in prototypes and **piloting already made (TRL 4-8)**. All parts require some research and testing in various environments and buildings as part of the system, or **may also be TRL 9 products**, already installed or existing equipment provided by any dealer;

1.6. [Solixi Solar Tracker Frame](#) (The same controller and frame as in Solar Concentrator C46)

1.7. Solixi thermal collector

1.8. Solixi water pumps, temperature sensors, intelligent heat circles

1.9. [Solixi manifolds and flexible hoses](#)

1.10. Solixi Electric Resistor

1.11. Solixi Heat Pump

1.12. Air-to-water Heat pumps

1.13. Geothermal heat as seasonal storage

1.14. Solixi Heat recovery, heat removal

The use of unknown components complicates system standardization, maintenance and modeling and not all benefits may be achieved. For this reason, Solixi strives to maximize the number of its own parts by affordable **serial production** and set clear boundaries. The clear boundaries are the heat exchangers between the building and the Solixi water boiler. In short, the Solixi system is outdoors and heat exchangers transfer hot or cold water to the building. **To model and calculate the whole system;** sizing, economy, savings and emissions (need to burn something to create heat) Solixi has developed **a web calculator**. The result of the metering and automation is **Solixi Control**, a way to compute the system for Resilient and Smart Cities:

- 1.20. Solixi [web calculator](#)
- 1.21. [Solixi Control](#), Resilient and Smart Cities
- 1.22. [Steps planned to take Solixi system to the market](#), serial production, risks



## 1.3. Solixi Water Boiler

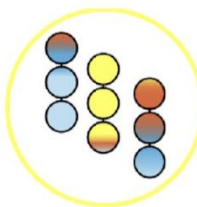


### How to lift a water boiler to a new level ?




#### Innovation - three tank containers

Volume **150 m<sup>3</sup>**  
Price 76.500€  
Capacity **15.000 kWh / 15MWh**  
Price/capacity **5€/kWh**  
The value of stored energy **750-1500€**  
Temperature range **0-120 °C**  
Heating, Cooling, Energy efficiency,  
Grid power stabilizer  
Outdoors, insulation **30-60cm**  
Payback time **1-4 years**



#### Regular water boiler

  
Volume **0,5 m<sup>3</sup>**  
Price 2000€  
Capacity **20 kWh**  
Price/capacity **100€/kWh**  
The value of stored energy **1-2€**  
Temperature range **20-80 °C**  
Heating  
  
Indoors, insulation **1-10cm**  
Payback time **10-30 years**



When the capacity is 15MWh and 6MWh of it can be used daily,  
annual energy transfer is 6MWh x 365 = **2,2GWh**

When there is fluctuation in energy price, outdoor temperature or consumption,  
smart energy storing can save 50% - **every second GWh is for free**

On the left Solixi's innovation in numbers. On the right is a regular indoors water boiler tank in numbers.

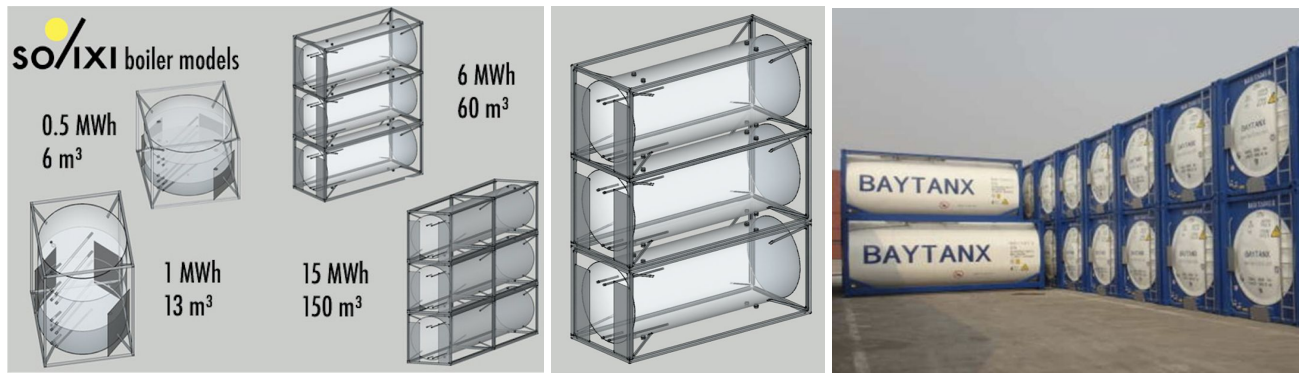
**Improvements are 10 or 100 fold and even more (not 10-100%).**

This is a real **game changer** to tackle the main challenge as societies move towards zero emissions. Solixi warm/cold thermal energy storage is the only standardised MWh capacity water boiler. It is also automatic and intelligent. It lifts the energy efficiency of the connected devices to a new level; heating and cooling by heat pumps, heat recovery and solar heat.

- Price to store energy drops to a fraction, **price €/ kWh is reduced by 80-95%**
- Volumes in cubic metres, not litres.
- Temperatures change between 0-120 °C instead of traditional 20-70 °C.
- Three compartments, store hot and cold simultaneously.
- Minimal heat losses. The uniform insulation thickness is tens of centimeters instead of centimeters. It is close to the building.
- Completely outdoors, can be underground and invisible, scalable, saves indoor space
- Quick and easy installation outdoors.
- Safe, no water or steam damage indoors.
- Transportable, standard container logistics, manufacturing, services
- Charging cycles do not affect capacity
- Lasts for decades, renovation and maintenance is normal routine ISO standard

**Why tank containers?** A little bigger is very difficult to transport, container logistics is the basis of all the logistics in the world. A slightly smaller diameter container would lose much of the capacity as the volume drops to a third potency. Half a million tank containers have already been manufactured. A robust and long service life and strong TRL 9. All is standardized. It is very affordable. They are easy to install, all you need is a solid foundation and an insulated hut to cover the pile of containers. Despite the very low price, tank containers

are the most expensive part of the energy system, accounting for about 30-60 % of the total Solixi investment.



Solixi has designed four models and sizes; [6 and 15 MWh](#) are modified tank containers, smaller [0.5 and 1MWh](#) fits into a sea container.

All models have a very **affordable capacity price € / kWh**. Smallest and largest model in detail;  
**0,5 MWh capacity**, 6m³ water volume; width 2,5m, length 2,5m, height 3m, 3-12 residences, 10-30 occupants, Recommended price 6300 €, VAT 0%,  $6300\text{€} / 500 \text{ kWh} = 12,6 \text{ €/kWh}$   
**15 MWh capacity**, 150 m³ water volume, width 3m, length 13m, height 8,5m, 150-500 residences, 500-1500 occupants, Price 76500€, VAT 0%,  $76500\text{€} / 15000 \text{ kWh} = 5 \text{ €/kWh}$  (traditional price is 100 €/kWh)

**Risks:** Solixi tanks are slightly modified. The way tank containers are used is new. There are pipes / pushes from which water flows in and out, to which manifolds and ball valves are connected. There are pipe holes for vertical flow of water to the top and bottom. Drawings have been made but full implementation has not yet been done.

Pressure vessel **regulations** vary from country to country, usually a control by (Solixi) controller is sufficient. The water tank outdoors is harmless even in the event of a leak, insulated walls are not hot or dangerous. Pressure control is done by an automatic compressor (TRL9) that has not been tested with the Solixi system. The risks are in general minimal, routine work for a person skilled in the art and for tank container manufacturers (Solixi subcontractor in China, ME Solutions Ltd).

**Standard Tank Container** can be used, in picture ISO type 1CC / 22T6 container (as Baytanx in the image):

- Tank design temperature is 120°C
- Test Pressure (Hydrostatic) 10,5 bar
- 3 bar safety valve, max. temp. is 120°C (water boils at 130°C)
- The capacity is achieved by a temperature difference of 85°C - 15 MWh of energy is needed to heat 150m³ of water 85°C.
- Temperatures are set in Solixi controller according to local regulations, need and use.

## 1.4. Solixi Solar Concentrator



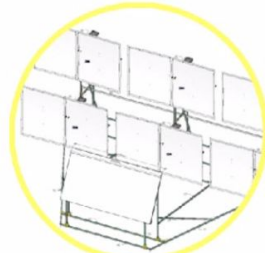
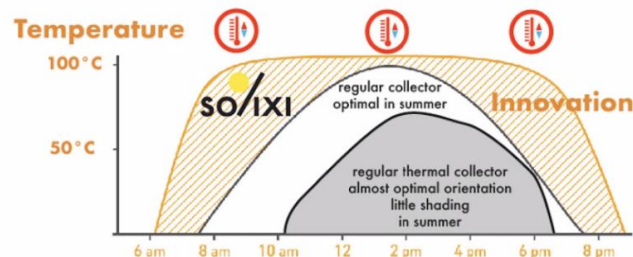
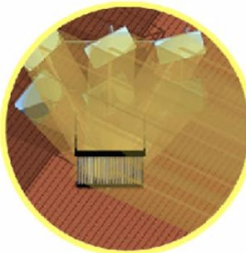
### Is solar heating possible in winter ?



#### Only Solixi Solar Concentrator can:



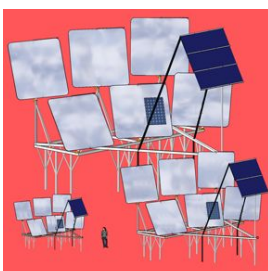
Heats always when the sun is shining.  
Provide even production from sun up to sun down all year long.  
Even a short glimmer of sun warms up.  
Heating with **temperature adjustment and on/off**.  
Orientates mirrors reflection to the collector, radiation **x10**.  
Over the shadows.  
Towards south independently of the shape of the roof.  
Little need to clean up, does not collect snow, dust or garbage.  
Light and easy assembly for all roofs in multiple sizes and models.



**Traditional installation** (in the diagram above, gray area), the collectors are attached to the roof lape with varying orientation. The energy yield depends on the shape of the roof, how long and when the sun shines on the collectors. Collectors are always on and produce warm (not hot) water. **Solixi will change all this;**

- Warms always when the sun is shining, hot even in the winter.
- Even production from morning to evening year round.
- Even a short glimmer of sun warms up, radiation x10.
- The only controllable solar collector, on/off, control of the produced temperature.
- Turning mirrors always follow the sun.
- Over the shadows on top of the rooftop.
- Towards south independently of the shape of the roof.
- Little need to clean up, does not collect snow, dust or garbage.
- Several sizes and models.
- Easy and fast assembly, can be dispersed into parts.

### Solar Concentrator models C13, C16, C43, C46 and C96



**Model; Mirror area, -plates; Power; Masts /Motors /Controllers; Price**

**C13;** 7,5 m<sup>2</sup>, 6pc.; 4 kW; 3 / 6 / 1; 2.490€

**C16;** 15 m<sup>2</sup>, 12pc.; 8 kW; 6 / 12 / 2; 4.100€

**C43;** 30 m<sup>2</sup>, 24pc.; 16 kW; 3 / 6 / 1; 5.350€

**C46;** 60 m<sup>2</sup>, 48pc.; 32 kW; 6 / 12 / 2; 9.900€

**C96;** 135 m<sup>2</sup>, 108pc.; 72 kW; 6 / 12 / 2; 17.000€

Nominal energy yield is achieved when insolation is 1000 W/m<sup>2</sup>.

A sunny day.



100% power at noon 6 hours plus 4 hours 60% power am/pm. Energy yield at latitudes 30-60 (EU).

## First Prototype in 2013, model C16



Model C16 early proto had 10m<sup>2</sup> mirror area in six masts. Four various mirror materials and other parts were tested. February 24th 2013 was a sunny winter day (Vantaa Helsinki, 60° latitude, very low winter sun), max power was 5kW and total 20kWh was produced. Regular collectors would have been under snow. In March 2013, without snow, 12m<sup>2</sup> of conventional collectors would have produced about 150kWh on this roof. **March 2013 C16 produced and measured total 723kWh, 72% of the heating energy consumption, normal sunny day 35kWh until water boiler was fully charged.** A lot of heat also on cloudy days. Daily statistics over 6 months available. In the serial production model, larger parabolic mirrors, a large boiler volume and an optimum collector (1.7.), and other planned improvements, further improve energy yield.

## Second Prototype in 2016, model C16



CEO Jyri Jaakkola waving C16 mast. Several weaknesses were found and 3D drawings were corrected; Jouni Heikintalo, Felix Tao and Mr. Zhong & team, Guangdong, China.

## Commercial level 2018-2020, model C16

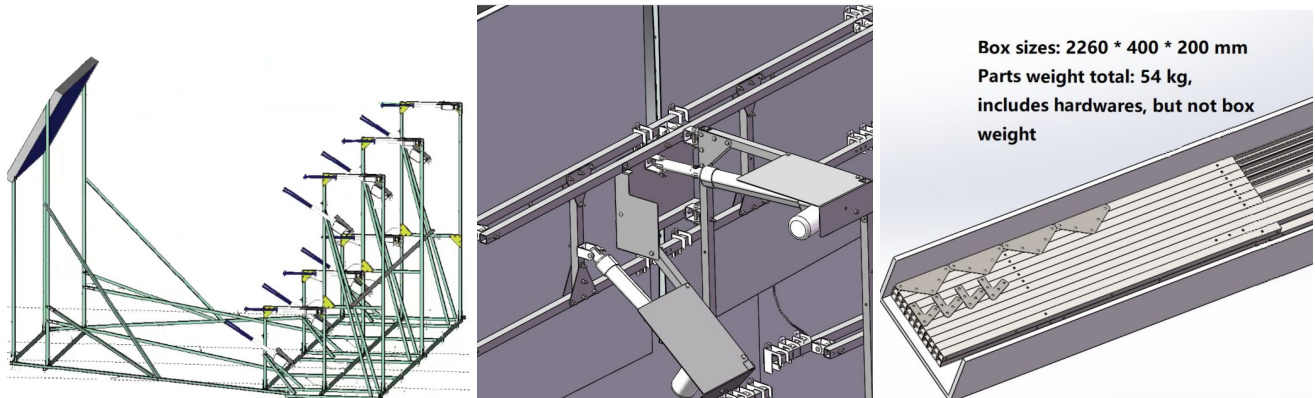


Assembling can be done on the ground or on the roof, or partially in both. Easy to disassemble and assemble in any part in minutes, bars and plates are connected with bolts. It takes about 2 to 4 days for two people to install the C16 - or a few hours if the structure is pre-assembled and lifted by crane on the roof. All models use the same components. Geometry, controller and software are the same in all models. Only the size can vary. Bars,

plates, mirror supports, geometry and the entire frame are 3D modeled, all models;



Metal parts can be made anywhere in a modern metal workshop. The **best value for money** is now in China. Light, durable, weatherproof, low cost commercial Solar Concentrator ready for serial production.

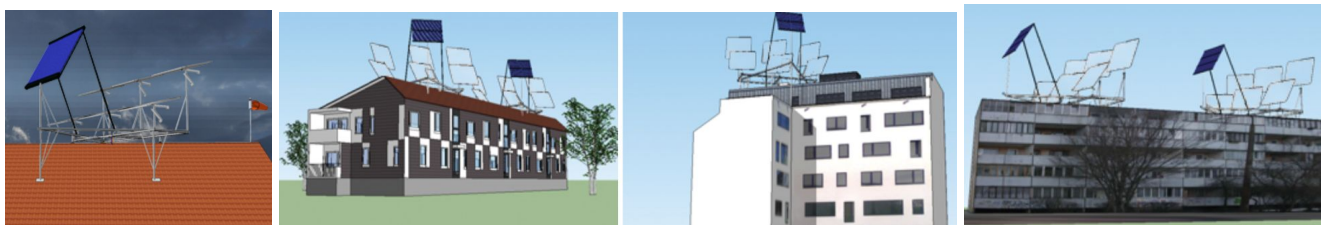


In **productization** the number of parts was minimized. Durability, installation, packaging, appearance and industrial manufacturing were all put in order. Electronics come from Finland, actuators are manufactured in Taiwan, mirror plates in Germany etc. The main components have been tested for at least one year.

**Risks, fears:** Usually the first impression is: it looks terrible and can't withstand a storm.



Video, [drive through Solixi City and check the views](#) by yourself. Imagine a clean city without chimneys.



Another concern is **the wind**, how does the structure withstand storms? C16 Solar Concentrators have been on the roof since 2013, no damage. During a storm, the mirrors can be turned to a favorable position. Solixi or ceiling not stressed due to the small wind surface. Wide frame with many legs, cross brackets and attachment points is very rigid. Much more robust than a radio mast. In the middle of the ceiling, Solixi is well protected from wind-blown objects and often also from falling trees. During a hurricane, mirrors can be brought to the shelter by removing a few bolts. Wind damage can be covered by Solixi insurance (1.23).

**Regulations may impose restrictions.** The appearance is likely to prevent installation on the roof of the church. It is easier to get permission for suburban blocks of flats, industrial area or the roof of the barn, where Solar Concentrators can be very big, large and effective (last image, model C96 ).



## 1.5. Solixi Controller

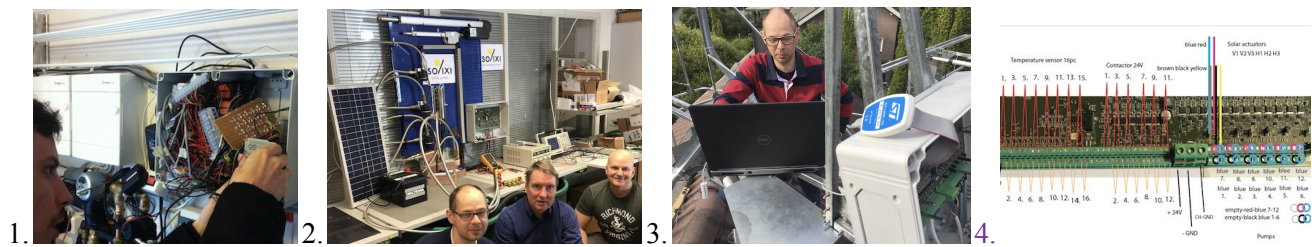


Image 1; Solar Concentrator Controller, **first prototype** manufactured by ElmerTech 2013.

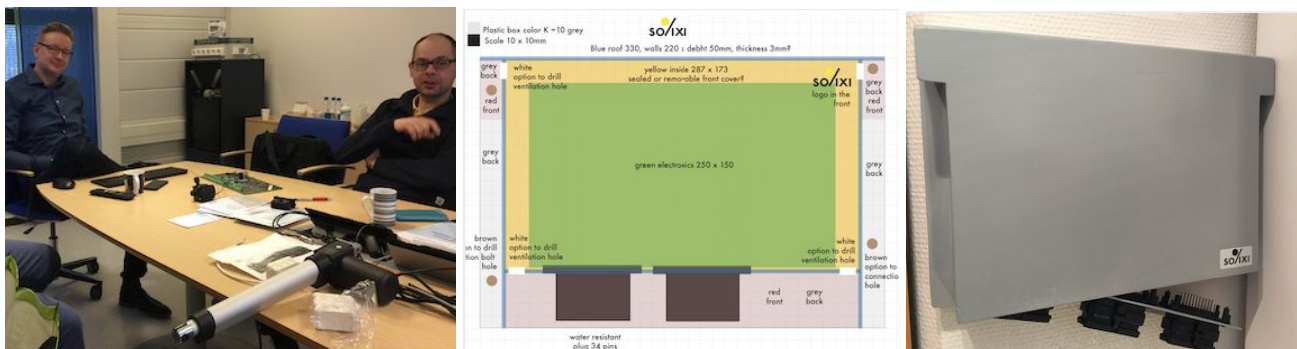
Images 2-4; **second prototype** 2016-2019, made 10 pieces, 3 currently in operation;

The **Controller** makes the Solixi solar concentrator and the large Solixi boiler to work. The same hardware, single model, orientates the mirrors and optimizes charging and discharging and runs Solixi water pumps.

Microteam is the designer of the unique IoT controller. Both the software and the I/O, which includes a processor, a memory and a GSM, has been designed with lessons learned from prototypes. The system can be expanded easily by adding more wireless controllers to the Solixi Controller Network.

The controller works independently, but it's smartness comes from Solixi Cloud Service. This password protected service is used to input the controller parameters, as latitude used to calculate the sun's position, to the desired temperature layers in the boiler, which also change dynamically with weather and energy price forecasts. Solixi Control (1.21.) saves backup-copies, supplies malfunction alarms and collects statistics. Data and graphs can be accessed from for example mobile phones. It is easy to increase the power of the Solixi Boiler by installing parallel pumps and controllers. A big boiler with big capacity stores energy for a long time. It is possible to increase reliability during blackouts by installing solar PV-system with batteries. Solixi electronics works at minimal 24 Volts electricity. No electrician is needed for basic installation.

Additional water heaters, heat pumps, heat recovery and cooling devices can be connected to Solixi tanks simply with pipes. The controller can be used to start and stop these as well at the right times and optimize the efficiencies of the heat pumps. The greatest savings in a hybrid system can be achieved by [accurate control of timing and temperatures.](#)

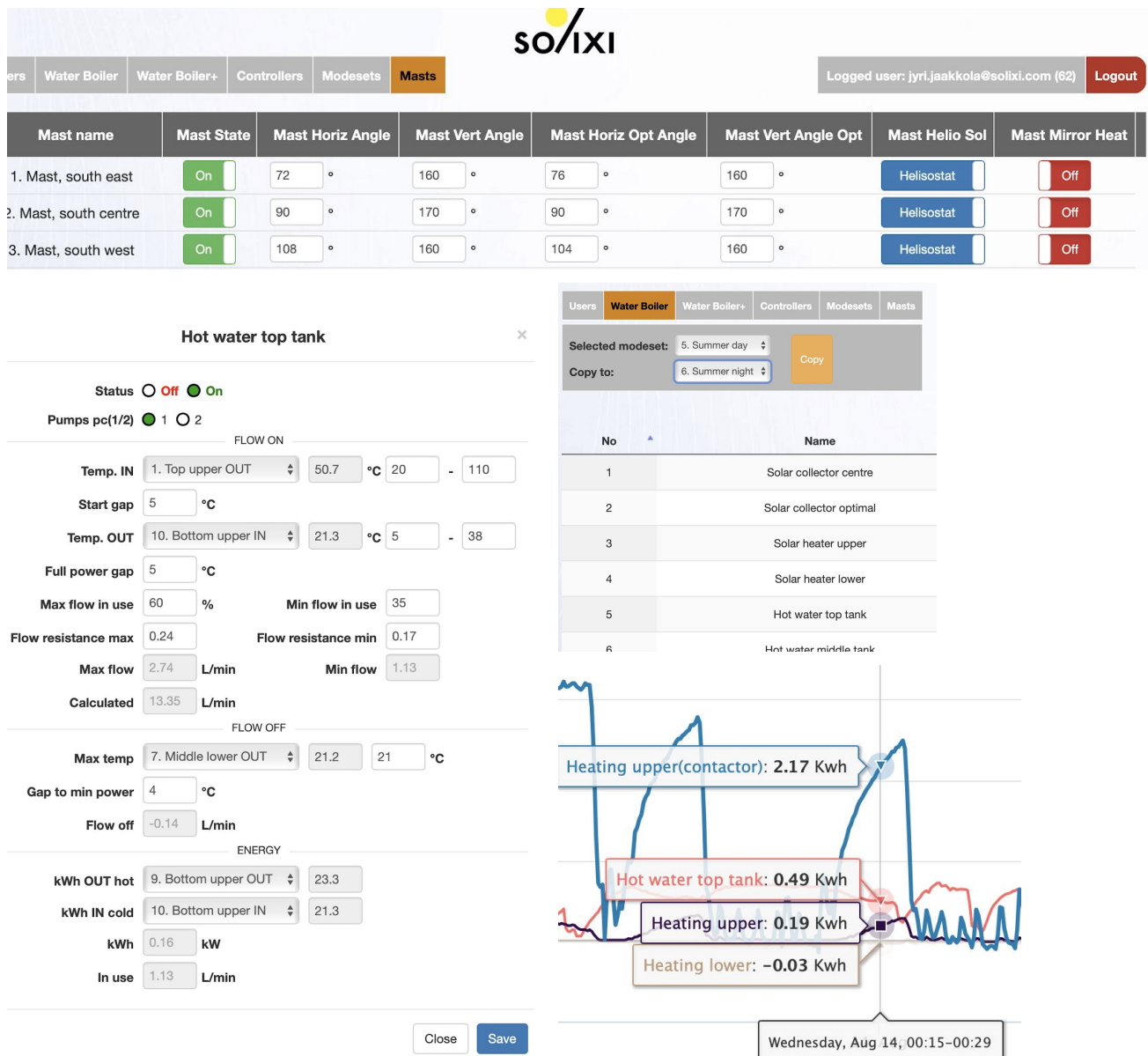


**Third version** is designed for serial production, **Solixi Controller 2020**;

The hardware will be manufactured by [Xortec](#) Ltd. Almost all software and functions as in previous model. The casing is weatherproof, approximately A4 size, with plug and play connectors on the bottom for cables. The price of serial production is a few hundred euros, the price level for similar controllers is a few thousand euros. Simple, data communication is secured, stand alone mode, extremely durable.

### Solixi has designed three controller software

SIOA software operates on the roof and orientates solar mirrors / heliostats. The picture below shows the parameter input page on the web and cloud service;

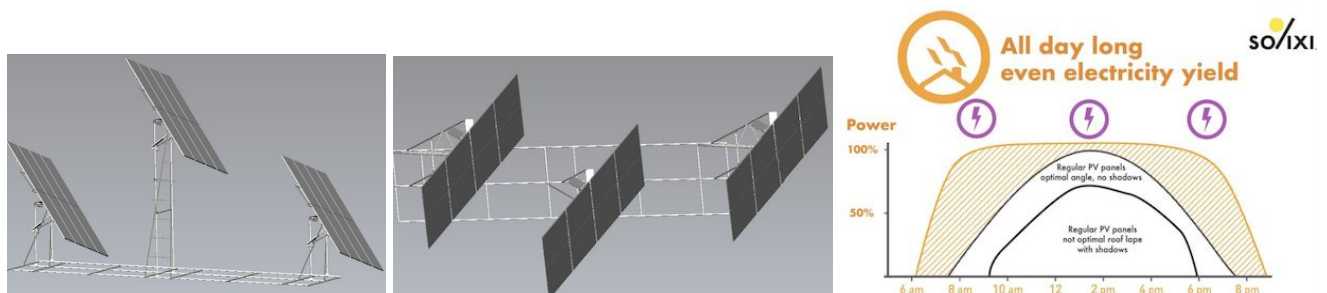


**SIOB1** is for water tank pumps. Algorithms, parameters, max/min flow rates, temperature limits and start gaps etc. settings input pages on the web and cloud service. Energy meter graphics.

**SIOB2** software is modified for Solixi heat pump and cooling features (1.11.).

All software SIOA and SIOB use the same controller hardware and casing.

## 1.6. Solixi Solar Tracker Frame



**Currently** there are no large photovoltaic (PV) panels installed on **solar trackers** on the roof. Conventional solar trackers usually have only one mast. It requires a massive and heavy footing and despite of it is still unstable and expensive, almost impossible on windy and sunny roofs.

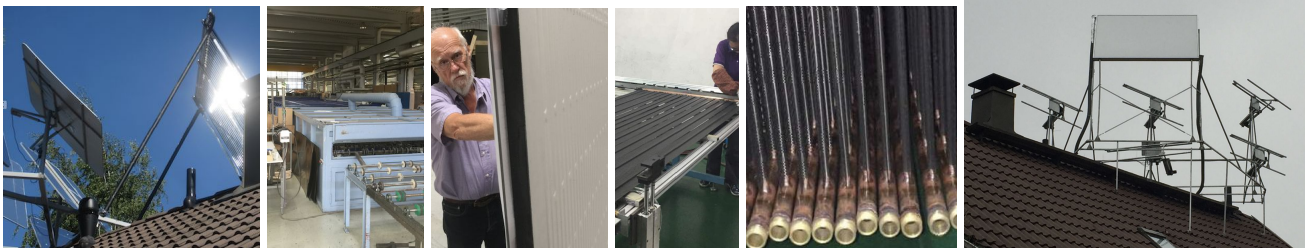


**The [Solixi C4PV](#) is different.** It is robust, affordable, light and intelligent; A very large flat bar foundation can be combined with strong roof pillars and structures almost freely. No torque or vibration at any coupling point. Towards the south, regardless of the shape of the roof. The C4PV is lightweight, only a few hundred kilos plus PV panels. The bars are thin (like on TV masts), but still the structure is solid metal triangle, it does not vibrate, it does not shake the building. Under C4PV you can have just anything; ventilation, chimney, windows, swimming pool... it fits into almost any roof. C4PV is intelligent and IoT; on / off, remote control, automatic rain, dust, night and storm direction. One affordable Solixi controller can handle all three masts. In general, any standard PV panel (1 × 1.6 m or 1x2 m) can be installed on a C4PV.

The C4PV is built from the same bars, plates, actuators, controller and services and as the C46 Solar Concentrator, logistics and packings are the same, only the thermal solar collector and mirrors are omitted. C4PV is a “free extra product” but still has a huge market. 24 x 300W PV-panels = 7,2 kW, PV panel area 24 x 1,6 m<sup>2</sup> = 38 m<sup>2</sup>, price € 2950, VAT 0%

**Full PV electricity nominal power up to 10 hours a day on any roof** (graph above, orange).

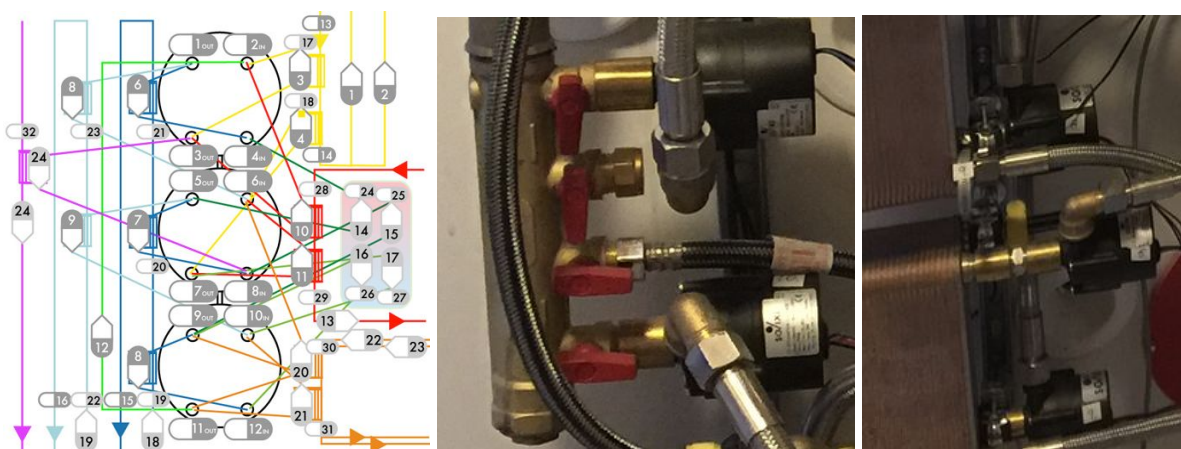
## 1.7. Solixi Thermal Collector



Solixi Solar Concentrators benefit from solar collectors designed for very strong solar radiation. Market collectors are “made for one sun”, are one-sided or partly transparent. Solixi takes the radiation on both sides and harvest more heat with a big non-transparent collector. High water flow rates and high quality hot water insulation and pressures of at least 6 bar are also useful. Solixi has plans and manufacturers in Finland and China for a solar thermal collector that is suitable for all Solar Concentrators. Only quantities vary by model.

**Collector designed for the Solar Concentrator is already installed** on the latest C16 model (last image). It is one-sided. The south side is for the PV panel or can be left in silver for a better look. Black collectors stand out against the sky.

## 1.8. Solixi Water Pumps, temperature sensors, secured heat circles



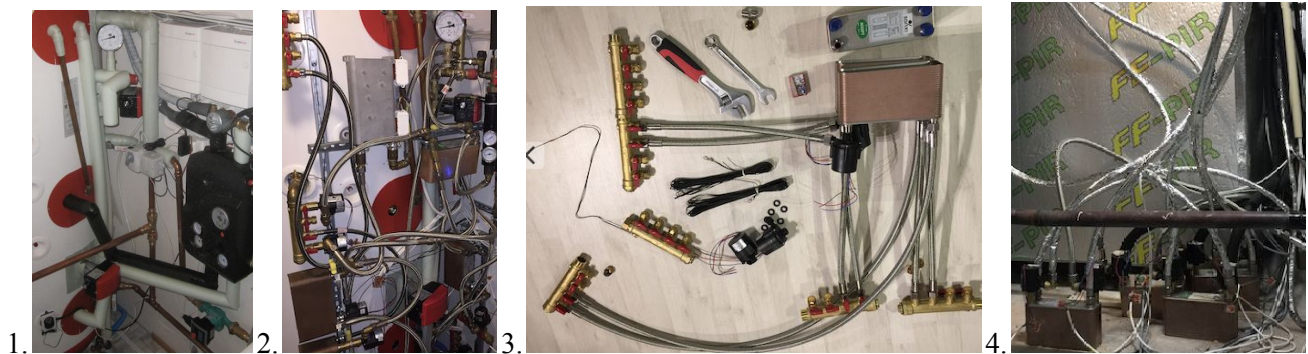
One Solixi [controller controls](#) up to 12 automated [water pumps](#) and provides information on 16 temperature sensors. **This makes Solixi a "water computer".**

The main functions are visualized in the [video](#). The controller not only turns the pumps on / off, but also controls the flow rate when the critical temperature changes. Each water pump is also a flow meter and an energy meter, i.e. the controller collects data and graphically visualizes how much energy each pump has pumped. Lots of intelligent heat circles that can be amplified by adding more controllers, pumps and temperature sensors.

A plumber and an electrician will install a standard water pump in a matter of hours, one pump costs a few hundred euros. **Anyone can install or replace a Solixi pump in minutes** (low voltage 24V, plug, threads, easy on/off valves) and **one pump costs tens of euros**. Solixi controller tests all Solixi pumps periodically.

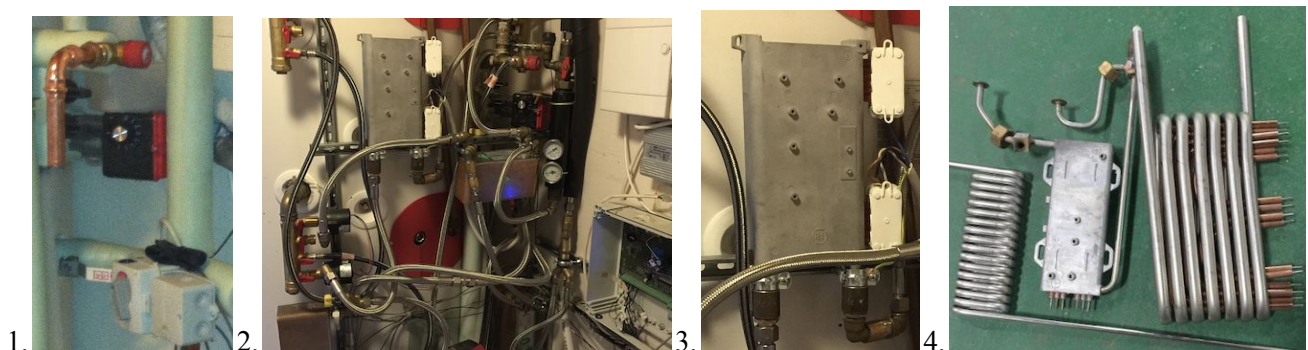
**Secured heating and cooling;** The heat circuits, Solixi pumps and controller, can easily be doubled. The cost is a few thousand euros, even in a large building and system.

## 1.9. Solixi manifolds and flexible hoses, installation



**In a conventional installation**, a plumber installs the pipes and pumps permanently. Typically a water tank has a few pumps and valves (1.). **Solixi** water tank has manifolds (6-12-24 pc.) with four ball valves (water flow on/off) on the side (2.). Installation does not require a plumber, it can be much more versatile and the installation can be changed in minutes. With a few affordable basic parts (3.) you can quickly assemble and get the desired combination (2., 4.). Flexible pipe hoses can be several meters in length (4.). The parts are uninsulated because they are inside the insulated hut of the water tank.

## 1.10. Solixi Electric Resistor



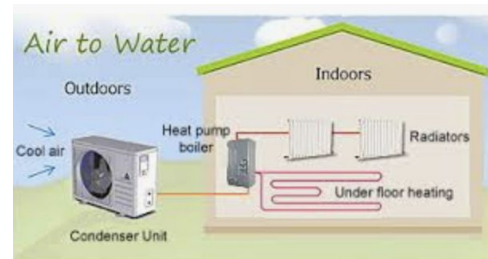
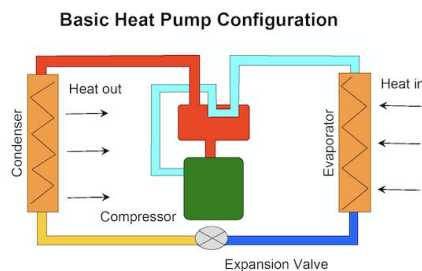
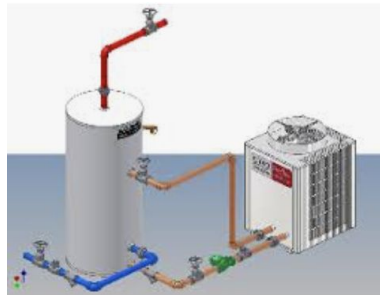
**In a conventional installation (1.)**, on the side of the water tank is a fixed electrical resistor with a thermostat to set max. temperature. The water is warmed up above the resistor gradually. The motor valve mixes the water to achieve the desired temperature for use (1.). Both can be adjusted remotely with specific controllers.

**Solixi's solution (2.-4.)** is to electrically heat the water flowing in the spiral pipe. The Solixi controller adjusts the flow rate so that the desired, usually hot (80-120°C), temperature is reached immediately. Another Solixi pump mixes the water between different volumes, or when the pump is off, only the top volume is heated. Solixi electric resistor is very cheap, robust and simple as it has no electronics. It is an ideal partner for another electric

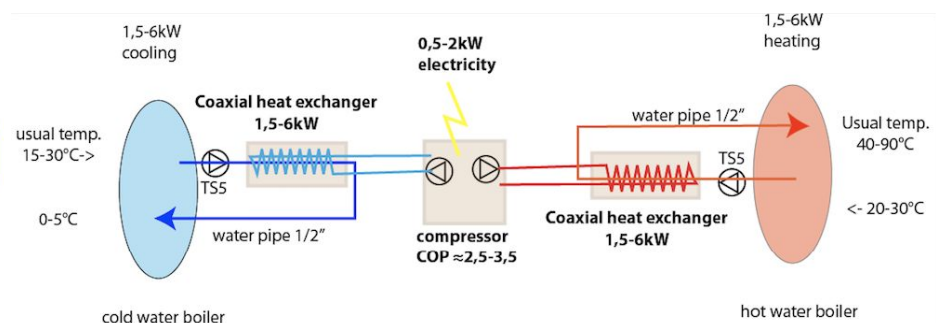
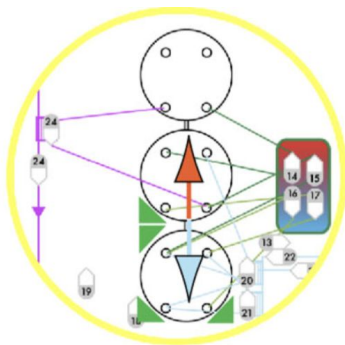


heater, the heat pump, which produces warm (40-60 ° C) water with less electricity (COP over 1). The Solixi controller intelligently controls both, one or both are ON when electricity is cheap and depending on the temperatures required for each water volume. No specific controllers nor extra expenses. Solixi has tested many resistors and found a good solution that works, **power is 2-4-6kW** (3.).

## 1.11. Solixi Heat Pump



An ordinary heat pump pumps cold or warm into a building. Part of the device, one heat exchanger, is outdoors. For example compressor power can be **6kW, price €20.000 and COP 3**. 1 kWh to the compressor creates 3 kWh heat into water. Heat pump is on when heating (or cooling) is needed, and the not wanted cold (or warm) is pumped out as a waste. The basics are simple, but installation, electronics and large heat exchangers add expenses a lot.



**Solixi heat pump** is a triangular case installed in a corner of a tank container (green, image 1). None of it is outdoors, it is completely inside insulated walls. It does not require space for installation. Weather does not affect. Runtime does not have to be dependent on consumption. Both heat and cold can be stored in large water tanks for later use. Installation is plug & play with flexible hoses. All these features are unique.

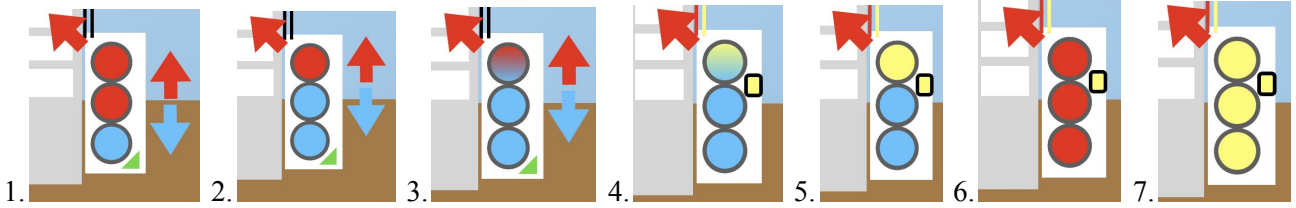
The heat pump pumps heat from lower tank to the upper. It strengthens and moves the water stratification. The central tank can be heated or cooled. Four water circuits (4 pumps, image 1) to optimize the heat pump's energy efficiency and three tank temperatures along with other installed devices. Electronics is four Solixi pumps and SIOB controller. In four compact coaxial heat exchangers (2x evaporator and 2x condenser) water flows through the spiral pipes. For example compressor power can be **2kW, price €3000, COP 5-10**. Both warm and cold are stored and used. Power and **security** is increased by increasing the number of heat pumps (green). Solixi has plans for serial production.

**Benefits;** The building uses water for cooling (2-10°C) and for heating (40-60°C). The return temperature in both is about 25°C. Energy content is used and empty when all tanks are at 25°C. The heat pump between tanks can be operated in many ways with very high energy efficiency (COP) and savings;

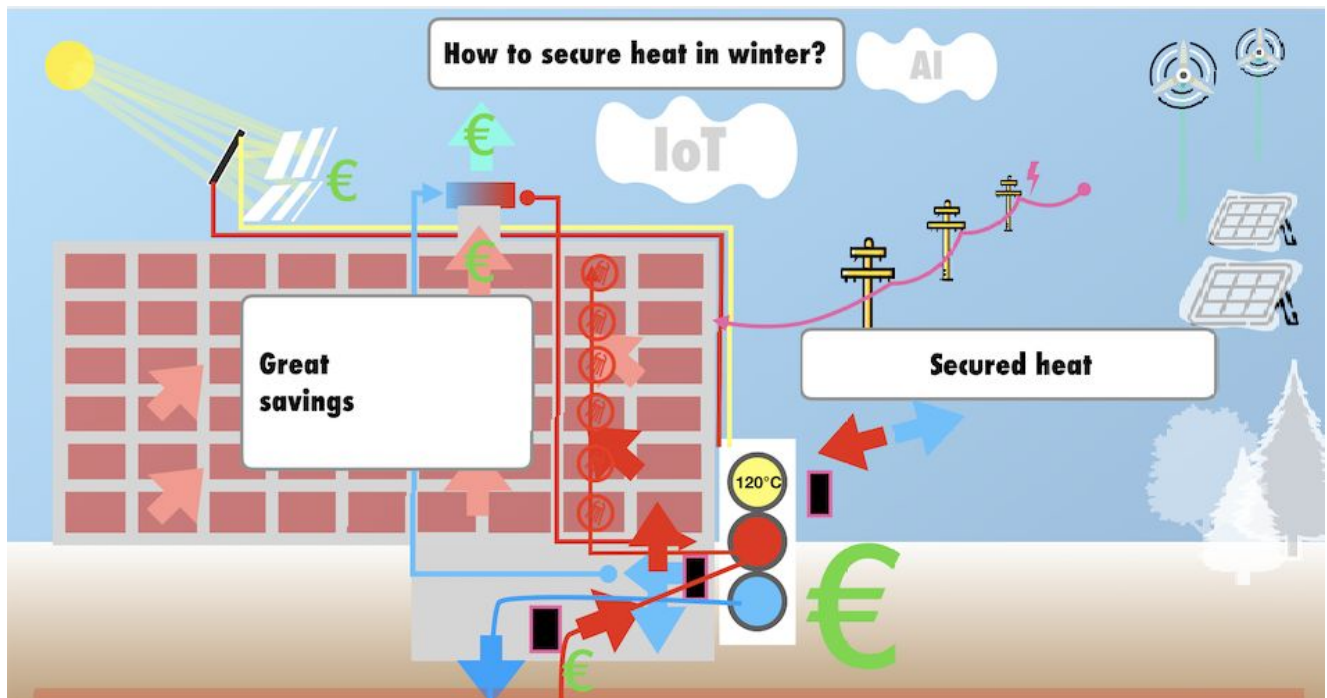
**1.)** The building needs just as much heating and cooling in a couple of days time period; The return from both temperatures (25 ° C) is led to the central tank, the Solixi heat pump transfers cold to the lowest tank and heats up to the top tank. Temperature range is optimal for heat pump in both, in evaporator and in condenser. COP is very high 6-10. Outside temperatures and consumption peaks have no effect, high capacity balances both.

Figure 1 consists of seven numbered diagrams (1-7) illustrating a sequence of actions for a robot arm. The robot arm is represented by a red arrow pointing downwards. The blocks are represented by colored circles: red, blue, and yellow. The background is a brown base and a blue platform.

- 1. The robot arm is positioned above the red block.
- 2. The robot arm is positioned above the blue block.
- 3. The robot arm is positioned above the yellow block.
- 4. The robot arm is positioned above the red block.
- 5. The robot arm is positioned above the blue block.
- 6. The robot arm is positioned above the yellow block.
- 7. The robot arm is positioned above the red block.



3.) It's summer and it's been hot for several days, and the same weather continues. In the hybrid system there is low power geothermal well (and affordable, small area in urban environment). Solixi pumps heat into the soil. It has already warmed up so much that the return heat (15°C) cannot be directly used for cooling. The Solixi heat pump cools the water slightly and transfers more extra heat to the soil. It warms up faster, the heat storage in the soil to be used in the winter increases, and the building gets cooling at very low electricity usage. Up to several months.



5.) It's winter and it's been cold for several days, and the same weather continues. The hybrid system has Solixi heat recovery. The cold water produced by the heat pump is circulated through the exhaust air heat exchanger on the rooftop (1.14.) where it heats up to 15°C. In this way, cold water is also useful for heating, COP is high and heat is kept indoors.

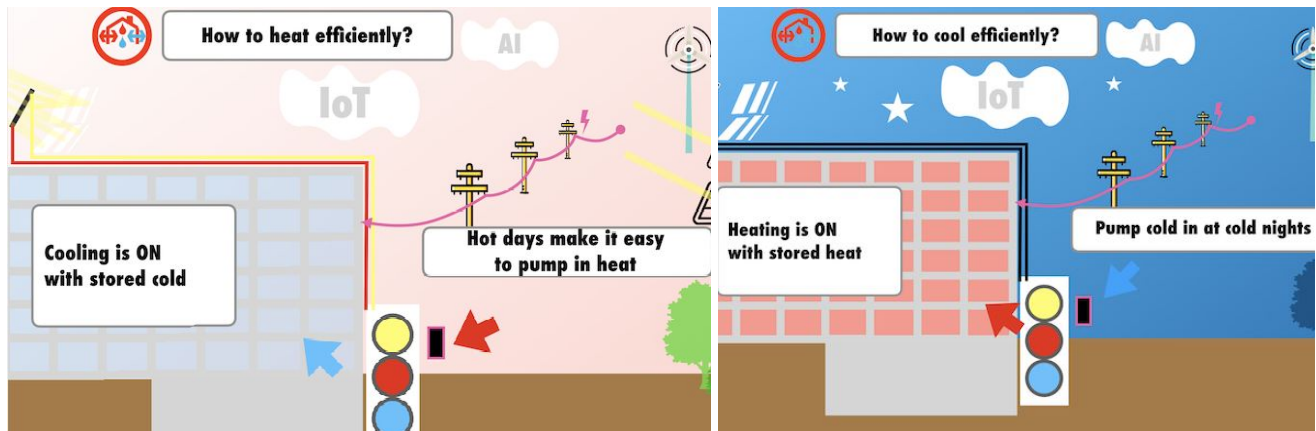
6.) Hot and cold water can also be pumped very cheaply between adjacent houses. One building may have high



heat pump capacity and a geothermal well, and another may have multiple solar concentrators, and both houses may benefit from both. Solixi system water tanks can be located hundreds of meters apart. Similarly, district heating or district cooling can be utilized.

7.) Many of these functions can be activated at the same time, depending on the need and the circumstances. Seven **unique selling points and key differentiation from competitors** are listed above.

## 1.12. Air-to-Water heat pumps

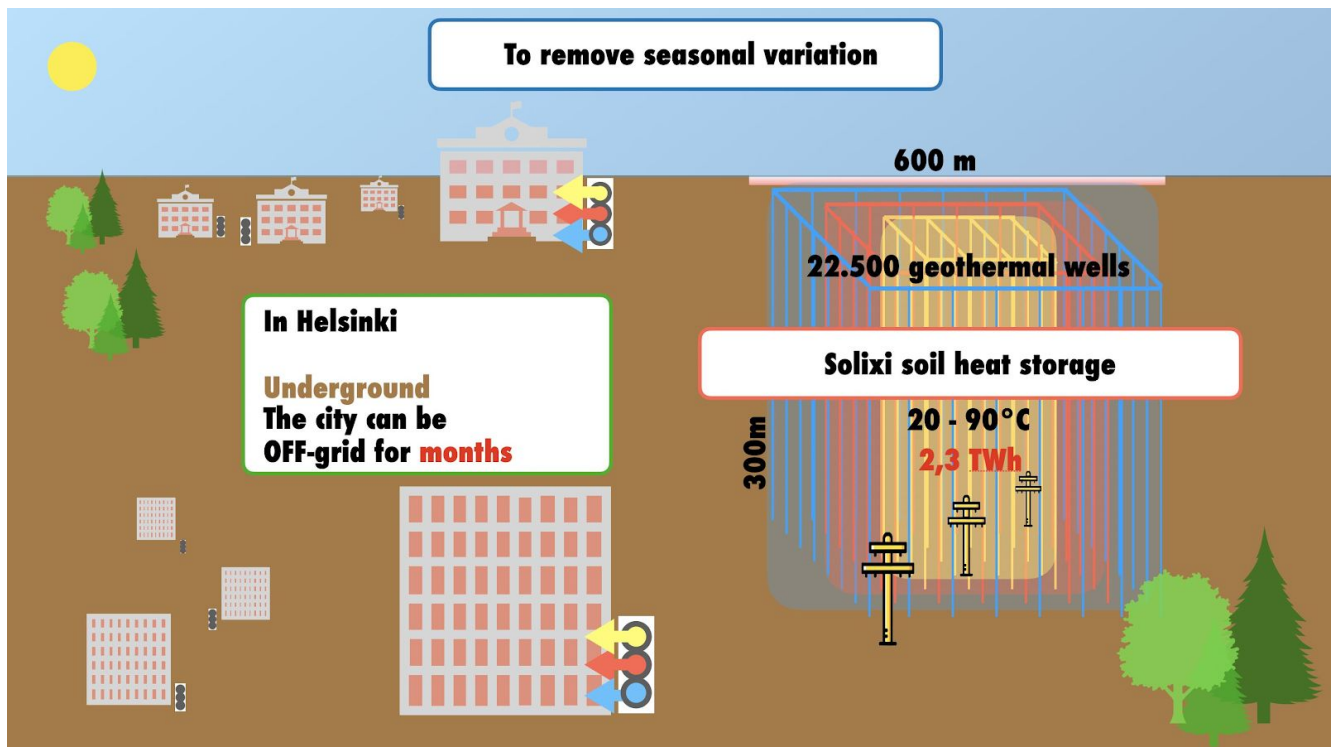


The huge capacity of Solixi water tanks and intelligent heat circles make it possible to improve the efficiency of Air-to-Water heat pumps. It easily charges heat at midday when the air is hot. It is effective to cool water on a cool night. This reverse order is possible only with Solixi; Effective heating during the day and cooling at night, both are secured at all times.

## 1.13. Geothermal Energy as seasonal storage

In 2020, the system was completed with TWh-sized seasonal soil heat and cold storage. Geothermal wells are used in the implementation, but they are drilled more densely than normal. The soil is heated by the heat generated in the buildings in summer. Standard thermal wells are 300m deep and when the width and length of the storage are in the same range the volume is huge. When there is a Solar Concentrator field on top of it, the center of the soil heat storage can rise to as high as 90 ° C in the fall.

It is not possible to build an energy storage of the same volume and capacity on land. In such a large storage, with insulated surface, heat is retained with almost no losses. The storage can be implemented advantageously with the current drilling technology. So, not building-specific geothermal wells, but a common Solixi soil well-field.



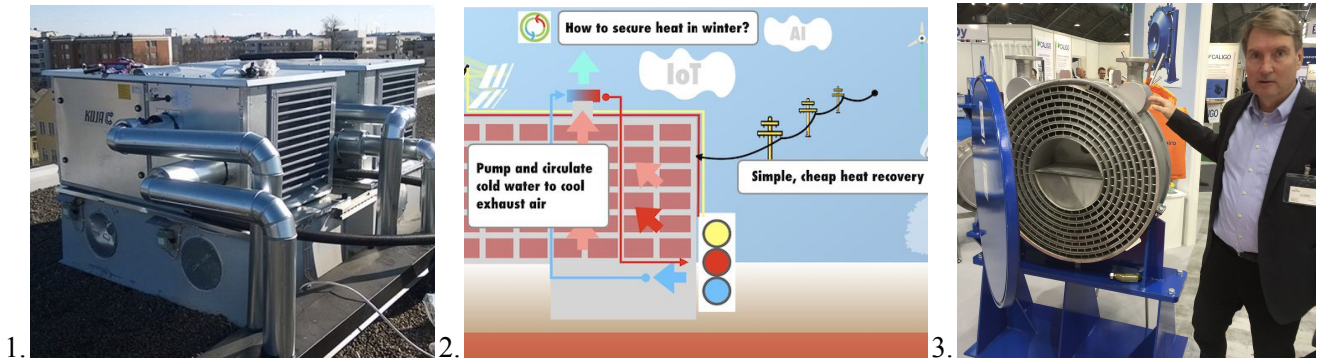
Soil is commonly used for storing seasonal energy. It is also very useful as part of the Solixi hybrid heating and cooling system. The soil beneath the city serves as a giant energy store.

**Traditionally**, a large building requires a large and expensive field of geothermal wells, which is not possible in urban areas. Soil is just like any other form of energy storage, in the long run it needs to be charged as much as it is discharged. In urban environments consumption peaks are high, soil cannot provide high power for a few hours. Heat losses are generally high, with about half of the heat charged into the soil in the summer being recovered in the winter.

**Solixi solves all these challenges;** Heat transfer to the soil can continue optimally at low power throughout the summer, and consequently the heat is obtained for several winter months regardless of the weather. The heat losses are lower than in the conventional case, because several adjacent heat wells are loaded throughout the summer and unloaded at the same time for optimal winter performance. All the soil under the city is heated or cooled at high power simultaneously for several months. Horizontally transmitted heat or cold is available at the adjacent building. High heating or cooling power is available any time from a hot or cold water tank. The tanks are a smart buffer between the soil and the building.

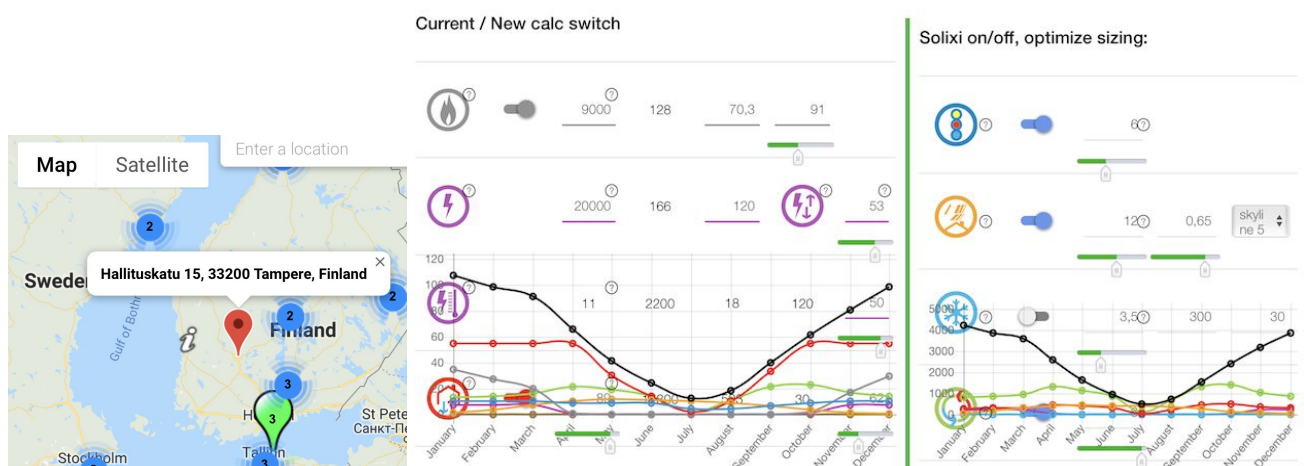
In some cases, a geothermal heat pump may be replaced by a Solixi heat pump (1.11.). Fewer geothermal wells are needed and each provide higher efficiency. All these significantly reduce investment costs.

## 1.14. Heat recovery, heat removal



Solixi heat pump, large water tanks and heat circles are the key to cheap heat recovery and heat removal. Cold or warm water is pumped through the roof heat exchanger and exhaust air (Images 1 and 2). The sewage water circulates through a spiral heat exchanger (Image 3). With Solixi all this very simply, thanks to the large water tanks. Heat recovery can work for a long time without heat pumps, and the Solixi heat pump can produce warm and cold water, along with other Solixi smart heating circuits when it is affordable.

## 1.20. Solixi web calculator



**System sizing and profitability calculation.** [Solixi Web Calculator](http://www.solixi.com/savings-calculator/) is a unique and revolutionary way to plan an energy renovation and model the whole system.

The first version in 2012 calculated Solar Concentrator energy yield. This updated version **calculate the whole system**. Calculating the economic size of the various components of a hybrid system is not easy. There are plenty of variables. Changing one affects the entire system. The web calculator does this. Building Information Modelling for energy has never been so easy, quick and affordable. Use the unique Solixi calculator, see how energy expenses and savings vary when you use on/off switches for devices and adjust the power, size, future estimations, prices etc. Smart algorithms will take into account other devices, the local weather, heating and cooling days and need for the map location as well as the latitude to calculate the sun's orbit. Immediate response; annual & monthly MWh:s and savings /the whole system. The calculator shows the direction for an energy renovation for a particular building at a specific location. It provides the basis for an investment plan.

<http://www.solixi.com/savings-calculator/> is a great tool for Solixi resellers and licensors because it quickly calculates key information to make a purchasing decision. All you need to get started is an energy bill and an address. The calculator is calibrated according to the actual data provided by the Solixi controller. Currently, the calculator is not being used because there is not enough Solixi Controller data available yet and resources are

missing to fix a few minor errors. Project team: CEO Jyri Jaakkola, Aalto University (Finland, [Reino energy project](#)) and [4tifier.com](#) (Ukraine, 3 persons) in years 2016-2018. TRL 6-8.

## 1.21. Solixi Control, security

**Solixi software and cloud service optimizes the operation of the system, taking into account consumption, weather, energy prices and supply.** This is done simply by changing the Modeset setting in the Solixi Controller software (1.5.) remotely (GSM, IoT). It can also be done automatically (stand alone mode) or manually for all Solixi systems in the area from the control room.

**The operation of the electricity grid can be optimized.** Solixi may use more or less electricity depending on the energy network situation. Adjustments can have a big impact when there are many Solixi systems. In the event of a power plant outage, consumption is reduced as once as the Solixi systems are switched to discharge mode. The huge capacity of water tanks will be taken into operation at the same moment. Charging mode is activated during stormy nights when wind power overload is on and electricity prices are low.

**Solixi system can also operate without active control** and exchange the Modesets according to the calendar. The program can change the settings automatically depending on the season or the daily rhythm. In this case, the weather and the price of electricity are not taken into account.

**The system is proactive;**

A.) If tomorrow is a sunny and warm day and the energy now in stock is sufficient till tomorrow morning, then the water tanks are in the discharge mode and energy is not purchased or produced. Heat pumps are off.

B.) If tomorrow is a cold and cloudy day and it is more affordable to make and purchase energy today than tomorrow, the water tanks are in charge mode. Electric resistors and heat pumps are on.

**Security:** Solixi allows off-grid mode for a few hours or even for days or weeks without affecting living conditions. Advantageously, the operation of the controller and the water pumps are safeguarded by a few solar panels (1.6.) and batteries. When the power is low, the pumping power is automatically limited. Heating and cooling is never completely interrupted. In the event of a crisis, heating (1.4.) or cooling (1.11.) is provided at least at some level. At all times.

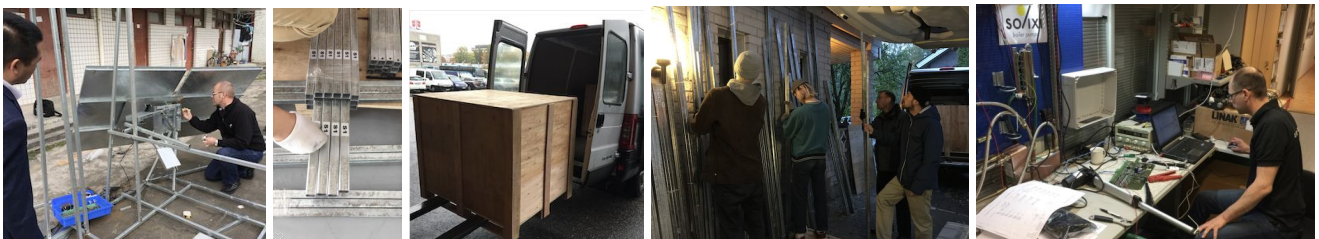
**No competitor has these security features.** Now, virtually all systems stop heating or cooling immediately in the event of a power failure. Society is helpless in times of crisis and everyone needs immediate help right away.

**Solixi buildings and cities are resilient and safe in crisis situations.**

## 1.22. Steps planned to take Solixi system to the market, Serial production, Risks

### Technological, practical and economic feasibility - Serial production

Electronics manufacturing, parts manufacturing, product development, piloting in different areas and buildings, metering, big data AI, Solixi Control, software development, systems optimization, logistics, maintenance, service, affordable pricing and marketing all around the world **require extensive serial production.**



Small industry is no longer an option, it has already been made (pictures). The system cannot be made and



commercialized without all or at least the most important components, devices, features and maintenance. Solixi has a strong supply chain from piloting and manufacturing to customer deliveries.

## **Technical and financial risks faced when bringing innovations to market**

When volumes are high, there are significant technical and practical risks. When one part is replaced, it has or may have an effect elsewhere.

The most expensive part in Solixi system is the water boiler, tank containers. They can typically account for 10-100k €, about 30-60% of the Solixi system investment cost in an urban building. There are no significant risks in this section. Thanks to modularity, dimensioning can be increased and reduced flexibly. The container holds its value under all circumstances, its transfer and sale are inexpensive. Any Solixi water tanks suits to almost any building.

The unit prices of other parts are affordable in mass production. Solixi is plug & play, all components are easy to replace.

However, there are costs involved in redesigning potentially weak or even unsuitable parts. When there are hundreds of systems installed around the world, maintenance needs to be carefully addressed. Because of the guarantee and reliability, the job has to be done for free and quickly. Extensive experimentation and testing in different countries and buildings is expensive, especially at the beginning, when routines have not yet been developed and all staff are new. Failure can be fatal for the Solixi brand and significantly hamper marketing. The risk can be eliminated through adequate financing. It enables quick response and customer satisfaction even when problems arise. The introduction of new products, especially energy systems, requires trust in the supplier and the seller. They are ready to launch Solixi on the market more enthusiastically when Solixi can take economic responsibility for product development and warranty.

Banks cannot take this risk and it is too big for most venture capitalists. Solixi aims to transform the entire energy system. Estimating costs is also very difficult, as they vary according to the nature, scale and magnitude of the problem. However, it can be assumed that about 5% of the initial installation parts will have to be replaced within a few years, at a cost of about 10% of the investment. These costs are quickly reduced as experience increases.

## **Risk mitigation**

Solixi is seeking funding to start serial production, to bring individual products and all innovations to the market. It enables system-level revolution in the heating and cooling of buildings and cities.

After serial production and sales are underway, the most important way to mitigate risks is a profitable business with good margins.