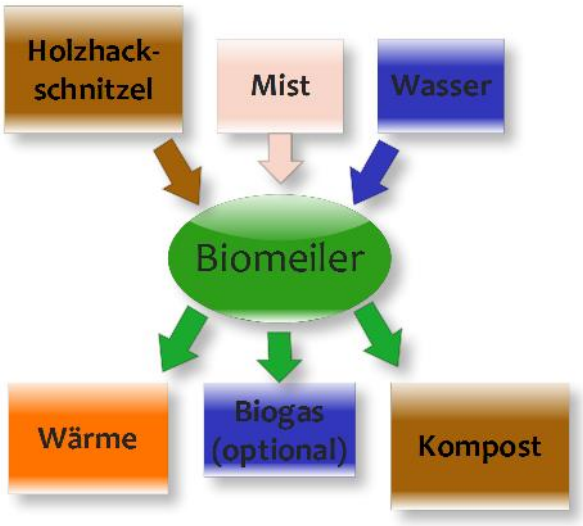
The Eco-Kiln

"Water heating and humus with brushwood compost"

Introduction

An Eco-Kiln is a facility that creates heat energy from biomass. Water hoses are arranged inside a pile of wood chips, and through a microbiological degradation process, heat is released over a period of 12 to 24 months. This heat can be used for heating indoor spaces as well as water heating. At the same time the Eco-Kiln produces biogas for cooking and as an alternative energy source. After the process is complete, the wood chips have transformed into valuable compost.



Advantages at a glance

- **Permanent heat source:**
  - usable with water or air circuits
  - temperatures of 70°C
  - provides heat and biogas for 18 months
  - provides heat without combustion
- **Ecological:**
  - recycling of local plant remains
  - very potent ecological compost, as a good fertilizer
  - stimulates the enhancement of humus (the bonding of carbon into soil)
  - negative CO2 – balance (through storage of compost in the humus)
- **Economical:**
  - low-tech & low cost construction
    - low capital costs
    - almost zero operating costs
  - supplies humus without mechanical work
- **easily combined with biogas production**

Historical Background

Eco-Kiln "Classic"

The Eco-Kiln was first developed by Jean Pain (1928-1981) in Provence. He used tree and bush cuttings to create a natural composting process which generated warm water, warm air, biogas and high quality compost. All this without combustion or waste.

Through the help of the composted wood he developed a system of farming that did not require watering or weeding (→ "Un Autre Jardin" or "Another garden"). This system consists of completely closed cycle ecological systems. Because of its simplicity the Eco-Kiln can be created by almost anyone. This increases the autonomy of the energy and compost production.

Microbial Carbonation (MC)

The Eco-Kiln System was further developed by Walter Witte. He modified the process by adding manure (horse- or goat-dung) to up to 30% of the total. The compost that is created in the MC contains more nitrogen, and is more quickly and thoroughly processed. In the MC-Eco-Kiln sustainably created humus also binds carbon. This process is aerobic and anaerobic at the same time. With 30% manure the Eco-Kiln reaches a maximum temperature of 70°C. For our purposes our Eco-Kilns contain only 10% manure.

Functional principle

Biochemical process

The Eco-Kiln uses a surface aerobic process and an internal anaerobic process through bacteria and their enzymes. The anaerobic processes prevent the generation of mineralized compost, instead generating highly complex combined carbon compound (humus). Unlike conventional compost in which combined carbons mineralize to $CO_2 + H_2O$, the Eco-Kiln sustainably binds carbon as humus.

After approximately eight months carbonization takes place. If no heat exchanger is installed, the compost can mixed with the top 10-15cm of topsoil before planting.

Common compost piles created by W. Witte use no brushwood, but instead are built of straw, slurry or dung. These are totally composted after only 8 weeks.

DIY Manual

Required Materials and Tools

Material Eco-Kiln		
Fabric (shade-cloth)	1 x 3 m x 30 m	117 €
Foil	1 x 8 m x 8 m á 1 mm	-recycelt-
Reinforcement steel mesh	5 x 2,30 m x 6m	290 €
Wire		-recycelt-
Thermometer (2 x)		10 €
Manometer (pressure measurement)		10 €
Circulation Pump		-recycelt-
Time switch		10 €
Ball indicator (to check flowrate)		10€
PE – pipe (spirals)	3 x 100 m, d = 32 mm	10€
Materials Green House		
PE – pipe (Distribution greenhouse)	50 m, d = 40 mm	
PE – pipe (flow and return)	50 m, d = 63 mm	
PE – pipe (400 m² ´ greenhouse)	400 m, d = 32 mm	1300 €
Adapter / Connections (greenhouse)		300 €
Tools		
Wheel loader		-
Shredder	3 h für 130 m³	525 €
Shovels		
Dung / pitchfork, rake		
Pliers, pipe-wrench, knife		

Eco-Kiln Design

Use the following table to estimate measurements for designing your Eco-Kiln. I do not give any warranty concerning the data and the resulting use of the table ;). Depending on the materials (such as the kinds of timber / brushwood, size, composition, moistness, microorganisms, and kind of manure) data such as output and weight may vary.

Power	Volume fresh	Volume old	Weight	Diameter	Heigt	Circumference	No. of r. steel mat	Spirals
[kW]	[m³]	[m³]	[t]	[m]	[m]	[m]	[1]	[1]
1	10,4	8	3	2,6	1,5	8,2	-	2
2,5	26	20	7	3,6	2	11,2	3	3
5	52	40	14	4,5	2	14,2	4	3
7,5	78	60	21	5,8	2,3	18,1	5	3
10	105	80	28	6	2,3	18,8	5	3
12,5	130	100	35	7,1	2,5	22,4	5	3
15	156	120	42	7,1	3	22,4	5	3
20	208	160	56	8,2	3	25,9	6	3
25	260	200	70	9,2	3	28,9	7	4

Heights of above 3 meters are structurally difficult to build and therefore are not listed in the table.

Supplying the materials

Wood

The costs and economic viability primarily depend on the source of wood cuttings. Wood cuttings should be free and fresh. Good examples of sources are for example public collection points and building yards which often have leftovers from tree pruning Alternatively the brushwood of forests and gardens can be used (as modeled by Jean Pain). This has the added benefit of reducing flammable brush in areas prone to wildfires. Other sources could include forestry, horticultural and gardening corporations or simply your neighbors.

Manure

If you would like to build an Eco-Kiln like the MC, the material must be mixed with manure from any common agricultural animal.

Caution! If you are planning to use cow dung it should not be sourced from any commercial intensive mass animal farming. The animals are fed antibiotics which kill the microorganisms responsible for the fermentation process. Without microorganisms there won't be any heat!

Water

Depending on the freshness and humidity of the basic raw material, about one third water should be added. The water both suppresses the air within the kiln (which is not desired for anaerobic reactions) and serves as a habitat for microorganisms It is important that the Eco-Kiln is neither too wet nor too dry. If it is too dry, composting does not take place and if it contains too much water it will rot. ,

We substituted part of the water with whey (leftover from cheese production) and goat urine (~ 3 m³).

Mix Ratio

There are quite a few variables in making the Eco-kiln work successfully. The correct mix ratio of woodchips (as well as what type of tree they are sourced from and their thickness) and manure (as well as what animal it is sourced from) is crucial for successful operation of the Eco-Kiln. The following parameters apply: operating temperature, starting time and operating time. Differences in these factors mean that each Eco-Kiln is unique.

Microbial Carbonation

The Eco-Kiln at Schloss Tempelhof contains 90 m³ freshly chipped wood, 10m³ fresh horse manure, 8 m³ dry chicken manure and about 15 m³ fluids. Of this 3000 l added diluted goat urine and 1000 litres of whey from the cheese diary.

Typically a MC-Eco-Kiln contains 30% manure and 40% lignin containing materials (wood or wheat straw). The missing 30% can be made of random fresh plant material.

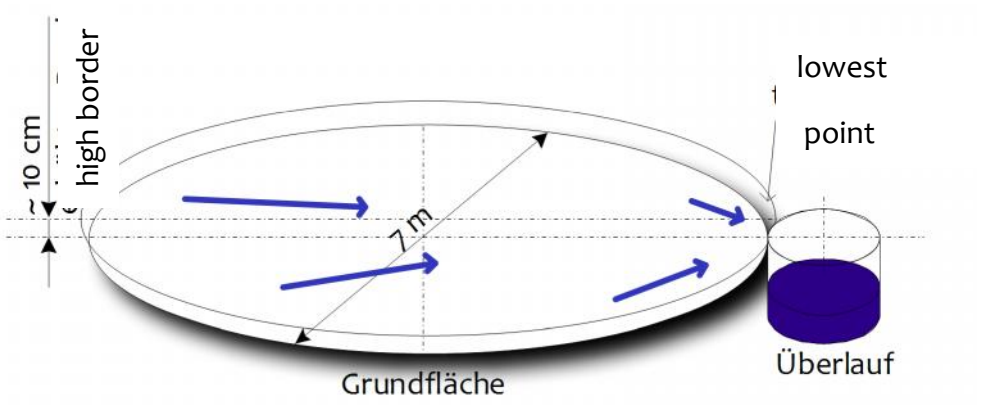
For more Information see the book "Mikrobielle Carbonisierung" (bibliography).

Classic

Jean Pain's "Classic" Eco-Kiln consists of only freshly chipped wood (max. 10 cm diameter) and water.

Preparation of the Area

Before the construction of the Eco-Kiln you should choose the ideal area and prepare it accordingly. It should be situated as close as possible to the place of heat consumption (green house, house, heater, shower), to reduce heat loss through extended pipe lengths . The area should be out of the way, flat and not prone to flooding in a floodplain as it will not be movable for 18 months.



- choose the area and stake off a circle with the appropriate diameter (here 7 m)
- slope the ground slightly on one side for drainage
- raise the outer edge (create with soil or a large drainage pipe)

- the barrier prevents the water from flowing out the sides of the water collector
  - dig a hole and insert a water barrel (~ 50 l) at the lowest point
  - add the foil and cut it appropriately
- the diameter of the foil should be 10 cm bigger than the diameter of the Eco-Kiln
- the foil prevents water from entering groundwater
- Leave a larger piece on the side with the overflow

Water from the overflow should be frequently poured back onto the Eco-Kiln to ensure that no microorganisms are lost.

Scaffold

We built the skeleton of this Eco-Kiln with reinforced steel mesh, as it is affordable and can be used multiple times before rusting. Additionally it is quick and easy to install. T

Staple the mesh on top of itself (50 – 100 cm overlapping) and attach multiple times with a strong wire.

We integrated an old wardrobe into the Eco-Kiln halfway between the steel mesh and the pump, to prevent the pump and the control center from getting wet or covered with snow during winter. We protected the back of the wardrobe with foil, and would recommend adding a strong metal frame, to prevent the additional weight from pulling the mesh apart as the pile gains height.

A long shade protection should be installed within the steel mesh to prevent the woodchips falling out.

Attention! This is only one option. There are many different versions to think about. If you can improve on this model, please e-mail us with your suggestions! Another option for building the Eco-Kiln is to use potato bags (check appendix).

Layers

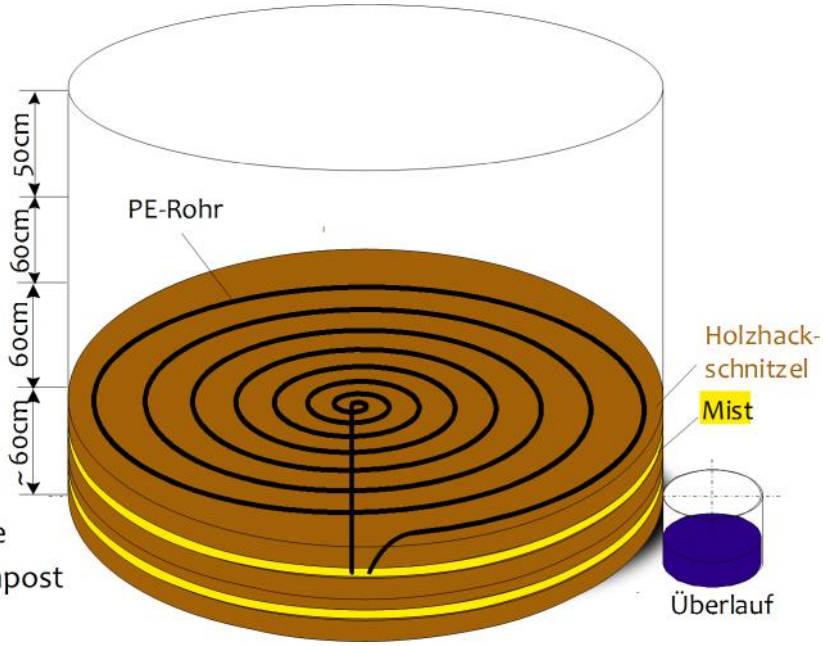
The different layers of our Eco-Kiln are made of chipped wood, and goat- and horse manure.

- The chipped wood and manure should be thoroughly mixed to ensure equal distribution of nutritious elements
- To create an equal distribution of water, sprinkle it constantly during layering and use pitch forks and rakes for mixing to prevent it from pooling on the surface.
- It is not possible to only add Water after building because this will create little channels that will result in dry spots in the Eco-Kiln

Heating spiral installation

The lower part of the Eco-Kiln will not get very warm. That is the reason why the first heating spiral has to be added at a height of 80 cm.

- distance of outside wall to pipe ~ 40 cm
- distance between coils ~ 30 cm
- length of pipes 100 m, aperture = 32 mm
- the pipes should be prevented from shifting by bracing and securing with wood, wire and string
- after placing the pipes cover them with 10 cm of chipped wood
- add a silo net on top of the layer of woodchips
  - This ensures an easier deconstruction of the Eco-Kiln as the pipes can be separated from the compost and reused



- Tip: We recommend covering the pipe ends with plastic bags to protect it from pollution during building.

Put in two more spirals at a height of 70 cm. After the third spiral 80 cms worth of material should be added. This layer will not heat that much. It serves primarily as an insulator and protects the Eco-Kiln. Additionally, in this third and last layer of material, there will be aerobic processes that are reliant on the anaerobic surface processes.

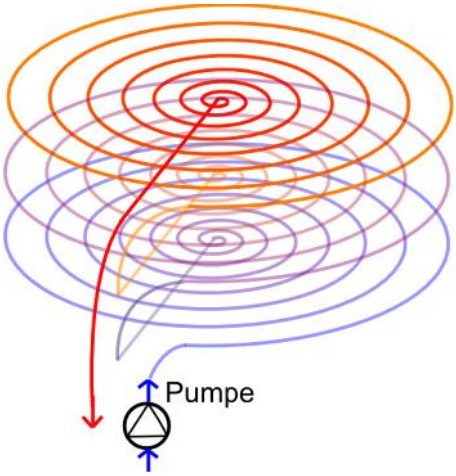
Dach

A dome has to be formed to enable water to flow to the outside of the Eco-Kiln, and to prevent flooding. A layer of water resistant bacteria and algae will automatically form within a few weeks. Eco-Kilns should never be built in enclosed houses or covered completely as some of the microorganisms need sunlight to survive.

Pipework and Heating System

Connecting the heating spirals

The Heating system has to be designed according to its proposed use. In our case we used the energy of the Eco-Kiln to heat a greenhouse in order to cultivate plants in the wintertime. Therefore a circulation pump was required. Sometimes these can be recycled from old heating systems.



The cold water will be pumped into the outer circle of the spiral, where it will heat up and flow out the middle (see picture). The water will be pumped through the three spirals consecutively. To ensure a complete and regular flow the spirals are arranged in a series.

Greenhouse Integration

The flow- and return pipes to the greenhouse (d = 63 mm) are placed 60 cm deep in the earth to protect them from frost. Ideally the warm pipe can be isolated to prevent heat loss. The pipes in the greenhouse are placed directly on the ground to keep the temperature above 0°Celsius without losing heat. The disadvantage is that the ground dries out faster.

For aeration a tap is installed at the highest point of the pipeline system.

Heating of Buildings / Other possible Uses

If you want to heat your house, a heat exchanger with buffer storage is necessary in between the Eco-Kiln and the heating circuit. This is because plastic pipes can absorb oxygen corrosion.. Of course the Eco-Kiln can be combined with other heating systems (e.g. solar thermic or geothermic systems, wood, etc.) Due to the Eco-kiln's heating capacity, it is possible to use non-potable water for washing dishes, and laundry and showering.

Another idea is to use air instead of water as the heat transfer medium. By installing pipes in the Eco-Kiln and adding a little fan , it can blow warm air into the building.

Operation

Temperature

If heat is not needed during summer, you should consider cooling the Eco-Kiln down. Although no case has ever been reported, it is theoretically possible that the combination of higher temperatures and strong solar radiation could cause incineration in the center of the Eco-Kiln.

If the temperature of the Eco-Kiln drops below 28°C the circulation will stop. Fungus will grow and the thermophilic anaerobic bacteria will die. In this case the Eco-Kiln cannot be started again. Therefore the temperature should never drop below 34°C! To ensure that the temperature never drops below 34°C a control is required. The control helps to regulate the water flow rate and the water transportation through the Eco-Kiln.

Control

Control with time switch

The easiest control uses two thermostats (one in the flow- and one in the return pipe) and can be regulated with one simple time switch. The time switch ensures that the pump is not constantly pumping water. Instead it interrupts the pumping circulation from time to time, so that the microorganisms have sufficient time to produce heat. For example the pump can run for one hour and then switched off for two hours. The ideal time varies in different Eco-Kilns depending on their ambient temperature and has to be discovered through experimentation.

Automatic control

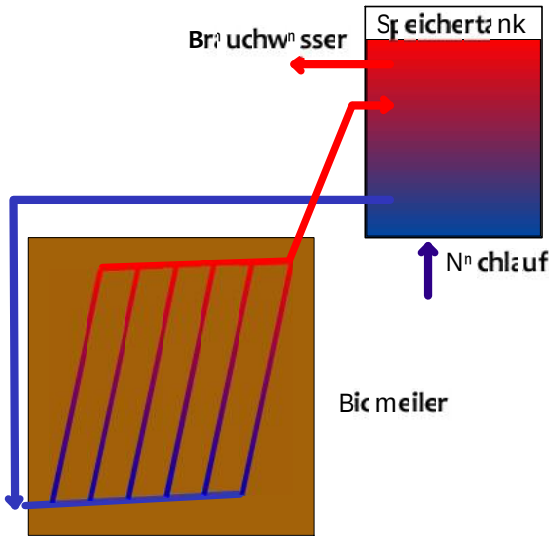
For greater efficiency and a more comfortable life for your microorganisms, consider integrating controls of solar thermal systems. These measure the incoming and outgoing temperature of the water constantly and regulate the pump to the ideal flow rate. This saves energy costs (modern pumps need less energy when pumping with less power) and the microorganisms don't suffer strong temperature fluctuations.

Operating pressure

The operation pressure inside the pipes should be 0.5 bar (excess pressure) to ensure the circulation pump does not run dry. This can be controlled with a manometer that is ideally installed close to the pump.

Self-regulating / Thermosiphon -principle

Another possibility is to build the system according to the thermosiphon principle (natural circulation / gravitational circulation). Warm water is lighter than cold water. Because of this a natural circulation without a pump can occur.



Note: This is a strongly simplified schematic sketch of a first attempt and not is appropriate for reproduction ;)

In order to do so following construction adjustments and considerations are required:

- Pipes need to be on an incline
- They should not be the right thickness
  - (depending on the inclination and the size of the Eco-Kiln they should be 32 - 40 mm diameter)
- They shouldn't be too long and should not have any curves
- The buffer storage needs to be at the highest point
- There should be several pipes installed in parallel which are connected with each other both above and below

Maintenance

During the runtime of the Eco-Kiln, the circuitry, temperature and pipes should be checked at regular intervals. Aside from this the Eco-Kiln is quite easy to take care of and does not require further care ☺.

Deconstruction

The composting process is finished if the temperature of the Eco-Kiln drops sharply (after 1 ½ years). You should be able to squeeze the wood chips in between your fingers easily. The compost can be used in the garden and fields.

It might be wise to first remove the reinforced steel mesh. After this you should deconstruct the Eco-Kiln layer by layer. Dig out the pipes while being careful not to damage them or other reusable things. The pipes will be easier to remove because of the net you installed while building the kiln. The deconstruction usually requires usually more time than building but is easily done in pieces. The compost is already packed, so that it can be directly transported to the place where it is needed.

Hint: The Eco-kiln can become a home for cockchafer grubs of the European rhinoceros beetle which is on the list of endangered species. Please handle the cockchafers with care =).

Suggestions

Biogas digester

Jean Pain integrated a biogas digester in his Eco-Kiln. The operating temperature was secured by the Eco-Kiln, and created 5000 l of gas which can be used for cooking, electricity generation or to run a car.

In Germany a system like this was not implemented. If intending to install such a system it is advisable to install both a loading canal and one to remove old biomass, as a fermenter works more quickly and needs to be fed more frequently.

Potato-bag Eco-Kiln

In locations that are not easily accessible with a bulldozer, you can pack the wood chips into potato bags to be easily transported. The material used for these bags is permeable meaning that water and bacteria will still be able to move freely

Soil, renaturation and humus

This document is more extensive than expected yet important information about the effects of the compost, the humus constitution and the carbon content are missing. It would take a whole book to include them, but others people have already dealt with this in the following sources:

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Initiator:	Michael Stang
Author & Photography:	Aurèle Haupt
Location:	Gemeinschaft Schloss Tempelhof

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