



## Clustering Building Design, Glass and Landfills

### **Executive Summary:**

There are many viable approaches to green building design, from utilizing nature's principles like the termite and zebra airconditioning, to using bamboo, which will be covered in another case. One such approach converts end-of-life bottles into foam glass to be used as a structural material for building. Not only does foam glass provide insulation and protection from humidity, it also creates functionality and value from waste glass and can be adapted for multiple uses. Glass often ends up in landfills despite the fact that it can continuously be re-used in different forms. Apart from a building material, it can also be used as a growth medium in hydroponics. This opens up glass recycling as a platform for multiple products and cash flows as well as job generation.

*Keywords: Green building design, foam glass, insulation, housing, resource efficiency, hydroponics, landfill, cash flow, jobs*

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### **Breakthroughs in Green Building design: It started with a Factory**

Had I ever mastered mathematics in high school, I would have opted for a career in building design. Ideas unfold before my mind's eyes and, though I never had the gift of drawing, actions ensure the implementation of these visions. I was first directly involved with a grand building project when I took over the leadership of a small Belgian detergent maker on the brink of bankruptcy. I re-launched the company by resolutely opting to construct Europe's first ecological factory. It was a gamble to spend 100 million Belgian Franks when the turnover was only 120 million at the time. In October 1992, when Carlo Ripa di Meana, the European Commissioner for the Environment, and Lester Brown, the founder and then president of the Worldwatch Institute, inaugurated the facility, CNN covered it on Prime Time News. This secured it a place in the annals of green design. The booklet on the building was distributed for free and described, open source, all the materials, costs and decisions made.



Carlo Ripa di Meana



Lester Brown



Paolo Lugari



Luigi Bistagnino



Heitor Gurgulino de Souza



The Ecover Factory from the air in 1993

© 1993, Ecover

## A Tropical Hospital

Two years later I was privileged to monitor the design and construction of the first self-sufficient hospital at Las Gaviotas in the Vichada of Colombia under the leadership of Paolo Lugari. The shift from a wooden industrial structure in a temperate climate to a public service building in a hot, humid, tropical climate provided the contrast that permitted me to learn fast track how to design green buildings using available resources and the local climatological conditions. The team enjoyed complete freedom from regulations and even from insurance companies, but faced strict yet ambitious targets: it was to become the first hospital self-sufficient in power and water with a budget limited to US\$300,000. The team of 15 had only one architect. The surgeon's room represented the greatest lesson in architectural design. Traditional wind patterns were combined with underground tunnels and equipped with aluminum rods to condensate the moisture. The uninterrupted airflow through the ducts secured fresh and dry air with humidity levels always under 17%, without using pumps or power thanks to a continuous under-pressure. Every system was driven by natural flows.



The self-sufficient hospital with 24 beds at Las Gaviotas, Colombia © 2000, Luis Camargo

I was then introduced by the late Prof. Dr. Carl-Göran Hedén MD, Member of the Club of Rome to the Swedish architect, Bengt Warne, who designed the “envelope house” (also known as Nature House) which could self regulate temperature and humidity in a similar manner to the hospital in Colombia. This exposure encouraged me to undertake a third breakthrough: the design and construction of the largest bamboo building ever in modern history. There was one caveat: it was going to be built with a German building permit. It is well known that German engineering and building codes are the most demanding in the world. Frau Sabine Mpho, director of the global projects at the The World Expo 2000, had been monitoring the initiatives of ZERI at the United

Nations University thanks to the leadership of Heitor Gurgulino de Souza, the Rector at the time. She offered us the opportunity to display the pioneering examples of business without emissions at the World Expo. When the seventh project<sup>1</sup> was approved and accepted for display, Sabine made a bold offer: she suggested that we build our own pavilion. Without consulting the team, I accepted the challenge.



Nature House by Bengt Warne © Warne



The ZERI Pavilion at the World Expo 2000 in Hanover © Luis Camargo

## A German Building Permit for a Bamboo Building

I immediately asked Simon Velez, the Colombian icon of bamboo architecture, to take charge of the design. With one phone call, Stephan Schmidheiny, the Swiss philanthropist, was prepared to pay for the first bill of many expensive laboratory tests at the German Universities. The process of getting the permits was unfolding quickly. Organizing the construction of two pavilions, one in Colombia and one in Hanover, within 14 months, in contrast, was an intensive course in building design and planning. Mario Calderon Rivera, the President of the Manizales Chamber of Commerce and Industry, was the indispensable partner who independently covered the costs of the Manizales Bamboo Pavilion with the support of Gabriel German Londoño and Nestor Buitrago. It still stands today and has become a symbol for the region<sup>2</sup>. I took responsibility for the Pavilion in Germany and it earned me an invitation as visiting professor at Politecnico di Torino due to the untiring support of Prof. Luigi Bistagnino.

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<sup>1</sup> The seven projects are: the brewery in Tsumeb (Namibia), the integrated fish farm in Suva (Fiji), the regeneration of the forest by Las Gaviotas (Colombia), the mushroom farming on coffee waste (Colombia) and on water hyacinth in Harare (Zimbabwe), bamboo building as earthquake safe structures in the Colombian Coffee Region, the transformation of solid municipal waste using an old cement kiln in Stora Vika (Sweden).

<sup>2</sup> For a detailed review of the construction of the ZERI Pavilion, please surf to <[www.zeri.org/ZERI/Home\\_files/ZERI%20PAVILION%202012.pdf](http://www.zeri.org/ZERI/Home_files/ZERI%20PAVILION%202012.pdf)>



Mario Calderon R.    Gabriel German Londoño    Nester Buitrago Trujillo    Simon Velez    Carolina Salazar Ocampo

experience of working with wood in a temperate climate, a hospital in the tropics and the largest bamboo structure at the time, gave me enough experience by 2000 to start experimenting on my own. The construction of a bioclimatic house, "La Miñoca" in Manizales (Colombia), with the support of Carolina Salazar Ocampo, the Colombian architect became my personal reference. When guests of the newly constructed house complained in 2003 that the bedroom was too cold, I knew I had understood the design options based on physics, and I may even have overdone them.

The academia began to show interest, starting with a surprise request from the Roberto Peccei, Vice-President for Research of the University of California Los Angeles (UCLA) to lecture on my architectural experiences. The green building councils from the USA to Australia and South Africa began listening to some proposals. However, I was not an architect and did not speak the jargon and thus looked at design differently. My objective was not to crack the greatest design, or to make a fortune from building but to expand housing and design into a broader cluster that could stimulate local economies and encourage communities to respond to their own basic needs. A house is not only about shelter, it is also about water, food, health, energy and the capacity to generate a large number of jobs<sup>3</sup>.



La Miñoca in La China



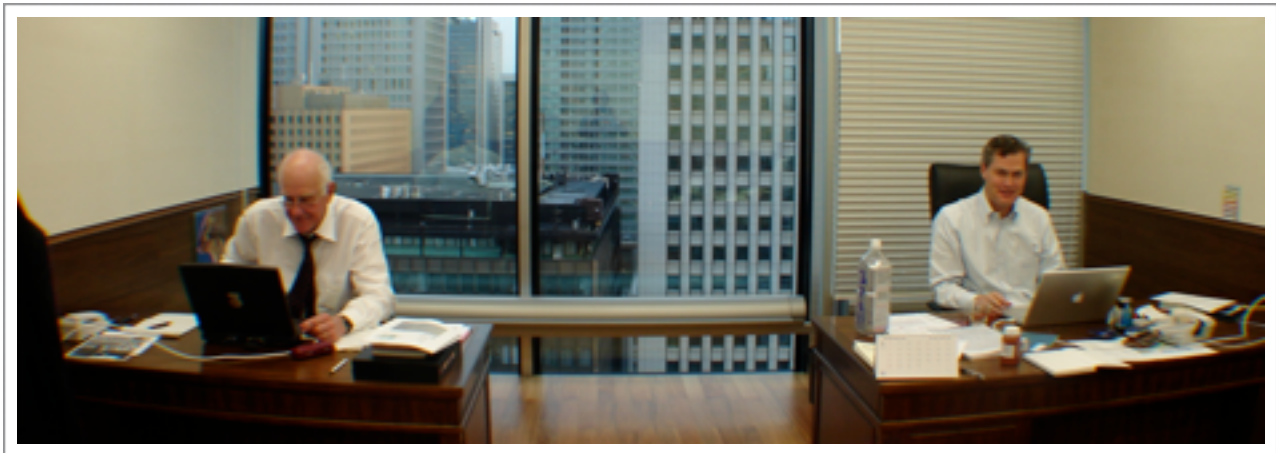
©2006, Pauli

ZERI Pavilion in Manizales - Symbol of the Department ©2000, L. Camargo

<sup>3</sup> For a detailed account of how a housing project can catalyze development in all sectors and secure that people are lifted out of poverty, read my blog on "Inclusive Growth" on the [gunterpauli.com](http://gunterpauli.com) website.

## Scandinavian Designs

The search for connections amongst architecture and other basic needs was theoretically not difficult, but I needed a place where I could see how innovations in architectural design stimulate clusters of new industries. I was proud to note that 250 new companies had emerged around the bamboo initiative in Colombia and approximately 7,000 new jobs had been generated. Later I learned how Hang Doa and his team in Vietnam took the experience from Colombia and grew the industry beyond what we ever imagined with an estimated 100,000 jobs and a fast growth in new fields like bamboo bicycles. I needed something more profound. At a workshop organized by Göran Carstedt with Peter Senge, in Umeå (Sweden), I came across Anders Nyquist, the Swedish architect who coined and implemented the EcoCycle House.



Sharing office with Anders Nyquist in Tokyo in 2006

© Pauli

Anders impressed me so much during our first encounter in 2004 that I changed travel plans for the summer holidays with my sons to visit him and see Rumpun, the ecovillage that he had imagined already in the sixties and implemented. I had visited ecovillages around the world, inspired by the network of Declan Kennedy, but had never heard of this one. The fact that other villages did not recognize it triggered my interest even more. I found proof, in Rumpun, that innovation in building design can be cheaper, healthier and build up a community. It was also clear that Anders and his wife, Ingrid, were dedicated to what they had proposed, and had turned it into their business philosophy. What emerged was a web of innovators around Anders, who were equally inspired by him and pushed themselves beyond the status quo. What I found was so refreshing, that it pushed me to a higher level of understanding how social and economic development can be sustainable provided the entrepreneurs believe in it. It was clear that I had found my grandmaster. Michael Raimondo produced nine video clips on the outstanding and yet simple innovations pursued by Anders Nyquist and resulting in new industries.<sup>4</sup>

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<sup>4</sup> [www.youtube.com/watch?v=BLef05yHcYA](http://www.youtube.com/watch?v=BLef05yHcYA)

Anders shared his experiences and frustrations with me. He introduced me to the entrepreneurs that constitute the core network of change agents in that part of the world. I came across a landmark green school built in the middle of the Swedish community of Timrå. I also saw the meticulous design of the GreenZone<sup>5</sup>, which included a car workshop, a gas station and a fast food restaurant. They clustered water, and energy and integrated technology that even the gurus in the United States had not heard of, resulting in incredible levels of water, energy and efficiency. Dozen of enterprises emerged around the pioneering work of Anders, each pushing the borders of sustainability, health and quality of life far away from the center of architecture and science. I concluded that because it is on the periphery there is greater freedom to act and think beyond the standard.



Laggberg School designed by Anders Nyquist © Nyquist

## Glass and Building Design

The extensive introduction was indispensable to disclose the knowledge and experience required for opportunities to emerge. It is not the mere invention of one bright technology, or the finances provided by an investor, it is an active and expanding

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<sup>5</sup> For details on the integrated design of the GreenZone surf to <[www.greenzone.nu/index\\_e.shtml](http://www.greenzone.nu/index_e.shtml)>

network of increasing complexity that allows us to steer societies towards sustainability<sup>6</sup>. While Michael Raimondo documented nine of the innovations<sup>7</sup>, and Lars Ling, a very dynamic coordinator for Middle Sweden, has published 9 video clips on the innovations clustered around Anders Nyquist, there was one particular business development that retained special attention: the cluster of glass, insulation and landfills. Anders introduced me to Åke Mård, the brain behind the Koljern prefabricated design of buildings. At first I wondered why I would be interested in pre-fabricated buildings, but I knew that I should trust Anders Nyquist. It quickly became clear that Åke had worked out a revolutionary concept: the creation of a house frame with foam glass at the core, made from recycled car windshields. While it sounded ludicrous, I went to the construction site and was impressed and when I visited a finished home the air quality and room temperature were remarkable.

Foam glass is 97% air, mainly CO<sub>2</sub> and sequesters it for about one hundred years providing a convenient way to reduce it in the atmosphere. These millions of tiny bubbles not only regulate temperature, they do not let any humidity through either. Furthermore, glass only melts at 1,100°C and does not catch fire, eliminating, or at least seriously reducing, the need for fire retardants. When I analyze any innovation, I look for a strong start. This was a strong start. Then I learnt that the raw material could be old glass. Pittsburgh Corning the Belgium-based supplier located in Tessenderlo, which started production in 1965, uses broken car windshields. This means that foam glass scores high on resource efficiency. Glass cannot be destroyed, it can only be transformed. This light foam also has structural strength, not just an insulating ability. The series of characteristics it has offer "multiple benefits and multiple cash flows", a core condition of the Blue Economy.



Glass foam in a prefabricated housing system designed by Åke Mård



© Nyquist

<sup>6</sup> The title of the book Fritjof Capra and I edited in 1995: "Steering Business Towards Sustainability" published by the UNU Press and which became on April 5, 1995 the first book ever presented on broad band internet

<sup>7</sup> See the video links at the end of this case

When Åke Mård explained the principles of foam glass I realized that it was another classic example of how an innovative product can substitute something with nothing. This core concept of the Blue Economy often causes hilarity amongst those who hear me say it for the first time. But, foam glass soon turned out to be my favorite case to demonstrate how one product, by design and systemic use, can eliminate the need of several products. This creates a new dimension for sustainability. It is not about improvement of resource efficiency of factor 4 or 10, it rather puts resource efficiency in magnitudes of 100 or even 1,000. What I learnt in Sweden was another case where I had to navigate between fantasy and reality. But reality was on display before me, the science and the business case were both solid.



Dr. Janis Gravitis

Åke Mård

Tamio Ishibashi

Our research team in the Baltic States, headed by Dr. Janis Gravitis from Riga (Latvia), pointed out that Russian scientists invented foam glass in the 1930s at the Mendeleyev Chemical Technological University in Moscow. Pittsburgh Corning from the US claims it invented and industrialized it. We were able to document that Gomel Glass (now located in Gomel, Belorussia) has been manufacturing foam glass for the local and Russian market for the past 50 years based on the original work of the 1930s<sup>8</sup>. Despite being a remnant of the Soviet Union it is not in disarray. Georgiy Kazak, (CEO) and Anatoliy Minin (Chairman) are clearly in charge of the company and continue to supply foam glass for the Belarus and Russian market.

### **The Success of the Glass Portfolio:**

The combination of the logic behind it and the prefabricated building design of Åke Mård motivated me to ask our ZERI network in Japan to assess the breakthrough. Mr. Tamio Ishibashi, the Senior Vice-President of Daiwa House is Japan's largest house builder, with some 40,000 units constructed per year sent a team to Sweden to assess the performance and the conclusion was positive. He was impressed with the work of Anders Nyquist and invited him to Japan to demonstrate the natural air circulation

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<sup>8</sup> [www.gomelglass.com/en/about/history/](http://www.gomelglass.com/en/about/history/)

principles in their office buildings in Sendai. The Japanese partners confidence, reassured us that my intuition was right. Following this, in 2005, was a meeting at the European headquarters of Pittsburgh Corning in Belgium. The executives received me politely but the management at the time did not grasp the potential economic impact they could have on a regional scale. Thus it is unsurprising that the leadership is shifting from one multination corporation to a portfolio of innovative companies.



Daiwa House offices in Sendai (Japan) designed by Anders Nyquist including zebra effect and termite ventilation © Daiwa House

As I had visited the glass foam factory in Tessenderlo (Belgium) I could compare its process engineering with the upstart company Earth Stone - an American venture created in 1995 by Gay Dillingham and Andrew Ungerleiter in Santa Fe, New Mexico. Pittsburgh Corning is focused on producing with an ever higher economy of scale and continuously lowering marginal costs. Dillingham and her team, in contrast, were dedicated to custom designed glass foam for uses I had never heard of before. The traditional business based on a core competence had put blinders on the eyes of Pittsburgh Corning and I realized that Pittsburgh Corning and ZERI were not an ideal fit and thus we did not insist. However, Åke pursued his design concepts and his decades of hands-on experience brought him a patent that turned the tables on his supplier: now that Koljern (Åke's construction system) built its logic around foam glass, the

multinational started to show interest beyond the supplier-customer relationship. Koljern evolved into a key component in the design of energy efficient housing, earning Åke Mård a well deserved 2013 Annual Swedish Innovator's Award for Buildings.



Meanwhile, Gay Dillingham (pictured to the left) had built up a portfolio of unique patents around another version of foam glass: 95% of her raw materials were diverted from landfills. She created the supply chain from the Albuquerque landfill. The glass was ground as fine as baking flour for bread and led to four product lines. The creation of this portfolio was driven by a desire to substitute mined raw materials with recycled glass. In line with the Blue Economy principles, the products manufactured have a higher value than the mere bottle from which it was made. Earth Stone still taps the market for insulation and green, structural light-weight building materials, but the core business moved on to horticulture<sup>9</sup>.

Glass recycling turned into a platform technology, penetrating multiple sectors. This is the pre-condition to provide a framework where one innovative business model stimulates dozens to innovate. One of the applications to unfold was foam glass as a growth medium for tomatoes and strawberries in greenhouses. Foam glass is highly porous, free of chemicals, and offers soil aeration while providing the right water balance to the roots. The production technique allows the growth medium to be customized to fit a wide range of plants and farming techniques. Considering that most hydroponic growth substrate is mined perlite or hydroton, this innovative application puts glass in an unending cycle. Foam glass can be reconditioned back into the next season's growth medium. It shows that a non-biodegradable product can be highly ecological, provided there is a solid effort spent on creating the loop. The success of "growstone" stimulated Gay and her team to spin off the business into a separate unit.



Rockstone made from recycled glass as a growth medium © EarthStone

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<sup>9</sup> [www.earthstoneinternational.com/our-company/our-technology](http://www.earthstoneinternational.com/our-company/our-technology)

The creative team at Earth Stone designed two additional product lines: consumers cleaning and personal care products, and industry abrasives, aggregates and filtration medium. The "QuickSand" sanding block lasts longer than sandpaper and each block is made from one beer bottle. The cleaning products for swimming pools and kitchens are alternatives based on "physics" rather than toxic chemicals. The four business sectors of Earth Stone and the experience of research, which started without previous experience in the field, resulted in a highly flexible foam glass production design that could accommodate nearly any technical requirement from the customer. The highly standardized volume production from Belgium stands now in stark contrast with the highly flexible small runs in the US.



Harvey Stone © Stone

When I began running a series of Blue Economy Training courses in Santa Fe, New Mexico (USA), my students of the first course in 2002, guided by Harvey Stone, had the chance to study the business model of Earth Stone and would make detailed assessments of the present and future opportunities of foam glass based on the raw materials, the industrial process, the marketing and the recovery of the used material. We ran the mathematics of the business based on the European and American experiences and came to some remarkable insights: foam glass produced from diverted landfill bottles reaches its break-even with only 5.2 million bottles and, using windshields, the equilibrium is achieved with about double the volume. When we started to apply the model to wine production, we realized that we have a new, systems approach to the debate of glass versus plastic bottles. The Bordeaux wineries distribute 450 million bottles per year, and France drinks 3.8 billion bottles.

## Chains of Factories

In 2010 American consumers surpassed the French, for the first time, as the biggest wine drinkers with a total volume of 4 billion bottles. We calculated that, solely based on the wine bottle waste, up to 750 glass recycling factories could be created in America and 700 in France. When we start extrapolating this emerging industry, the logic shifts away from the traditional recycling of glass where a bottle is converted back to a bottle. We know this is not competitive, and therefore it can only be undertaken if the law obliges companies and additional costs and fees are applied. But we identified something that is much better: entrepreneurs can embrace the addition of value to the spent glass by injecting CO<sub>2</sub> and jobs are created beyond what the glass industry has been able to achieve. It generates multiple cash flows and therefore can offer products at competitive prices. A recycled product (glass bottles from glass bottles) that struggles can rather be converted to a portfolio of recycled products that generate multiple cash flows. This is an excellent case of The Blue Economy.

Switzerland is a unique market for glass since it is the world champion of glass collection. With 98% the Swiss have the highest glass-recycling rate: 320,000 tons of waste converted back into raw materials. Unsurprisingly, the Swiss produce more value from glass than anyone else. Misapor AG is the market leader and Daniel Engi, the CEO since 1995, has a clear, regional growth strategy controlling 4 factories. Misapor produces 200,000 m<sup>3</sup> foam glass per year in Switzerland with 2 production units, 240,000 m<sup>3</sup> in Germany and 30,000m<sup>3</sup> in Italy. The company licensed its technologies for foam glass production to ENCO, a Swiss engineering group based in Chur, to ensure a fast internationalization of its know-how. Jakob Federspiel, Director of ENCO (Switzerland) offers marketing to turn-key projects from production under the name Misapor® and they have dozens of initiatives in the making.



Daniel Engi centre with white hat © WesrDeutsche Zeitung



Glass foam house in Switzerland by Misapor © Dolores Rupa

The product portfolios and the production techniques we were able to witness on both sides of the Atlantic demonstrated that, more than substituting a bottle, it is about substituting multiple different products with a potential to shift resource efficiency by a factor of one hundred or more. Glass can always be reconditioned and always be recycled. It should be viewed as an asset and not as a cost on balance sheets. When the market leader leaves such an opportunity untouched and one entrepreneur shows the inroads that could be made, it invites more competition. At ZERI, information is always shared open source and, since products like foam glass are local products that could enter many niches, new initiatives across the globe would not compete against each other. Pittsburgh Corning had a late wake-up call, and created a new production unit in Klasterc (Czech Republic). Now that the pressure is on, as described below, the company is constructing a facility in China to meet growing demand there. While Earth Stone continues to focus on the vast US market, it also ventured into the Netherlands with its growstone product range for horticulture and greenhouses. This encouraged others, such as tomato farmers, to be pro-active entrepreneurs.



### **Foam glass in the future:**

The European Union recognized the opportunity of foam glass from waste glass and funded the creation of JSC Stikloporas ([www.stikloporas.lt](http://www.stikloporas.lt)) in Druskininkai (Lithuania). Since 2012, Edgaras Krusas, the CEO, has hired 24 glass foam experts who ensure a 24/7 production. The company started lightweight construction of homes in Poland, Russia, Belorussia and the Baltic States. It is competing directly with the Finnish foam glass maker, Uusioaines Ltd. ([www.foamit.fi](http://www.foamit.fi)), which inaugurated its factory in 2011 with a production capacity of 150,000 m<sup>3</sup>, under the leadership of Jari Stenberg (Chairman) and Lassi Julin (CEO). Our current estimate of the European market is that at least 10 factories have been constructed are under construction across Europe, driven by the competitive portfolio of products and services. The total investment has exceeded €100 million and the job generation is now 1,200 direct jobs. However if we include the indirect employment from the collection and separation of glass at source another 3,000 jobs could be added.

While the present production volume in Europe is just above one million m<sup>3</sup>, it is increasing at a double-digit rate, and we expect that, before 2020, there will be 25 factories operational on the continent and that the Asian market will take off. Countries like Switzerland, where the glass recycling rate has hit the limit, the substitution of plastic containers with glass is a guaranteed growth strategy for foam glass. The only way to increase the supply of glass is to revert back to glass containers from the plastic containers and, now that demand for insulation in houses is reaching new highs, we see this reversal as the trend of the future. This signals a fundamental restructuring of the bottling industry. We see foam glass as one of the very few re-industrialized initiatives driven by newly found resource efficiency. Glass cannot be composted or incinerated, but it can be re-used with more value. Plastic for drinks has a functional life numbered in days, and a half-life of decades, perhaps even centuries. With this innovation, we can put the economy on a blue track entrepreneurship.



## Translation into Gunter's Fables

The business of glass is translated into the fable #52 entitled "The Crystal Palace". It is dedicated to Åke Mård, who already had inspired the creation of this cluster, back in 2004, with his Koljern technique.

## Documentation

[www.youtube.com/watch?v=BlvFA7WwxFw](http://www.youtube.com/watch?v=BlvFA7WwxFw)

[vimeo.com/album/2916248](http://vimeo.com/album/2916248).

[www.earthstoneinternational.com/our-company/our-technology](http://www.earthstoneinternational.com/our-company/our-technology)

[www.misapor.ch/files/kurzportrait-misapor.pdf](http://www.misapor.ch/files/kurzportrait-misapor.pdf)