EXPLORING THE FRONTIERS OF GLASS IN DESIGNED ENVIRONMENT ACROSS SCIENCE, TECHNOLOGY AND THE ARTS

AGC

The Journal of Architectural Glass Concepts

LIVING AT THE EDGE EFFECT

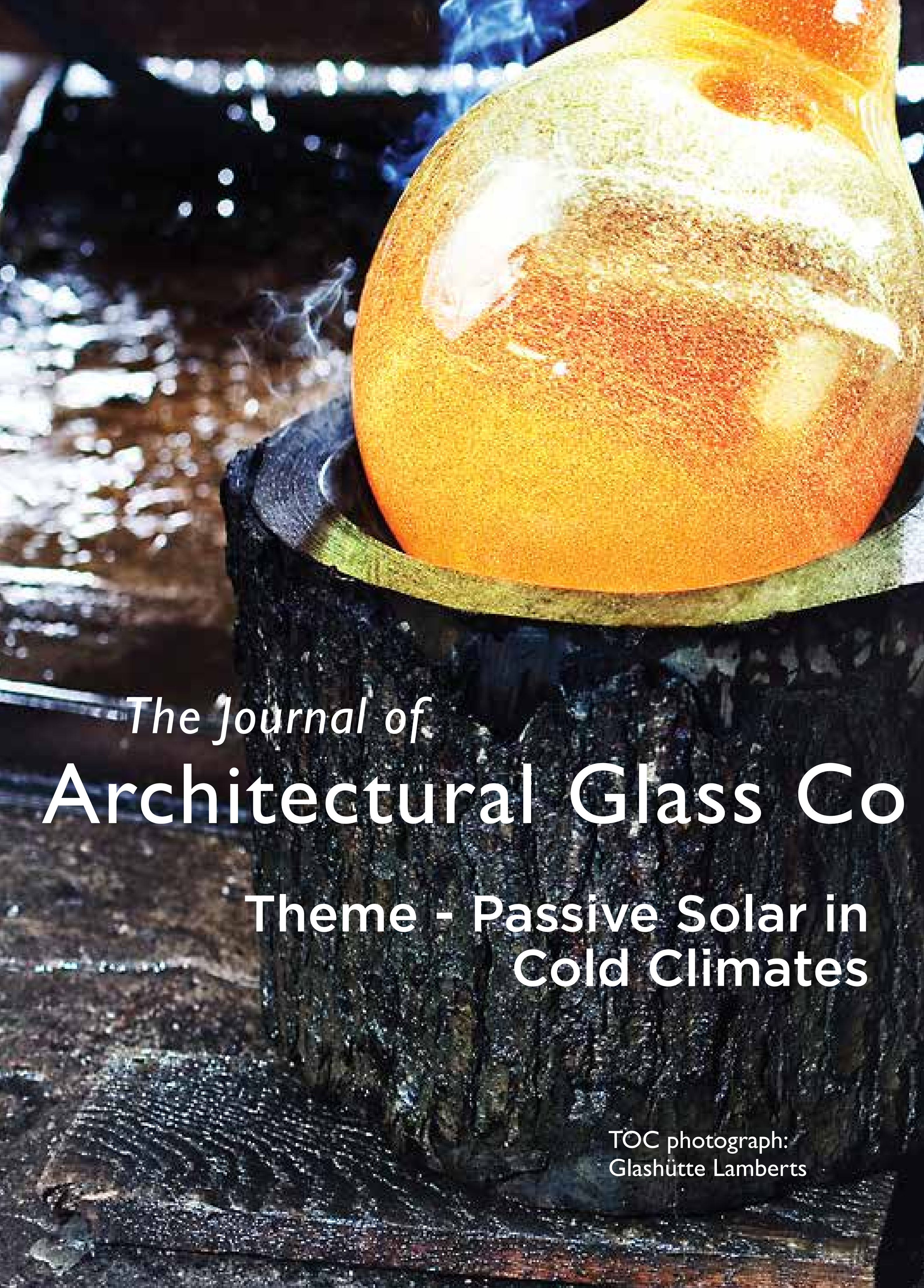
PASSIVE SOLAR IN COLD CLIMATES

WASTE GLASS FOR THERMAL INSULATION

GLASHÜTTE LAMBERTS MOUTH-BLOWN PROTECTION UV GLASS: TRANSPARENCY IN SECURITY

THERMAL RECOVERY - THE NEGLECTED RESOURCE

Volume 6, Issue 1 2013



The Journal of

Architectural Glass Co

Theme - Passive Solar in Cold Climates

TOC photograph:
Glashütte Lamberts

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Cover photograph: Tyler Lake

Robert Roggasch

LIVING AT THE EDGE EFFECT

Photograph: Tyler Lake
This photo was taken at Golden Gardens on Puget Sound, Seattle, Washington.

ABSTRACT:

This article looks at pre-industrial and passive solar home design, with respect to insulation, based on working knowledge and research done in 1970s Alaska. It presents a formula developed by Robert Roggasch, which he calls a "Roggasch 6,000 BTU ecological and economical house" developed by indigenous technologies. Further, it discusses how glass in a window frame raises thermal bridging (edge effect) issues. These thermal bridges are often significantly underestimated in the cost of heating and cooling a residential building.

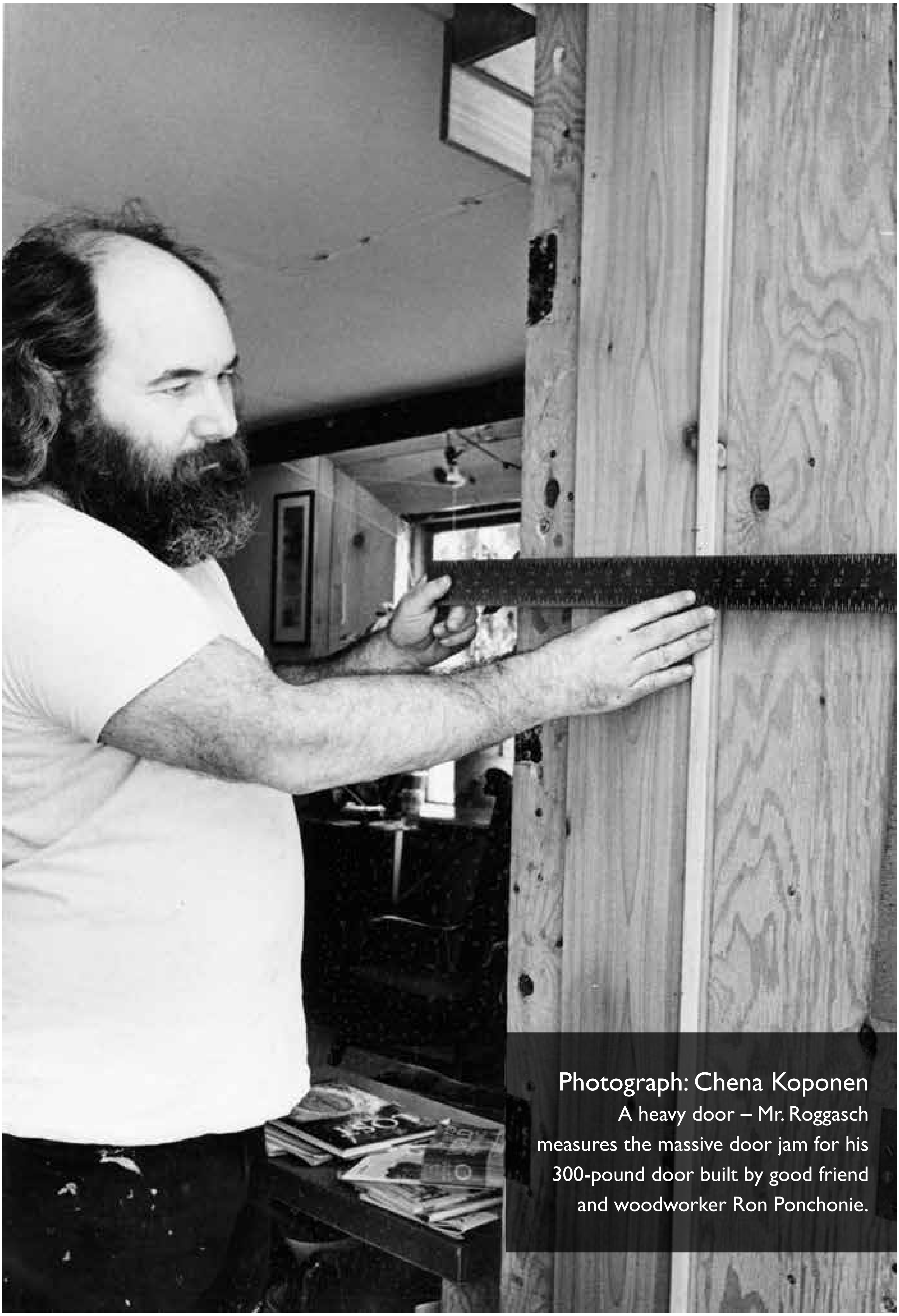
THE BASIC FORMULAS AND THE ROGGASCH DEGREE-DAY FORMULA

This article uses Imperial inch-pound (IP), British Thermal Unit (BTU, the amount of energy needed to cool or heat one pound of water by one degree Fahrenheit), square foot, and Fahrenheit system. In this system, the unit U-value or U-factor (coefficient of heat transmission) is 1 BTU/hr-sq ft °F. This is the rate heat is transmitted through 1 square foot of building envelope for a 1 degree Fahrenheit difference in temperature between indoors and outdoors. Metric U-values are given in watts per square meter per Celsius. To convert metric U-values to Imperial inch-pound U-Values, divide by 5.678. For example, a metric U-value of 1.1 equals 0.19 BTU/hr-sq ft °F. To convert IP U-values to Metric U-values, multiply by 5.678.

An R-value is the thermal resistance value of a material. R is expressed as the thickness of the material normalized to the thermal conductivity. The R-value always refers only to a building material, not to an entire component, and is the reciprocal of U-value. To put another way, the U-value measures the energy that goes in or out of a building and the R-value measures the resistance to that transfer of energy.

Degree days are calculated by integrating over time to determine the amount by which temperatures exceed (or fall short of) some baseline, typically the desired interior temperature of a structure. By adding heating and cooling degree days, a total annual degree day is obtained. Multiplying that by 0.004 (Roggasch degree day formula) results in an optimal R-value that gives a U-value of 6,000 BTUs per square foot annually. This value should drive the design to achieve the heating and cooling load for the structure's walls, ceiling and floor. Windows and doors are openings: their economical optimal R-value would be between 4 and 7. U-values are often used by window and door manufactures to rate their products. Air exchange and air infiltration are the only other variables.

At any given time, Delta T is the temperature difference from outside to inside. Annual degree-days and Delta T are the most important concepts to understand in order to properly insulate a passive solar house. The precise calculation of degree-days can be problematic because temperature varies in the course of a day, and a single day might require heating at one time and cooling at another; but, for example, if the desired interior temperature were 75 degrees, a day with an average temperature of 50 degrees would contribute 25 degree-days to the need for heating. One can use average monthly temperatures to calculate the approximate number of degree-days per year. The heating and cooling have to be kept separate for design purposes, but one can still add them together for annual degree-days and then multiply by 0.004 to get the recommended R- value. So, if one has 10,000 total annual degree-days, then 10,000 x .004 = R-value of 40. The reciprocal of R-40 is 6,000 BTUs for walls, ceiling and any above-ground floor.



Photograph: Chena Koponen
A heavy door – Mr. Roggasch measures the massive door jam for his 300-pound door built by good friend and woodworker Ron Ponchonie.

ABOUT THE AUTHOR

Robert Roggasch began designing, building and testing energy efficient homes in the late 1960s and through the early 1980s. Mr. Roggasch started a few businesses, including window manufacturing in Alaska and a radio show that addressed questions on the overall topics of well-insulated homes.

ABORIGINAL STRUCTURES

Original indigenous structures before the industrial revolution were all built in what we call passive solar. Passive solar is the use of the least amount of energy for the amount of time you are living in the house whereby the sun is used for heat.

With the help of Axle R. Carrolton at the University of Alaska Cooperative Extension Services, I was able to understand the indigenous passive solar home with his cooperative extension laboratory controlled hot boxes. We reviewed old ship logs that recorded house styles and looked at the Alaskan and world history of indigenous homes and collected samples for testing.

TRADITIONAL HAWAIIAN HOUSING AND THE USE OF TRUMBE WALLS

A traditional Hawaiian house called a hale is a classic example of a passive solar wall that would equate to a style of Trumbe wall in modern architectural terminology. Trumbe walls use glass on the outside sun-exposed wall of a structure with a dark insulated void in the wall whereby heat convection builds and hot air can be released inside and cold air from below from inside a lower floor level or basement of the house when vents are opened. Static hot air voids between stone or soil based materials on the inside wall and glass panes on the outside are also called Trumbe walls and they passively store solar heat in the day for transfer inside when it cools down. Overhangs can be used to limit the thermal gain on hot summer days.

The Hawaiian hale wall is constructed from dark colored stacked lava rock that was built thick, with large exterior surface area and no type of mortar. Lava rock can provide air pockets within the stone to accelerate heat transfer efficiency. The steep roof angles provided good water diversion and equal sun exposure by alignment with the sun so that the house would have even solar exposure.

Ship log accounts confirmed that the hale was made of a lot of pili grass. When tested in hot boxes, it took about 12 inches of pili grass to equal 12 inches of fiberglass insulation. The Hawaiians had bundles of pili grass that could cover the openings and stack up against the walls for environmental changes. In addition there was a thick thatched roof for above insulation with woven mats to create thermal breaks from stone walls and floors. From the mountains to the beaches of Hawaii passive solar housing thrived on a grand scale across significant population and diverse regions.

TRADITIONAL ALASKAN HOUSING

The housing structures of the Alaskan Athabasca, Ingalik, and Eskimo population had some unique winter structures that went below the ground all the way to the frost line and then logs were arranged to create walls that went above the outside ground level (the total log wall height was about 4 feet). Constructing a dome shape was done by using the top wall log as a pivot point of leverage and then by bending poles and lashing them together. Depending on materials available, spruce bark would be used below 12 to 18 inches of peat moss, with soil on top of that. The underside of the poles could carry rawhide and firs and could replace bark on top of the poles if needed. Then they would build a span around the upper third to midway point and this is where people would sleep and walk below on the spruce bows. During winter from the outside all you would see is a mound of snow with smoke coming from the center of the domes.

It fit the design value that I worked out from studying with Axle Carlson. We went further north and found exactly the same results when we measured with hot boxes the insulating material the Eskimos used, like peat moss. They would always have an insulating barrier on the ground and everything they stored inside was in the cold part of the house. All aboriginal structures were passive solar design or else they would perish.

MODERN ARCTIC PASSIVE SOLAR

The relationship between the thermal mass, thermal resistance, and the floor area volume is basically the number of degree days in which you define your comfort zone. If there is the right proportional amount of mass to the resistance envelope, to the space and air, then passive solar has been achieved. If there are 15,000 heating degree days annually, the mass would be approximately 3 to 5 thousand degree day's storage of low grade heat inside the thermal barrier of the house.

In a cold climate, after 36 hours with no heating, most residential water pipes will burst. Understanding the relationship between mass, resistance, floor pattern and window space/ solar furnaces/ skylites is the key. The window space is the solar gain, the resistance is the solar collector and the mass is solar collection, and is stored inside the building envelope of the house. Every house should have at least a week's worth of thermal low-grade heat. Thermal batteries can be water, sand, soil, concrete and such. If you pour a concrete slab in the house, remember there is a surface ratio, and the BTUs can only come out in that surface ratio. If a concrete slab floor is basically inside an insulated box (otherwise known as radiant floor heating), there is storage for low-grade heat, and cold air can be regulated by that mass. The thermal mass will regulate moisture and mitigate stratification. That is how a house stays warm: the mass doesn't heat the house; instead it absorbs the coolness. Low-grade temperatures have probably been used since the beginning of mankind's dwellings.

PRE-INDUSTRIAL PASSIVE SOLAR TRADITIONAL SPANISH HOUSING

It was common for the Spanish housing structures to make 12 to 18 inch earth based walls. The amount of sunlight on the outside walls will take around 12 hours to transfer through to the other side. That was an old way of heating residential structures: they would even put logs under the house so they could heat the floors up with the hot rocks and cover them back up again.

Passive solar housing has been in use for a long time and it depends on the right amount of sunlight coming in and absorbing that heat and moving to the top of the house or cave. If you were in a Spanish style house in the Sun Belt, you would still have cold floors and would sleep on the top bunk where it would be warm at night. The difficult thing with living in a cave or living underground is raising the temperature up above the Earth's temperature, i.e. it has to be insulated to get warmer. The same effect can be seen with a house that is built on a concrete slab without insulation.

SPOT HEATING AND COMFORT ZONE

In Alaska I designed a house called the Bluebird House, whose owner took my course and built a 3-story house. It took a week in winter, if left alone, to cool 10 degrees, and it would take a week to raise it 10 degrees. There is no quick solution because it is a fixed amount of energy in low-grade heat. (Note: one BTU is equivalent to the amount of energy produced by one wooden kitchen match burned.) The amount of heat that is lost is only 6,000 BTUs per square foot per year. About 15 to 20% of that amount should be stored in low-grade heat. There is an issue once a house gets warmed up around 80 degrees and an occupant is feeling chilly and does not want to throw another log on the fire, so a heat lamp or small heater could be used to warm up a specific area instead of raising the whole house temperature several degrees more.

North Koreans have a technique of heating the mass of the floor with a chimney running sideways under their first floor and then up. One of the ways of keeping warm is not just heating the air, but by heating some of the mass of the floor with a chimney.

NORTH AMERICA COMFORT ZONE CHANGE

Prior to the energy crunch of the early 1970s it was common for people to have their homes heated from 78 to 82 degrees, if that was the desired temperature for the occupants. The Department of Energy has manipulated the true degree days. If you follow the degree days of the government, you are bound to lose in comfort, because they mix and match with co-generation and lower the annual degree day to say 10,000 when it needs to be 14,000 to have a better comfort zone and efficiency.

Heating the Earth with Thermal Bridges to Nowhere

SLAB ON GRADE AND THERMAL BRIDGING

Slab on grade can be insulated around the outside perimeter of the slab with glass foam or closed cell chemical-based foam and, if in design phase, glass foam insulation can be used under the slab. Here is what happens with heat inside a home: there is a bubble of heat coming down to the slab where the coldest part is the edge, so the heat transfers to the coldest part, quickly escapes the building and acts as a thermal bridge. If the concrete slab is insulated from its edge downward, it will really slow down the heat loss by trapping the heat in. This concrete edge effect is similar to the window edge effect and the type of frame the glass sits in will determine how efficient the window is overall.

A lot of housing has concrete right to the outside edge of the house, which transfers the heat right outside, the worst thing one could do.

Indigenous peoples worked with sod. They took their structure and put sod all around it, so when the heat escapes outside it would transfer through sod and would never go directly to the outside air. A lot of housing has concrete right to the outside edge of the house, which is the worst thing in terms of heat transfer efficiency or thermal bridging. Indigenous populations built their homes with walkways around the interior edges. We take our floors out to the edge and live at the edge on little two by fours there. The way it needs to be done is that the square footage of house needs to be insulated as uniformly as possible and in 360 degrees, walls, floor, and ceiling. The first level floor is more difficult to insulate because they have a colder degree day with a constant pull from the Earth. If you have a first floor that is not insulated, then you need a lot of energy to get your house hot due to stratification and the first level floor will still be colder than the inside air temperature.

AIR INTAKE AND EXHAUST

Benjamin helping dad place the window trim and showing off the depth of the window sill. Photograph: Robert Roggasch.

In our 1,500 square foot Fairbanks house I had a constant air intake, close to the ceiling with no insulation covering it. At the opposite end of the house, not too far from the floor, the out-feed pipe was located and acted as a weep-hole for air that was baffled by insulation; that is how I regulated the pressure as well as condensation release for our home. Having outside air coming in is not a concern if the house is well insulated because cold air does not really have that many BTUs to bring down the temperature. Having the right amount of air coming in the house is crucial and I did it passively: I had an electric motor that ran 200 to 300 cubic feet a minute though a 6-inch pipe for an intake. I could never feel an air blast because in a well-insulated house there is a high relative humidity and the high humidity has a lot of heat in the water, so when you bring in cold lower humidity air it quickly warms up.

Bedroom image shows a one third/ two third thermally broken vapor barrier wall system. Refer to the Canadian R-2000 for similar systems. Photograph: Robert Roggasch

Having adequate positive air pressure helps keep the desired temperature uniform throughout the home and helps prevent mold from growing on window frames or anywhere because there is little dew point. When using a forced air furnace drawing outside air to feed the furnace, it will create positive pressure while running. If the furnace air intake is drawing from inside, it will make negative air pressure. Having positive pressure will force air out the cracks and weep holes in window frames instead of having cold air infiltration.

American housing stock is built like a 1978 Chrysler Imperial gas hog.

The head of the Energy Administration of America and the Energy Resource Council from 1974 to 1977 was Frank Zarb. He called for no insulation under the floor, and four inches in the walls and a foot in the ceiling, and this was a so-called perfectly insulated house. Zarb had previous ties to the oil industry and was following the industrial building standards and not the human standards. I designed houses for humans, not corporations.

AGC editorial notes on heated glass advancements

In the 21st century heated glass can be used to heat a home with remarkable efficiency. In interior spaces with no windows nearby electric current can be applied to mirrors or glass radiator panels to meet demand. Often these types of heated glass are used in maritime industry, skylights, and glass overhangs with snow loads. Inside a home heated glass increases window efficiency and can be a good way to heat interior spaces and eliminate mold and fungus growth around window frames.

Modern heated window features came about from airplane windshield advancements in de-icing capabilities with thin metal oxide coating technology. Today lamination and coatings are used for heating and defrosting windows without unsightly wires. Wires are used for defrosting very thick glass laminates like military armored windows with only small alternators for power. Ships and working boats also lean towards wires to keep windows from icing up and defrosting. Thick windows with limited power resources use wires.

THE EDGE EFFECT OF GLASS; DEFROSTING AND SHUTTERS

When a window is viewed with a thermal camera, the heat is seen in the center as a circle and from there it travels to the edges; as the heat dissipates and transfers outward to the glass edge it frosts up unless there are deep thick frames and pressurized hot air and/or defrosters.

From my experience of building removable shutters for day and night, it did not work so well. If you leave rigid foam covering the window in part or whole on for days, then there is a difference, otherwise it goes back to pressurizing the house and or heating the glass.

In windows all the heat moves from the center to the edge; it can be contained with a non-conductive frame but it will always start the humidity for mold growth if not heated. The thicker the frame and deeper the glass edge sits inside the frame, the better the window does overall in cold environments. By adding a heat strip around the edge of the windowpane the efficiency of the window is increased and mold growth and condensation are decreased. Heat strips operate in low voltage Direct Current (DC) and can be found at auto part supply stores for defrosting vehicle rear windows in cold climates.

COLD FLOORS = STRATIFICATION:

Stratification occurs when cold air has no place to go because the floor is cold. Once you have a well-insulated first floor you will have a warm floor, then there is no stratification. I measured the stratification in a three-story house that I helped design, called the Bluebird House; it was a 2 degree difference from the first floor to the third floor, so there was basically no stratification in that building. In most houses in cold climates there is 20 degrees difference between upstairs and downstairs.

INSULATION OPTIONS FOR WALLS, ATTIC AND ABOVE GRADE FLOORS

Whether in a cold climate or a hot climate, insulation is the true hero of the house and is the key to a passive solar home. If you live like most of us in a standard home built of two by fours and concrete with an edge effect, it is vastly inadequate for occupancy without the heavy consumption of hydrocarbons or electricity for heating and cooling. A thermally broken house in 360 degrees is required for a sustainable house. Standard western framed, or most any North American conventional building for residential purposes with minimal insulation is not going to be a desirable comfort zone without heavy energy use.

Dead wool or types of mineral wools are favorites for Alaskans; they are made from industrial byproducts like slag from steel and metal foundries because it repels rodents. Mineral wools are more common from stone sources now and easier to touch and work with. Rock wools are good for fire ratings and sound deadening.

Fiberglass is most commonly used and is low cost compared to rock wools. Cellulose insulation treated with fire retardant borax has more thermal mass than fiberglass, less air infiltration and is low cost/ with no toxicity. Rigid foams tend to be toxic and extremely flammable, and spray foams can be as well; I know of soy-based spray foam but time will tell if it turns to mold, and working on structures that have been sprayed can be difficult unless you have spray foam that is easily removable. Spray foams have advanced and perform the best when space is limited. When you are considering fiberglass loose fill in an attic space, it will have a loss from air infiltration that is significant depending on the environment. Cellulose can be applied as a topping coat for fiberglass to slow the air infiltration to increase efficiency in attics. The weight ratio of fiberglass versus borax treated cellulose is enough to be mindful of on ceiling drywall loads. Cellulose is inexpensive and effective for the cavity filled house walls, attics and floors. The density of cellulose works well for reducing sound travel.

ROGGASCH DEGREE DAY FORMULA WITH A BUILDING ENVELOPE MODEL

Designs for floors, walls and attics that are thermally broken as a track house onsite above grade for western framing energy consumption and insulation model with Jack trus and Trus Joist I-Joist (TJI)

Designing a house starts with taking into account the degree days and environment conditions. For this model we will use 13,000 annual heating and cooling degree days with around 1,400 square foot house:

> 13,000 annual degree days total x .004 = R-52 with an equal U-value for all surface areas except windows and doors. (Note: this formula does not exceed a footprint of 90 feet x 90 feet x 30 feet tall or 3 stories and is most efficient as a dome.)
>
> Floor area at 1,400 square feet x 6,000 U-value/ BTUs = 8,400,000 BTU U-value, divided by BTU/kilowatts hour 3,412. = 2,462 kilowatt per annual estimated for heating and cooling for the floor with a comfort zone ranging in the 70 to 80 degrees Fahrenheit in heating season and air conditioning to comfort of occupants in cooling seasons.
> Floor and ceiling are the same at 2,462 + 2,462 = 4,942 kilowatt annual.
>
> Walls at 8 foot high and 37.5 linear feet x 4 = 150 linear feet x 8 = 1,200 wall square footage, minus holes/ windows and doors.

2 standard doors at 3 x 6.5 feet = 19.5 x 2 = 39 square feet.

5 windows at 111 square feet.

Total 111 + 39 = 150 square feet total holes.

1,200 square foot walls - 150 = 1,050 square foot total wall minus windows and doors x 6,000 U-value = 6,300,000 BTU U-value divide by BTU/kilowatt hours 3,412 = 1,846 kilowatt per annual estimated.

4,942 kilowatt annual floor and ceiling + 1,846 kilowatt annual wall area = 6,788 kilowatts annual total estimated heating and cooling load, not including holes.

6,788 kilowatts per year average x US kilowatt average cost of .12 cents = $ 814. Divide by 12 months = $ 68. Monthly heating costs minus holes and air infiltration.

Include holes and air infiltration when you have the manufacturer's U-value or double average costs to estimate maximum energy needs.

Average fiberglass R-value per inch is R- 3.5.

R- 3.5 divided into R- 52 = 14.85 inches needed. Estimate 15 inches of insulation for floor, walls and ceiling for a Roggasch 6,000 BTU, super-insulated house. It's best to insulate equally around the entire house and not add more insulation to the attic or to a floor when you are building new and meeting the standards of a 6,000 BTU per square foot per year house. A perfect example is a Stanley thermos that is round and insulated equally on all sides just as a house should be. Depending on your environment products like a Solar Furnace can significantly reduce the heating requirements with solar thermal systems. See article "Thermal Recovery… The Neglected Resource" in this issue. Further heating efficiency can come from using a thermal keel.

JACK TRUSS WITH TJI SYSTEM FOR NEW CONSTRUCTION

This brief example is to give you the concept of building a working energy-efficient house without being too specific. There are so many building materials, methods, and codes that, in my experience, it is best to use math to know what you need and design for your environment.

Above grade floor design for our 1,400 square foot home example will be set with a 40 x 40 foot floor package and foundation for 1,600 square feet; that will end up around 37.5 x 37.5 inside measurements. It is worth mentioning that if you build a bigger house it becomes more efficient overall up to 90 x 90 x 3 stories tall. Once you go too far beyond this size you start to change to other degree day formulas.

THERMAL KEEL

For simplicity of concept we are keeping this a very basic house example, but once you get the understanding you can obviously add more architectural features to your design. An above ground floor would ideally allow the center of the house footing to carry the home's thermal keel load at 20,000 pounds with no problem for a 1,400 square foot home. A thermal keel keeps consistent temperature and humidity control. The thermal mass or thermal keel is what regulates a well-insulated energy efficient home. A water tank can be used and is recommended if you need stored water for your location; otherwise a concrete slab, rocks, gravel, steel or even sand or dirt can be used for low-grade mass to regulate temperature and humidity. (If you do use potable water be sure to have no light on the water to control algae growth and allow for expansion release for freezing.)

In colder climates your connections for water sewer and such can run through larger insulated pipe and flange to your hole through the floor or wall if you wish to design it so and do not have a basement. Try to use the least amount of utility holes for your design. For most other environments in the world that do not have access to western framing products the same principles apply. If you are building with concrete walls on the outside and/or brick with sand and steel like in Eastern Europe, you will still need a cavity filled with insulation all around you to have a desired comfort zone.

A forced air system bringing in outside air can pressurize the home and control air leak location and features. When helping to design the Canadian R-2000 I experimented with different builds and windows and found this concept an affordable and efficient design that met our family's needs with a nice comfort zone. We used a 2,000 gallon water storage tank and always had a couple of Caterpillar batteries for running small efficient marine appliances if power was spotty.

RETROFIT OPTIONS

Super-insulated retrofit options will offer long-term energy savings but are not easy to do. By building a box for your window holes on the ground you can add them to a balloon framed outer wall off your eave.

Foam glass. Image courtesy of Glapor

By using metal studs you end up with straight lines for the siding. Hanging this outer wall off the eaves and then adding plywood boxes for the holes you can hold everything up on the outside. Then you cover the bottom with a ripped piece of plywood, say 16 inches wide, and you go around the house with kickers for more support. If you have heavy windows or a tall building you might opt for a footing around the house.

BELOW GRADE AND SLAB EDGE GLASS FOAM INSULATION

Insulating products like FOAMGLAS, GLAPOR and other glass products work well for load bearing and soil contact insulation. The below grade insulation is the key to a comfortable house built on grade and it has been the most difficult to achieve, due to the pressures, moisture and lack of products and knowledge in this area. See article "Waste Glass Becomes Thermal Insulation" in this issue.

Another difference between FOAMGLAS and GLAPOR is that GLAPOR is close to a 100% recycled glass product and FOAMGLAS is around 60% silica and mixed with other minerals and is annealed longer. FOAMGLAS architectural products are much more common in Europe. In the USA FOAMGLAS has been used mainly for industrial purposes for fire-rated thermal breaks starting in the 1950s. Foam glass products can be used under slabs and to make a break from the Earth that can hold heavy loads and not mold or be chemical based, flammable or toxic.

ENERGY CONSUMPTION

The passive solar house I built in Fairbanks Alaska would take a 1,500 watt electric heater to heat the house when it was 20 below outside. When it was zero degrees it took no heat whatsoever. Basically my house could be heated with a 1,500 watt hairdryer, in the coldest time of the year.

We have become too accustomed to wasting energy, which is not necessary. The house I originally wanted to build took 3,000 gallons of oil a year; the house I built took 200 gallons with the first floor completed, so even at 400 gallons it was nothing compared to 3,000. Most post-industrial revolution houses were made to pass by the oil company. The oil companies can look at the temperature differences and know exactly how much fuel you were using in your house because they follow it with a true degree day.

Front door with a thermal protective cover for the stained glass door window. Photograph: Robert Roggasch

INTERNAL POLLUTION AND RADON

Often internal pollution is Radon, which is the decaying of uranium that is found in nearly all soils. It typically moves up through the ground to the air above and into your home through cracks and other holes in the foundation. Concrete can release Radon. In the house I was building there was a question of how much Radon was accumulating. The reason for the pressurization of the house with outside air is also so there would be no Radon build up. I was able to deal with Radon with a continuous air intake, which was enough to displace it. If you don't have a house with enough pressurization or air infiltration the Radon can build up inside. Homes built above ground have no Radon unless there is substantial stone work or radiant heat in concrete inside and even then it may not release any Radon. Radon causes what's called black lung disease, for example, when miners had poor mining conditions underground in rock that produced Radon. Black lung disease was blamed on rock or coal dust, but in reality it was because of the half-life of the decaying rock.

Paints and common carpet can release a lot of toxins especially when new. Floor laminates and particle board consistently off gas in your home for a long time. Lower grade MDF/ particle board tends to have ammonia in it and is often used for entire kitchen cabinets, bathroom vanities and many household items.

LIVING HEAT/ CO-GENERATION AND OIL LAMPS

Lamp oil is nice heat, but it really does put out a lot of carbon. Carbon pollutants in our house can be pushed out by air pressure and a controlled leak. Electric lighting also puts off heat and in the cold seasons this co-generation heat is welcomed.

Pouring the concrete slab with friends. Photograph: Ann Roggasch.

There are other elements of co-generation, which are related to living matter. Chickens emit 25 BTUs per hour per bird, ten birds equal 250 BTUs per hour. If we look at a human giving living heat, it is about the same as ten chickens, somewhere around 200 to 300 BTUs per hour. This is why your house gets so warm when people are visiting, because the heat generated is going into the air, and when you have a well-insulated house you can build the heat more than what you want, so we would open the door in winter when we had a lot of guests over to let heat out.

THIRD WORLD TECHNOLOGIES OF PROTEIN CONVERSION BASICS

Once you have a well-insulated home without thermal bridges and have moved out of the leaky barns of last century, you can establish a protein conversion if so desired. Depending on your outbuildings and environment you may have the need for a simple protein conversion inside a thermal envelope. Raising earthworms, little fish, grubs, sprouts and grass give a nice rounded diet for your chickens. Mosquito eating larva fish will also eat the algae that grows in chicken manure in warm water; this green algae is grown in a separate tank and then scoped out with a net and fed to the fish. Due to the high nitrogen chicken manure, it can be an effective conversion.

If you need a lot of protein conversion quick, grubs work. In my protein conversion I made a box 10 feet long by a foot and a half wide and six inches tall with two little doors to fit food trays through. The first door is outside the chicken coop and is where you slide a fresh tray of food waste for the flies. The second door was inside the coop and that's where you would remove a tray a day for the chickens to eat and if a fly got out while feeding the chickens would hunt it down.

Worm bins work day and night and do not make a fuss but you need a lot of them so you can keep a steady supply. Worm castings are a great and valuable benefit from raising worms.


Robert and Benjamin Roggasch finishing the winter chicken coop nests Photograph: Ann Roggasch.

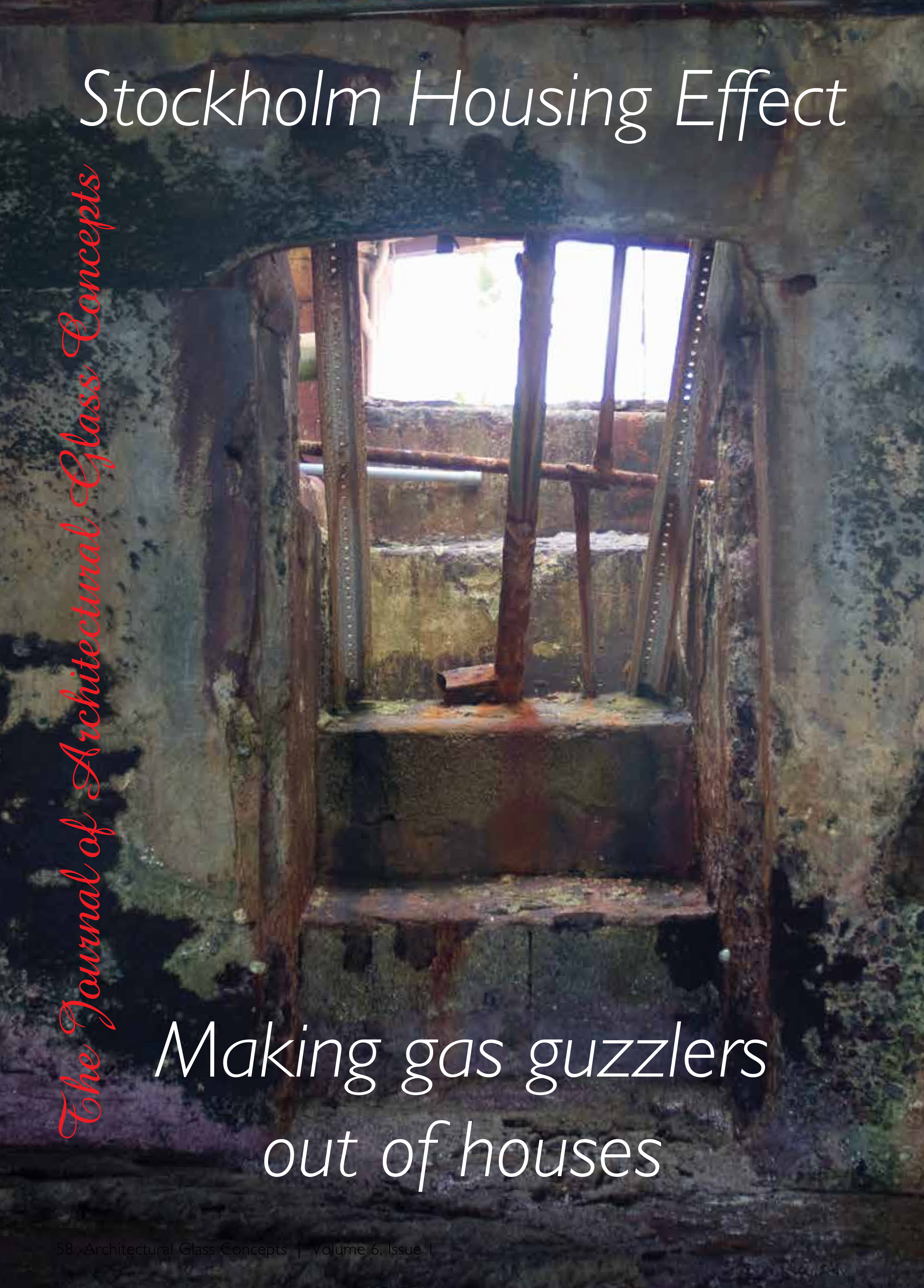
For the fish habitat to be released for chicken consumption I used a couple of hot water tanks cut in half and laid down un-level with a portion of around a third and the shallow end inside the chicken coop. Raise the floor up around the trough so the chickens are less likely to sit on the rim. This way you keep the water clean and it works as a watering hole for the birds as well as a place to catch a fish and they love the hunt for a little fish.

ACKNOWLEDGMENTS

Axle R. Carlson with the University of Alaska cooperative extension service for his studies and research into aboriginal structures and significant contributions; Ron Ponchonie for building my front door for the Fairbanks house; US President Jimmy Carter's Administration for creating the platform to win the prize in 1980 Department of Energy Most Northwestern States Energy Efficient Home; for my Fairbanks Alaska house, and the community of people that came together to help build the house.

The Journal of Architectural Glass Concepts

Stockholm Housing Effect



Making gas guzzlers out of houses