# CONTEXT STONE WOOL

MASTERTHESIS
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# 01 INSULATION

In the realm of building construction, thermal insulation refers to the capacity of a material or material assembly to deliberately slow down the transfer of heat across a building's outer envelope. Its primary function is to establish a neutralizing thermal barrier that separates the interior from the external environment.

Although the building envelope significantly decelerates the process of heat transfer (measured in W/mK), the movement of heat remains an unavoidable outcome when objects or systems with different temperatures come into contact.

Insulation, whether in the form of a material or product, exists due to its specialized ability to resist this exchange of heat with the surroundings. The capacity of an insulation material is determined by its thermal conductivity (λ), heat storage capacity and thickness of the material. This factors seemingly have the aim to challenge the principles of thermodynamics.

However, it is essential to recognize that insulation cannot serve as an absolute barrier. Instead, it orchestrates heat flows over both space and time.

A building, as a whole, operates as an open thermal system and cannot be completely cut off from its surroundings. In this context, insulation, like any material, cannot establish a physical boundary that would manage to retain heat permanently.

Insulation*: (en) to make into an island*

Isolation: *(fr) the act of seperating, dosconnecting, limiting exchange*

Dämmung: *(de) a barrier, to stop something by a dam*

*01: Etymology*
*Source: Online Etymology Dictionary, 2023*

Achieving a perfectly isolated interior within an environment with different temperatures is thermodynamically impossible (according to the laws of thermodynamics).

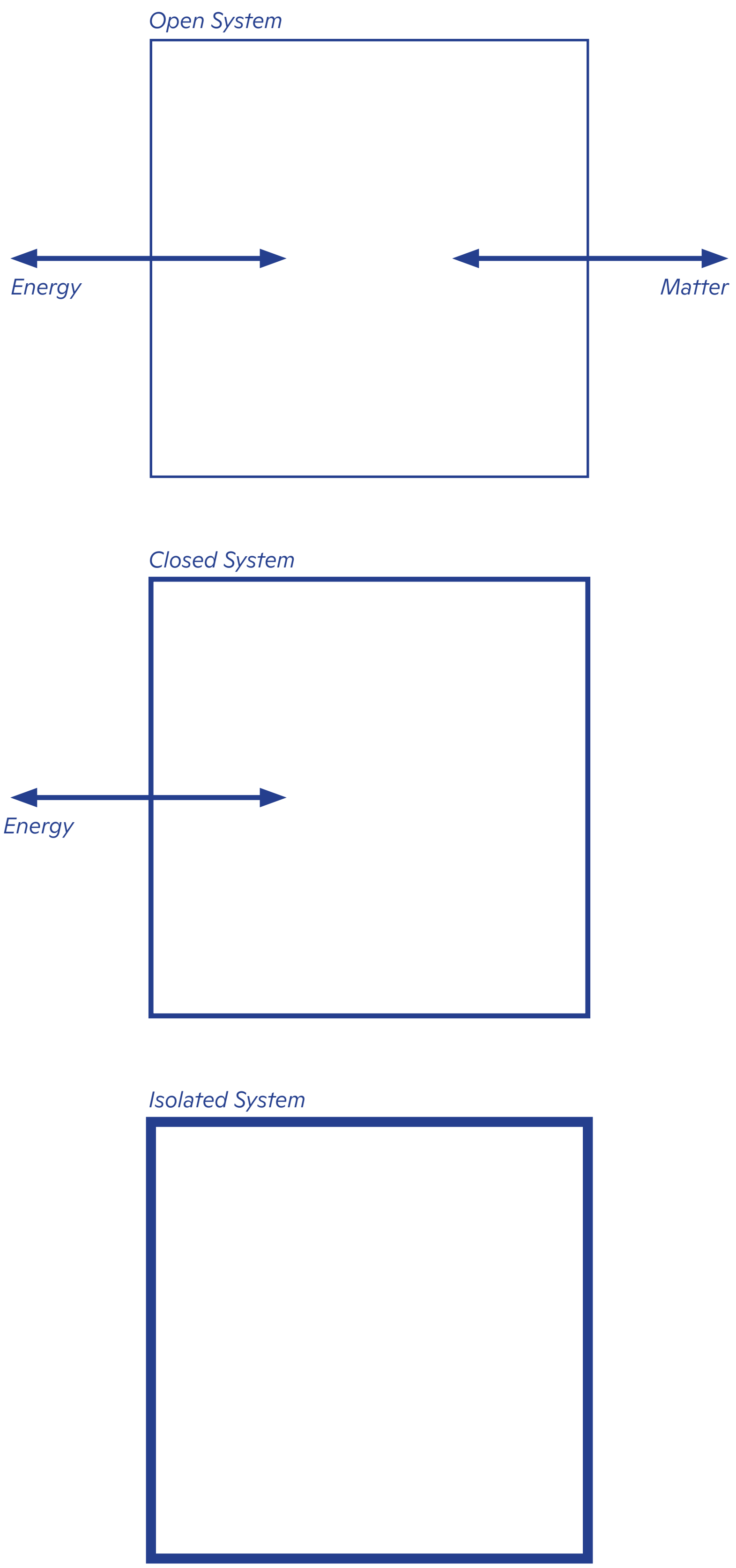
Energy constantly and spontaneously moves within and around buildings, ranging from heat movements within materials to interactions with the built and unbuilt surroundings. These energy exchanges occur on both short-term and long-term cycles, influenced by factors like sunlight, outdoor temperatures and the activity of the inhabitants.

It's important to undertstand that because of this insulation can only create thermal resistance or act as an obstacle over time, but not create an isolated thermal system.

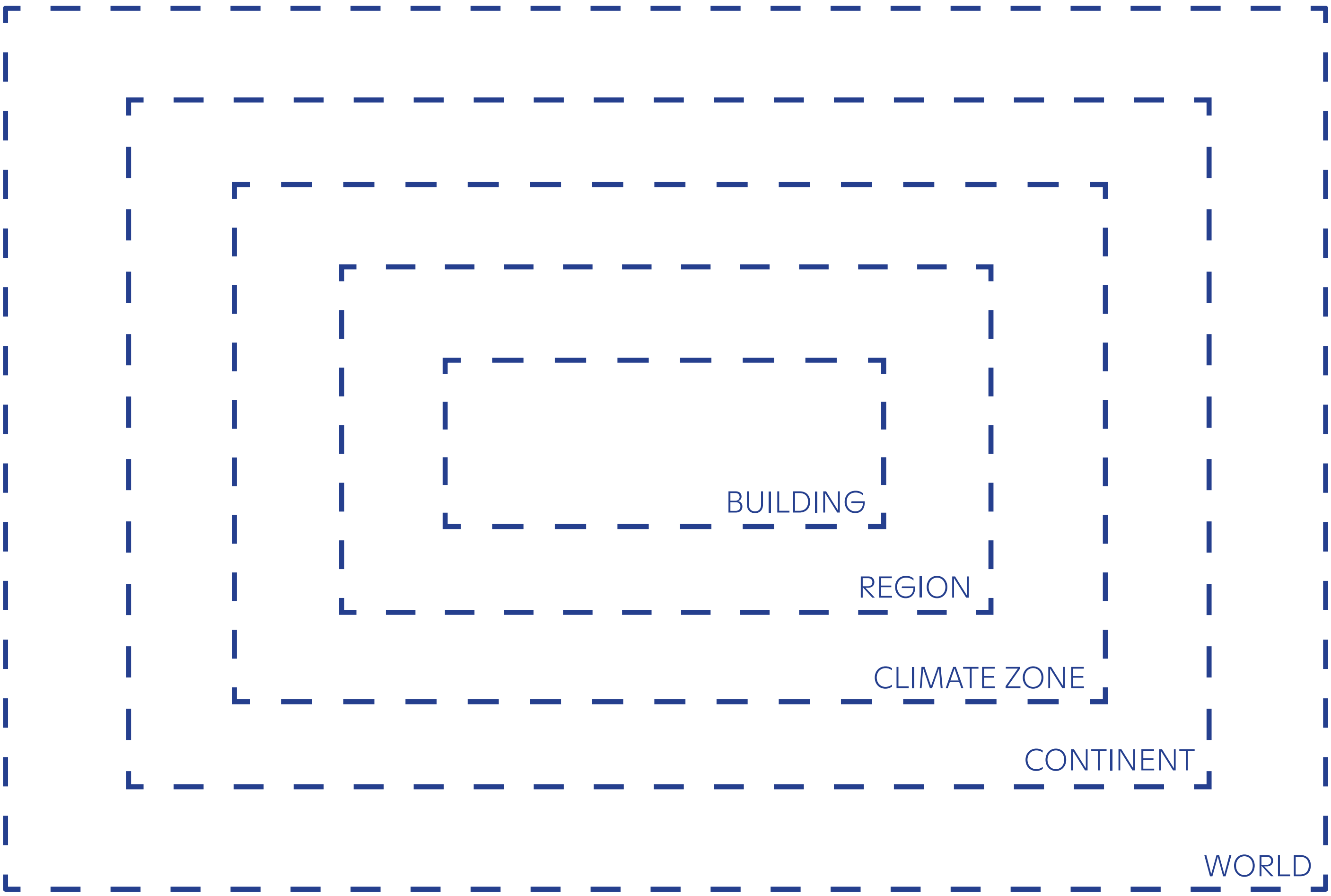
Trying to hermetically isolate buildings is a phenomenon of modernity of a primordial, instinctive search for strategies to improve our surviving in thermal conditions, beyond our optimal thermal range.

"Unlike thermos bottles, buildings are not hermetically sealed or detached from their surroundings. They are open thermodynamic systems that interact with their environment on various scales and timeframes. They exist and persist as massive conveyors of energy and matter that are far from equilibrium. As a spatial and material construct the whole building can capture, transport, store and release energy, and thus stear the flows of dissipating heat which traverse it." [1]

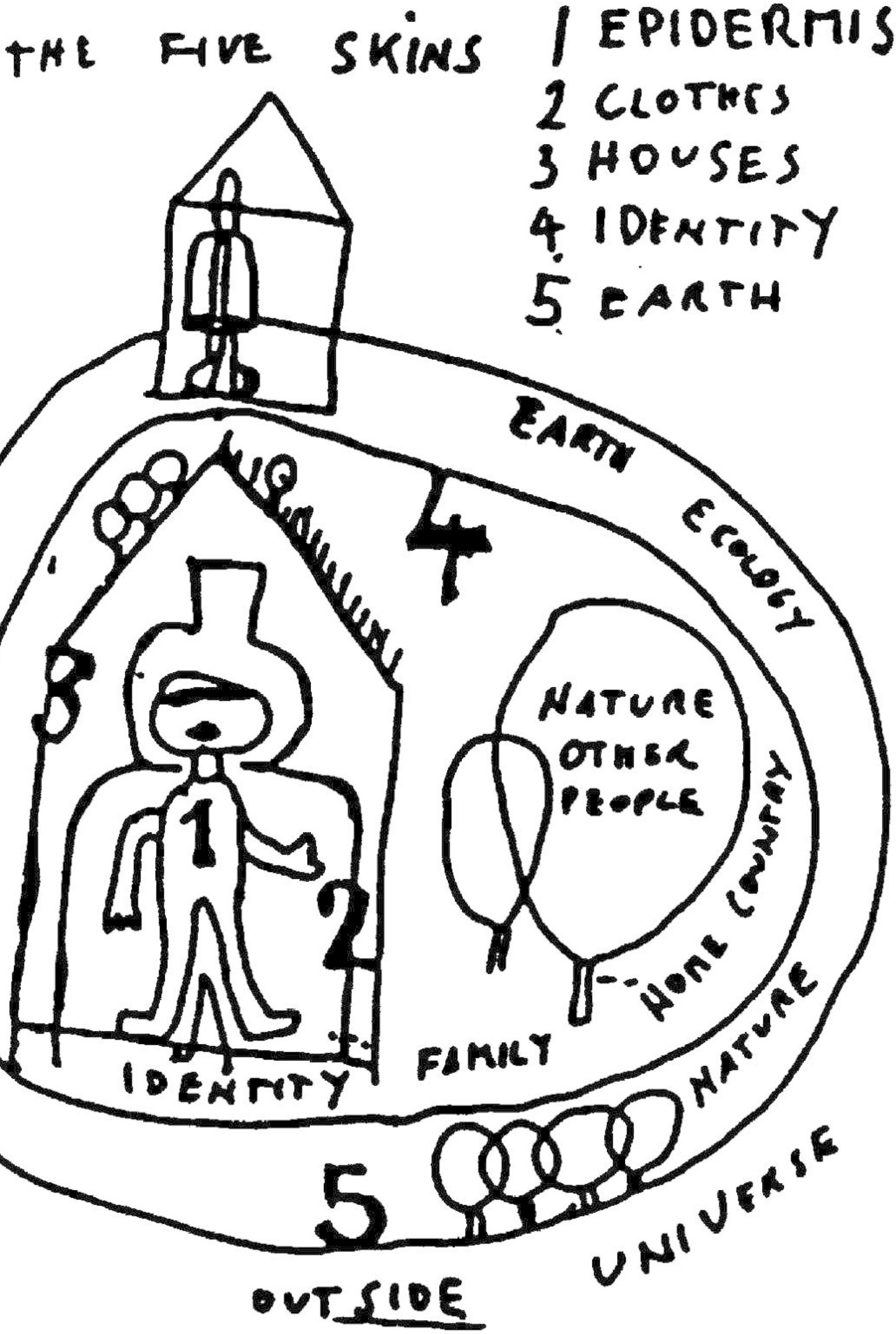
*[1]: Kiel Moe, Insulating Modernism, p. 14, 2014*




*02: Types of Thermal Systems*
*Source: Own Graphic*




*03: Thermodynamic Interactions*
*Source: Energy and Architecture,*
*Javier Garcia-German, 2017*
*Graphic: Own*




*04: Men's Five Skins, Friedenreich Hundertwasser, 1997*

# 02 THERMAL STRATEGIES

The search for more optimal thermal conditions is a multi-layered, historical process, ranging from complex bodily regulatory mechanisms to the development of specialised thermal clothing to finally the creation of shelter.

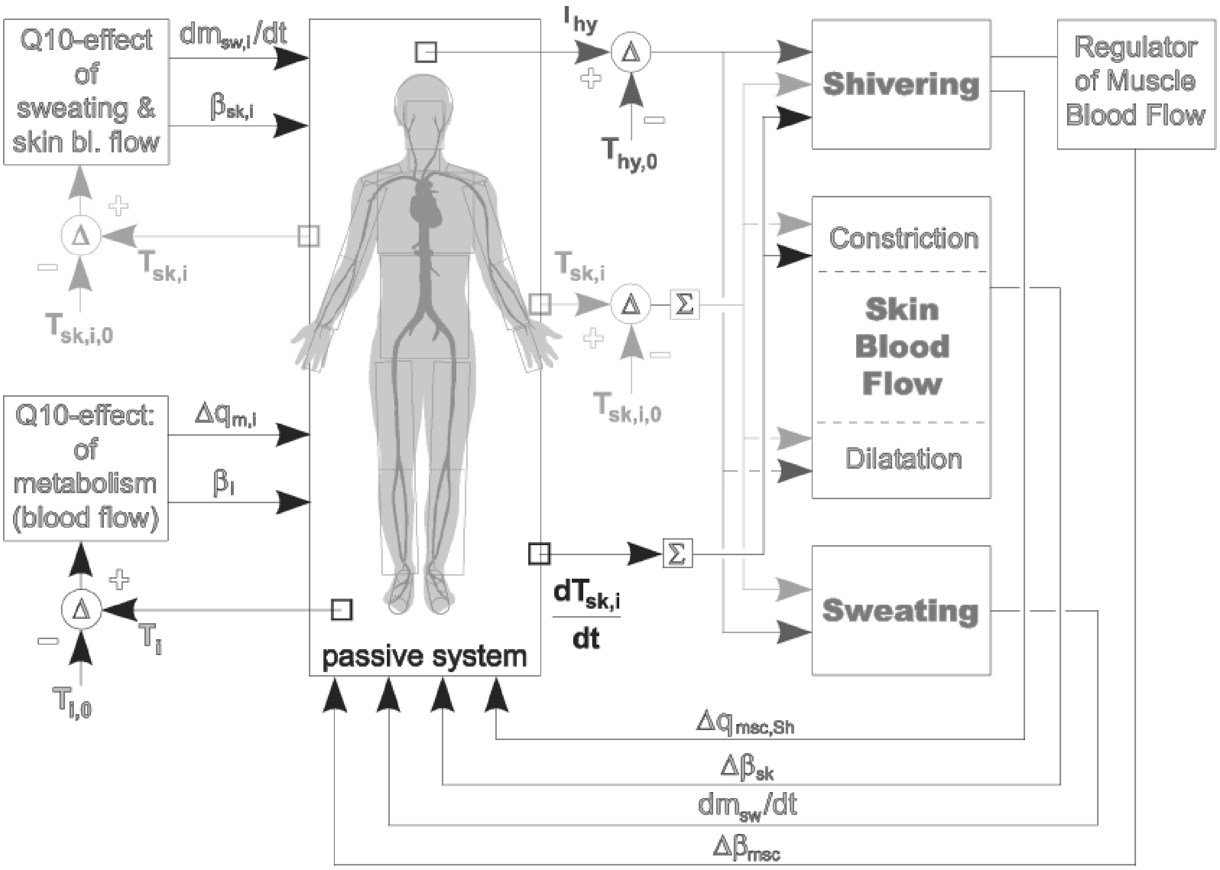
Humans are equipped with the ability to adapt to different thermal environments and employ a number of processes to maintain an internal temperature supportive of their well-being. Since this adaptability only works until certain limits, inventions such as thermospecific clothing are essential to ensure comfort in different climates.

Clothes act like a second skin, insulating or ventilating as needed, and have evolved over the centuries to improve the assigned thermal qualities.

The culmination of this search for favorable thermal conditions ultimately manifests itself in the creation of shelters in which environmental variables are tightly controlled, providing a space where people can feel comfortable over an extended time span regardless of external conditions.

“Animals and plants have found various forms of how to cope with temperature differences. From hibernating, to contracting the muscles to produce heat, regulating the internal body temperature to migrate to another place. In addition to these metabolic responses, warm-blooded animals have another very important method to regulate heat loss. This is with the variable insulation afforded by subcutaneous fat, fur, or feathers. “[2]

*[2] :Lisa Heschong, Thermal Delight in Architecture, p. 10-11, 1973*




*05: Human Thermal Regulation System*
*Source: Dusan Fiala, 2001*

“Organic materials have served as early natural prototype for thermal insulators. The same materials used for clothing were also used for insulating a house: cotton, wool and straw. ”[3]

“As technology developed, so did innovations to improve the comfort of human beings. Introduction of the fireplace and chimney by the Norwegians and people of Iceland during the twelfth and thirteenth centuries provided controlled, artificial heat. ”[4]

[3] *:Rick Bynum, A Brief History of Thermal Insulation, p. 3, 2000*

[4] *:Albert Bemis, The Evolving House, p. 107, 1933*

In addition, the use of fire within a home offered for a long time an enormous potential to affect the interior thermal environment with the creation of a radiant heat source.

The stove brought with it the revolutionary idea that a fire could be used to heat the air indirectly and that the warmed air could then circulate to keep the whole house warm. It initiated the changeover from a radiant to a convective heat system.

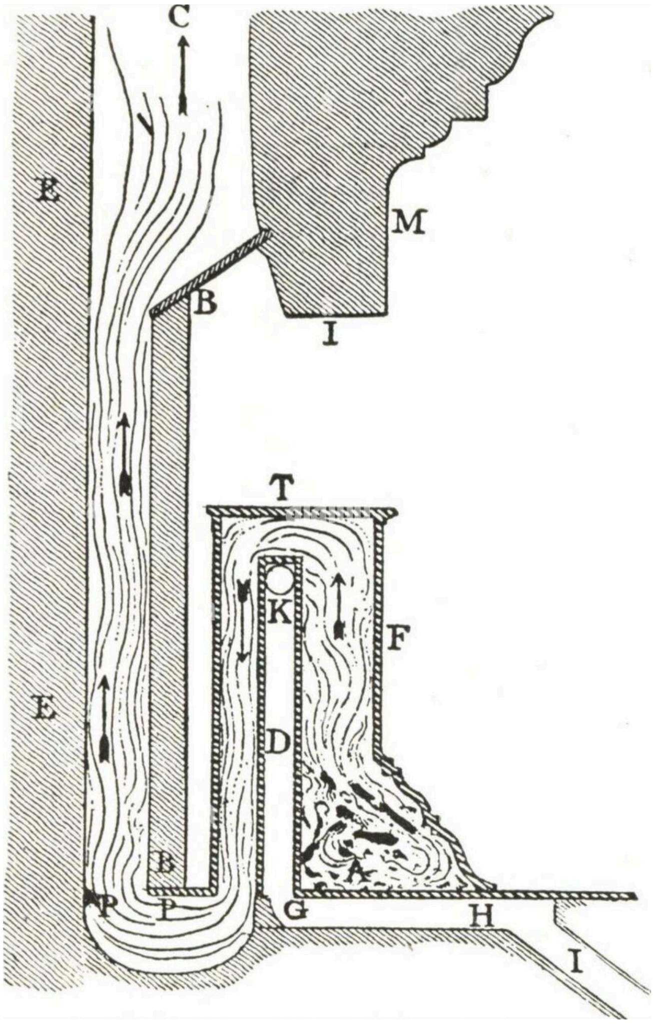
For the first time the building was seen as the enclosure of a bubble of warm air. This shift was crucial because it also led to the realization in building construction that attention had to be paid to making the building more airtight.

This ambition remains until the present day.

Another discovery was, that electric fans could blow warmed air throughout the building. These motors could maintain steady temperatures with no attention from the occupants.

Around the 1900s the invention of the air-condition brought another significant addition as it was from now on possible to also control the humidity level withtin a building. For the first time, all the elements of thermal control were available.

A great deal of research has since been done to determine the effects of temperature upon human beings, and to pinpoint the comfort zone where a person functions most efficiently, uninfluenced by thermal discomfort.




*06: Heat Flow Model T (Franklin Stove), Benjamin Franklin, 1742*

"But when firewood began to become scarce, people looked for a heating system that would be more efficient than open fire. By making the fireplace more and more sophisticated led to the invention of the stove as a heating system in the 18th century." [5]

*[5] :Lisa Heschong, Thermal Delight in Architecture, p. 22, 1973*

"The British comfort zone lies between 17 and 21 °C; the comfort zone in the United States lies between 20.5 and 26 °C; and in the tropics it is between 23 and 29 °C." [6]

*[6] :Olgay Victor, Design with Climate, p. 17, 2015*

Despite the discovery that comfort zones do vary across climat zones, the notion of a thermal optimum persists. In the 1960s the first charts for universal comfort standards have been released.

The American Society of Heating, Refrigeration, and Airconditioning Engineers (ASHRAE) has published standards for thermal comfort that are used frequently and have been incorporated into many building codes until today.

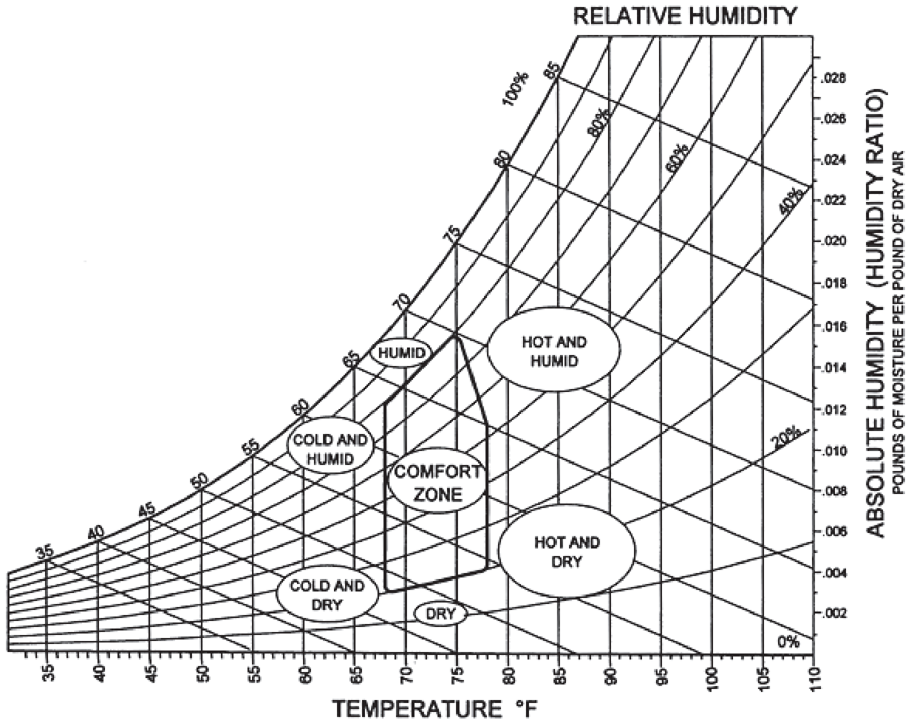
Within all this it seems that it had gone forgotten that the places that provide a thermal experience also play a profound role in the cultural life of people and that the transformation of the urban environment in a state of thermal neutrality could also create a cultural loss.

The technology of heating and cooling aims to achieve a thermal steady-state. Such uniformity is extremely unnatural, and therefore requires a great deal of effort, and energy, to maintain this thermal neutrality.

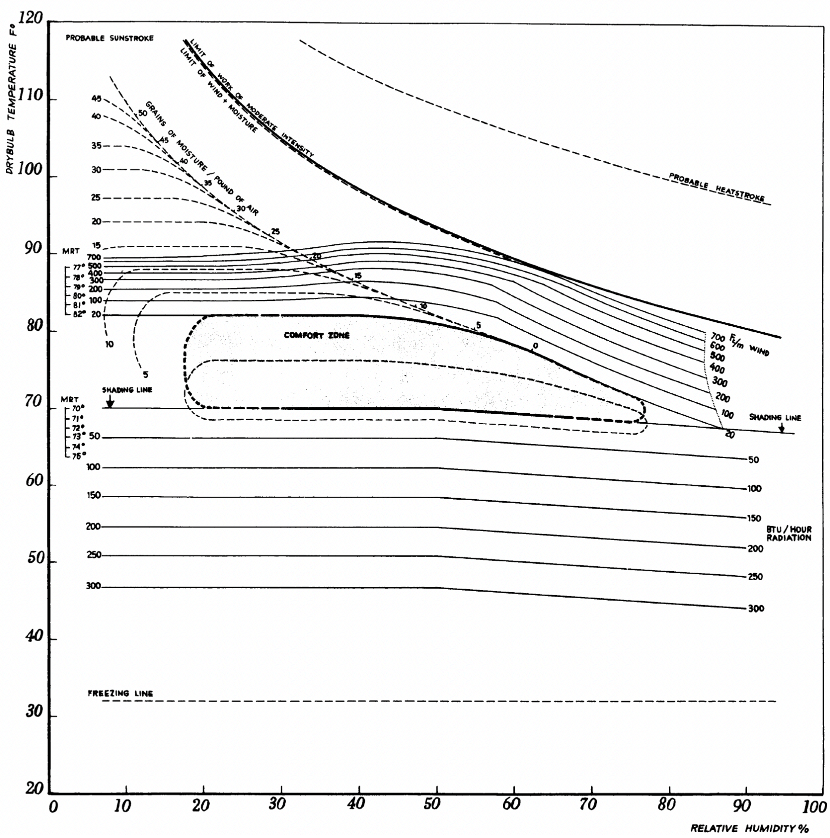
When thermal comfort is a constant condition, it becomes so abstract that it loses the potential to focus affection, create gatherings or understanding of thermal processes.

An example of this would be the exterior wall. An important function of the exterior wall of a building, in a cold climate, is to act as an insulator between the interior of the building and the outside. To improve the thermal performance of modern buildings, products haven been and are developed to stuff between the construction parts or on top of it.

The insulation is then completely covered over with finish materials, so that only someone who had built or planned the wall would understand its material reality and appreciate it for its thermal abilities.




*07: The Comfort Zone,*
*ASHARE, 1966*
*Source: ASHARE*




*08: Bioclimotic Chart, for U.S.*
*Moderate Zone Inhabitants*
*Source: Olgay Victor, Design*
*with Climate, p. 22, 2015*

# 03 INDUSTRIAL PRODUCTION

It was the industrial age that brought materials with which were specifically produced for insulating purposes. Steam engines and industrial heat applications created a need for specialised insulation materials to reduce the high heat losses of machines and therfor reduce the production costs.

So new insulation materials were primarly needed, invented and manufactured for use in industry. The history of insulation materials in the building industry is in parallel a history of a succession from matter, to material, to products.

“One of the earliest industrial insulating product is the mineral wool or slag wool. It was first developed in Wales in 1840 by Edward Perry. Industrial production and commercialization of the product occurred first in Osnabrück, Germany in the early 1870s. By the early 1890s insulating batts of mineral wool began to appear in North American building industry journals.” [7]

*[7] :Kiel Moe, Insulating Modernism, p. 107, 2014*

*09: Gimco Rock Wool House Insulation, ca 1938 Source: Gimco*

# "HEAT NEARLY DROVE US CRAZY LAST SUMMER

**. . . until we discovered how to make our home cooler with Gimco insulation!**

**LISTLESS DAYS:** By the end of the day the heat had us all exhausted. No one had any pep or energy, and no one felt like eating. Even the children were cross and irritable.

**SLEEPLESS NIGHTS:** Restful sleep was almost impossible. Our bedrooms stored up heat in the day and at night stayed hot and stuffy. The whole family suffered until . . .


**OUR ARCHITECT TOLD US** how heat penetrates empty walls and ceilings . . . how it can easily be checked in any kind of home by filling these spaces with Gimco Rock Wool Insulation.

**COMPLETELY INSULATED:** Our Gimco dealer sent a crew of trained workmen who quickly blew the insulation into our side walls and over the top floor ceiling, too.

**RESTFUL NIGHTS:** Now our bedrooms are much cooler. No more tossing and turning. Everyone sleeps soundly. In the morning we wake up feeling refreshed and ready for the day's work.

**CAREFREE DAYS:** Even on the hottest days Gimco keeps every room comfortable. Guests often say, "This is grand. I wish we could keep our home as cool as yours."

**PAYS FOR ITSELF:** Just think! All this comfort—yet Gimco will soon pay for itself. By conserving furnace heat, it reduced our fuel bills a lot last winter. And now we'll save this money *every year!*

**FOR NEW HOMES** architects specify "wall-thick" Gimco Sealal Bats throughout the whole house. They stop more heat than ten feet of solid concrete. They cost less to install, too, because their own natural resiliency holds them in place without any additional support.

**WHY SUFFER FROM SUMMER HEAT?**
**Gimco keeps any home up to 15° cooler!**

This year, enjoy the cool comfort of a Gimco-insulated home. Gimco costs surprisingly little (actually less than many thinner type materials)—yet it gives you the extra protection of full "wall-thick" rock wool insulation. If desired, liberal terms, as low as a few cents a day, can be arranged under the Gimco Finance Plan. Terms can also be arranged under the F. H. A.

Hot weather is ahead. So consult your Gimco dealer now. Let him tell you more about Gimco's advantages . . . how it provides greater year around comfort and at the same time *saves you money!*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**ROCK WOOL HOUSE INSULATION**

Made by the world's largest exclusive manufacturers of rock wool products

*See . . . . . Page 121*

In its earliest manifestations, insulation was made to fit existing buildings. It was primarily from manufacturer brochures that architects became introduced to insulation and with it insulation became incorporated into buildings.

The insulation thicknesses in ceilings and between or under the rafters were 2 - 4 cm at the beginning of the 20th century according to the brochures of the manufactors (see brochure of Heraklith on the next page).

In the first half of the 20th century, however, mineral wool was not yet as strong on the market. The industry had yet to develop, while cork and peat were the market leaders.

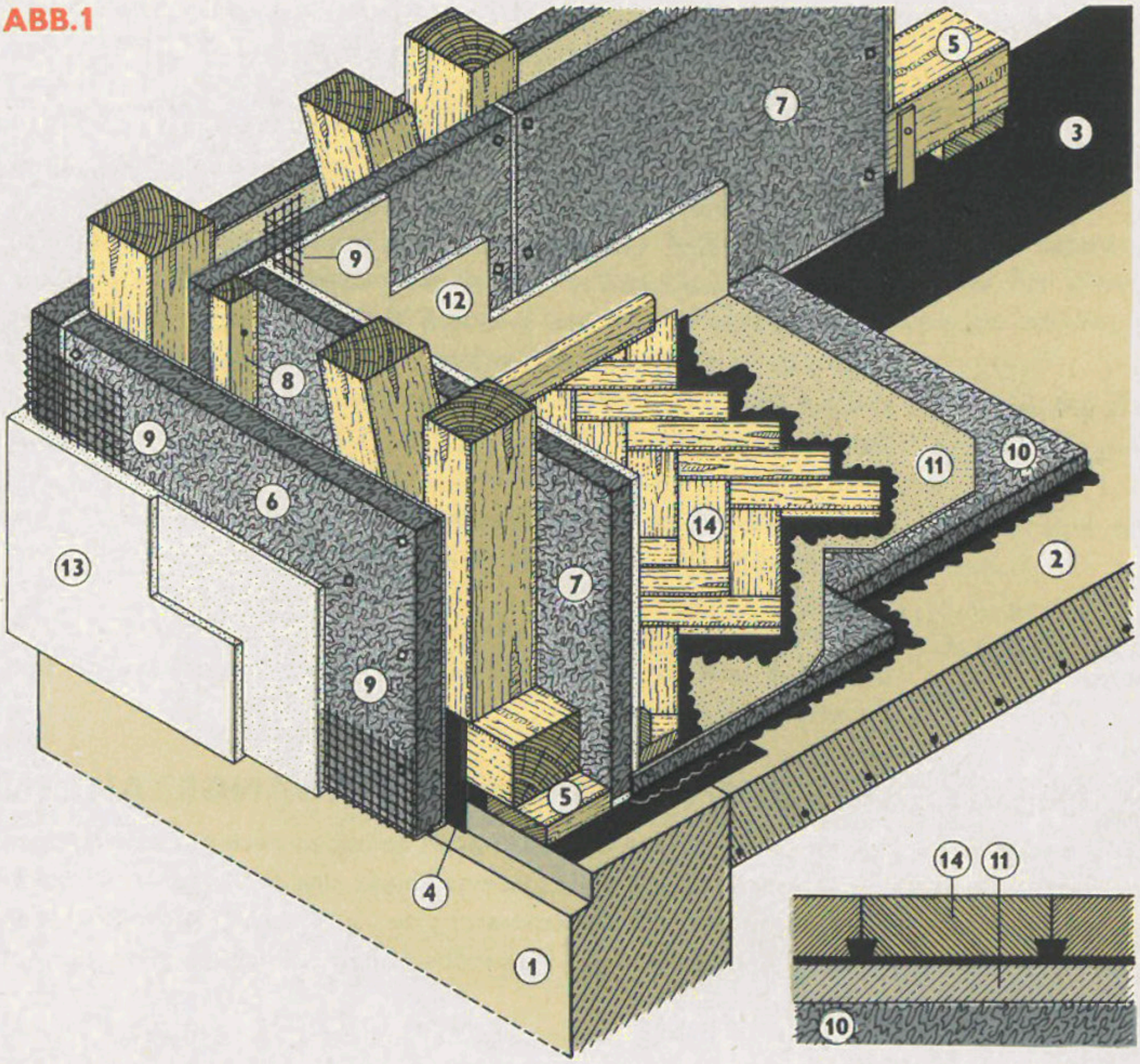
From 1960 onwards, rigid foams were added. Polyurethane and extruded polystyrene (XPS) as well as foam glass also entered the market. Because of their good insulating properties their special features in terms of moisture and pressure resistance, these oil-based products have gained a firm share of the market until today, despite the oil-crisis in the 1970's.

*10: Heraklith Technische Anleitung Brochure, p. 20, 1939*

**K1**

# HOLZFACHWERK BEIDERSEITS MIT HERAKLITH VERKLEIDET

ABB.1



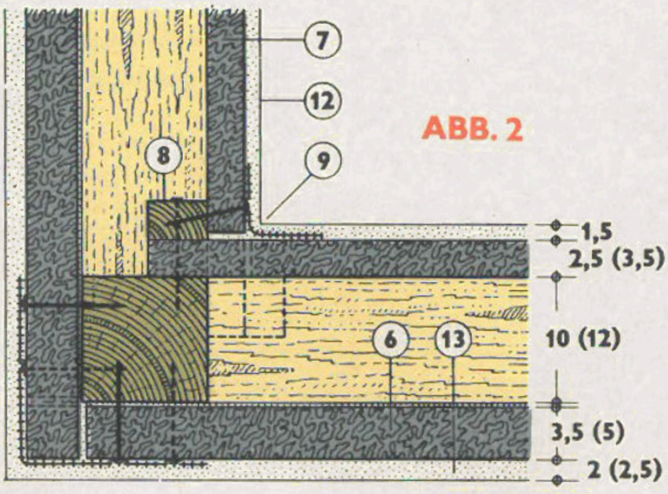




ABB. 2

1 = GRUNDMAUERWERK (SOCKEL SCHARRIERT)
2 = BETONDECKE
3 = ISOLIERPAPPE
4 = PAPPSTREIFEN
5 = HARTHOLZKLÖTZCHEN 12 X 12 X 3 cm
6 = HERAKLITH 3,5 (5) cm MIT INNENSEITIGEM MÖRTELVERSTRICH
7 = HERAKLITH 2,5 (3,5) cm
8 = LEISTE 2,4 X 4,8 cm
9 = BANDAGE (DRAHTGEWEBE)
10 = HERAKLITH 2,5 (3,5) cm IN HEISSASPHALT / VERL. ZEMENTMÖRTEL
11 = ZEMENTRAUHSTRICH 1–1,5 cm
12 = WANDINNENPUTZ 1,5 cm
13 = AUSSENPUTZ IN 2–3 LAGEN, MINDESTENS 2 cm DICK (WASSERNASE)
14 = PARKETT IN HEISSASPHALT

# 04 OIL & EENRGY CRISIS

The oil and energy crisis of the 1970s gave rise to the use of insulation. For the first time, the global public was confronted with finiteness, scarcity of resources and energy. From this multiple governments started legislative action to mandate energy efficiency standards and regulations.

The first Energy Policy was adopted in the USA as early as 1975. In Switzerland, the first Energy Policy was only incorporated into the Federal Constitution in 1990. [8]

The Kyoto protocol was the first agreement among nations to mandate country-by-country reductions in greenhouse gas emissions. This was creating awareness of how insulation can contribute to significant reductions in $C0_2$ emissions. This resulted in an EU paper presented in 2000, which for the first time documented that 40.3 % of total energy consumption comes from buildings and underlined the importance of energy saving mechanisms such as insulation in the building sector. [9]

*[8] :Energy Policy,Swiss Federal Office of Energy, 2023*

*[9] :World Climate Summit,Kyoto,1997*

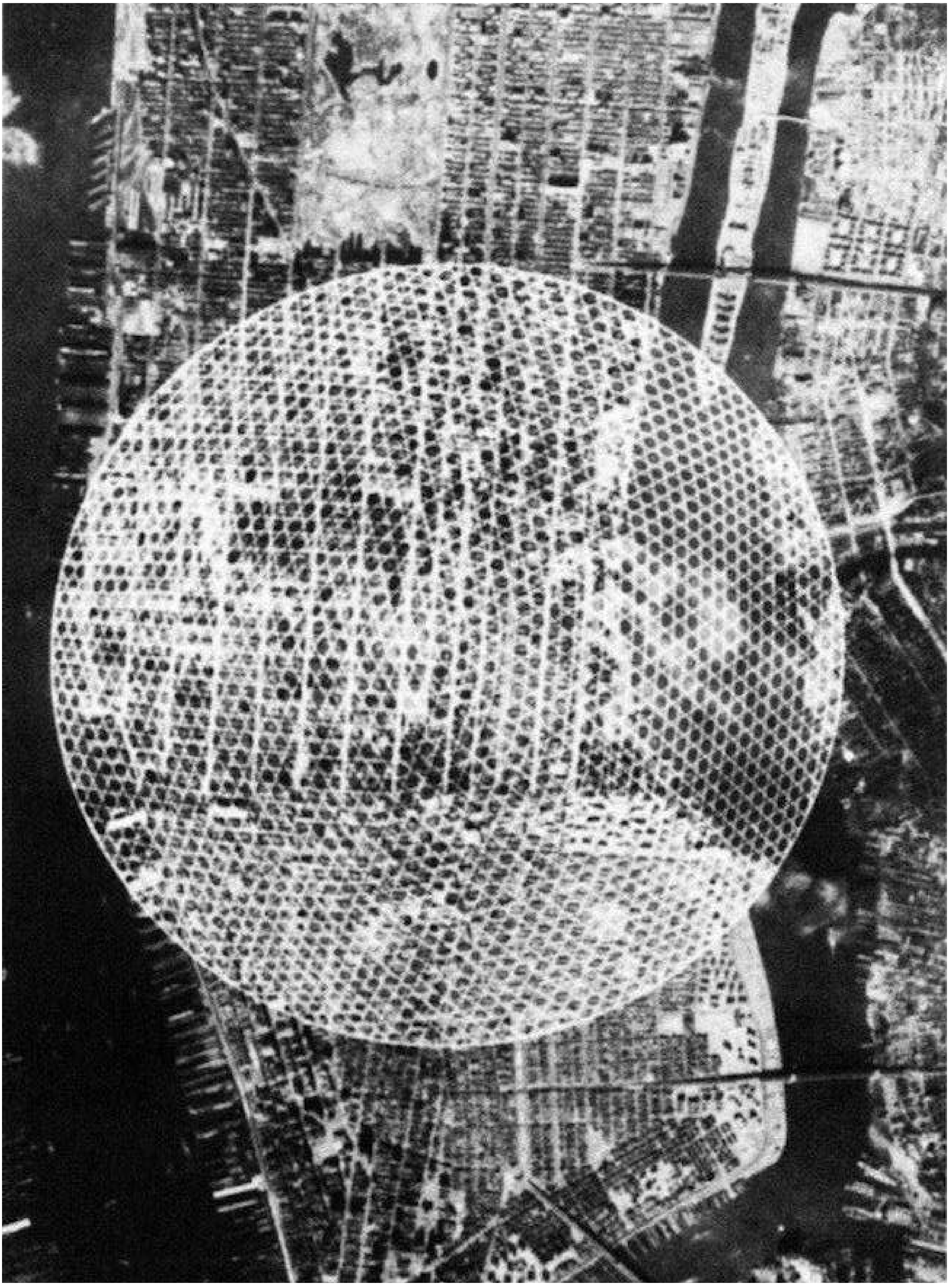
*11: Collage of Kyoto-Protocol Cover and thermal Conductivity*
*Source: Own Graphic*

# KYOTO PROTOCOL TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

0,035 – 0,045 λ [W/(m·K)]

UNITED NATIONS

# 05 ISOLATED UTOPIAS

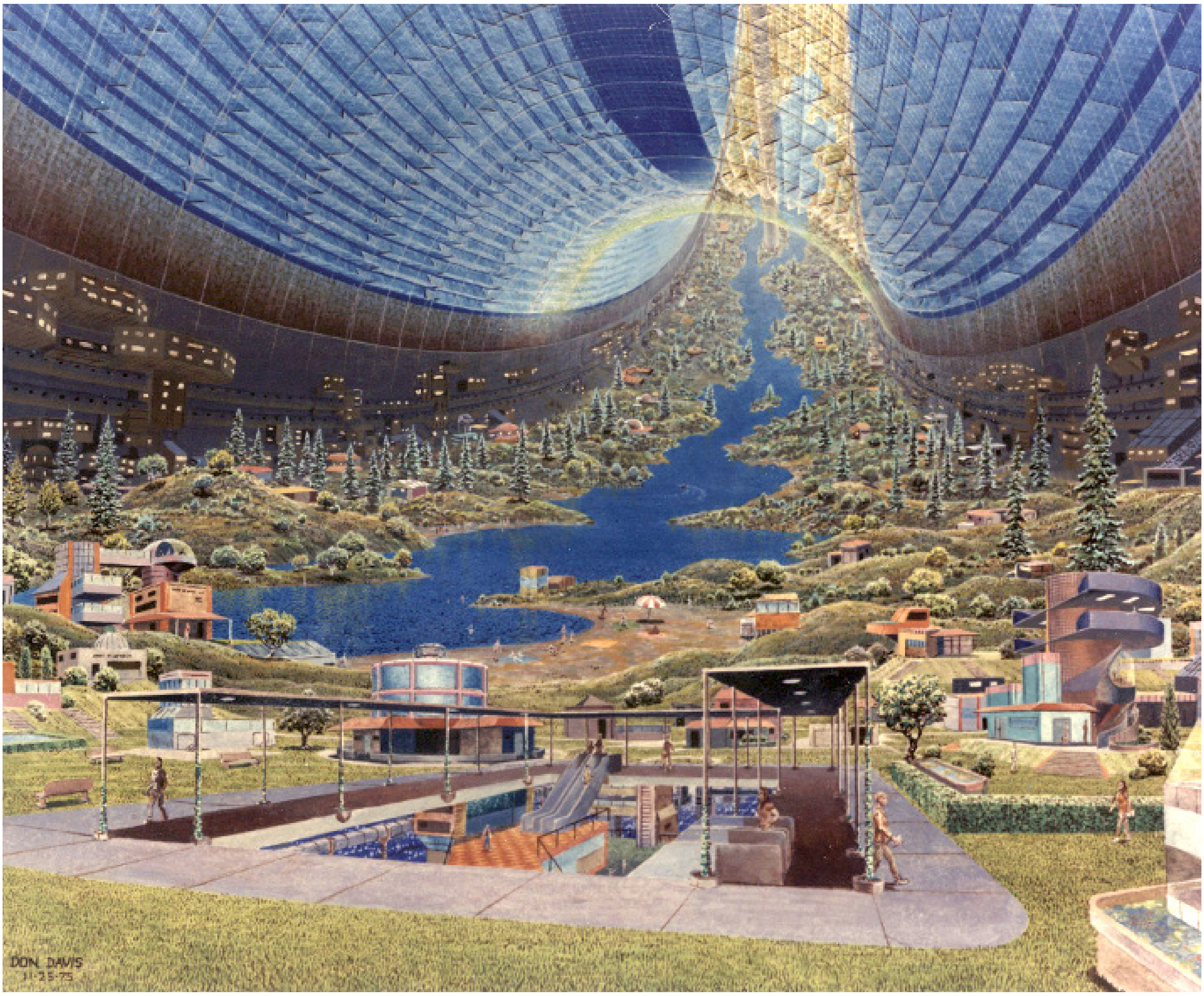


*13: Geodesic Dome,*
*Buckminster Fuller, 1960*

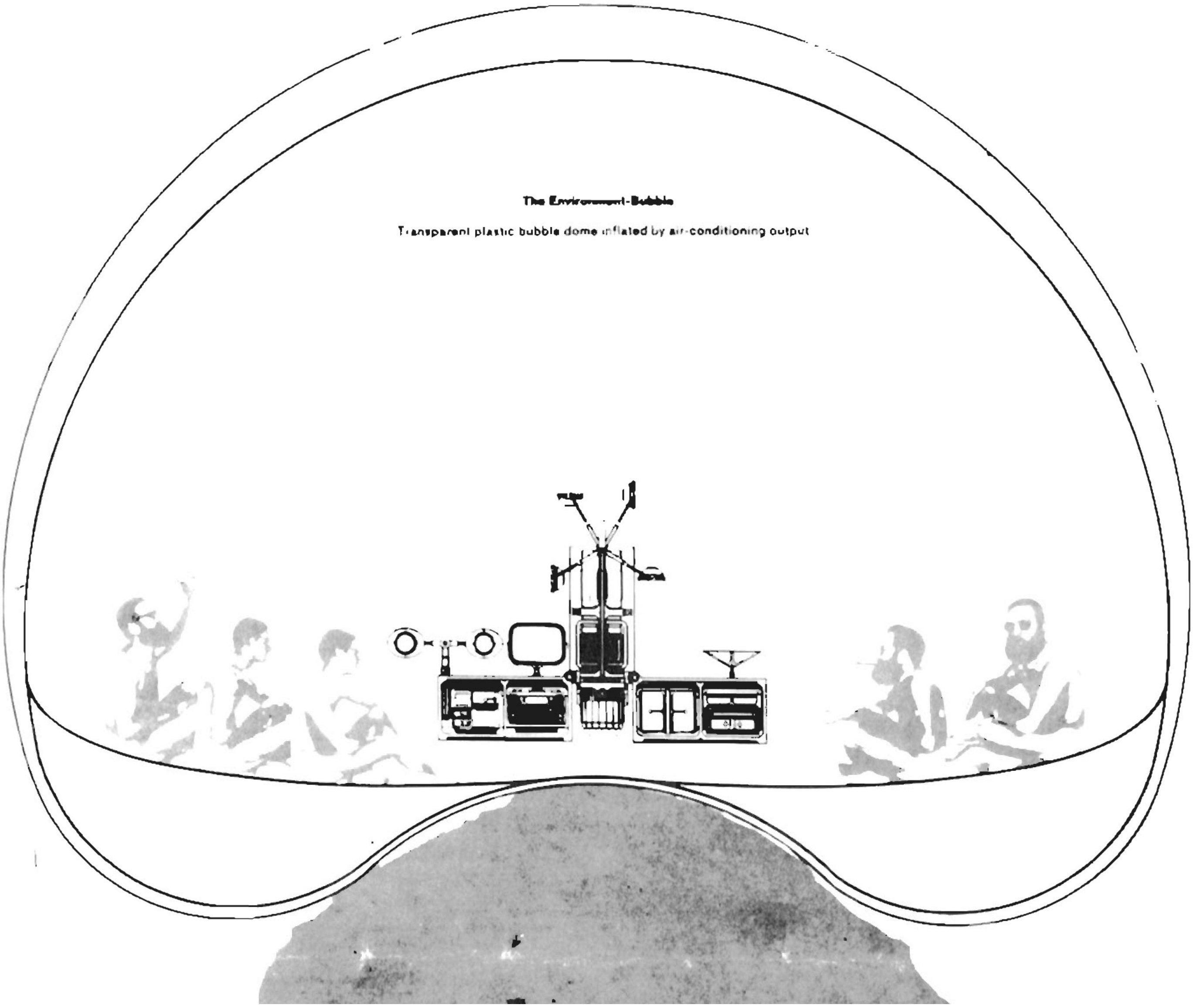
With the emergence of energy-storing measures, there has also been speculation about solutions at the architectural and urban planning spheres. Buckminster Fuller, for example, also had such intentions with the Geodesic Dome over Manhattan. He advocated to reduce energy usage in New York City to 20% of what it was in 1960 by implementing such structures. [10]
Others followed his example in developing urban, isolated systems designed to keep energy from being lost.

*[10] :Buckminster Fuller, 1960*
*Source: Budds, Diana, 2016*

*12: Geodesic Dome,*
*Buckminster Fuller, 1960*




*14: Space Colonies, Gerard O'Neill, 1970*
*Source: NASA*




*15: The Environment-Bubble,*
*François Dallegret, 1965*
*Source: Duende PR*

# 06 ENERGY REGULATIONS

From this point the quantity and volume of insulation materials used in Switzerland has increased sharply over the last 40 years.

This is due to the fact that new buildings in Switzerland have been better and better insulated since the 1970s due to the increasing energy requirements enforced by law following the oil and energy crisis.

The concept of the Minergie standard dates back to 1994. In 1997, the Minergie brand was taken over by the cantons of Zurich and Bern, and in 1998 the Minergie Association was founded. The Minergie standards are very important in the Swiss market today and "the standards will be further tightened in autumn 2023, so that energy requirements will reduce further." [11]

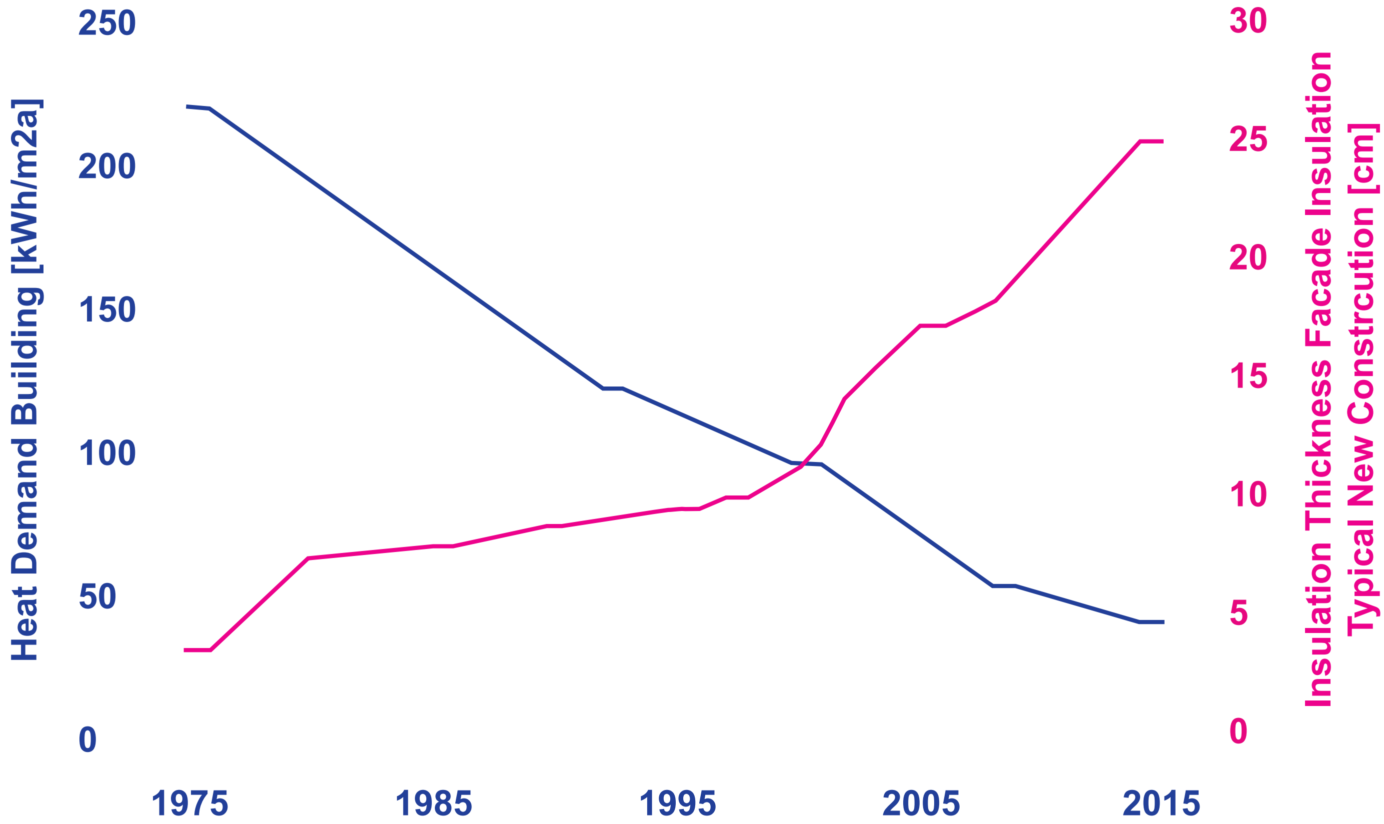
Also because of this certification tool, the insulation thickness has increased about sixfold in the period of 1975 and 2015. [12]

In addition, all cantons enact their own thermal insulation regulations and are increasingly tightening standards. [13]

*[11] :History of Minergie Switzerland*
*Source: Minergie, 2023*

*[12] :Entsorgungssituation von Dämmmaterialien in der Schweiz*
*Source: Energy and Resource Management GmbH, 2016*

*[13] :Vollzugsordner Energie, Kanton Zürich*
*Source: Amt für Abfall, Wasser, Energie und Luft, 2023*




*16: Development in Heating Demand and Insulation Thickness Switzerland*
*Source: Vogel, B., Wärmedämmung und Gebäudetechnik, BFE, 2014*
*Graphic: Own*

*"When I look back to the 1980s, I feel transported to another world: When building insulation was discussed back then, it was about insulation thicknesses of three to six centimetres. Today, insulation thicknesses of over 30 centimetres are nothing unusual"*

*Marco Ragonsi , RSP Bauphysik AG, 2014*

**Tabelle 3** **Historischer Verlauf der k- bzw. U-Werte (W/m²K) von opaken Bauteilen (berücksichtigt: Wand, Dach) gegen Aussenluft bei Vorschriften und in den SIA-Normen** (ohne Spezialfälle wie Hallenbäder, Heizflächen, erhöhte optische Anforderungen etc.)

| | Vorschriften Kanton ZH (mit Ausnahme von Δ: CH) | | | | SIA-Normen | |
|---|---|---|---|---|---|---|
| | Einzelbauteil-nachweis | | Bei Nachweis nach Durchschnittsbetrachtung (SIA 180/1) bzw. System-nachweis (SIA 380/1) | | Grenzwerte (GW), Zielwerte (ZW) Rechenwerte (RW) Einzelbauteile | Einführung, Aktualisierung |
| 1970 | | | | | Keine k-Werte publ. | Einführung SIA 180 |
| 1977 | | | | | Dach 0.7, Wand 0.9 | Empfehlung SIA 180/1 |
| 1980 | | | | | Dach 0.5, Wand 0.6 | Empfehlung SIA 180/1 |
| 1981 | 0.4 | (g1) | SIA 180/1 | | | |
| 1985 | | | | | SIA D 80 | SIA 380/1 als Vornorm |
| 1986 | 0.4 (W)<br>0.35 (D)<br>0.4 | (g2)<br><br>(Δ) | 0.5 (W)<br>0.4 (D) | SIA 180/1 mittlerer k-Wert, $C_0$≤0.65 | | |
| 1988 | | | | | Dach: 0.5, Wand 0.6<br>0.4 (GW) 0.3 (ZW) | Norm SIA 180, 180/1<br>Empfehlung SIA 380/1 |
| 1989 | 0.4 (W)<br>0.35 (D) | (g2) | 0.5 (W)<br>0.4 (D) | SIA 180/1 (mittlerer k-Wert, $C_0$≤0.65) | | |
| 1991 | 0.4 (W)<br>0.3 (D) | | 0.4 | Einzelbauteile nach SIA 180 | | |
| 1992 | 0.3 (D, W) | (Δ) | " | " | | |
| 1994 | 0.3 | | " | " | | |
| 1997 | 0.3 | | " | " | | |
| 1999 | | | " | " | 0.4, $U_T$ ≤0.2 (Dach) | Norm SIA 180 |
| 2000 | 0.3 | (ΔΔ) | | | | |
| 2001 | | | " | " | 0.3 (GW) 0.2 (ZW) | Norm SIA 380/1 |
| 2002 | 0.3 | | | | | |
| 2007 | | | | | 0.25 (GW) 0.15 (ZW) | Norm SIA 380/1 |
| 2008 | 0.25 (+)<br>0.2 (++)<br>0.2 (+)<br>0.17 (++) | <br><br>(ΔΔ)<br>(ΔΔ) | | | | |

(Δ) Musterverordnung 1986 bzw. 1992 (ΔΔ) MuKEn
(g1) Gebäude ≤ 2000 m² (g2) Gebäude ≤ 500 m²
(D) Dach (W) Wand (+) mit bzw. (++) ohne Wärmebrückennachweis

*17: Historical development of the k- or U-values (W/m2K) of opaque building components Source: Jakob M., Grundlagen zur Wirkungsabschätzung der Energiepolitik der Kantone im Gebäudebereich, p. 13, 2008*

# 5. Einzelbauteilnachweis Neubau

## 5.1 Anforderungen

**Neubauten und neue Bauteile**

*Für Neubauten und für neue Bauteile bei Umbauten und Umnutzungen gelten die folgenden Anforderungen:*

| | Grenzwerte $U_{li}$ in W/(m$^2$·K) | |
|---|---|---|
| Bauteil gegen / Bauteil | Aussenklima oder weniger als 2 m im Erdreich | unbeheizte Räume oder mehr als 2 m im Erdreich |
| opake Bauteile Dach, Decke, Wand, Boden | 0,17 | 0,25 |
| Fenster, Fenstertüren | 1,0 | 1,3 |
| Türen | 1,2 | 1,5 |
| Tore (SIA 343) | 1,7 | 2,0 |
| Storenkasten | 0,50 | 0,50 |

*Tabelle 2: Grenzwerte für flächenbezogene Wärmedurchgangskoeffizienten bei 20 °C Raumtemperatur.*

# 6. Einzelbauteilnachweis Umbau und Umnutzung

## 6.1 Anforderungen

**Umbau oder Umnutzung**

*Für alle vom Umbau oder von der Umnutzung betroffenen Bauteile gelten die folgenden Anforderungen:*

| | Grenzwerte $U_{li}$ in W/(m$^2$·K) | |
|---|---|---|
| Bauteil gegen / Bauteil | Aussenklima oder weniger als 2 m im Erdreich | unbeheizte Räume oder mehr als 2 m im Erdreich |
| opake Bauteile: Dach, Decke, Wand, Boden | 0,25 | 0,28 |
| Fenster, Fenstertüren | 1,0 | 1,3 |
| Türen | 1,2 | 1,5 |
| Tore (SIA 343) | 1,7 | 2,0 |
| Storenkasten | 0,50 | 0,50 |

*18 :Vollzugsordner Energie, Kanton Zürich, Amt für Abfall, Wasser, Energie und Luft, p. 8, 2023*

# 07 EUROPEAN MARKET

So who are the companies providing the insulation that is required by the building regulations?

Some of the major insulation production companies in europe are BASF, Saint-Gobain SA and Rockwool International AS.

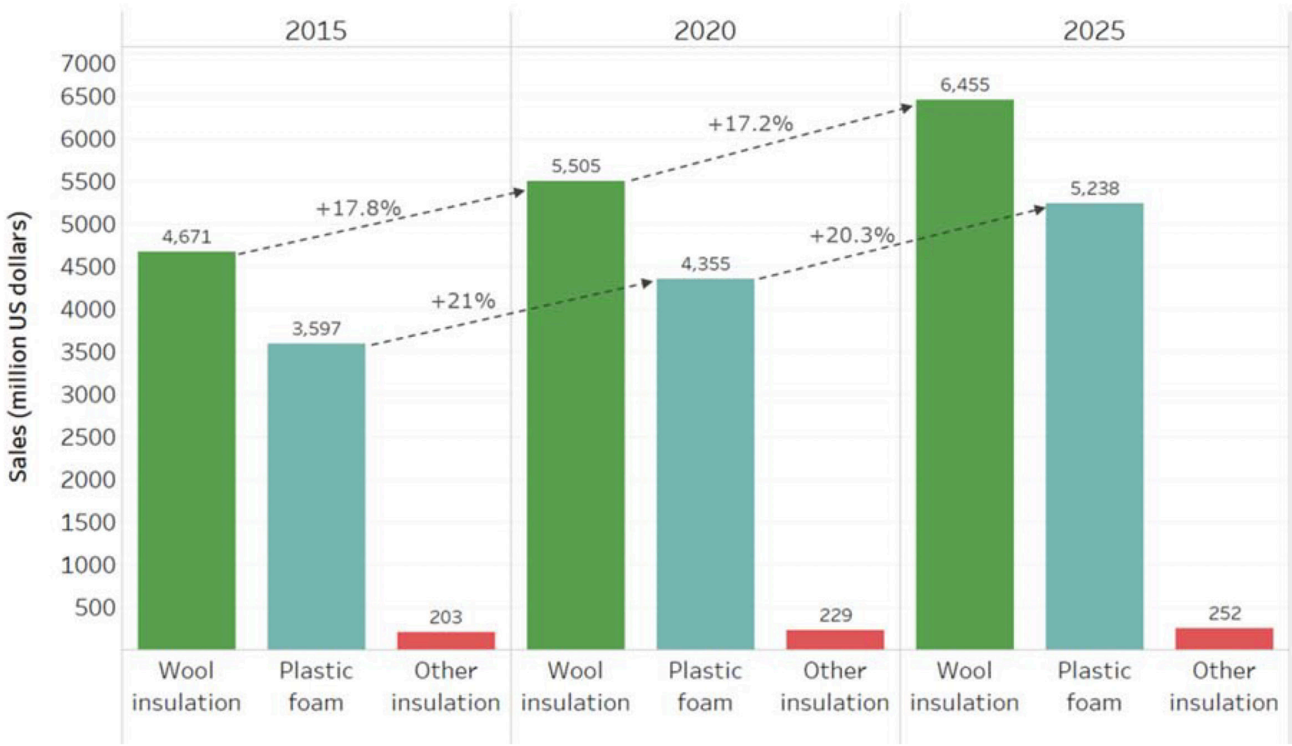
And six out of the 10 major manufacturers of building insulation materials are European companies. The Rockwool group is the world leader of stone wool insulation products.

The most produced insulation materials are mineral wool. Glass and stone wool represent 58 % of the European thermal insulation market. The market is expected to increase by 38 % in the period of 2020-2025. [14]

Mineral wool gained market share in recent times due to the emphasis on using non-burnable insulation materials, because of new EU regulations governing the fire resistance of insulation materials for buildings above 28 metres (European class A1 and A2), which came into effect following the Grenfell Tower fire. [15]

The increase demand for thermal insulation materials in building applications is a combination of measures for greenhouse gas emissions reduction, cost efficiency and government regulations on energy efficient buildings.

*[14, 15] : Competitive landscape of the EU'sinsulation materials industry forenergy-efficient buildings, EU Comission, p.6, 2018*




*19: Competitive landscape of the EU'sinsulation materials industry forenergy-efficient buildings, EU Comission, p.7, 2018*

ROCKWOOL

SAINT-GOBAIN

BASF The Chemical Company

*20: Three Major Global Insulation Companies (The Rockwool Group only produces stone wool) Source: Rockwool Group, Saint-Gobain SA, BASF*

# 08 SWISS MARKET

Switzerland has also been focusing on improving energy efficiency in buildings to reduce energy consumption and greenhouse gas emissions. This has created a demand for various insulation materials.

Common insulation materials used in Switzerland today include fiberglass, mineral wool, expanded and extruded polystyrene (EPS and XPS), and polyurethane foam. New technologies have so far only formed niche products. But there is a growing interest in sustainable insulation materials made from recycled or renewable sources. [15]

Based on the latest data surveys, the market shares of insulation materials input in Switzerland are

[t/a]: [16]

| | |
|---|---|
| Stone Wool: | 77'000 |
| Glas Wool: | 41'000 |
| Wood Fibres: | 35'000 |
| XPS & EPS: | 27'000 |

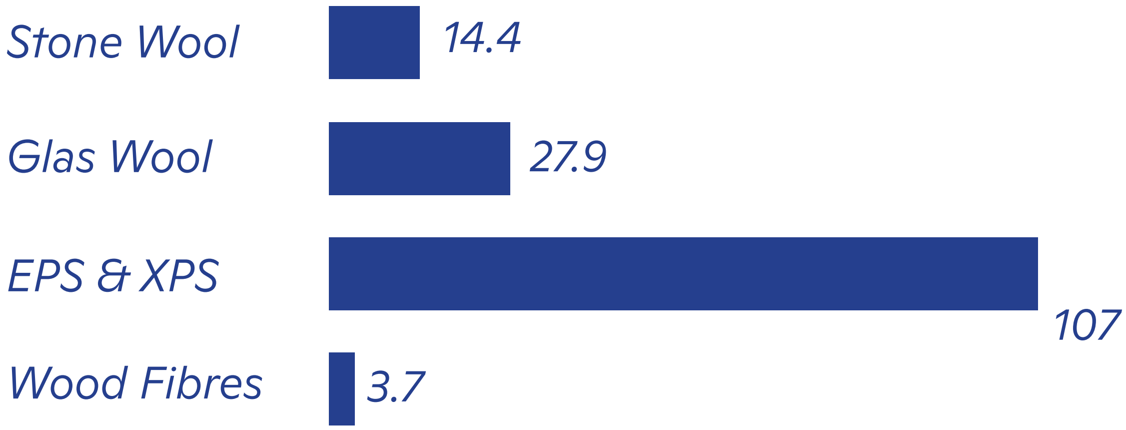
[m³/a]: [17]

| | |
|---|---|
| XPS & EPS: | 1'670'000 |
| Stone Wool: | 860'000 |
| Glas Wool: | 830'000 |
| Wood Fibres: | 180'000 |

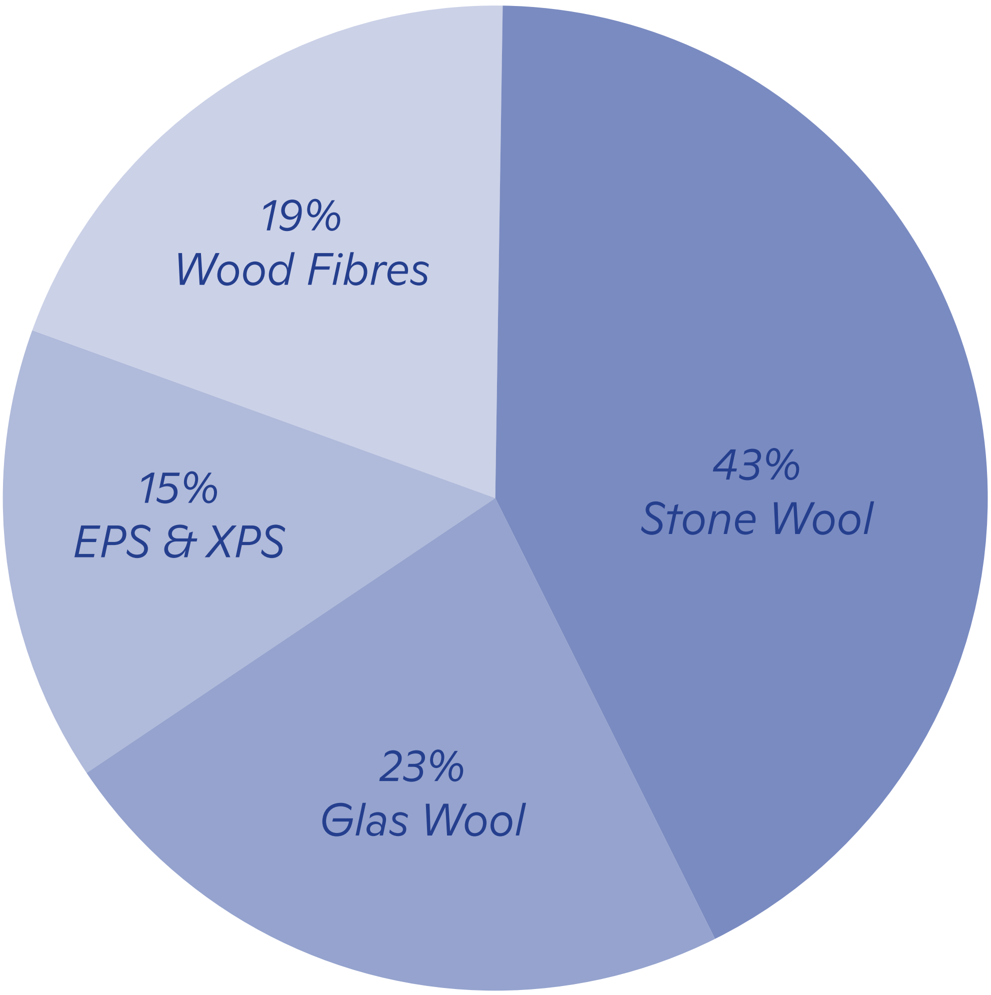
In the further course of the thesis, stone wool is examined in more detail as a case study of an insulation product.

*[16] :Dämmmaterialien im Gebäudepark der Schweiz, Amt für Hochbau Stadt Zürich, p. 15, 2015*

*[17] :Entsorgungssituation von Dämmmaterialien in der Schweiz, Energy and Resource Management GmbH, p. 13, 2016*




*21: Grey Energy in Production Process*
*Source: KBOB, 2016*
*Graphic: Own*




*22: Swiss Market Insulation Material Input [t/a]*
*Source: Amt für Hochbau Stadt Zürich, 2016*
*Graphic: Own*

# 09 STONE WOOL

Stone wool is mostly used for insulation in the form of boards, as clamping felt or loose. The insulation boards are produced in different thicknesses between 30 and 240mm. They are used for insulating ceilings, often the top floor ceiling or the basement ceiling, but are also used for insulating the facade, in a thermal insulation composite system (WDVS) or a rear-ventilated facade.

Due to the good properties of stone wool, especially with regard to fire protection and sound, the material is also produced in other forms, for example as fire bars or sound absorption boards.

Stone wool insulation boards require a thickness of at least 22 centimetres to achieve a heat transfer coefficient (U-value) of 0.15 $W/m^2$-K required for insulation materials according to the Minergie standard.

The price of the insulation boards increases with their material density. A 60 $kg/m^3$ board cost between CHF 50 and 60 per square metre. [18]

The Swiss market is composed of a variety of mineral-based insulation products. The largest manufacturers include: Flumroc, Isover, Knauf, Paroc, Rockwool and Xella. With Flumroc being the only company with a production facility in Switzerland.

*[18] :Steinwolle - mineralisch und günstig dämmen?, Energieheld Schweiz, 2023*


*23: Stone Wool Sample*
*Source: UMAR, EMPA*
*Switzerland*

*24: Stone Wool Sample*
*Source: UMAR, EMPA*
*Switzerland*

## Physikalische Kennwerte – Steinwolle

| Eigenschaft | Einheit | Kenngrößen |
|---|---|---|
| Rohdichte | kg/m³ | 20–200 |
| Wärmeleitfähigkeit | W/(m•K) | 0,035–0,045 |
| Wärmespeicherkapazität | J/(kg•K) | 600–840 |
| Brandverhalten<br>Euroklasse<br>Baustoffklasse | <br>A1<br>A1 (nicht brennbar) | |
| Wasserdampfdiffusions-widerstandszahl | – | 1–2 |
| Langzeitwasseraufnahme | kg/m² | ≤ 3 |
| Anwendungsgrenz-temperatur langzeitig<br>mit Bindemittel<br>ohne Bindemittel | <br>°C<br>°C | <br>100–200<br>600–750 |
| Druckspannung bei 10 % Stauchung oder Druckfestigkeit | kPa | 15–80 |
| Druckfestigkeit bei Verkehrslast (Trittschalldämmstoffe) | kPa | 5–20 |
| Strömungswiderstand | kPa•s/m² | 6–43 |

*25: Physical Properties of Stone Wool*
*Source: Dämmstoffe richtig eingesetzt, Bundesministerium, 2022*

# 10 FLUMROC

In 1900, the Spoerry family built the company P.&H. Spoerry, Carbidwerk, after operating a textile factory for the previous 40 years. Carbide was used for lamps, for welding or for the production of artificial fertiliser. During the Second World War, the Spoerrys had to shut down the smelting plant for calcium carbide production and, by order of the Swiss Confederation, they had to smelt iron ore. In 1950, the company opened up the business field of stone wool, following the growing demand for insulation products in the building sector. Also because the melting of stone is similar in steel production as well as in the production of stone wool.

Initially, the stone wool was supplied in bags and used mainly to insulate already existing beamed ceilings. [19]

In 1969, the Spoerry family signed a license agreement with the Danish Rockwool Group, whereby they became Flumroc.

Today, Flumroc produces around 50,000 tonnes of stone wool per year, being one of the major employers in Sarganserland with around 240 employees. [20]

[19] *: Fabrikerbe der Zukunft, Hochparterre AG, p. 30, 2017*

[20] *: Ysker Olaf, Project Manager Environment at Flumroc AG, 2023*

*26: Carbidwerk Flums, 1910*
*Source: Archiv Innobas*


*27: Packaged Stone Wool,*
*1955*
*Source: Archiv Innobas*

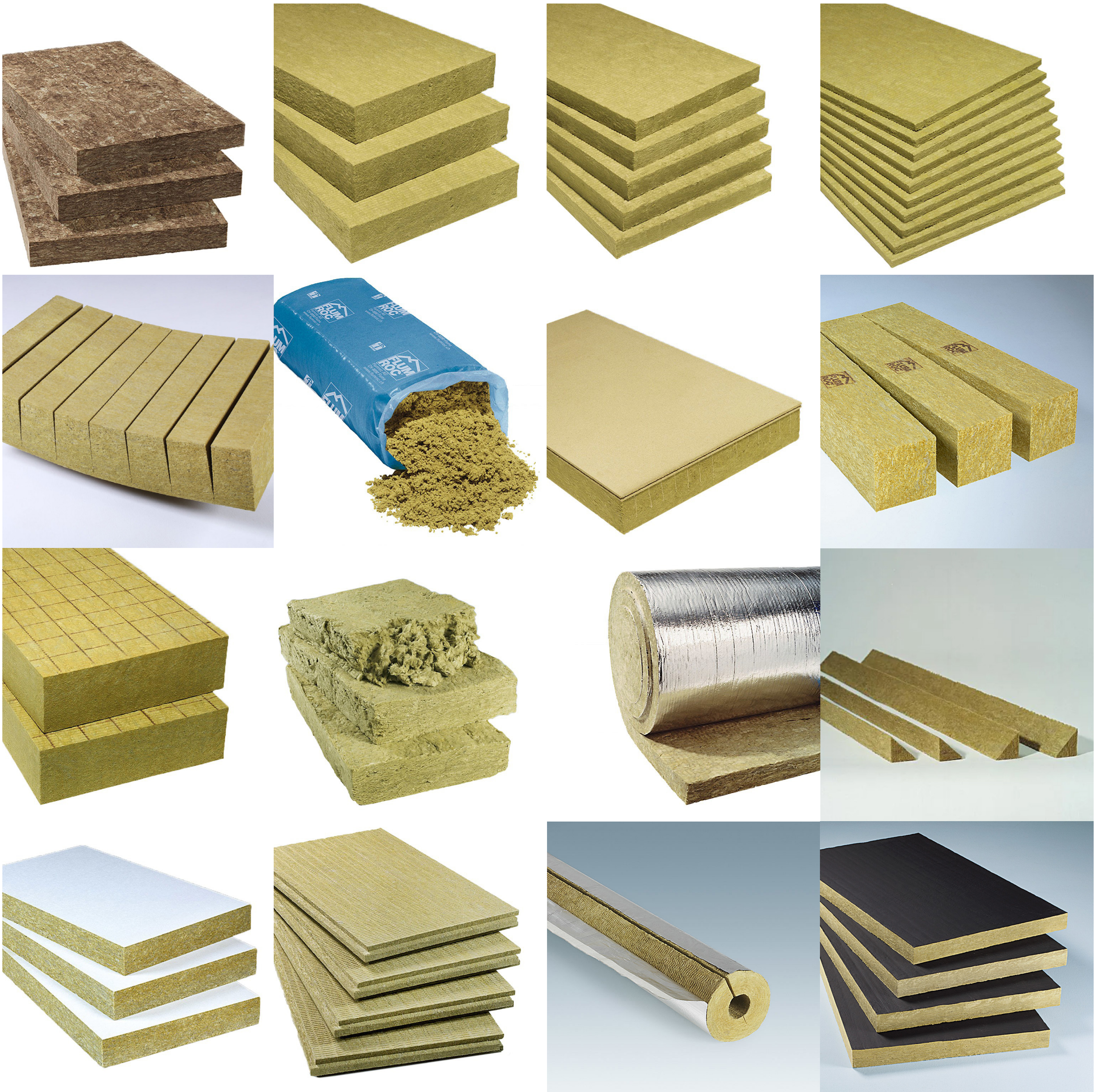
*28: Flumroc, Flums, 1977*
*Source: ETH Bildarchiv*

*29: Flumroc, Flums, 2022*
*Source: Flumroc*

Flumroc produces a wide range of products for construction and industry. They differ greatly in density and shape. All products come from the same production line and are only customised afterwards.
Flumroc's latest product is made with a natural sugar-based binder and therefore differs from the colour of the other products (brownish). [21]

Most products are primarily used for thermal insulation, but some products are specifically suitable for increased sound or fire protection.

*[21] : Ysker Olaf, Project Manager Environment at Flumroc AG, 2023*



*30: Flumroc Products, 2023*
*Source: Flumroc*
*Unternehmer-Preisliste, 2023*

| | Wärmeleit-fähigkeit W/(m K) | Rohdichte kg/m³ |
|---|---|---|
| Flumroc-Dämmplatte 1 | 0.035 | 38 |
| Flumroc-Dämmplatte SOLO | 0.035 | 38 |
| Flumroc-Dämmplatte 3 | 0.033 | 60 |
| Flumroc-Dämmplatte DUO | 0.034 | 50 |
| Flumroc-Dämmplatte DUO D20 | 0.034 | 50 |
| Flumroc-Dämmplatte DUO C | 0.034 | 50 |
| Flumroc-Dämmplatte ECCO | 0.036 | 75 |
| Flumroc-Estrichbodenelement ESTRA | 0.034 | 80 |
| Flumroc-Dämmplatte TOPA | 0.034 | 80 |
| Rockfon Facett | 0.035 | 85 |
| Rockfon Facett Lux | 0.035 | 85 |
| Flumroc-Dämmplatte PARA | 0.034 | 85 |
| Flumroc-Dämmplatte LENIO | 0.034 | 85 |
| Flumroc-Dämmplatte LENIO 341 | 0.040 | 150 |
| Flumroc-Dämmplatte DECO | 0.035 | 85 |
| Flumroc-Bodenplatte | 0.034 | 110 – 130 |
| Flumroc-Bodenplatten-Randstreifen | | |
| Flumroc-Dämmplatte PRIMA | 0.038 | 120 |
| Flumroc-Gefälledachsystem PRIMA | | |
| Flumroc-Dämmplatte 341 | 0.040 | 150 |
| Flumroc-Dämmplatte DISSCO | 0.040 | 150 |
| Flumroc-Dämmplatte MEGA | 0.045 | 170 |
| Flumroc-Gefälledachsystem MEGA | | |
| PEGAROCK | 0.065 | 475 |
| Conlit® Steelprotect Board | 0.040 | 150 |
| Conlit® Steelprotect Board Alu | 0.040 | 150 |
| Conlit® Steelprotect Section | 0.040 | 150 |
| Conlit® Steelprotect Section Alu | 0.040 | 150 |
| Flumroc-Stopfwolle FLB 700 | 0.040 | 100 – 170 |
| Flumroc-Feingranulat | 0.038 | 90 – 110 |
| Flumroc-Dachrandkeile | | 150 |
| Flumroc-Trapezstreifen Akustik | | 60 |
| Flumroc-Trapezstreifen Brand | | 60 |

| | Wärmeleit-fähigkeit W/(m K) | Rohdichte kg/m³ |
|---|---|---|
| Conlit® Steelprotect Board | 0.040 | 150 |
| Conlit® Steelprotect Board Alu | 0.040 | 150 |
| Conlit® Steelprotect Section | 0.040 | 150 |
| Conlit® Steelprotect Section Alu | 0.040 | 150 |
| Flumroc-Dämmplatte T42 | 0.036 | 60 |
| Flumroc-Dämmplatte FPI 700 | 0.034 | 120 |
| Conlit® Ductboard 30 LW | 0.034 | 70 |
| Conlit® Ductboard 60 LW | 0.035 | 130 |
| Conlit® Ductboard 90 | 0.037 | 180 |
| Flumroc-Dämmmatte FMI 500 | 0.035 | 80 |
| Flumroc FMI 500 FP | 0.035 | 80 |
| Rockwool 800 | 0.035 | 100 |
| Flumroc-Dämmplatte 341 | 0.040 | 150 |
| Flumroc-Stopfwolle FLB 700 | 0.040 | 100 – 170 |
| Flumroc-Feingranulat | 0.038 | 90 – 110 |
| Conlit® Fix | | |
| Conlit® FPS | | |
| Conlit® DRP | | |
| Conlit® DRP-A | | |

*32: Flumroc Products*
*Technical Insulation, 2023*
*Source: Flumroc*
*Unternehmer-Preisliste, 2023*

*31: Flumroc Products*
*Construction, 2023*
*Source: Flumroc*
*Unternehmer-Preisliste, 2023*