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Assessment of the long-term reliability of installed external thermal insulation composite systems

Conducted on behalf of
Verband für Dämmsysteme, Putz und Mörtel e.V.
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1 Introduction

Since the beginning of the 1960s, external thermal insulation composite systems (ETIC systems) have been used for external wall insulation. In the early phase, these insulation systems were initially only made with polystyrene rigid foam panels and synthetic resin plasters. Later, mineral systems were also used. Since the 1970s, the Fraunhofer Institute for Building Physics in Holzkirchen has been commissioned by the Fachverband für Wärmedämmverbundsysteme e.V. (specialist association for external thermal insulation composite systems), now Verband für Dämmsysteme, Putz und Mörtel e.V. (association for insulation systems, plaster and mortar), at various times to carry out inspections on finished buildings in order to determine condition and appearance of the applied ETICS in practice. In 1975, initial investigations were conducted for a total of 93 buildings in Germany, Austria and Switzerland [1]. The inspection was repeated for 87 buildings in 1983 [2]. In 1989, corresponding investigations were also performed on ETIC systems with mineral insulation materials [3]. Control examinations followed at the same buildings in 1995 [4], 2004 [5] and 2014 [6]. Another eight years later, the assessment was then carried out on the buildings as in 2014, and the spectrum of ETICs has been extended to include wood fiber (WFI) and polyurethane (PUR/PIR) insulation panels. These insulation systems were included to assess a wide cross-section of possible ETIC systems on the market, also with respect to their durability. All available data concerning renovation measures and other important building data of the additional buildings with WFI, and PUR/PIR insulation were compiled and evaluated. Thus, it is possible to obtain information on the long-term behavior of various ETIC systems on a selected number of larger buildings.

2 Conducted investigations

2.1 Assessed buildings

2.1.1 Building stock as of 2014

The properties assessed in 2014 - in other words, eight years before - are listed in Table 1 with information on the locations and the type of ETICS applied as well as the renovation work carried out up to that time. This enables a comparison between the newly determined façade conditions and the earlier situation Figure 1 schematically shows the chronological sequences of production, inspection and evaluation of the condition up to 2014.

The specified evaluation groups were taken from the earlier classification and are described again in Chapter 2.3 with an explanation of their causes and quality.

Table 1:
List of assessed buildings, including information on the system structure until 2014.

Object no.	Location	Address use of the building	Insulation material type and thickness	Application		Renovation until 2014
				Building	ETICS	
16	Munich	Burgkmaierstr. 9 Retirement home	mineral wool 60 mm	1960	1986	none
96	Nuremberg	Thumenberger Weg 11 Residential building	EPS 60 mm	1982	1982	1995 painting (silicone resin paint)
95		Fenitzer Platz Residential building	EPS 60 mm	1979	1979	2002 painting due to pollution
51		Krugstr. 17–23 Residential building	EPS 50 mm	?	1969	1987 painting everywhere, 2001 only ground floor street side (north) 2004 only garden side (south)
56	Neumarkt/Opf.	Am Evangelienstein 2 (formerly Efastr. 2) Residential building	EPS 50 + 40 mm	1970	1970 + 2008	1993 second insulating layer 40 mm with plaster; 2008 painting (emulsion paint)
54		Mühlstr. 1–3 Residential and commercial building	EPS 20 + 80 mm	1972	1972 + 2008	2008 doubling with 80 mm EPS; painting with silicone resin paint
34	Geislingen/Steige	Bolzstr. 6–8 Residential building	EPS 30 mm	1961	1970	1981 painting 2000 painting
33		Bolzstr. 9–12 Residential building	EPS 30 mm	1961	1970	1981 painting 2005 painting (silicate paint)
32		Ebertstr. 1–7 Residential building	EPS 30 + 100 mm	1961	1970 + 2006	1981 painting 2006 doubling with 100 mm EPS; painting (silicate paint)
31		Brüningstr. 2–8 Residential building	EPS 30 + 100 mm	1961	1970 + 2006	1981 painting 2006 doubling with 100 mm EPS; painting (silicate paint)
30		Stresemannstr. 2–6 Residential building	EPS 30 + 100 mm	1961	1970 + 2006	1981 painting 2006 doubling with 100 mm EPS; painting (silicate paint)

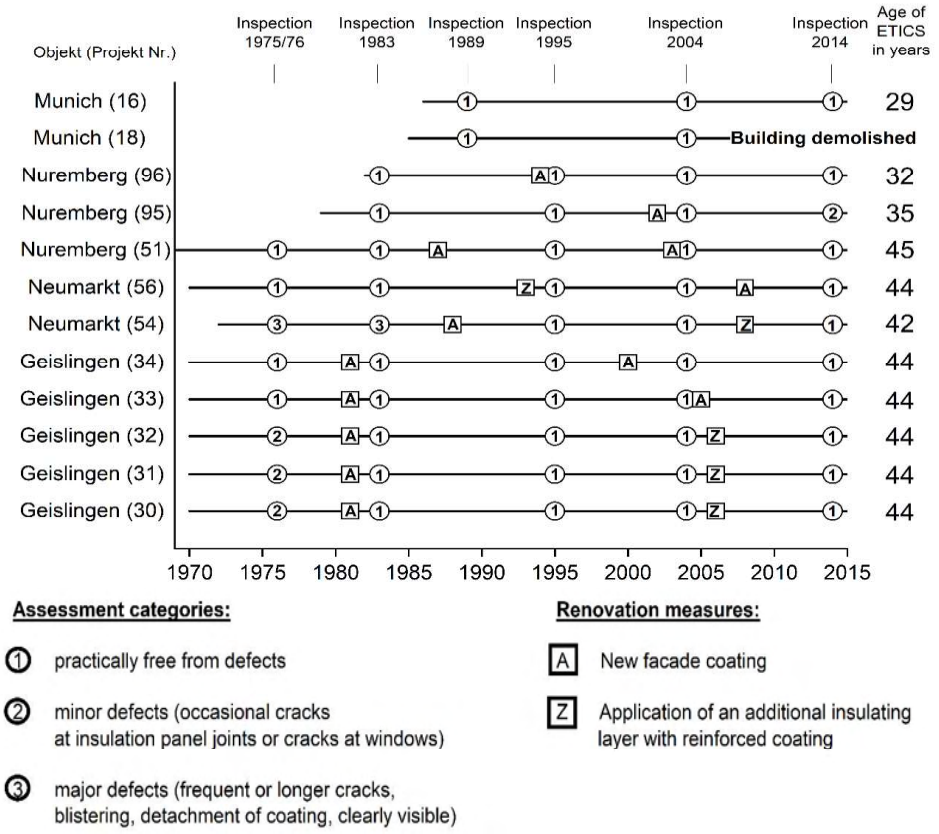

Figure 1:
Chronological sequences of production, inspection and renovation of the investigated ETIC systems, with information on the evaluation groups up to 2014.

2.1.2 Additional newly selected buildings from 2022

Table 2 lists the buildings additionally taken into consideration, including a short description. In addition to several buildings with PIR/PUR insulation and with wood fiber insulation, two buildings in Munich were also included, one with mineral wood insulation and one without ETICS.

Table 2
List of newly assessed buildings, including information on the system structure.

Object no.	Location	Address use of the building	Insulation material type and thickness	Application	
				Building	ETICS
1	Überlingen/Owingen/Radolfzell	Hauptstr. 24/Hinter den Gärten 32, Owingen residential building	brick 140 mm purenotherm synthetic resin plaster	1995	PUR/PIR
2		puren GmbH workshop Rengoldshauser Str. 4 factory building	brick 50 mm purenotherm mineral plaster	1973	1986 PUR/PIR
3		puren GmbH reception building Rengoldshauser Str. 4 office building	Reinforced concrete 100 mm purenotherm synthetic resin plaster	1997	PUR/PIR
4		Zur Äsche 11; Überlingen residential house	brick 80 mm purenotherm synthetic resin plaster	1991	PUR/PIR
11		Am Döbel 22, Überlingen residential house	brick 80 mm purenotherm synthetic resin plaster	1978	PUR/PIR
5		Kuchelmannweg 2, Überlingen residential house	brick 140 mm purenotherm mineral plaster	1998	PUR/PIR
6		Konstanzerstr. 21, Radolfzell residential house	renovation of old stone-work 80 mm purenotherm mineral plaster/Schwenk WEDI profiles	1997	PUR/PIR
7	Munich	Nanga-Parbat-Str. 67–91 residential building	mineral fiber	1987	MW
8		Alfred-Drexel Str. 2 residential building	no ETICS	1988	
9	Binzen/Waldshut-Tiengen	Rebbergweg 1c residential building	60 mm wood fiber insulation	1998	WFI
10		Breitenfeld 51 residential building	wood fiber insulation	1999	WFI
13		Steinbrunnenmatten 1 residential building	wood fiber insulation	1998	WFI

2.2 Causes of defects in ETICS

Because the individual components of an ETICS are specified in the approval documents and manufacturers are required to "stay in the system", material faults are generally relatively rare when a system is implemented. However, defects can result from the manner of execution, from mechanical or climatic impacts and from aging. Over the course of the observation period, which now spans several decades, the properties of the external plastering systems on the market have changed. Further aspects can also be considered as the causes of defects, which will be discussed in the following.

- **Plaster properties:** By now, external finishing plasters are configured to be more vapor-permeable by varying the organic binders. As a result, differences in the hygrothermal properties of finishing plasters and mineral-bound reinforcement plasters have decreased, as is apparent from a comparison of the diffusion properties of synthetic resin plasters between 1980 and 2010 [8]. Consequently, delamination and blistering of the finishing plaster have become less frequent.

- **Edge effects:** At the edges or connections of plastered wall surfaces, e.g., on window and door installations, the deformation and stress situation are different form the conditions in the plaster in the undisturbed central areas of a wall. This can result in local plaster delamination or damage as explained in [9].

- **Moisture (driving rain exposure and night-time condensation):** Temporary exposure to driving rain can have a cleaning effect on the façade. On the other hand, persistent surface moisture due to slow drying (shade) or external condensation can enable the growth of algae, black fungus or lichen.

- **Uneven plaster surfaces:** With ETICS, a slight unevenness can occur in the plaster surface that becomes visible especially with grazing light incidence´. It may reveal the surface structure, and insulation panel joints or other irregularities. This can occur particularly with plaster coats that are thin or have varying thickness, and it can also affect the type of soiling or algae formation.

- **Aging:** The properties of many building materials change over the course of time; they age. With mineral-bound finishing plasters, the outermost coat can loosen due to leaching or binder dissolution (sanding, especially in the case of lime containing plasters) or a post-solidification can set in overtime due to increasing binder hardening, which may result in late shrinkage cracks. Synthetic resin-bonded plasters and coatings can become brittle over time due to the leaching of plasticizers and processing additives. Preventing or mending such aging effects requires "maintenance work", e.g., by renewing coats of paint or repairing any defects that have occurred. This concerns all types of plaster and all façade constructions in general [10].

2.3 Condition assessment classes

The condition of the façades was assessed after a thorough inspection - as in the earlier investigations - according to three evaluation classes:

Class 1 - Practically without defects

No defects visible from a normal viewing distance; small hairline cracks are not considered.

Class 2 - Minor defects

Isolated cracks, e.g., longer toe cracks starting from window corners or isolated cracks along the insulation panel joints, not conspicuous, only visible upon closer inspection.

Class 3 - Major defects

Numerous or longer cracks, usually along the insulation panel joints, blistering or detachment of coatings, clearly visible.

Small cracks in connection with window or door corners are not system-specific; they can also occur with other construction types and normally do not cause any further damage. Cracks along the insulation panel joints are classified as system-specific, though. According to available studies, such cracks have practically no effect on the moisture content of non-water absorbing insulation materials and thus the insulating effect of the system, however, and no consequential damage is to be expected either [11]. Algae formation is not considered a technical defect but an "optical impairment" The term "algae" in the following is understood to include various types of microbial growth without further differentiation, which was not done as part of the investigations.

3 Results

In the following,
explains the results of the current façade assessment in 2022 of the 11 buildings from earlier inspections and Figure 3 explains the results for the 12 newly selected buildings. The diagram presents all available information on the ETIC systems such as application period, renovation work carried out, e.g., a new coat of paint or "doubling", i.e., adding a further insulation layer with plaster finish on top of an existing ETIC system. (a new system applied on top of an existing one). The current condition of the façades was classified according to the described evaluation groups 1-3.

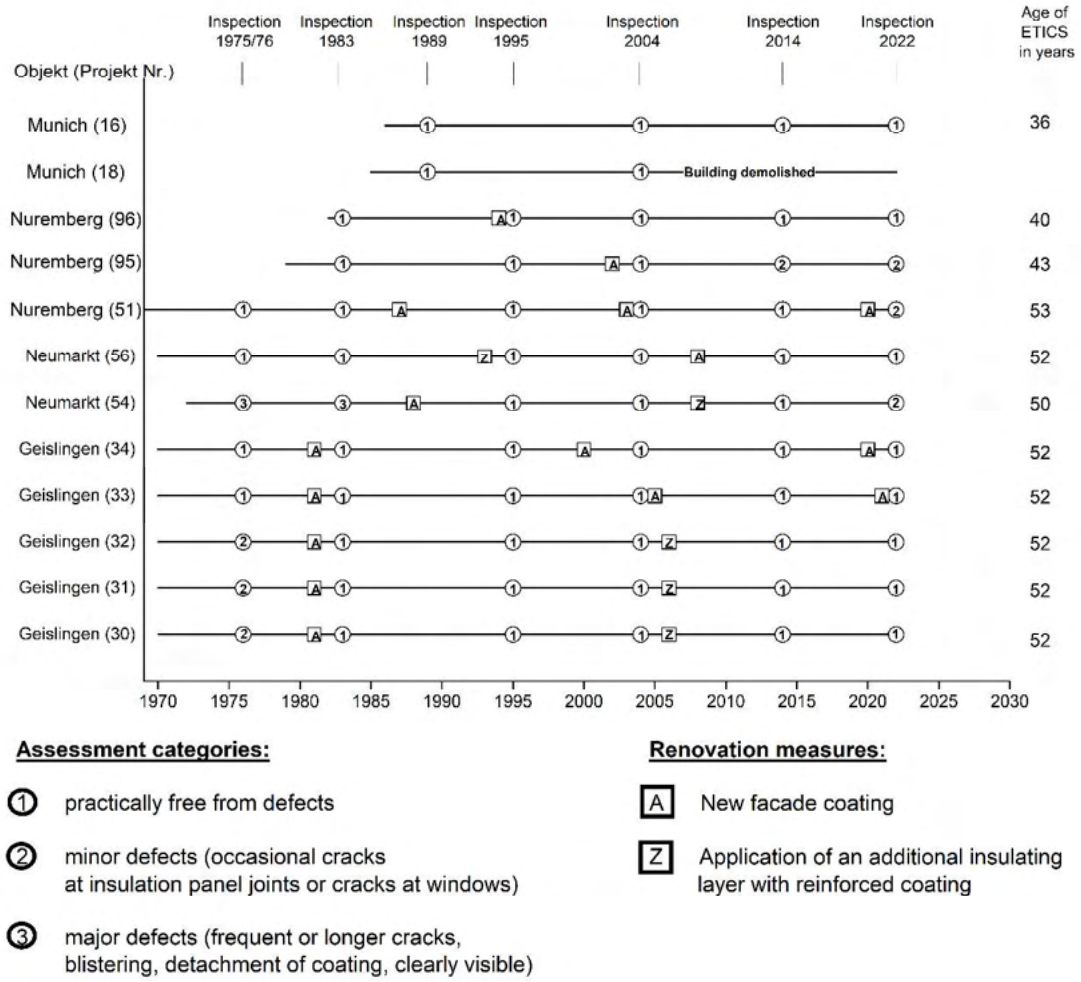

Figure 2:
Chronological sequences of production, checking and renovation of the investigated ETIC systems, indicating the evaluation groups from 1970 to 2022.

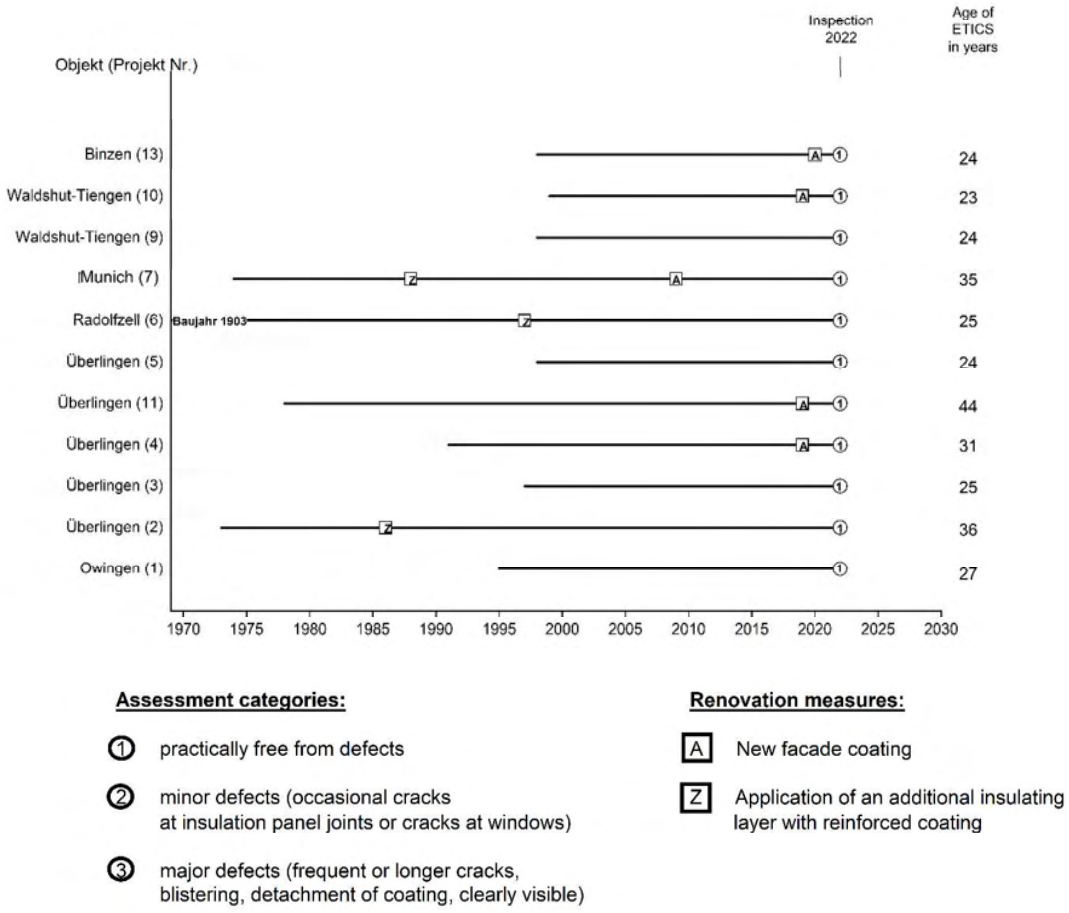

Figure 3:
Chronological sequences of production, checking and renovation of the newly investigated ETIC systems, indicating the evaluation groups in 2022.

The age of the investigated ETIC systems ranges between 36 and 53 years for the already repeatedly assessed buildings and between 23 and 44 years for those additionally assessed starting in 2022. Among the buildings, only two had been repainted over the course of the last eight years. Most of the buildings newly included in the investigations have not been renovated since the façades were created. Only four of these buildings have been painted in the last eight years. The owners were surveyed to determine whether and what renovations were carried out on the façades. The measures of the last eight years are listed for all buildings in Table 3
List of façade renovation measures carried out on the assessed buildings during the period of 2014–2022

Table 3
List of façade renovation measures carried out on the assessed buildings during the period of 2014–2022.

Object no.	Location	Address use of the building	Existing ETICS	Renovation 2014–2022		Other remarks
				Doubling of the ETICS	Coating	
Buildings from other investigations						
16	Munich	Burgkmaierstr. 9 Retirement home	mineral wool 60 mm	-	-	
96	Nuremberg	Thumenberger Weg 11 Residential building	EPS 60 mm	-	-	
95		Fenitzer Platz Residential building	EPS 60 mm	-	Partially renovated	No precise details are available on renovation measures
51		Krugstr. 17–23 Residential building	EPS 50 mm	-	-	
56	Neumarkt/OPf	Am Evangelienstein 2 (formerly Efastr. 2) Residential building	EPS 50 mm + 40 mm (1993)	-	-	
54		Mühlstr. 1–3 Residential and commercial building	EPS 20 mm + 80 mm (2008)	-	-	
34	Geislingen/Steige	Bolzstr. 6–8 Residential building	EPS 30 mm	-	2020	
33		Bolzstr. 9–12 Residential building	EPS 30 mm	-	2022	
32		Ebertstr. 1–7 Residential building	EPS 30 mm + 100 mm (2006)	-	-	

Object no.	Location	Address use of the building	Existing ETICS	Renovation 2014–2022		Other remarks
				Doubling of the ETICS	Coating	
31		Brüningstr. 2–8 Residential building	EPS 30 mm + 100 mm (2006)	-	-	
30		Stresemannstr. 2–6 Residential building	EPS 30 mm+ 100 mm (2006)	-	-	
Newly assessed buildings from 2022						
1		Hauptstr. 24/Hinter den Gärten 32 88696 Owingen	140 mm purenotherm	-	-	
2		puren GmbH workshop Rengoldshauser Str. 4 88662 Überlingen	50 mm purenotherm	-	-	
3		puren GmbH reception building Rengoldshauser Str. 4 88662 Überlingen	100 mm purenotherm	-	-	
11		Am Döbel 22 88662 Überlingen	80 mm purenotherm	-		
4		Zur Äsche 11 88662 Überlingen	80 mm purenotherm	-		
5		Kuchelmannweg 2 88662 Überlingen	140 mm purenotherm	-	-	
6		Konstanzerstr. 21 78315 Radolfzell	80 mm purenotherm	-	-	
7		Nanga-Parbat-Str. 67–91 80992 Munich	mineral fiber	-	2009	
8		Alfred-Drexel Str. 2 80992 Munich	mineral fiber	-	-	
9		Rebbergweg 1c 79761 Waldshut-Tiengen	60 mm wood fiber insulation	-	-	
10		Breitenfeld 51 79761 Waldshut-Tiengen	wood fiber insulation	-	2019/20	
13		Steinbrunnenmatten 1 79589 Binzen	wood fiber insulation	-	2020 only partially	

3.1 Results of buildings from earlier assessments

Object 16 - Retirement home in Munich

Figure 4 and Figure 5 show the west façade of object 16 (retirement home in Munich). The change in the façade over 33 years can be clearly seen here. The top image shows the façade three years after a 60 mm thick mineral wool insulation was applied (1989). The façade had not been reworked since it was created. In the lower image of Figure 4, some graying and algae formation can already be seen on unprotected wall sections (2004). The upper image of Figure 5 shows the façade condition in 2014, and the lower image shows the condition of the façade today after 33 years. In the meantime, nearly the entire façade has grayed, or the façade color has weathered away. The fastening dowels of the ETIC system are clearly visible (see Figure 6). The high weathering stress on the façade is also indicated by the condition of the balustrades, which show a considerably stronger discoloration than the ETIC system. No significant defects are visible on any of the four façade orientations. No cracks are visible over the surface. This is the oldest assessed building not maintained with functional ETICS, even though it needs renovation from an optical point of view. Overall, the façade has not significantly deteriorated since the last assessment.

Figure 4:
West facade of object 16 (retirement home in Munich) in 1989 (top), in 2004 (bottom). The different color appearances are solely due to the coloring of the photo.

Figure 5:
West facade of object 16 (retirement home in Munich) in 2014 (top), in 2022 (bottom). The different color appearances are solely due to the coloring of the photo (weather).

Figure 6:
View of the facade of object 16. With noticeable appearance of the dowels on the first and second floor.

Object 96 - Thumenberger Weg 11, Nuremberg

Object 96 was another building on which no renovation had been carried out since 2014. In Figure 7, the east side in 2014 is shown on the left and that in 2022 on the right. Since the last coat of paint was applied in 1995, some algae growth had occurred, which had only slightly increased in the past eight years. The façade is strongly shaded by a large tree and by the neighboring house, which is located a relatively short distance away. In addition, the light discolorations on the corners of the building (Figure 8) are still clearly visible in 2014 (left) and 2022 (right). The panel joints of the corner connection appear slightly here, but there has not been any noticeable change in the condition since the last assessment here either. Otherwise, there are no externally visible defects on the building facades.

Figure 7:
East side of object 96 (left in 2014 and right in 2022) with algae formation and slight rippling at the insulation panel joints. (The rippling is not caused by cavities in the plaster but by unevenness in the plaster layer that is recognizable by the different graying.).

Figure 8:
South-east corner of object 96 with appearance of the insulation panel joints through color differences (hardly visible from a distance).
Left: View in 2014.
Right: View in 2022.

Object 95 - Fenitzer Platz, Nuremberg

Object 95, which is in Nuremberg, is a large building complex (see Figure 9), in which five-story, interconnected residential houses are built around a large interior courtyard. The last known renovation of the existing ETICS façades took place in 2002 when a coat of paint was applied. Since then, cracks, graying and plaster detachment have occurred on individual façades. The top image in Figure 10 shows a west façade, which is oriented in the direction of the inner courtyard, on which graying, and algae formation could be seen over the entire height of the building in 2014. The image below shows how the same façade section currently looks in 2022. A renovation was obviously carried out here; however, the property management was not able to provide any precise information. Further defects are seen on the east and south-east façade facing the inner courtyard in Figure 11 ; blotchy areas have occurred here. Figure 12 also shows that a cleaning effect results from water flowing down from the sheet-metal window areas on the upper story. The façade surfaces are clearly grayer below the window. In Figure 12, spalling of the plaster is apparent between the windows on the east façade. Overall, the web-like crack formation as in 2014 can no longer be seen on the building; there are some blotchy areas again in 2022 but in different façade sections than in 2014.

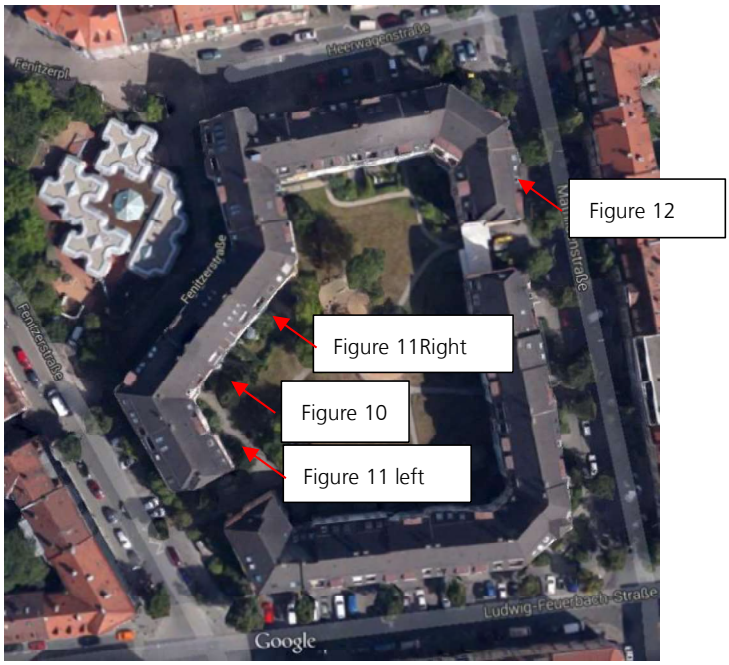

Figure 9:
Top view of object 95, Fenitzer Platz in Nuremberg [source: www.google-maps.de].

Figure 10:
View of the exterior façade with west orientation in 2014 (top) and 2022 (bottom).

Figure 11:
View of the east façade (left) and south-east façade (right) on object 95 with noticeable splotch formation but no crack formation.

Figure 12:
View of the east façade of the part of the residential complex that borders Mathildenstrasse. Noticeable crack formation and plaster separation between the windows.

Object 51 - Krugstr. 17–23, Nuremberg

The changes in the north façade of object 51 can be seen in Figure 13 for the periods of 2004, 2014 and 2022. It was painted the last time 19 years ago. By now, the façade shows noticeable weathering characteristics as well as noticeable, extensive graying. Some lighter areas are still visible on the surface. It can be assumed that there is a joint of the insulation panel underneath. As a result of the different temperature conditions in these areas, a minimally changed microclimate occurs on the surface. Within the last eight years, the condition of the façade has optically grayed further, but no visible damage such as cracks or spalling is visible. Figure 14 additionally shows a section of the north façade in 2014 and 2022 on the upper stories. Clear condensation trails and light areas are visible on the plaster that appear along panel joints of the ETICS. No damage is visible. The south side of the building looks somewhat different, however. Isolated blistering was already visible here in 2014, and this has now developed further into noticeable cracks and bulges in the plaster. Figure 15 shows a close-up of the south façade in a balcony and at the connection to the garage in which blistering, and cracks are visible when comparing 2014 and 2022.

Figure 13:
North façade of object 51 in 2004 (top), 2014 (center) and 2022 (bottom).

Figure 14:
View of the top north facade in 2014 (top) and 2022 (bottom) of object 51 on which noticeable condensation trails and light areas along the panel joints of the ETIC system are clearly visible.

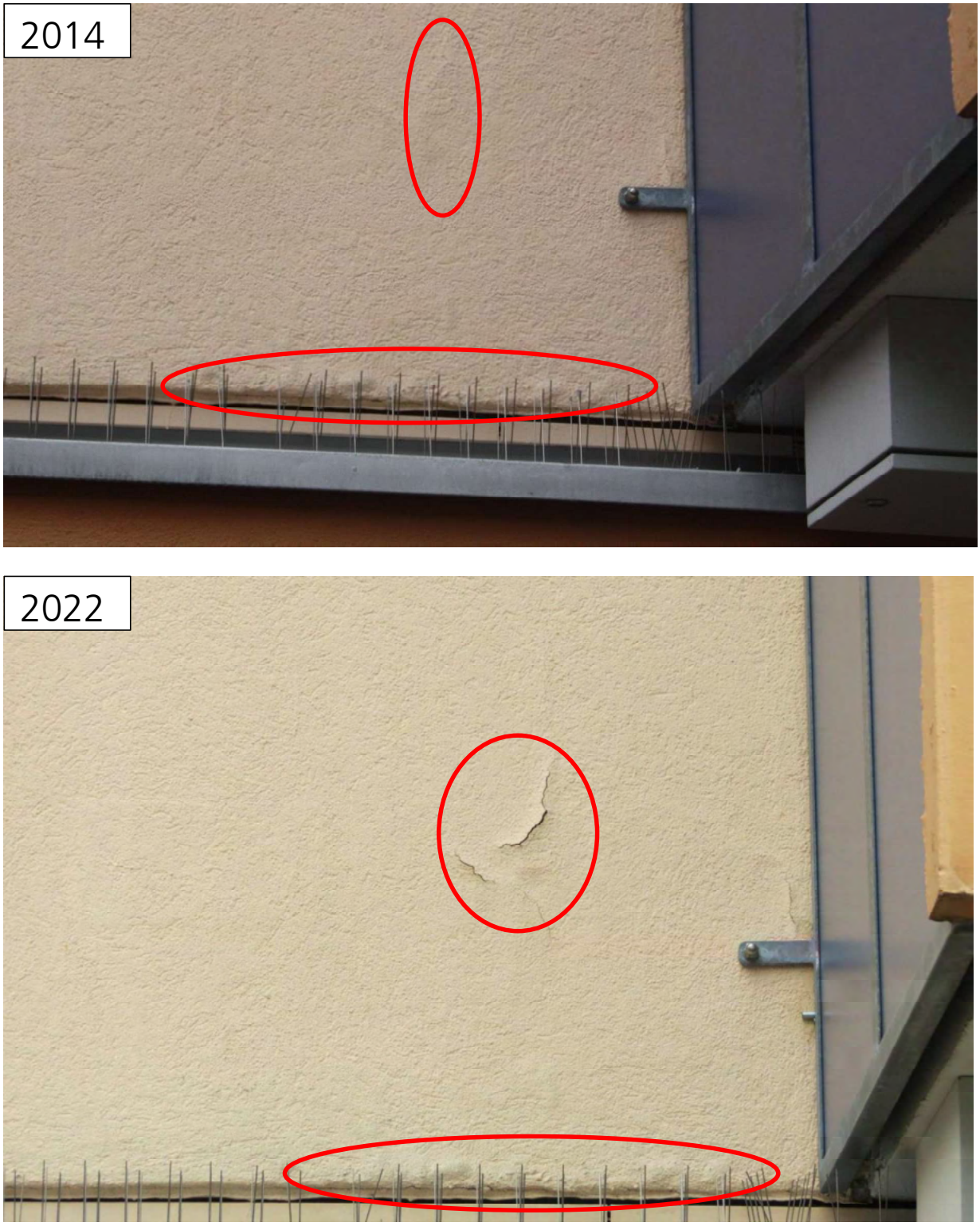

Figure 15:
View of the façade connection to the garages in 2014 (top) and 2022 (bottom) on the south side of object 51; noticeable blistering or crack formation is visible here on the lower plaster edge as well as occasionally in the plaster surface.

Object 56 - Am Evangelienstein 2 (formerly Efastr. 2) Neumarkt i. d. Oberpfalz

Object 56 in Neumarkt i. d. Oberpfalz was last painted in 2008. Figure 16 shows the view of the south façade in 2004 at the top, in 2014 in the center and in 2022 at the bottom. The façades have considerably grayed in the past eight years, but no crack formation or spalling is visible. On the east side, a slight rippling (see Figure 17 - top in 2014, bottom in 2022) in the plaster surface is visible where the edges of the ETICS panels appear with an oblique light incidence. This phenomenon is not considered a defect since it can occur due to slight differences in the thickness of the insulation panels and due to fluctuations in the layer thicknesses when a thin plaster is applied. Otherwise, a noticeable graying is visible over the entire surface here as well.

Figure 16:
South view of the façade of object 56 (formerly Efastr.), in 2004 (top), 2014 (center) and 2022 (bottom).

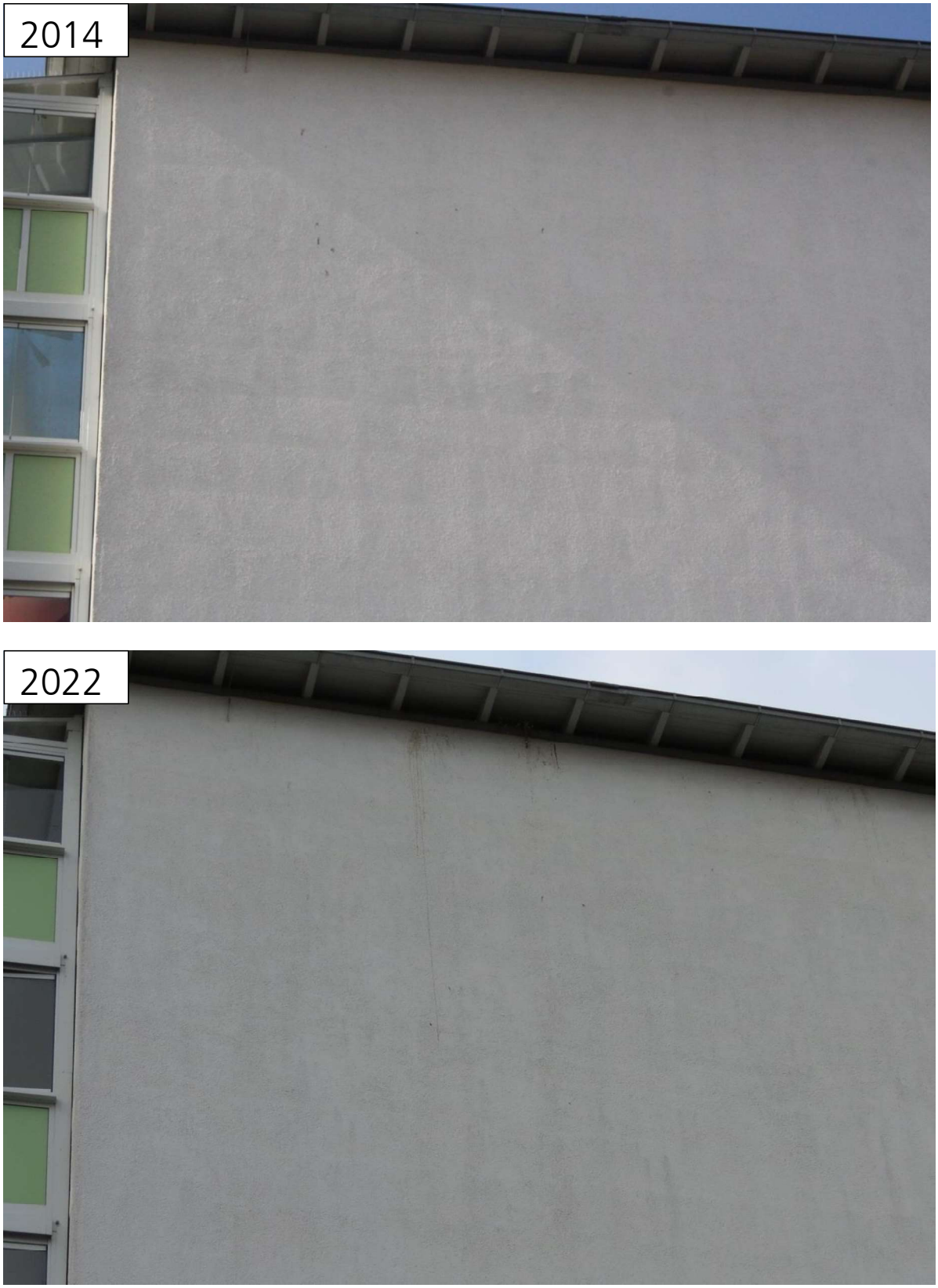

Figure 17:
East façade in 2014 (top) and 2022 (bottom) of object 56 with slight rippling at the panel joints of the insulation, which is only visible with oblique light incidence.

Object 54 - Mühlstr. 1–3, Neumarkt i. d. Oberpfalz

A further building that had not been renovated in the past eight years was object 54 in Neumarkt i. d. Oberpfalz Figure 18 shows images of the east and south façade in 2004, 2014 and 2022. No significant changes are visible on the south and east façade from a distance. Upon closer inspection, a slight green growth is apparent in the white color strips in some places on the east side as well as a slight blistering in one place. The north side (see Figure 19) of the building shows a strong greening. Here the gray stripes are also green. The thick vegetation on the north side of the building strongly favors the growth of algae on the shaded side. In addition, blisters in the plaster are also visible on the west façade, which is offset to the rear, next to the back entrance (see Figure 20).

Figure 18:
East and south façade (from right) of object 54 in Neumarkt in 2004 (top), 2014 (center) and 2022 (bottom).

Figure 19:
North façade of object 54 in Neumarkt in 2022 with noticeable greening in the white façade areas.

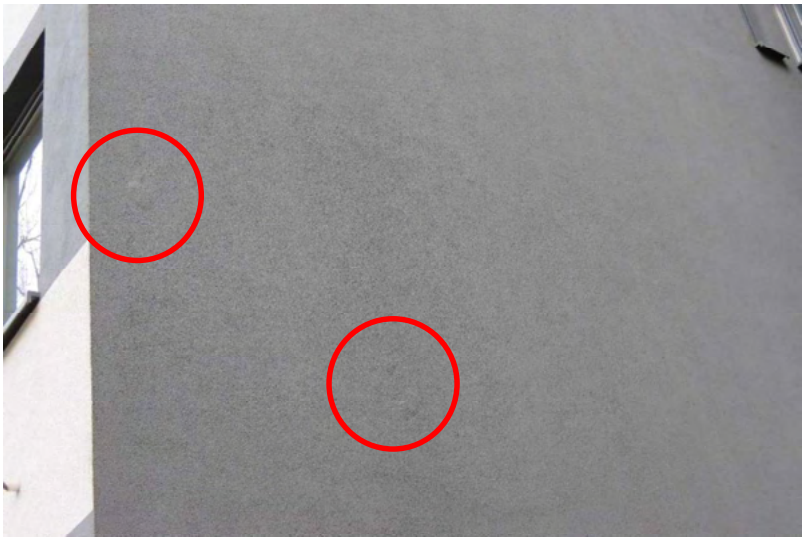

Figure 20:
The west façade, which is offset to the rear, next to the back entrance of object 54 in Neumarkt in 2022 with noticeable blistering.

Object 34 - Bolzstr. 6–8, Geislingen a. d. Steige

On object 34, the façade coating had been renovated with a silicone resin paint in 2020 and was without visible defects. The comparison of the façade view from 2014 to 2022 is shown in Figure 21.

Figure 21:
North façade of object 34, in 2014 (top) with noticeable discolorations of the white plaster surfaces and in 2022 (bottom), freshly painted approx. two years before.

Object 33 - Bolzstr. 9–12, Geislingen a. d. Steige

Object 33 is characterized by the same structure and the same location as the previous property 34, with the difference that this building façade was renovated in 2022 with a new coat of paint. Figure 22 shows images of the north façade in 2004, 2014 and 2022. No defects are visible.

Figure 22:
North view of object 33 (Bolzstr. 9–12, Geislingen a. d. Steige), in 2004 (top), 2014 (center) and 2022 (below).

Object 32 - Ebertstr. 1–7, Geislingen a. d. Steige

For object 32, Figure 23 to Figure 25 show the chronological sequence of the views of the north façade over the course of the last 39 years. In the period of 1981–2006, no work took place on the façade. Since the energy-related renovation measures in 2006, the façade of the building had not been worked on. The pictures from 1983 to 2022 do not show any crack formation or spalling defects over the years. The picture from 2022, however, shows noticeable discolorations and appearance of the ETICS dowels in the upper stories on the façade. Figure 26 shows the east view of the building in comparison: in 2014 on the left and in 2022 on the right. The graying has become more noticeable, and the ETICS dowels clearly appear on the entire façade surface. In the connection area to the grass strip, it is evident that algae growth / soiling has considerably increased since 2014 (see Figure 27). This is due to the short distance to the grassy area and the related spray water.

Figure 23:
View of the north façade of property 32 (Ebertstr. 1–7, Geislingen a. d. Steige) in the period between 1983 and 1995.

Figure 24:
View of the north façade of property 32 (Ebertstr. 1–7, Geislingen a. d. Steige) in the period between 2004 and 2014.

Figure 25:
View of the north façade of object 32 (Ebertstr. 1–7, Geislingen a. d. Steige) in October 2022.

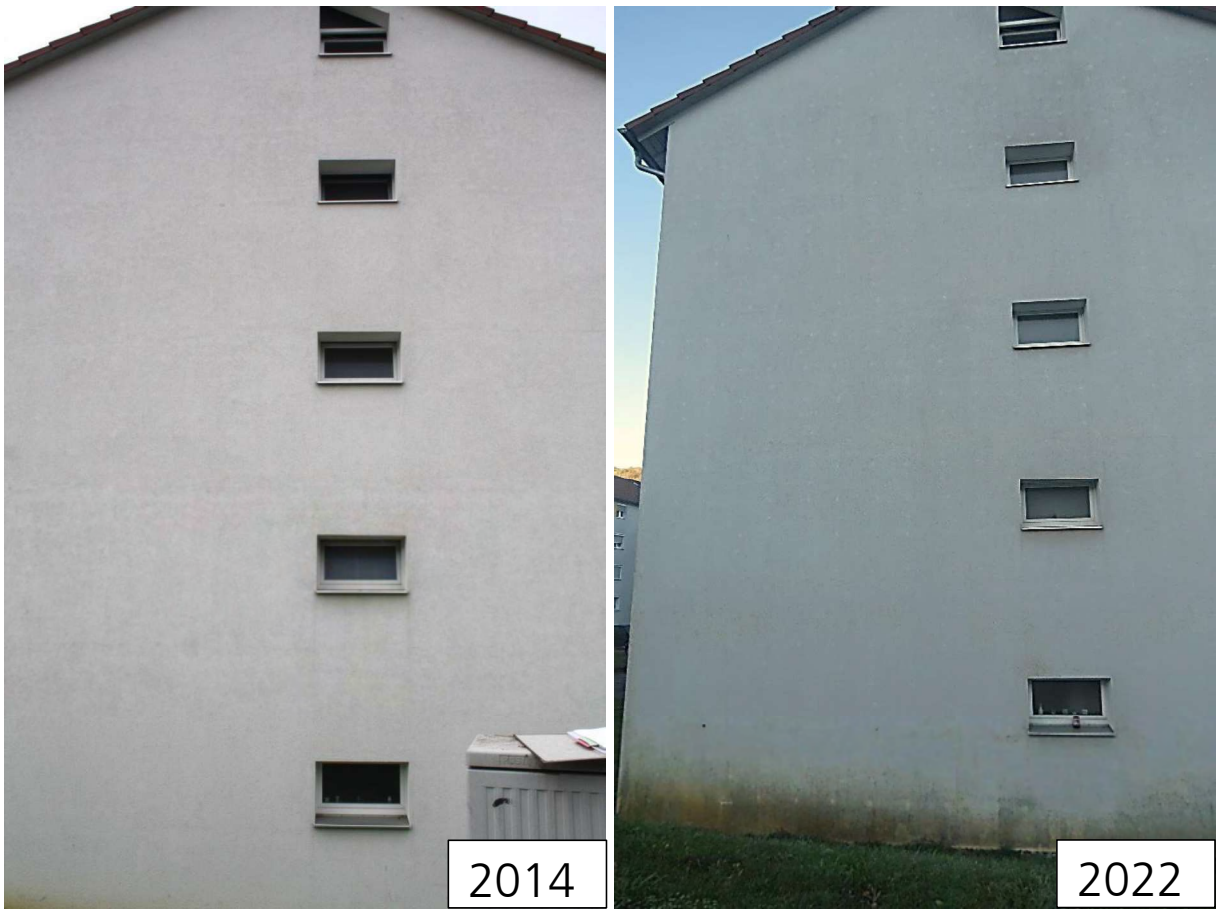

Figure 26:
East view of the façade of object 32, in 2014 (left) and 2022 (right).

Figure 27:
View of the lower east façade surface in 2014 (top) and 2022 (bottom) at the connection to the grass strips with noticeable algae growth and soiling of the plaster surface by spray water as well as the appearance of dowel areas.

Object 31 - Brüningstr. 2–8, Geislingen a. d. Steige

On object 31, no façade renovation measures had been carried out since 2006. Figure 28 shows the south view of the building in 2004, 2014 and 2022. There are no crack formation or blistering defects on this building. Overall, a noticeable graying of the façade is visible mainly in the area between the windows. On the west façade (see Figure 29), extensive graying of the entire façade is visible, but no crack formation.

Figure 28:
View of the south façades of object 31 (Brüningstr. 2–6, Geislingen a. d. Steige), in 2004 (top), 2014 (center) and 2022 (bottom).

Figure 29:
View of the west façade of object 31; in 2014, noticeable color differences could be seen between the area underneath the windows and the undisturbed façade; in 2022 an even graying is visible.

Object 30 - Stresemannstr. 2–6, Geislingen a. d. Steige

On object 30, no façade renovation measures had been carried out since 2006 either. Figure 30 shows the view of the north façade in 2004, 2014 and 2022. On the façade, the growth of black fungus is seen above the windows on several residential units on the first floor, just like in 2004 and 2014; this is due to windows that had been tilted open for a longer time. Here, moist, warm indoor air flows upwards along the façade and condensate forms because of the cold surface, leading to the formation and growth of black fungus. Except for the usual graying, no defects could be detected on the façade. Another, more noticeable detail can be seen in Figure 31. In 2014, algae growth occurred on the south-west corner of the building, which only appeared on the edge of the building. During the assessment in 2022, there was algae growth on the north-west corner of the building as well as the beginning of algae growth over the surface of the façade. In addition, significant condensation trails were visible in the upper area of the west façade (see Figure 32).

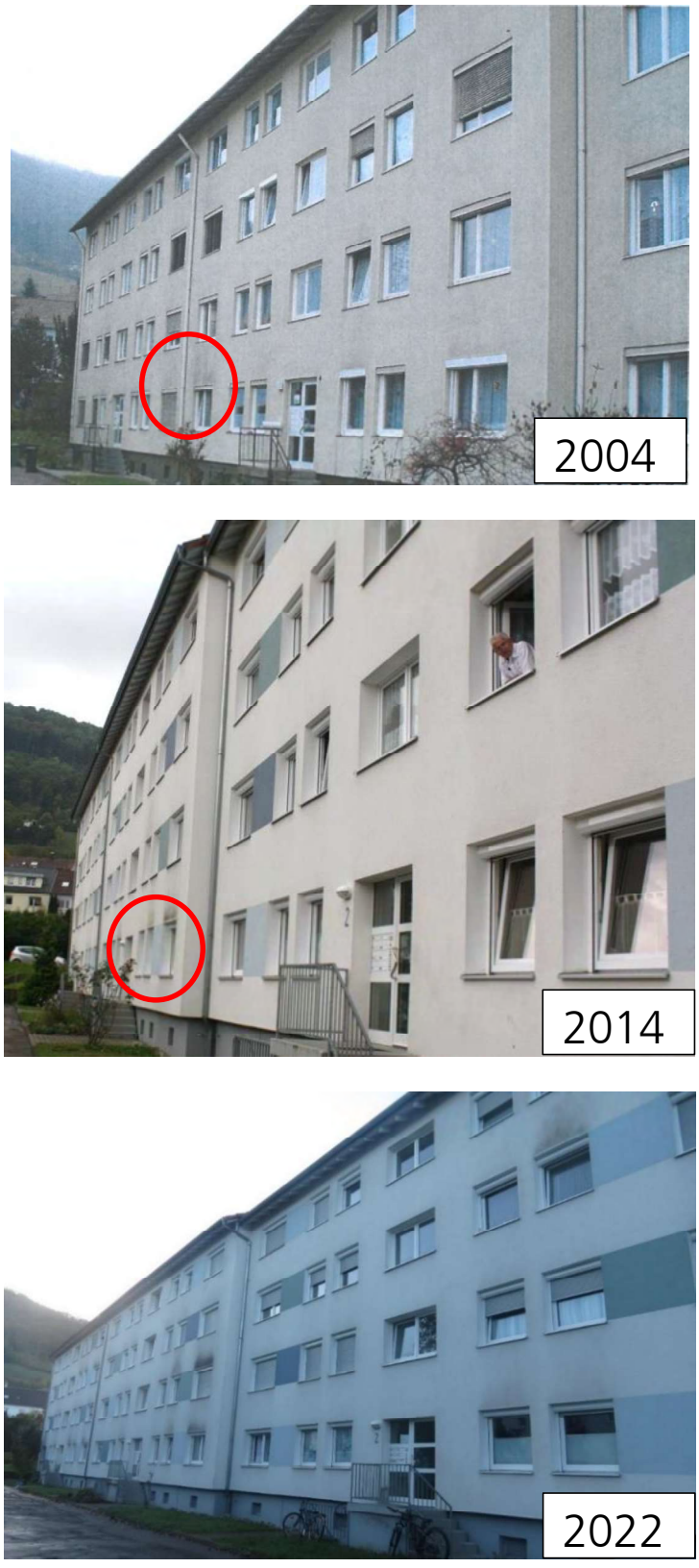

Figure 30:
View of the north façade of object 30 (Stresemannstr. 2–6, Geislingen a. d. Steige), in 2004 (top), 2014 (center) and 2022 (bottom).

Figure 31:
View of the south-west corner of the building in 2014 (left) of object 30 and the north-west corner of the building in 2022 (right) with algae growth on the edge of the building.

Figure 32:
View of the west façade (2022) of object 30 with noticeable condensation trails and the beginnings of algae growth.

3.2 Newly assessed buildings from 2022

Object 1 - Hauptstr. 24/Hinter den Gärten 32, Owingen

For object 1 in Owingen, it was only possible to visually assess the façades that can be seen from the street, because it was unfortunately not possible to determine the property management/owners to receive permission to take pictures of the building. During the visual assessment of the façade facing the street (east façade), no damage or graying could be documented. When assessing the façade, however, it should be noted that there is a very large roof overhang, as well as stair and entrance areas in front of the building, which significantly reduces the weathering influences on this facade. The north side shows some splotchy, slightly grayed beginnings of weathering.

Object 2 - puren GmbH workshop, Rengoldshauser Str. 4, Überlingen

Object 2 is a workshop building that was built in 1973 and insulated in 1986 with 5 cm PUR/PIR insulation and mineral plaster. Since then, the façades have not been renovated anymore. The façade construction was thus 36 years old. No damage is visible over any of the surfaces (see Figure 33). Some damage can be seen only in the base area, although this is likely to have been caused by mechanical influences. Biological growth is also discernible in the lower area of the façade, which is probably due to spray water from the ground. On the south side (Figure 34), noticeable gray areas and condensation trails are visible in the upper façade area.

Figure 33:
View of the three façades of object 2.
Top: north façade.
Center: east façade.
Bottom: south façade.

Figure 34:
View of the upper south facade.

Object 3 - puren GmbH reception building, Rengoldshauser Str. 4, Überlingen

Object 3 is an office building with a base area that was constructed in 1997 with 10 cm of PUR/PIR and a synthetic resin plaster. The façade surfaces on top of this are cladded with façade panels. The assessed surfaces on the north, west and south side of the building (Figure 35 and Figure 36) do not show any biological growth or damage in the base area. Only at the connection of the exterior cellar stairs to the insulated exterior cellar wall (Figure 37 there are significant traces of weathering from rainwater flowing down onto the cellar stairs, but there is no crack formation.

Figure 35:
View of the base area of the north façade, which is insulated with purenotherm.

Figure 36:
View of the base area of the west (left) and south (right) façade, which is insulated with purenotherm.

Figure 37:
View of the base area of the west façade at the stairs going down, which is insulated with purenotherm.

Object 4 - Zur Äsche 11, Überlingen

Object 4 is another building with PUR/PIR insulation. This house was built in 1991 and constructed with 8 cm ETICS and synthetic resin plaster. The façades have been painted over once. Figure 38 and Figure 39 show the west and north façade including a windowsill connection. It can be seen here that the façades are in perfect condition. There are no objectionable cracks or graying.

Figure 38:
View of the west façade (left) and a windowsill connection (right) of object 4.

Figure 39:
View of the north façade (left) and a windowsill connection (right) of object 4.

Object 11 - Am Döbel 22, Überlingen

Object 11 was built in 1979/1980 and insulated with an ETICS made of 8 cm PUR/PIR panels. The façades had been painted twice since the building was constructed. The condition of the façades was perfect and free of damage. Views of the west and north façades can be seen in Figure 40.

Figure 40:
View of object 11 of the west (top left) and north façade (bottom) as well as a windowsill connection on the west side (top right).

Object 5 - Kuchelmannweg 2, Überlingen

Object 5 is another building with partial insulation. It is a town house built on a slope, and only its east side and its south side on the first floor are insulated with PUR/PIR. Unfortunately, neither the age nor the thickness of the system is known. As can be seen in Figure 41 (orange areas), there is no damage or graying or biological growth on the surfaces.

Figure 41:
View of the east (top) and south façade (bottom) of object 5.

Object 6 - Konstanzerstr. 21, Radolfzell

Object 6 is a building that was already built in 1903. In the period of 1996–1998, the façades were completely renovated by removing the old plaster and the cement asbestos panels from the 1960s and replacing them with an ETICS, consisting of 8 cm PUR/PIR panels (without dowels) and a mineral plaster system as well as a silicate coating. During the renovation, façade profiles were applied to restore the original appearance of the house from 1903. Since 1998 there had been no further work on the façades. The façades (Figure 42 to Figure 44 of the house were completely damage-free after 24 years. No cracks, blistering or spalling can be seen. Algae growth and significant graying are visible above all on the north-west and south-west façade of the building. The thick greenery around the house slightly increases the risk of microbial growth on the façades. In addition, growth is visible on the façade profiles and in the connection area of the exterior stairs and the façade, which can be encouraged by spray water in these areas.

Figure 42:
View of all four facades of object 6. The building is at a 45° angle to the main orientation. The views are as follows:
Top left: north-west façade.
Top right: north-east façade.
Bottom left south-west façade.
Bottom right: south-east facade.

Figure 43::
Close-up of the NW façade (left) and SW façade (right) with noticeable greening.

Figure 44:
Close-up of a window connection with a frieze on the NW façade.

Object 7 - Nanga-Parbat-Str. 67–91, Munich

Object 7 consists of four large housing blocks with five stories each (Figure 45 to Figure 49), which were all renovated at the same time. All the buildings were equipped with an ETICS consisting of a 6 cm layer of mineral wool and a 2.5 cm thick layer of plaster in 1987–1988. A renewal coating of silicone resin paint was applied in 2009. The only difference between the buildings is the paint and sometimes the orientation of the building. No crack formation, blistering or spalling of the plaster is visible on any of the buildings. Only on the east side of house number 85 (yellow façade) is there a slight green growth visible on the lower north-east half of the façade, as evident in Figure 48, as well as in a small area on the north side on the first floor (Figure 49).

Figure 45:
North (bottom) and south view (top) of the house numbers 67–69.

Figure 46:
East views of the housing block house numbers 73–77.

Figure 47:
Views of the facades of house numbers 79–83.
Top left: north façade.
Top right: east façade.
Bottom left: south façade.
Bottom right: west façade.

Figure 48:
View of the east façade of house number 85, including a close-up of the lower north-east façade surface with algae growth.

Figure 49:
View of the north façade of house number 85, including a close-up of the lower façade surface with algae growth.

Object 8 - Alfred-Drexel Str. 2, Munich, Germany

Object 8 (Figure 50) was added to the assessment list; however, upon inspection of the building, it turned out that the building did not have any ETICS yet. Unfortunately, there was no further information on whether and when a new coat of paint was applied to the façade. Optically, there are no irregularities.

Figure 50:
View of the north (top) and south façade (bottom) of object 8.

Object 9 - Rebbergweg 1c, Waldshut-Tiengen

Object 9 is a duplex house where the west side of the building was assessed. The house was built in 1998, insulated with 6 cm wood fiber panels and plastered. The south-west side (Figure 51) of the building shows a slight graying without any features. In the middle of the duplex house, a section of the façade is offset towards the rear. On the south side (Figure 52), the fastening dowels of the ETICS panels appear directly underneath the roof overhang; significant graying of the surface is also visible. On the northwest side, a canopy is mounted in the recess of the building. In the area of the center fastening of the steel construction (Figure 53), cracks have formed over the plaster, which are related to the load transfer of the structure, though. Otherwise, no cracks are visible on any of the three house façade surfaces.

Figure 51:
View of the south-west façade of object 9.

Figure 52:
View of the south-east façade of object 9, which is offset to the rear.

Figure 53:
Connection detail of the canopy on the north-west side of object 9.

Object 10 - Breitenfeld 51, Waldshut-Tiengen

Object 10 is a free-standing single-family house in a rural setting. The building was constructed in 1999 with an ETICS made of wood fiber panels and finishing plaster. The façade was renovated by applying a new coat of paint in 2019/2020. The views of the house are shown below (Figure 54 to Figure 56). On the south side in the connection area of the conservatory, there is the only place on the entire building where a crack in the plaster is visible. This is probably due to the detailed design of the conservatory connection. Otherwise, no crack formation or blistering or discoloration is visible.

Figure 54:
South view of the façade (left) of object 10. Crack formation visible at the upper connection of the conservatory (right).

Figure 55:
View of the north façade of object 9 with close-up of the ventilation opening next to the windows.

Figure 56:
View of the west façade of object 9

Object 13 - Steinbrunnenmatten 1, Binzen

Object 13 is another building with wood fiber insulation. This is a duplex house from 1998. The east side was selected for the assessment. The west side was completely repainted in 2020 and on the east half only the south-east façade (street side) (Figure 57 top left); the other façade areas have not been renovated yet. During the assessment, it was determined that the east side of the house had a large garden with a lot of vegetation as well as climbing plants on the façade. The visible areas of the north-east façade (Figure 57, bottom left) show graying across the surface. Looking at the north-west façade, a clear difference could be seen between the west, painted façade and the east façade

(in original condition). On the east half, a slight green coating was visible, while the west half was bright white. No crack formation, blistering or spalling is visible on any façade.

Figure 57:
Views of the façades of object 13.
Top left: south-east façade - painted in 2020.
Top right: north-west façade - only western half painted in 2020.
Bottom left: north - east façade.
Bottom right: south-west façade - painted in 2020.

4 Summary and conclusions

The repeated inspection of 11 multi-story residential buildings with different external wall insulation systems also called external thermal insulation composite systems (ETIC systems), of which some are already more than 50 years old, can be summarized by the following statements: Systems that have not been renovated for almost 20 years show mostly only isolated, minor technical defects in the form of cracks and blistering. Most façades are free of real damage; but may have esthetical blemishes such as noticeable graying and the distinct appearance of fasteners or individual panel joints across their surface and at the corner of the building. Weathering of paint coats can also be detected on some properties.

Properties that had undergone a retrofit by ETICS doubling do not show any damage at this time. As already determined during the assessment in 2014, algae formation occasionally occurs on the façade near the ground. Graying and the related appearance of fastening systems have now become visible on many façade areas regardless of their orientation. However, the façades in north and west directions (the west orientation suffers by far the highest wind driven rain load in Central Europe) show considerably stronger graying than the south and east façades.

One system showed already defects in the plaster in 2014 after the application of a new paint coat. At that time, blisters and web-like cracks were locally discernible as well as visible discolorations, possibly because of an inappropriate execution. In the meantime, some façades of this building complex have been renovated again. Other façades that had not been renovated since the last assessment still showed discolorations and isolated paint coat and even plaster delamination.

In the 2022 assessment, eleven additional buildings were included to obtain a larger cross-section of different ETICS insulation materials. Buildings with PUR/PIR, wood fiber and a further building with mineral wool have been added. These ETIC systems are 23 to 44 years old. As already described above, no technical defects can be found on these buildings. Some systems had merely been painted a second or third time.

Finally, it can be affirmed that no excessive algae growth has occurred on the façade surfaces of any of the assessed buildings. Significant algae growth only occurs in areas in which there is a great deal of vegetation near the building.

The maintenance costs due to real defects are very low for the assessed ETIC systems, and the durability of the systems can also be considered as very good. A service life of 50 years and possibly more can be expected provided the right material combination is used and the system is properly maintained.

5 Literature

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