Mining for Embodied Coal. Building Material Reuse in the Postwar Reconstruction of Warsaw

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Abstract

The conditions prevailing in Warsaw in the aftermath of World War II were ones of urban and industrial ruination, material scarcity and resource depletion. The way in which such conditions led to the development of a distinct urban strategy of energy conservation during the reconstruction period is the core subject matter of this paper. The presented investigation commences with the analysis of various types of calculation through which architects and engineers tried to grapple with rubble – a defining material feature of Warsaw's ruined landscape. This then leads into a highlighting of the development of embodied-coal calculations, with consideration given to their role in securing the support of the socialist government for the recycling of rubble in architecture. The resulting argument offers a new historical entry point into a discussion of the circular economy in architecture, by embedding rubble recycling in the energy landscape of postwar reconstruction in Europe.

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Received:
11 November 2023

Accepted:
27 May 2024

DOI:
10.17454/ARDETH13.09

ARDETH #13

The *Studiengesellschaft für Trümmerverwertung* (Scientific Association for Rubble Recycling) had been established a few years previously, to coordinate research into the use of rubble in the postwar reconstruction of cities across Germany.

Introduction

In summer 1947, a group of engineers from Warsaw arrived in Hamburg in what was then the British-administered zone of occupied postwar Germany. Antoni Kobyliński and his colleague Kazimierz Kamiński were being hosted there by the *Studiengesellschaft für Trümmerverwertung* (Scientific Association for Rubble Recycling). That Association had been established a few years previously, to coordinate research into the use of rubble in the postwar reconstruction of cities across Germany. To this end, the period 5th-20th July 1947 saw the Association organise an industrial fair at Hamburg's Planten un Blomen Park.

Visiting that *Interzonale Ausstellung für Trümmerbeseitigung und Trümmerverwertung* (Inter-Zonal Fair for Rubble Clearance and Recycling), the Polish engineers came upon a robust private industry in rubble recycling. The latter had emerged in response to the material conditions produced in urban areas of Germany by the Allied "strategic bombing" (Friedrich, 2008). For their part, the Polish engineers were paying their visit so as to learn of and introduce recycling methods into the mountains of rubble left in the wake of Germany's 6 years of occupation of Poland.

Kamiński reported on the visit in a 1948 article published in *Numer Gruzowy* ("The Rubble Issue") of the magazine *Inżynieria i Budownictwo* ("Engineering and Building"). That article opened with a listing of the "universal values" that were to govern construction activity in the postwar period: "Don't waste iron, save cement, build from basement to roof without the use of wood, remember about energy – coal, converted into building materials, as well as the lack of skilled labour" (Kamiński, 1948, 2). According to the engineers, the most promising way in which these resource-and energy-conservation imperatives might be pursued, was through an intensified use of rubble in the postwar reconstruction of cities.

Thus did the proliferation of ruins and rubble in postwar Europe trigger both a conceptualisation and an implementation of a new architectural paradigm entailing the conservation of resources and energy. The present paper elaborates on this historical development, tracing the conceptualization of embodied-energy calculations as Warsaw's postwar reconstruction went ahead. The paper also defines the role assigned to rubble recycling in architecture, in the context of socialist Poland's developing politics and forms of economic management.

Energy- and resource-conservation in architecture
While contemporary discussion of sustainable architecture has tended to focus primarily on the energy performance of individual buildings, this dominant paradigm is now shifting, albeit in two directions. We find a concern with – on the one hand – the consumption, conservation and production of energy in larger urban assemblages (Roesler, 2022), and on the other embodied energy and emissions associated with building-material production, as well as construction (Calder, 2022). The present paper seeks a consolidation of these two approaches by developing an inquiry of novel temporal and spatial scope, given the retrospective look at conservation of resources and energy in Twentieth century architecture.
While embodied energy has been addressed by scholars since the 1970s (Hannon et al., 1978), only recently has its conservation through material reuse and recycling started to become central to the debate taking place among lawmakers, corporate actors and architects (Heisel et al., 2022). This has reflected wider recognition of the destructive effect of the construction industry on the Earth's environment, as well as the growing urgency of climate-neutrality goals being reached in all economic sectors (Arup, 2016).
In this context, architectural historians have worked to further interrogate and nuance understanding of the relationship between architecture, environment and a capitalist economy. Tracing the history of architectural obsolescence across the Twentieth century, Daniel Abramson has shown how the profit imperative of capitalist development shortened the temporality of buildings, neighbourhoods and cities radically (Abramson, 2016). Today, such accelerated cycles of urban development and creative destruction lead to a proliferation of demolitions, and an unprecedented rise in amounts of waste generated: worldwide, 2025 is likely to see some 2.2 billion tonnes of construction and demolition waste produced (Jarzombek, 2019).
Abramson's work also shows the concept of sustainable architecture as rooted historically in opposition to the excessive consumption of energy and resources

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that built-in obsolescence entails. The oil crisis of the 1970s led to a rise of sustainable building practices and discourses in which building from waste also featured (Abramson, 2016: 131). Walter Stahel notes that it was also that period that first saw US economists, engineers and architects articulate the paradigm of the circular economy (Stahel, 2020). The further development and implementation of that economic paradigm has become a central focus of sustainable architecture and construction in recent times.

Stahel sees the envisioning of the circular economy as a means by which to "decouple wealth (value) creation from resource consumption" thanks to improved management of existing stocks and the maintenance of their value (Stahel, 2020: 10). Within architecture and construction, the approach can be associated with a variety of use-centred practices, from maintenance, renovations, and adaptive reuse of whole structures through to a careful deconstructing of buildings, with reuse and recycling of building materials. It is particularly the latter set of practices that attract professional and scholarly attention today, often as conceptualised under the umbrella term of "urban mining" (Kobi et al., 2023). Yet, as critical scholarship on the topic has shown, the concept of the circular economy remains a highly ambiguous one, as does its relevance to development that would be truly sustainable (Corvellec et al., 2022). At the same time, contemporary architecture has as yet failed to find a way to implement building-material reuse on a scale larger than that of the individual experimental building (Stricker et al., 2022).

This paper sets out to expand the scope of current reflection on the circular economy in architecture, by investigating the history of Poland's capital city in the aftermath of World War II. The case of Warsaw highlights the fact that, alongside obsolescence, it was progressively industrialised and urbanised warfare that shortened the lives of buildings in the Twentieth century so radically. While historians have in recent years started to articulate these ways in which WWII shaped the professional and institutional landscape of architecture (Cohen, 2011; Allais, 2018), postwar urban and architectural development is still associated primarily with the "Great Acceleration" in the consumption of resources and energy (Bonneuil and Fressoz, 2016).

Against that background, work detailed here draws on long-term historical investigation seeking to trace ways in which the ruins of Warsaw were transformed in postwar decades, by being wasted, salvaged, reused or recycled. The research in question was pursued through the whole 2019-2022 period at multiple archives and sites in Warsaw and across Poland. This leaves the narrative presented here as founded in a wide variety of historical sources, if primarily those published in professional magazines during the historical period in question; as well as those present in the archival collections of the leading state institutions involved in the reconstruction. The written sources are supplemented by archival photographs – an essential resource when it comes to apprehending the conditions of ruination prevailing in Warsaw in the wake of war.

Material Excess

The six years of the German occupation of Poland during WWII left society, the environment and cities in ruins. The ruination of Polish urban areas during that time was not just a side effect of the industrialisation of warfare (Bonneuil and Fressoz, 2016, Ch.6), being also the outcome of deliberate acts of planned destruction, or “urbicide” (Coward, 2008). The destruction of Warsaw can be deemed representative of fullest implementation of that strategy by the occupant.

Resulting damage and destruction did vary across the capital city, being focused in “Left-Bank Warsaw” (vis-à-vis the River Vistula), i.e. the central districts. Here, total destruction encompassed 9.865 buildings, denoting 57.8% of the city’s built-up area (Dunin-Wąsowicz, 1984: 370). In the same area, a further 2.873 buildings (17.4%) were devastated to a very considerable degree, while 4.225 could be regarded as damaged only moderately. The areas of what the Nazi authorities had delineated as the Jewish Ghetto were joined by inner-city areas of *Śródmieście* District, as well as the so-called Old Town in being almost completely razed to the ground (Figure 1). While 84% of the buildings of Left-Bank Warsaw can be thought of as obliterated, the same fate was reserved for 65% of the entire city, meaning that districts in Right-Bank Warsaw were also much affected.

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(some 40M tonnes) of rubble lying spread across the capital in the wake of WWII. In October 1945, architect Eugeniusz Olszewski wrote: “to realise the volume of rubble lying in Warsaw, it suffices to calculate that, to transport it, you would have to load 2 million freight wagons, which is 20 times the total annual transport of all goods and raw materials to Warsaw before the war” (Olszewski, 1945: 8). In the following years, such assessments were extended to the wider context of amounts of rubble in all urban areas of Central and Eastern Europe (Tyszka, 1948). It was estimated that some 175M m3 of matter was spread across the urban areas of Poland (perhaps 260M tonnes), even as the same article attributed amounts of rubble to Germany and the Soviet Union respectively equalling 300M m3 (approx. 450 Mt.) and 460M m3 (690 Mt). Other articles in the professional press urged readers to consider amounts in relation to population size, given that this was also labour force. In such an assessment Warsaw came first with 20 m3 of rubble per inhabitant, as compared with 16 in Berlin and 3,5 in London.

These calculations allowed for some translation into the rational language of numbers and estimates of what was a simply unfathomable scale of wartime destruction. However, an underlining of the unprecedented challenge that lay ahead had been a further goal of the analytical work, and here a certain disservice was done as rubble was rendered in terms of its being uniform waste matter in need of clearance from city areas. This was a suggestive simplification that led, ever since, many historians to account for rubble solely as an obstacle to reconstruction plans (Kohlrausch, 2019). However, a closer look at the archival documentation suggests the emergence of a much more complex and insightful understanding of rubble among architects and engineers in 1940s Warsaw.

Costs assessment

During WWII the construction industry in Poland shared the same fate as befell the buildings it had helped to erect in the preceding decades. The occupation brought a halt to any new building works beyond what might serve to further the plans of the Occupant (Popiołek-Roßkamp, 2021). That meant stagnation and depreciation for any facilities in existence that

Fig. 1 - The ruins and rubble of the Old Town, Warsaw, 1947. Socialist Press Agency, National Digital Archive.

produced bricks or made timber ready for use in construction (these being the primary building materials in pre-war Poland). By the war's end, once-abundant sources of timber had been depleted, clay had gone unextracted for years, and brickworks lay in ruins. An abrupt intensification of renovation work in postwar Warsaw had a dynamic effect in raising prices of materials and rates for skilled labour. The postwar circumstance of resource depletion and industrial ruination thus had an inevitable role in shaping the organisation of the effort at planned reconstruction. From 1946 onwards, the architects and engineers of the reconstruction focused on the development of expertise, technology and practice that would maximise the "rationality" and the economical nature of their work, meaning a process of construction frugal in terms of its use of both resources and energy. In that way a core objective of this branch of the reconstruction effort was for architecture to make productive use of rubble. An initial report on this matter came out in late 1946, being the work of *Biuro Odbudowy Stolicy* (the Office for the Reconstruction of the Capital

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City). The report's authors asserted that the salvaging and reuse of materials found in rubble would be the most cost-effective way of procuring a supply of building material in general, for the reconstruction work that was to take place over the period. To make their point, they argued:

> The profitability of salvaging is confirmed when one takes into account, on the one hand, the entire process of production and supply of new bricks to the construction site (extraction of coal, its transportation to the brickyard, manufacture of new brick and its transportation to the construction site), the lacking industrial capacity to produce the quantities of bricks required, finally the cost of new bricks; and on the other hand, the billions of bricks lying in situ in the ruins of the city, their suitability to be used in the new construction, and finally their low cost. (Nowiński, Mazurkiewicz, 1946: 12).

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Comparison of production and salvaging costs led those authors to argue for a revaluation of rubble, and reorganisation of the planned reconstruction around this postwar resource. This was in fact to dignify a process already taking place literally and figuratively "on the ground" in Warsaw, in an unplanned, unsupervised way. In the Warsaw of the late 1940s, hundreds of small construction firms were finding employment in carrying out renovations for private clients. Salvaging from rubble was their chief means of sourcing bricks, as well as a variety of other interior components – to the extent that these could actually be thought of as quickly, cheaply and directly obtainable *in situ* (figure 2).

The dependence of these small actors on salvaged material can be associated with their attractive price. The survey of the market for building materials published monthly in *Przegląd Budowlany* (the "Building Review") – as a leading platform of the private construction industry – reveals a May 1946 cost of 3.500 zloty for 1.000 new bricks, as opposed to 1.800 for the same number of salvaged bricks (*Przegląd Budowlany*, 1946). The corresponding figures in the following year were 6.700 and 3.500 zloty respectively (*Przegląd Budowlany*, 1947); while in 1948 a similar differential in price was maintained, with 7.400 zloty needing to be paid for new bricks, as opposed to 4.800 for those that had been salvaged (*Przegląd Budowlany*, 1948). Importantly, these data take no account of bricks obtainable with no market transaction needed, given the possibilities of theft or appropriation in the absence of inhabitants or owners for many a ruined building. The comparison of prices set by the dynamic local market was a crucial way in which employees of the reconstruction administration assessed the "rationality" of the specific material or construction technology in the immediate postwar period. However, many of them were also involved in the development of a planned economy and socialist politics in Poland. They therefore sought to depart from market price as the sole indicator of a rational and economically justified decision – a perspective associated at the time with decision-making under a capitalist economy. They searched for other indicators which would allow reconstruction materials to be assessed, such as: "[...] the amount of coal or oil needed to produce a given building material," as well as "the use of waste materials" in their production (Nechay, 1947: 35).

Fig. 2 - Brick salvaging in the ruins of the central Warsaw, 1948. Socialist Press Agency, National Digital Archive.

Fig. 3 - Cover of the special "Rubble Issue" of the Engineering and Building published in January 1948. National Library, Warsaw.

The embodied energy calculation

It was in January 1948 that the aforementioned *Numer Gruzowy* ("Rubble Issue") of *Inżynieria i Budownictwo* ("Engineering and Building") magazine was published. The introductory article there was authored by engineer Stefan Pietrusiewicz, a Vice-Minister at the Ministry of Reconstruction. He begins with these words: "A huge mass of rubble amounting to 160 billion m3 is scattered around our cities, it is a burnt-out material, for the production of which millions of tonnes of coal have been used, therefore it is a reserve that should be utilised" (Pietrusiewicz, 1948). That statement hints at a novel understanding of rubble that was taking hold within the state administration during the first period of the planned economy in Poland (1947-1949). The importance of rubble being used in reconstruction was argued for, not in relation to the price of salvaged materials, but rather on account of the extended energy they embodied, i.e. the coal that had been used in production.

The period in question indeed saw extensive use made of processes of ruin demolition and planned salvaging – by both state institutions and state-commissioned firms – with a view to building materials being procured (Przywara, 2023). Simultaneously, an intensive approach to the reuse of rubble had been developed. Considerable state funding had been extended to the development of so-called “new materials.” The latter were to become a viable alternative to the bricks and timber that had been used traditionally. They were also engineered specifically to save coal during production. The initial studies of new materials focused on the “clean rubble,” which constituted approximately 1/3 of any mound left after the demolition of a ruined building had taken place (figure 4). This rubble could be crushed and sorted, and substituted for aggregates and sands in the production of concrete mix.

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In the discussed issue of *Engineering and Building* magazine we find the report from the visit to Hamburg quoted in the Introduction to this paper. In his article, Kamiński elaborates on the coal-conserving capacities of rubble recycling: “As far as rubble materials are concerned […], the most coal is needed for the production of cement, which, in the manufacture of such materials, is a commonly used binding agent” (Kamiński, 1948: 2). Nevertheless, as he argues, materials made of rubble require smaller amounts of fossil fuels than their traditional counterparts: “Burnt clay brick (German format), requires 300 kg of coal per 1.000 pieces. Sand-lime brick - 220 kg, while rubble brick with 150 kg of cement in 1 m3 of concrete requires 170 kg of coal” (ibid.).

In Kamiński’s article, we thus encounter developed reflection on the fossil-energy consumption inherent in different ways of producing building materials. His calculations do not concern the materials salvaged from rubble, which were the cheapest and, one could add, most coal-efficient material available. Instead, the engineer focuses on discerning the most coal-efficient trajectory for the production of new building materials. As he concludes clearly, most coal can be saved where air-bricks are manufactured from rubble

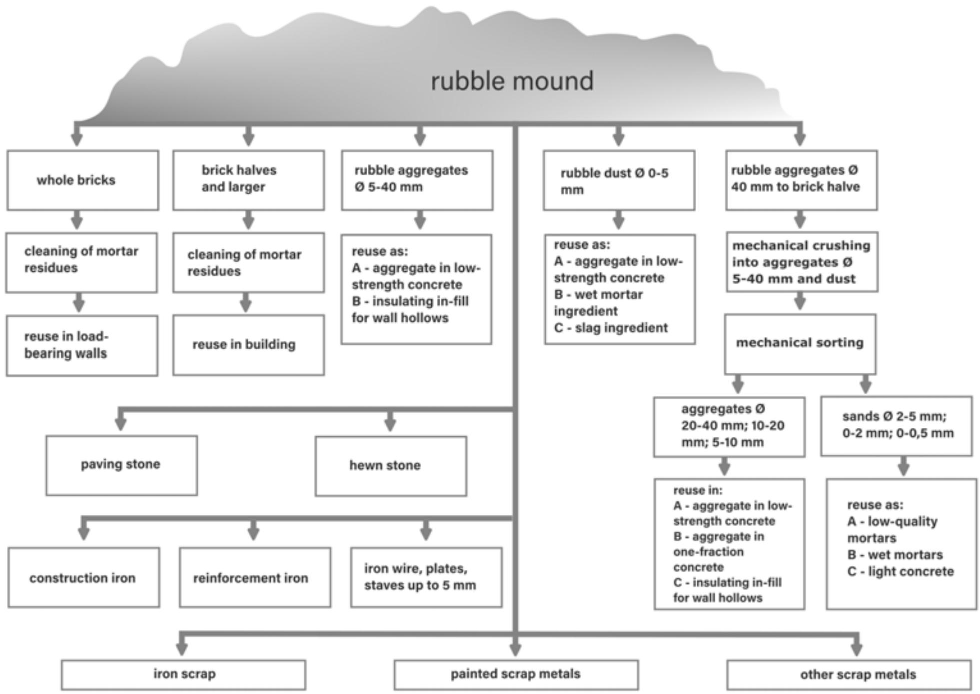

Fig. 4 - Diagram showing typical contents of the rubble mound and their use, excluding waste matter (Redrawn and translated by the author from Kiepal and Rogalewicz, 1950).

aggregates and sand (figure 5). The latter, the engineer claims, would require only around half as much coal as the traditional fired-clay brick.

Concluding, Kamiński returns to the question of the most economical and rational construction, asserting that this is an issue that changes dynamically, and one that: "[...] especially in the current planned economy, can in no way be measured merely by the 'price' of a unit of a given building, as we did before the war" (ibid.). As he further explains, by referring his calculations to the broader economy of the period: "Today - one zloty in an export material or raw material, e.g. iron, cement and coal; and one zloty in a non-export material — e.g. brick or rubble air-brick, or gravel — is not the same zloty" (ibid.). The last section of this paper will focus on explaining that difference, while positioning the embodied energy calculations in a broader economic landscape of socialist reconstruction.

Fig. 5 - Air bricks made from a mix of crushed-rubble aggregates and sands with cement and water, Warsaw, 1948. Socialist Press Agency, National Digital Archive.

Energy conservation in the Planned Economy

The funding for scientific research on the use of rubble in reconstruction came from the government, through the Three-Year Plan of Economic Recovery (1947-1949). Publications summarising the achievements of this first period of planned economy, often compared the outputs of different branches of industry in the circumstances of pre-war and postwar Poland. One such comparison noted that the extraction of coal exceeded pre-war outputs as early as in 1948. It is therefore relevant to ask why, if not for reasons of scarcity, would government investment support coal-conservation strategies in architecture?

Modernisation of production was a crucial item on the political and economic agenda of the socialist government. The pursuit of that goal required both technologies and infrastructure, which the state could only obtain abroad. Coal, as well coal-intensive materials like steel and cement, were crucial goods tradeable on the European market of the time. This left support for the conservation of energy and resources in architecture as directly related to government spending abroad. And that relationship can be further inter-

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Fig. 6 - Rubble crusher and sorter in operation in central Warsaw, 1948. It is one part of the larger mechanical assembly producing air bricks, eighteen of which were acquired in Switzerland in 1946. Military Photographic Agency, National Digital Archive (WAF, 1948).

rogated if a look is taken at the transactions allowing coal-conserving rubble recycling to be pursued in the context of Warsaw's reconstruction.

Between May 16 and July 3 1946, Polish engineer Walenty Karnaś visited several companies and industrial associations across Switzerland on behalf of his employer – the Ministry of Reconstruction. Karnaś spent 6 June 1946 in Zurich, where he finalised a deal with a consortium of firms led by Schindler & Co and Brun & Co based in Lucerne (Karnaś, 1946). The Swiss firms were commissioned to provide six sets of machines for rubble crushing and sorting, as well as eighteen machines for the production of rubble concrete airbricks (Figure 6). The cost of the order was estimated at 500.000 Swiss Francs. However, the consortium was paid indirectly through the Polish government's "coal account" with the Swiss National Bank.

This "coal account" was a line of credit the Swiss government offered to Poland in the wake of the war. Switzerland remained neutral during WWII, and thus

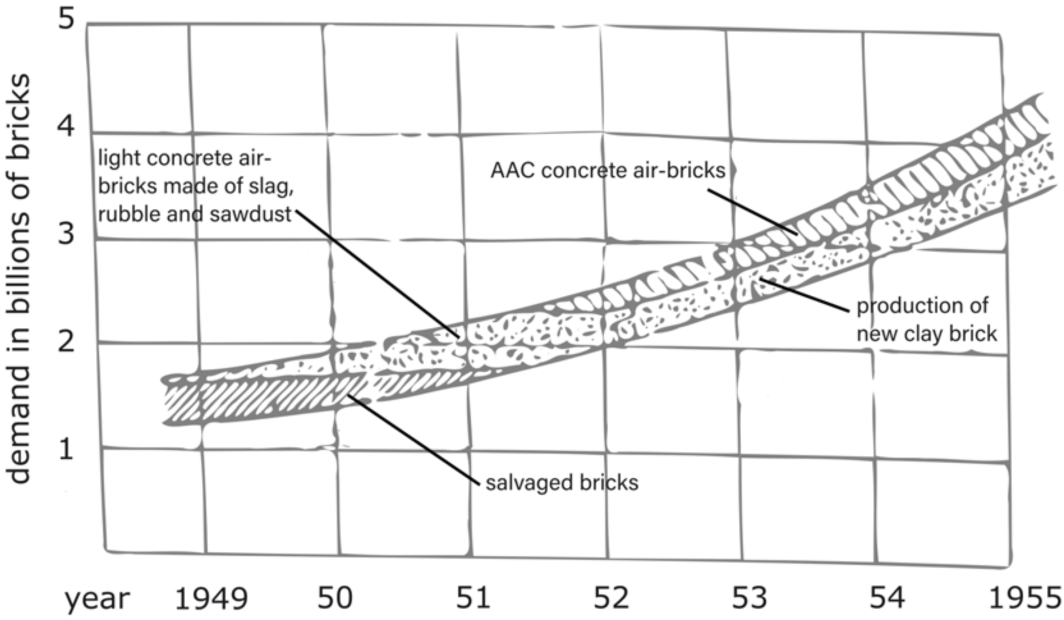

Fig. 7 - Projected growth in the planned reconstruction's demand for building materials over the 1949-1955 period. Marked is the projected supply of building materials capable of covering the rising demand (Redrawn and translated by the author from Nechay, 1949: 30).

saved its private industry from wartime ruination. Yet, ever since the 1920s, the country had been fully dependent on the importation of coal from abroad. The "coal account" was thus a financial tool set up to secure the provision of coal from Poland, while allowing the Polish government to buy from Swiss private industry without needing to resort to money. Instead, the Polish government delivered the coal-equivalent of the incurred costs to its Swiss counterpart, which subsequently set the accounts with private firms. This example shows how the Polish state administration traded coal for technologies from abroad, *inter alia* seeking to achieve coal-efficient architectural reconstruction back at home.

The machines which arrived from Switzerland in 1947 initiated the process of rubble recycling in the planned reconstruction of Warsaw. They provided for the manufacture of rubble air-bricks – as non-bearing materials used for walls, callings and floors, substituting the traditional clay brick. In the circumstances of 1940s Warsaw, such air-bricks were used extensively in all the projects funded by the state, as well as in its subsidiaries. That meant use in various headquarters buildings of governmental institutions, in workers'

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housing estates, and sporting facilities. When at the end of the decade the availability of their main competitor material, i.e. salvaged bricks, declined rapidly, the new materials became further reinforced in terms of their significance to the socialist reconstruction of Poland. The chart presented at the 1949 Conference of the Polish Engineers' Association highlights this fact (figure 7). The resource- and energy-conserving materials made of recycled waste (i.e. rubble, slag and sawdust) won for themselves a central role in the supply of construction sites across the country within the framework of the 1950-1955 Six-Year Plan, which was marked by the accelerated industrialisation the Stalinist faction of Poland's postwar government was able to press on with.

Conclusion

In recent years, the idea of energy conservation through maintenance and reuse of the fossil fuels embodied in building materials has come to shape the knowledge and practice of sustainable architecture (Stricker et al., 2022). The practice of diverting demolition waste from the landfill back into construction is promoted as vital if production is to be maintained, even as its impact on the global environment is reduced (Arup, 2016). Such practices in architecture and construction fit into the version of capitalism reformulated around an idea of circularity that has gained promotion since the 1970s as an innovative solution to a wasteful and destructive economy (Stahel, 2020). However, as it draws on far-older historical sources from Poland in the period following WWII, the present paper contributes to a critical reformulation of the existing discussion surrounding embodied-energy conservation as it makes reference to the practices of urban mining, as well as the reuse and recycling of building materials in architecture.

In the wake of WWII, ruins and rubble had been a defining material feature of the cities across Central and Eastern Europe. In Warsaw, the administration in charge of reconstruction first conceptualised rubble in terms of waste. However, that was a perception that changed quite rapidly, as rubble re-entered the fray – this time being viewed as a resource in the reconstruction economy. Recognised as a source of salvageable materials and conceptualised as a component of new ones, rubble came to occupy a central position in the discussions engaged in by architects, engineers and politicians, when it came to reconstruction being both efficient and rational. The latter, pursued as a transition to a planned economy, sought to break with market price as the sole index underpinning material choice. Instead, a start was made to the use of embodied energy, or references to stocks of coal converted into a given building material in the past, as indices of rationality and efficiency when it came to planned procurement of materials.

This paper argues that the shift in question related to the role urban reconstruction was intended to play within the broader planned economy of the postwar Polish state. By implementing and pursuing resource – and energy-efficient technologies based on the reuse and recycling of rubble, the state administration diverted coal from being used on local building markets, instead drawing benefit from its being traded on international markets. There, coal represents a commodity exchangeable for technologies which could allow for further improvement of resource efficiency in reconstruction, as well as contributing towards the industrialisation and modernisation of postwar Poland's economy. In the absence of an environmental incentive, it was the politics and economics of planned reconstruction that drove the development of embodied-energy calculations, urban mining, and the reuse and recycling of building materials.

The history of Europe's postwar reconstruction provides a vital example upon which to engage in a critical rethink of urban mining as a practice in energy conservation that operates on the scales of the city, state or international market, as opposed to the individual building. It follows that the invoking of historical examples allows for a preliminary reimagining of the challenge of energy-conservation in construction, as linked intrinsically with politics and economics, rather than technological innovation implemented on the scale of the single experimental building.

Translations

All the quotes from archival sources that the article presents are translated from Polish into English by the Author.

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