Carbon Pasts, Low Carbon Futures:
Teaching Low Energy Architecture Through Adaptive Reuse of Heritage Sites in the South Wales Coalfield

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ABSTRACT: As we rethink resilience in the face of the climate emergency, it becomes increasingly important to consider embodied carbon, and not only the reduction of operation carbon emissions. Whilst it has been acknowledged for some time that we must retain and reuse our current building stock, architectural education predominantly maintains it focus on the teaching of the design of new-build construction. This is despite the fact that within the construction industry, over half of construction work engages with existing buildings. Architectural students are now requesting the opportunity to engage with design work exploring adaptive reuse, building conservation, and retrofit. This paper presents the development and delivery of a final year architectural design unit that has come about through such demands. For the past three academic years the unit "Carbon Pasts, Low Carbon Futures" has challenged students to propose sustainable reuse strategies for former mining infrastructure within the South Wales Coalfield, transforming these sites once responsible for the UK's carbon legacy into part of the solution to its devastating effects. To date, proposals have included renewable energy production, storage and distribution; reuse and recycling centres; low carbon manufacture; education and knowledge sharing; wellbeing facilities; and innovation and research centres.
KEYWORDS: Education, embodied carbon, low energy design, adaptive reuse, industrial heritage

1. INTRODUCTION

It is now over sixteen years since the then president of the American Institute of Architects (AIA), Carl Elefante, famously stated that "The greenest building is…one that is already built" [1], and yet architectural education continues to focus on new-build design [2, 3], even when teaching passive and low energy architecture. This is despite estimates that between 50-70% of global construction work is on existing buildings [4], and the growing importance of embodied carbon, as highlighted by the Architects' Journal's RetroFirst campaign [5], the RIBAs' new "Reinvention" prize [6], and the recent outcome of the public inquiry against the proposed demolition and replacement of Marks & Spencer's Oxford Street store [7].

Set against this context, it is encouraging that "Conservation and Retrofit" was in 2019 voted 3rd by Master of Architecture (MArch) students at the XXX School of Architecture with regards to areas of key interest for their final year design thesis. This came just above "Zero/ Low Caron Design", as also reflected in their free text comments (Fig.1).

On the basis of this, the author was approached to create a design unit combining reuse, retrofit, and passive and low energy design. The development and results of which are presented in this paper.

Figure 1: Word cloud from free-text requests from MArch students requests for final year design thesis unit topics 2019 highlighting high interest in sustainable conservation and retrofit.

2. CARBON PASTS, LOW CARBON FUTURES

The South Wales Coalfield was chosen as the studio unit's focus to immediately engage the students with the UK's carbon legacy, and the current climate emergency. At its peak in 1913, the South Wales Valleys were one of the largest sites of carbon extraction in the world [8]. However, the subsequence decline and eventual end of the coal industry's dominance in the region [8], has led to a continued period of economic hardship.

As in other communities who have lost their primary industry, the impact of this on collective memory and identity has still yet to be fully understood [9], and there is the danger of "Smokestack Nostalgia" [10]. Yet at the same time, industrial heritage has been argued by some as the key to these communities future [11]. The remaining evidence of coal mining in the South Wales Valleys sits at the border of what is viewed as heritage and what is viewed as waste. For some they are symbols of pride, yet for others they embody exploitation, of people and natural resources, and economic and political disenfranchisement. This dichotomy provides the ideal springboard for finding alternative uses that transform these remnants into key components in the areas low carbon future. They provide the opportunity to explore the major challenges facing 21st century society, including circular economy; social inclusion; passive and low energy design; the UK's carbon legacy; and our role in tackling the climate emergency.

3. LIVE PROJECT SITES

For the each of the three academic years that the unit has so far run (2021/22, 2022/23 and 2023/24), a different site within the South Wales Coalfield has been selected for study. These have been selected using the following criteria; i. they have a historical link to the coal industry; ii. they have substantial surviving built heritage; and iii. they have real and ongoing challenges currently leading to an uncertain future.

For the academic year 2021/22, unit focused on the grade II* listed Crumlin Navigation Colliery (fig.2), located in the heart of the Welsh Valleys. Once the source of high-quality steam coal, the site now offers low carbon opportunities, including the low enthalpy geothermal energy in the flooded mines [12].

Figure 2: Crumlin Navigation Colliery (Whitman, 2021)

In 2022/23 the unit studied the grade II* listed Cefn Coed Colliery (Figure 3), in the west of the Valleys Region. At one point the world's deepest anthracite mine, it ceased operation in 1968, and became a museum in 1986. Today its future is uncertain having failed to reopen following the pandemic due to maintenance and financial concerns. A complementary use is therefore crucial and yet again mine water heat recovery could hold the key.

Figure 3: Cefn Coed Colliery (Whitman, 2022)

For the academic year 2023/24, the attention shifts from sites of carbon extraction to the social infrastructure that grew up during the 19th and 20th centuries to meet the needs of the miners and their families. Pontypridd Market Quarter (Fig.4) is a complex mixture of a working market, high street shops, underused office spaces, a lost chapel, and an abandoned theatre.

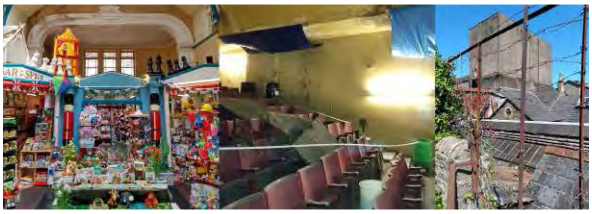

Figure 4: Pontypridd Market and Town Hall Theatre (Whitman, 2023)

4. PEDAGOGICAL METHODOLOGY AND THEORIES

The pedagogical approach followed in the development and delivery of this teaching have been incrementally developed over a period of more than 15 years by the author. This has parallels with "The Double-layered Asymmetrical Model" [13], especially as it is understood and presented by Salama [14], which provides a systemised, yet personal approach to complex existing contexts. The process starts (Fig.5 (A)) with a period of information gathering in groups.

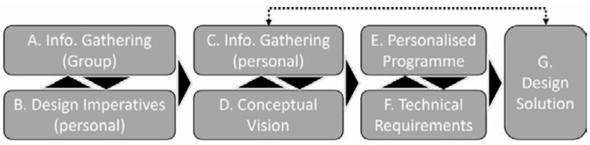

Figure 5: Process of student design, adapted from [14]

This involves desktop review of secondary sources (including archival research and literature review), original data collection (including building surveying, sketching, photography, and community engagement in the form of surveys and semi-structured interviews). This stage results in the production of a dossier of information that is then shared as unit-wide resource to inform the subsequent stages. Simultaneously students are asked to develop and record an initial personal response (B) which begins to define individual design imperatives. For this the students are encouraged to experiment with the capturing of subjective, often abstract and intangible ideas through a range of artistic mediums from painting to sculpture, and creative writing.

This first stage is then followed by further individual information gathering (C), whilst simultaneously developing a conceptual vision and an intellectual position to test through the design thesis (D). In turn this leads the development of personalised programmes (E) informed by the previous stages and the definition of technical requirements (F), from which the design solution is developed (G). Further cyclical iterations then follow, refining the design solution and increasing in detail. As stated by Salama, the model encourages students to provide their own interpretations, with the tutor supporting in this process [14].

Given that the teaching uses existing sites, with real-life problems, and the involvement of third parties (communities and owners), the pedagogical approach can also be categorised under the umbrella of Live Project Teaching [15]. These projects offer the potential to bridge between mainstream architectural education and professional practice [16], and by doing so bring many benefits. However, care must be taken to avoid unintended consequences, such as false expectations from non-academic partners, and extractive or exploitative research [17]. With the aim of overcoming, or minimising these risks, promoting transparency and clarity from the start, the School has co-created an online induction module for students, staff, teaching practitioners and community partners [xx], a key component of which is promoting appreciative inquiry. This places the emphasis on identifying and building upon strengths [18], rather than focusing on weaknesses, which often student projects are unable to address. As such, it is hoped that students benefit from applying their design skills to real life scenarios, whilst non-academic partners are provided with new ideas that challenge preconceptions and innovate.

At the end of each academic year the work is shared with the non-academic partners. The work of the first year (2021/22) was presented on-site as a public exhibition, open to both the local community, the current site custodians, and local and regional government representatives. The second year (2022/23) was presented only to the site owner, the local Borough Council, however, it is hoped this year (2023/24) a public onsite exhibition will once again be possible.

5. IMPLEMENTATION AND RESULTS

The richness of the existing contexts have inspired students to go on an develop very different building programmes and architectural responses that are technically advanced and highly creative, despite each year sharing a common site**.** These have included renewable energy production; renewable energy storage and distribution; reuse and recycling centres; low carbon manufacture; education and knowledge sharing; wellbeing facilities; nature conservation; and innovation and research centres. Equally, through individual investigation and initiatives, key low energy design strategies have been incorporated (Table 1). Whilst implicit in the brief, it is the students' engagement with the existing buildings that has ultimately led them to adopt these low carbon technologies.

Table 1: Key low energy themes tackled by unit members (2021/22 and 2022/23 only).

Theme	No. of students
Renewable Energy	16
Design for Disassembly	13
Low Carbon Materials	12
Retrofit	9
Biophilia	4
Phytoremediation	2

There follow four examples of students' work, that foreground the possibilities of students engaging with existing buildings with a common focus on low energy architecture.

5.1 Example 1 – MedTech Research Centre

For this project the student, Jordan Grady, took inspiration from the heritage theories explored by historian David Lowenthal in his book, "The Past is a Foreign Country" [19], exploring the notion of building conservation and heritage as a continuous narrative. As such, the industrial legacy of Crumlin Navigation Colliery perpetuated through the proposed reuse for one of South Wales's emerging key industries, Medical Technology, or MedTech. To achieve this, the new programme was conceived as the insertion of new "machinery" (Fig.6).

Figure 6: Internal render of proposal at Crumlin Navigation Colliery for MedTech Research Centre, showing inserted "machinery" (Grady, J., 2022)

This employed box-in-box construction for laboratory and research spaces, to meet their high environmental specification, whilst allowing the less onerous requirements of circulation spaces to be met by the historic fabric itself, with limited interventions. U-values of 0.1 W/m²K, excellent airtightness, controlled ventilation with heat recovery, acoustic separation and reverberation times of 1.2 sec, were all achieved within these new insertions.

5.2 Example 2 – Renewable Energy Storage Facility

This time the student, Rowan Luckman, took as a starting point Crumlin Navigation Colliery's history as a past store of solar energy in the form of coal, and explored this through Burke's notions of the sublime [20] and subsequent ideas of the post-industrial sublime [21]. The result was a storage facility for renewable energy investigating alternatives to chemical batteries and their inherent environmental impact and use of non-renewable resources. Technologies incorporated included pumped hydroelectric using the abandoned mine workings as the lower reservoir, winch-based gravity batteries in the south upcast mine shaft, and subterranean compressed air storage (Fig.7).

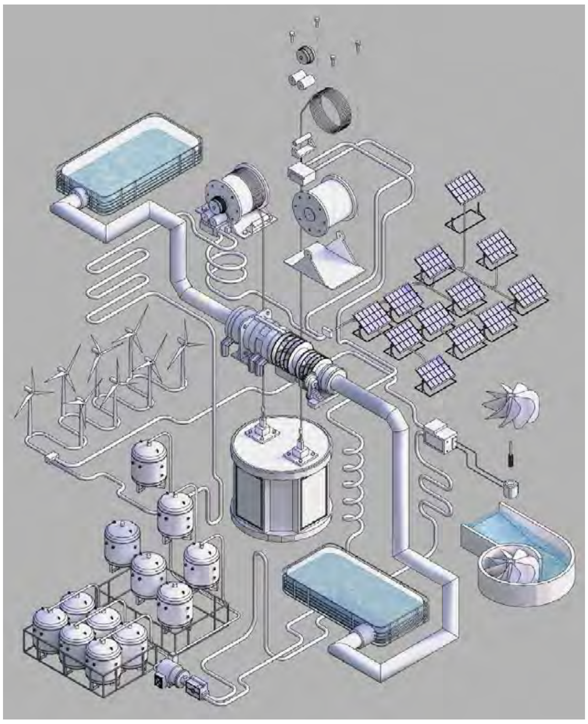

Figure 7: Conceptual image of energy storage technologies for proposal at Crumlin Navigation Colliery for Renewable Energy Storage Facility (Luckman, R., 2022)

This linked to a wider landscape masterplan, integrating photovoltaic, wind and small-scale hydro energy production. For the interventions on the existing buildings, lightweight materials were explored to reduce the loads on the historic fabric (Fig.8).

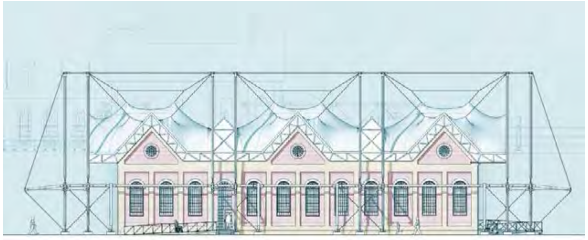

Figure 8: Elevation of renovated Power House, part of a proposal at Crumlin Navigation Colliery for Renewable Energy Storage Facility (Luckman, R., 2022)

However, due to the structural forces involved in both energy production and storage, the use of low carbon materials was limited, however a calculation was undertaken offsetting the new embodied carbon against that saved through increased renewable energy injection at peak-demand hours. This showed a carbon payback of just 2.7 days. There are potentially some oversimplifications in these calculations, however the basic precepts and methodology is correct.

5.3 Example 3 – Mine Water Heat Recovery Research Centre and National Coal Archives

The third proposal for Crumlin Navigation Colliery presented in this paper emerged from a detailed study undertaken by the student, Alexander McCormick, into the subterranean elements of the site (Fig.9), using historic mine plans, borehole logs, geological data, personal histories of former miners and their families, and peer reviewed research documents.

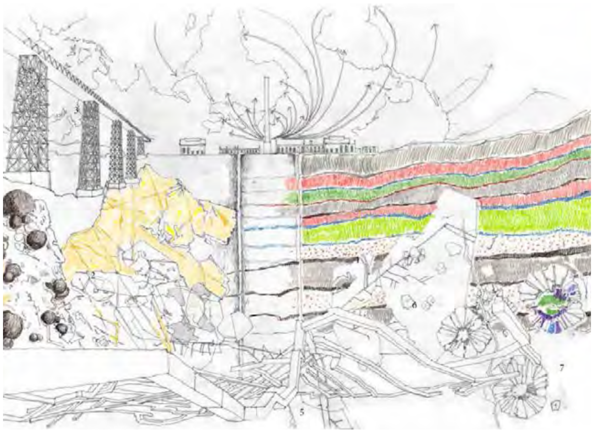

Figure 9: Conceptual collage of subterranean and global connections, leading to the proposal at Crumlin Navigation Colliery for Mine Water Heat Recovery Research Centre and National Coal Archives (McCormick, A., 2022)

This led to the design of a research centre for mine water heat recovery, combined with a National Coal Archives (Fig.10). Part of the project was designed as an earth sheltered building, using compressed earth blocks and charred Welsh larch. With the rest of the programme being incorporated into the refurbished existing buildings, connected by a timber framed roof, the geometry of which was derived from principal coal seams present below the site. Across the site, space heating was provided from mine water sourced heat pump, based on a mean temperature of the mine water of 15.2°C [12].

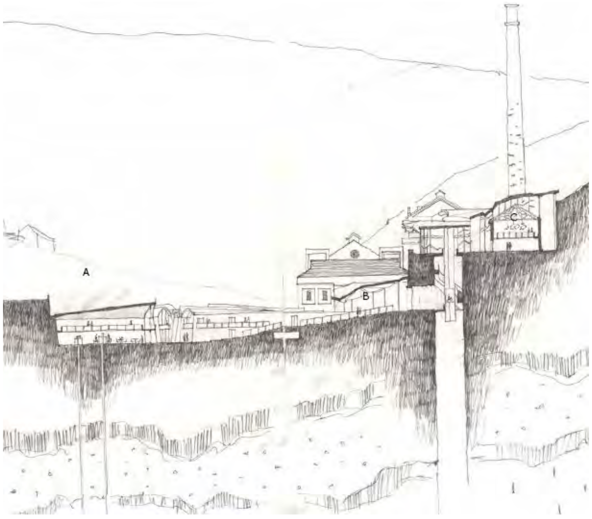

Figure 10: Cross section of proposal at Crumlin Navigation Colliery for Mine Water Heat Recovery Research Centre and National Coal Archives (McCormick, A., 2022)

5.4 Example 4 – National Museum of Energy and Renewable Energy development Park

The final example is one from the academic year 2022/23 by Morgan Taylor and looks at Cefn Coed Colliery Museum. Again, the theme of energy is taken as the focus of the project, this time proposing a National Museum of Energy, as part of the *Amgueddfa Cymru* (National Museum of Wales) portfolio, accompanied by a renewable energy development park (Fig.11).

Figure 11. Aerial axonometric of proposal at Cefn Coed Colliery for a National Museum of Energy and Renewable Energy development Park (Taylor, M., 2023)

The museum exhibits depict industrial, transportation and domestic uses, and are curated to into three themed areas covering energy past, present and future. Energy past is displayed in the renovated existing historic buildings, energy present takes the form of demonstration low energy dwellings based on current new-build and retrofit technologies, and energy future incorporates a mine water heat recovery and ambient loop and creates a new enclosure for the grade II* listed range of boilers, replacing the current condemned asbestos shelter (Fig.12). All this lies at the centre of a low carbon mobility masterplan, thereby considering low energy design at the full range of scales.

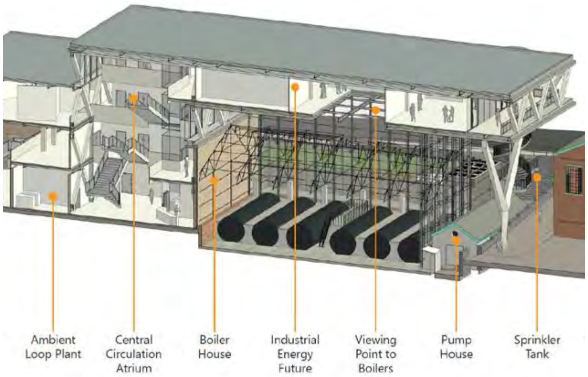

Figure 12. Sectional axonometric of the "Energy Futures" building, enclosing the grade II listed boiler house, as part of the proposal at Cefn Coed Colliery for a National Museum of Energy and Renewable Energy development Park (Taylor, M., 2023)*

5.5 Outcomes

As these four examples have demonstrated, there is a high level of engagement with low energy architecture engendered by working with these examples of industrial heritage. At the same time the quality of architectural creativity and complexity has not been restricted by the constraints posed by the existing buildings and structures, with a higher percentage than the year average of students being awarded a 1st or 2:1 degree. The work of the first year 2021/22 was unprecedently nominated as an entire unit by the School for the RIBA Silver Medal, whilst the top student from the second year 2022/23 was awarded the School prize for best in year and was nominated for the RSAW medal.

Following this success, and recognising the growing interest and need for designing with existing buildings, work has been undertaken, as part of a wider undergraduate curriculum redesign, to extend engagement with adaptation and reuse throughout the undergraduate BSc Architecture course.

The work of this academic year, 2023/24, is still in its early stages, however initial work is showing interesting new areas of investigation emerging, with a growing emphasis on social sustainability, and the role that communities can play in tackling climate change.

6. CONCLUSION

The work presented in this paper has highlighted the value of engaging with existing buildings in architectural pedagogy, and the level of success that is possible, especially with regards to the teaching of low energy architecture. It has shown how working specifically with sites that form part of the historical UK carbon legacy can inspire students to provide innovative solutions to the resultant climate emergency. It is hoped that the increased acknowledgement by the architectural profession of the need to challenge demolition and new-build, now also being seen in our students and teaching, will continue to grow and expand to encompass the global construction industry as a whole. If we are to meet our ambitious targets of limiting anthropogenic climate change, it is essential that our focus shifts to making the most of the built assets that already exist and maximising their embodied carbon. In these six pages it has not been possible to share all details and fully reflect on the benefits of working with existing buildings. The author looks forward to the opportunity to expand on this and share their experience with the PLEA community in Wrocław!

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REFERENCES

1. Elefante, C. *The greenest building is... one that is already built*. in *Forum Journal*. 2007. NATIONAL TRUST FOR HISTORIC PRESERVATION.

2. Grant, E.J., *Mainstreaming environmental education for architects: the need for basic literacies.* Buildings and Cities, 2020. 1(1).

3. Waite, R., *'Students told to ignore existing building' – survey reveals retrofit teaching gap.* Architects' Journal (London), 2022.

4. Cramer, J. and S. Breitling, *Architecture in existing fabric: Planning, design, building*. 2012: Walter De Gruyter.

5. Hurst, W., *Introducing RetroFirst: a new AJ campaign championing reuse in the built environment.* Architects' journal (London), 2019.

6. Harrabin, R., *Riba launches Reinvention prize to encourage refurbishment over demolition*, in *The Guardian*. 2023.

7. Gove, M., *Called-in decision: 456-472 Oxford Street, London W1 (ref: 3301508 - 20 July 2023)*, H.C. Department for Levelling Up, Editor. 2023, HMG: Online.

8. Hughes, S.R., *Collieries of Wales: Engineering and Architecture*. 1994: Royal Commission on the Ancient and Historical Monuments in Wales.

9. Berger, S. and C. Wicke, *Introduction: Deindustrialization, Heritage, and Representations of Identity.* The Public Historian, 2017. 39(4): p. 10-20.

10. Strangleman, T., *"Smokestack Nostalgia," "Ruin Porn" or Working-Class Obituary: The Role and Meaning of Deindustrial Representation.* International labor and working class history, 2013. 84(84): p. 23-37.

11. Smith, L. and G. Campbell, *'Nostalgia for the future': memory, nostalgia and the politics of class.* International Journal of Heritage Studies: Nostalgia and Heritage: Potentials, Mobilisations and Effects, 2017. 23(7): p. 612-627.

12. Farr, G., et al., *Low enthalpy heat recovery potential from coal mine discharges in the South Wales Coalfield.* International Journal of Coal Geology, 2016. 164: p. 92-103.

13. Goldschmidt, G., *Doing design, making architecture.* Journal of Architectural Education, 1983. 37(1): p. 8-13.

14. Salama, A.M.A., *Spatial design education : new directions for pedagogy in architecture and beyond*. 2015, Farnham, Surrey ;: Ashgate.

15. Brown, J.B., *Learning theories for live projects*, in *Architecture Live Projects: Pedagogy into Practice.*, Harriet Harriss and L. Widder, Editors. 2014, Routledge: New York. p. 18-23.

16. Morrow, R., *Live Project love: building a framework for Live Projects*, in *Architecture Live Projects: Pedagogy into Practice*. 2014, Taylor and Francis. p. xviii-xxiii.

17. Almond, C. *Tackling the Unintended Consequences of Live Projects: Co-creating an induction module towards better practice*. in *Architecture 101: Questioning the Fundamentals*. 2023. Newcastle: Newcastle University.

18. Hall, J. and S. Hammond, *What is appreciative inquiry.* Inner edge newsletter, 1998: p. 1-10.

19. Lowenthal, D., *The past is a foreign country-revisited*. 2015: Cambridge University Press.

20. Burke, E., *A Philosophical Inquiry into the Origin of Our Ideas*. 2012: Simon and Schuster.

21. Baptist, K.W., *The Post-Industrial Sublime or Forgetting Love Canal*, in *Dialectics of Space and Place across Virtual and Corporeal Topographies*. 2016, Brill. p. 325-339.