Pioneering Power: How economic motives shaped the design of energy infrastructure in the post-war period

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Abstract

Protecting the visual amenity of remote landscapes and dispersed populations from the impact of new energy infrastructure and industry became a core duty of the commissioning authorities of electricity generating stations in the post-war period. Interest in the environment was prompted by hard economic enquiry, procured by the government to assess the organisation and efficiency of the nationalised bodies responsible for generation and transmission. Findings resulted in statute intended to secure the adaptability of nationalised bodies to respond to future demands, such as those posed by the development and commercial rollout of the UKs first nuclear power programme.[1]

Interdisciplinary design cooperation, particularly across engineering, architecture and landscape architecture, gained currency during this period, especially in the delivery of the first atomic power stations, where unprecedented technology, scale and location provided a challenging brief demanding cross-disciplinary input. This paper will examine how acknowledging the significance of both environment and economics in the Electricity Act 1957, helped to shape design and engineering collaboration and the resulting aesthetic of infrastructural and industrial landscapes. The highly coordinated administrative approach in place for the development of the civil nuclear programme is thought to have led to closer design liaison between architects, landscape architects and engineers, consequently, special attention is paid to the last power station and largest reactors to be built as part of the UK's first commercial nuclear programme, located at Wylfa, Anglesey, where the input of Sylvia Crowe was integral to its success.

Introduction

Design collaboration in the electricity sector, particularly across the disciplines of power engineering, architecture and landscape architecture, gained currency in the period following WWII. The nationalisation of the electricity sector sparked increased interest in the economics and efficiency of electricity generation and transmission, leading to a series of developments that resulted in a core agenda to protect environmental interests. Consequences of this included the early appointment of architects and landscape architects in the design process for power station sites and ultimately a paradigmatic shift in the aesthetic approach to power station design.

The design and delivery of the UK's first commercial nuclear energy programme had huge implications for the aesthetics of industrial architecture and the integration of large-scale infrastructure in the landscape. Power stations, unprecedented in size, scale and location demanded significant coordination between key consultants, not simply in the domain of engineering plant and power. Analysis of the administrations responsible for electricity generation and transmission during the post-war period reveals the

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motives that shaped the aesthetic of industrial architecture, which represents some of the key advancements in mid twentieth century technology. These key aesthetic changes are the result of organisational and policy developments that embedded an increasingly strong design focus in each station design as the programme progressed. The results are visible in the first and last stations in the programme, Calder Hall, Cumbria (1956) and Wylfa, Anglesey (1969), respectively.

Despite being driven by the economic and organisational motives of the Herbert Report,[2] the Electricity Act (1957) included an 'amenity clause' outlining the requirement to minimise the impact of generating and transmission sites on scenery, flora and fauna. This unique requirement of a major nationalised industry to consciously balance "the twin objectives of cheap electricity efficiently produced and respect for the environment"[3] propelled changes within the structure of the electricity authority.

It was the responsibility of architects and landscape architects to unite the seemingly competing interests of economy and environment. Not without scepticism rooted in a misunderstanding of design as a discipline, concerns that "intellectuals, ignorant of the complicated techniques of electricity generation and supply, [would] demand that [engineers] make their machines look pretty",[4] the reorganisation of the electricity authorities was launched with a positive outlook. The combined efforts of the Central Generating Electricity Board (CEGB) Chairman, Christopher Hinton, and advisory board members, keenly publicised an integrated approach to power station architecture and landscape. The newly formed CEGB Architect's Section would oversee the coordination of this approach. Headed by Michael Shepheard, the department would advise William Holford, Professor of Town Planning at University College London, who held a special responsibility as part time member of the CEGB for architecture and the conservation of amenity. With this, Holford's objective was to improve coordination between architects and engineers, stating that it is "too seldom considered" that industrial buildings or plant might have aesthetic qualities."[5]

This paper documents three successive economic drivers which appear to have underpinned the value of the environment and visual amenity and consequently, given credibility to the objectives of Holford and others to increase design collaboration in power engineering. A review of the *Enquiry into Economy in the Construction of Power Stations* (1953)[6] during the early years of nationalisation, exposes how architectural input is encouraged to make use of material advancements made during the war with a view to maximise the cost efficiency of power station construction. Subsequently, technological advancements leading to increases in generating capacity and hence plant footprint were underpinned by economic drivers to secure future demand. In recognition of this, administrative and organisational reform led by the findings of the Herbert Report (1956)[7] into the efficacy of electricity supply in the UK provided a context for increased design collaboration by making the protection of visual amenity a legislative requirement through the Electricity

Act (1957) and introducing an Architect's Section to the coordinate such matters.

Method and Resources

This paper is based on the analysis of primary sources, including: theoretical writings, reports, papers, journal articles and drawings in addition to cabinet papers and policy relating to the period. These sources relate to discourses and decisions concerning the implementation of the UK civil nuclear programmes. Materials relating to design and in particular Sylvia Crowe's contributions to the field of power engineering have been sourced from the archives at the Museum of English and Rural Life (MERL).

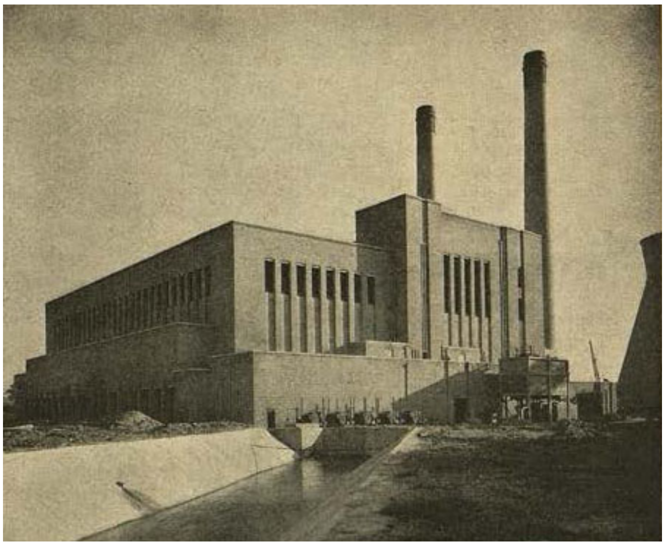
The paper is intended to provide a context for further inquiry into interdisciplinary design and coordination and its role in shaping power station aesthetics during the period of the first civil nuclear power programme in the UK. As a Further resources at the University of Liverpool, which holds material relating to Sir William Holford during this period, in addition to non-digitised material held by the National Archives demand thorough exploration.

Findings and Discussion

1. Economies of Construction

Power station architecture in the post-war period made a radical shift from the monumental brick cathedral, epitomised by Sir Gilbert Scott's treatment of Battersea Power Station, to "a more open, honest and integrated approach" to power station architecture, which expressed the technical and engineering functions of electricity generating plant.[8] Following WWII, the electricity supply system was nationalised and the British Electrical Authority (BEA) was made responsible for the generation and transmission of electricity across 12 geographically associated generating divisions. Initially, the organisation was not associated with any significant developments in architectural style, which aligned with the conservative approach of the BEA Chief Engineer at the time and was perpetuated by the traditionalist mindset of the Royal Fine Art Commission, by whom all new designs were reviewed.[9]

Conscious shifts in architectural style appear to have been driven by the economic interests of the *Enquiry into Economy in the Construction of Power Stations.*[10] Instructed by the Ministry of Fuel and Power, the report recommended that the BEA should "'encourage the experiment of new building techniques in the interests of economy'" in addition to the integration of "architects as equal partners in the design team of each new power station"[11]. Whilst renowned for their brick clad contributions to power station design, Farmer and Dark Architects received significant attention for their prompt change in approach. Described by the Architectural Review as "a suitable skin drawn over […] mechanical parts",[12] stations at Willington (1954 – 60), Marchwood (1954 - 59) and Belvedere (1954 – 60) made use of steel frames with brightly coloured aluminium cladding and patent glazing. With this new style, the monumentality of former 'brick cathedrals' was broken down and aggregate engineering elements, were more clearly expressed through built form, with the turbine hall as centrepiece.[13] Specialist architectural input was not unprecedented prior to this, but under the BEA and the subsequent Central Electricity Authority (CEA), acting in response to the new economic directive, it became significantly more common.



Llynfi Power Station, Farmer and Dark Architects (c.1940)

Marchwood Power Station, Farmer and Dark Architects (1955)

Key figures in the design of generating stations Farmer and Dark Architects championed the change in aesthetic direction led by the *Enquiry into Economy in the Construction of Power Stations.* They are reported to e the first to react to the directive shifting from the traditional 'brick cathedral' to steel framed and aluminium clad structures which expressed rather than concealed the engineering plant it protected.

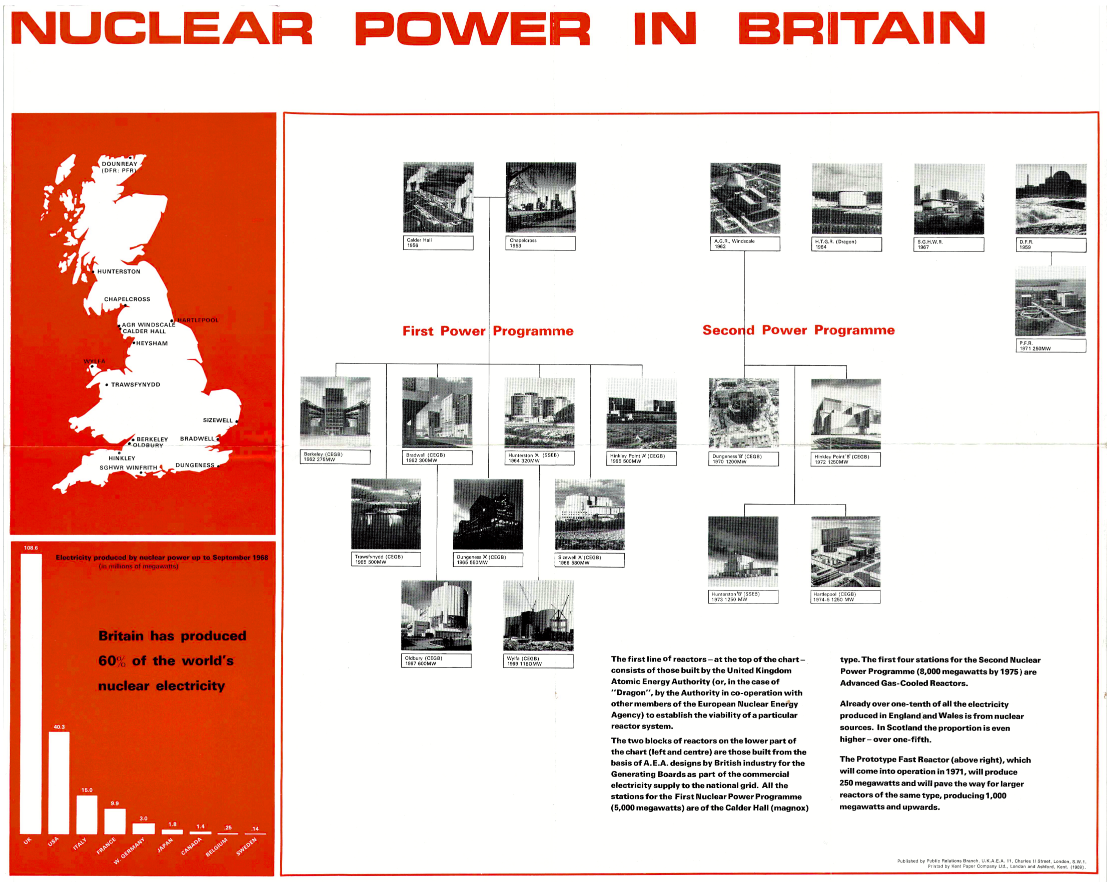
Source: Left: Four Power Stations. (1947) *The Architects' Journal (Archive : 1919-2005),* **106**(2741), p. 229.
Right: Three Power Stations. (1960). *The Architectural Review (Archive : 1896-2005),* **127**(760), p. 393.

2. Economies of Technology

A number of factors propelled the further integration of architects and landscape architects in the design of major energy infrastructure. Firstly, the footprints of conventional (coal, oil, gas) generating stations burgeoned as a result of increasing reactor outputs. Secondly, the development and implementation of atomic energy was gaining pace as the United Kingdom Atomic Energy Authority (UKAEA), established in 1954 to coordinate national nuclear research and development for both civil and defence purposes,[14] commissioned its first 50MWe prototype reactor at Calder Hall in 1956.

Known as MAGNOX, after the magnesium alloy used in the fuel rods, the first reactor designs followed a gas-cooled, graphite moderated typology.[15] From this prototype, the first nuclear power programme was developed comprising 9 new power stations in the UK. Further reactors were supplied internationally, but demand for exports fell short of expectations.[16] [17] Initially, reactor designs were developed competitively between four industry consortia.[18] First tenders to respective electricity authorities were required to offer a design for a complete twin-reactor power station which could be chosen for construction at either Berkeley, Bradwell, or Hunterston (Scotland). Reports from an engineering perspective suggest that for the first tenders the electricity authorities "had little influence on the designs […], perhaps because their nuclear engineering and project management organisations were still being established."[19]

The close working of consortia under turnkey contracts and vested interest at a national level from the UKAEA meant that "nuclear power stations were planned and built by groups of manufacturers set up to do the job."[20] Arguably, this tight administrative structure made the context for nuclear power station design less complicated, as fewer manufacturers were involved. Notwithstanding this, finding a unified approach to engineering plant, built form and landscape treatment was not without difficulty. Sylvia Crowe reported that the Government responded to the unprecedented siting territory for nuclear power, by "asking various concerns each to present projects for a reactor on an unknown site […] obviously concerned with attracting the best brains to present a variety of solutions to a very urgent problem."[21] Unimpressed by this approach for ignoring the idiosyncrasies of each individual site and the importance of designing reactor housing in relation to existing context, Crowe expressed; "although [the reactors] have the same technical requirements, [each] is in a quite different type of landscape, which must affect they type of building which will best fit into it."[22]



Poster produced by the UKAEA in 1969 to publicise and promote the near completion of the MAGNOX programme and present the advances made in reactor output in the second programme.

Source: UKAEA (1969)

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The Government's appeal to the design disciplines made it clear that nuclear power stations demanded a new approach to site: proximity to cooling water was necessary and bedrock footings were highly desirable, not to mention distance from dense populations. Previously, proximity to populations had not always been a critical consideration as conventional power stations with lower outputs had been located close to areas of distribution for reasons of transmission efficiency. Conventional stations with larger outputs and corresponding building footprints, however, had begun to creep away from populated centres, but not to the extent of siting in National Parks and unspoilt headlands as was proposed under the nuclear programme. In an article presenting stations designed by Farmer and Dark, the Architectural Review reported that "Because atomic power stations are news, and because they have usually gone to spectacular areas in unspoiled country, their siting has been vigorously discussed, to the exclusions of all other power station siting."[23] It concluded: "It is no use protecting our scenery from atomic blight, only to have it blighted by conventionally powered plant."[24]

3. Economies of Organisation

Whilst issues of size and scale across both conventional and atomic stations were clear drivers for specialist design input, real emphasis on visual amenity stemmed from legislation driven by the economic interests of maintaining a sustainable business model for the industry. The independent Herbert Committee, appointed by the Ministry of Fuel and Power, undertook an assessment of the CEA's efficiency. Findings reported that the industry was not "inefficient", but, referring to imminent changes in the industry as a result of increasing demand and the introduction of atomic power, that it was at risk of "losing efficiency."[25]

Despite being driven by economic and organisational motives, the resulting statute paid significant attention to the environmental implications of power station design and construction. Section 37 of the Electricity Act (1957), later dubbed the 'Amenity Clause', required the minimisation of the impact of generating and transmission sites on scenery, flora and fauna.[26] It was considered unique that a major, recently nationalised, industry was to work within "…statutory guidelines which required it *not* simply to produce electricity as cheaply as possible, with a little cosmetic landscaping tacked on as a gesture; but consciously to balance in each project the twin objectives of cheap electricity efficiently produced and respect for the environment."[27]

One outcome was the reorganisation of the CEA into the Central Electricity Generating Board (CEGB) and Electricity Council. The CEGB owned and operated the transmission system and generating stations in England and Wales, and was responsible for the supply of electricity to 12 area boards and its duties included the provision of new generation and transmission capacity. The gravity with which the new statutory duties were treated was reflected in the appointment of Sir William (later Lord) Holford. Previously, Holford "had played a crucial role in getting landscape design built into the planning of the post-war new towns."[28] Holford was not new to this sector or role as he had

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provided advice in various capacities to the form incarnations of the CEGB. In this latest position, his objective was to avoid the treatment of design as token cosmetic gesture.[29] Through a good relationship with the CEGB Chairman, Sir Christopher (later Lord) Hinton, the pair presented a paper to the Royal Society of Arts in 1959, titled *Power Production and Transmission in the Countryside: Preserving Amenities*,[30] which served as a benchmark for the early appointment of landscape architects in the design of power stations.

The CEGB branding in flame orange designed by Richard Guyatt, graphic consultant to the CEGB Public Relations department.

Standardisation spread to all areas of the CEGB. The variety of vehicles used was cut from 15 to 5.

Administrative reorganisation and the introduction of the CEGB was accompanied by rebranding which served both a cost effective strategy and established a coherent appearance in the public interest. "As the relations between the engineers and the architects section [of the CEGB] are so good, it is inevitable that gradually the work of the section is being expanded from pure architecture and amenity to the industrial design of equipment."[31]

Source: Left: https://c2.staticflickr.com/6/5241/5316535695_45b3e35bfc_b.jpg
Right: https://serendipityproject.files.wordpress.com/2011/10/design-drawing-one-by-john-rolfe-cegb-queens-award-to-industry.jpg

The appointment of Michael Shepheard as Chief Architect was further demonstration of an enlightened attitude to landscape and architecture. Acting from Head Office and initially supported by a team of three, his role was to brief and advise Holford and three project groups relating to geographical regions. During his tenure between 1959 – 1970, Shepheard's team grew to 32 designers comprising architects and landscape architects,[32] their role being to coordinate the work of appointed "architects and landscape architects for each project with the requirements of project engineers on a continuing basis during the design process, and by preparing design memoranda for the guidance of those responsible for the building work."[33]

With these figureheads in place alongside a growing list of consulting landscape architects, landscaping became embedded in the early the procedural aspects of power station design. Every second stage consent required a landscape scheme as part of the proposal, which would be reviewed by the local planning authority, and schemes would "frequently run the gauntlet of public inquiries, with landscape architects called to give evidence as expert witness.[34] Greater and earlier consultancy input meant that the responsibilities of each consulting team had to be clarified. "Architects

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and landscape architects as members of the project team advise on site layout, orientation and shapes of buildings, and the choice of texture and colour in the stations main visual components". [35] Landscape proposals comprised "detailed design and maintenance proposals, including conservation of existing trees and shrubs, ground contouring and tree planting, both on site and whatever agreement can be obtained in strategic positions off site."[36] By the time of the design for Wylfa, Crowe was demonstrating the value of landscape input far beyond these limited responsibilities.

Scale was the issue at the crux of interdisciplinary design coordination. Design teams were entering unchartered territory with nuclear power stations; the combination of typically unspoilt location and reactor size meant that power stations were edifices entirely disconnected from the human scale. Crowe asserted that the treatment of things on such a scale as power stations, could not, and should not, easily relate to human proportion, from the exterior at least. She noted that "the scale and majesty of reactors and turbine houses should be accepted; nothing can humanise them or relate them to a small scale landscape. If the human scale is desired for the sake of the workers it should be designed to be seen from within only while from without it is contained within the big-scale composition."[37] With this she identified that, if treated appropriately, landscape can accommodate and potentially bridge this scalar disconnection. However, she stressed that landscaping confined to the site perimeter would accentuate the fact that the enclosure is out of scale with the building.[38]

4. Wylfa: A Case Study

As the last station to be built as part of the first programme of nuclear power stations in 1969, Wylfa was arguably the most considered and successful ensemble of engineering and landscape design. Comparatively, Crowe's involvement with Trawsfynydd (1965), set in the Snowdonian National Park, received greater attention as a consequence of its setting and notable architect, Basil Spence. Wylfa was special in that it exhibited some of the most advanced features in the reactor series and by the point of design, the reactor capacity was almost double that of any other generating facility in the programme, reaching 1180MW from two reactor cores. By contrast, the capacity at Trawsfynydd was 500MW.


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Trawsfynned, Snowdonia National Park (1965)
Architect: Basil Spence. Landscape: Sylvia Crowe

Wylfa, Isle of Anglesey (1969)
Architect: Farmer and Dark. Landscape: Sylvia Crowe

Trawfynned received great attention for its positioning in the Snowdonian National Park and as a result of Basil Spence's involvement, however Wylfa was much more complex in engineering terms as a result of its 1180MW reactors and as the second station to install the reactors and steam generators in pre-stressed concrete vessels.

Source: Author's own.

An instrumental part of the design team at this site, alongside Farmer and Dark Architects, Crowe strongly advocated design cooperation and commanded great respect amongst her colleagues[39]. Such an increase brought with it design challenges, which Crowe skilfully reconciled within the Area of Outstanding Natural Beauty in which Wylfa sits. Being only the second station to have the reactors and steam generators contained in pre-stressed concrete construction. It is unsurprising the formal qualities of these spherical vessels; pinnacles of reactor technology at the time, are expressed in the geometry of the reactor housing and that the site was specifically coordinated by Crowe to showcase this. Described in her 1962 *Wylfa Landscape Report*[40] for the CEGB, Crowe considers the appearance of the site from all vantage points. She explains how the view from Wylfa headland should "be dominated by the station, and the drama of its scale should be given full play."[41] Special consideration, she goes on to say, should be given to the location of roads and perimeter fencing from these view points. Walking the coastal paths, which predate the station, but were extended by Crowe, the heroic positioning of the reactors is a spectacular sight, further augmented by the omission of fencing along the seaward perimeter. Invisible boundaries defined by the landscape are without the visual signifiers of dangerous territory and allow the reactors a uninterrupted seaward display which Crowe described as a "new focal element"[42] and the "finest part of the landscape"[43].

Ancillary buildings, in contrast to the reactor house, were purposefully less remarkable and located landside. With views considered from populated areas in addition to long views from distant peninsula, ancillary buildings are arranged and shielded in the landform. In a 1960 paper titled *Power and the Landscape*, Crowe articulates her dislike for "the spiky, disintegrated shapes" of sub-stations which "spread monotonously over too great an area."[44] With stations rendered obsolete without one, again at Wylfa she notes, "The sub-station presents a greater problem than the reactors because its great area will over-ride the contour patterns of the terrain."[45] Her solution: to sculpt the land using 500 cubic yards of spoil made available from the site which would conceal the substation from certain vantage points, while creating a foreground from which the building emerges in other views.

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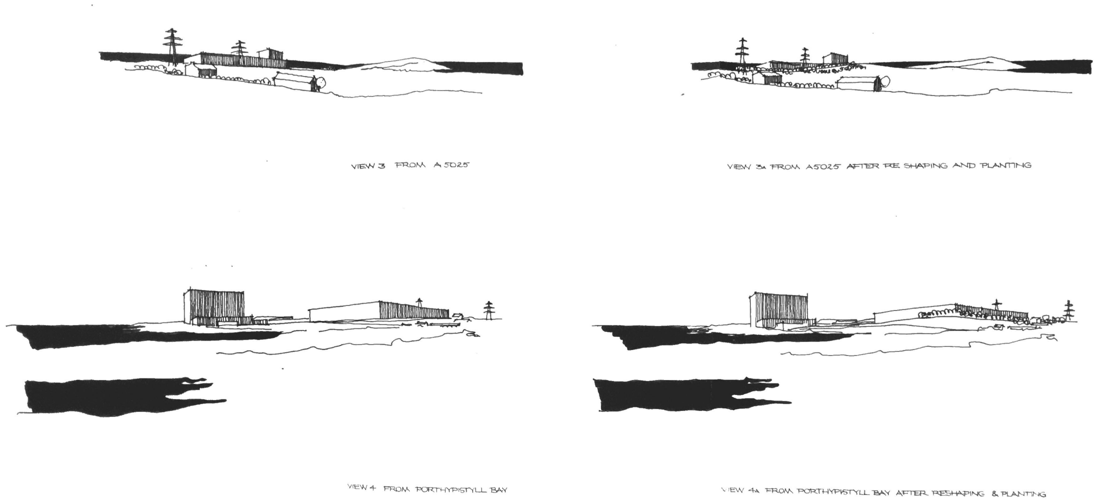

Crowe's sketches of Wylfa from a range of vantage points to explore the massing and composition of forms in the landscape. Taken from Crowe's Landscape Report No. 2 in the early stages of the design process.
Source: Landscape Report No. 2 for the CEGB (1962). Sylvia Crowe Collection at the MERL Archives, Reading.

Crowe demonstrated her sphere of influence at Wylfa to exceed that of the restricted definitions given to landscape architects by the CEGB. In part her role at Wylfa may have flourished in the limited presence of Bernard Frankland Dark, who was in semi-retirement by the point of design and construction.[46]

Conclusions

This paper has shed light on three economic drivers which generated the conditions for the input of architects and landscape architects early in the design of electricity generating sites by highlighting the value of design in utilising new materials, responding to progress in engineering and managing considerable issues of scale in difficult and cherished landscapes.

Whilst, these conditions apply to the design of both conventional and atomic power stations, special attention has been paid to the work of Sylvia Crowe in the design of Wylfa, the largest, most advanced and final station in the first wave of commercial nuclear power generating stations. Throughout this programme landscape input becomes increasingly significant. Secrecy and the closed research and development of Calder Hall and the experimental reactors at the outset of programme may have limited the scope for architectural and landscape input initially. The expansion in reactor size and site scale of the programme means that greater design input is required in later projects to handle the relationship between human and industrial scale. This, in addition to the increasingly rehearsed coordination of consultant and specialist design input, combined with an increasingly discerning project team, delivers unique outcomes, characteristic of the challenges that created them.

Whilst this paper has focussed on one station, each generating site in the first nuclear programme was distinguished, with geographic context and topography taken into consideration, all exhibit forward and collaborative

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thinking about the manifestation of infrastructure in the landscape, as well as its perception by wider society. Equally, alongside landscape setting, each station symbolises and makes manifest the technology and legislation of the epoch: from the air-cooling methods via cooling towers at the initial Calder Hall, to the manicured views of Wylfa, interventions range in distribution and footprint, from those so vast they are imperceptible, to those prominently condensed, coordinated and celebrated as landmarks.

Perhaps even more remarkable is that this is the product of economic drivers, typically seen to be at odds with environmental concerns and additional consultancy, often seen as superfluous to the engineering task at hand. Consequently, these factors demand greater attention to understand and offer insights into the implications of future infrastructures.

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