Toward a Post-industrial Era.
Lessons Learned from Evaluating Ågesta Nuclear Plant

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Introduction

There are currently around 500 commercial reactors throughout the world. More than 100 have already been decommissioned, and many more will close as the first generation of reactors is phased out. Throughout Sweden, there are about 25 nuclear facilities, including those used for mining, nuclear waste and freight transportation. Nuclear power accounts for 40% of Sweden's electricity production – the remainder being predominantly hydroelectric power. Nuclear power raises many questions about the conservation of large-scale industrial plants. Interest in nuclear power as cultural heritage has also begun to be recognised, both nationally and internationally.

2005–2008 I conducted, together with Eva Dahlström Rittsél and Per Lundgren, a study of Sweden´s first commersial nuclear power plant - Ågesta Nuclear Plant. We wanted to discuss which aspects of the Ågesta site were the most important to focus on, and what consequences the choice of perspective might have for how the site was to be evaluated – and, thereby, also for what we considered to be most worthwhile preserving. Two methods were tested for the analysis of the Ågesta site's potential as an example of cultural heritage – one a well-established evaluation system from the Swedish National Heritage Board, the other based upon narratives related to nuclear power and Ågesta. This work was compiled in the report *Ågesta – kärnkraft som kulturarv.*[1] The report has also been used in research context. In addition, for the last years the significance of Swedish nuclear power has also been highlighted in academic and heritage circles in Sweden.[2]

Ågesta Nuclear Plant

The Ågesta site was built at a time dominated by the Cold War, with a desire for self-sufficiency and optimism surrounding technology.[3] At an early stage, Sweden identified

Fig. 1: Ågesta Nuclear Power Station Exterior, 2008. Ågesta Nuclear Power Station was the first nuclear power reactor to produce power and heating for the market in Sweden. It was operational between 1963 and 1974. The plant is situated 15 kilometers south of Stockholm and had an output of 80 MW: 12 MW for electrical generation and, 68 MW for heating. The plant was built as a prototype heavy water power reactor. The Ågesta Nuclear Power Station is planned to be decommissioned around 2020.

Fig. 2: The reactor hall at R1 – the first nuclear station in Sweden, operational 1954–1970, today the entire reactor is dismantled, all the reactor is dismantled, and all the technical equipment gone. The hall is used for events.

the potential of nuclear power – for both civilian and military purposes.[4] In 1945, a commission was launched with the aim of promoting research in the field of nuclear physics and nuclear chemistry. Two years later, a company was established to conduct the prospecting for, and extraction of, materials in Sweden to be used for nuclear energy, as well as for building nuclear reactors on behalf of the research community and industry.[5]

In 1955, the Swedish state appointed a public commission to examine the possibilities of domestic atomic energy. The results highlighted the potential for Sweden to become self-sufficient, which was important from both a civil and a military perspective. It was also emphasised that Sweden did not have full control of the plutonium formed by the irradiation of uranium purchased from other countries.[6] This was a key factor behind the decision that heavy water moderated reactors were considered the most appropriate solution. The Atomic Energy Commission stated the importance of a centralised, state programme where AB Atomenergi would take responsibility for all aspects of atomic energy production. The main result of the commission's work was the adoption by parliament of the 1956 Atomic Energy Act (1956:306), concerning the right to produce atomic energy.

As early as 1954, a research reactor – RI – was built in an underground cavern in central Stockholm.[7] Planning for the Ågesta reactor followed in 1957, with trial operations starting in 1962. Some 50 Swedish industrial companies were involved in its construction. It became fully operational in spring 1963, thus becoming Sweden's first nuclear power plant. It was used to produce heat but also to a limited extent electricity. The Ågesta site represented part of a larger plan for Swedish nuclear power, later known as 'the Swedish Line'. The Swedish state planned a network of small nuclear power stations, powered by Swedish uranium and Norwegian heavy water.

Ågesta Nuclear Plant remained in operation until 1974, when it was closed due to technical considerations and security.[8] Swedish nuclear power was subsequently expanded with the addition of larger-scale light water reactors. Even though these larger power plants were built with a somewhat different technology, the Ågesta plant represents a crucial step on the road to today's nuclear power stations. The technical equipment bears witness to Swedish research in the field of nuclear energy, as well as to the capacity of Swedish industry to develop technically advanced equipment even by international standards.

Evaluation

A nuclear power plant is not a typical object for a cultural and historical evaluation, and there is limited experience with regard to evaluation, conservation and collections. Discussing the evaluation is therefore important, both in terms of the conditions and potential consequences. Two methods were employed in evaluating the Ågesta site: the Swedish National Heritage Board's method for evaluating

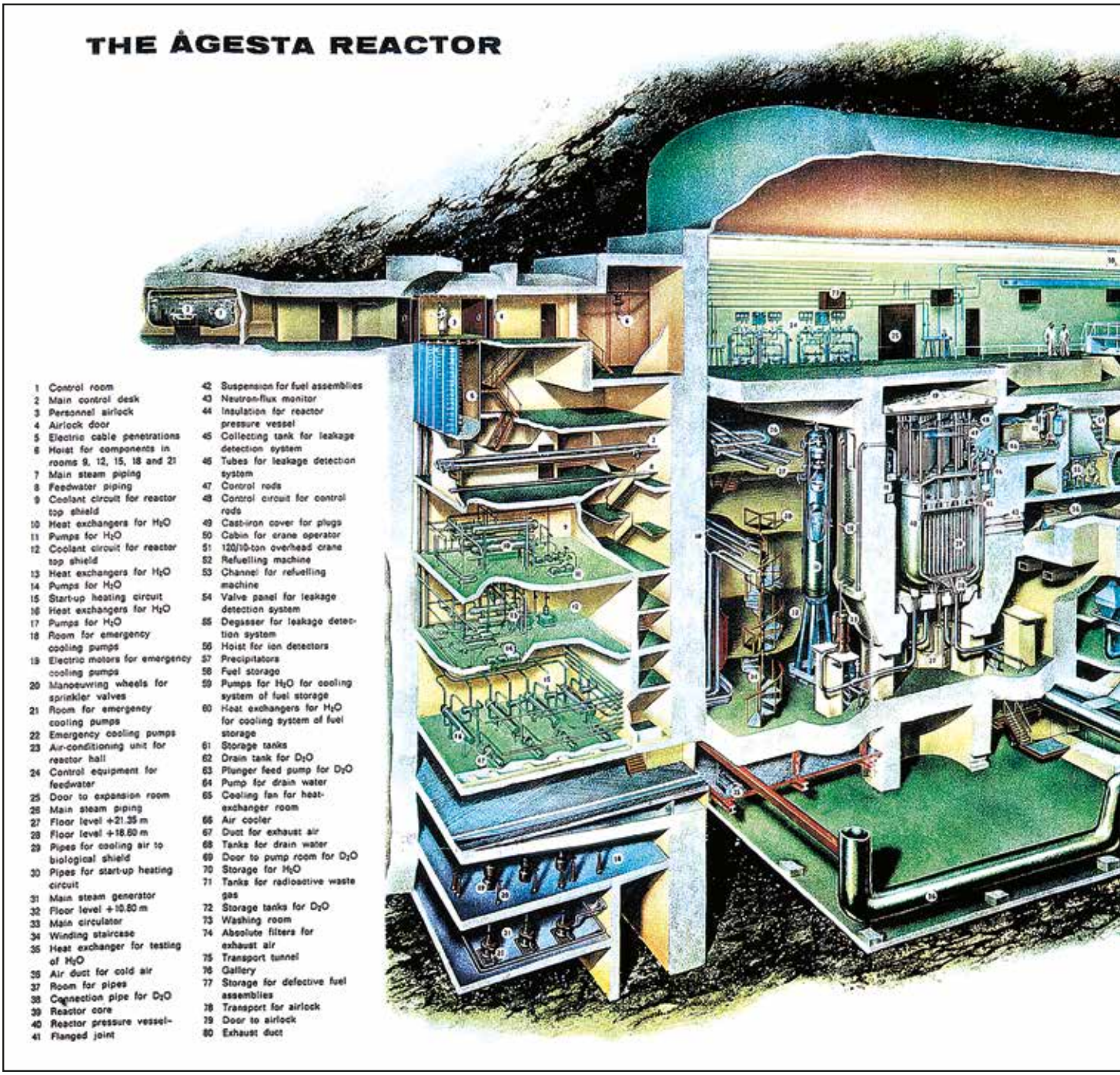
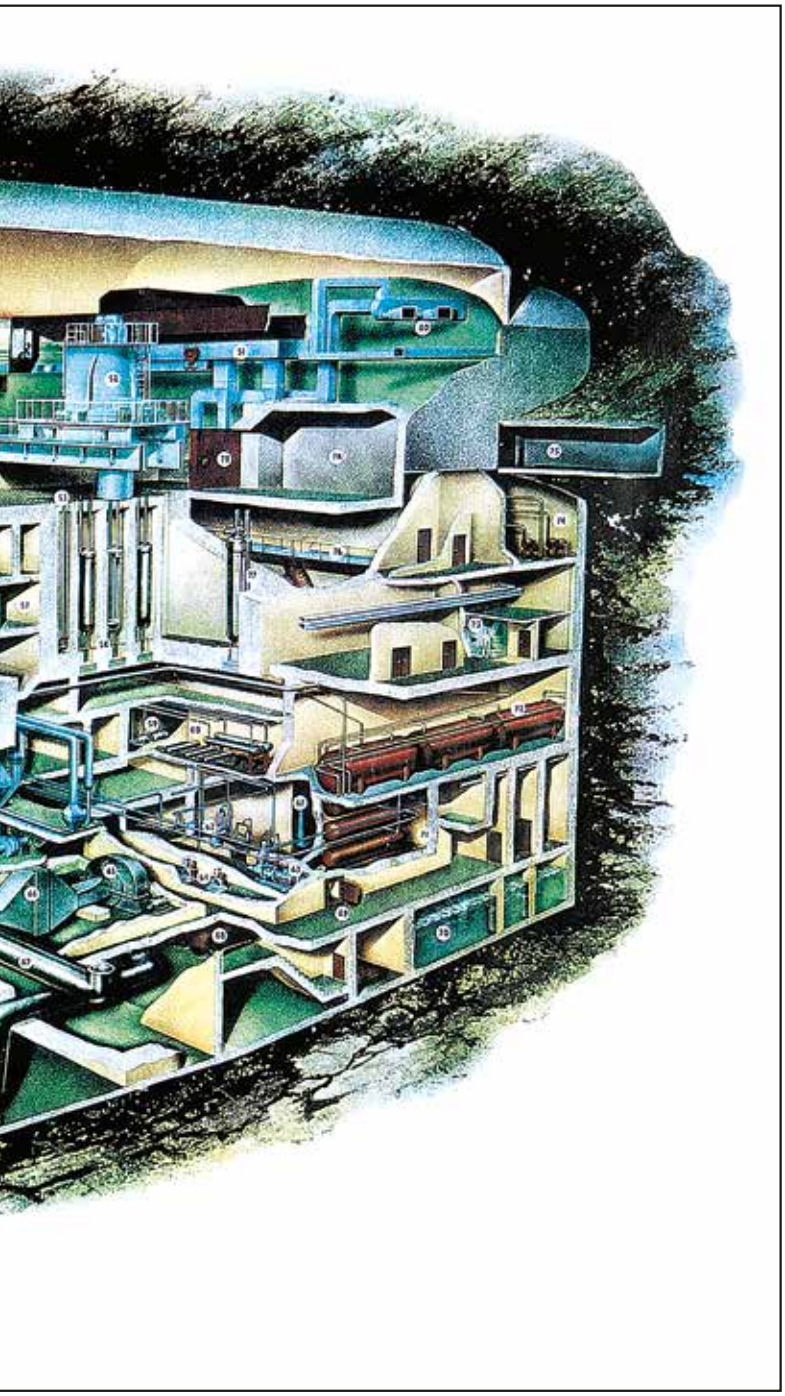


Fig. 3: Cutaway drawing of Ågesta Nuclear Power Station. The atomic artist Arvid Nilsson was employed by the AB Atomenergi to interpret the engineering drawings.

buildings, and our own method based upon an analysis of the plant as a means of conveying important narratives.

Analysis of Ågesta Nuclear Plant using the Swedish National Heritage Board's evaluation system

In Sweden, matters of conservation, care and documentation are usually based upon a thoroughly considered justification and objective. The object evaluated is defined and described with reference to various predetermined evaluation criteria. These are divided into documented and experiential values. Documented values, based on historical characteristics, are further divided into building value, construction-technology value, patina, architectural value, socio-historical value, personal value and technological value. Experiential values refer to aesthetic characteristics, experiences or social engagement, and are divided into architectural or artistic value, patina, environmentally creative



value, identity value, continuity value, traditional value and symbolic value.

Of significant importance for the evaluation is how rare or authentic the site is. The evaluation system defines four levels of criteria of evaluation. Each of these is linked to practical follow-up measures with regard to legal protection, documentation and care.[9]

The Ågesta plant is an important representative of the development of Swedish nuclear power, of Sweden's great industrial period, and of the Cold War era – both in Sweden and internationally. An assessment of the various evaluation categories shows that, for technological and industrial-historical values, Ågesta is in a class of its own. It also shows that its socio-historical and construction-technology value can be emphasised, along with symbolic values: the site has strong authenticity. Combined with the obvious interest of the control room and reactor hall, this constitutes a great educational value. There is also a major quality value regarding construction technology and materials.

Evaluation based on 'important narratives'

We created an alternative model built upon the idea of 'important narratives', lending to the Ågesta plant a significance which extends way beyond the local context. Its cultural value lies primarily in its bringing to life, in a simple way, historical processes of vital importance to the creation of modern Sweden.[10]

The first step of the analysis focuses on the narrative judged to be the most relevant to the environment under study. Factors such as social class, gender and ethnicity all affect the ways in which we perceive the world around us. When choosing a narrative, the persons performing the evaluation must first reflect upon their own position as judges of such matters. Then, the environment must be put in its context. What were the stages or events that led to the construction of the site? Once constructed, how was it influenced by society and its prevailing conditions? To what extent do the preserved structures explain or reflect such influences? By this stage, a general perception should have emerged of the most desirable narrative for the site to convey. In fact, a certain narrative may well be optimal for the environment, without being so for the story.

The selected narrative underpins a detailed analysis of the site. Which material structures are more important to preserve and draw attention to convey the narrative, and which are less important? This ranking of physical structures is significant, both for the effectiveness of the conservation efforts and for the clarity with which the site will be able to tell its stories. The procedure can be summarised as: 1) investigation of context, 2) selection of narrative, 3) comparison with other objects, and 4) analysing the site and ranking its physical structures.

Analysis 1 – the Swedish Line

This term allows various interpretations but, as a physical object, the Ågesta site primarily represents 'the Swedish Line'. As we have seen, this site was essentially a relatively small civil heating plant. However, the experiences gained there could also be used for military purposes.[11] Very few people would argue that the selected narrative is unimportant. The Swedish Line is of key significance as a manifestation of post-war moods, security policies, energy policies, ideas about infrastructures, and the development of industry.

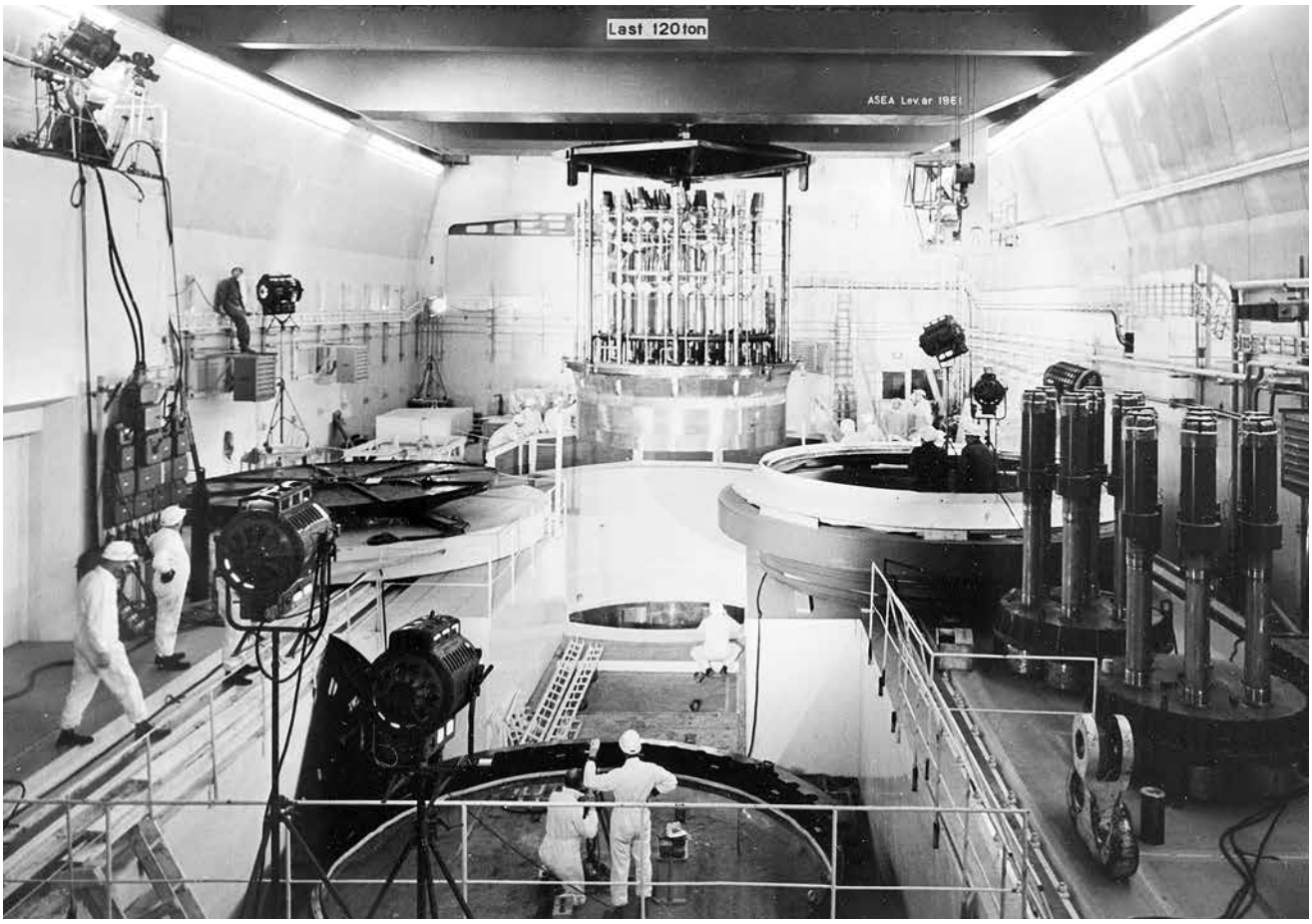


Fig. 4: Reactor containment during test run in 1962.

And it contributes to a better understanding of notable events in our modern history. It also provides a valuable backdrop for the heated discussions about nuclear power that took place throughout the 1970s and 1980s. Thus, the Swedish Line may well be the optimal narrative for Ågesta Nuclear Plant. But is this environment optimal for the narrative? In addition to Ågesta, two other sites also represent significant manifestations of the Swedish Line – the full-scale Marviken plant in Östergötland and the Ranstad uranium extraction facility in Västergötland.

Ranking the physical structures

What parts of the Ågesta site will be particularly valuable for conveying the chosen narrative? From an international perspective, one of the most interesting aspects of the idea of the Swedish Line is the use of small-scale nuclear power plants for district heating. This singles out the Swedish Line from international equivalents, which usually involved plans for nuclear weapons in their nuclear programmes. Reactors using heavy water as a moderator and coolant, together with domestically produced natural uranium as a fuel, are not, however, specific to the Swedish Line. There was an equivalent in Canada – the CANDU Programme – which, like the Swedish programme, was under state control. Consequently, the particularly important parts of the Ågesta site are those showing the plant's function as a supplier of heating to the suburb of Farsta, and those making it clear a nuclear reactor supplied it. It is also important to show the plant was operated using heavy water and natural uranium, but in this analysis, it is less of a priority. The parts related to the production of electricity, however, are less important. A prerequisite for nuclear-powered district heating plants is proximity to the consumers, which makes it essential for the plant to be protected in a reassuring way. The Ågesta plant's location in an underground cavern is, therefore, of crucial significance to the manifestation of the civil aspects of the Swedish Line.

Analysis 2 – Swedish nuclear power

Swedish nuclear power history can broadly be divided into four parts. An initial phase (approx. 1955–1970), characterised by optimism about the possibilities of technology, saw the introduction of research reactors, with experiments, studies and tests with heavy water reactors. It was succeeded by a Golden Age (approx. 1970–1980) involving the

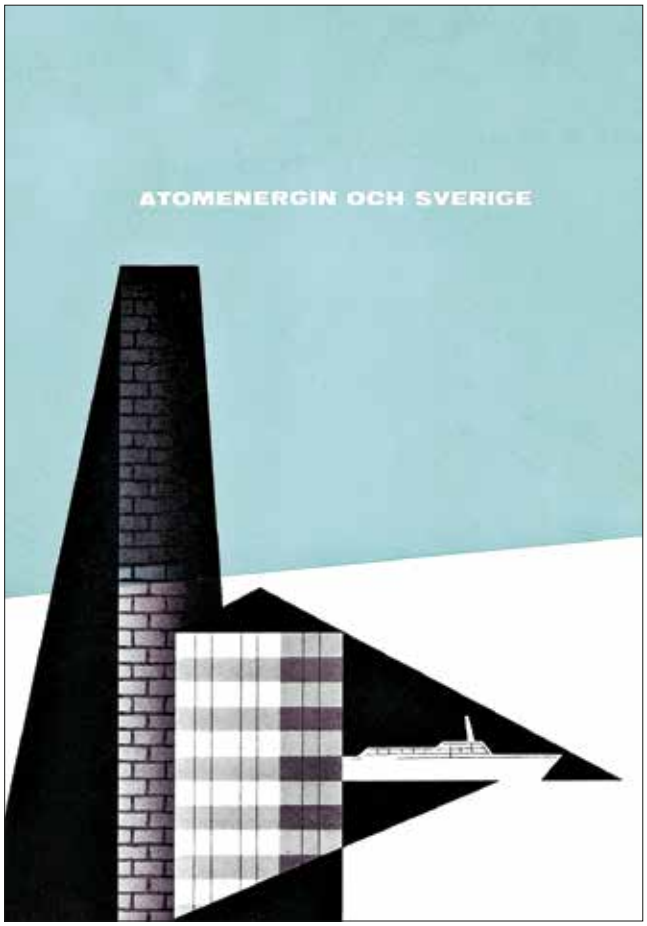


Fig. 5: Reports from the 1950´s and 60´s regarding the atomic program in Sweden and particularly about Ågesta.

Fig. 6: Bottle of Heavy Water from Norsk Hydro.

construction of large-scale light water power plants. Then came a period of re-evaluation (approx. 1980–1997) with notable events such as a referendum on nuclear power and the Chernobyl disaster. The final phase was a period of discontinuation (1997 onwards), when no new nuclear power plants were built while, at the same time, the old light water reactors were decommissioned. By the end of the 1960s, the role of the Swedish Line had ceased to be relevant, and the choice of reactors for the new plants was no longer determined by the findings of the 1956 Atomic Energy Commission. A completely different reactor technology was now preferred, and plants were used to produce electricity. However, the Ågesta Nuclear Plant was significant for the choice of modern technology. A lot had been learned from the experiences gained, and the nuclear power industry benefited from skilled and experienced engineers and technicians who could move on to new assignments.

Selection of object and narrative

The Ågesta site can tell the story of Sweden's early history of nuclear power. This narrative resembles that of the Swedish Line. If the entire story of Swedish nuclear power was to be told, the ideal choice would be one of the large-scale light water reactors from industry's heyday – a facility that made more than a marginal contribution to the nation's electricity supply and which serves as a representative of the turbulent years around the referendum on nuclear power. In a situation where other, more appropriate nuclear plants cannot be preserved, the site at Ågesta could be a potential conveyor of the wider narrative of Swedish nuclear power. In such an event, we would be at a point where the narrative is not optimal for the environment but the environment optimal for the narrative. If Ågesta is to represent the entire nuclear power era, it will be necessary to bring into focus those structures which can tell the nuclear power story on a more general level. This would apply to the reactor and control rooms as well as the cooling towers. The need for security is illustrated by sluice chambers and radiation-proof doors. The parts illustrating the plant as a producer of district heating would become less significant as no more heating-producing nuclear power plants were built. Other important aspects are the way nuclear power engineers were trained at the Ågesta plant, and the way security problems arose and were resolved. Unfortunately, the interiors of the engineering and laboratory building have been completely transformed and the exterior substantially rebuilt. Had it been well preserved, this building would have

Fig. 7: The atomic artist Arvid Nilsson was employed by the AB Atomenergi to draw cutaway drawings from the engineers' blueprints. He has also created monumental paintings at different nuclear stations, like this from Studsvik. The young family symbolize hope for the future as the optimism for the atomic age with workers, engineers and researchers working side by side.

represented an important part of the narrative about technological development and of the Ågesta site as a training ground for Swedish nuclear technology.

Discussion

Each of the two methods clearly has its own strengths and weaknesses, but the choice of evaluation method is crucial to the outcome. The systematic approach of the Swedish National Heritage Board's evaluation system ensures essential values and aspects are not overlooked in the analysis. The system is also easy to use and understand. At the same time, this method is not wholly appropriate as a selection instrument. Cultural and historical value, for example, may be found anywhere, regardless of the object being analysed. The results of the analysis primarily contain information on the ways in which the heritage asset or object is useful as opposed to how valuable it is – for example, in relation to other objects.

Cultural and historical evaluation based upon a selected narrative provides a clear ranking of the importance of the objects and structures included in the narrative – on an international and national level, as well as on a site level. The narrative itself serves as an instrument for ranking. At the same time, however, the ranking and the evaluation are only valid within the context of the selected narrative. The choice of narrative is therefore a critical element of the analysis.

The two methods illustrate different ways of looking at the object/heritage asset being analysed. In one case, the environment is seen as being the bearer of values that can be given prominence and explained. Evaluations based on narratives get tied to the narrative rather than the environment. The highlighted context is seen as essential and the environment becomes a medium for understanding and discussing this context. This also means the evaluation can result in the focus shifting towards other environments, completely different to the original point of interest as they can prove to represent the most important conveyors of the chosen narrative. The evaluation gets more controlled, but it also becomes clearer because what is being highlighted and preserved is also what supports the selected narrative: it becomes clear that the evaluation has been made based on certain values.

Cultural heritage uses of Ågesta Nuclear Plant

Regardless of the evaluation method used, it can be asserted that Ågesta Nuclear Plant has major cultural and historical value. The narratives linkable to the Ågesta site concern Sweden during the Cold War and decisions about energy supply and defence issues made in those days. These stories also relate to the rapid growth of industry in the post-war period, which paved the way for access to cheap energy and expertise in a variety of fields. Accounts exist of the local conditions applying to Ågesta – such as opposition to the very existence of the plant and what it was like to work there.

By concentrating on a narrative, focus shifts from the material object to the immaterial context in which the plant originated. The Ågesta Plant should be regarded as representative of an interesting part of Sweden's post-war history. The construction of the site was a matter of national importance, involving government and parliament, a range of government authorities, research institutions, and many industrial companies, both large and small. Therefore, it is reasonable to profile the site at Ågesta as being representative of a narrative at a national level. This argument is also valid for other nuclear installations, and perhaps even for other environments where part of their value resides in an immaterial context.

An evaluation based upon the narrative of the Swedish Line results in certain parts of the site being judged as more valuable than others. To begin with, Ågesta Nuclear Plant was built for district heating purposes and not for distributing electricity. The plant also represents a very high level of specialist engineering. The reactor's location in an underground cavern is explained by the fact that it was a district heating plant situated close to the destination of the heating, which necessitated additional security arrangements. The reactor hall shows clearly how the reactor was operated. The fuel elements were stored here while waiting to be fed into the reactor. The room was adapted to accommodate technical installations and to ensure the various stages would run as smoothly and as safely as possible. This also resulted in an aesthetic design at the same time emphasising rationalism and consistent with the prevailing optimism of the time regarding technology. To an even greater extent, this also applies to the control room, which was built to enable efficient monitoring and managing of the reactor. At the same time, the design is typical of the period, regarding the fixtures and fittings in the form of gauges and controls. A clear difference from later nuclear power stations is the analogue measuring devices, which were eventually to become digital. This sit-

Fig. 8: The Control Room is situated in a separate cavern within the rock, connected to the reactor hall by airlocks. The Control Room allowed supervision of the entire plant from one place.

Fig. 9: Solenoid valves in the Fuel Element Failure Detection System, detail. This bank of valves is used to sequentially connect cooling water samples from the fuel elements to the fission gas scrubbers. Swedish art of engineers in the 1960s.

Fig. 10: Oskarshamn 1 (O1), the first light water reactor in Sweden in grand scale opened in 1972 as a private project run by OKG Group. The capacity of O1 was 400 MW. The reactor was followed by two late reactors. O1 was closed down in 2017.

uates the plant in the context of the period, which facilitates understanding that context. In addition to the reactor building, which is connected to the turbine hall, the site has five more buildings: an administration building, an engineering and laboratory building, a guardhouse, a house for waste management, and a building for residential and training purposes. It is clear from the laboratory part that tests were conducted here. In fact, Ågesta was partly used as a testing facility. But laboratory buildings also form part of nuclear plants used only to produce electricity. Some of the interiors (and, to a certain extent, the exteriors) of these buildings were later adapted to other uses, but they remain of intrinsic importance for the environment and for understanding Ågesta Nuclear Plant.

A review of the legislation governing nuclear installations shows any possible conservation to be complicated, since the law states that all nuclear plants must be decommissioned, and that those no longer in operation must be demolished. But no mention is made as to *when* this must be done.

It would be appropriate for restricted parts of the plant to be exhibited, including the control room, the reactor hall and the storey beneath the reactor hall. Along with the surrounding environment, these would be enough to convey an experience of early Swedish nuclear power. Those parts of the plant have been judged both necessary and sufficient for a worthwhile presentation of the Ågesta site and the narrative of the Swedish Line.

Sweden's nuclear power industry forms an important aspect of our post-war history by illustrating the vulnerability of the Swedish state's perception of the relation between the superpowers. But it also shows confidence in the country's own scientific research and in the capabilities of Swedish industry. Conserving and communicating the narrative about the Ågesta plant is of pressing importance.

Two of the most important sites for the narrative of the initial stages of Swedish nuclear power have ceased to exist since the report was written. The Ranstad uranium extraction facility has been demolished, and the Marviken plant has been decommissioned and offered to the private market to be converted into a hotel.[12] Not one of these early-period nuclear facilities was provided with any formal protection as to its cultural and historical value. Of the very first reactor, the R1, only an empty underground cavern is left. Discussions about nuclear power as cultural heritage are thus highly topical, and it remains to be seen how the cultural and historical value of the Ågesta site has been affected by the fact that other facilities have changed. Our two models give different answers to this.

According to the Swedish National Heritage Board's evaluation methodology the Ågesta plant acquired greater value due to the demolition and decommissioning of the uranium extraction facility and the Marviken plant, since it remains the only representative of the Swedish Line. It has become 'indispensable'. On the other hand, according to the con-

Fig. 11: Forsmark reactor 3.
Forsmark is the latest of Sweden's nuclear power plants it was commissioned in the 1980s and run three reactors. Forsmark will also house a spent fuel repository for approximately 6 000 copper canisters of spent nuclear fuel.

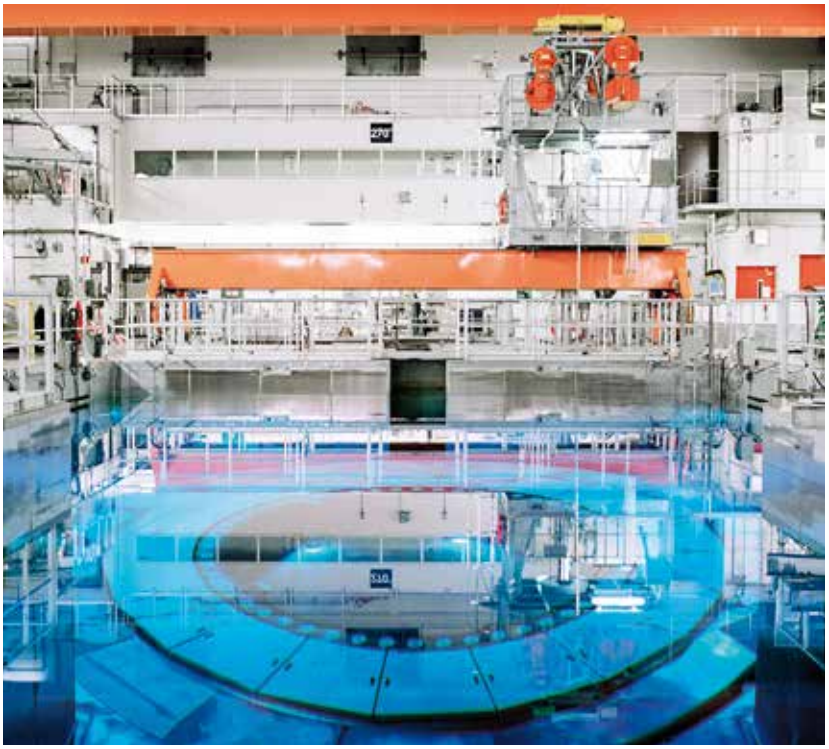


Fig. 12: Barsebäck Nuclear Plant, close the Danish Border. Operated 1977–2005.

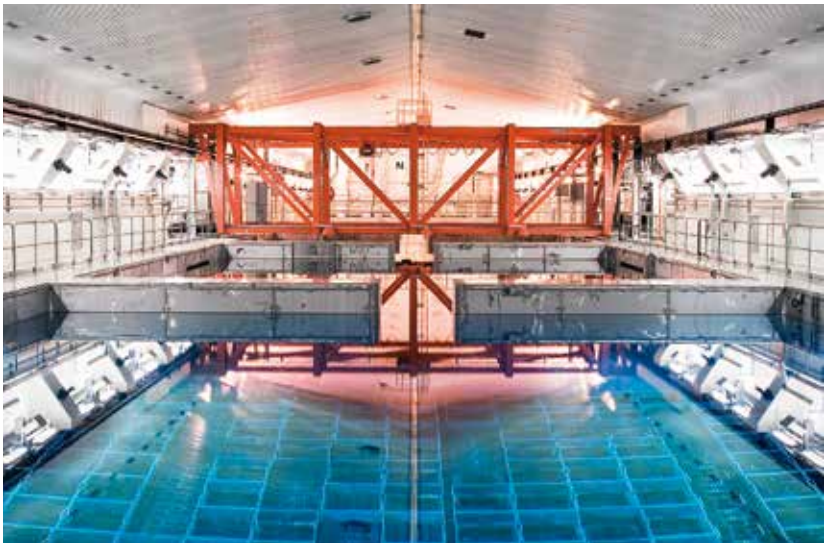


Fig. 13: Central interim storage facility for spent nuclear fuel, CLAB, Oskarshamn.

textually-oriented approach the value of the Ågesta site has decreased. Stockholm's County Administrative Board is currently conducting an examination of the classification of historic buildings, and this process will continue during 2018. Ågesta Nuclear Plant also attracted international attention during the past year – not least by means of an international conference organised by the Nuclear Legacies project, a collaboration between researchers from Sweden, France, Lithuania and Russia.[13]

It is extremely important to exchange experiences and to see the potential for cooperation to inform the discussion of cultural heritage concepts, as well as of legislation, finance and protection from radiation. It would be desirable if the issues surrounding nuclear power as cultural heritage were also addressed more consistently by, for example, TICCIH (The international Committee for the Conservation of Industrial Heritage).

I will end with a quotation by Dr Alan Flowers, a British university radiation protection officer. For more than 35 years, he has been engaged in the safety aspects of nuclear energy production in the UK, and visited Ågesta in September 2017. He supports maintaining the legacy of Ågesta as a physical entity that honours and demonstrates – with stunningly visible reality – the magnificent engineering and safety-oriented culture of the early Swedish nuclear programme[14]:

"The engineered rock cavern environment of Ågesta is a unique example of nuclear power plant engineering in its early years of the mid-20th century. Combining this with preservation of the remaining historic nuclear instrumentation and materials handling equipment, it provides a very special statement of Swedish mid-20th century quality design and engineering. This could be used to provide the inspirational core feature of a technology park or technology museum for the enlightenment and enjoyment of future generations."[15]

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Zusammenfassung

Auf dem Weg in eine post-industrielle Ära

Erkenntnisse aus der Begutachtung des Kernkraftswerkes Ågesta

Das südlich von Stockholm gelegene Kernkraftwerk Ågesta, von 1963 bis 1974 in Betrieb, war Schwedens erstes kommerzielles Kernkraftwerk. Es wurde errichtet, um eine neu geschaffene Vorstadt mit Fernwärme und Strom zu versorgen. Gleichzeitig war es Teil der Umsetzung der Atomstromstrategie „Schwedische Linie“. Ziel der schwedischen Regierung war, das Land aus der in den 1950er Jahren als bedrohlich empfundenen Abhängigkeit von Kohle und Öl zu befreien, indem Schweres Wasser (Deuterium) und schwedisches Uran genutzt wurden. Das Kernkraftwerk Ågesta ist lange abgeschaltet und seine Zukunft ungewiss. Auf Basis von Erkenntnissen aus einem Forschungsprojekt zur Anlage betrachtet dieser Artikel das Kernkraftwerk als Kulturerbestätte. Sein Wert als Kulturerbe wird anhand von zwei verschiedenen Modellen analysiert. Der Artikel endet in einer Diskussion darüber, wie die Wahl eines Modells zur Begutachtung die Sichtweise auf das Kernkraftwerk als Kulturerbestätte beeinflusst und gibt einige Überlegungen zu Anforderungen des Kernkrafterbes in der Zukunft mit auf den Weg.

[1] Tafvelin Heldner, Dahlström-Rittsel, Lundgren 2008.

[2] e. g Storm, 2010, 2014 Krohn Andersson, 2012, Tafvelin Heldner, Dahlström Rittsél, Lundgren, 2013, Fjaestad 2001, 2012, Fjaestad and Jonter, 2012.

[3] Tafvelin Heldner, Lundgren och Dahlström-Rittsel (2008) p. 27–58.

[4] Lindström, 1991 p. 11ff.

[5] Atomenergien: Betänkande med förslag avgivet av 1955 års atomenergiutredning, SOU 1956:11 (Stockholm 1956).

[6] Atomenergien, 1956, SOU 1956:11.

[7] Fjaestad, 2001.

[8] Östman, 2002, p. 21.

[9] Unnerbäck, 2002, p. 27 ff.

[10] Tafvelin Heldner, Dahlström-Rittsél, Lundgren, 2008, p. 61–98.

[11] Lately the relation between the Ågesta site and the plans for a Swedish Atomic Bomb has been articulated, Fjaestad och Jonter, 2012 och Wallerius, 2012.

[12] ”Marviken ska säljas – blir hotell?”, Norrköpings tidningar 2018-03-19. http://www.nt.se/norrkoping/artikel.aspx?articleid=7938156, 2018-03-19.

[13] https://nuclearlegacies.wordpress.com/, https://atomicheritage.wordpress.com/ International projects hosted from Sweden.

[14] Flowers also addressed the need to reflect on the holding and displaying of radioactive materials in museums.

[15] Statement by Alan Flowers from mail to Anna Storm, presented at meeting 2018-11-22.