The Reuse of Decommissioned Facilities and Sites as an Emerging Means to Alleviate the Decommissioning Burden and its Potential Applications within IAEA's International Decommissioning Network-9001

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ABSTRACT

Around the world, but particularly in developing Member States, there are disused nuclear facilities or those approaching the end of their useful lives, for which appropriate decommissioning steps have not been taken, primarily due to limited technical and financial resources or competing priorities. One way of alleviating the financial and social burden associated with the final shutdown and decommissioning of nuclear facilities is the redevelopment of decommissioned facilities and sites for new, productive uses, either nuclear or non-nuclear. Sustainable development implies economic development with maintenance of social and community integrity. This objective can best be served by the sensitive redevelopment of sites to provide continuity of employment and new productive activity. Finally, experience to date with redevelopment both inside and outside the nuclear field suggests that successful engagement of the stakeholders can be a key success factor in promoting outcomes which are both profitable for the operator and recognised as responsible and worthwhile by the wider community. Following a generic discussion on factors and issues inherent to the re-development of decommissioned sites, this paper expands on several examples. It is noted that experience from the non-nuclear industrial sector is much more extensive than from the nuclear sector, and lessons from this sector should not be neglected.

Many of world's nuclear facilities are small and widely distributed geographically, e.g. ~300 aging or shut-down research reactors. Requests for assistance to address this issue from Member States exceed the capability of IAEA (and others) to deliver. However, integrating individual initiative into a designed-for-purpose network may compensate for these limitations. A new IAEA initiative amongst organizations from both potential "donor" and "recipient" Member States has taken the form of an "International Decommissioning Network (IDN)".

The objectives of the IDN are to improve the flow of knowledge and experience amongst those engaged in decommissioning, and specifically to enhance the "user-oriented" focus for all IAEA decommissioning activities. The IDN provides a "bridge" between those Member States with specialized knowledge and those that need to apply it, and encourages an exchange of practical knowledge and skills. In this paper it is shown that integrating site reuse into the decommissioning strategy at its outset has a number of advantages and this experience should be shared.

INTRODUCTION

The initial concept of decommissioning management was that of a closed life cycle for nuclear facilities, which entailed the final disposal of waste and the restoration of a site to its original condition. This concept is no longer acceptable. Decommissioning should not be an endpoint of a facility or site but should enable opportunity for Redevelopment/Reuse [1](R/R) of a facility or site. Total demolition of a facility or site should be only one decommissioning option under consideration, and various R/R options should be considered in the decommissioning strategy.

The R/R of disused and decommissioned buildings, facilities and sites should be promoted as an opportunity rather than a constraint. In recent times R/R as a decommissioning end point has moved to the forefront, in view of industrial development due to:

- The increase in demand for scarce industrial development sites, including the nuclear industry (nuclear renaissance)
- A preference for redevelopment of brown field sites instead of green field. The principal economic driving force here is the reduced decommissioning cost due to less strict regulations with regard to decommissioning to brown field rather than green field criteria,
- A preference for development of new nuclear sites or facilities at locations previously used by the nuclear industry
- Specialized or robust infrastructure associated with nuclear facilities that may be valuable for other uses or reuse.

The R/R of nuclear facilities after decommissioning is an option that is currently not optimized. The Nuclear Renaissance is starting to apply pressure on the developers to redevelop and reuse existing nuclear sites. With the nuclear renaissance comes a new appreciation by host communities. A few years ago, local officials were faced with an end to local tax revenues and years of being host to a plant with a negative value. Today they see years of continued operation, with an alternative future productive use of the site. R/R options are now being promoted by several legislations. One such a case is the new decommissioning law passed in New Hampshire, USA. The law changed the existing green field cleanup requirement to a commercial /industrial site restoration standard. This included a specific mandate to the local community of Seabrook with a voice in the ultimate fate of the decommissioned site. Recognizing the importance of the economic development of the region was also made a requirement in site restoration [1].

Decommissioning costs can be significantly lower if the R/R potential of facilities or sites are identified at an early stage in the life cycle of a facility since the extent of decommissioning can be influenced by the R/R options. It is not too soon to incorporate strategies that will aid decommissioning when engineering new facilities. Early reuse and redevelopment plans will ensure that best use is made of the assets and land resources associated with the sites. This approach also minimizes decommissioning waste, thus saving money for the owner.

The need for space renders the early consideration of R/R strategies for industrial building important so that the use of vacant industrial facilities and sites and the well developed infrastructures (e.g. roads, railways, electrical substations, etc.) associated with these industrial facilities and sites can be optimized.

Many disused industrial sites have historical contamination problems from decades of poorly controlled industrial activities. Examples of industrial contamination may include asbestos, lead and other heavy metals, solvents, PCBs, and other chemical contaminants. Nuclear sites have the additional complication of potential radiological contamination. Removal of these materials is necessary to protect human health

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[1] Similar keywords found in the literature are “revitalization”, ”regeneration”, “reindustrialization”, “rehabilitation” etc. These terms are often used interchangeably although, strictly speaking, they do not have identical meanings. .

and the environment, and must be accomplished by trained personnel. The presence of contamination is an additional barrier to the redevelopment of facilities but should not be seen as impossible to overcome. These contaminated industrial facilities and sites must be assessed on a case-by-case basis with regard to R/R options and their associated decommissioning.

Sustainable development also implies the need to combine socio-economic development with conservation of natural resources such as land and maintaining community integrity. The operators of nuclear and non-nuclear facilities have a responsibility (ethical, if not legal) towards the employees and the local communities. This responsibility must not be seen as a burden but must be converted into a possible profitable action for the operators, ensuring sustainable development. Reusing facilities/sites contributes to the overall concept of sustainability.

The location of a facility to be decommissioned is an important factor that needs to be considered from a socio-economic perspective. Mostly older facilities targeted for decommissioning were originally constructed on the edge of a growing city but are now in the centre of an urban area and are engulfed by city sprawl (e.g. research reactors). The overall public sensitivity towards the environment and possible discharges and pollution has increased significantly. Water pollution in the case of facilities located adjacent to surface water bodies and visual airborne discharges are further examples of issues that aggregate negative public response. Industrial redevelopment around water bodies may not be supported by the public. Arguments such as that the disused facilities were there first do not sway the public. Within urban areas buildings may become obsolete for present day uses, although remaining structurally sound. The fate of these buildings is in the hands of the owner and depending on his appreciation and sensitivity toward the public sentiment. The need to preserve the historic buildings is an important part of maintaining the historic industrial character that forms an anchor for future redevelopment. In this regard, one should also note that reused buildings/factories tend to be publicized and turn into tourist attractions generating extra revenues to the owner (media coverage, tickets sold etc). To this end it is often convenient to keep signs of the former use (e.g. a historical façade).

For a long time, urban regeneration has been driven by a combination of political will and business economics. But it has depended heavily on public money and has been often complicated by bureaucracy. More recently, experience has helped developers to tackle bureaucratic obstacles. Less public money is needed to back projects, as investors are becoming more attracted to regeneration projects as a sound place to put their funds. The creation of jobs in areas afflicted by unemployment is certainly a complementary measure. At London Docklands the working population rose from none to 64,000. The number of visitors attracted to a city is another important aim when regeneration schemes have financed cultural showpieces. The Guggenheim Museum was the result of a move by Bilbao (in Spain) authorities to attract the Guggenheim Foundation to the city, when the traditional industries of shipbuilding and steelmaking collapsed in the early 1990s. Within two years after the first full year of the Museum (2001) extra tax revenues had already covered the cost of bringing the museum to Bilbao [3].

Finally, it should be emphasized that the R/R of non-nuclear facilities and sites is more mature than the R/R of nuclear installations. The latter has been often hindered by remaining or suspected radioactive contamination (although this can be reduced to levels compatible with an adaptive reuse) or rather by the nuclear stigma. This report expands also on non-nuclear applications and tries to identify where non-nuclear experience can be successfully exported to the nuclear sector.

An extensive discussion on factors to be taken into account when considering reuse options is given in [4]. In summary they can be listed under the following categories:

- Socio-economic impact (job retention or creation, financial benefits, etc.).
- Decommissioning impact (scope of decommissioning work, waste generation, timing, regulatory issues, etc.).
- Environmental impact (conservation of green fields, level of contamination).
- Stakeholder impact (public needs and demands and regulatory framework).

These factors vary in content for nuclear and non-nuclear R/R. For sake of brevity, only power plants will be described in this paper as examples of redevelopment projects.

REUSE OF POWER PLANTS (TURBINE HALLS, ELECTRIC STATIONS AND GRIDS)

During the past few decades great changes in the electric utility industry have been experienced. Part of the fallout from these changes is that some older power plants are becoming expendable or obsolete. It is often too expensive to upgrade the current power plants to meet the new regulatory requirements or the location of the facility in a densely populated centre can result in the closure of an urban power plant. Negative public perception regarding a power plant in an urban centre could lead to closure of such a facility, even if it can meet the new operating and environmental requirements and standards.

Power plants have a number of qualities that make them ideal for redevelopment. The design style of older power plants makes them attractive for reuse from an aesthetic or historical perspective. Older power plants were constructed with large turbine-generator halls mainly because they were steam-cycle based that required large buildings and control rooms. These large spaces present major opportunities for developers to reuse the space. The large open spaces make old power plants ideal for conversion into museums and exhibit halls but the options should not be limited to museums and heritage facilities.

Older power plants were equipped with a good infrastructure (e.g. railways, roads and water supplies, used for cooling). The older power plants were initially constructed outside towns but became surrounded by other industrial and residential development. The value of the land and buildings of these older power plants have increased significantly. Older power plants are an excellent financial opportunity for R/R.

The decision for adaptive reuse options are influenced by a combination of factors of which the current owner’s view and the driving force(s) (internal and external) behind creating a new use for the facility are very important. The internal driving force is the owner’s vision regarding the redevelopment of the old power plant (e.g. development as offices, warehouse space, or selling the property for a profit). External driving forces such as economic development groups, museum committees, businesses, or government entities such as municipalities play an important role.

Nuclear industry

In the light of the ongoing nuclear renaissance, it is anticipated that existing nuclear sites are likely to be reused for new nuclear power plants. Reasons include:

- The number of locations committed to long-term restricted use and periodic surveillance and maintenance could be limited.
- The burden of long-term care and final disposition of retired nuclear power plants could be eased.
- Overall environmental impacts from the construction and operation of the power plants could be reduced.

- Time and money in completing licensing proceedings could be saved.

However, some stakeholders are opposed to construction of new nuclear power plants. In some cases the site of a former NPP may be used for other purposes, especially non-nuclear power plants that take advantage of the presence of the electrical distribution system and other suitable infrastructure. Some examples of planned or implemented reuse of nuclear power plants are given below.

Fort St.Vrain Power Station, Colorado, USA [6]

Original Use: Colorado US Fort St Vrain was a nuclear power plant that was converted to a natural gas fossil fuelled power plant. The plant was America's only commercial High Temperature Gas Cooled reactor design. The operation of the nuclear power plant was terminated in 1989.

Redevelopment: Complete defuelling and decommissioning of the main nuclear plant was completed by 1992. In 1996 the plant was converted to generate 130 MW of power burning natural gas and utilizing the old main steam turbine. The plant was expanded up to a total of 720 MW in 2001.

Outcome: Fort St. Vrain power station was successfully decommissioned and some of the original buildings and plant were reused for fossil fuelled power generation.

Pacific Northwest, B Reactor, Columbia River, Hanford, USA [7]

Original Use: The B reactor was the world's first large-scale nuclear reactor and was originally part of the Manhattan project. B Reactor was a major contributor to world history, science, technology and engineering. The reactor operated from 1944 to 1968.

Redevelopment: The B Reactor was part of the largest scientific, engineering and construction project ever (The Manhattan Project) and played a key role in ending World War II. These heritage values were sustained through the proposed reuse of the B Reactor as a Museum forming part of the American and world history. The Museum will be a commercial undertaking and will be open for tours. This reuse was demonstrated through a series of tours.

Outcome: The B Reactor Tour Route is free from hazards:

- The asbestos has been removed.
- Electrical system has been upgraded and emergency lighting installed.
- The ventilation system was improved to control radon levels.
- Fire protection improvements have been provided including emergency lightning and egress enhancements.
- It was confirmed that the exhaust stack meets seismic standards
- Safe radiation levels are ensured through continuous monitoring

The B Reactor has been recently designated as a US National Historic Landmark. The reactor currently holds up to 50 public tours annually. It is planned to increase public access to the B Reactor in response to growing public interest. Other Manhattan sites have already been designated as historic landmarks: the Los Alamos Scientific Laboratory, the X-10 Graphite Reactor at Oak Ridge, The Trinity Site in New Mexico and the Chicago Pile 1.

Shoreham NPP, Long Island, USA [8]

Original Use: After a three-decade political battle, the Shoreham NPP was permanently shutdown shortly after it went critical. Opponents of Shoreham, including local government, argued at the time that Long Island could not be successfully evacuated in the event of a major accident. Shoreham never reached commercial operation and has sat idle since its decommissioning in 1994. Now it could again generate electricity. Or maybe the 58-acre (240 000 m ^{2}) waterfront site on Long Island could become a ferry terminal or marina.

Redevelopment: A non-nuclear power plant was the most voiced option as the Long Island Power Authority (LIPA) convened in June 2008 the first meeting of a new Shoreham Advisory Committee established to find a use for the site. Over the past 14 years since the plant was mothballed before ever operating commercially, ideas for its use have been floated. Some suggested a ferry terminal for service to Connecticut. Others recommended a non-nuclear energy-generating plant. And there were proponents of demolishing the distinctive dome to create a waterfront park. Because of opposition or inertia, nothing came of the proposals. Other ideas included a ferry terminal, a marina with restaurants, a boatbuilding factory, a museum or an educational facility, windmills or some form of renewable energy technology. The property is zoned light industrial, so it would have to be rezoned for housing. The only use that is not an option is another nuclear plant because the statute that created LIPA prohibits that.

Outcome: Long Islanders - as taxpayers and utility customers - continue to pay off the billions in debt incurred in building and shutting down Shoreham.

Magnox South, Hinkley Pont NPP, UK [9]

Original Use: Hinkley Point NPP (two Magnox-type units) operated from 1965 to 2000. One of the most significant decommissioning activities to date has been the de-planting and refurbishment of the turbine hall.

Redevelopment: A huge space, covering 3500 ft^2 (300 m^2) in Hinkley's de-planted Turbine Hall, is the home of the De-planting Mockup Simulator (DMS), and it is planned that there will soon be a similar one built at Sizewell A. The DMS model was brought about by a similar scenario-based simulator built at Rocky Flats Environmental Technology Site in 2001. The DMS, which was opened in November 2007, is a decommissioning experience that allows the staff to gain first-hand knowledge of the environments they will encountered through different decommissioning activities. It creates conditions which include: noise, heat, cold and working with live tools. Simulated experiences are created that can involve staff working at height, in trenches and within soft-sided spaces.

Outcome: Initially the DMS will help to re-skill and retrain Magnox staff in de-planting and decommissioning activities, but is perceived to be of real value to all trainees, regardless of their experience.

Greifswald NPP, Germany [10]

Original Use: The Griefswald facility was used as a nuclear power generating station until operation was terminated in 1990.

Redevelopment: While the 5 NPP units are being dismantled the rest of the site is being converted to a number of new applications namely: an industrial harbour, waste management facilities, power plants, factories, etc. Some buildings were converted to new applications.
Outcome: The redevelopment process is intended to alleviate unemployment in an economically depressed region of the country, which depended on the operation of the NPP in the past. The

decommissioning project is extended over a long period of time intentionally allowing for the development of alternative industries.

Non-Nuclear industry

Most non-nuclear power plants were constructed not to far from a town or city. Over time these facilities became part of the city development, and are not isolated any more. Local governments strive to limit urban sprawl and eliminate inner-city poverty and decay. Obsolete power plants can be a risk to control urban sprawl and a challenge for regeneration. With the development of recent legislative and regulatory initiatives and innovative risk management tools, the market for brown field redevelopment is a strong motivation to encourage regeneration of urban land. Environmental insurance is a valuable tool that can eliminate uncertainty and encourage many projects to proceed.

Power plants have solid structures and are situated along lakes/rivers or have large sources of water available. The buildings have large floor space and height. This make the buildings ideal for reuse options such as museums, aquariums, restaurants, offices, hotels, libraries, science and technology centres, arts centres and stations for public transportation systems. A combination of the options can be used.

The R/R options influence the decommissioning endpoints especially in the case of museums or heritage facilities. In the case of industrial museums most of the equipment (e.g. power generators, control systems etc.) are to be kept in the original state and decommissioning includes clean-up actions and restoration options but not necessarily includes the dismantling and demolishing of equipment and parts of buildings. The architectural scale and open spaces of former power plants are very well suited to being used as museums. Some of these facilities are presented in more detail as case studies below.

Tate Modern museum, London, United Kingdom [11]

Original Use: A conventional fossil fuelled power station.

Redevelopment: The Tate Modern is a high profile world class and renown modern art museum converted from former Bankside Power Station, located on the south side of the River Thames. Attributes toward R/R of the former Bankside Power Station as a museum were its architectural distinction, location opposite St. Paul’s Cathedral (enabling the linking of the two by riverboat service and a new bridge), and the historical significance of the surrounding area. The Bankside Power Station supplied over 370 000 ft ^{2} (33 000 m ^{2}) of internal floor area which are used for display and exhibit space, shops, cafes, an auditorium, education area, and support areas. It was a very striking and distinguished building.

Outcome: Tate Modern is a leading example of the reuse of a conventional power station building (Fig. 1).

Fig. 1. The Tate Modern Building, a former power plant

Centrale (Power Plant) Montemartini, Rome, Italy [12]

Original Use: The power plant was started in 1912. It was close to the river to have continuous availability of water and outside the city borders to be exempted from local taxes on fuel. Initially power generation was 7000 kW but later on in 1924 increased to 16 000 kW with the addition of steam turbines. In 1963 parts of the plant were shut down and a few years later the plant was closed**.**

Redevelopment: Centrale Montemartini's conversion into an Art Centre started in 1980s. The transfer of hundreds of sculptures from the Capitoline Museums in 1997 marked the conversion milestone.

Outcome: Centrale Montemartini houses part of the Capitoline Museums' fine collection of ancient sculptures. Gleaming classical statues stand amongst rows of machinery, and although the contrast is bizarre it is also memorable and effective. The museum's habitual emptiness makes it all the more atmospheric. The main gallery on the first floor is a lofty industrial space, dominated by two huge diesel motors constructed by the firm Tosi in 1933. Around these are lines of marble busts and statues as well as segments of temples and triumphal monuments (Fig. 2).

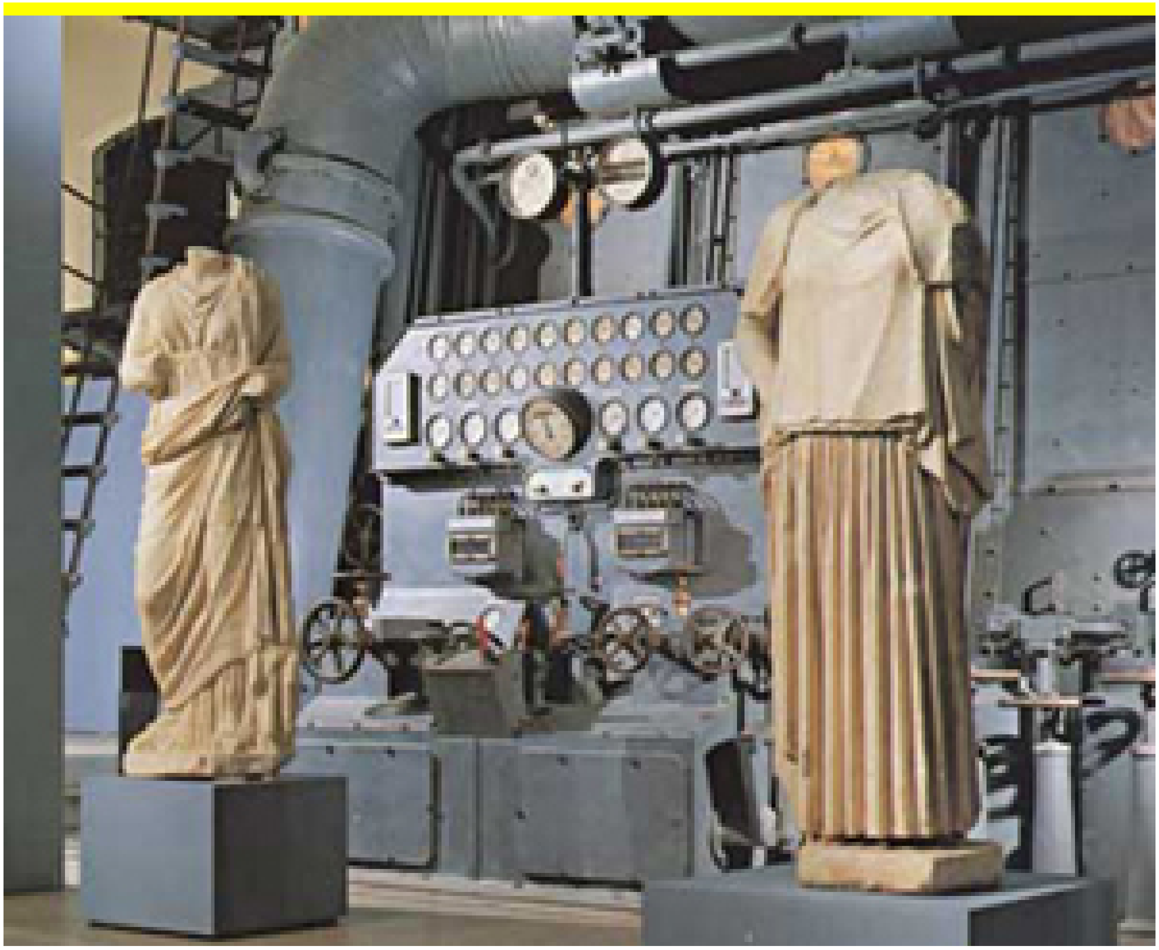

Fig. 2. “Centrale Montemartini”, Rome: from diesel power plant to museum of Roman antiquities

Former power plant, Baltimore, Maryland, USA [5]

Original Use: A former power plant facility.

Redevelopment: In Baltimore, Maryland, a former power plant facility located on the east side of the City’s Inner Harbor has had multiple uses since the original conversion. Historically, the power plant has been oriented to commercial uses but the businesses located there have not always prospered. This is in spite of the overall popularity of the Inner Harbor and the proximity of the power plant to the outstanding National Aquarium. The Power Plant complex underwent additional renovations in 1995 to make the area more commercially viable. One of the high profile businesses that was brought into the power plant complex was a Hard Rock Café restaurant

Outcome: An example of redevelopment of a power station facility for a use other than a museum.

New Braunfels Power Plant, Texas, USA [13]

Original Use: The power plant was originally built in 1921 and operated as an electrical generating facility until 1977.
Redevelopment: In New Braunfels, Texas, a power plant owned by the Lower Colorado River Authority is currently in the middle of the process of adaptive reuse. The facility is located adjacent to the Comal

River and popular Landa Park, both of which are popular public recreational areas. The power plant equipment has now been dismantled and the environmental issues addressed. These environmental considerations included primarily asbestos and metals-based paint. The future use of the facility was determined by a request for proposal process in which any interested party was encouraged to submit a proposal for reuse of the facility.

Outcome: The selected reuse is planned to be a commercial complex with a hotel and restaurants open to the general public. The adapted reuse of the shell of this former power plant is expected to work well with the surrounding public recreational activities.

Riga Contemporary Art Museum, Riga, Latvia [14]

Original Use: A conventional power plant.

Redevelopment: The existing power plant now houses the educational, media-related and production sections of the museum. The museum displays a variety of experiences from video to research to public programs and performances, organized around the art without necessarily implying a direct confrontation with the art objects. The exhibition space and the museum shop are located in an extended perimeter surrounding the existing power plant. The result was a single continuous neutral space with a flat roof and a glass façade, embedding the old in the new, making the power plant work for the museum in a utilitarian rather than symbolic way.

Outcome: Successfully redeveloped as a museum.

CONCLUSIONS AND RECOMMENDATIONS

There are numerous examples of successful projects where obsolete facilities have been converted into museums, libraries, office buildings, or commercial businesses such as restaurants. These projects can be performed economically by following a focused assessment, planning, and implementation process as described in this paper. There is a strong economic incentive for the R/R of historic buildings. The benefits of reuse relate to the individual building, and also to the wider area and community.

In the coming decades a large number of nuclear installations will reach the end of their useful lives and require decommissioning. Many of these installations will be decommissioned with the aim of replacing them by new installations that may serve the same purpose or another completely different purpose. By recognizing and promoting the redevelopment potential of sites early in their life it is possible to enhance the prospects for worthwhile redevelopment offsetting the costs of decommissioning and ensuring that best use is made of the material and land resources associated with the sites.

It should be noted that the need for R/R of decommissioned facilities/sites is ubiquitous across IAEA Member States having nuclear applications. This paper gives specific examples of R/R of power plants only, but similar approaches can be taken for research reactors, large industrial buildings, bunkers, underground vaults, medical facilities and the like. It is felt that R/R can alleviate the decommissioning burden for all Member States and sharing information and practical guidance on this emerging strategy can be mutually beneficial. In this way, R/R represents one important component of the newly-launched IAEA International Decommissioning Network, which is extensively described in another paper of the author in this symposium. As a specific example of this principle, in this paper it is suggested that experience on post-decommissioning redevelopment can be readily transferred by those having successfully exploited this option to those considering decommissioning in the short term.

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