

# EDUCATIONAL ASPECTS OF NUCLEAR TOURISM: SITES, OBJECTS AND MUSEUMS

N. Mazeikiene<sup>1</sup>, E. Gerulaitienė<sup>1</sup>

<sup>1</sup> *Vytautas Magnus University (LITHUANIA)*

## Abstract

The interest in everything atomic has increased upon the opening of the nuclear age. The public now has a way to embrace the history of the atomic age—through nuclear tourism. Throughout the world, sites where governments built Nuclear Power Plants (NPP), tested atomic bombs and where scientists performed research on atomic energy are now becoming tourist destinations. The paper discusses the educational aspects of nuclear tourism and presents it as a new niche of industrial tourism, theorize on how it overlaps with other types of tourism (energy tourism, dark and toxic tourism, etc.), and discuss specifics concerning its forms, sites, objects, locales, and possible impact on education. The research explores the sites, objects and museums of the nuclear tourism around the world focusing on museums presentations in official sites of nuclear tourism museums, sites and visitors' centres (such as Dukovany power plant information centre; Temelin power plant information centre; Hiroshima Peace Memorial Museum; 'Chernobyl Exclusion Zone'; The National Museum of Nuclear Science & History and other) to understand what how educational aspects are presented in the virtual museum self-presentation. It is concluded that the benefits and impacts of forms of nuclear tourism for local communities and the environment must be further researched.

Keywords: Nuclear tourism, industrial tourism, science museum, education, dark tourism.

## 1 INTRODUCTION

The article presents efforts of the authors to scientifically substantiate development of new educational nuclear/ atomic tourism route in the Ignalina Nuclear Power Plant (hereafter, INPP) region in Lithuania in the framework of the project EDUATOM<sup>1</sup>. The project team is seeking to apply new approaches in STEM education and use the practice of similar nuclear tourism science, history and technology museums, Nuclear Power Plants' (NPP) information and visitor centres and sites in other countries. It is planned in the future nuclear tourism tour to include into the exposition of the INPP Information Centre such activities as lectures, creative laboratories, camps, events, performances, temporary exhibitions. The scholars and staff of the INPP envisage to create the exposition which would be based on the best practices of Science Centres and meet educational needs of different groups of visitors. Current exposition at the Information Centre at the INPP is dedicated mostly to technological and security aspects of decommissioning. The town Visaginas was built in 1975 by workers, most of whom were of Russian origin, arrived or were sent by soviet authorities from various places in the Soviet Union. Initially designed by Soviet authorities as a satellite-settlement for the workers of the plant, Visaginas is still isolated from the rest of the country both culturally and geographically. Decision on decommissioning was made upon Lithuania's accession to the EU. The first block the INPP was suspended in 2004, the second in 2009. The completion of the INPP decommissioning works is planned for the year 2038. The current exposition presents the historical and social development and identity of the town of Visaginas quite fragmentarily.

Current trends in development of nuclear tourism in other countries could become a valuable source of new ideas and approaches for the INPP region.

<sup>1</sup> The project 'The Didactical Technology for the Development of Nuclear Educational Tourism in the Ignalina Nuclear Power Plant (INPP) Region (EDUATOM)' (No. 01.2.2-LMT-K-718-01-0084/232) is funded by the grant from the Research Council of Lithuania.

## 2 METHODOLOGY

The purpose of the article is to reveal educational potential which is envisaged in existing nuclear tourism sites and tours around the world while analyzing cases of nuclear tourism sites, objects and museums and focusing on their presentations in official websites and social media. The authors raise a question how the practices of other nuclear tourism sites could be applied to design the tourist route in Visaginas and INPP region.

The research explores the sites, objects and museums of the nuclear tourism around the world focusing on museums presentations in official websites and social media channels of nuclear tourism museums and sites (such as Dukovany power plant information centre; Temelin power plant information centre; Hiroshima Peace Memorial Museum; Chernobyl Exclusion Zone; The National Museum of Nuclear Science & History and other). The research is aimed to understand what educational aspects are presented in the virtual self-presentation of the museums by using research strategy of case study, including methods of secondary data analysis, scientific literature review and qualitative content and thematic analysis, which allowed researchers to reveal the concepts and themes while analyzing and studying webpages of different tourist sites, objects and museums. The authors revealed such themes as: Energy tourism at the Information/ Visitors Centers of nuclear power plants; Dark tourism in the places of nuclear disasters; Military nuclear tourism and STEM education in nuclear tourism museums and NPP information centers. We explored the sites, objects, museums of nuclear tourism from the outside perspective and studied them from the point of a potential visitor and learner.

## 3 RESULTS

### 3.1 Nuclear tourism for energy literacy

Nuclear tourism can be considered as a specific form of energy tourism. This specific area of tourism is characterized by the tourism attractiveness of industrial sites in the country, new technologies or power plants ([1]). Extensive development of tourism is closely associated with a rise in the education demand of activities of tourism. Industrial, respectively nuclear tourism is a special interest tourism when certain groups of tourists (experts in energy, engineers, students of technology universities, pupils of high schools, etc.) have specific interest in the subject. Nuclear tourism is a segment of energy tourism. The term energy tourism is widely discussed in the paper by B. Frantál and R. Urbánková ([2]), and the authors provided analysis of energy tourism in the Czech Republic; they evaluated tourist attractions related to energy sector and described nuclear power plant and surface coal mine.

On the one hand, 'energy landscapes' ([3]) become tourist attraction as something very specific and different from places where tourists themselves live. Energy landscapes perceived as visually or environmentally polluted, potentially discouraging tourists from visiting them. On the other hand, energy facilities and energy landscapes may also become the tourist attraction. Tourists want 'to gaze on different landscapes and townscapes that are unusual for them' ([4], [2]). Therefore, objects such as giant cooling towers at nuclear power plants could be experienced as tempting and fascinating by tourists. Places where atomic disasters happened, which have been conceptualized as dark tourism destinations (e.g. tours to the Chernobyl power plant accident area), can also be considered as fascinating and mysterious and attracts more and more visitors every year.

Nuclear power plants with giant cooling towers can be regarded as kinds of modern cathedrals ([5]), presenting tourists with not only a technical education but also with an extraordinary visual experience; this could be one of the reasons why people organize wedding ceremonies with a nuclear plant as a backdrop, as in the case of Temelin power plant in the Czech Republic ([6]). The authors ([2]) point out that the energy tourism (including nuclear tourism) has potential to improve people's 'energy literacy', improve understanding how we consume energy, raise awareness of nuclear waste repository or potential impacts of nuclear activities on local economies. Regarding nuclear power plants certain content of knowledge and experience could be exposed here: history and construction of power plants; the principles and technology of atomic energy production and related matters, such as nuclear safety and security; topics related to radioactive waste disposal; environmental and landscape impacts. So, educational impact of energy tourism is obvious – it becomes a part of science and STEM education, promotes environment education, contributes to the development of responsible citizenship, knowledge on heritage and history. New forms of nuclear tourism combining environmental education, the presentation of novel technologies, interactive popular science

experiments, and various outdoor activities have been designed to attract not only the technologically curious tourism segment (i.e. expert energy tourism), but also family oriented or adventure seeking tourists (i.e. experience energy or nuclear tourism) ([2]).

All these declared and anticipated educational benefits of the energy tourism (including nuclear tourism) are questioned and they raise some doubts taking into consideration very strong intention of energy companies supporting and organizing this tourism to influence public opinion about certain energy branch. The companies seek to represent themselves as socially responsible and environmentally aware producers. The companies tend to show certain energy sector and energy sources as safe and economically useful ([2]). So, implementation of educational benefits is contested and challenged by the 'hidden curriculum' (concealed content and message as a part of public relations and corporate branding strategies of energy companies).

The use of nuclear tourism (Nuclear Power Plants (NPP), atomic bomb museums, etc.) to influence public opinion and shape public policy in favour of the pro-nuclear agenda has already become a usual public relations strategy of the nuclear industry ([7]). Just recently, energy companies have begun offering new event and experience-oriented tourism products to attract – separately from experts, enthusiasts, or businesses – additional segments of tourists, such as young people, families with children, or seniors.

In order to answer what is the educational potential of nuclear tourism we will explore the sites, objects and museums of the nuclear tourism around the world focusing on museums presentations in official websites of Nuclear tourism science, history and technology museums (such as Dukovany power plant information centre; Temelin power plant information centre; Hiroshima Peace Memorial Museum; Chernobyl Exclusion Zone; The National Museum of Nuclear Science & History and other and other) to understand what and how educational aspects are presented in the virtual museum self-presentation.

### **3.2. Energy tourism at the Information Centers of nuclear plants: case study of Dukovany and Temelin Nuclear Power Plants:**

Dukovany and Temelin Nuclear Power Plants (NPP) information centers present an attractive journey to electricity from the atomic core in the midst of historic interiors and are providing variety of educational activities: visitors can learn about the exhibited models of the reactor and the reactor unit, deposition of spent nuclear fuel and get other technical information. Also there is an opportunity to get an idea on the functioning of the nuclear power plant using modern audio-visual technologies. The mission of the Dukovany and Temelin nuclear power plant's information centres is to introduce the public to the technology of nuclear energy generation and related matters, such as nuclear safety and security, or radioactive waste disposal. Energy tourism has a potential to improve people's 'energy literacy', understanding how we consume energy, raise awareness of nuclear waste repository or potential impacts of nuclear activities on local economies, environmental and landscape impacts. Professional guides working in the Information Centres provide visitors with detailed information and explanation on the power plant and nuclear power engineering. A visit to the power plants' information centres includes a film on the history and construction of power plants, the principles of atomic energy production and radioactive waste disposal, and interactive exhibits with various 3D models and plans of the plants. Comparing to Dukovany NPP information centre, Temelin NPP information centre is more interactive and visual, as there is an opportunity to stroll through the virtual Nuclear power plant tour and find some more information (<http://virtualniprohlidky.cez.cz/cez-temelin-aj/>). It is exceptional that Temelin's information centre serves also as a popular place for wedding ceremonies, where newlyweds can be photographed with giant cooling towers in the background as witnesses to their wedding vows ([6]) as it is housed in a preserved historical chateau called Vysoky Hradek, which is located close to the power plant.

### **3.3. Dark tourism in the places of nuclear disasters: Hiroshima Peace Memorial and Chernobyl Exclusion Zone**

R. Stone et al. ([8]) describe Hiroshima as educational and emotional example of "dark tourism," "grief tourism" or "battlefield tourism," which include Nazi concentration camps in Europe, Cambodia's torture prison and killing fields, and West African slave ports, as well as the Nagasaki Peace Park and Atomic Bomb Museum and many other. The Hiroshima Peace Memorial Museum (HPMM) collects and displays belongings left by the victims, photos, and other materials that convey the horror of that

event, others that present the current status of the nuclear age. Each of the items displayed embodies the grief and pain of real people. It is stated in website of HPMM that Hiroshima's deepest wish is the elimination of all nuclear weapons and the realization of a genuinely peaceful international community. Hiroshima Peace Memorial Museum (HPMM) memorial is one of the most popular tourist destinations in Japan. All pupil visit this place during their studies in the school.

The official site of the HPMM emphasizes educational part of the museum through testimonies and lectures and learning about the A-bomb and Peace, which includes educational page for children called "Kids Peace Station". This is the peace education website especially for children. It uses animation and illustration charts to explain the reality of the A-bombing with a particular focus on the life of Sadako, who is known in the world as a girl of paper cranes ([http://www.pcf.city.hiroshima.jp/kids/KPSH\\_E/top\\_e.html](http://www.pcf.city.hiroshima.jp/kids/KPSH_E/top_e.html)). The page for kids is divided into 3 topics with different materials and forms presented in each: 1) The Sadako Story 21- philosophical and existential learning animation to introduce children experience facing the outcomes of nuclear weapons; 2) Sadako and the Atomic Bombing, which presents the damage of the atomic bombing through the story of Sadako's life. This part provides detailed information on bomb construction that was dropped on Hiroshima with the title of the bomb "Little Boy" and animated flash video with its construction inside, measurements of the bomb in comparison with the child standing and the mechanism of activation and explosion; 3) Special part is dedicated to radiation. It is based on physics and chemistry subjects and provides relevant data and interactive information on radiation topics.

The atom bombing place plays an important educational role in citizenship and history education; it is considered as an essential element of the national project in constructing collective memory and building post-war national identity in Japan. So-called 'atomic-bomb nationalism' is promoted by creating the 'victimization narrative' and unifying national feelings of suffering and being victims after defeat in the war ([9]). One more constituent elements of postwar identity in Japan besides collective mourning and grief is an anti-nuclear stance and seek for peace. These messages of suffering, the traumatic experiences of victims during the bombing and its aftermath, anti-nuclear discourse and promotion of peace are reflected strongly in the part of HPMM which was built first and expresses a traditional approach in representations of history and identity. Scholars ([9]) distinguish and describe new messages and themes in more recent parts of the Hiroshima Peace Memorial Museum (the East Building exhibit) where other messages than suffering and pain are exposed. The museum presents three exhibitions: "Introductory Exhibit," "The Dangers of Nuclear Weapons," and "Hiroshima History". New topics presented are the history of Hiroshima City before and after August 1945, Hiroshima's rebirth and reinvention as the City for Peace. According to C.-L.Chen ([10]), the exhibit introduces Hiroshima's importance as a military supply base and port during the World War II and in this way provides an explanation why Hiroshima was chosen as an atomic bombing target. One of the exhibits - a panel entitled 'Lessons of History' reflects a critical examination of not just the atomic bomb but also war and the causes of war. However the author [10] states that the exposition doesn't present critically the role of Japan in the war and doesn't reveal its imperialist and colonial ambitions, aggressive militarism and its victims. The museum presents a-bombing in the context-free manner. Similarly, other scholars stress the amnesiac relationship between atomic bomb memory and Japan's wartime past ([9], p. 352).

Another emerging 'dark tourism' destination is the Chernobyl power plant site and its surroundings. In recent years, the 'Chernobyl Exclusion Zone' (the area around the exploded Chernobyl reactor) has become quite popular among tourists. As G. Yankovska & K. Hannam ([11]) mentioned in their study referring to other sources, 7500 tourists traveled to the exclusion zone. The "Zone" is still dangerous for visitors - in some place there is still a high level of radiation and this area is still contaminated. The authors conducted interviews with tour guides (tourists guides) and tour agents (who sell the tours) and identified the content of tours, educational and other impacts on individual groups. The overall educational potential of dark tourism in the Zone is the educational lessons to be learned from the Chernobyl disaster about the tragedy and human catastrophe, reasons and impacts of the disaster, ways to prevent future catastrophes.

It can be assumed that in this case, dark tourism is related to the aforementioned energy tourism too, since it reveals the consequences of the destructive use of the atom when catastrophes happened due to technological and personnel mistakes and technological unsafety and insecurity of nuclear industry, which lead to thousands of people's deaths and causes enormous suffering. Nuclear tourism

in this object as an example of the combination of energy tourism and dark tourism, makes it possible to better understand the controversial aspect of nuclear energy, the potential consequences and the effects of radiation on people affected by the accident and future generations. The tourism in this place is classified as toxic and environmental tourism ([11]). The toxic tourism which deals with the relationship between environmental and social degradation (including situation of underprivileged local communities) reveals effects of industries (in this case nuclear energy industry), terrible environmental effects on nature and humans living in the area.

The study of G. Yankovska & K. Hannam ([11]) revealed the content and topics of the tours that have strong educational experience and hypothetical educational effect:

- picture the pre-disaster life in the town of Pripjat, the information about the communist USSR and the exclusion zone.
- details about the catastrophe and what people experienced (authentic, “real” stories about experiences of tourist guides themselves and other people)
- emotional, existential and educational impact on tourists after their personal interaction with the local residents of the exclusion zone; learning about their style of life, feelings and memories.

It is interesting to notice that the tourist organizers participated in the research conducted by G. Yankovska and K. Hannam ([11]) distinguish 2 different types of tourists according to their motives of visiting the place. Younger tourists (age 18-28) are more interested in getting strong emotions of having adventure („fun, fear and thrill“). For them the tour is associated with environment and activities of famous video game S.T.A.L.K.E.R. created by Ukrainian game developers. This game refers to the novel ‘Roadside Picnic’ (The Strugatsky Brothers) and the movie ‘Stalker’ (Andrei Tarkovsky), so for more informed and educated tourists this place and the tour have additional symbolic meaning. Another type of tourists composed of older people (age 28-40) is interested in learning more about suffering, radiation and other consequences of the disaster. So, different programmes and tours are organised for these two types of tourists. It can be assumed that they are two different types of learners who get different experiences and educational effects. However, in both cases the main reason for going is the intention to get experience from the encounter with death in the place of disaster. That is why from educational point of view it becomes an important task to transform this thrilling experience of facing the death to the educational experiences of learning.

The educational potential of dark tourism cannot be limited to the acquisition of knowledge and gaining the understanding. Visiting such places can be perceived as an existential experience. The authors who analyze the dark tourism in the Chernobyl zone ([12]) distinguish a particular existential feeling experienced by visitors in dark tourism sites - a post-modern sublime. It is a mixture of ungraspable and unimaginable horror with pleasure and excitement. The sublime is ‘a mode of subjective experience, a broadly pleasurable sense stimulated by landscape, but combining terror and awe, which anticipates dark and thana-tourism as a leisure activity...The sublime combines fear in the face of the infinite or incomprehensible, with a transcendence of that fear’ ([12], p. 127-128).

Chernobyl is the place where this experience of the sublime is felt that is why the authors ([12]) call the ‘Zone’ a site of ‘sublim tourism’. This dark experience gained while being in the ‘Chernobyl Exclusion Zone’ can become an aesthetical perception and be expressed through an artistic attempt. It is more sophisticated form of educational experience which unites all educational aspects mentioned above – deep and strong existential experience, aesthetic perception, environmental awareness and concern, philosophical and sociological understanding of consequences of nuclear disaster and the greatest human catastrophe. The authors ([12]) analyzing dark and ‘sublime’ tourism in Chernobyl came up with the observation that many tourists who visited the site seek to share their impressions online for public viewing. It can be assumed that in this way existential and educational impact on broader international audiences and greater number of people is done. The website [www.pripyat.com](http://www.pripyat.com) contains hundreds of photographs made by the tourists (the town of Pripjat is former town-satellite of Chernobyl NPP) which became an iconic representation of the nuclear disaster. Tourists who visited Chernobyl expressed their specific existential pre-reflective experience of sublime in the photographs as an artistic expression. According to the scholars ([12]) these photos depicting tourists’ engagements with the abandoned town Pripjat present the post-modern sublime - intangible, direct personal and indirect cultural experience, cultural trauma and anxiety of nuclear disaster, ambivalent attitudes towards science and technology.

Summarizing the above-mentioned statements about the educational potential of dark tourism, it could be stated that it deals with increase in tourists’ environmental awareness, critical approach toward destructive nuclear power technologies. That’s no less important, the educational potential derives

from deep transforming existential experiences like sublime and from artistic attempts to express an aesthetical perception and ungraspable feelings of visiting places of death and suffering.

### 3.4. Military nuclear tourism

Sites of the Manhattan Project is one of most popular nuclear tourist destinations. The Manhattan Project was dedicated to the development of the world's first atomic bomb. A bomb research and design laboratory in Los Alamos, New Mexico was initiated and uranium enrichment facilities (reactors) at Oak Ridge, Tennessee, and the world's first plutonium producer B' Reactor at Hanford in Washington State were created. Los Alamos, New Mexico, Oak Ridge, Tennessee, and Hanford, Washington are the main sites for the program and secret cities where scientists performed research on atomic bombs (later atomic energy). The Manhattan project sites include also places where atomic bombs were tested. Nowadays nuclear tourism is organized in museums, field sites and laboratories: New Mexico's Bradbury Science Museum in Los Alamos (it is the official museum of the Los Alamos National Laboratory (LANL); the National Museum of Nuclear Science and History in Albuquerque, the American Museum of Science and Energy in Oak Ridge, the National Atomic Testing Museum in Las Vegas sixty miles south of the Nevada National Security Site (formerly the Nevada Test Site), and the Columbia River Museum of Nuclear Science and Technology in Richland Washington (near Hanford nuclear production complex). All these objects reflect and expose America's nuclear defense landscape. Nuclear tourism is dedicated to the history of the Manhattan Project, at the same time it deals with history of nuclear weapons and the sites where they were tested. Several internet websites (<https://www.atomictourism.net/> and <http://www.atomictraveler.com/>) were created to promote this type of tourism in U.S.A. and worldwide (including such objects like Chernobyl, Hiroshima and Nagasaki)

In U.S.A. the nuclear tourism has an idea of commemoration of history of the Cold War and nuclear developments. Scholars ([13]) describing this type of tourism in U.S.A stress importance of these objects and sites for residents and citizens of the country. While visiting historical places of the Manhattan Project the residents feel "a sense of civic pride", "learn about the birth of the atomic age, and stand where history was made", "commemorate this important period in history", "share the history that shaped their generation with their own children". Numerous institutions seek to preserve historical sites and artefacts of the Manhattan project as heritage objects (i.e. The Atomic Heritage Foundation (AHF), a nonprofit corporation dedicated to "preserving the history of the Manhattan Project and the Atomic Age").

These sites are considered as a valuable part of the historical and nuclear heritage which has to be preserved. Their role in commemoration of important historical events and periods is significant; at the same time the nuclear discourse has an important impact on building national identity. Scholars analyzing the role of the Manhattan project ([14], [15]) consider it as the American nation-building project which started after World War II, lasted during Cold War and has been developed in post-Cold war period. A revival of the 'nuclear nationalism' has been observed after September 11, 2001.

Main institution which takes care about preservation of historical heritage of the Manhattan Project and promotes nuclear tourism is the Department of Energy (DOE). All these museums are supported by DOE. Scholars ([15]) who reveal interests of governmental institutions to promote nuclear tourism and preserve nuclear heritage stress interrelation of nuclear discourse in the nuclear tourism with prevailing national defense policy and practice.

The scholar ([15]) highlights complexity and controversy of the legacy of American nuclearism when balancing between appreciation of constructive power of nuclear energy and the recognition of its destructive past and potential. It is asked by this researcher how to deal with challenge and controversy, on the one hand, to celebrate American nuclear science and, on the other hand, to adequately acknowledge the suffering caused by nuclear power to people in the past (nuclear devastation of Hiroshima and Nagasaki, suffering of regional residents who are chronically affected by radiation of atomic testing).

The educational impact of the nuclear tourism in the Manhattan Project focuses primarily on residents and citizens of the country whereas national identity is constructed through the development of so-called 'nuclear nation' by providing knowledge of industrial nuclear heritage, forming pride in national science and industry, and shaping the perception that the country was a leader in entering the Atomic Age, conducting stunning scientific discoveries about the atomic energy. This tourism has a positive educational potential for raising the interest of young people in science, promoting science education (the research laboratories in these museums carry out this function). At the same time, the exhibitions can hypothetically have a positive educational effect on development of energy literacy - providing

knowledge about production and use of nuclear energy, advantages and disadvantages of peaceful use of nuclear energy, environmental, economic, political and other aspects of the deployment of nuclear energy. At the same time, the controversy of this tourism manifests itself, as fascination with the scientific discoveries made in the country and the creation of a powerful nuclear industry is simultaneously constructed along with the pride of the military power of the country, and industry of nuclear weapons. Even more controversial is the interaction of the pride and fascination with the perception of the destructive and catastrophic consequences of the military nuclear industry (atomic bombs blasts in Hiroshima and Nagasaki and victims of the nuclear industry in the country).

The most important nuclear museums in the United States, proclaiming its atomic heritage are the Bradbury Science Museum, The National Atomic Testing Museum and the National Museum of Nuclear Science and History. The National Atomic Testing Museum information on the exhibitions presents experiential and simulation-based activities in the museum. There are several exhibitions: A simulated atmospheric bomb blast features a bunker with a simulated bomb explosion; Tracking, monitoring and measuring radiation; Atomic culture and etc. The Museum uses lessons of the past and present to better understand the extent and effect of nuclear testing. It provides collection-based exhibits and learning activities for the public. Its collections and activities are targeted toward visitors and learners of different age, background and knowledge level. The museum official website provides a variety of educational materials, for example video lectures (<http://nationalatomicmuseum.org/education/lectures/>), also free Radiological Education Seminars to middle, high school and college students, and adults interested in studies in radiation science. These seminars include such topics as: Radiation Fundamentals; Radiation in the World Around You; Biological Effects of Radiation; Medical Applications of Radiation; Radiation Detection; Radiation in Consumer Products; Global Radiation Accidents; Radiation in Space. The official website of the museum provides also an information for parents (<http://nationalatomicmuseum.org/education/parents/>) about three topics (the Nevada Test Site, the Manhattan Project, the Cold War). The museum exposes its exhibits in three main galleries. The Defense Gallery reflects the central mission to ensure the safety, security, and reliability of the U.S. nuclear deterrent while reducing the global threat of nuclear, chemical, and biological weapons. The exhibits present Little Boy and Fat Man, the first nuclear bombs; Historic Manhattan Project Sites; WWII: A World at War; The Plutonium Legacy; Underground Testing and other. The Research Gallery conducts leading-edge research in many areas of science and technology to help solve national problems related to energy, the environment, infrastructure, and health. As Gerster ([15]) writes, it reflects the Laboratory's basic and applied work, from 'environmental successes' at home in cleaning up radioactive waste (overlooking what created the problem in the first place), to the use of LANL technology to probe the surface of Mars. But perhaps the most popular is the 'History Gallery', which traces the making of Los Alamos into a dedicated professional community that would proverbially alter the course of history. Exhibits presented in this gallery: *The Atomic Age Timeline*; *Manhattan Project History*; *They Changed the World: The People of Project Y at Los Alamos*; *A New Look at Trinitite*; *The Fireset: How Fat Man was Triggered*.

### **3.5. STEM education in nuclear tourism museums and NPP information centers**

Informal learning in museums may contribute to enhancing scientific literacy on environmental issues, technical and engineering skills, develop responsible citizenship, knowledge on heritage and history. STEM education through Informal learning and "out of classroom experiences" is encouraged on most levels of the educational system as means of strengthening students' interest and motivation. Museum visits represent one type of such experience, and museums are investigated as means of improving the scientific literacy of both students and adults ([16]). The potential of museum visits for producing lasting memories has been documented ([17]), although research indicates that an exhibition's potential for mediating learning of new concepts is limited ([18]). New forms of nuclear tourism combining environmental education, the presentation of novel technologies, interactive popular science experiments, and various outdoor activities attract schools to organize educational visits to museums in order to give understandable and unbiased scientific information about different topics: atoms, radiation, ionizing radiation and health, reactors, robots, physics and much more. Dukovany and Temelin Nuclear Power Plants (NPP) information centers organize school visits, which are supplementary to physics and chemistry curriculum. Regarding school visits to museums, studies have shown that a museum visit, in combination with pre- or post-visit experiences in the classroom, may provide considerable learning outcome for students ([16]). Many educational activities in STEM are provided in the Information Centre of Dukovany, for example: Reactor core model and Reactor

model allow students to get knowledge about even relatively small details of the reactor and to learn what happens inside the reactor in the course of operation. Informal evaluation of pupils' knowledge in physics might be performed through a "Play", where the players (visitors/ learners) are invited to connect and relate images (faces) of discoverers (scientists), their names and their discoveries. Education activities are provided through simulations how electric energy is produced in the Dukovany Nuclear Power Plant. Temelin NPP information centre provides STEM education through such educational activities as Cloud chamber, which is one of a few devices enabling the observation of radiation particles trajectories. The National Museum of Nuclear Science & History exhibits spanning the early research of nuclear development through today's peaceful uses of nuclear technology. The official site of the museum has developed a variety of educational programmes for 3 groups: kids camp; for teachers; homeschool. The educational programme is based on learning about robots, biology, forensics, engineering, chemistry, physics, weird science and more. Information for teachers is presented in detailed and interactive way. Beside the communication on 2 relevant annual events "Discover STEM week" and "Nuclear Science week" (<http://www.nuclearscienceweek.org/about-nsw/>), there is also presentation of variety of educational programmes for school children from grade 2 to 12 in the field of energy, electricity, chemistry and physics. The museum organizes simulation activities in atomic energy production, introduction to nuclear radiation, builds understanding of isotopes and their stability, develop critical reasoning skills to explore if nuclear power is the right choice for their community.

As an example of museums' activities relevant for school curriculum could be mentioned a research conducted by Henriksen E.K. and Jorde D. ([16]). The Norwegian Museum of Science and Technology (NMST) developed an exhibition "Our Radiant World" (Norwegian: "Vår strålende verden") in cooperation with the University of Oslo. Its aim was to provide comprehensive scientific information about three radiation-related topics often encountered in the environmental debate. The exhibition's central themes were: Ozone and UV radiation; The greenhouse effect and global warming; Ionizing radiation and health. The research showed, that museum educators should become familiar with school curricula and carefully consider which aspects of the museum's service may become the best complement to the school science curriculum. When developing exhibitions aimed at students, aims of school curriculum must be considered in the exhibition development process. In addition museums may make their services and expertise available to schools in a number of ways, including: involving students into museum work (collection, information gathering, and exhibit design); offering Internet services suited to the goals of school curricula and giving students opportunities to interact with museum staff; offering activities such as field trips, drama sessions, demonstrations, etc.

## 4 CONCLUSIONS

The analysis of nuclear tourism sites and objects and the scientific literature review give insights and provide practical guidelines how to create a nuclear tourism route in the Ignalina Nuclear Power Plant (INPP) region and Visaginas (Lithuania) in the framework of the research project EDUATOM. Exposition in the Information Centre at the INPP is considered as an object of energy tourism presenting nuclear power as a resource of energy and the INPP as a former part of energy industry of the country. The current exposition and the one updated in the future expose the process, principles and technology of production of nuclear energy and may contribute to the development of 'energy literacy'. The closing and decommissioning of the INPP create a specific content of the exhibition when technological aspects of this process are demonstrated. Other important elements of 'energy literacy' (awareness raising on nuclear waste repository, environmental concerns, potential impacts of nuclear activities on local economies, economic and social aspects of nuclear energy industry) are presented in the current exposition according to communication strategy of closing the INPP and performing the decommissioning. On the one hand, the exhibition gives an implicit anti-nuclear message since the rationale for the closing was potential unsafety of the INPP because of model of nuclear reactor which is the same as in Chernobyl). On the other hand, the exposition presents the decommissioning and related issues (nuclear waste repository, environmental and landscape impacts) in line with pro-nuclear agenda by showing the decommissioning as safe and reliable process which is 'in good hands' of professionals by not showing potential environmental risks of waste repository. It could be noticed that the exposition is a part of public relations of the INPP. The authors who analyze energy tourism stress its controversial nature when energy companies (organizers of energy tourism) use tours and exhibitions as a part of their public relations and corporate branding strategies showing their responsibility, reliability and expertise. Seeking to develop a more critical version of energy

literacy tourists and visitors as learners should get an opportunity to develop multiple perspectives on nuclear energy industry which would combine pro-nuclear and anti-nuclear arguments. Storyline on Chernobyl disaster in the exposition could strengthen anti-nuclear agenda and show horrible environmental and human consequences of mistakes and irresponsibility in nuclear energy industry.

Besides energy literacy and environmental education, nuclear tourism has educational potential on promoting STEM education, strengthening scientific literacy, technology and engineering skills. Science education activities at nuclear tourism museums, visitors and information centres show that very wide range of topics and subjects in many science disciplines can be presented. Expositions and experimental science education activities help students and other learners to improve their knowledge and skills in physics, biology, engineering, chemistry, environmental topics. Prevailing topics are nuclear energy and radiation-related themes. At the same time attractive forms of informal learning are used as a complementing element of formal education and school curriculum. Interactive science experiments, outdoor activities, creative laboratories, performances, camps and other learning attractions are arranged in cooperation with schools and other local educational institutions.

Analysis of Hiroshima Peace Memorial Museum in Japan and the Manhattan project in U.S.A. revealed important role of nuclear tourism in nation building processes and citizenship education. As it was delineated by the authors analyzing 'nuclear nationalism' and national projects of identity, a critical approach and critical awareness should be enacted here by giving learners and citizens diverse perspectives on history and heritage. Trying to apply these ideas to the development of nuclear tour in the Ignalina Nuclear Power Plant (INPP) region and Visaginas, the developers (including the authors of this article) recognise the importance of the nuclear tourism for the identity building - the tour could strengthen and at the same time redefine the place identity of the Ignalina Nuclear Power Plant (INPP) region and Visaginas town which can be presented in nuclear tourism as a site of industrial and urban heritage.

## ACKNOWLEDGEMENTS

This article is the part of the research work in the project EDUATOM. The project 'The Didactical Technology for the Development of Nuclear Educational Tourism in the Ignalina Nuclear Power Plant (INPP) Region (EDUATOM)' (No. 01.2.2-LMT-K-718-01-0084/232) is funded by the grant from the Research Council of Lithuania.

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