JOURNAL OF ENERGY TECHNOLOGY
Vol. 18, No. 3, pp. 169–176, November 2025

Professional Article

DESIGN AND FABRICATION OF A DEMONSTRATION MODEL FOR PROMOTING LOW-CARBON ENERGY TECHNOLOGIES

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Submitted
1. 10. 2025

Accepted
26. 10. 2025

Published
28. 11. 2025

Abstract This article presents the design, construction and educational application of a large-scale model representing renewable energy facilities that do not yet exist. The model features a circular layout with a diameter of 2 metres, divided into two halves: the Mokrice Hydropower Plant and a nuclear power plant with an accompanying low- and intermediate-level radioactive waste repository. The Mokrice half highlights key ecological and technical features, including two fish passages and a solar power plant installation, with realistic water effects achieved using epoxy resin. The nuclear half includes a removable low- and intermediate-level radioactive waste repository, allowing viewers to explore the storage arrangements via a cross-sectional view. All the components were fabricated using FDM 3D printing, assembled, finished with paint and landscaping materials, and mounted on a wooden base with a metal support structure. While the model was not intended to achieve exact technical scaling, it communicates complex energy infrastructures effectively, facilitating public understanding, awareness and dialogue about low-carbon technologies. The combination of additive manufacturing, interactive features and detailed landscape representation, demonstrates the value of models as tools for education, demonstration, and the promotion of sustainable energy solutions.

Keywords
model,
nuclear power plant,
hydro power plant,
3D printing,
CAD

https://doi.org/10.18690/jet.18.3.169-176.2025

University of Maribor Press

1 Introducton

Physical models are employed frequently as effective instruments for communication, education and public outreach. Their primary role is not necessarily to achieve technical precision or exact dimensional accuracy, but rather to provide a tangible medium through which complex infrastructures and technologies can be presented more comprehensibly to non-expert audiences. In this sense, the models serve as cognitive bridges, translating abstract or large-scale systems into accessible and visually engaging forms.

The demonstration model was commissioned by GEN energija, for promotional purposes, in collaboration with HESS and IBE, who are preparing the documentation for the Mokrice Hydropower Plant. The infrastructure of the Mokrice Hydropower Plant has been documented, while the nuclear aspect is still in the spatial planning phase. The model's design emerged from a collaborative brainstorming process involving the entire team of authors, balancing the client's requirements, technological constraints and the need for simplification in scaling.

A demonstration model was developed with the specific purpose of promoting the concept of a new nuclear power plant and illustrating its integration with associated infrastructure, such as a repository for low- and intermediate-level radioactive waste. Complementing this, the model also included a representation of the Mokrice Hydropower Plant, thereby demonstrating the coexistence of different energy technologies within a unified energy landscape. The aim of this model was not technical perfection or full-scale accuracy, but rather to raise public awareness, enhance understanding, and stimulate dialogue regarding nuclear energy and its role in low-carbon energy production.

2 Objective and purpose of the model

The primary goal of the model was to function as a communicative and educational tool rather than a technical prototype. Energy infrastructure models are often complex and abstract, making it difficult for non-specialist audiences to understand their structure, operation and interconnections fully. By transforming these systems into a tangible representation, the model helps the public to grasp the scale, spatial arrangement and functional principles of renewable and nuclear energy facilities.

The circular design, with a 2-metre diameter, provided a compact yet comprehensive display, dividing the model into two halves: the Mokrice Hydropower Plant and a nuclear power plant facility. This configuration was chosen deliberately, to allow simultaneous comparison and highlight the coexistence of diverse low-carbon energy technologies within a single energy landscape. The model's layout enables viewers to observe the spatial relationships, infrastructure integration and environmental context, fostering a more intuitive understanding than diagrams or photographs alone.

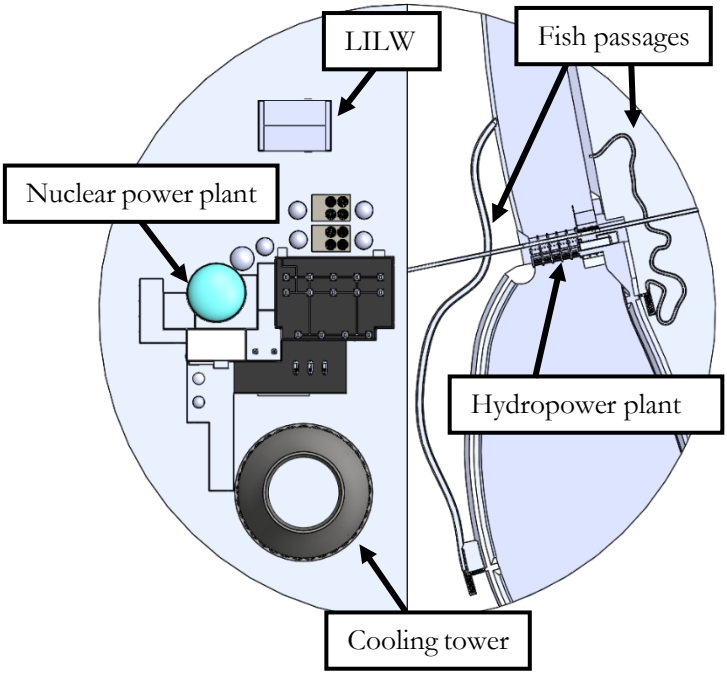

Figure 1: Model layout.

Moreover, the model emphasises the role of public outreach in energy planning. Engaging the public with accessible visualisations promotes transparency, encourages dialogue, and raises awareness about sustainable energy solutions. It also serves as a tool for educators, policymakers and industry stakeholders to communicate complex concepts effectively, thereby bridging the gap between technical knowledge and societal understanding.

3 Mokrice hydropower plant model

The Mokrice Hydropower Plant model is characterised by distinctive technical and ecological features. The facility incorporates two fish passages, designed to allow the safe migration of aquatic species and to maintain the river ecosystem connectivity, as well as a solar power plant installation integrated on the left side of the riverbank. These elements illustrate how renewable energy systems can combine hydropower with solar technology while addressing ecological considerations.

The original model was provided by IBE and adapted for 3D printing, requiring simplification of the geometric details to fit the circular layout. The adjustments included shortening certain distances, such as the left fish passage, without compromising the educational value of the representation. This process highlights the need to balance the physical constraints of model construction with fidelity to real-world characteristics. The printing was carried out on FDM (Fused Deposition Modelling) Prusa MK4 3D printers. Due to the printer size limitations, the model was divided into multiple parts, which were, later, assembled with adhesive and filler to ensure continuity and stability.

Figure 2: Combined parts that were filled with filler and sanded.

Post-processing included painting and texturing. Sand was applied to the riverbed, the stones along the embankments and static grass for vegetated areas. To represent the river, a layer of epoxy resin was applied to simulate water, giving the model a realistic appearance with depth and gloss. Trees and shrubs were added to create a realistic landscape, enhancing the model's visual and educational impact.

The completed hydropower half allows observers to examine the key functional components, spatial relationships and environmental integration. It demonstrates how a renewable energy infrastructure can coexist with natural ecosystems, serving as a model for public understanding of sustainable energy practices.

4 Nuclear power plant model

The nuclear half of the model provides a generalised representation of a nuclear energy facility, including a reactor, cooling tower, and a repository for low- and intermediate-level radioactive waste (LILW). A specific reactor type was not selected, reflecting the current uncertainty regarding the final contractor and reactor design.

A key educational feature is the removable LILW repository, which exposes a cross-section illustrating the arrangement of the storage casks. This feature enables the viewers to understand the spatial and safety considerations involved in nuclear waste management. It provides a rare opportunity for the public to visualise normally hidden or restricted facilities, making complex safety concepts more comprehensible.

Like the hydropower half, all the nuclear components were 3D printed, assembled, filled and painted. Roads, parking areas and ancillary infrastructure were added to provide context, while landscape features such as grass, trees and shrubs improved the realism. The nuclear half complements the renewable energy half, demonstrating the diversity of low-carbon technologies and highlighting the role of nuclear power in a balanced energy mix.

Figure 3: 3D printing of the cooling tower segments.

5 Assembly and final touches

The base structure was supplemented with a metal support fabricated by TEB - Termo Elektrarna Brestanica, providing stability for handling and display. The final model represents a compromise between scale, visual fidelity and practical construction constraints. Detailed finishing, including painting, static grass, stones and vegetation, allowed the model to convey realistic textures and environmental integration.

This assembly process demonstrates the interdisciplinary collaboration required for educational model creation, combining engineering, design, 3D printing technology and landscape modelling. The result is a visually compelling tool that communicates complex energy concepts effectively to diverse audiences.

Figure 4: Finished model.

6 Discussion and implications for low-carbon energy awareness

The completed model illustrates the complementary roles of hydropower, solar and nuclear technologies in achieving low-carbon energy goals. By presenting renewable and nuclear facilities together, the model highlights how different technologies can coexist within a unified energy strategy.

Educationally, the model provides an accessible entry point for the public to engage with a complex energy infrastructure. Interactive features, such as the removable waste repository, enable the viewers to explore normally inaccessible aspects, promoting understanding of the technical, safety and environmental considerations. The realistic depiction of landscape integration and technical features fosters a deeper appreciation for the planning, design and operation of energy facilities. It is important to emphasise the extensive work involved in preparing, detailing and setting up both the geometry and technological aspects for 3D printing.

Models of this type are valuable for public outreach, education and stakeholder engagement. They facilitate informed discussions, promote transparency and support communication, helping bridge the gap between technical knowledge and societal understanding. By combining additive manufacturing, detailed surface finishing and interactive elements, this model serves as an effective medium for demonstrating low-carbon technologies and raising awareness about sustainable energy solutions.

Acknowledgment

The authors would like to acknowledge the financial support provided by the GEN and HESS foundations (Grant No. GEN/23/2024), which made this work possible.

Povzetek v slovenskem jeziku

Zasnova in izdelava makete za promocijo nizkoogljičnih virov. Članek predstavlja zasnovo, izdelavo in izobraževalno uporabo makete, ki prikazuje obnovljive vire energije. Maketa ima krožno postavitev s premerom 2 metra, razdeljeno na dve polovici: hidroelektrarno Mokrice in jedrsko elektrarno z odlagališčem nizko- in srednje radioaktivnih odpadkov (NSRAO). Polovica makete, ki predstavlja hidroelektrarno Mokrice, izpostavlja ključne ekološke in tehnične značilnosti, vključno z dvema ribjima stezama in sončno elektrarno, nameščeno na levi strani struge, pri čemer je voda vizualno prikazana s smolo. Jedrska polovica vključuje odstranljivo odlagališče NSRAO, ki obiskovalcem omogoča vpogled v razporeditev sodov skozi prerez. Vsi deli so bili izdelani s 3D-tiskanjem, sestavljeni, pobarvani in dopolnjeni z detajli ter nameščeni na leseno podlago s kovinsko podporo. Čeprav maketa ni bila namenjena natančni tehnični reprodukciji, učinkovito prikazuje kompleksne energetske infrastrukture, kar omogoča javnosti boljše razumevanje, ozaveščanje in spodbujanje dialoga o nizkoogljičnih tehnologijah. Kombinacija aditivne proizvodnje, interaktivnih elementov in podrobne predstavitve okolja kaže vrednost maket kot orodij za izobraževanje, demonstracijo in promocijo trajnostnih energetskih rešitev.