U.S. DEPARTMENT OF ENERGY
NUCLEAR ENERGY RESEARCH INITIATIVE
ABSTRACT

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Title: **Generation IV Nuclear Energy System Construction Cost Reductions through the Use of Virtual Environments**

For new nuclear capacity to be constructed, the capital costs must be reduced to be competitive with those of non-nuclear energy sources, most notably gas turbines. Current estimates for the advanced reactors such as the AP600 are in the neighborhood of $1300/kilowatt for the nth plant. This cost is about 30% higher than the $1000/kilowatt that is generally considered to be needed for nuclear to be competitive with fossil sources.

Efforts to reduce costs beyond those of the AP600 have resulted in the design of generation III+ and IV reactors. Such reactors include the AP1000, a generation III+ reactor and the pebble bed reactor, a generation IV reactor. For the AP1000, the costs for the nth plant are estimated to be less than $1000/kilowatt. There is still a large uncertainty that this cost can be realized for these plants. Construction costs of nuclear generating plants must be reduced in order to expand the future use of nuclear energy.

Two of the drivers of plant construction costs are the cost of financing during the construction duration and the substantial amount of skilled craft labor hours needed on site during construction.

Additional effort to reduce construction costs for new design reactors such as the AP1000 and the South African design pebble bed reactor may be required. The application of information technology (IT) is being used to examine the potential to reduce both of these drivers.

It is likely that the extensive use of modular construction in shipyards or other heavy construction facilities of large subassemblies or modules will reduce the fabrication costs by reducing the work that must be done in the field under less than optimum conditions. This approach has its drawbacks however. In a complex structure such as a nuclear island, the sequence of installation of these modules becomes important. One must for example ensure that adequate clearances exist to handle and then weld these assemblies together.

Current practice within the nuclear industry is to use 2D and 3D CAD representations of the systems on a workstation to aid in developing the installation sequence as well as the actual design. While this allows one to eliminate the obvious interferences encountered using older design methods, it does not allow for a complete checkout of the installation sequence. One can only do this using a full-size or small-scale mockup of a facility.

The Naval Reactors program has done just that to aid in the design of several classes of nuclear submarines. In most cases, the mockups are full size replicas of the engine rooms and reactor compartments under design. They are constructed from plywood, cardboard, rope and a minimal amount of steel and sheet metal. Yet, they have a high degree of fidelity enabling such minor features as ¼ in. gauge lines to be represented and their runs reviewed for such problems as water traps. Unfortunately the construction alone of such mockups is itself very costly. To build such a mockup of a commercial nuclear island would be a challenge considering the scale of the containment alone is many times that of a submarine reactor compartment.

One possible alternative is to use a full-scale virtual reality simulation of the complete power station including the nuclear island, turbine hall, auxiliary building, control room and any other critical areas. It is the purpose of this proposal to demonstrate the feasibility of this idea in support of the evaluation of potential cost reductions that can be realized in Generation IV Nuclear Energy Systems installation and construction sequences.

The objective of this work is to test the suitability of Immersive Projection Display (IPD) technology such as a CAVE™ or a CAVE-like system, in the design of future nuclear power plants. The intent is to see if this type of IT can help to improve arrangements and reduce both construction and maintenance costs as has been done using full-scale mockups.