



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D. C. 20555

FEB 14 1979

MEMORANDUM FOR: Harold R. Denton, Director  
Office of Nuclear Reactor Regulation

FROM: Saul Levine, Director  
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER #45 - THE CONCEPT COMPUTER  
CODE AND CAPITAL COSTS FOR BOILING WATER REACTOR PLANTS

Introduction

This memorandum transmits the results of completed research updating and expanding the CONCEPT computer code for forecasting capital costs of boiling water reactor plants. The work was performed by United Engineers and Constructors, Inc., Philadelphia, Pennsylvania under the direction of the Environmental Effects Research Branch of RES in response to a research request from your office (RR-NRR 76-6).

In 1971 the Atomic Energy Commission authorized power plant investment cost studies, which culminated in the WASH-1230 reports (1000 MWe Central Station Power Plants - Investment Cost Study) published in 1972. Their purpose was to facilitate policy and economic decisions about electric generation facilities in the public and private sectors. The WASH-1230 report series consists of five volumes: Pressurized Water Reactor, Boiling Water Reactor, Coal-Fired, Oil-Fired and High Temperature Gas-Cooled Reactor power plants. National priorities on energy, the regulatory environment and the cost of labor, equipment and material have changed significantly. These changes dictated the necessity of updating this series of studies, and expanding the scope to consider the fuel cycle and the total generating cost. As a result, a program to study, reassess and produce a new set of updated reports was authorized and undertaken.

The current series includes investment cost reports for a Pressurized Water Reactor Plant, a Boiling Water Reactor Plant, High Sulfur Coal Plants, and Low Sulfur Coal Plants. The Oil Fired Power Plant Study was not updated because utilities are not expected to build significant numbers of these plants, and the High Temperature Gas-Cooled Reactor Plant Study was not updated because these reactors are not now being marketed. Investment cost reports on multi-unit stations and for different cooling system types are included. In addition, the series addresses fuel supply investment costs and total generating costs for both nuclear and coal fired power plants.

The studies in these series have a uniform set of economic and technical criteria and a uniform accounting system as contained in Guide for Economic Evaluation of Nuclear Reactor Plant Designs, NUS-531, January 1969. The investment cost estimates in these series are developed for reference plants constructed at a hypothetical site called "Middletown, USA."

The reference investment and total generating cost estimates can be used for baseline comparisons of different generating systems. However, the major use of the investment cost data is as input to the CONCEPT computer code which was developed for DOE at the Oak Ridge National Laboratory (ORNL). The CONCEPT computer program adjusts the baseline cost estimates contained in these studies for different plant sizes, regional variations in material and craft labor rates, different construction schedule lengths, and different escalation and interest rates. These adjustments result in preliminary sets of alternative cost estimates for electric power plants constructed anywhere in the United States.

### Methodology

The investment cost study for the 1190 MWe boiling water reactor (BWR) central station power plant consists of two volumes. Volume I includes the Foreword and Summary, the Plant Description and the Detailed Cost Estimate. Volume II contains the Drawings, Equipment List and Site Description.

Additionally, Volume II, Section 6 presents the "Site Description" and major ground rules used in this study as follows:

The reference plant design is based on the General Electric Technical Reference Plant Design, the General Electric Standard Safety Analysis Report (GESSAR), the General Electric 238 Inch Reactor Pressure Vessel (RPV) Nuclear Island Study arrangements, and United Engineers experience.

The reactor plant design is based on the General Electric references listed above. Key plant parameters for the nuclear steam supply system (NSSS) and steam and power conversion system are shown in Tables 2-1 and 2-2 in Section 2.

Cost data is based on prices effective July 1, 1976.

A full complement of licensing and design criteria circa January 1, 1976 are utilized. Safety classifications, seismic categories and design codes for the major structure and equipment are addressed in Section 2 and in the Equipment List (Volume II, Section 5).

The detailed cost estimate is developed for a single unit station, with sufficient land area to accommodate an identical section unit.

The design of the main heat rejection system is based upon the use of mechanical draft wet cooling towers. The nuclear ultimate heat sink is also based on mechanical draft wet cooling towers.

Escalation and interest during construction are not included in the cost estimate.

The plant has an onsite nuclear reactor core storage capacity for 5/4 core.

The design uses two independent offsite sources of power; one at 500 kV and one at 230 kV.

The plant design life is 40 years during the first part of which it will be baseloaded.

### Results

The estimated total base construction cost for the 1190 MWe BWR reference design is \$582,748,330 or \$490/kW based on July 1, 1976 prices. Summaries of the Detailed Cost Estimate at both the two and three digit account levels are shown in Tables 1-1 and 1-2 respectively. The cost estimate does not include normal contingency costs for the equipment, material and labor components of the total base construction cost; nor does it include escalation and interest during construction. Other items not included in the cost estimate are listed in the beginning of Section 3, Detailed Cost Estimate. As noted, for a specific site, this baseline cost estimate must be adjusted for regional variations in material and labor rates, different construction schedule lengths, and escalation and interest rates incurred during construction.

### Conclusions and Recommendations

The total base construction cost for the BWR power plant (1061 MWe net output) reference in WASH-1230 was approximately \$213,000,000 or \$201/kW, based upon prices effective January 1971. Thus, the 1977 study indicates approximately a 143 percent increase in the cost of the plant in terms of \$/kW. The principal factors contributing to this increase are as follows:

Cost escalation from January 1971 to July 1976.

Regulatory requirements for additional engineering and safety features, and environmental considerations affecting plant design.

These result in increased engineering, management, labor, equipment and material costs due to increased scope and lengthened schedules.

The increase in direct construction costs of the current plant design

(using the updated CONCEPT Code) over those estimated in WASH-1230 are directly related to increases in the quantities of the various construction commodities required for compliance with licensing and design criteria circa January 1, 1976. Following are examples of the differences in the quantities of some of these construction materials:

	WASH-1230 BWR 1061 MWe Net Output (1/71)	BWR 1190 MWe Net Output (1/76)
Concrete, cu. yds.	115,000	196,400
Reinforcing Steel, lbs.	$22.0 \times 10^6$	$40.6 \times 10^6$
Structural Steel, lbs.	$8.7 \times 10^6$	$20.8 \times 10^6$

Table 1-3 is a summary breakdown of the direct craft labor costs and hours for this reference design. The total direct craft labor cost of approximately \$139,500,000 corresponds to an average hourly rate of \$12.29. Approximately 11,350,000 craft labor manhours average about 9.5 manhours/kW. These compare to averages of \$8.84/hour and 6.3 manhours/kW respectively for the earlier design reported in WASH-1230.

This study provides the NRC cost-benefit analyst with an updated methodology for forecasting investment costs of boiling water reactor plants. In the performance of NEPA obligations to evaluate alternatives to the proposed action, the NRR staff must reach a conclusion as to the comparative costs of generating power among the feasible alternatives. For the past five years, the NRR staff has used the CONCEPT computer code to obtain forecasts of plant capital costs. The code was developed and used on the premise that basic designs for a given type of steam power plant are sufficiently similar so that capital costs for any plant can be reliably estimated given parametric specifications for the regional cost variation, labor efficiency and interest cost.

The study and its methodologies have been reviewed extensively while in progress by the RES project manager and various staff members from NRR. RES recommends that the updated methodology be used by NRR for application to the identified regulatory need (RR-NRR 76-6). Technical questions related to these results may be directed to David Barna at 427-4358.

  
Saul Levine, Director

Office of Nuclear Regulatory Research

Enclosures:

1. NUREG-0242, Volume 1
2. NUREG-0242, Volume 2

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Saul Levine, Director  
 Office of Nuclear Regulatory Research

**Enclosures:**

1. NUREG-0242, Volume 1
2. NUREG-0242, Volume 2

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