UNIVERSITY RESEARCH REACTORS IN THE UNITED STATES; THEIR ROLE AND VALUE - FROM THE 1988 STUDY BY THE NATIONAL RESEARCH COUNCIL

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ABSTRACT

This paper provides a brief overview of the 1988 National Research Council study of the role and value of university research reactors in the US.

I. INTRODUCTION

There are currently 35 operating university research reactors (URR's) on 33 sites in 24 states. Figure 1 shows the distribution of URR's by power level and Figure 2 shows their location in the USA. Concern about these facilities has been widespread in the URR user community, in university administrations, in government, and often among the public, especially individuals residing relatively close to these research facilities. The concern about the cost (including safety) and the value of URR's has been heightened by the increasing number of URR shutdowns. The number of these facilities has diminished by a significant fraction during the last several decades.

A result of heightened concern in the federal government was the USDOE's 1985 questionnaire to URR operators. This was designed to assess URR productivity. As a result it was clearly shown that URR's were continuing to make major contributions to education and research despite their inadequate and diminishing funding base. To obtain an unbiased picture of URR costs and value by a blue ribbon national committee, the USDOE in 1986 requested the National Research Council to evaluate the contributions of university-based research reactors to research and education in nuclear science and engineering. Consideration was to be given to:

a) Increasing costs at universities

b) Decreasing enrollments and research in nuclear science and engineering programs

c) Anticipated increases in URR regulations

d) Concerns about reactor safety and security

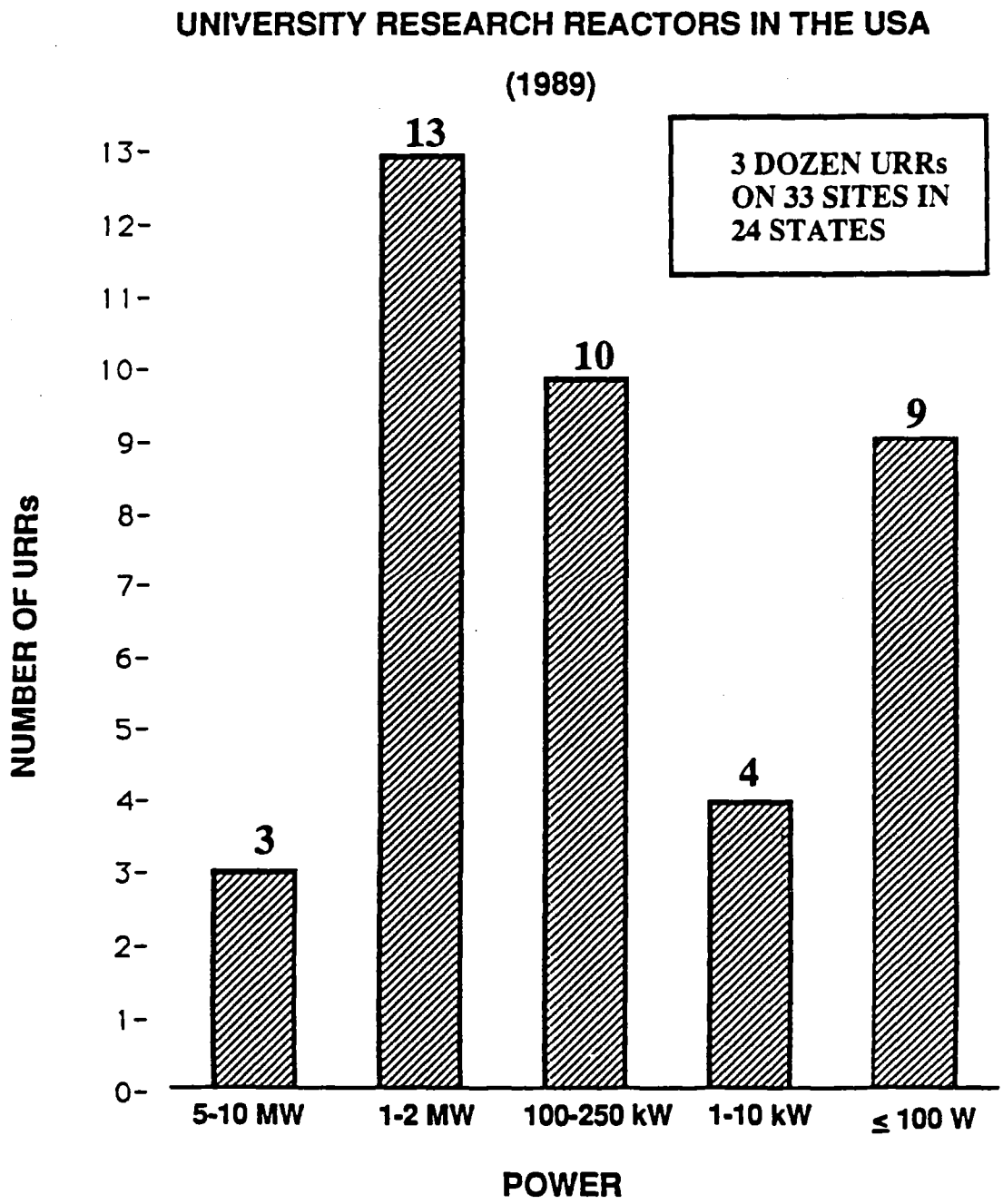
UNIVERSITY RESEARCH REACTORS IN THE USA
(1989)
3 DOZEN URRs
ON 33 SITES IN
24 STATES
NUMBER OF URRs
0-
1-
2-
3-
4-
5-
6-
7-
8-
9-
10-
11-
12-
13-
3
13
10
4
9
5-10 MW
1-2 MW
100-250 kW
1-10 kW
≤ 100 W
POWER

Figure 1

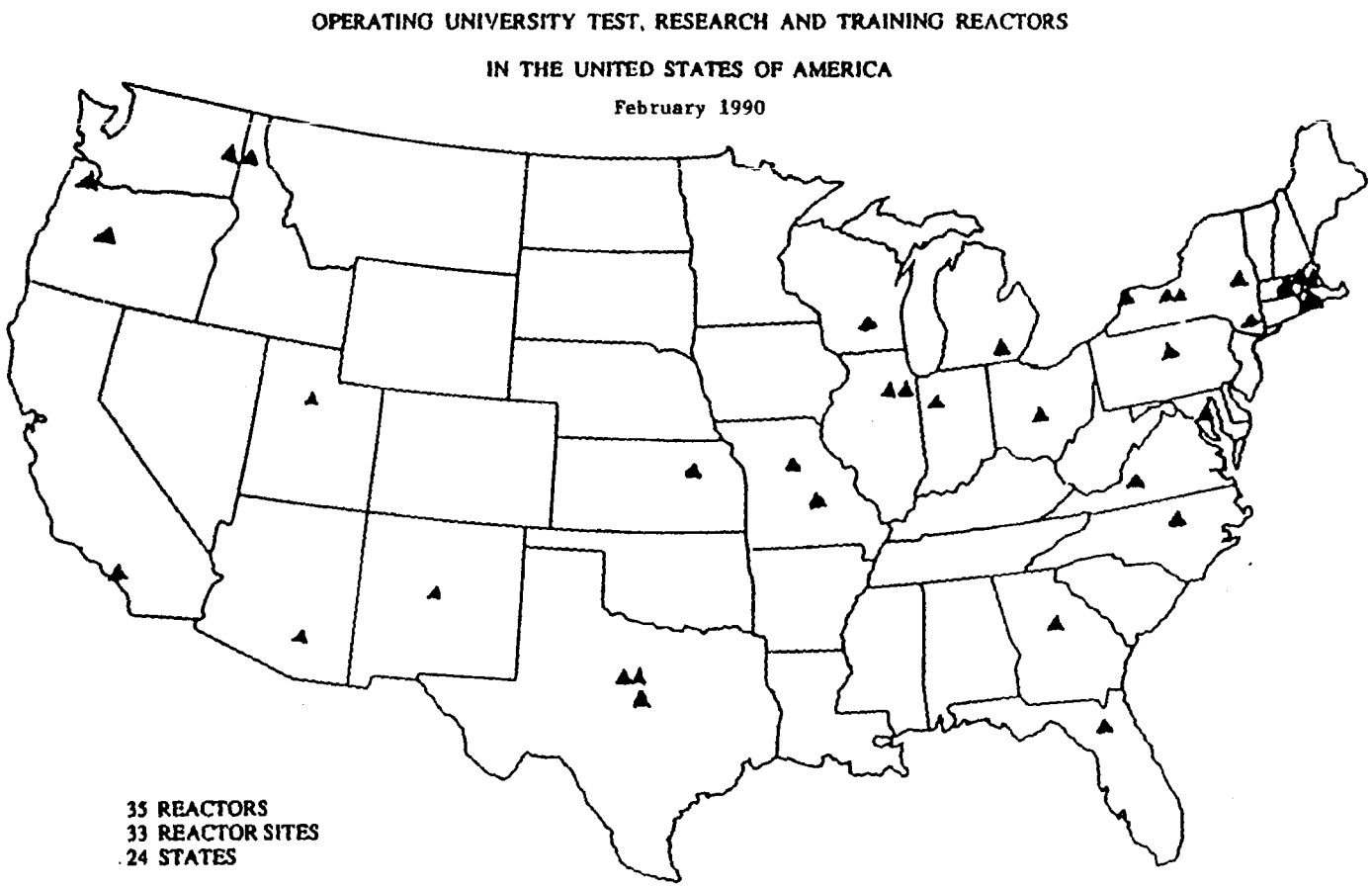
OPERATING UNIVERSITY TEST, RESEARCH AND TRAINING REACTORS
IN THE UNITED STATES OF AMERICA
February 1990
35 REACTORS
33 REACTOR SITES
24 STATES

Figure 2

I. THE NATIONAL RESEARCH COUNCIL STUDY

The National Research Council (NRC) accepted the DOE-sponsored study and decided to divide their efforts into the following tasks:

1. Review and evaluate existing university research reactors to determine their role in meeting the needs to education, training, research, and service in relevant fields of science and engineering.
2. Evaluate the specific mandates and interests represented by academic, government, and industry organizations with respect to university research reactors.
3. Review and evaluate the use and support of similar reactors elsewhere, in Western Europe, for example.
4. Review security and safeguard issues involving university research reactors.
5. Evaluate the role of university administrations and other entities in support of URR programs.
6. Evaluate the role of the federal government in support of URR programs.
7. Provide recommendations and/or options for federal and other support of university research reactors.

An interdisciplinary group of experts, with strong representation from outside the university reactor community, was appointed to conduct the study. The members of the NRC committee are listed below:

David A. Shirley (Chairman), Director, Lawrence Berkeley Laboratory, Berkeley, California

Robert M. Brugger, University of Missouri, Columbia, Missouri

Geoffrey L. Greene, National Bureau of Standards, Gaithersburg, Maryland

John S. Laughlin, Memorial Sloan-Kettering Cancer Center, New York, New York

Mihran J. Ohanian, University of Florida, Gainsville, Florida

John Poston, Texas A&M University, College Station, Texas

Clifford G. Shull, Massachusetts Institute of Technology, Cambridge, Massachusetts

Bernard I. Spinrad, Iowa State University, Ames, Iowa

Anthony L. Turkevich, University of Chicago, Chicago, Illinois

Edwin L. Zebroski, Electric Power Research Institute, Palo Alto, California

During the study the NRC committee reviewed the following areas and reached the following conclusions:

1. The spectrum of research at university reactors:
   - Neutron activation analysis – extremely wide range of applications, bulk of US work is done at URR's.
   - Neutron scattering – a large fraction of neutron scattering experts were trained at URR's.
   - Neutron radiography – a wide range of uses, including industrial.
   - Medical diagnostics and therapy – the bulk of the USA's innovative research in this area is done at URR's.
   - Radiation effects in materials – radiation damage studies prepare students for work in the national facilities.
   - Nuclear engineering and reactor physics – a major contribution to the national programs through research, covers a wide range.
2. Research reactors in education and training:
   - URR's of all sizes are an important part of the educational process in a broad multi-disciplinary sense. URR's are useful in teaching nuclear science at all levels, from high school through graduate school.
   - URR's often provide a unifying theme for nuclear engineering programs in presenting reactor behavior in a realistic way, and in being a primary research tool.

- Those universities which have nuclear engineering programs and a broad educational program in applications of the nuclear sciences will be best equipped for this purpose if they have a URR on campus.

3. Research reactor services for other users (outreach):

   - URR's play a vital role as a service facility in the nuclear sciences – related disciplines. Service is provided to other universities, industry, government laboratories and departments. Service is a significant component of the reactor utilization at several URR's.

   Typical services include:

   - radioisotope production and application
   - neutron activation analysis
   - neutron radiography
   - neutron gauging
   - neutron scattering
   - gamma-ray scattering
   - standardization assays
   - radiation shielding testing
   - radiation damage testing in structural materials
   - personnel training
   - radiation chemistry
   - safety analysis

4. Research reactors in other countries, especially Europe:

   - There is a strong perception that western Europe occupies a position of leadership in reactor based science. This is strikingly evident in neutron beam tube research.
   - The Europeans support a strong network of reactors which include the major national facilities and the university class research reactors.

- Many techniques now used at the national facilities originated at the URR's.
- University reactors in Europe receive base support for operation and a base in-house research program. Typically, several million dollars per year for a reactor of several MW.
- The user base is considerably larger at the European URR's compared to the large US URR's.
- Success of the European URR's is possible because of a national community-wide effort that encourages efforts at reactors of all sizes and encourages cooperation between them.
- Whether US URR's as a national resource are adequately employed is germane to the planning of our national program in the neutron sciences, including the advanced neutron source. URR's are also particularly germane to the question, whether there will be an adequate community of younger scientists and engineers to use the advanced neutron source and other national facilities.

5. Safety and safeguards of URR's:
   - Safety hazards:
     - damage to the fuel core and consequent spread of radioactivity in or beyond the reactor containment building
     - spread of small amounts of radioactivity or medical isotopes from experimental programs
     - spread of radioactive coolant in the event of leakage
     - injury to personnel from weapons, fire, and explosive devices
   - Safeguards hazard:
     - theft and diversion of nuclear material
     - intrusion and theft of materials or equipment other than nuclear materials
     - intrusion, sabotage, and vandalism

- Conclusion of NRC study (related to safety):
  - the safety records of URR's are excellent
  - the safety hazards are small relative to large power reactors
  - the effective functioning and continued operation of the present URR's are more affected by disproportionate public and institutional perceptions of risk than be actual physical or nuclear hazards.

6. Institutional and federal support of URR's:
   - Based on its deliberation, the NRC committee believes that a national program of support for URR's is justified by their educational, research, and service value to the nation.
   - There is no consistent, dependable pattern of support for URR's at either the local or national level.
   - Total need of URR's is estimated at ~ $ 35M annually for a healthy program with high utilization.

III. CONCLUSIONS OF THE STUDY

- URR's merit a base of federal support because of national benefits that accrue from a healthy URR program.
- URR's merit support from state and local governments and industry because they train workers and provide services of direct benefit.
- If URR's are to play a vital role in research and in the education of scientists and engineers, they need immediate funds to:
  - bring current operations up to a level adequate to maintain vital programs
  - purchase instrumentation and equipment needed to modernize reactor operations, research, and teaching programs
  - the federal government should consider committing up to $20 million per annum to assist in funding URR operations and upgrades.

IV. PRINCIPAL RECOMMENDATIONS OF THE STUDY COMMITTEE

- The federal government, in partnership with the universities and the national laboratories, should develop and implement a national research reactor strategy, the elements of which should include:
  - development of university and national laboratory centers of excellence in specific areas of the neutron sciences and reactor technology for world-class research as well as for education
  - anticipation that as some university reactors are upgraded and a user's network is created (see below), others are likely to close
  - mechanisms to assure that such closures do not go so far as to damage the national interest related to research and educational capabilities in the nuclear sciences and engineering
  - development and support of a reactor network to provide enhanced utilization and productivity of U.S. research reactors involving researchers from universities with and without on-campus reactors, and from the national laboratories
- To implement the above strategy:
  - a single federal agency should be designated to administer programs in support of the national research reactor programs
  - the federal government should create a standing advisory structure to advise on a continuing basis on all aspects of this program
- In pursuit of this strategy, the federal government should:
  - adopt the goals of meeting U.S. research reactor needs, and regaining a position competitive with Europe and Japan in the neutron-based sciences
  - study, in detail, the approaches of other advanced countries to operating research reactor networks such as that of linking the major facility at Grenoble with smaller reactor research centers in Europe
  - establish and support such a network, adapted to U.S. needs

- make up to $20 million available annually (as a preliminary estimate to be modified as improved data becomes available) to universities through the designated federal agency, specifically for operational support and facility upgrades of university research and educational reactors
- create a peer review mechanism to assist the designated agency in making grants to universities

- The Nuclear Regulatory Commission should examine its current approach to the licensing and regulation of university research reactors in terms of the following issues:
  - the small nuclear materials inventories and low power densities of university research reactors, which result in risk factors related to safety and safeguards are considerably lower than commercial power reactors
  - avoiding unnecessary exposure of small university reactor operators to costly hearing and litigation procedures as a condition for licensing upgrades and improvements
- Finally, the Nuclear Regulatory Commission should consider grants of technical and financial assistance to help university reactor operators to comply with upgraded safety and safeguard requirements, including and continuing beyond the current program of assisting with the conversion to low-enriched fuels.

V. REFERENCES

[1] "University Research Reactors in the United States – their Role and Value," National Academy Press, Washington, D.C., 1988.