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MFN 01-020

May 15, 2001

US Nuclear Regulatory Commission
Document Control Desk
Washington DC 20555

Attention: Chief, Information Management Branch
Program Management
Policy Development and Analysis Staff

Subject: **Non-proprietary Version of GE Proprietary Slides presented at May 9, 2001 GE/NRC Meeting**

A meeting was held with members of the NRC Staff and representatives of GE on May 9, 2001. The topic discussed was the GE proposal to introduce the TRACG code for ECCS/LOCA analysis.

Attached is the non-proprietary version of the GE proprietary slides presented at the May 9 meeting.

Sincerely,

J.F. Klapproth, Manager
Engineering and Technology

Attachment: May 9, 2001 Presentation Slides (Non-Proprietary Version)

cc: R. Pulsifer (NRC)
R. Caruso (NRC)
G. Watford (GNF)

YG01
1/1

*GE Nuclear Energy*

# TRACG Application to ECCS/LOCA


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**May 9, 2001**

# Agenda

- **Scope and Schedule**
- **Discussion of Application Framework**
  - TRACG Model Description Revision 3
  - TRACG Qualification Revision 3
  - TRACG Application for ECCS/LOCA Analysis
- **Summary**

# Scope

- **ECCS/LOCA analysis**
  - Excludes analysis of containment performance for LOCA
- **Plants:** **BWR/2/3/4/5/6**
- **Events:** **All break locations and sizes**
  - Same Events as Currently Approved for SAFER
- **Documentation**
  - TRACG Licensing Application Framework for ECCS/LOCA Analysis, NEDC-33035P
  - TRACG Model Description LTR, NEDE-32176P, Revision3
  - TRACG Qualification LTR , NEDE-32177P, Revision3
  - TRACG Application LTR for ECCS/LOCA Analyses, NEDE-33005P
- **Review Scope**
  - One SER for Application of TRACG to BWR ECCS/LOCA
    - Applicability of TRACG models for ECCS/LOCA
    - Qualification
    - Application Methodology for ECCS/LOCA

# Plants

- **BWR/2**

  **Non jet Pump Plants with External Recirculation Loops**

  Oyster Creek, Nine Mile Point 1

- **BWR/3/4**

  **Jet Pump Plants with LPCI through Recirculation Lines**

  Dresden 2/3, Quad Cities 1/2, Pilgrim, Millstone, Monticello
  Hatch1/2, Browns Ferry 1/2/3, Susquehanna 1/2, Brunswick 1/2, Cooper, Duane Arnold, Fitzpatrick,
  Vermont Yankee, Peach Bottom 2/3, Enrico Fermi 2

  **Jet Pump Plants with LPCI into Core Bypass Region**

  Limerick 1/2, Hope Creek 1

- **BWR/5/6**

  **Jet Pump Plants with LPCI into Core Bypass Region**

  LaSalle 1/2, Columbia Generating Station 2, Nine Mile Point 2
  Perry, River Bend, Grand Gulf, Clinton 1

# Analysis Scope

- **Same class of events as currently approved for SAFER**
  - Entire range of pipe break sizes and locations ranging from small breaks to a double-ended rupture of a recirculation line
  - Analysis will include effect of single failures of active components in the ECCS
  - Analysis will cover range of BWR operation, fuel and exposures
- **Analysis will be in compliance with requirements of 10CFR50.46 and Reg. Guide 1.157**
  - Upper Bound PCT relative to 2200 ºF limit

**Realistic, Rigorous, Statistical Basis**
**No 1600 °F Limitation**

# CSAU Methodology and USNRC Regulatory Guide 1.157

## •14 CSAU Steps

| Step | Task |
|---|---|
| 1 | Scenario Specification |
| 2 | Nuclear Power Plant Selection |
| 3 | Phenomena Identification and Ranking Table (PIRT) |
| 4 | Frozen Code Version Selection |
| 5 | Code Documentation |
| 6 | Determination of Code Applicability |
| 7 | Establishment of Assessment Matrix |
| 8 | Nuclear Power Plant Nodalization Definition |
| 9 | Determination of Code and Experimental Accuracy |
| 10 | Determination of Effect of Scale |
| 11 | Determination of Effect of Reactor Input Parameter and State |
| 12 | Performance of Nuclear Power Plant Sensitivity Calculations |
| 13 | Determination of Combined Bias and Uncertainty |
| 14 | Determination of Total Uncertainty |

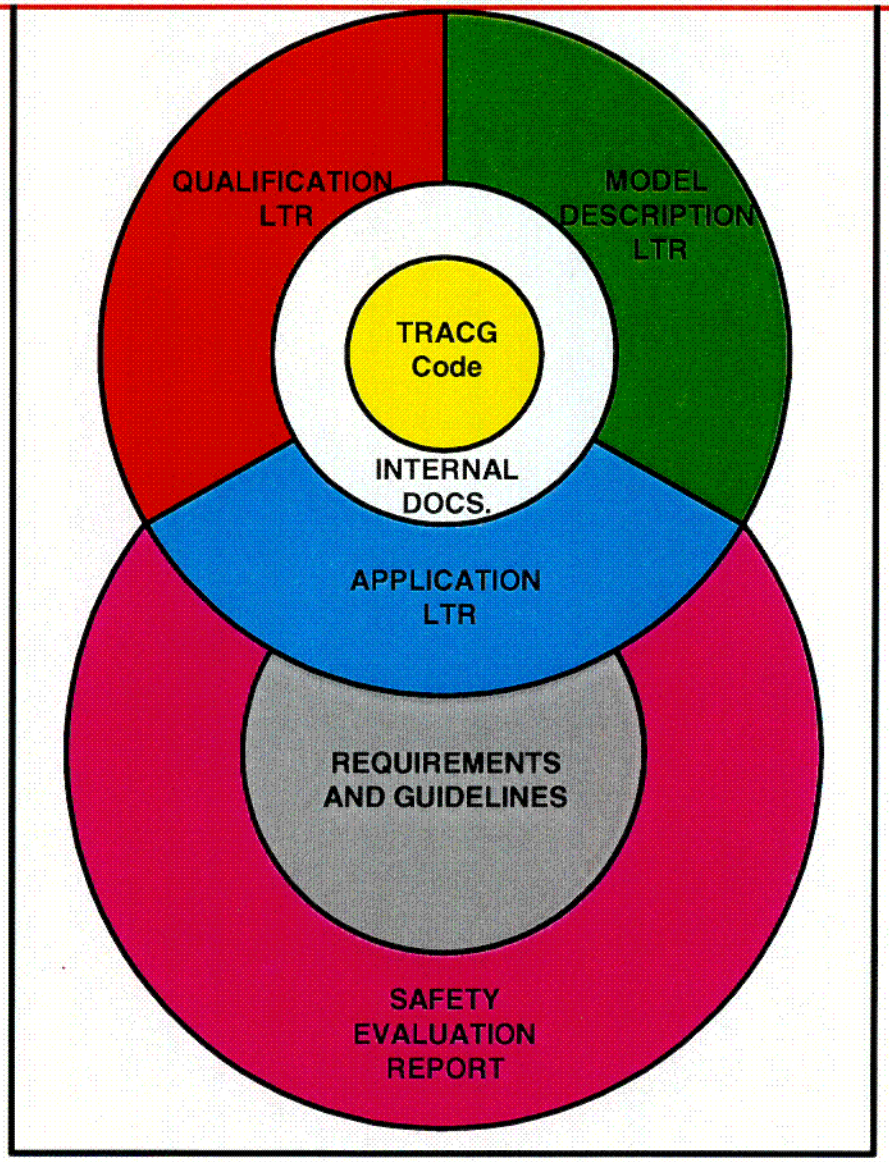
# Review Scope

| Review Element | Comment | NRC Review Status |
|---|---|---|
| TRACG Licensing Application Framework for LOCA/ECCS Analysis NEDC-33035P | Regulatory requirements and guidelines | Submitted for information only.<br>Follows AOO process – identify any problem areas |
| TRACG Model Description NEDE-32176P, Rev. 3 | Rev. 2 is supplemented for LOCA applications.<br>Minor additions. | Rev. 1 reviewed for SBWR.<br>Rev. 2 being reviewed by in connection with AOO applications. |
| TRACG Qualification NEDE-32177P, Rev.3 | Rev. 2 is supplemented with additional qualification for LOCA applications | Rev. 1 reviewed for SBWR.<br>Rev. 2 being reviewed in connection with AOO applications. |
| TRACG Application for LOCA/ECCS Analyses NEDE-33005P | Approach described in Application Framework.<br>Follows RG 1.157. | LOCA application LTR similar in approach to AOO application LTR currently under NRC review. |

# Overview and Schedule for LTRs

- **TRACG Application Framework for ECCS/LOCA Analysis**
  - NEDC-33035P, May 2001
  - Describes proposed application process
  - Demonstrates compliance with RG 1.157
- **TRACG Model Description LTR**
  - NEDE-32176P, Rev. 3, 4Q2001
  - Minor additions for LOCA analysis
- **TRACG Qualification LTR**
  - NEDE-32177P, Rev. 3, 4Q2001
  - Supplements LOCA qualification basis
- **TRACG Application LTR for ECCS/LOCA Analyses**
  - NEDE-33005P, 4Q2001
  - Application methodology and sample calculation results

# TRACG Application Framework

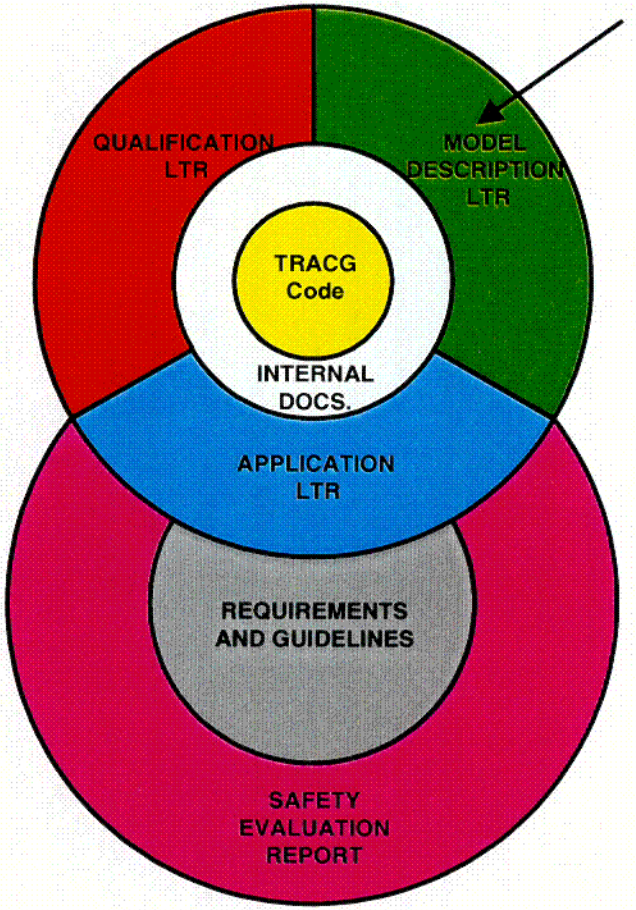





C01

# TRACG Model Capability

- **Structure**
  - Capability to model plant geometry
- **Basic Equations**
  - Capability to address global processes
- **Models and Correlations**
  - Capability to model and scale individual processes
- **Numerical Methods**
  - Capability to perform efficient and reliable calculations

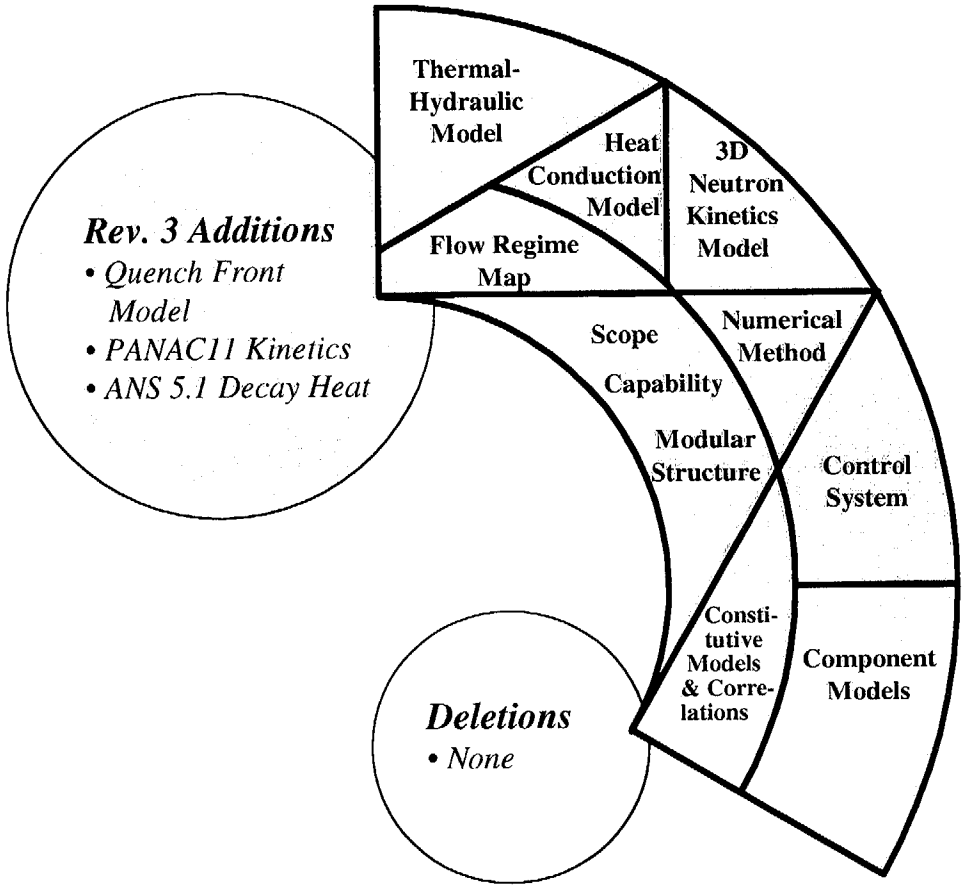





C02

# Outline of Model Description LTR (NEDE-32176P Rev. 3)

1. Introduction
2. Modular Structure
3. Thermal-Hydraulic Model
4. Heat Conduction Model
5. Flow Regime Map
6. Models and Correlations
   - Range of applicability
   - Model uncertainty
   - Implementation
7. Component Models
8. Numerical Methods
9. Three-Dimensional Neutron Kinetics Model
10. Control System




**High Level Outline Unchanged from Prior Reviews**
**Review Comments Addressed**

# Model Additions for ECCS/LOCA

- **Re-implementation of model for axial conduction quenching**
  - Established model (TRACG, CORECOOL, SAFER)
  - Important for quenching of channel by spray (BWR/2)
- **PANAC11 Kinetics**
  - Insignificant for LOCA
  - Primarily for transient applications
  - Separate informational update on AOO applications

    TRACG Application Methodology for AOO, NEDE-32906P, Section 2.6
- **ANS 5.1 (1979) Decay Heat Standard**

# Models not reviewed for AOOs

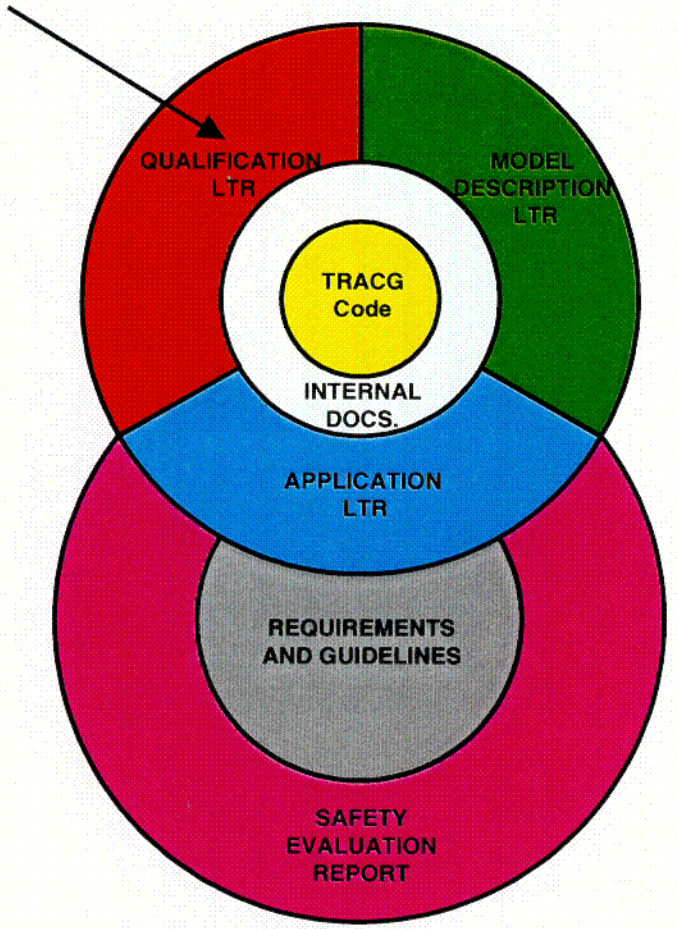
- **Core heatup models**
  - Film boiling, thermal radiation, axial conduction controlled quenching, metal-water reaction
- **Upper plenum models**
  - ECC distribution at top of core

**Small Incremental Amount of Review**

# TRACG Qualification

- **Qualification Strategy**
  - Separate Effects Tests
  - Component Performance Data
  - Integral System Effects Tests
  - Full Scale Plant Data
- **Determination of Adequacy of TRACG Models**
- **Determination of Model and Experimental Uncertainty ***

* A section defining model biases and uncertainties for all highly ranked PIRT parameters will be contained in Application Methodology LTR

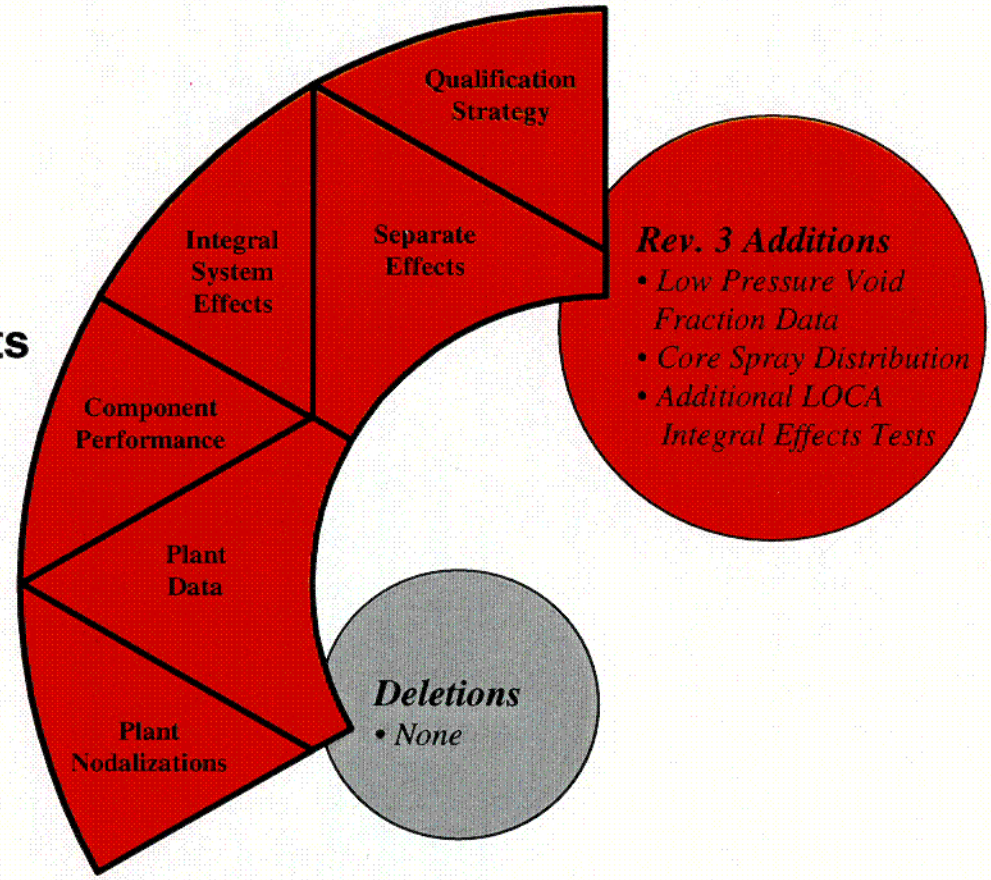





C03

# Outline of Qualification LTR (NEDE-32177P Rev. 3)

1. Introduction
2. Qualification Strategy
3. Separate Effects Tests
4. Component Performance Tests
5. Integral System Effects Tests
6. BWR Plant Nodalization
7. Plant Data
8. Conclusions




**High Level Outline Unchanged from Prior Reviews**
**Review Comments Addressed**



C04

# Supplemental Qualification for LOCA

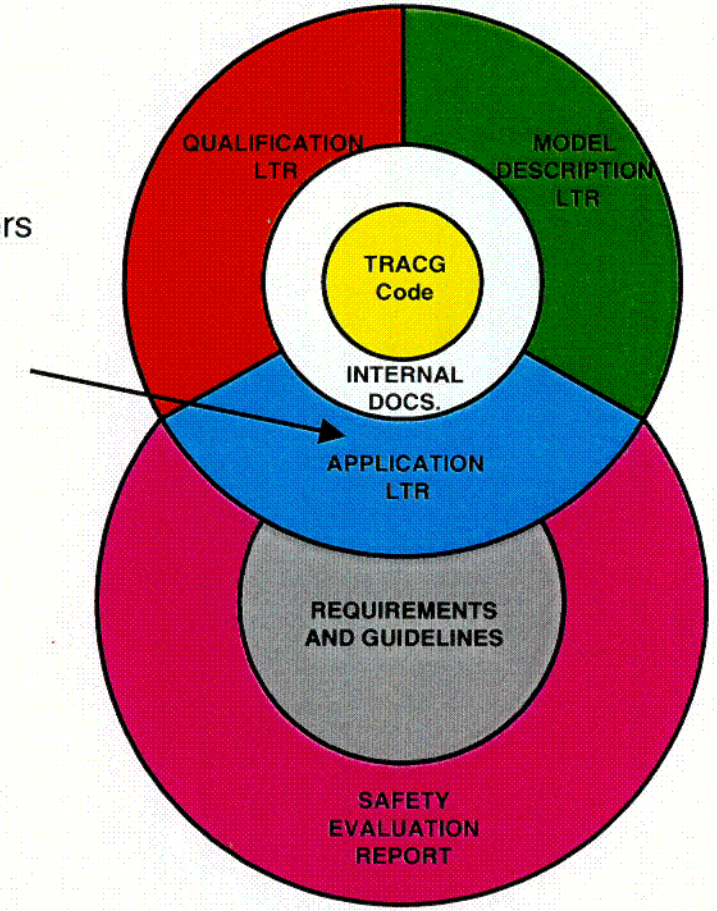
- **Separate Effects Tests**
  - Core spray heat transfer tests (CSHT, Toshiba)
  - Void fraction data at low pressure (Toshiba) and large diameter (Ontario Hydro)
  - Spray distribution from individual ECCS nozzles in steam (Horizontal Spray Facility)
- **Component Performance Tests**
  - Core spray distribution across top of core (SSTF)
- **Integral System Effects Tests**
  - Large break and small break LOCA (ROSA 4 Bundle Facility)
  - Large break LOCA for non-jet pump plant (FIX)
  - BWR/4 refill phase following LOCA (SSTF)
- **Nodalization and Sensitivity Studies for LOCA**

**Moderate Incremental Amount of Review**

# Application Methodology – Current vs. Proposed

# TRACG Application Methodology - Major Elements

- **Plant and Event Definition**
- **Identification of Important Phenomena**
  - Plant types and break size/location
  - Ranking by Impact on Critical Safety Parameters
- **Determination of Code Applicability**
  - Structure, Basic Equations, Models and Correlations, Numerics
- **Qualification and Determination of Code Uncertainty**
  - Separate Effects Tests, Component Tests, Integral Effects Tests, Plant Data for AOOs
- **Determination of Effect of Reactor Input Parameters and State**
- **Determination of Total Uncertainty**
  - One Sided Upper Tolerance Limit (OSUTL) for Critical Safety Parameters



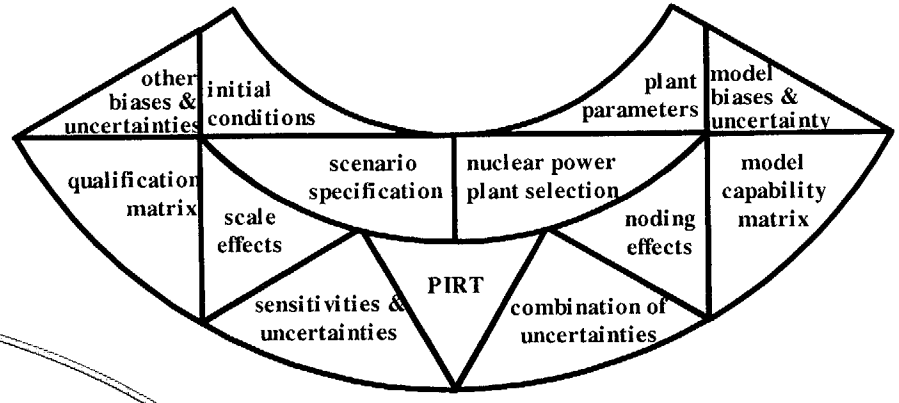

**Structured Approach Similar to AOO Evaluations Consistent with CSAU Methodology and RG 1.157**



C05

# Contents of Application LTR (NEDE-33005P)

## Described in Section 3.1.3 NEDC-33035P




1. Approach
2. Introduction

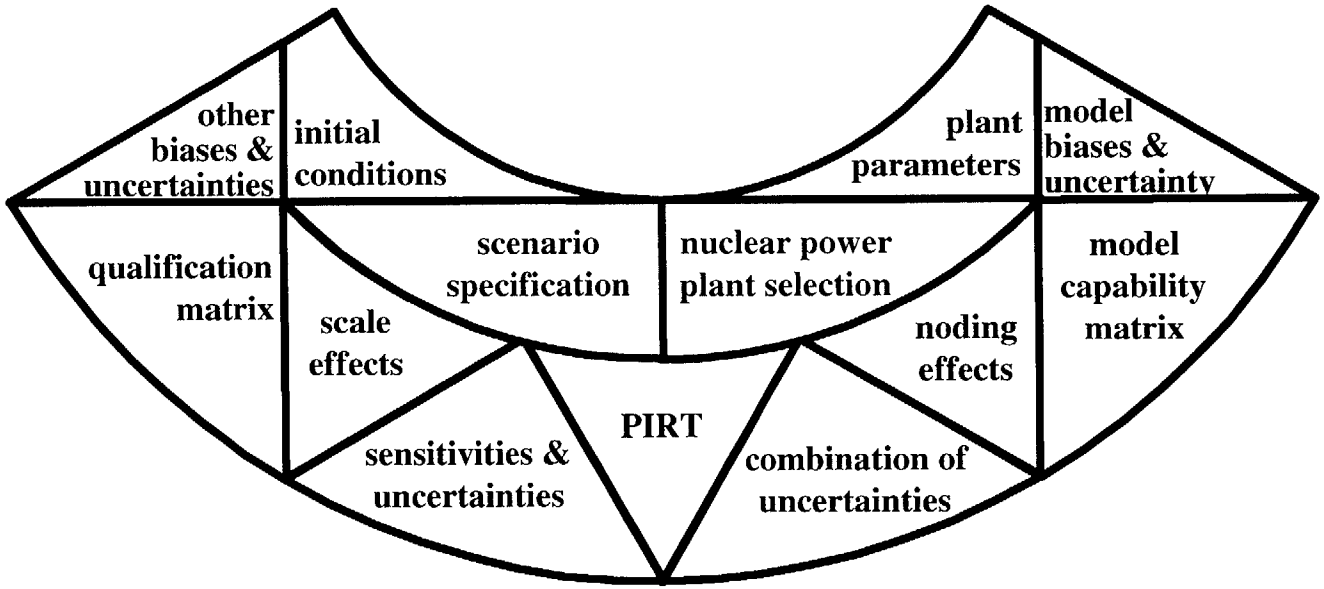
REVIEW ELEMENTS

3. Requirements and Capabilities
4. Assessment and Ranging of Parameters
5. Sensitivity and Uncertainty Analysis
6. Combination of Uncertainties
7. Results
8. Conclusions

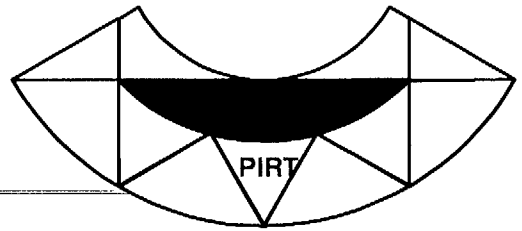
9. References

# Requirements and Capabilities

- Scenario Specification
- Nuclear Power Plant Selection
- Phenomena Identification, Ranking (Table 3-2 NEDC-33035P)

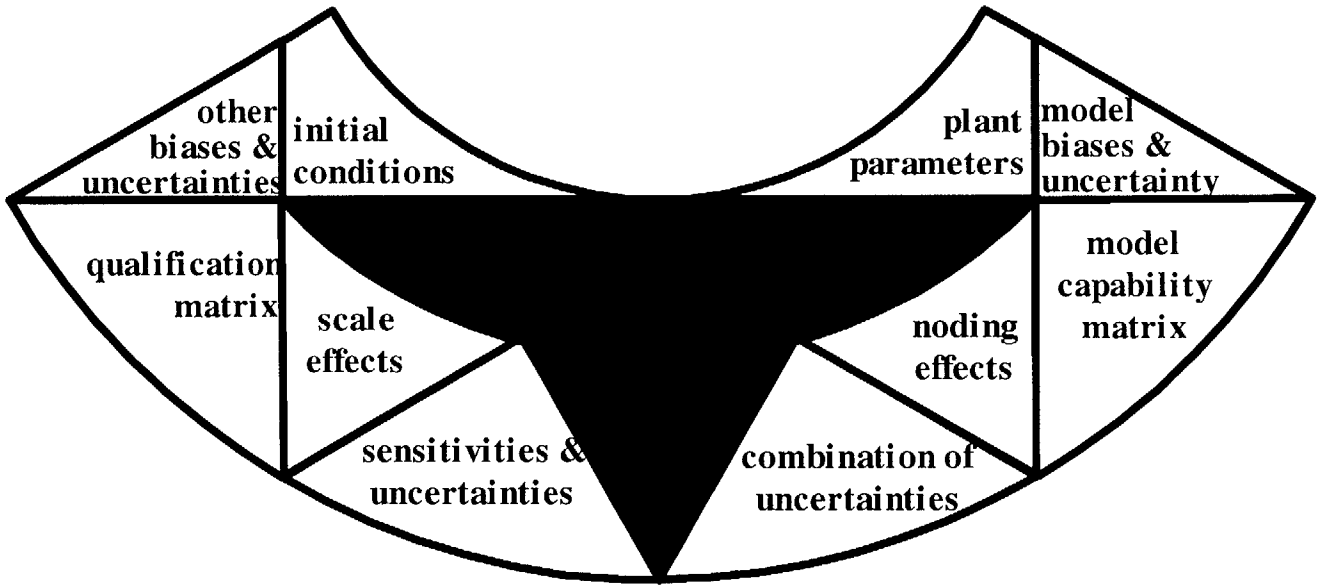


# Important Phenomena for BWR ECCS/LOCA (Table 3-2)

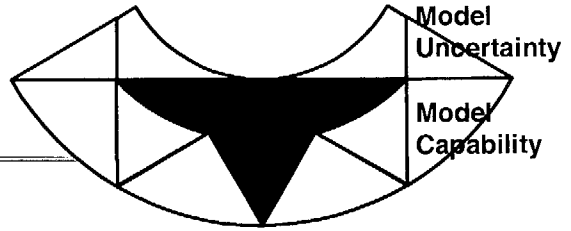


# Assessment and Ranging of Parameters

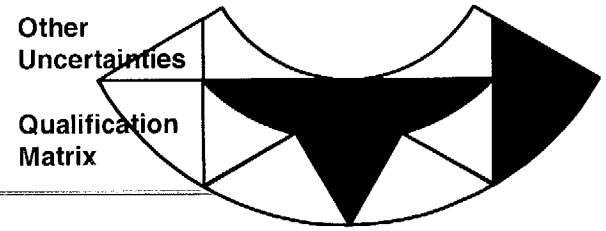
- Model Capability (Table 3-3 NEDC-33035P)
- LOCA Qualification Matrix (Table 3-4 NEDC-33035P)
- Model Uncertainties and Biases
- Other Uncertainties and Biases (IC and Plant Parameters)



# TRACG Model Capability Matrix for BWR ECCS/LOCA (Table 3-3)

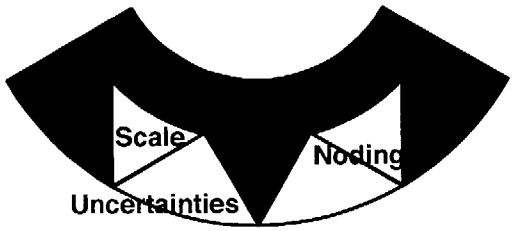


# TRACG Qualification Matrix for BWR ECCS/LOCA (Table 3-4)



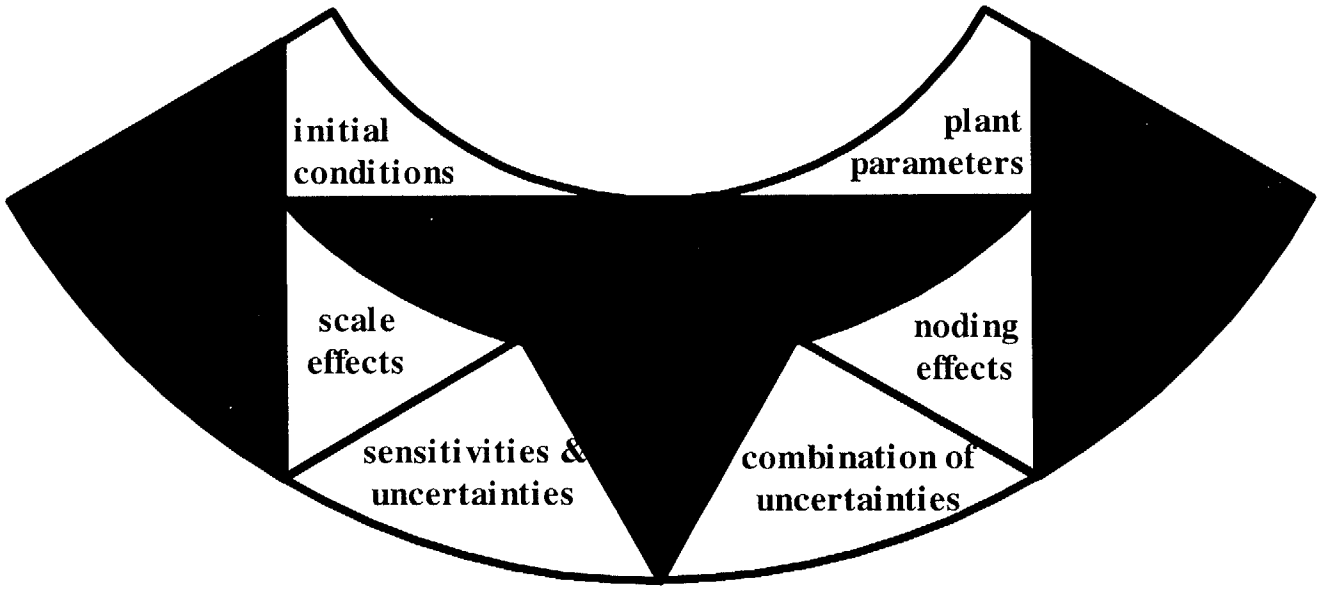
# Qualification LTR (NEDE-32177P Rev. 3) Sections

# Demonstration of Model Uncertainty and Bias



# Sensitivity and Uncertainty Analysis

- Uncertainty Inputs
- Scale and Noding Effects
- Initial Conditions (Table 3-5, NEDC-33035P)
- Plant Parameters (Table 3-6, NEDC-33035P)



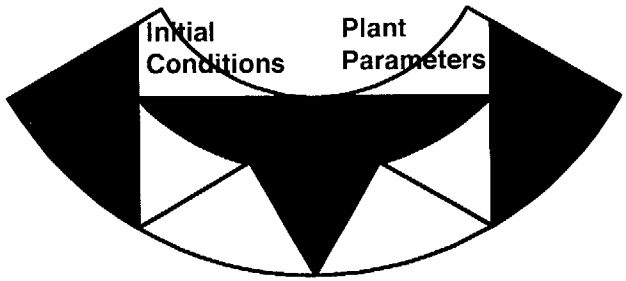
# Effects of Scale

# Proposed Scaling Comparison

# Geometry, Initial Conditions and Plant Parameters

- **Geometry inputs**
  - Lengths,
  - areas,
  - volumes,
  - hydraulic diameters,
  - loss coefficients.
- **Initial conditions - key plant inputs that determine the overall steady-state nuclear and hydraulic conditions prior to the transient.**
  - Essential to determining that the steady-state condition of the plant has been established.
- **Plant parameter – key plant inputs that influence the characteristics of the transient response not steady-state operation**
  - Examples: Protection system setpoints, ECCS pump capacities and Diesel Generator start times.

# Plant Parameter and Initial Condition Uncertainties.



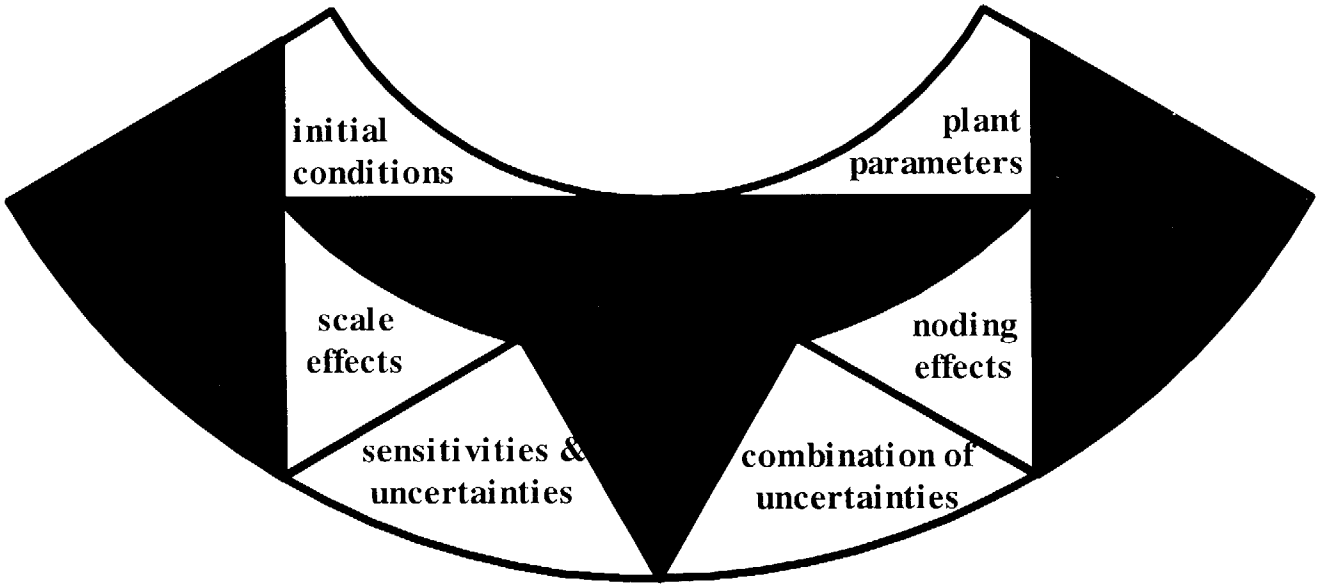
## Consideration of uncertainties in:
## Initial Conditions and Plant parameters

# Example:
# Proposal for Initial CPR / LHGR / Axial peaking

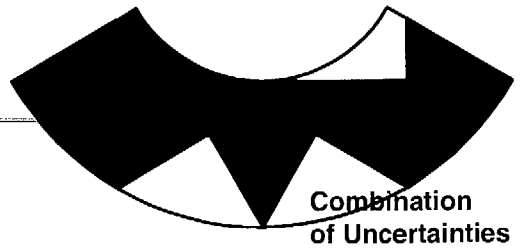
# Application range

# Combination of Uncertainties

- Examples of Recommended Approach
- Planned Confirmation Calculations



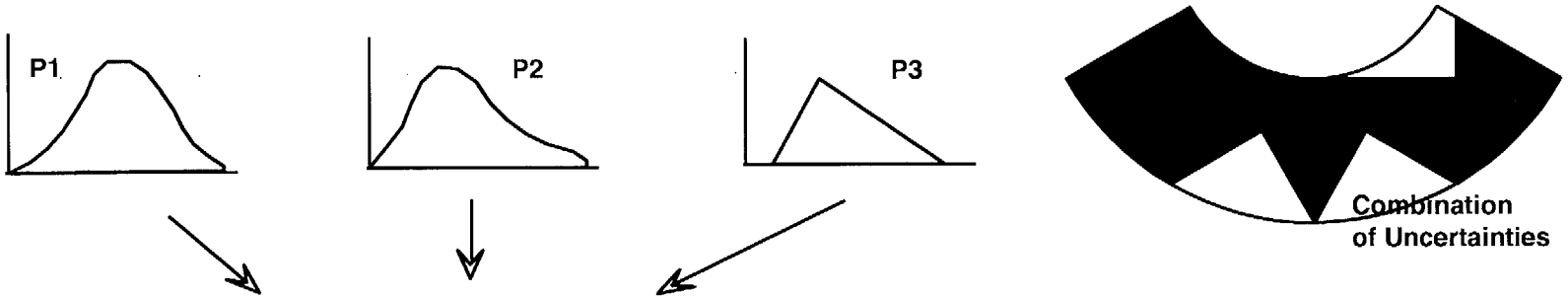
# Combination of Uncertainties



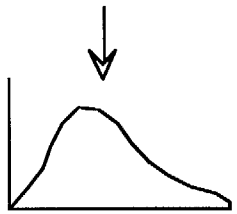

- Statistical treatment of Overall Calculational Uncertainty

# Order Statistics or Normal Distribution OSUTL

Major Model and Plant Parameters, e.g.,Film Boiling HTC, LHGR, ...

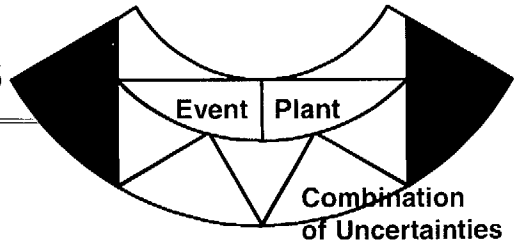



Determine Sensitivity Y = f(P1, P2, P3, ··· )



Critical Safety parameter, e.g., PCT

# Application Methodology Calculations



# Summary

## TRACG Application to BWR ECCS/LOCA Analysis

- **Scope: BWR/2-6**
- **Meets All Regulatory Requirements**
- **Demonstration of Model Capability and Applicability**
- **Extensive Prior Reviews and Acceptance of TRACG**
- **Rigorous and Sound Statistical Methodology**
  - Follows RG 1.157, CSAU
  - Model Uncertainty quantified
  - Initial Conditions and Plant Parameter Uncertainties considered
  - One Sided Upper Tolerance Limit calculated for Critical Safety Parameters
- **Application Methodology Demonstrated for Large and Small Breaks**

**Request SER for TRACG Application to BWR ECCS/LOCAs by 4Q02**