Status of the activities related to the use of RELAP5-3D at the Technical University of Catalonia

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Introduction

- Since 2003, the Thermal-Hydraulics Studies Group of the UPC has been using RELAP5-3D
- The code has been applied to different analytical studies related, in a greater or a lesser degree, to the usual group activities:
  - PANDA experiments
  - Use of Ascó and Vandellòs II NPPs models
  - BEMUSE project

Introduction

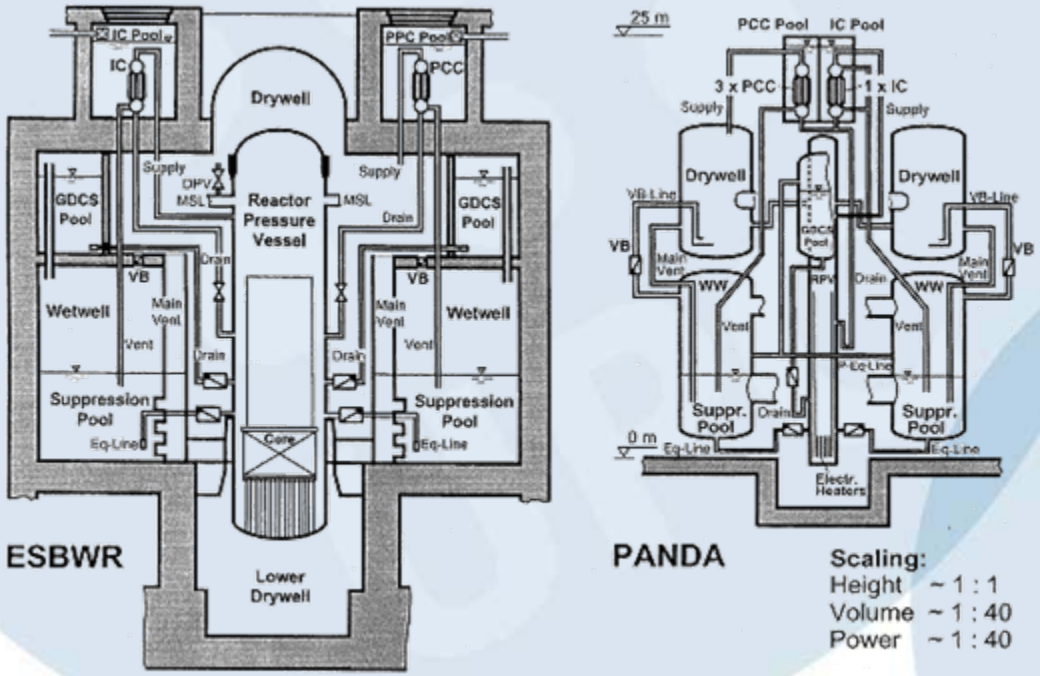
- Besides, a Graduate Thesis is on course
- The objective is to simulate a combustion process in an improved rural kitchen
- RELAP5-3D is used, taking advantage of the multiple independent NC gases capability
- 3D options are not discarded in this issue

Introduction

- These kitchens reduce the indoor pollution and save fuel (wood)

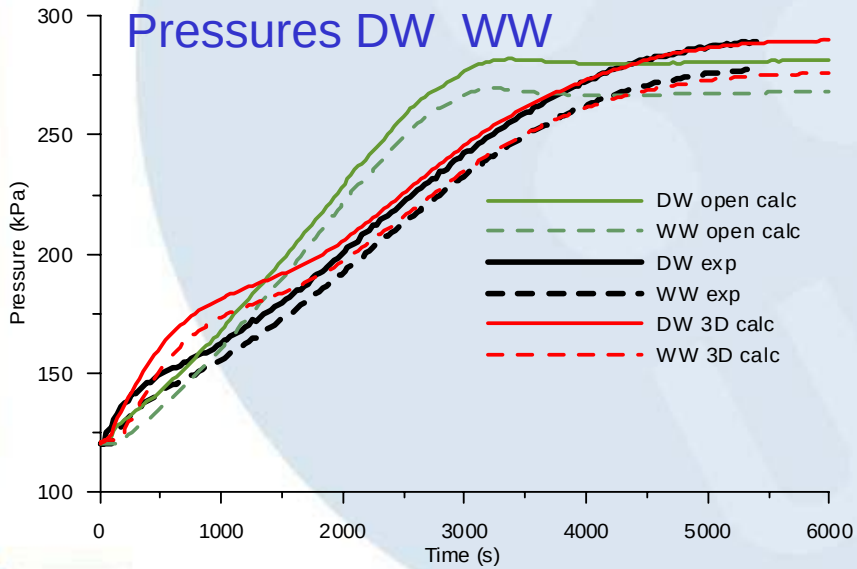
Introduction

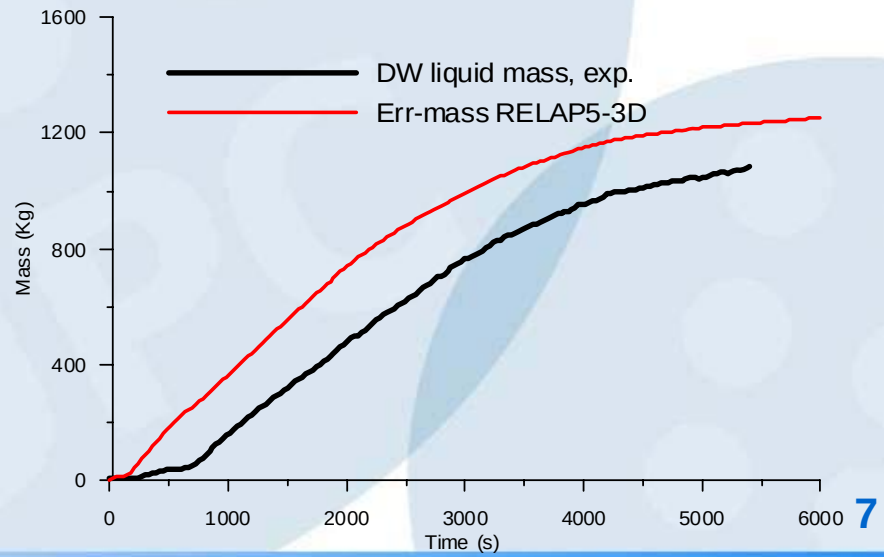
- For example, RELAP5-3D was used as a complement of the calculations performed during ISP-42 on PANDA experiments



Introduction

- In 2003 some results were presented and discrepancies were reported
- Nevertheless, the UPC is not working in this field now





Introduction

- This presentation deals with the use of RELAP5-3D in analysis related to activities that are considered relevant by UPC:
  - Use, maintenance, validation and qualification of the RELAP5 models of Ascó I and II and Vandellòs II NPPs, all of them 3 loop Westinghouse PWRs
  - Contribution to code validation and maintenance
  - Application of an Uncertainty and Sensitivity Evaluation Methodology to BE Thermal Hydraulic Analysis

Development of a 3D model for Vandellòs II

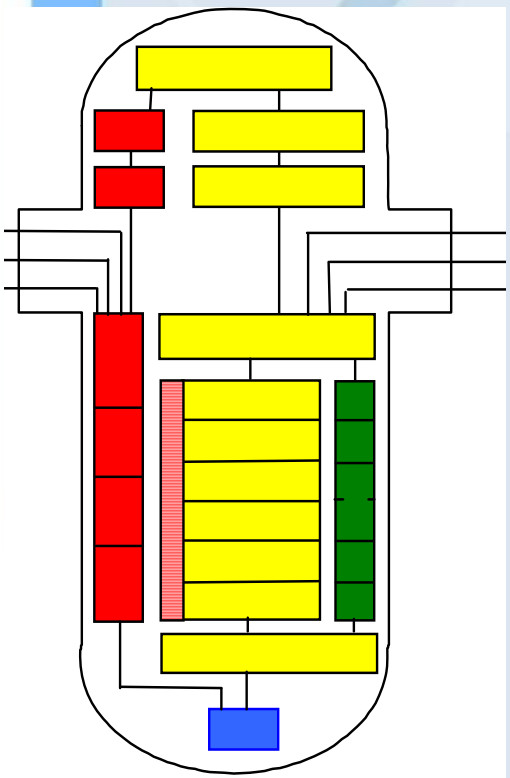
- Taking advantage of UPC experience in modeling the three Catalan NPPs, RELAP5-3D has been used to simulate some asymmetric transients and accidents in a commercial NPP:
  - The results of the simulation of a primary coolant pump transient occurred in Vandellòs II were presented at the RELAP5 Users Seminar in 2003.
  - The model developed to perform the analysis of the RCP transient was modified and improved in order to simulate a MSLB and a LB LOCA. The results of those simulations were presented at the 2003 and 2004 Seminars.

Development of a 3D model for Vandellòs II

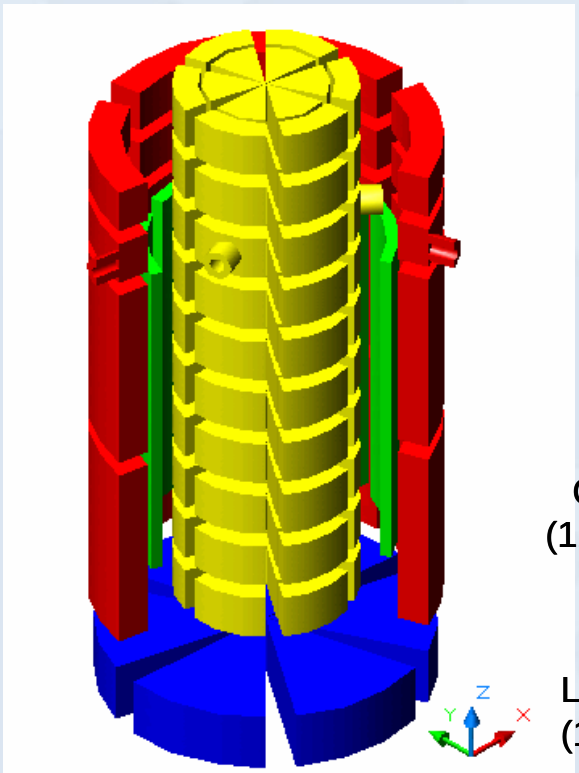
- The RELAP5-3D model of Vandellòs II is currently being improved not only in its hydrodynamic 3D aspects but also in coupling it with 3D neutronic kinetics:
  - Sensitivity to the downcomer/lower plenum nodalization is being analyzed
  - A previous RELAP5/PARCS model is being used a a basis to develop a RELAP5-3D/NESTLE model
  - Some modification to the existing 3D model should be done in order to use the neutronic data available (1/8 symmetry)

Development of a 3D model for Vandellòs II

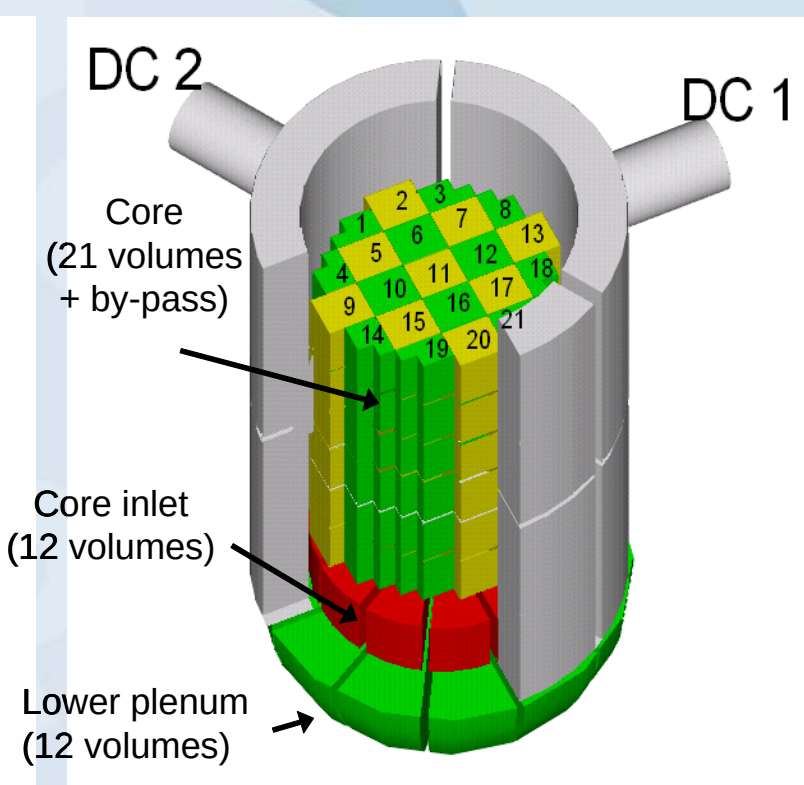
1D Vessel Model Relap5/3.2



3D Vessel Model Relap5-3D

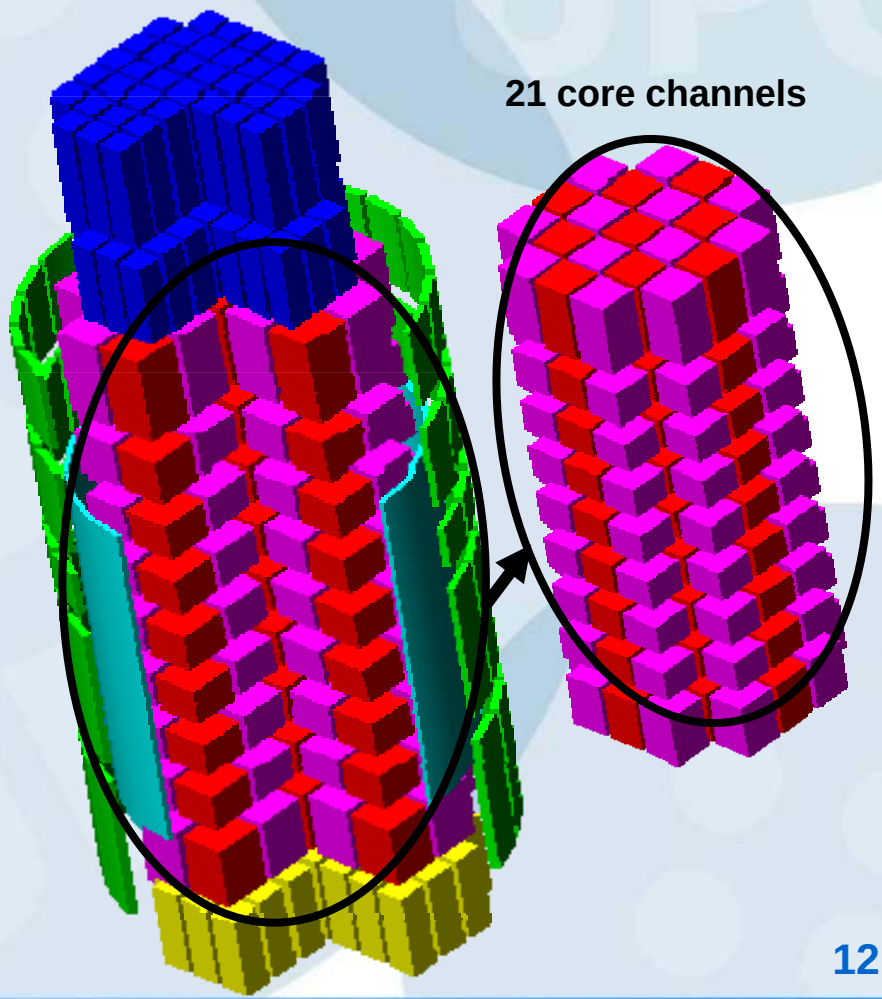


Pseudo 3D Model RELAP5/PARCS



Development of a 3D model for Vandellòs II

- A Graduate Thesis is on course on this issue
- Here is one of the nodalization proposals:
  - RPV consists of 5 multid (cartesian + cylindrical)
  - 500 hydraulic nodi
  - Some of them are disabled (by applying small volume factors) in the corners



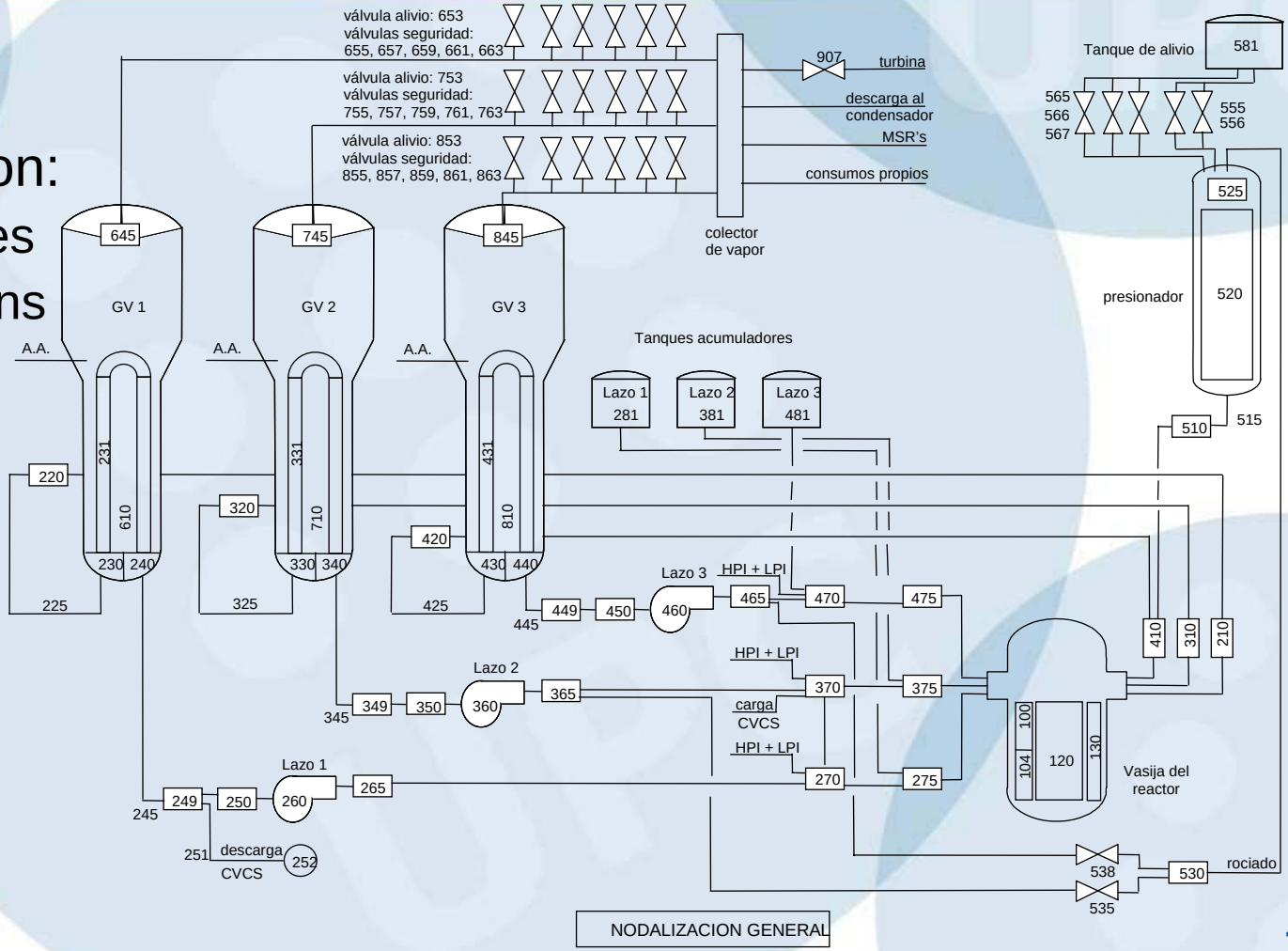
Simulation of a load rejection in Ascó

- RELAP5-3D has been successfully used with the full 1D model of Ascó
- Compared with the RELAP5-3D model for Vandellòs II, the full 1D models (both for Ascó and Vandellòs II) are more complex and complete:
  - They incorporate a large portion of the fluid systems of the plants
  - They contain a very detailed description of the control systems

Simulation of a load rejection in Ascó

General nodalization:

- 403 volumes
- 444 junctions
- 106 heat structures
- 418 mesh points

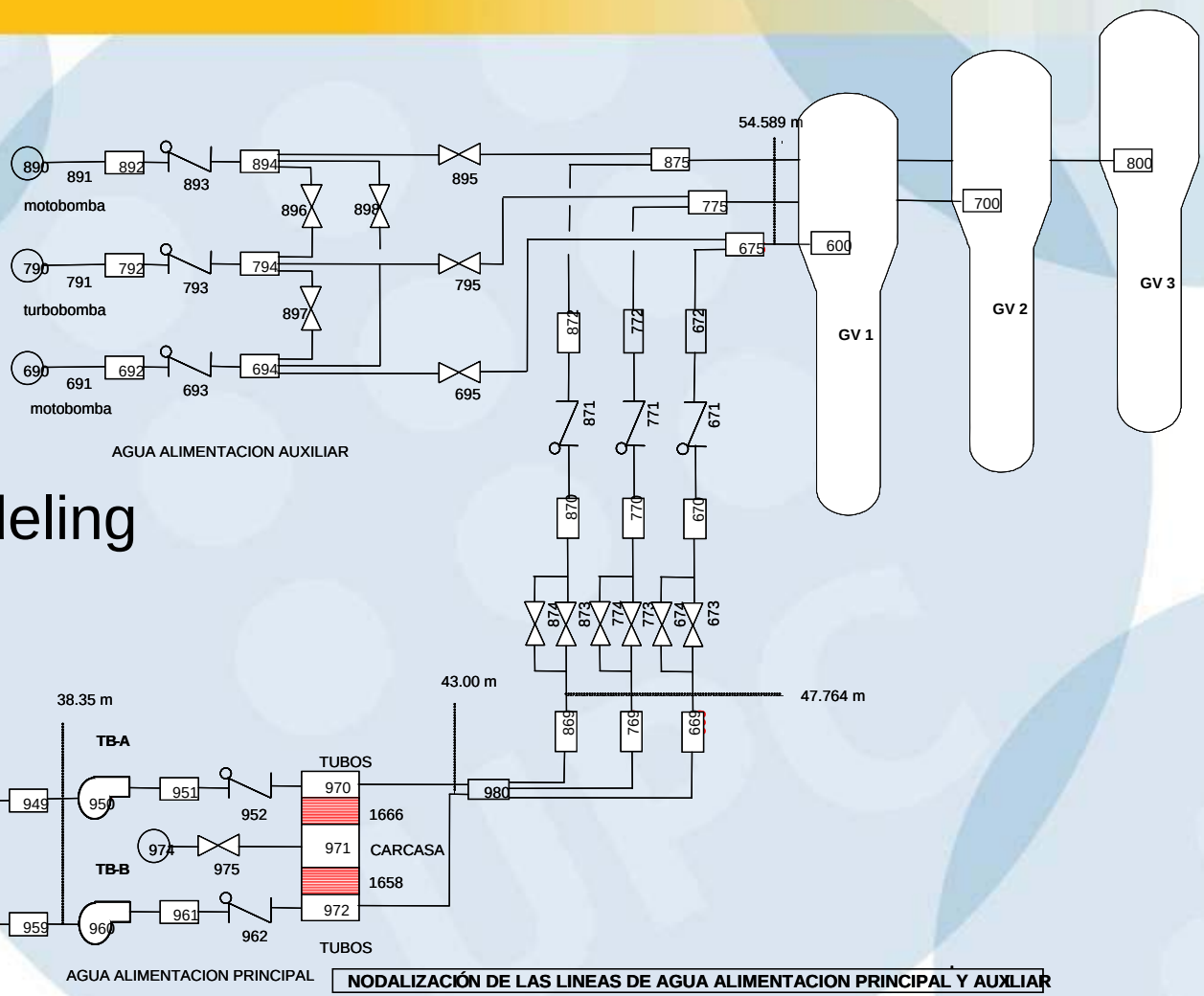


Simulation of a load rejection in Ascó

AFW

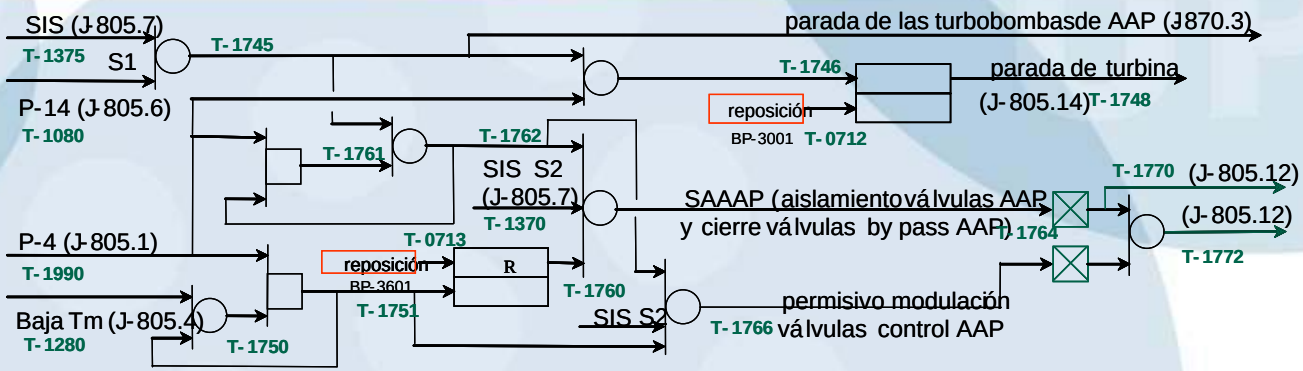
FW modeling

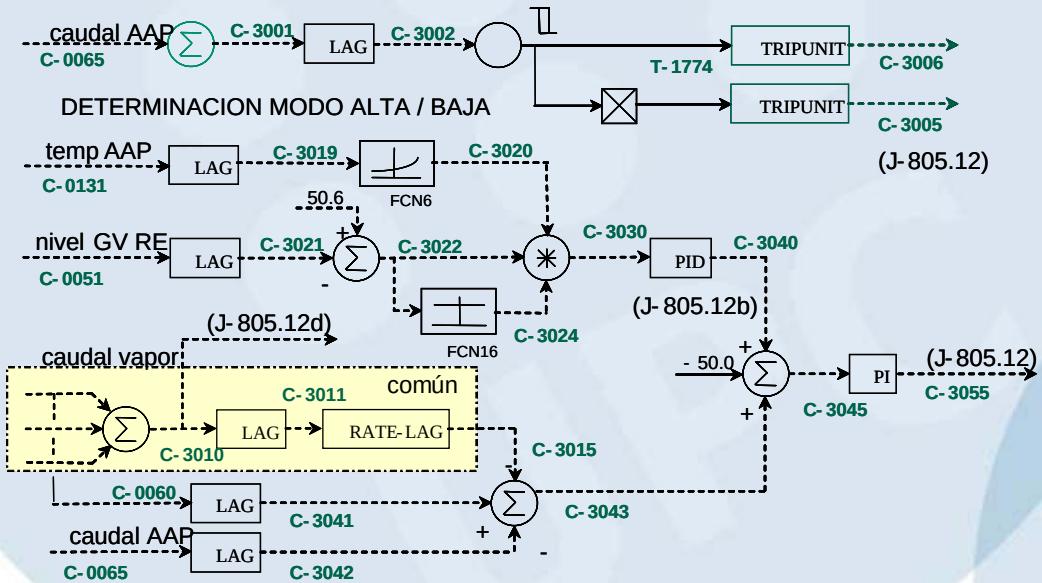
MFW



Simulation of a load rejection in Ascó

Logic diagram (partial) of the MFW control system





numeración

GV 1	GV 2	GV 3
C-3001	C-3201	C-3401
C-3002	C-3202	C-3402
C-3005	C-3205	C-3405
C-3006	C-3206	C-3406
C-3019	C-3219	C-3419
C-3020	C-3220	C-3420
C-3021	C-3221	C-3421
C-3022	C-3222	C-3422
C-3024	C-3224	C-3424
C-3030	C-3230	C-3430
C-3040	C-3240	C-3440
C-3041	C-3241	C-3441
C-3042	C-3242	C-3442
C-3043	C-3243	C-3443
C-3045	C-3245	C-3445
C-3055	C-3255	C-3455

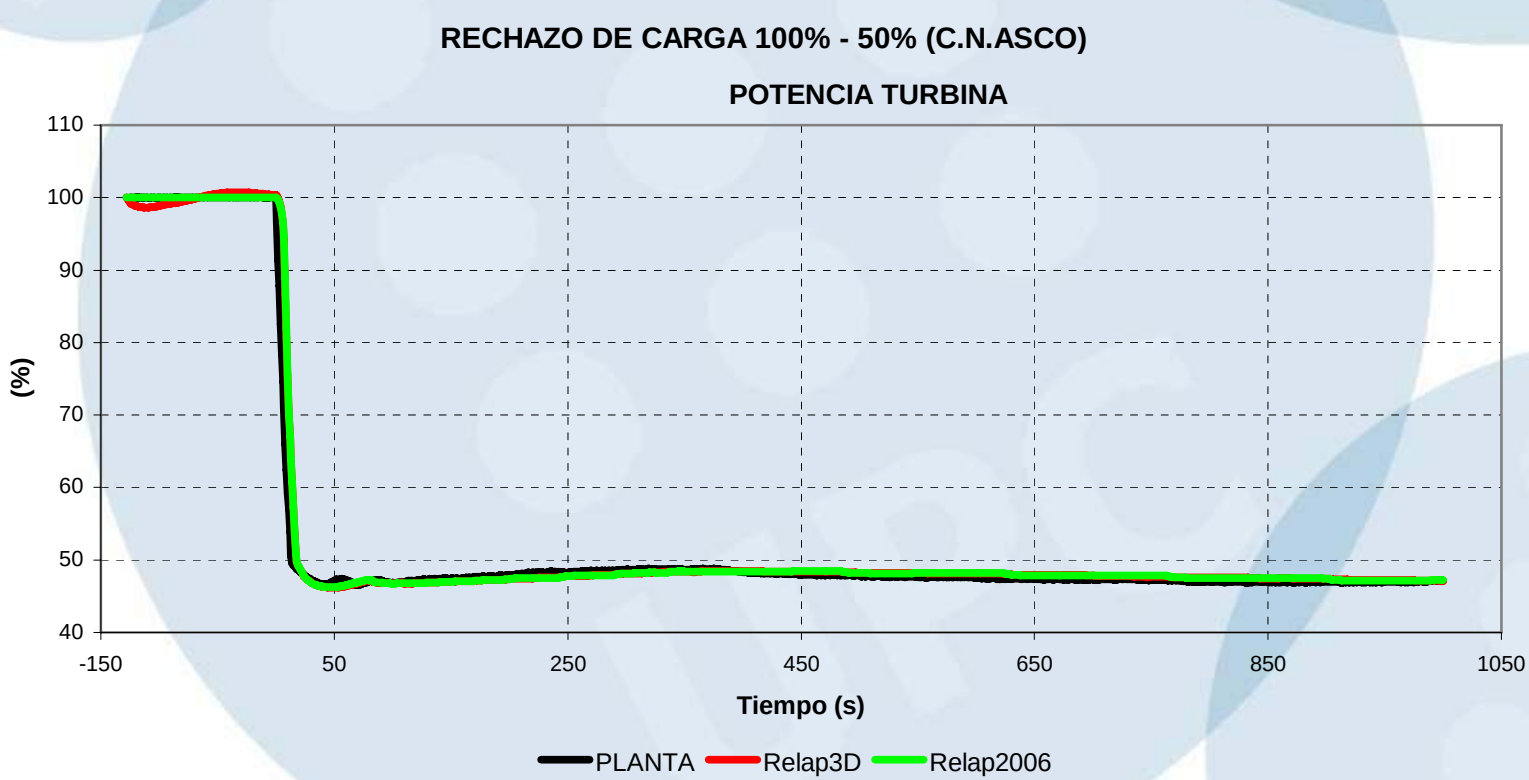
CONTROL Y AISLAMIENTO AGUA ALIMENTACION PRINCIPAL

Simulation of a load rejection in Ascó

- Both models are continuously updated and re-qualified following a specific methodology
- The transient that follows is maybe the most relevant belonging to Ascó qualification matrix
- Load rejection (50%) corresponding to the testing after fuel reload (Ascó I, 1999, cycle 13)
- Intervention of kinetics, TH, control systems; the actuation of one system affecting the others
- Next, RELAP5-3D results are compared to plant data and RELAP5/Mod3.2 (2006 calculation)

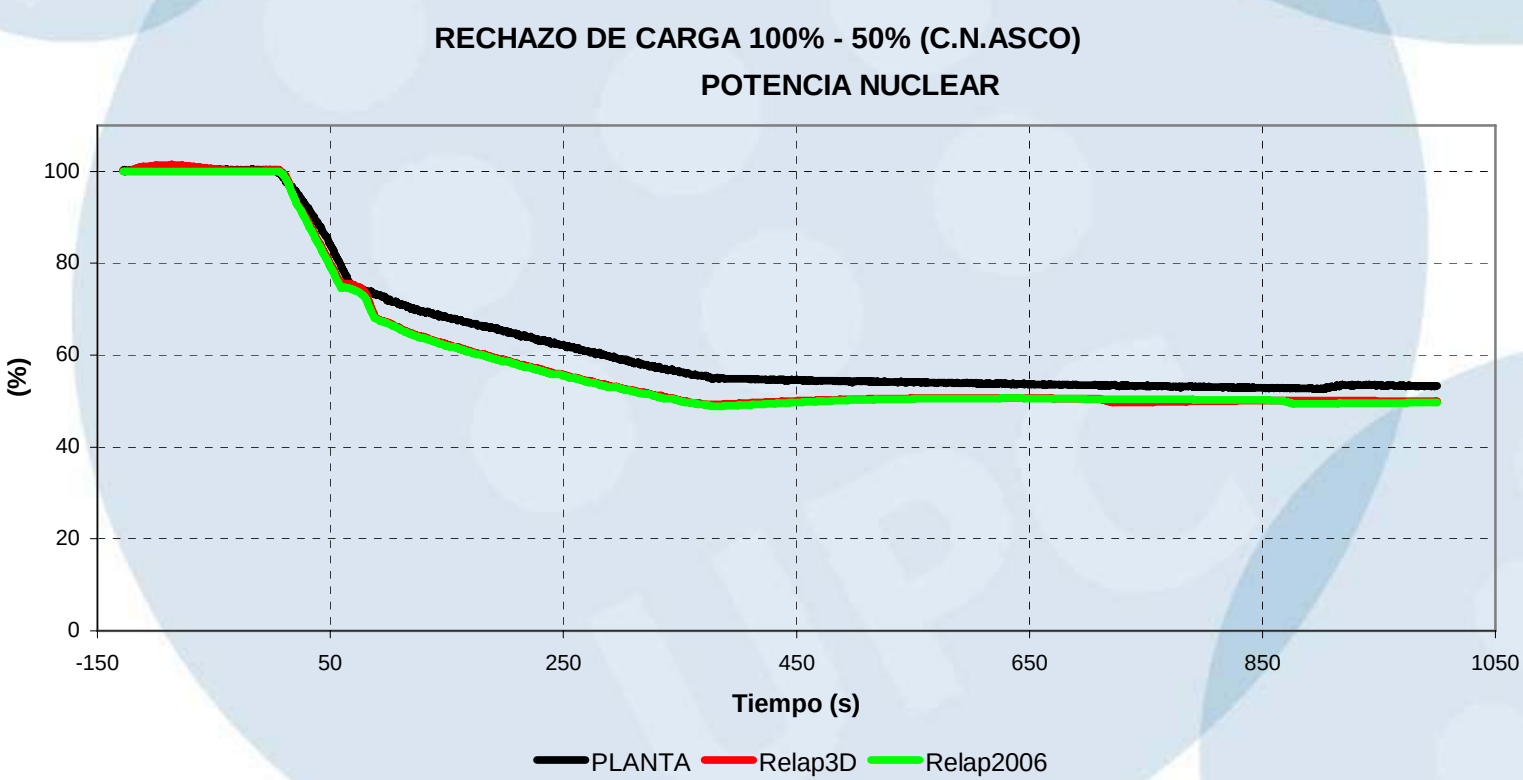
Simulation of a load rejection in Ascó

- Some results: Turbine Power



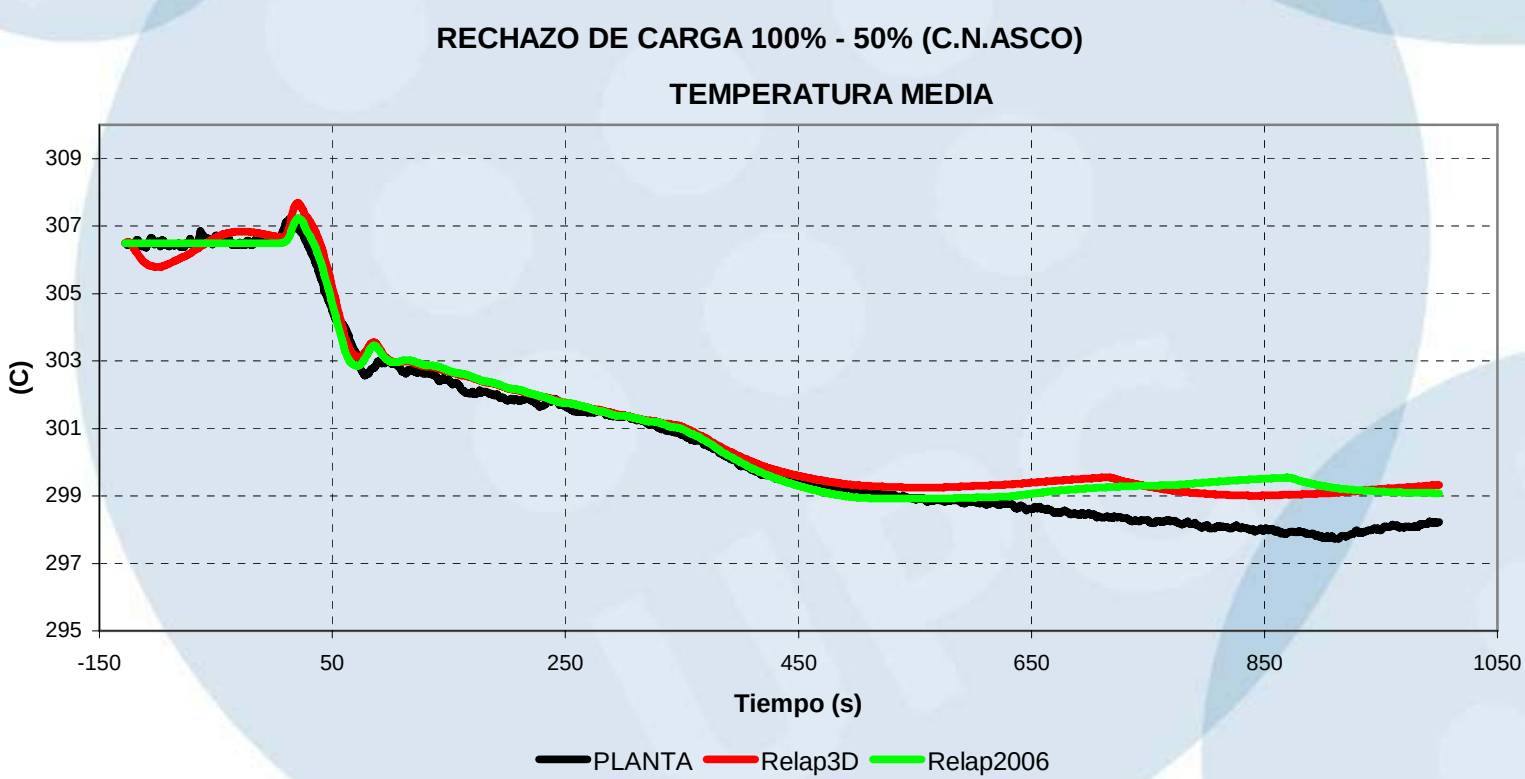
Simulation of a load rejection in Ascó

- Some results: Nuclear Power



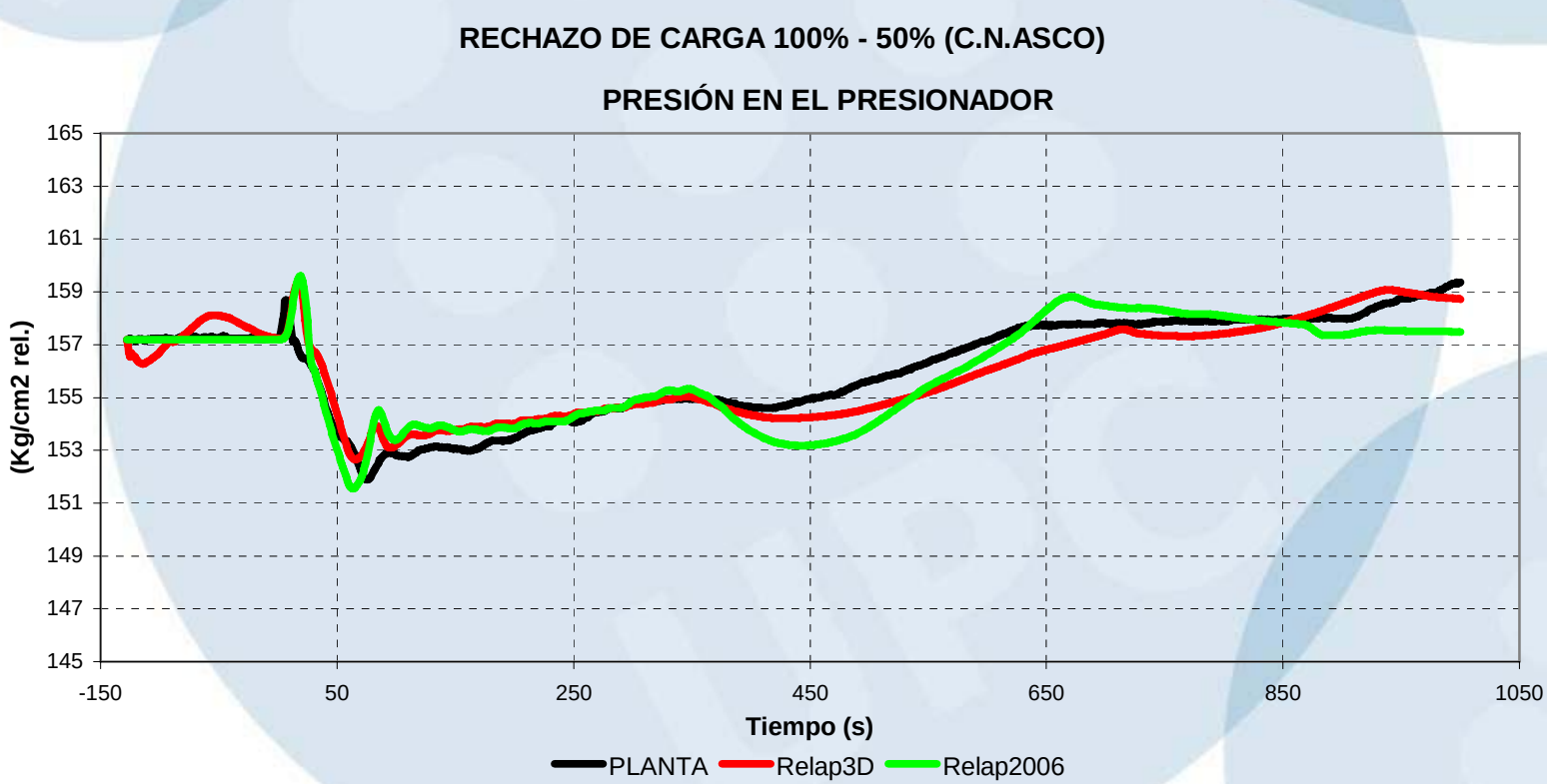
Simulation of a load rejection in Ascó

- Some results: Mean Temperature



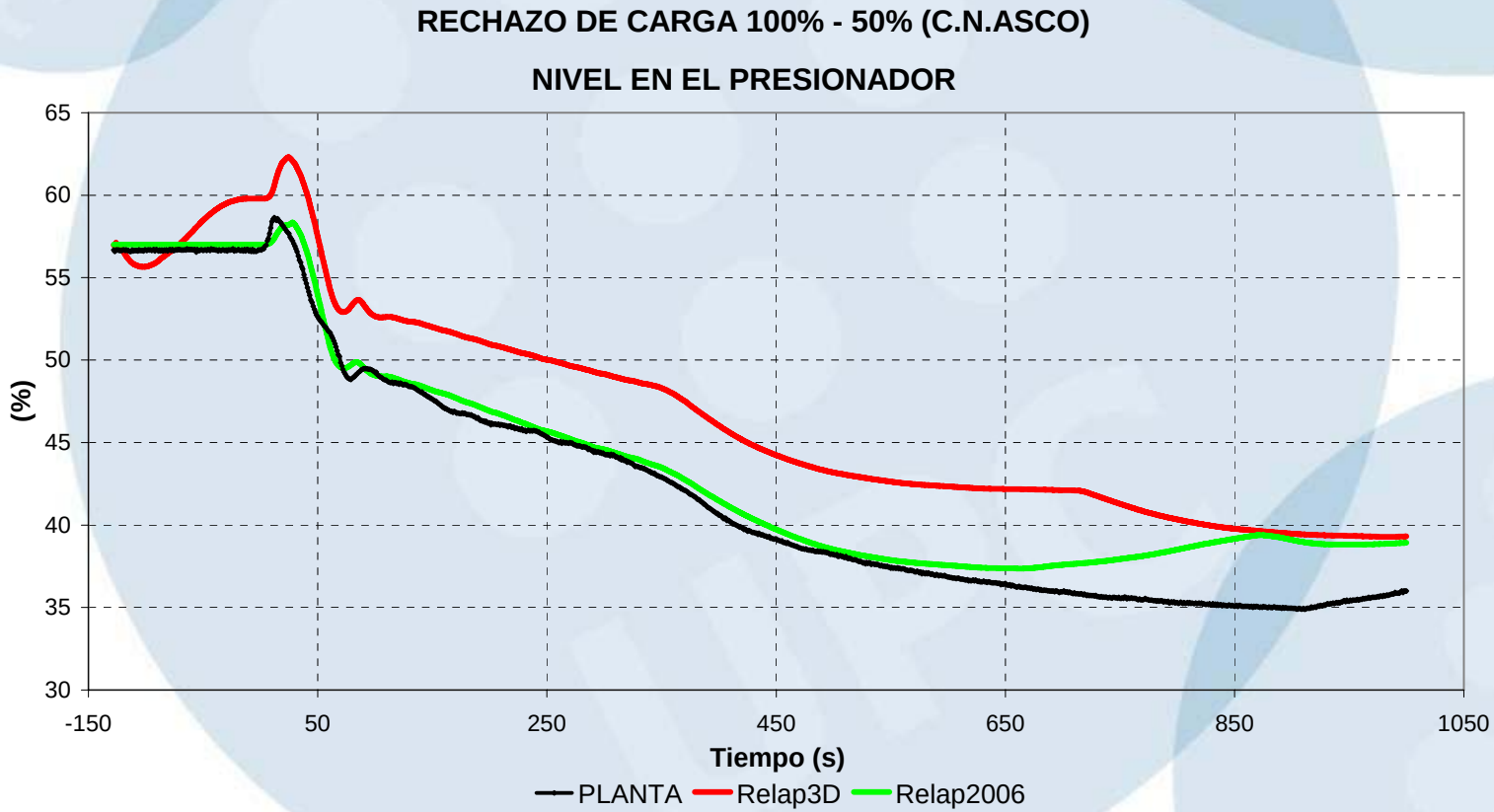
Simulation of a load rejection in Ascó

- Some results: Pressurizer Pressure



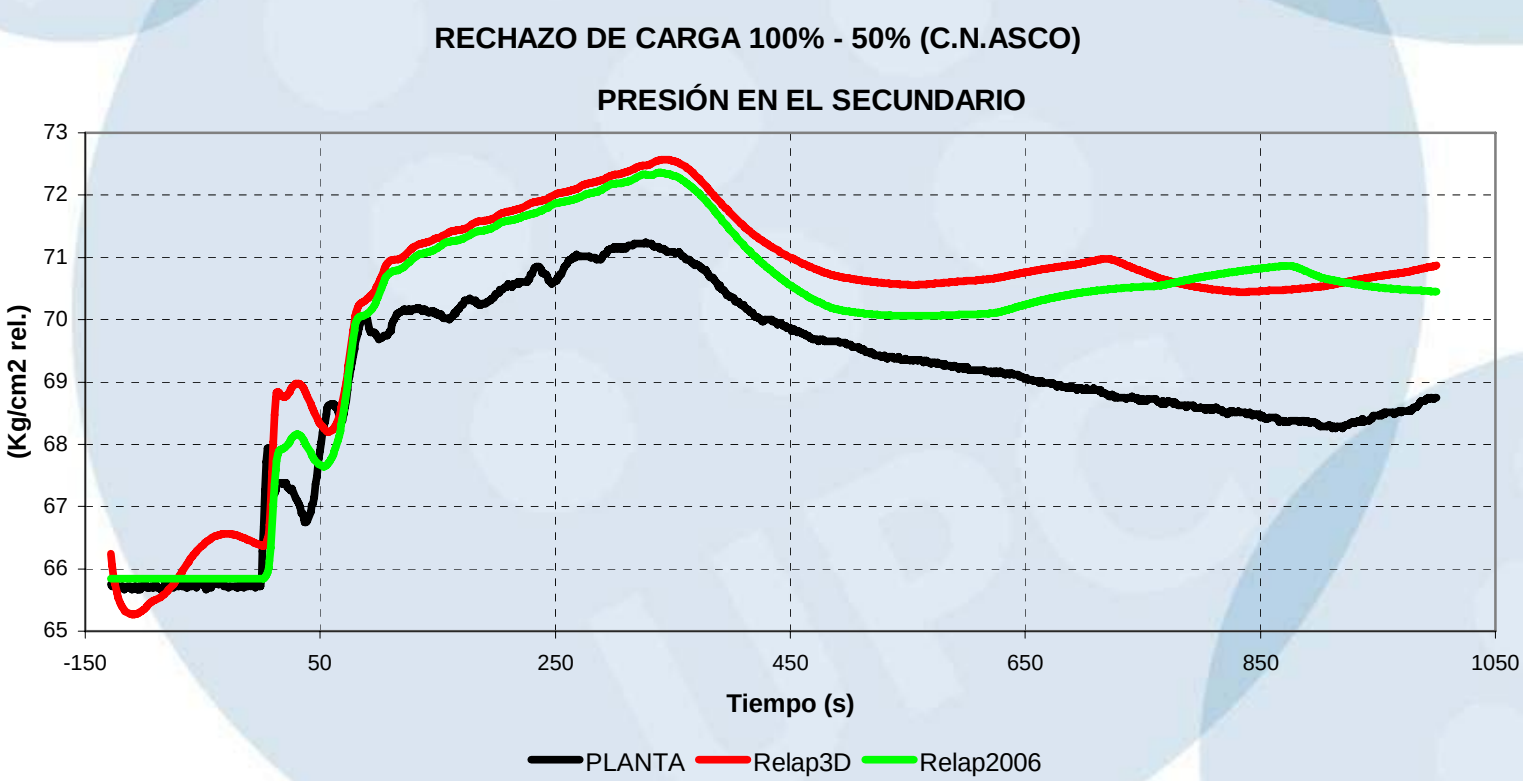
Simulation of a load rejection in Ascó

- Some results: Pressurizer Pressure



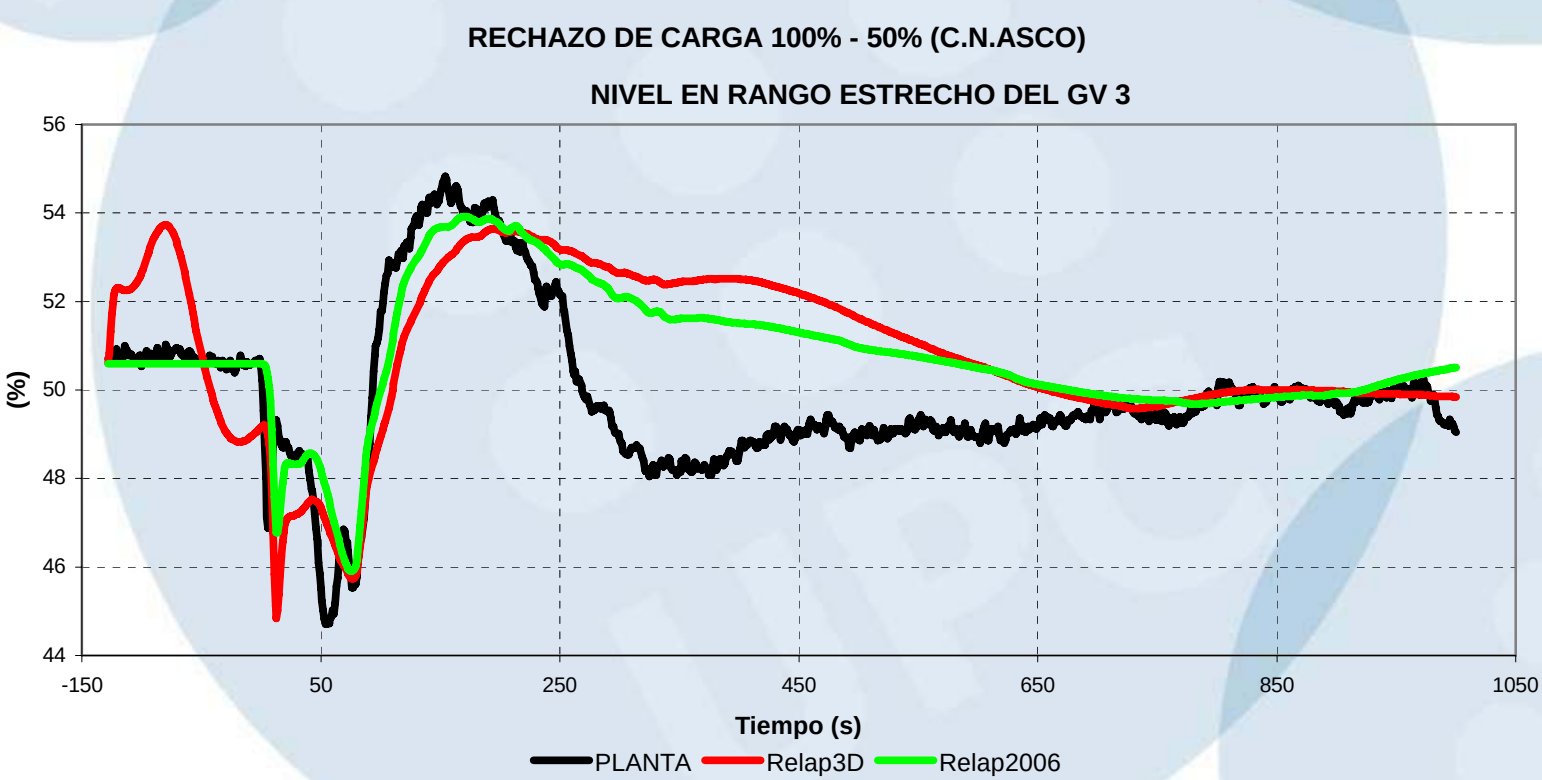
Simulation of a load rejection in Ascó

- Some results: Secondary Side Pressure



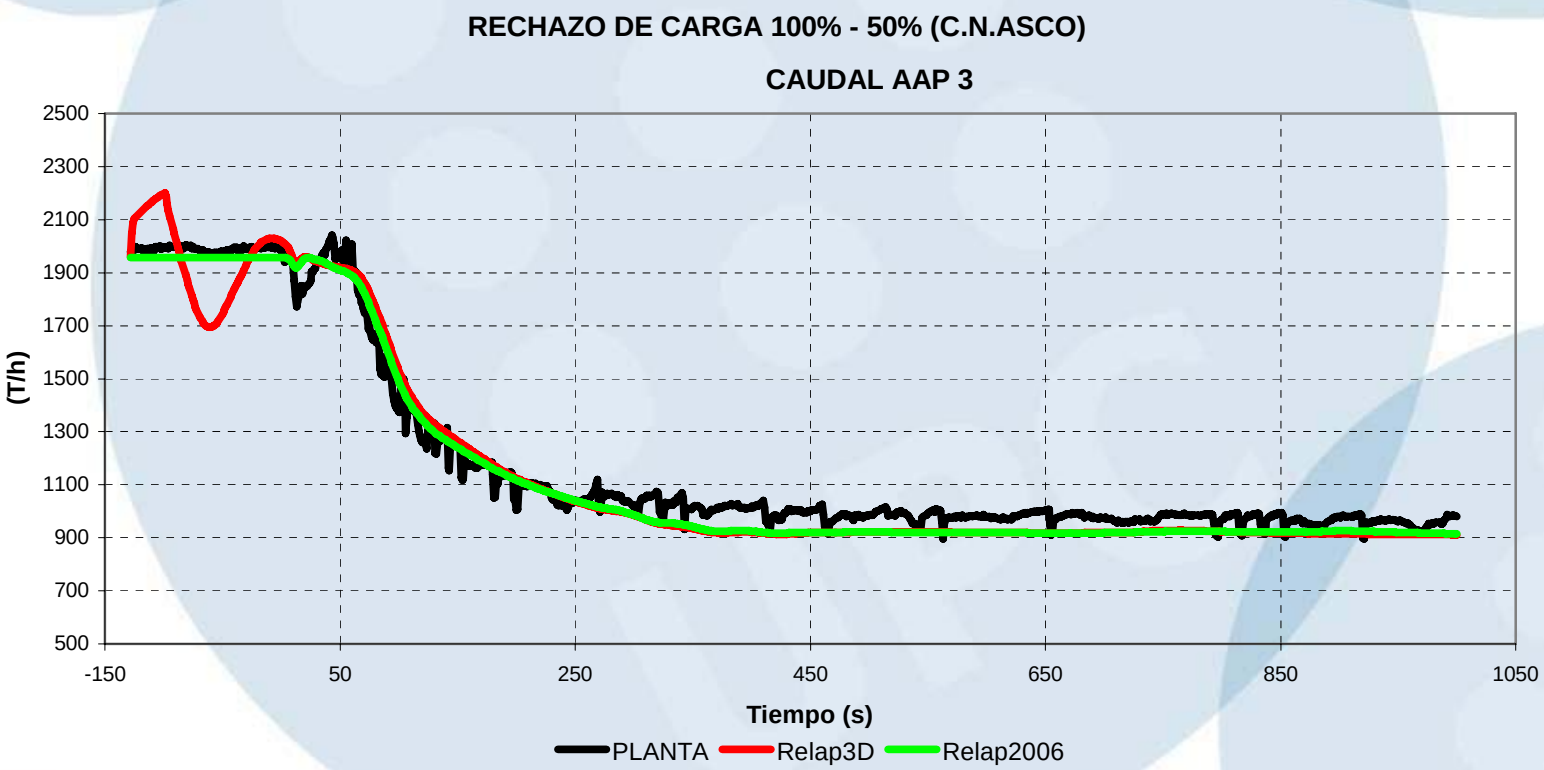
Simulation of a load rejection in Ascó

- Some results: SG3 Narrow Range Level



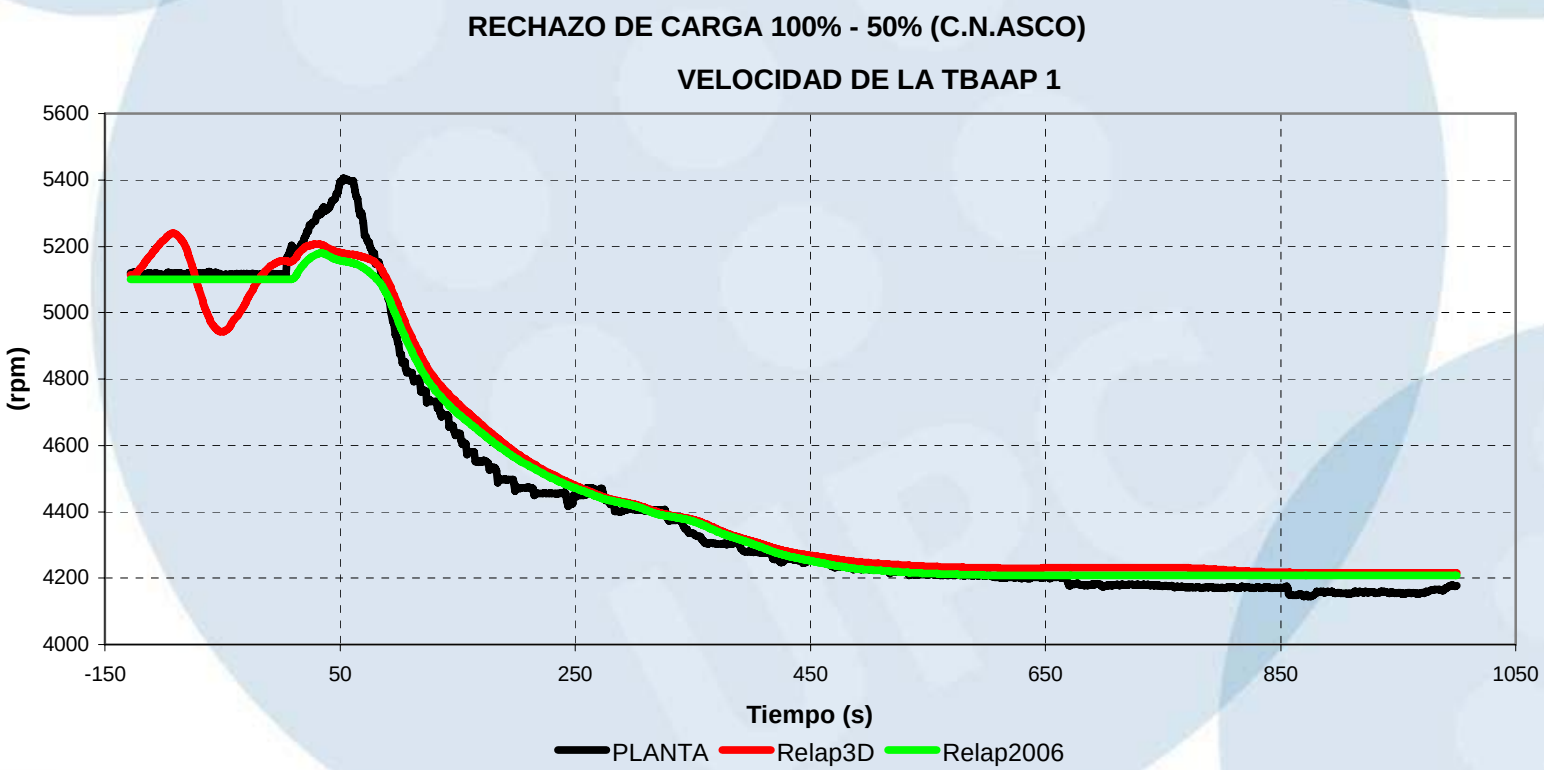
Simulation of a load rejection in Ascó

- Some results: Feed Water Mass Flow SG3



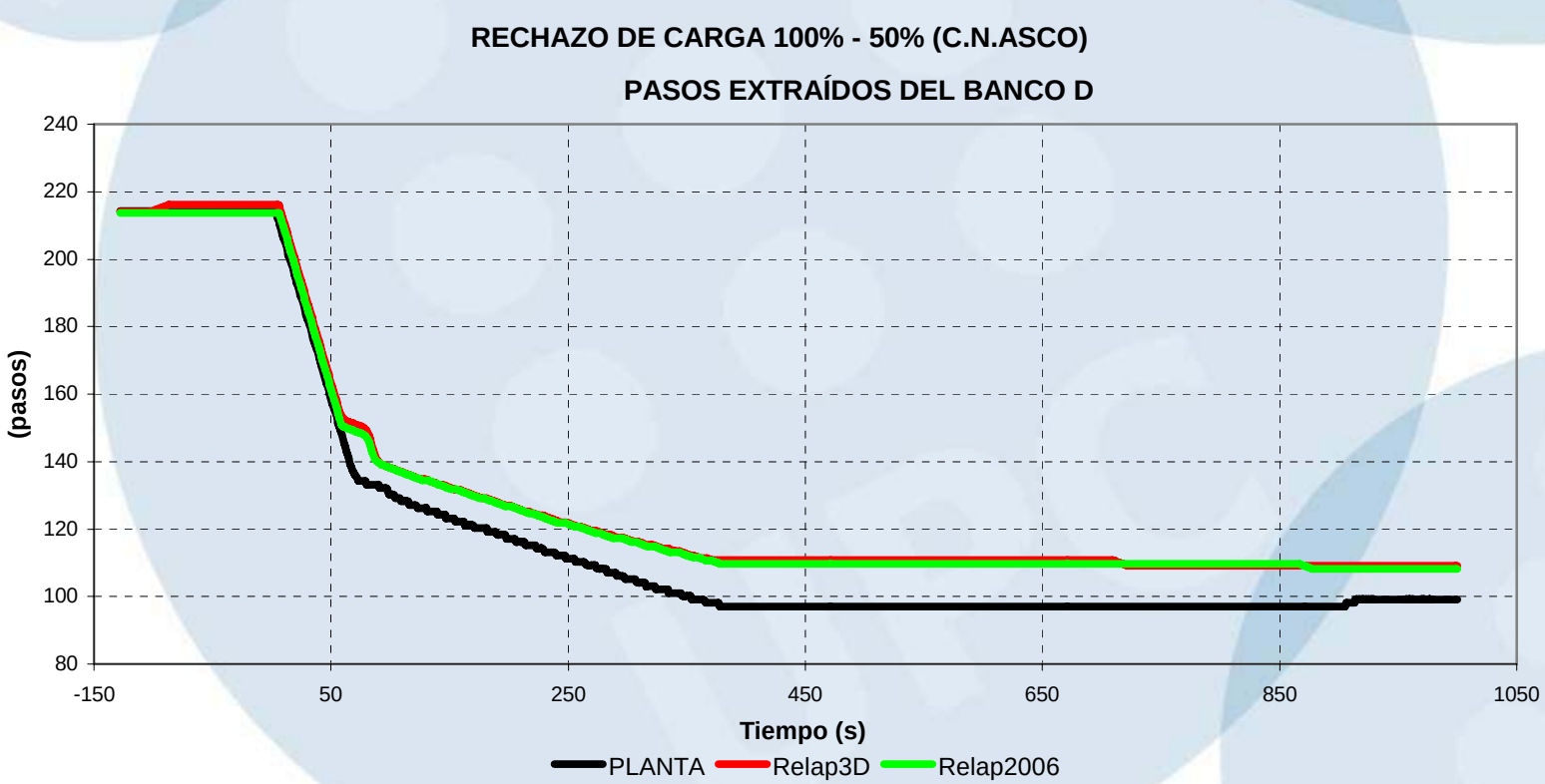
Simulation of a load rejection in Ascó

- Some results: MFW TurboPump1 Velocity



Simulation of a load rejection in Ascó

- Some results: Bank D Withdrawn Steps



Simulation of a load rejection in Ascó

- It is worth to recall that the same input has been used for the 3D and 1D versions of the code
- Results obtained with the two codes are similar but it seems that the NRC version performs slightly better
- Nevertheless, the discrepancies are primarily related to an initial instability (3D version), and to the procedure followed (deadband restitution…) to arrive to a stationary state (both issues are linked)

Opportunities for code validation

- The full 1D RELAP5 models of the plants are being continuously reviewed, in a thorough validation and qualification process.
- There is a great number of applications of the 1D models already performed:
  - Quite a large number of them could be revisited and come up with better results with RELAP5-3D
  - Scientific interest (UPC)
  - In future UPC results could stimulate utility and regulator interest

Opportunities for code validation

- Being able to use those models with RELAP5-3D with some minimum modifications (the only major change being the replacement of the 1D vessel by a 3D RPV) may have some interesting applications.
  - RELAP5-3D could be easily used to analyze operational transients of both plants as part of the code validation process
  - some safety related anticipated asymmetric accidents could be reanalyzed using the 3D version of the code.

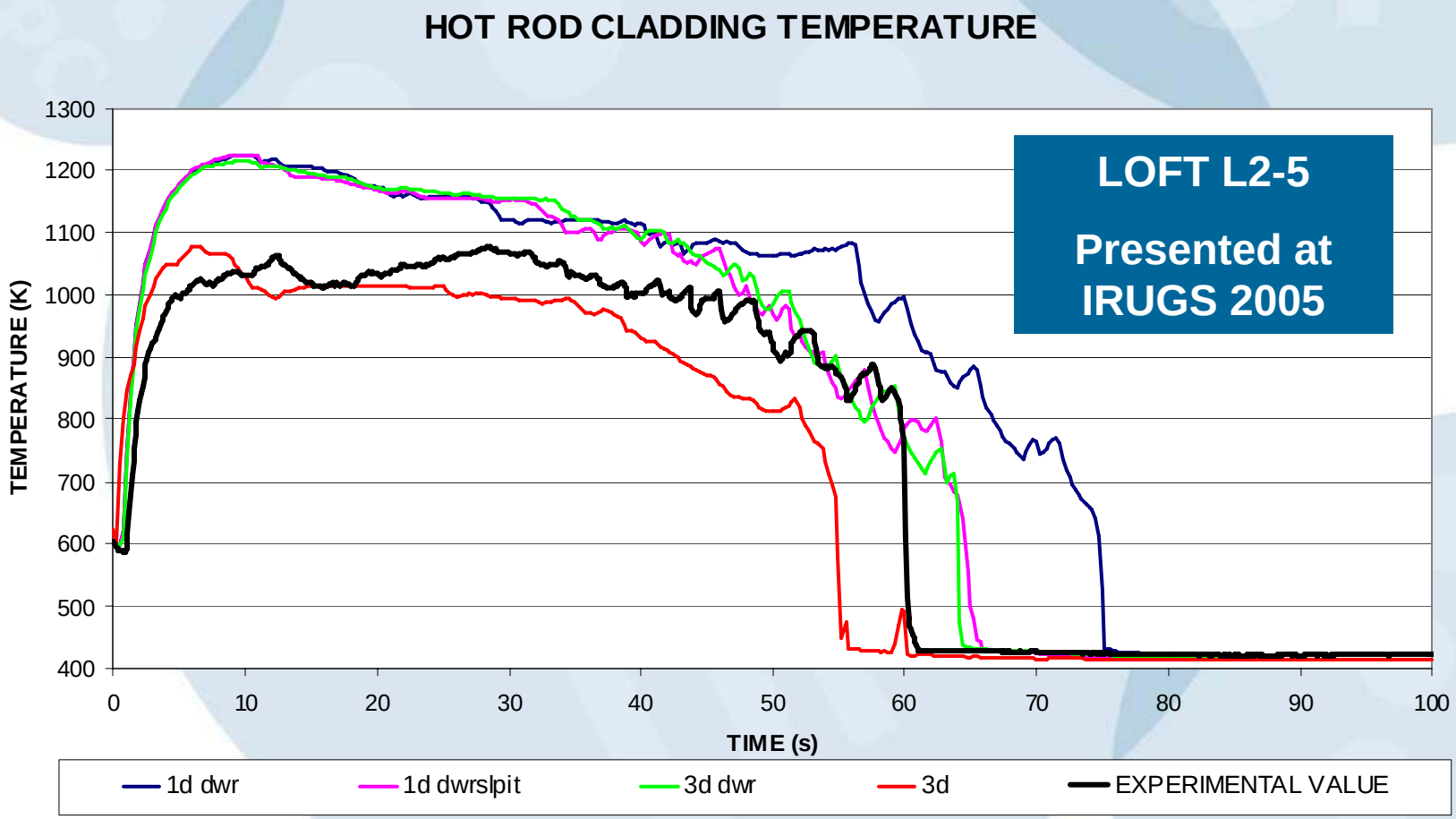
The BEMUSE project

- OECD BEMUSE (BE Methods – Uncertainty and Sensitivity Evaluation) project (September 2003/ end 2007):
  - Use of methodologies developed for uncertainty analysis of results obtained in computational simulations
  - Phases 2 and 3 (out of 6) were related to LOFT L2-5
  - During phases 4 and 5 the participants will apply their respective methods to the analysis of a LB LOCA in a commercial four loop PWR

The BEMUSE project

- Our group is using a CAMP version of the code RELAP5/MOD3.3 to calculate the benchmark simulations: we need to modify internal parameters in some heat transfer subroutines
- Nevertheless, our intention is to perform some additional analysis with RELAP-3D (results of the use of RELAP5-3D in the simulation of the L2-5 were presented in 2005 IRUGS)

The BEMUSE project



The BEMUSE project

- Our group has been designated to lead the phases 4 and 5 of BEMUSE which started in May 2006
- This new step of the project provides a good opportunity to apply RELAP5-3D to the evaluation of uncertainties
- The strong starting point that encourages this activity is the fact that, for L2-5 base case, the results with RELAP5-3D were substantially more accurate than those obtained with the 1D version

Conclusions

- RELAP5-3D has been a useful analytical tool for UPC in the recent past
- The use of the code together with qualified models of the three Catalan NPPs can lead to fruitful results, both from the analyst point of view and for code validation
- UPC interest is growing in specific areas (BE+Uncertainties)
- Some minor problems have to be solved or clarified (code stability + steady state procedure)