NC2I-R
Nuclear Cogeneration Industrial Initiative Research and Development Coordination

Nuclear cogeneration: advantages of the HTR safety concept

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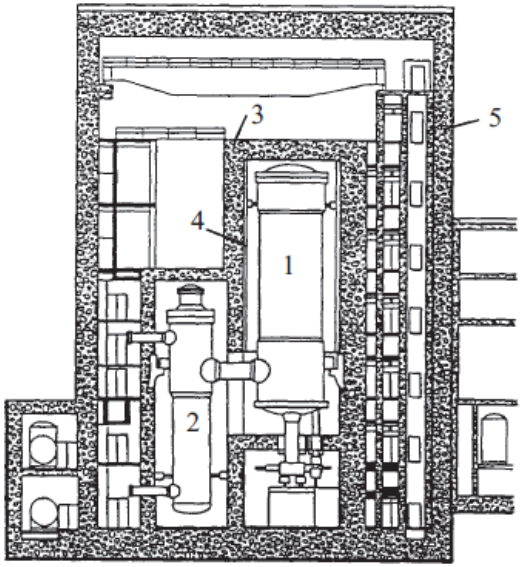
Safety studies in the NC2I-R FP7 project

- Main questions:
  - ❑ Are there specific licensing risks associated with nuclear cogeneration?
  - ❑ How to cope with?
- Main goals of safety studies in NC2I-R
  - ❑ Analyse the feedback on nuclear cogeneration
  - ❑ List the specific issues associated with cogen. and propose a set of safety requirements adapted to cogeneration
  - ❑ Identify the potential impact on licensing procedure (or construction authorization)
  - ❑ Make the synthesis of R&D items to support safety demonstration

Lessons from feedback

- Nuclear plants in operation
  - ❑ Mainly PWRs
  - ❑ Heat production
  - ❑ Heat production has low impact on the nuclear plant operation
  - ❑ Primary circuit is separated from the heat grid by two « barriers » at least (steam generators, heat exchangers)
  - ❑ No specific safety case in the Safety Report

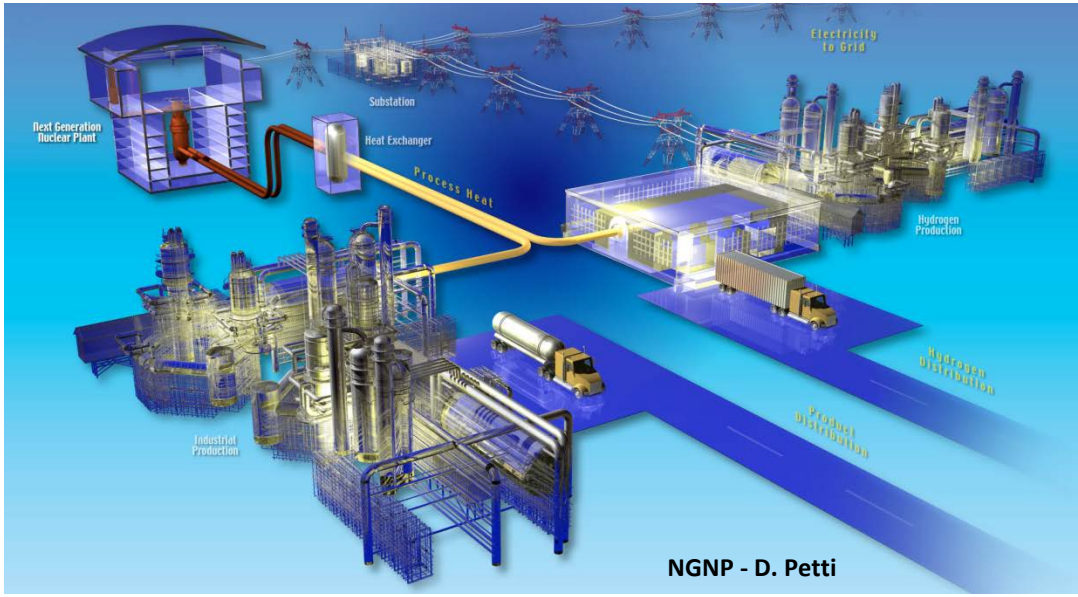


HTR Module elevation (SIEMENS)

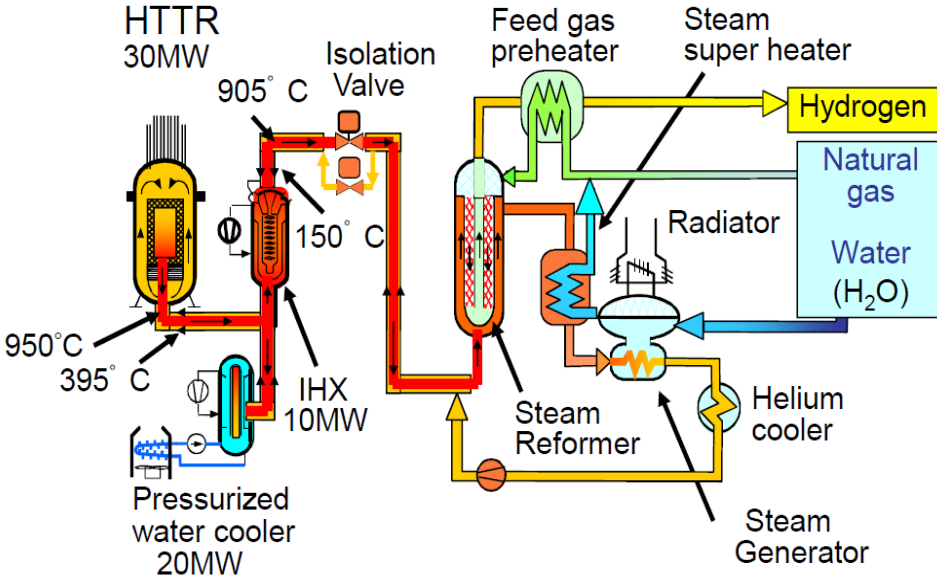
- Past projects with HTRs
  - ❑ Specific risks identified for process heat => R&D programs on hydrogen production process – analysis of chemical risks, explosion risks
  - ❑ Process steam: studies on tritium permeation

Foreseen layouts

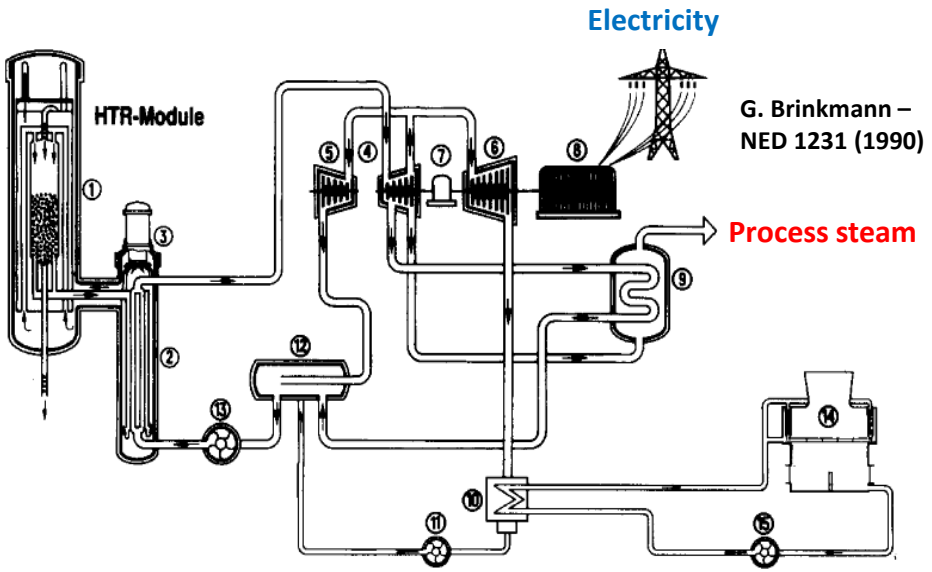
- Multipurpose installation : heat (steam, hot water) & electricity for an urban and industrial zone
- Heat (process steam) & electricity production for an industrial cluster



NGNP - D. Petti



Steam reforming – K. Verfondern
ICTP-IAEA school Trieste 2011



G. Brinkmann – NED 1231 (1990)

Recall of « generic » licensing steps

1) Presentation of the safety objectives and safety options
   - ❑ Discussions with Safety Authorities / Commissions of experts
   - ❑ First review by TSO

2) Public inquiry: Environmental impact study + Risk analysis (extract from Preliminary Safety Report)
   - ❑ Review by local Authorities / security authorities
   - ❑ Review by independent associations, etc.

3) Construction and operation license: Safety Report + Emergency Planning
   - ❑ Safety analysis of the SR, EP report
   - ❑ Feedback of commissioning tests

Integration in site industrial make-up

Interface with industrial risks

Specific safety studies

Interface with industry EPs

Cogen.

Validation
Safety approach
Feasibility

Legal aspects
Public acceptance
Site validation

Safety demonstration
Security

Elements for licensing application

- Application for licensing/construction authorization => based on risk analysis
- Some items of the RA relevant for cogeneration:
  - ❑ Demonstration of sufficient separation between the radioactive materials in the NPP and the fluid delivered to the customer (whether industrial or domestic)
  - ❑ Analysis of the external hazards potentially induced by the processes and specific equipment in the vicinity (explosive materials in processes, turbines, conventional boilers used as back-up facilities, etc.)
  - ❑ Analysis of the risks induced by the nuclear plant (radioactive or chemical release, missiles from turbines, explosions)
  - ❑ Potential for domino effects (multiple installations => accident worsening)

Non specific

Specific safety requirements

- Elimination of the risk of noticeable contamination of the delivered fluid (water, steam or helium) / guarantee of an efficient monitoring of the fluid quality
- Limitation of exclusion zone and low population zone => ex.: no protection measures needed for the industry operators in the vicinity of the plant (= if needed, operators of industrial sites could continue to monitor processes in case of accident on the NPP)
- No significant impact of heat demand variation on the core and reactor structures loading
- No significant increase of the contribution of external hazards in the global risk when cogeneration is taken into account (i.e. risk due to the proximity of industrial facilities low in relative)

Advantages of HTR safety concept for cogeneration

- Low risk of contamination of the delivered fluid:
  - Low contamination of primary helium (=> continuous purification)
  - primary pressure < secondary pressure
- Low sensitivity to helium cooling transients
  - High neutronic stability of the core
  - High thermal inertia of the graphite vs core power
  - Helium cooling limits the severity thermal shocks
- Easy load following (modularity)
- Structural robustness of the design
  - Mechanical stability of the core structure
  - Residual heat removal by conduction in core => tolerance to deformation of cooling channels
- Ultimate cold source diversification = air and water
  - Protection against water contamination by industrial processes
  - Protection against external fire hazards

Pending options

- Mastering of tritium permeation to secondary circuit => technical solutions to be validated

Note : objective is that tritium concentration in process steam remains lower than an "approval free" limit.

- Definition of an envelope safety case involving radioactive releases (ex.: depressurisation accident)
  - ❑ Not cogen. Specific
  - ❑ Depends on confinement strategy and design

Outline

- HTR safety concept is robust against external hazards
- HTR Technical features should allow for flexible operation
- HTR has a potential for very low radioactive releases in case of accident (exclusion zone close to the plant) – no interference with safety distance (against external hazards)
- Current licensing procedures are convenient for nuclear cogeneration with HTR provided some adaptations:
  - ❑ consistency of nuclear and conventional emergency planning
  - ❑ Regulatory basis for assessment of delivered fluid safety