RECYCLING OF RARE METALS FROM THE DECOMMISSIONING OF NUCLEAR FACILITIES

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net RWTH AACHEN

CONTENT

- Phase out and decommissioning in Germany
- Project “recycling of rare metals”:
  idea, project partners, project goals
- Sustainability and public acceptance
- Work schedule
- Material mass flow and metals in focus
- Activation calculation and decay of activity
- Assessment of recyclability of rare metals
  from decommissioning

PHASE OUT AND DECOMMISSIONING IN GERMANY

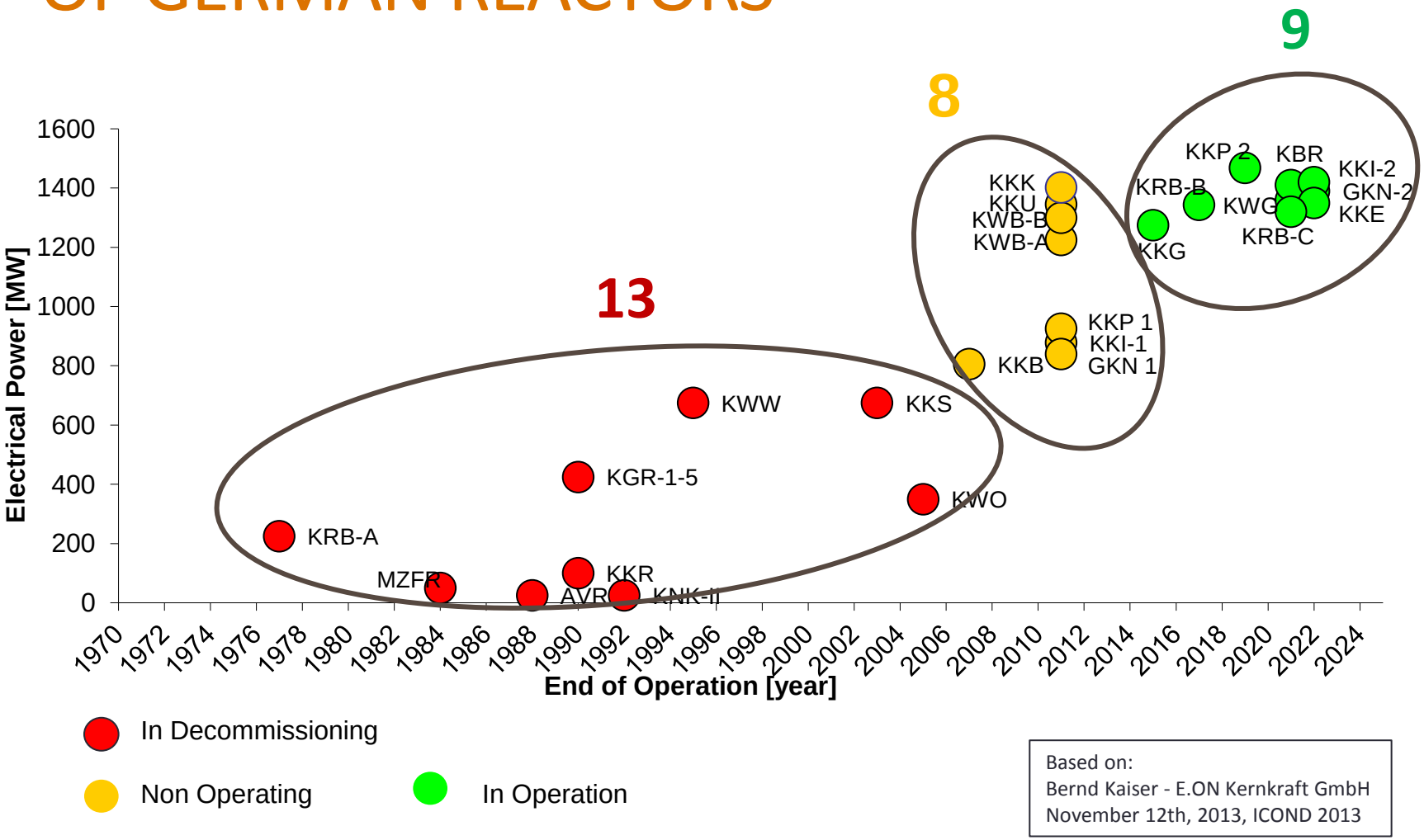
SITUATION IN GERMANY

- In 2011, 19 NPP`s had been in operation

- Life Time Extension of German NPP`s 01/2011
- Fukushima accident: 03/2011
- Shut down of 8 NPP´s 08/2011

Consecutive shut down of
the remaining 9 NPP`s by the end of 2022

DECOMMISSIONING OF GERMAN REACTORS



Based on:
Bernd Kaiser - E.ON Kernkraft GmbH
November 12th, 2013, ICOND 2013

RECYCLING OF RARE METALS - PROJECT IDEA AND PROJECT GOALS

PROJECT IDEA

Recycling of rare metals from decommissioning of nuclear facilities:

Investigation, into which strategically important rare metals are present in nuclear facilities and whether they are economically recoverable or not.

PROJECT PARTNERS

- NET - RWTH Aachen University
  Institute for Nuclear Engineering and Technology Transfer
  - Decommissioning
  - Waste Management
  - Nuclear Simulation
  - Final disposal, storage

- IME - RWTH Aachen University
  Institute for Process Metallurgy and Metal Recycling

  „IME is Europe's leading institute for process metallurgy and metal recycling"

RECYCLING OF RARE METALS - PROJECT GOALS (1)

- Identification and quantification of relevant metals in selected components
- Calculation, as to which of these components are not radioactive and are accessible for a further metallurgical recycling
- Calculation, regarding which of these components are accessible for metallurgical recycling after the decay of activity or after decontamination

RECYCLING OF RARE METALS - PROJECT GOALS (2)

- Process evaluation of the recoverability and recyclability of rare metals of the identified components

- Presentation of the economic importance of a resource-efficient metal recycling programme

SUSTAINABILITY AND PUBLIC ACCEPTANCE

SUSTAINABILITY AND PUBLIC ACCEPTANCE

- Non recycled metals are permanently lost
- Waste reduction
- Reduction of mining activities
- Conservation of resources

Higher public acceptance for decommissioning projects

GENERAL WORK SCHEDULE

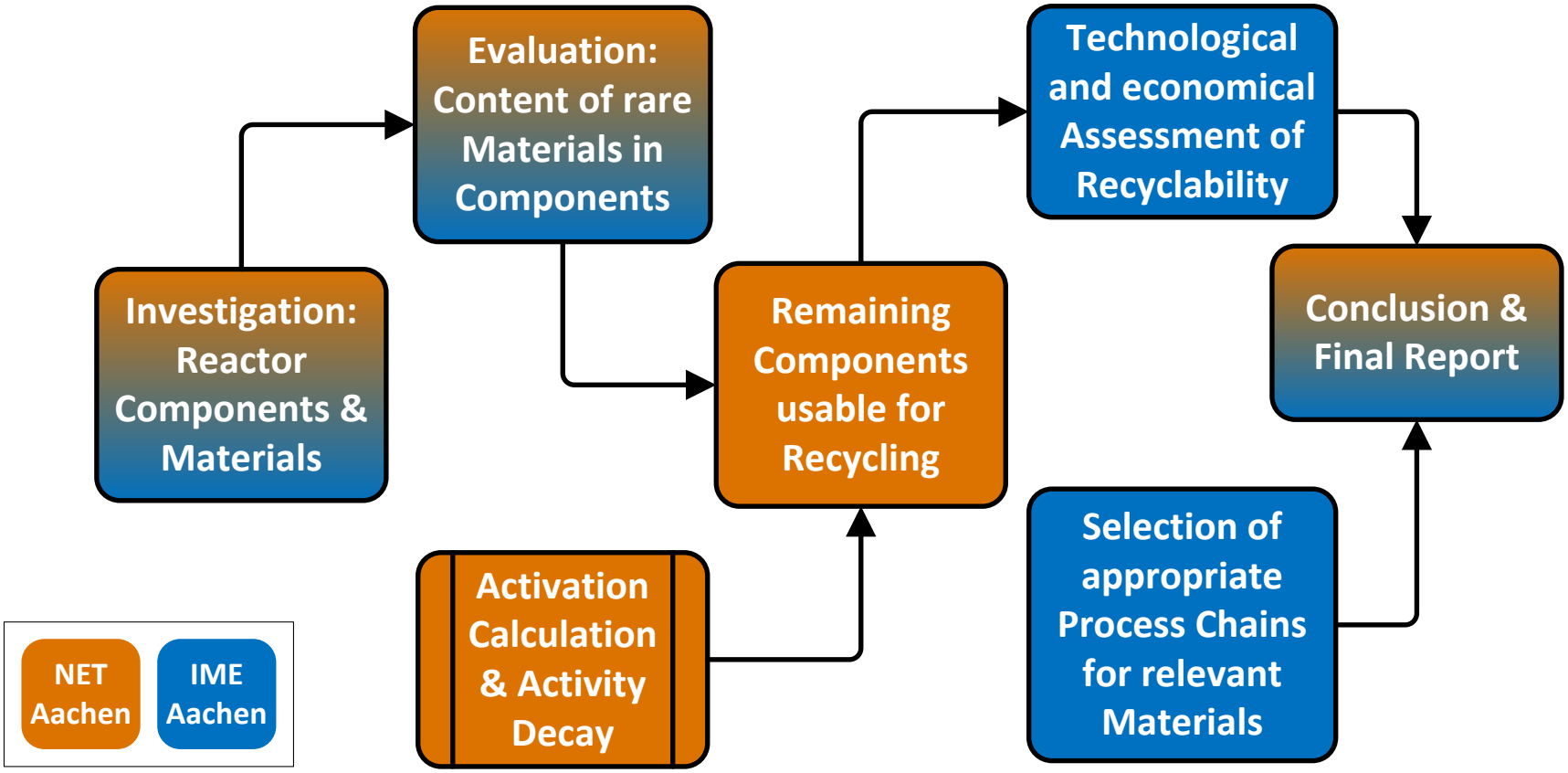
GENERAL WORK SCHEDULE (1)

- Creating a data base for identified economic strategically relevant components and metals
- Establishment of a simulation model to determine the activation of the components of the NPP
- Identification and analysis of the recyclability of relevant components and determination of technically possible recoverable amounts

GENERAL WORK SCHEDULE (2)

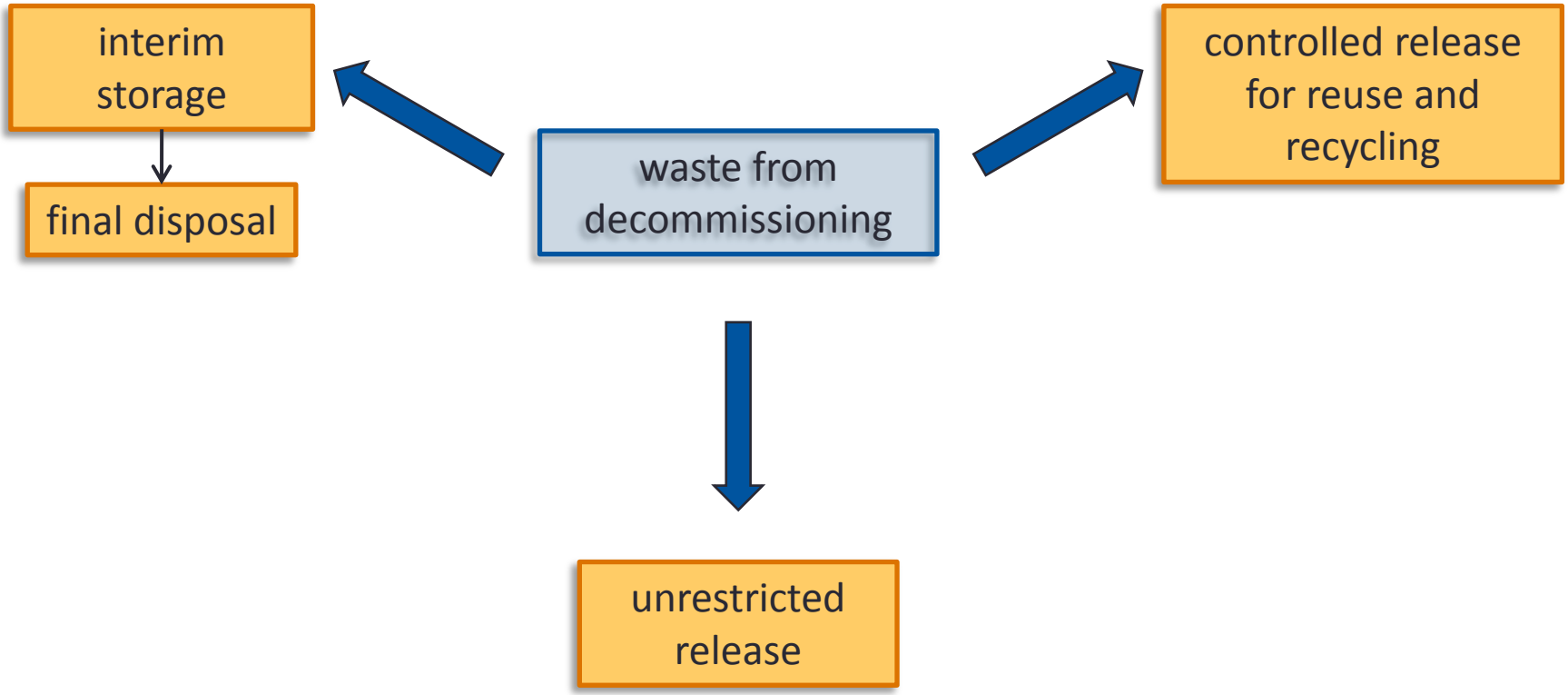
- Development of a resource-efficient recovery technique for these rare metals
- Concentration in appropriate recycled products (material-groups and alloy-groups)
- Evaluation of the economic potential of an optimized decommissioning

GENERAL WORK SCHEDULE (3)



MASS FLOW AND METALS IN FOCUS

MATERIAL FLOW FROM DECOMMISSIONING

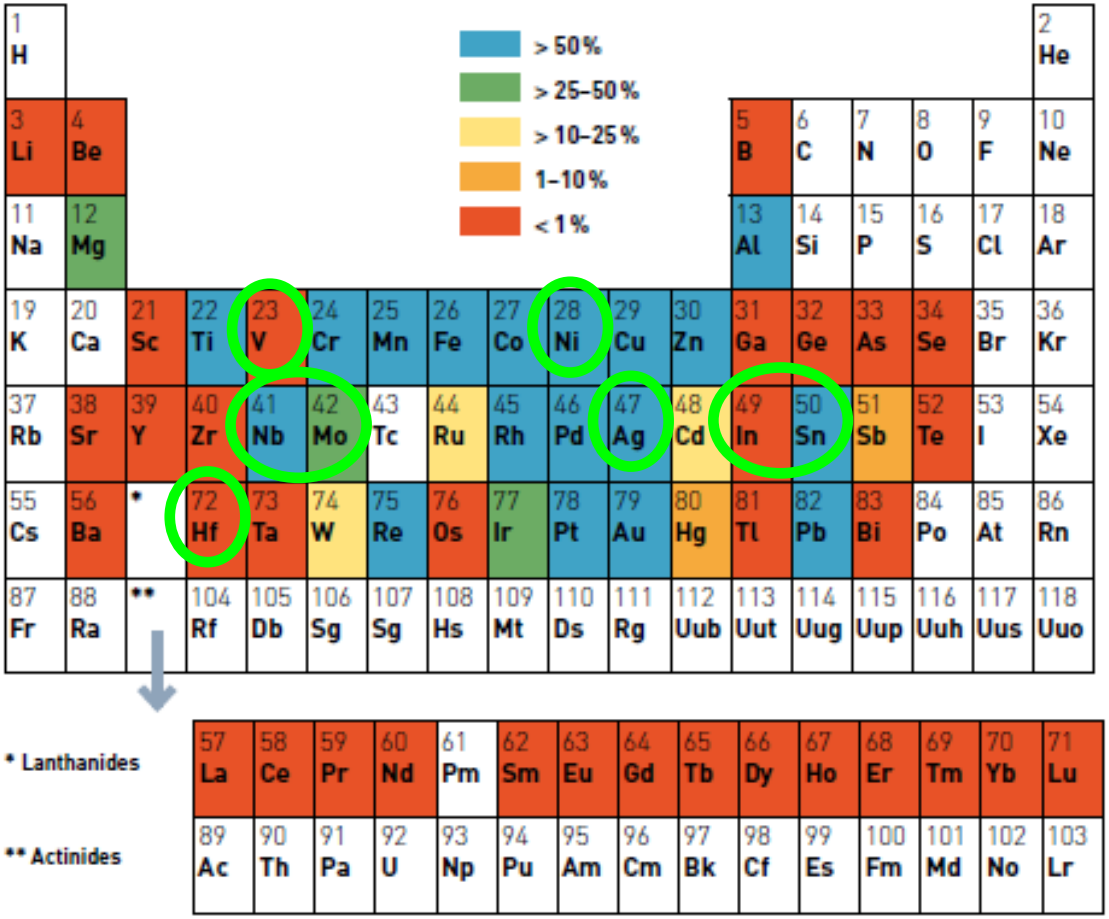


DECOMMISSIONING AMOUNTS EXAMPLE NPP STADE

non-nuclear area	nuclear area		
198.000 t	132.000 t		
	controlled release	controlled reuse and recycling	radioactive waste
	128.500 t	500 t	3.000 t
	97,3 %	0,4 %	2,3 %

PWR-NPP Stade [E-ON]

NON-FERROUS METALS IN FOCUS (E.G.)



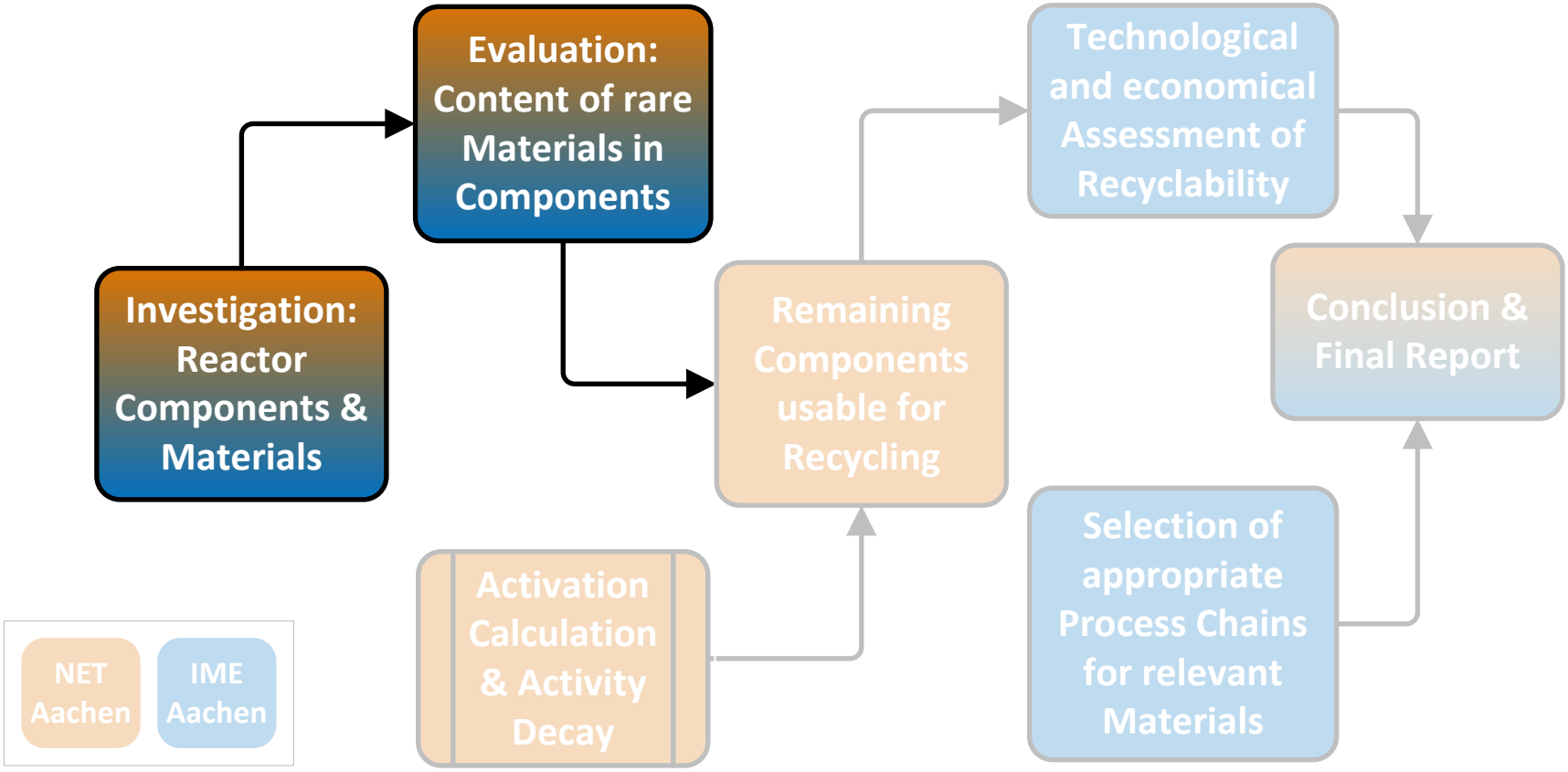
- indium (In)
- niobium (Nb)
- vanadium (V)
- tin (Sn)
- nickel (Ni)
- molybdenum (Mo)
- silver (Ag)
- hafnium (Hf)
- …

RELEVANT COMPONENTS (E.G.)

- Components of the primary circuit
  - Reactor internals
  - Absorber-facilities
  - Grid structures
- Components of the control technology
- Pumps
- Fittings
- Heat exchangers
- Steam generator

ACTIVATION CALCULATION

STEP 1


Evaluation: Content of rare Materials in Components
Technological and economical Assessment of Recyclability
Investigation: Reactor Components & Materials
Remaining Components usable for Recycling
Conclusion & Final Report
Activation Calculation & Activity Decay
Selection of appropriate Process Chains for relevant Materials
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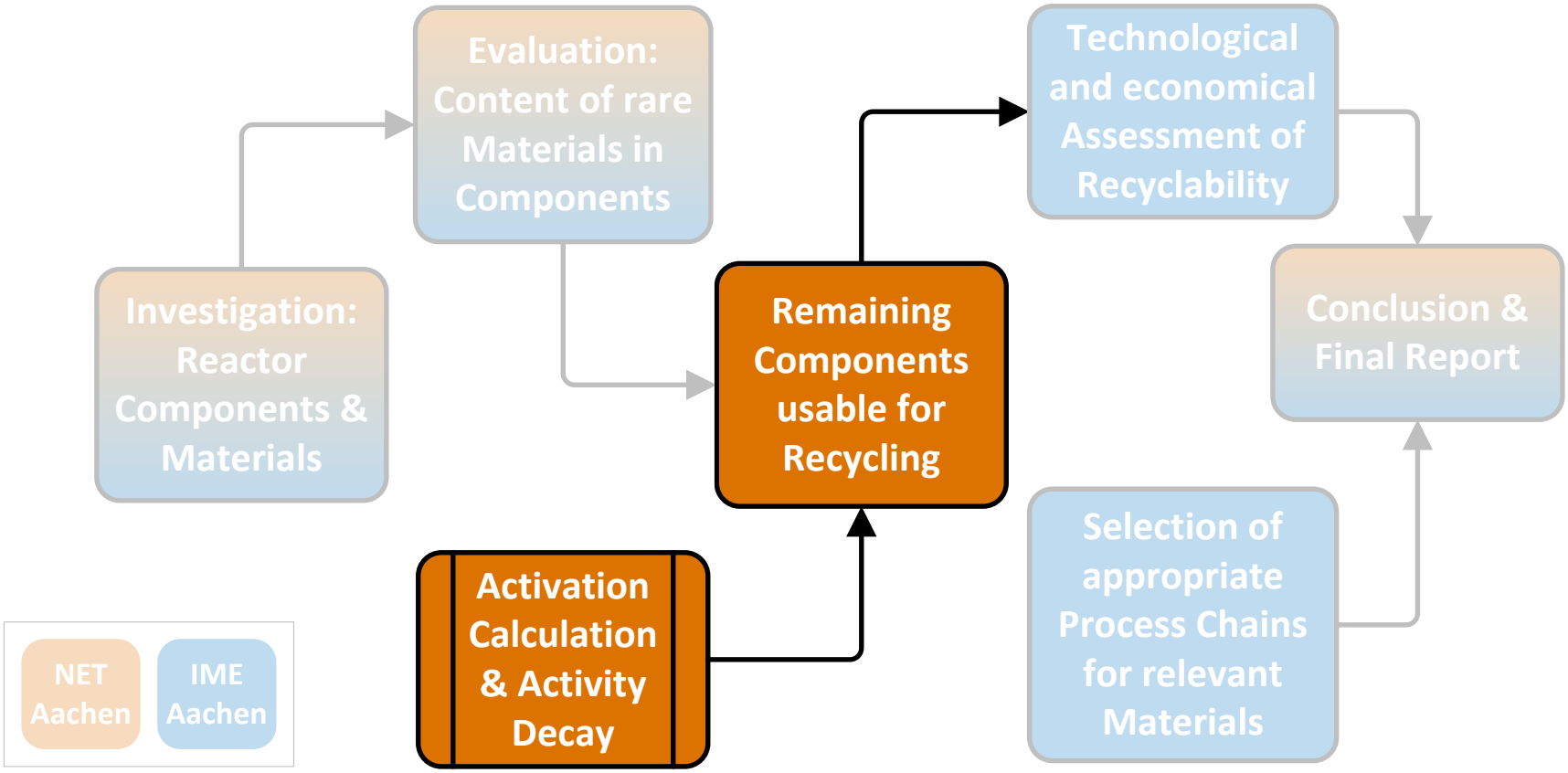
STEP 2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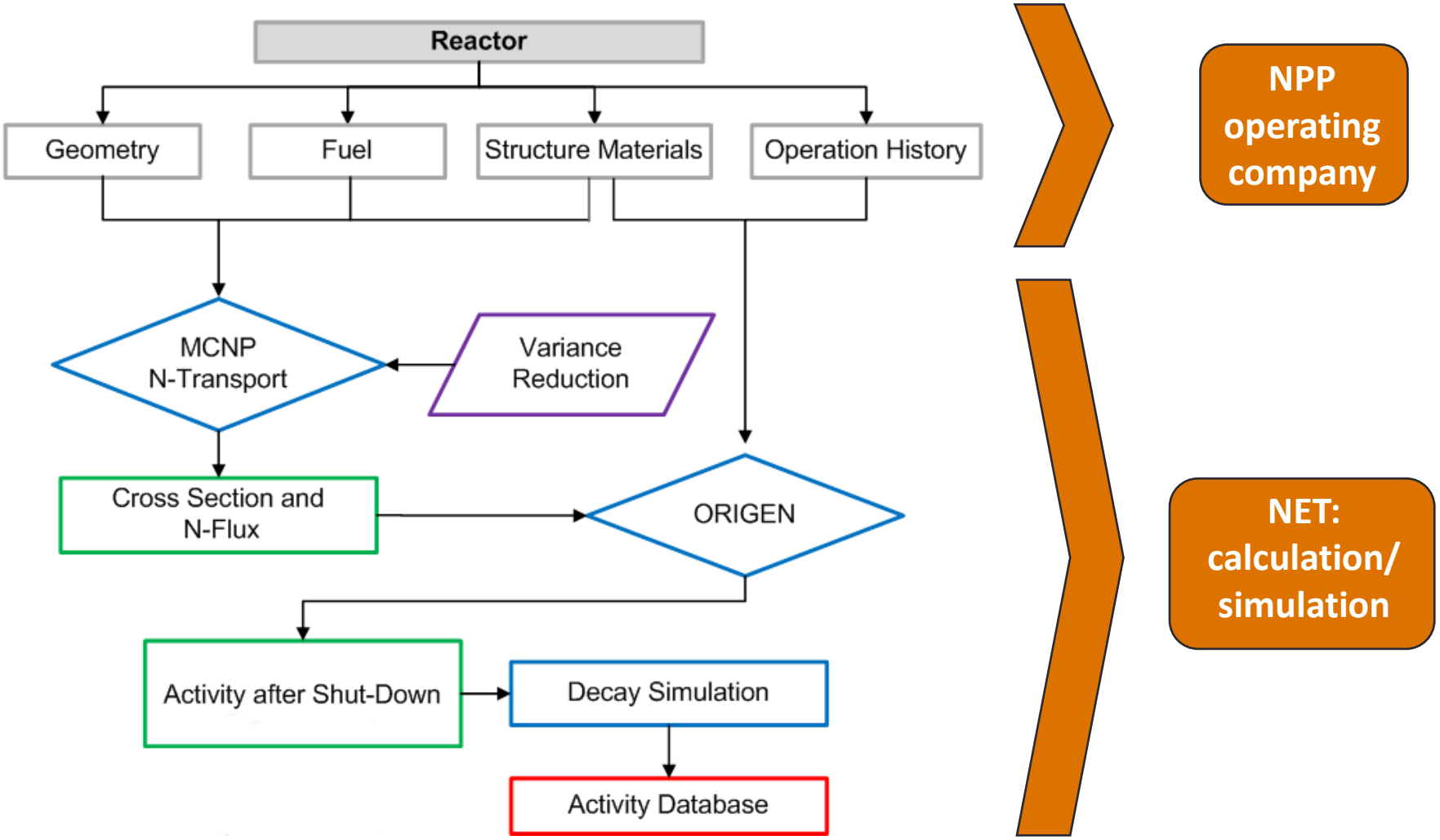
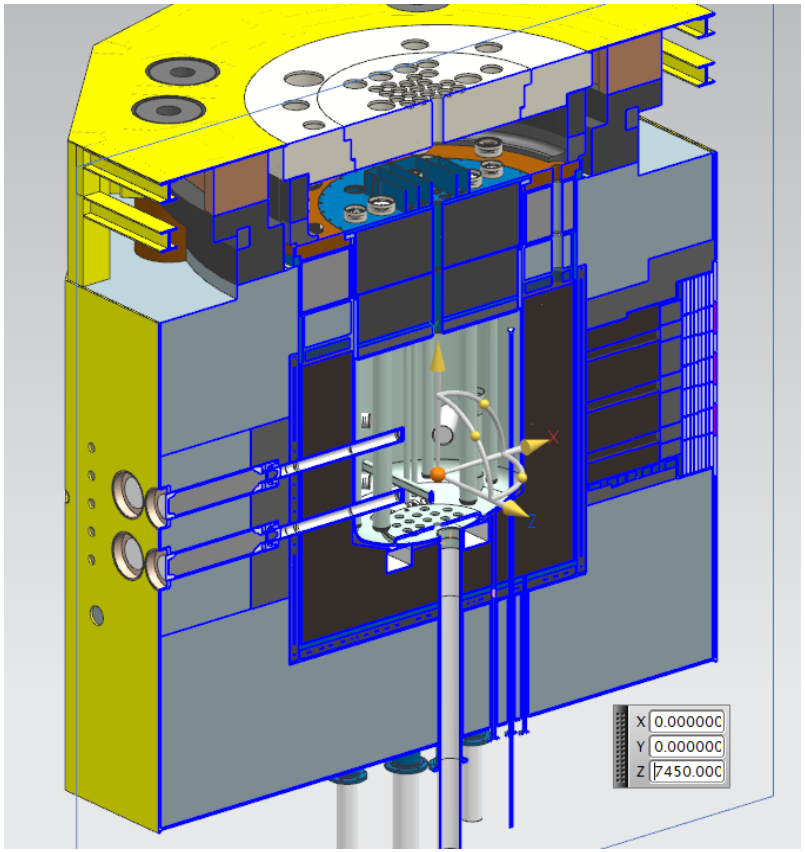
ACTIVATION CALCULATION SCHEDULE

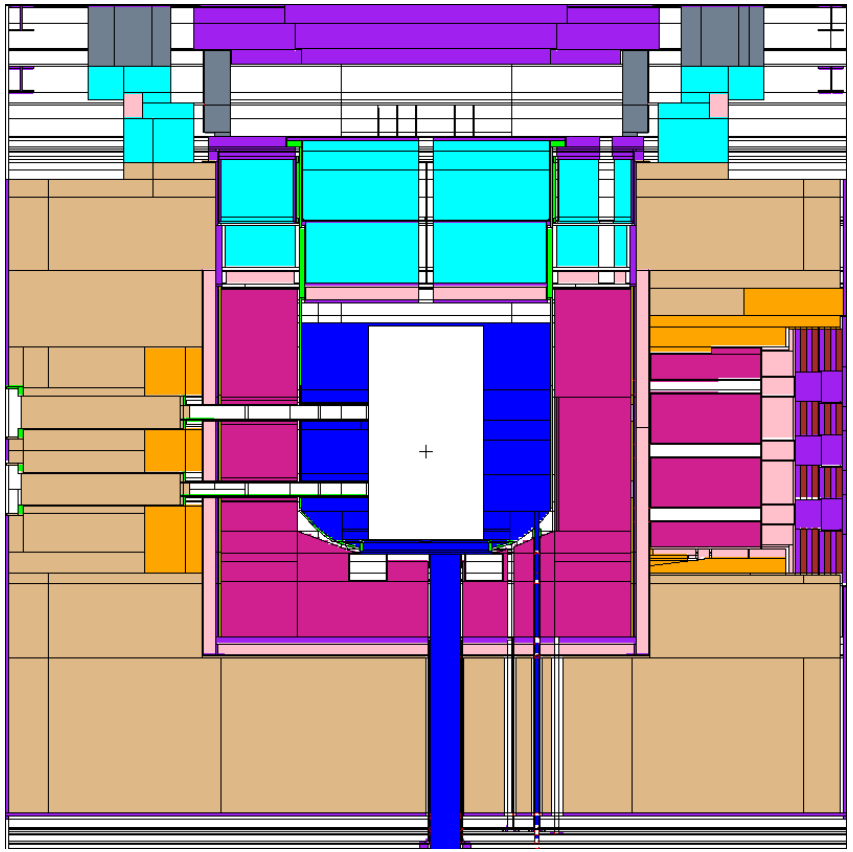


FRJ-2, JÜLICH

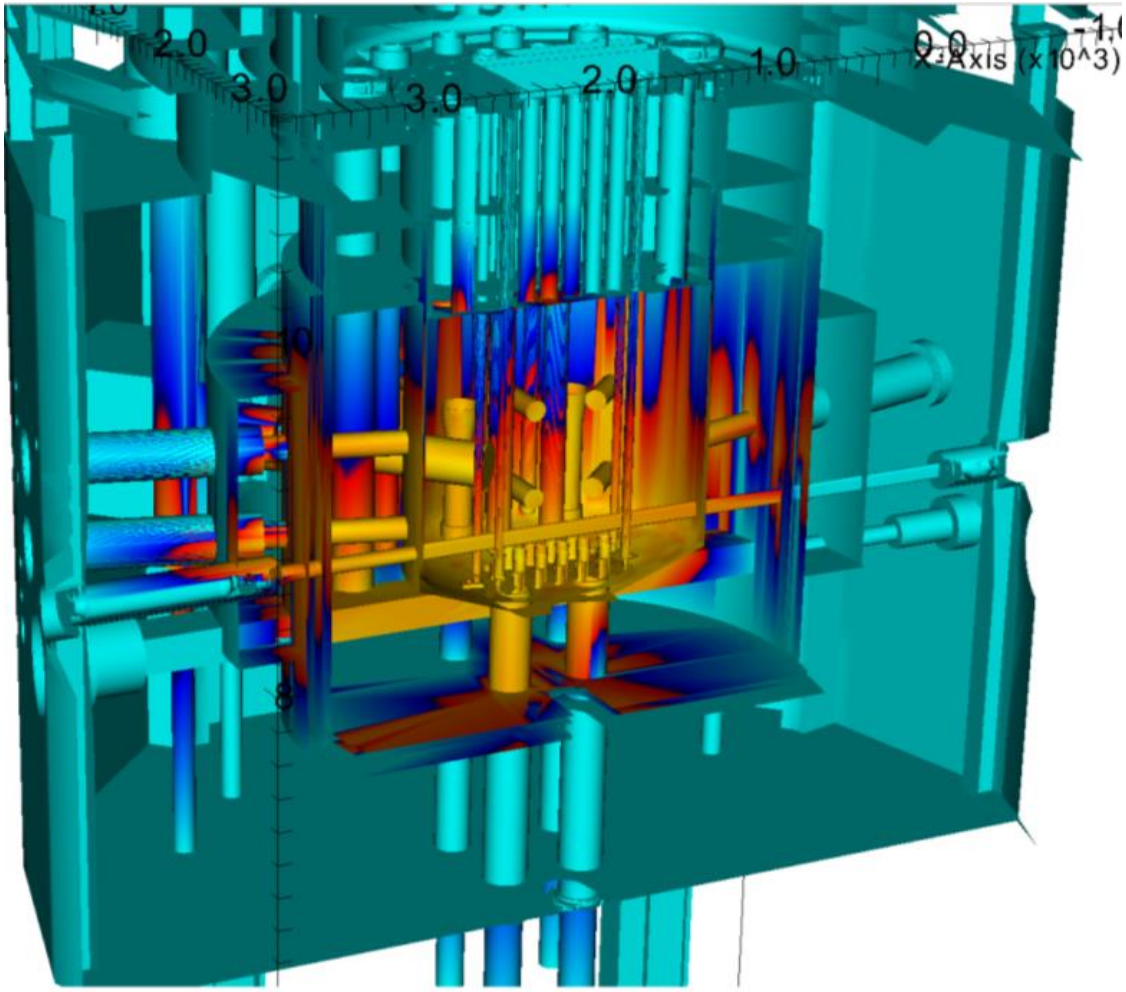
CAD



MCNP



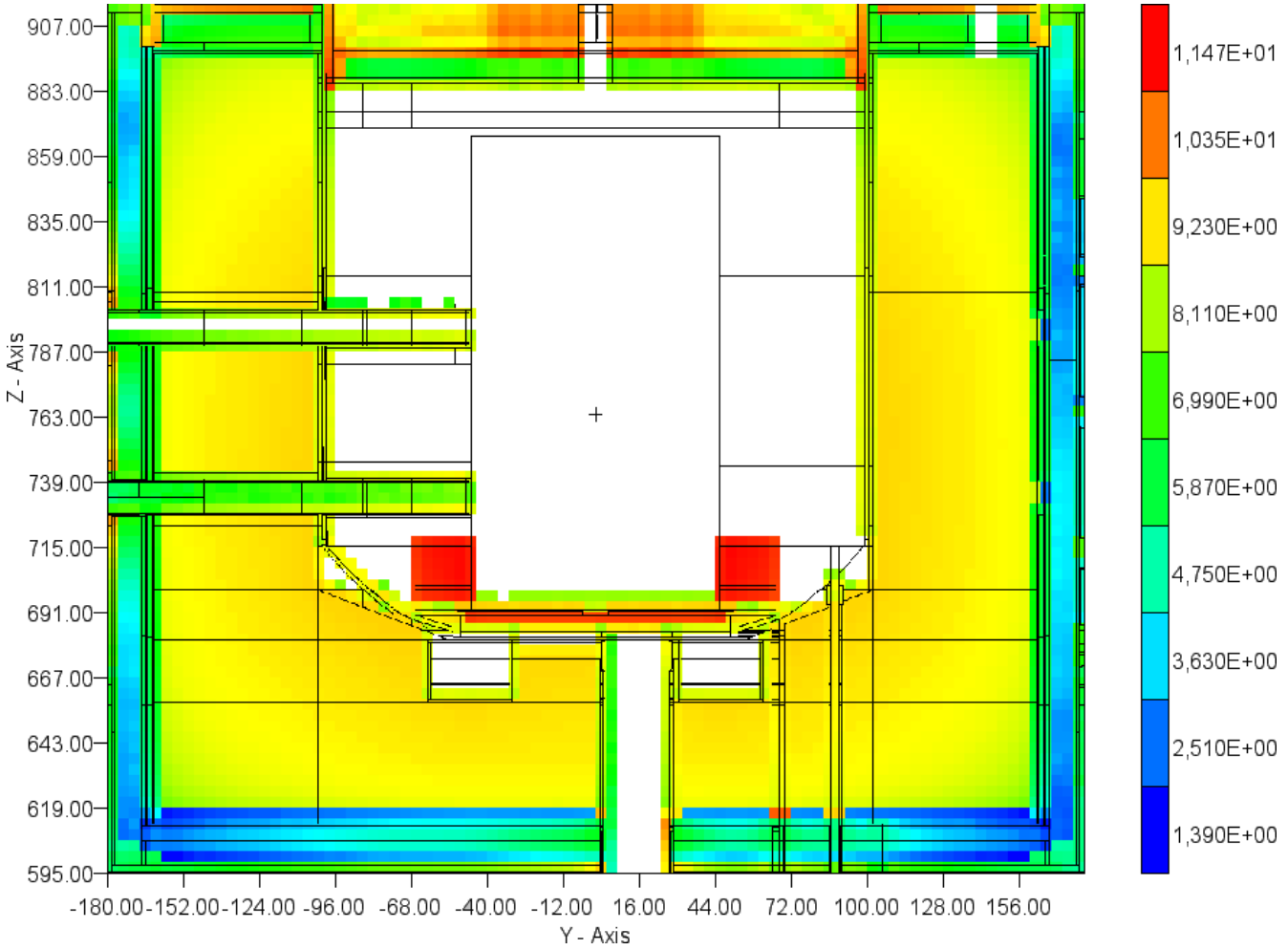
NEUTRON-FLUX



“Virtual Reactor” with neutron flux distribution calculated by MCNP

ACTIVATION CALCULATION

Calculated with ORIGEN based on neutron flux distribution and detailed material composition



DECAY OF ACTIVITY

DECAY OF ACTIVITY

- component-wise determination of the nuclide vector and the activity inventory
- calculation of the activity attenuation over time with respect to decay chains of the nuclides
- calculation of the period after which the specific components can be recycled

ASSESSMENT OF RECYCLABILITY

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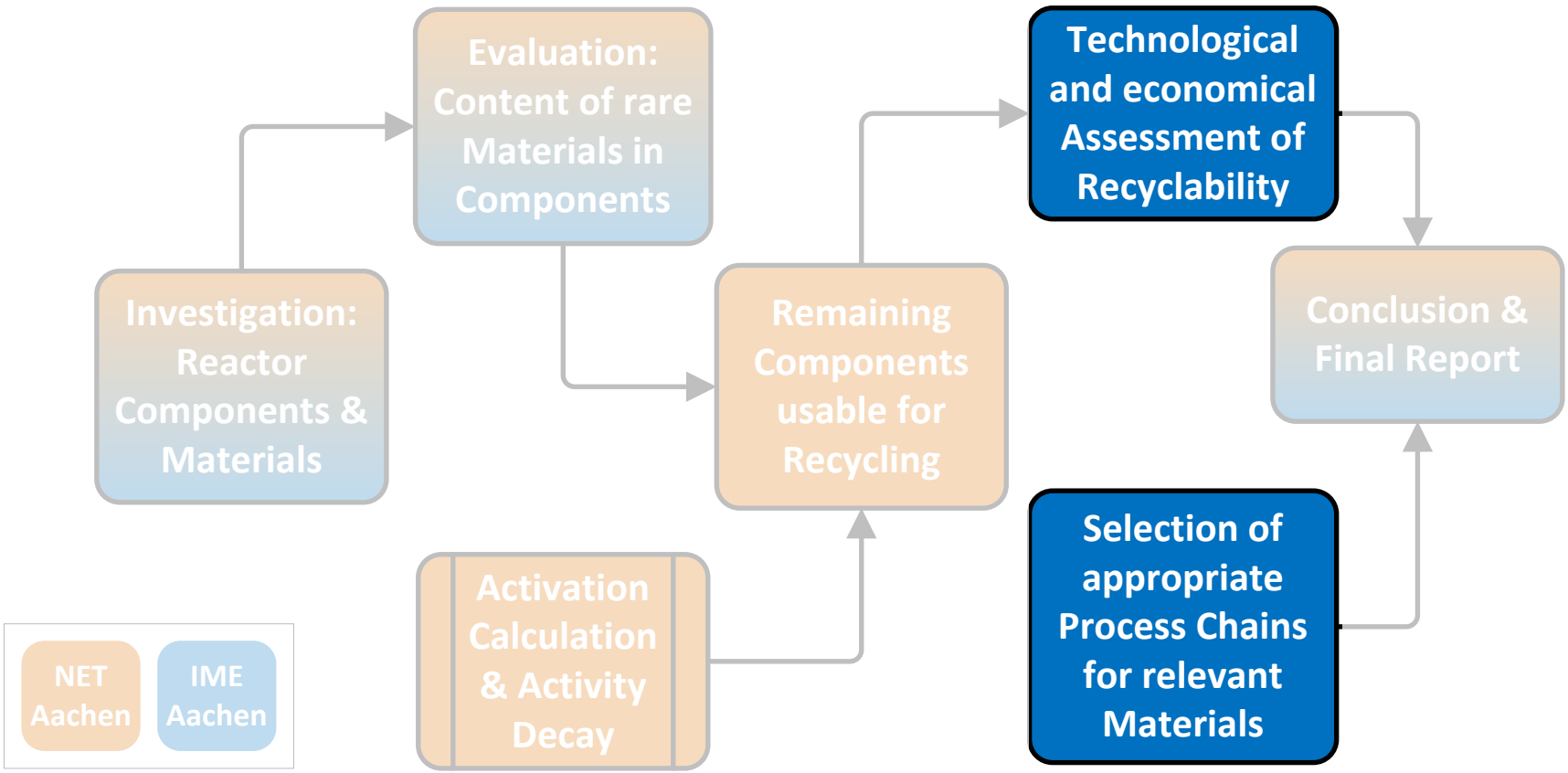

ASSESSMENT OF RECYCLABILITY (1)

- Classification of the identified materials by recyclability:

  analysis of the material shape, texture and the composition of the structures, alloys and components

- Selection of suitable process chains for metal recycling

ASSESSMENT OF RECYCLABILITY (2)

- Presentation of the distribution of recoverable and recyclable non-ferrous metals
- Evaluation of the results
- Decision to be taken, if recycling of specific components is feasible and of economical interest

SUMMARY

SUMMARY (1)

Recycling of rare metals from the decommissioning of nuclear facilities

- Detection of rare metals in relevant components
- Interdisciplinary approach:
  - nuclear simulation
  - activation calculation
  - metallurgical consideration
  - feasibility of recycling
  - economic consideration

SUMMARY (2)

Recycling of rare metals from the decommissioning of nuclear facilities

- Decision, if substitution of raw materials by recycling of rare metals from decommissioning is
  - technically feasible and of
  - economical interest

RECYCLING OF RARE METALS FROM THE DECOMMISSIONING OF NUCLEAR FACILITIES