Radiation Protection during Decommissioning of Nuclear Facilities – Experiences and Challenges

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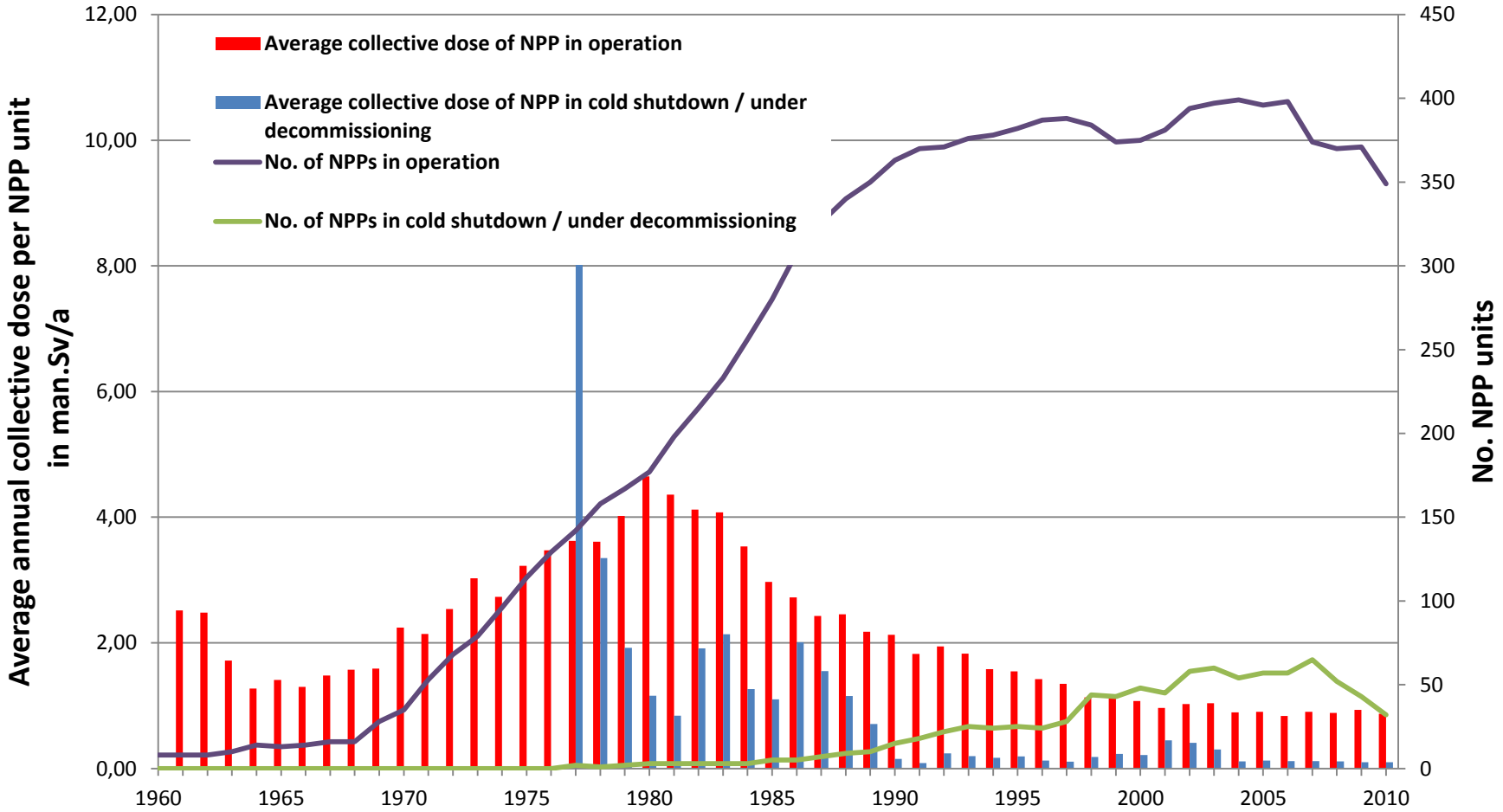
- “Daily” Radiation Protection Challenges during Decommissioning
- Selected Experiences from Past and Current Projects
- Conclusions and “Future” Radiation Protection Challenges

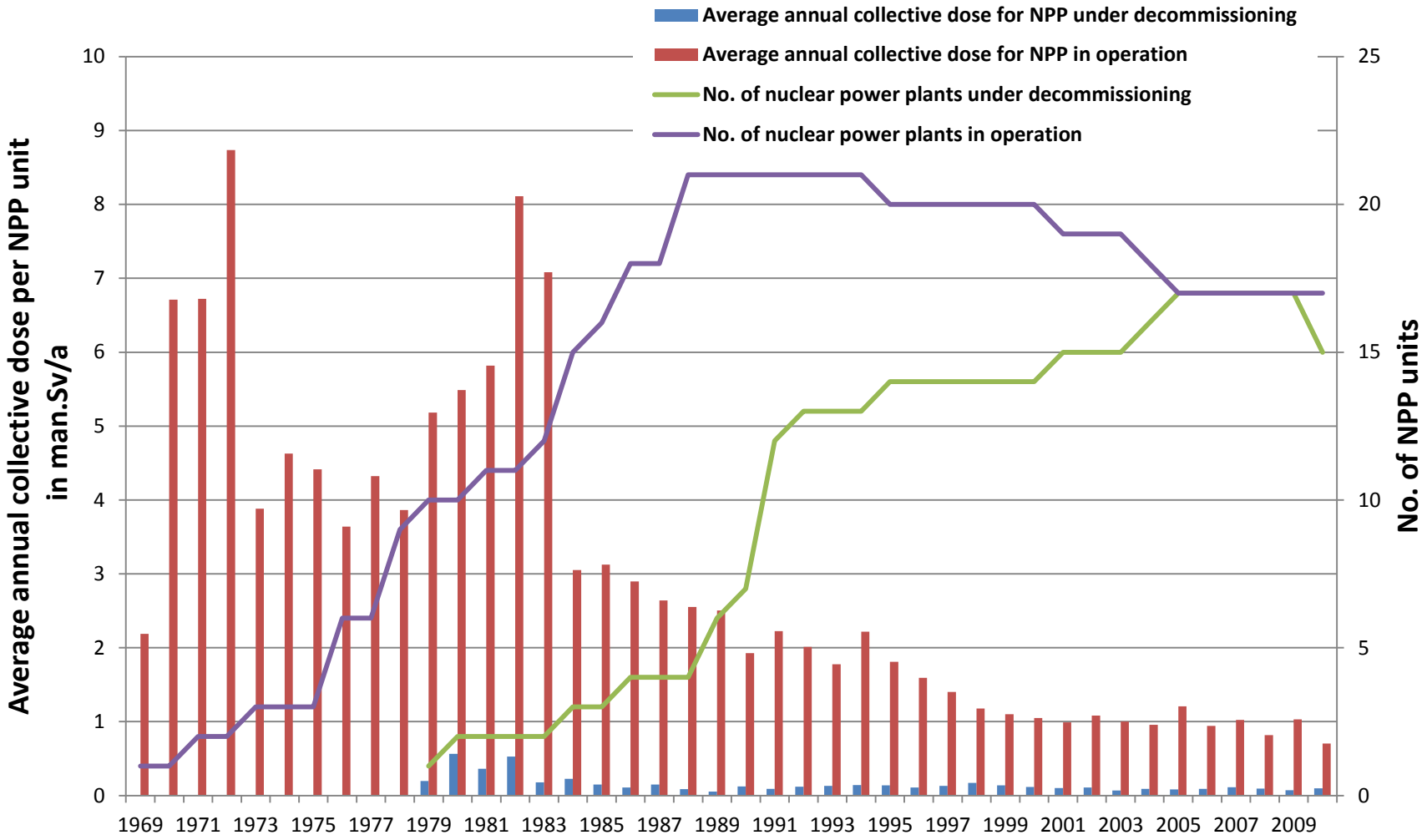
Overview on Occupational Exposure during Decommissioning of NPPs

- Evolution of average annual collective effective dose, based on data of a majority of worldwide NPPs



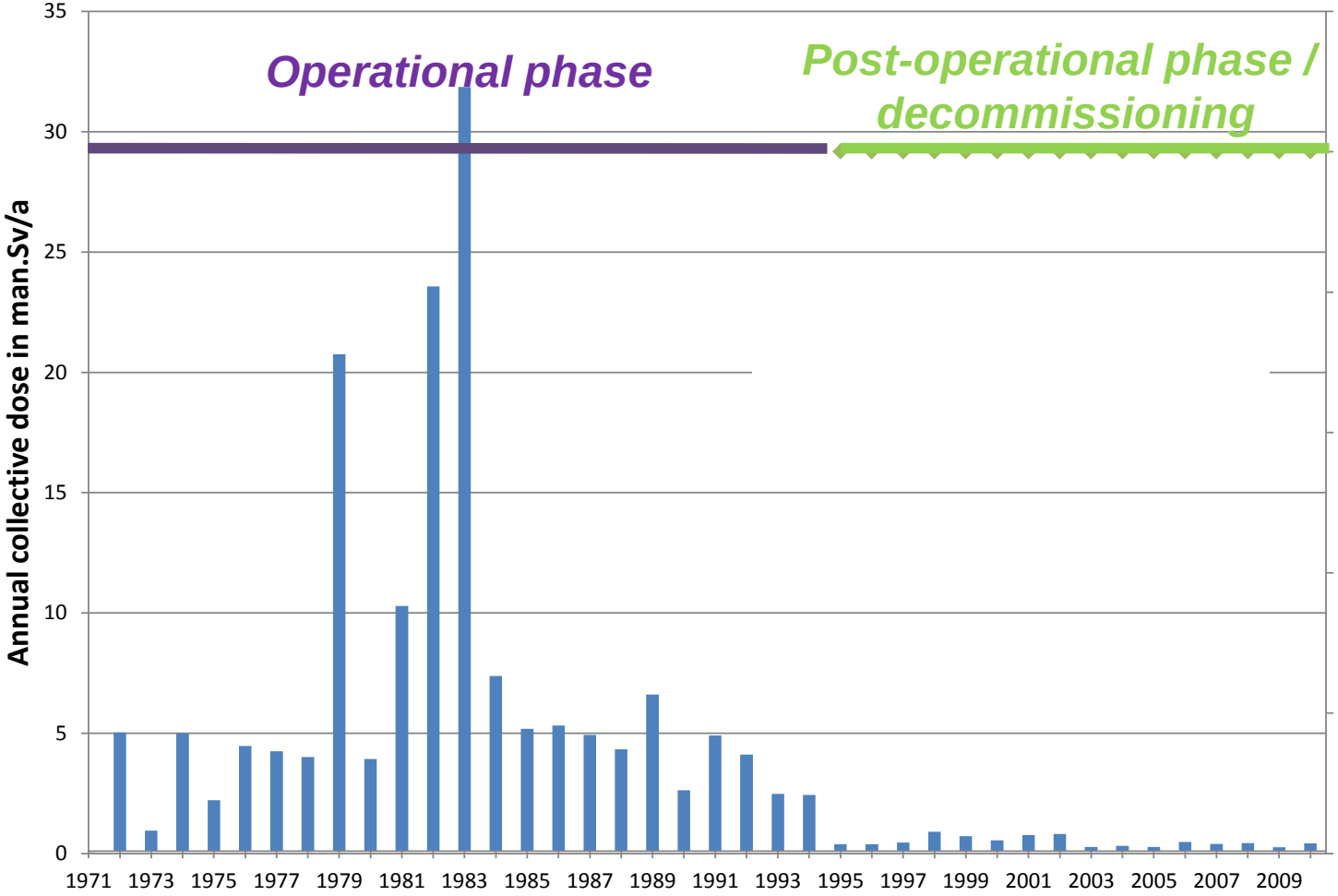
Overview on Occupational Exposure during Decommissioning of NPPs

- Evolution of average annual collective effective dose for German NPPs



Overview on Occupational Exposure during Decommissioning of NPPs

- Example on the evolution of the annual collective effective dose during life cycle of a NPP in operation and decommissioning



Overview on Occupational Exposure during Decommissioning of NPPs

- Some key observations
  - (Average) Annual **collective effective dose** for NPPs in **operation higher than** for NPPs under **decommissioning**
    - depends inter alia on the reactor type and decommissioning concept / approach used
    - open question, whether this will change for modern reactor designs
  - Annual **collective effective dose** of a NPP under decommissioning **varies from year to year** and depends inter alia from
    - annual work load and project plan (structure & schedule) and progress of work
    - radiological conditions (e.g. contaminations, quality of system decontaminations)
  - Both, **utility and contracted personnel involved**
    - typically large number of contracted personnel active during whole year

“Daily” Radiation Protection Challenges during Decommissioning

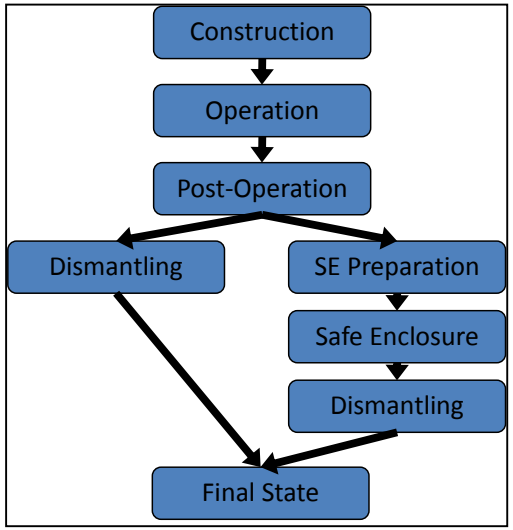
- From a **far distance** – **“Decommissioning” = “extended Outage”**
  ➔ no other “daily” challenges than during outage
- But from a **closer distance** – **aspects more relevant / new** now requiring
  - flexible planning, preparation & work control and establishment of oversight on all processes under conduct
  - early involvement of RP professionals
  - well RP trained personnel to appropriately respond

  ➔ new “daily” challenges other than during outage, inter alia
  - – continuous change of the facility status (technical, radiological relevant)
  - – increased number of (long-lasting) work activities with interdependencies
  - – access to workplaces, inaccessible during operation
  - – new / improved techniques to conduct / speedup decommissioning activities
  - – (need for) deviations from plans on the conduct of work
  - – high volume of radioactive / non-radioactive material flow
  - – replacement of technical barriers by administrative ones (incl. PPE)

  ➔ but: **Decommissioning RP measures are mainly the same as for operation**

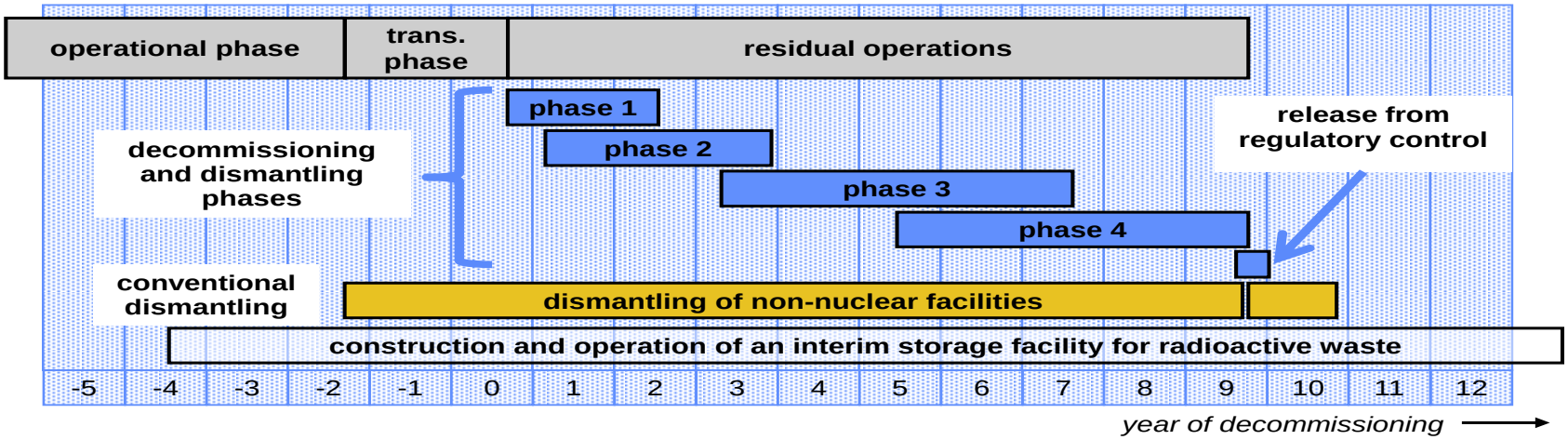
Selected Experiences from Past and Current Projects

- Experience in general shows: radiation protection during decommissioning depends inter alia on
  - radiological situation of the nuclear facility
  - complexity of the nuclear facility
  - conceptual decisions as e.g.
    - decommissioning strategy
    - project structure / *multiple phase approach*
    - sequence of decommissioning activities
    - conduct of measures to reduce the radioactive inventory (e.g. full system decontamination)
    - *cutting of component in-situ or ex-situ, especially removal of large components*
    - *pre-selection of techniques*
    - waste management concept



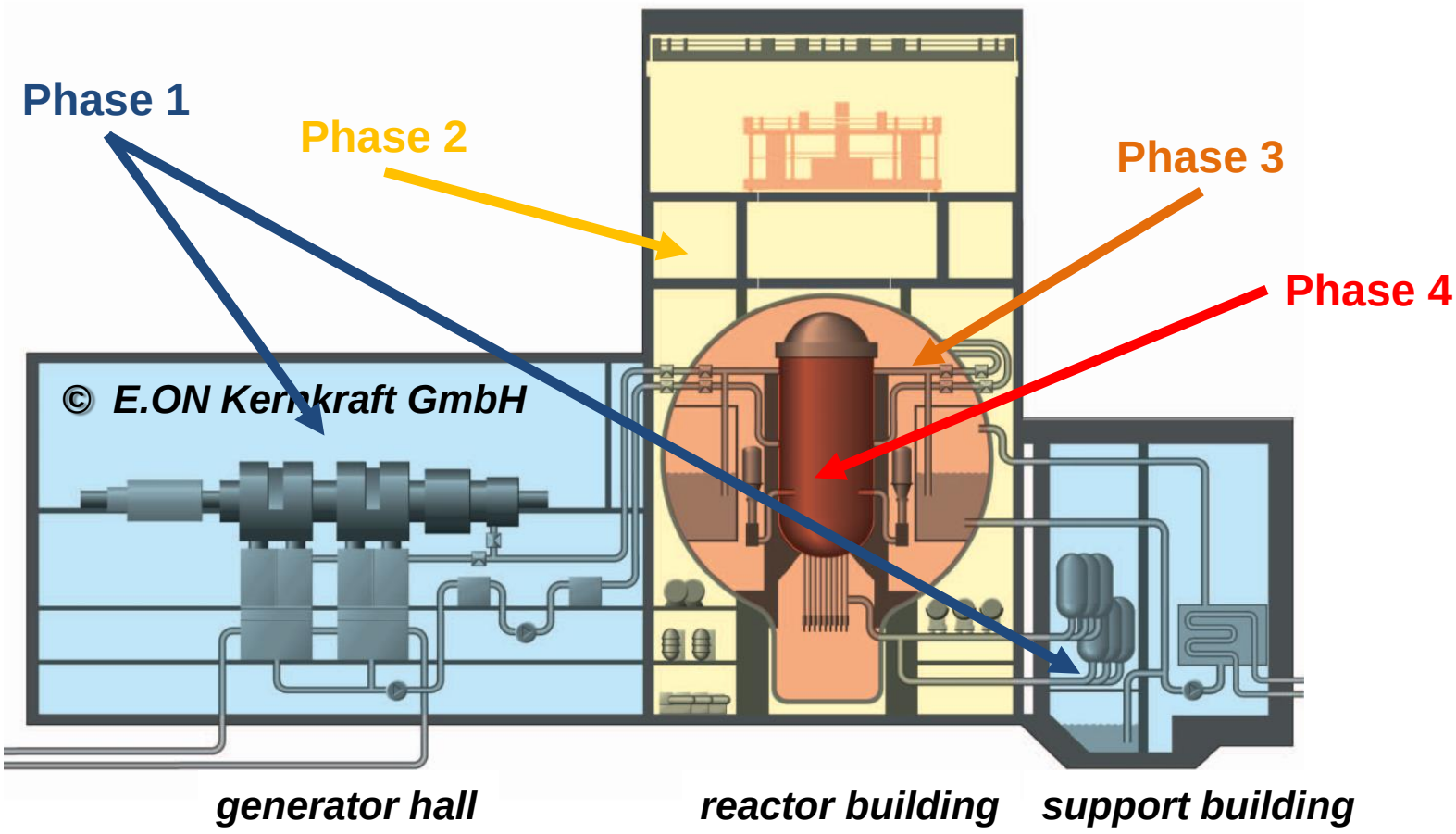
Selected Experiences from Past and Current Projects
Multiple Phase Approach

- Multiple phase approach
  - serves to divide large projects into smaller parts and to reduce complexity
  - allows stepwise planning of phases
    - first to be detailed
    - following less detailed until they will be commenced (and approved by regulatory body)
  - helps to stage the process of radiological characterization
    - information for later phases can be evaluated during current phases
  - requires a clear adjustment of the individual phases



Selected Experiences from Past and Current Projects
Multiple Phase Approach

- Example for a multiple phase approach



Selected Experiences from Past and Current Projects
Removal of Large Components

- As an alternative to in-situ dismantling and cutting of large components
  - removal of the whole component as one piece
  - dismantling at a different position then the build-in position (ex-situ)
    - within the nuclear facility
    - at the site in a specific facility
    - off-site, e.g. by a service provider
  - advantages
    - optimization of the schedule
    - improvement of radiological conditions (not necessarily resulting in lower doses!!)
  - closely related to waste management strategies
- Special form of removal of large component
  - removal and long term storage before dismantling
    ➔ “decay storage” to take benefit from radioactive decay

Selected Experiences from Past and Current Projects
RP & Selection of Dismantling & Decontamination Techniques

- Generic selection process

project strategies
(➔ *RP aspects on high level*)

More strategic factors ⇧ *and considerations*

Potential decision factors, inter alia
- decommissioning strategy
- release of radioactive material
- radiological / conventional worker protection
- radiological conditions at the working place
- regulatory requirements
- know-how on the nuclear facility
- own experiences on the use of the technique
- technical work specification
- applicability / type of the technique, incl.
  - dismantling capacity
  - safety aspects
  - infrastructure / workspace needed
  - (de-) installation / maintenance time
- aspects of costs
- rad. waste generation and disposal roots
  - aspects of clearance

available techniques

⇩

pre-selection

⇩

pre-selected techniques

⇩

assessment and comparison of techniques

⇩

set of techniques to be considered during detail work planning

Detailed RP consideration as part of the detailed work planning

Conclusions and ...

- In the past decommissioning of nuclear facilities was performed successfully (and safely) to reach defined end states
- “Daily” challenges require flexible planning & work control, management of many processes and an early involvement of RP professionals
- Recent experiences show inter alia
  - A multiple phase approach helps
    - to manage large and complex decommissioning projects and
    - to solve the problem of radiological characterizations during planning
  - Large component removal is a way to optimize project plans and to improve the radiological conditions for dismantling (but leads not necessarily to lower doses)
  - RP is considered on a high level in project strategies and in detail during work planning on base of selected techniques
    - worker protection will become ALARA during the detailed work planning
- Today, for (mostly) any technical question related to decommissioning
  - either standard solutions exist or can be adapted, or
  - can be individually developed for the specific situation

... and “Future Radiation Protection Challenges”

- In general terms, **RP challenges seem to be under control** for most situations, except for accident situations (➔ special challenge to remove spent fuel)
- “Future Radiation Protection Challenges” may relate to
  - the **radiological characterization** (before approval by regulatory bodies) which
    - sets the base for the preparation of decommissioning plans and
    - forms the basis the waste and material management strategies

    as
    - it’s difficult **to decide on the appropriate level of detail**
    - to **gain the information** needed
  - the **final radiological survey**, which demonstrates that the final end state was reached as
    - especially in case of sites remaining contamination either of natural origin strongly vary or of artificial origin exist, both resulting in practical problems for a background identification and reduction

➔ further need on **experience feedback** among RP experts, e.g. by means of ISOE, IAEA / NEA

Thank You for Your Attention!