R2D2P Workshop on Cost Estimates

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Overview of cost calculations and key concepts

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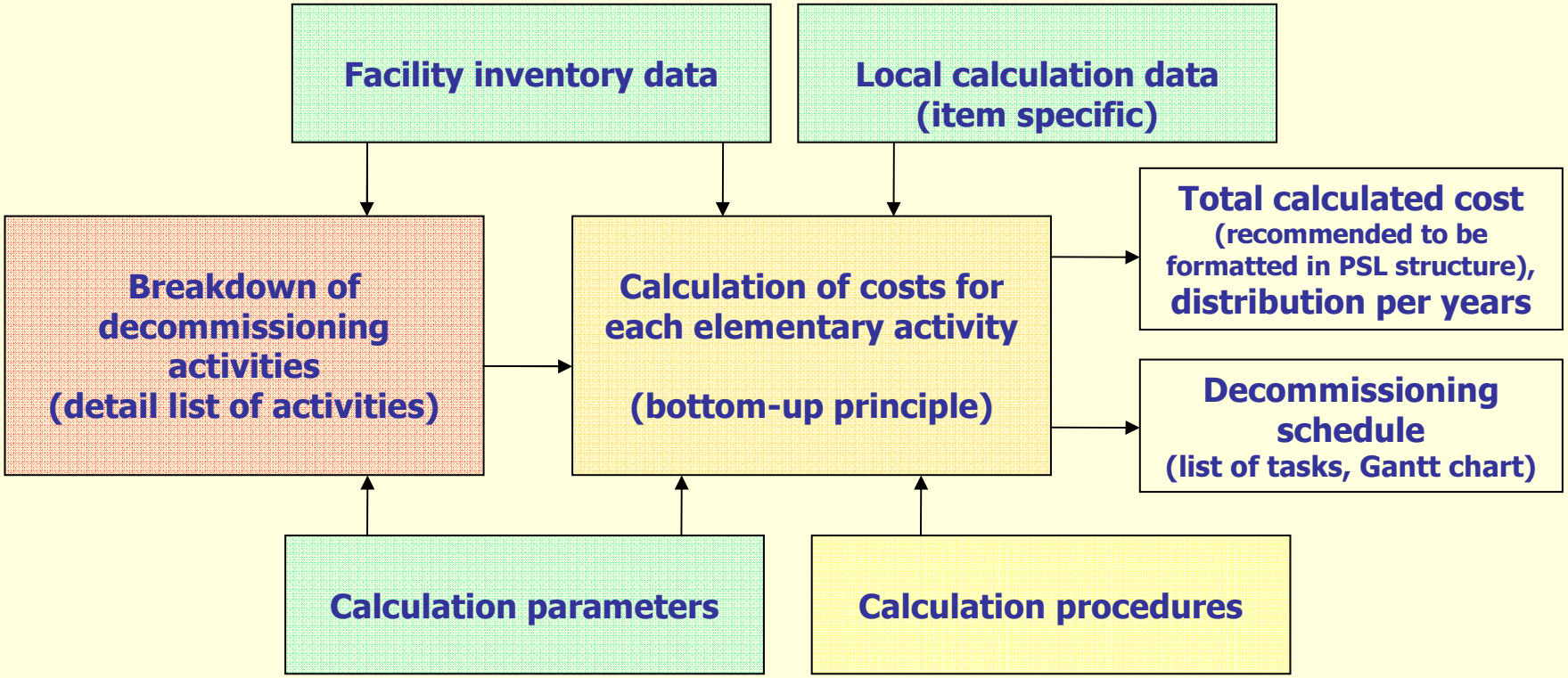
1. Introduction – main issues

- One of the main messages for future activities in decommissioning costing, it that it is increasingly important to ensure that greater **cost effectiveness** should be achieved in the management of nuclear liabilities, including research reactors.
- Current decommissioning costing is based on **unit factor approach**. This methodology is **gradable** starting from the preliminary costing levels up to detailed final costing
- Developing the **input data** is the prerequisite for decommissioning costing. The facility inventory database and the database of unit factors are the main groups of input data for decommissioning costing
- Implementation of the **bottom-up principle** is recommended as the most accurate procedure. For this purpose, the decommissioning activities should be broken down to the level of elementary decommissioning activities.
- The level of details of input data and breakdown of decommissioning activities should correspond each other
- There is the strong demand on **harmonization of decommissioning costing**. For these purposes a universal structure of decommissioning activities was developed and is recommended for general use

1. Introduction

- Practical costing is carried out by identifying **all work activities** together with their associated labor, material, equipment, and service requirements.
- Subsequently, estimation is made of the costs arising from **each elementary activity** as the discrete and measurable elementary work activity (**bottom-up principle**) for which unit costs are calculated or estimated - **unit factors approach**.



2. Review of costing methodologies
General aspects of decommissioning costing

Decommissioning costs estimation methods, identified in major decommissioning projects are based on cost unit factors approach with following main steps:

1) Definition of Cost Categories

- Inventory-dependent costs, related to the extent of "hands-on" work like dismantling
- Period-dependent costs, proportional to duration of individual activities/phases
- Collateral costs and costs for special items which can neither be assigned to hands-on work activity nor to period-dependent activity

2) Identification of Decommissioning Activities and Inventories

- Identification of discrete elementary activities for which unit factors are defined
- Completion of the list of activities with a plant buildings/equipment inventory in order to define the overall extent of activities.

3) Definition of Unit Factors

- Unit factors are defined in accordance to the details of the items considered in the plant inventory and in the decommissioning activities listing
- Unit factors are defined for ideal working conditions and correction factors are defined that reflect the specific working conditions (radiation, working height, etc.)

2. Review of costing methodologies
General aspects of decommissioning costing (2)

4) Project Scheduling and Staff Requirements

- Project time schedule construction based on calculated duration of individual hands-on work phases and based on the plant inventory data.
- Identification of critical path for decommissioning activities.
- Calculated duration of decommissioning activities / phases are used as a basis for definition of duration of period-dependent activities for which the staff is defined.

5) Collateral Costs and Costs for Special Items

- Definition of collateral costs and costs for special items, like cost for heavy equipment for site support, health physics equipment and supplies, licenses and permits, costs for lighting, heating, cooling, income from sold equipment or scrap, etc.

6) Total costs definition

- Total costs estimate are obtained as a sum of the costs three categories: inventory-dependent costs, period-dependent costs, collateral costs
- The cost estimates may be adjusted to include a contingency that reflects the level of uncertainty in the estimates.
- A separate contingency expressed in some special cost items may be applied to the total cost estimate for the processes with high uncertainty.

2. Review of costing methodologies; practical steps in costing

Practical procedure in decommissioning costing, taken into account in the proposed costing methodology for research reactors, involves following principal steps:

- Developing the **facility inventory database** - the inventory of systems, the inventory of structures and radiological parameters. Radiological parameters are measured or calculated by modelling. Evaluation of activation of reactor structure are special cases.
- Preparation of the **database of unit factors** and other data related to decommissioning activities. Normally, the data are prepared based on data from decommissioning projects completed, based on published data or the data are adapted from non-nuclear industry.
- Configuration of **calculation options** based on existing or planned decommissioning infrastructure and decommissioning strategies to be evaluated. The calculation options correspond with the activities presented in the decommissioning plan. The extent of options should cover relevant combinations of strategies, D&D techniques and waste scenarios.
- Calculation and optimization of options and selection of optimal option. Each decommissioning option is calculated and optimised individually. The recommended procedure for choice is the **multi attribute analysis** [3] based on data from the set of evaluated options.

[3] Selection of decommissioning strategies: Issues and factors. Report by an expert group. IAEA-TECDOC-1478, IAEA, November 2005

3. Input data for decommissioning costing; review of main input variables

- **Inventory-dependent costs** include activities such as decontamination, removal of components, packaging, shipping and disposal of wastes, etc. Costs arise from labour, materials, energy, equipment and services.

- Main **input variables** determining the cost (volume of work) are the facility inventory data (mass of components of systems and structures, areas, ...), specific unit factors related to individual categories of systems and structures (normalised manpower unit factors or cost unit factors) and work difficulty factors reflecting the working conditions at the place of performing the decommissioning activity (increase factors).

- From the point of view of cost calculation, the waste management technologies including transports are included into this category. Main input variables in this case are mass, volumes of waste per individual categories, unit factors of individual technologies, etc.

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3. Input data for decommissioning costing; review of main input variables

- **Period-dependent costs** are proportional to the duration of individual activities or to the duration of the entire project. They arise from project management, administration, routine maintenance, radiological, environmental and industrial safety and security activities.
- Main input variables determining the cost (or volume of work) is the **duration** of the activities and the composition of **working group** (number of personnel and theirs labour cost unit factors). Input variables are specific for individual calculation items.
- **Collateral costs** and costs for special items which can neither be assigned to a certain work activity nor to a period-dependent activity.
- Typical character is the fixed cost allocated to a time point. Main input variables determining the cost are the list of equipment to be procured and payments – periodical per year or a given period and non periodical.

3. Input data for decommissioning costing; review of main input variables

The input data used for calculating of costs can be sorted into following groups:

- **Facility inventory data**
  - **Items of facility technology systems, identified according the technological systems, their location in individual cells and types reflecting the materials, shapes and other parameters with impact on decommissioning**
  - **Building objects data, identified according the object structure, types of materials, building surfaces**
  - **Radiological data which include the dose rate in rooms, at the vicinity of equipments, contamination of inner and outer surfaces and nuclide composition**
- **Calculation data**
  - **National specific data for labour force, data for decommissioning techniques (unit factors, increase factors), material data, cost data for materials, electricity and technological media, etc,**
  - **Project specific data of the decommissioning infrastructure which include the data of waste management technologies, waste disposal and material release.**

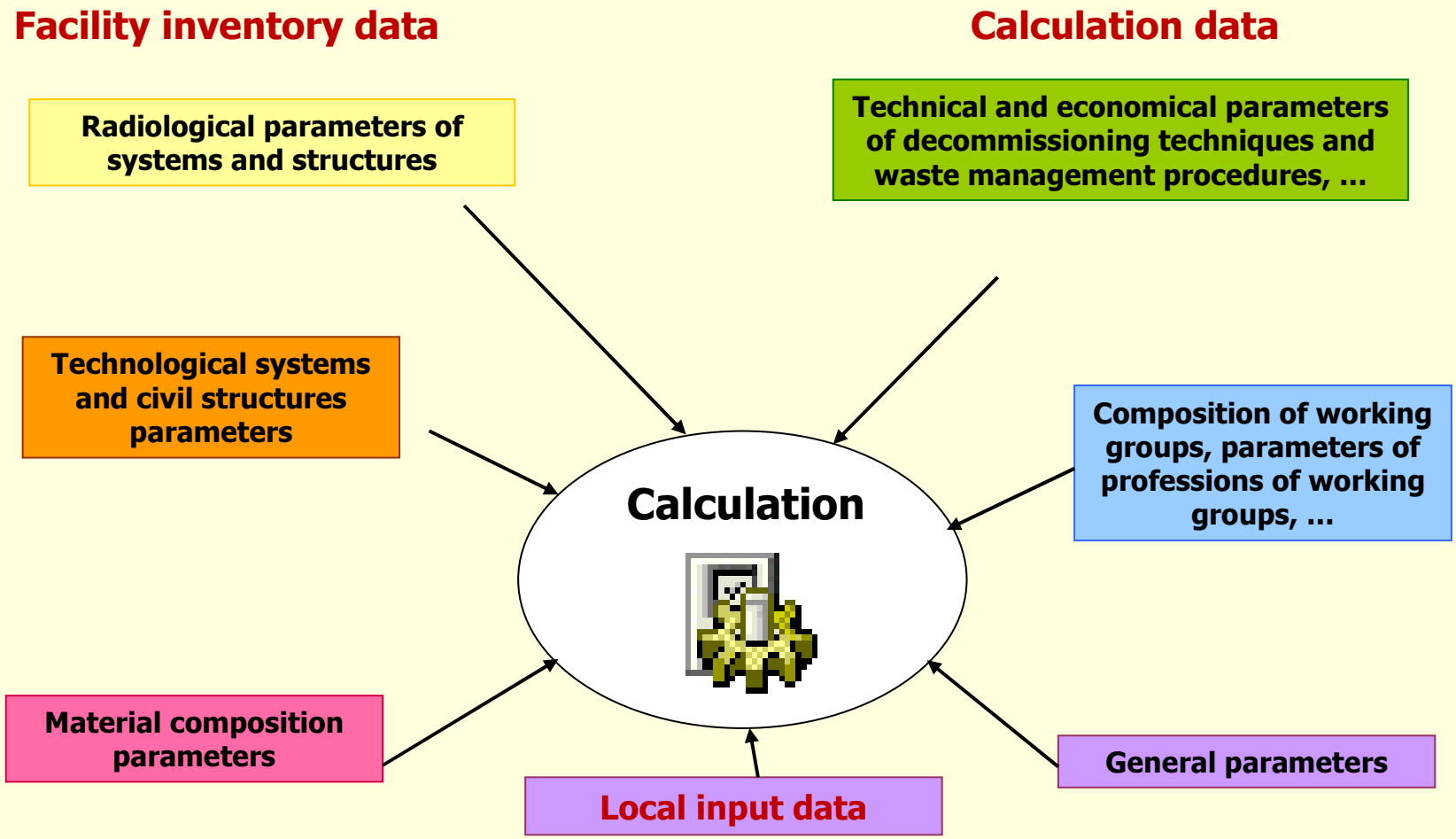
3. Input data for decommissioning costing; review of main input variables

Specific calculation data (local input data at the calculation item level)

- Calculation item specific data which reflect the local calculation conditions applied in individual calculation items, like manpower increase factors, number of working groups, shift work, etc.
- Data for definition of period dependent activities – definition of the professions, duration,
- Collateral cost specific for calculation item like investment items, payments, …

3. Input data for decommissioning costing; review of main input variables

Review scheme of data structure for cost estimating



3. Input data for decommissioning costing; review of main input variables

Structure of data in the inventory database

- **Identification data** which involves the allocation data for referring to upper levels within the principal hierarchical structure of the facility inventory database, allocations to structures and allocation to systems. Identification data are needed for implementation of the room oriented and system oriented dismantling approach.
- **Physical data** like mass, area of surfaces, volumes which are used as input variables. Physical data can be prepared mainly by review of technical documentation (project and operational documentation), historical data (operational records), by inspections on site, by reviewing the experience of operation personnel.
- **Radiological data** – contamination of internal and external surfaces, activation of components of reactors and of biological shield, mass activity and relevant composition of radio-nuclides. The comprehensive review of preparing the radiological data by in situ measurement and computer modelling can be found in [TRS 399]
- **Decommissioning data** – decommissioning **categories** of equipment which are used for calculation of decommissioning parameters. This kind of data is specific and normally is prepared by decommissioning experts. Specific types of the data of this kind are the **PSL allocation data** which are used for generation of the standardised cost calculation structure

3. Input data for decommissioning costing; review of main input variables

Structure of data in the calculation database

These data are the second main source of input data for decommissioning costing. It contains the input data specific for the decommissioning project which are normally used as the common data for the project. These data describe the activities and processes which are carried out during decommissioning process. The database can be divided into following main groups according the character of data:

- General calculation data - cost unit factors, personnel specific data and other overall data not depending of specific decommissioning activities.
- Calculation data specific for decommissioning activities – parameters of techniques and processes (manpower, cost, media consumption unit factors), working group data
- Increase factors
- Waste data
- Nuclide data

3. Input data for decommissioning costing; review of main input variables

Development of the inventory database

Development of the good inventory database is the pre requisite for effective decommissioning costing. The general procedure for development of the inventory database is divided into four steps where following groups of data are developed:

- **A)** Primary data to be collected from facility technical documentation and based on physical inspection and measurement in individual premises of the facility.
- **B)** Secondary date derived from the primary data by calculation.
- **C)** Data used in the generation of the calculation database (data for complex equipment).

3. Input data for decommissioning costing; review of main input variables

Development of the inventory database, cont.

- **D) Inventory data for complex reactor structures, developed in separate tasks. Preparation of this kind of data requires additional complex calculations like the neutron flux calculations, calculation of activation of reactor construction of materials, development of a hierarchical inventory database structure which corresponds to a proposed dismantling procedure.**

  This kind of data should be prepared by decommissioning specialists.

- **E) Radiological data, mostly the contamination levels and the nuclide composition of contamination or dose rate. It is expected that the main radiological parameter – the dose rate in the defined distance (0.5 m) from the equipment - is collected in the frame of collecting the primary data by the operational personnel.**

  The contamination data can be calculated, based on calculation models of categories of equipment, if they are not available as the primary data. The nuclide composition can be derived from the radiological analysis of relevant samples.

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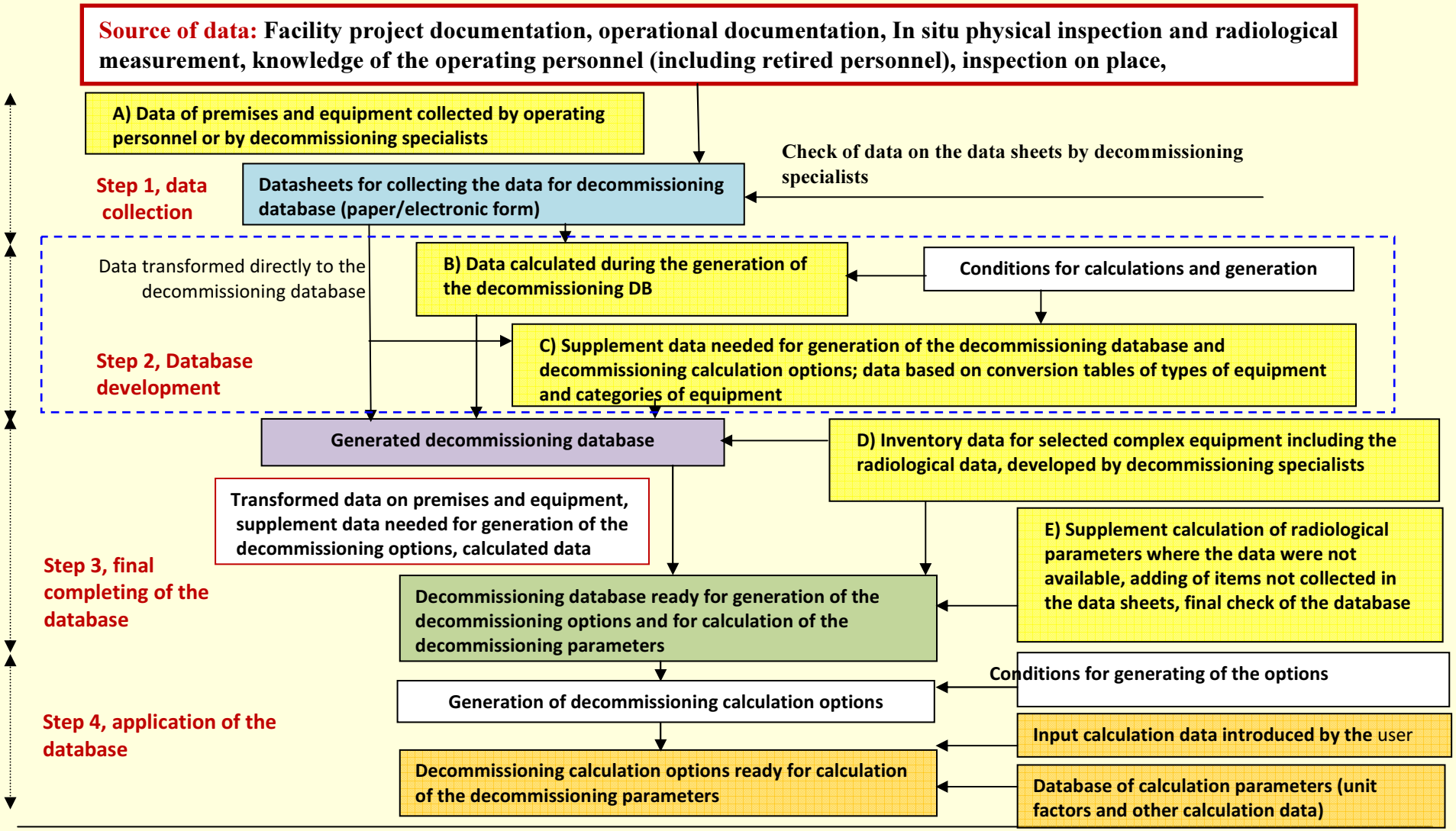
3. Input data for decommissioning costing; review of main input variables



4. Breakdown of decommissioning activities for costing

- **Identification of extent of decommissioning activities is the base for any decommissioning costing**
- **The principle of bottom up approach means that the decommissioning activities should be identified at the lowest level of details, at the level of discrete elementary decommissioning activities, corresponding to the character of the decommissioning project.**
- **The procedure of identification of decommissioning activities is different for individual cost categories and grading can implemented in defining the decommissioning activities**
- **Separate calculation items should be available for each elementary decommissioning activity, identified for the project**
- **It is recommended to use the standardised cost structure at least as the check list for identification of extent of decommissioning activities**
- **For repetitive activities related to facility inventory database, the room oriented and system oriented approach are normally used for development of calculation structures**
- **Calculation procedures are allocated for each elementary calculation item depending of the type of the cost category (inventory dependent, period dependent, …)**

4. Breakdown of decommissioning activities for costing

Example of the room-oriented approach, implemented in dismantling

Set of preparatory activities:

- covering of the floor with protective foils to inhibit the contamination of the floor
- installation of local ventilation to suppress the aerosols from dismantling
- installation of scaffolding for dismantling activities
- installation of temporary electrical connections and media for dismantling
- delineation of cuts on equipment
- transport of dismantling tools to the room
- isolation of equipment from electrical connection or operating media
- preparation of dismantling tools for the work
- installation of protective tenting for suppressing the spreading of aerosols
- preparation (instructions) of the working group for the work
- transport of containers with dismantled materials
- specific preparatory activities defined by the user

Set of dismantling activities according the ALARA principle:

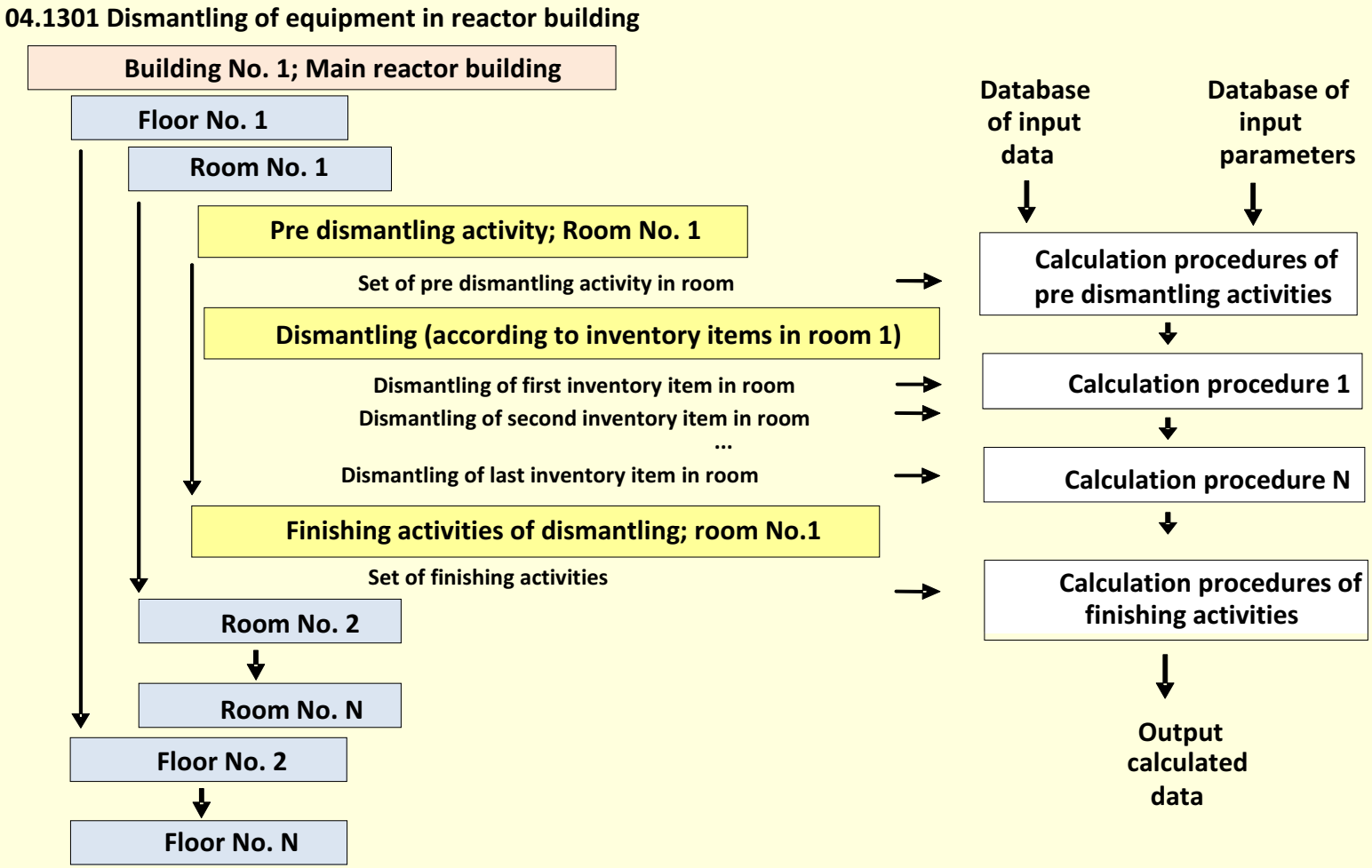
- dismantling the inventory item with the highest dose rate at the working distance
- sequential dismantling of inventory items according the decreasing dose rate
- dismantling of the last inventory item with the lowest dose rate

Set of finishing activities:

- removal of protective foils on floors
- removal of local ventilation
- removal of scaffolding
- removal of temporary electrical connections and media for dismantling
- removal of protective tenting
- removal of dismantling tools
- transport of containers
- final cleaning of the room after dismantling
- specific finishing activities defined by the user

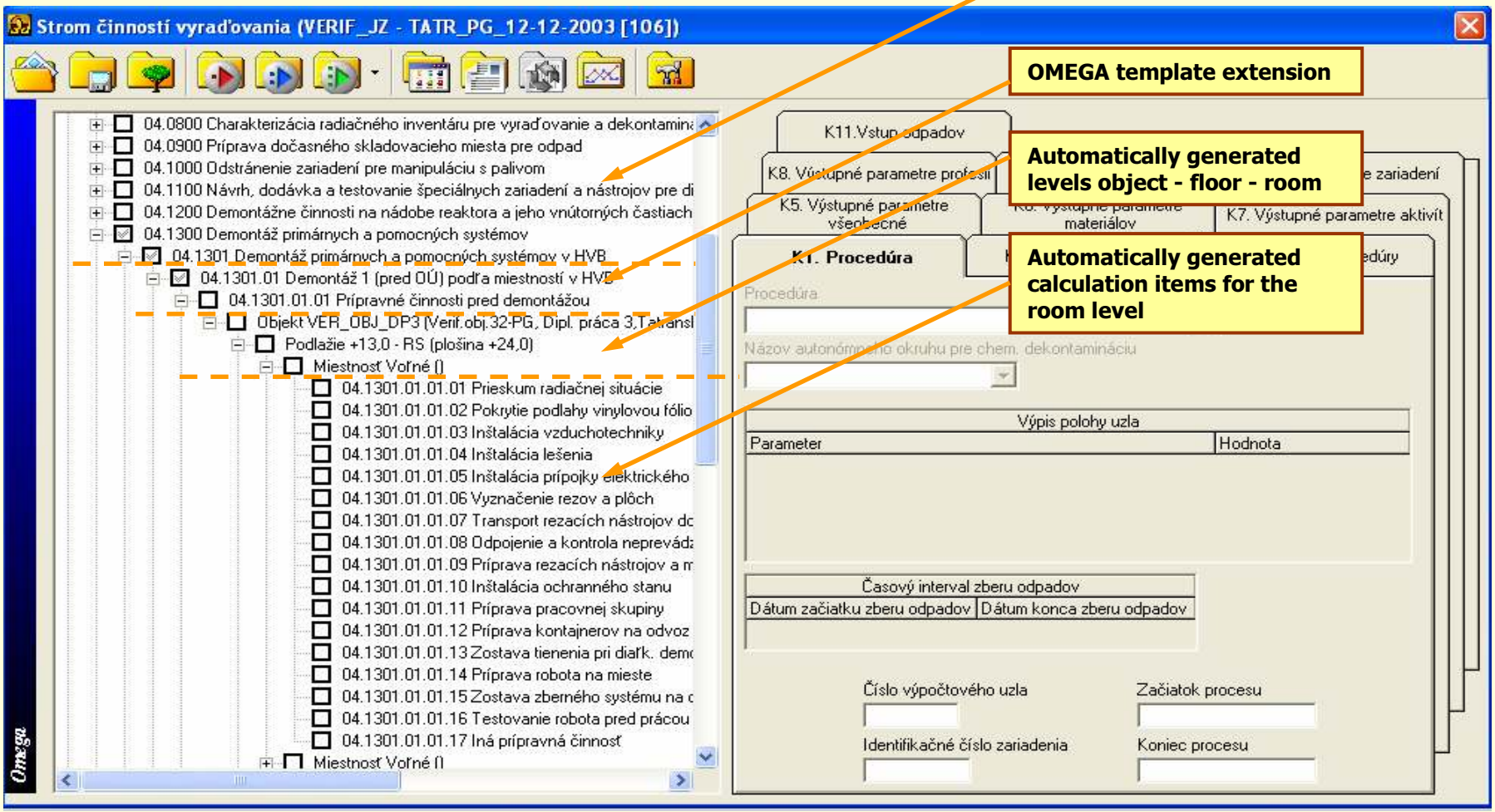
4. Breakdown of decommissioning activities for costing

Principal scheme of the room-oriented approach



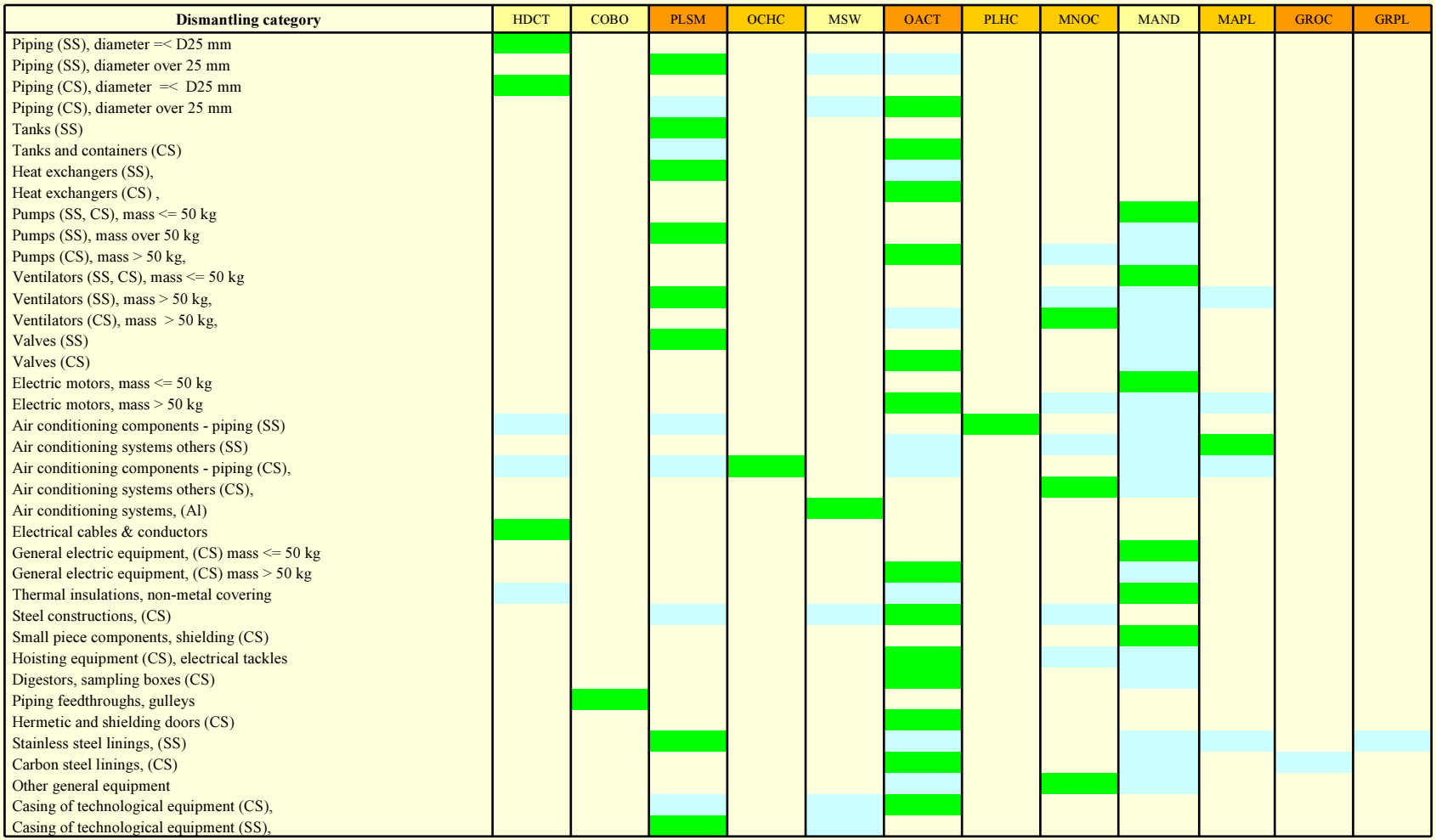
4. Breakdown of decommissioning activities for costing

Example of a standardised calculation structure for room oriented approach as implemented in the computer code OMEGA



5. Selection of decommissioning techniques

Example of allocation of dismantling techniques. The techniques coloured by green colour are recommended, those coloured by blue are possible.



5. Selection of decommissioning techniques

Example of allocation of dismantling techniques.

HDCT	Hydraulic shears cutting
COBO	Core boring
PLSM	Plasma cutting
OCHC	Oxygen cutting - hydraulic cutting (combined technique)
MSAW	Mechanical cutting by saw
OACT	Oxygen cutting (oxygen - acetylene cutting)
PLHC	Plasma cutting - hydraulic cutting (combined technique)
MNOC	Manual dismantling - oxygen cutting (combined technique)
MAND	Manual dismantling (by tools)
MAPL	Manual dismantling - plasma cutting (combined technique)
GROC	Grinding - oxygen cutting (combined technique)
GRPL	Grinding - plasma cutting (combined technique)

PLSM	Release factor = 10 %
OCHC	Release factor = 1 %
HDCT	Release factor = 0,1 %

4. Breakdown of decommissioning activities for costing

Principal scheme of the system oriented approach, used for dismantling of complex structure like reactors.

The procedure is normally inverse to construction.

Set of supporting activities:

Set of supporting activities with durations adjusted over the complete dismantling or over specific phases of dismantling

Set of general preparatory activities:
- Set of general preparatory activities
- Set of specific preparatory activities defined by the user

Dismantling of the construction sub-assembly No. 1:
- Set of preparatory activities for the sub-assembly No.1
- Dismantling of individual components of the sub-assembly No.1
- Set of finishing activities for the sub-assembly No.1

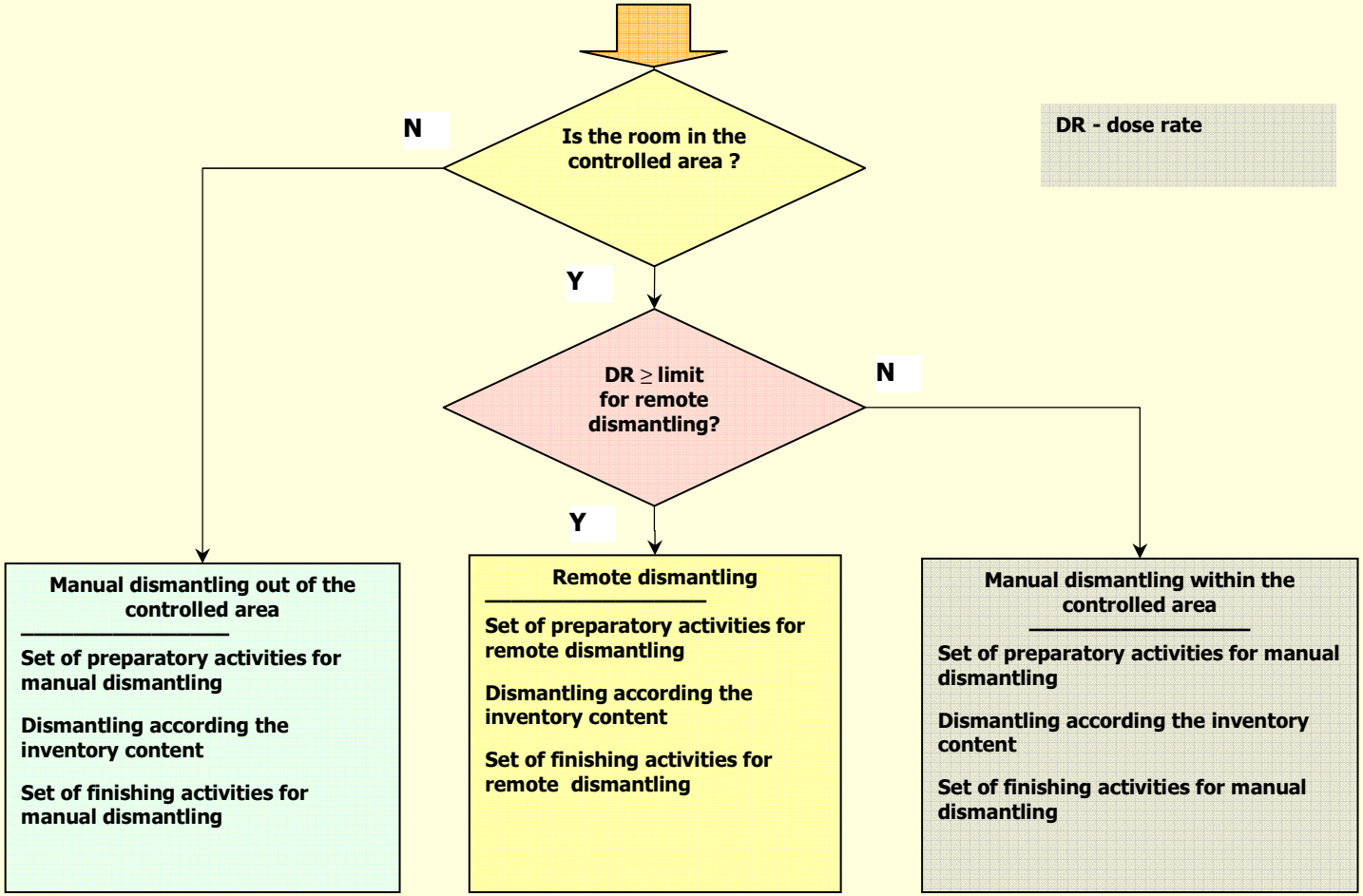
Dismantling of the construction sub-assembly No. 2:
- Set of specific preparatory activities for the sub-assembly No.2
- Dismantling of individual components of the sub-assembly No.2
- Set of finishing activities for the sub-assembly No.2

Dismantling of the construction sub-assembly No. N:
- Set of specific preparatory activities for the sub-assembly No.N
- Dismantling of individual components of the sub-assembly No.N
- Set of finishing activities for the sub-assembly No.N

Set of general finishing activities:
- Set of general finishing activities
- Set of specific preparatory activities defined by the user

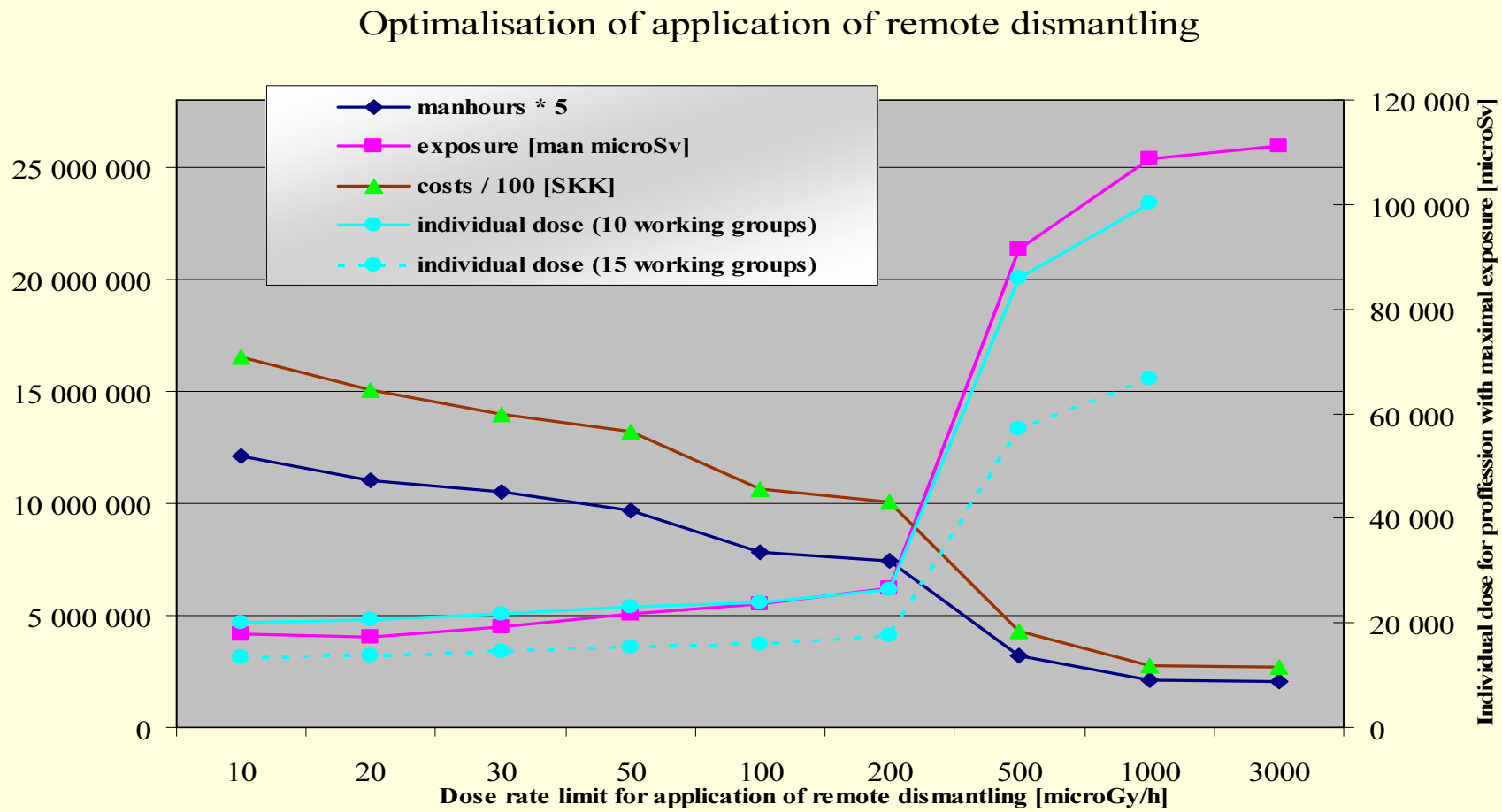
4. Breakdown of decommissioning activities for costing

Simplified scheme for implementation of remote controlled techniques and for manual dismantling within the controlled area or outside of controlled area



4. Breakdown of decommissioning activities for costing

Evaluation of costs for dismantling of the primary circuit of A1 NPP versus dose uptake by changing the limit for application of remote dismantling



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4. Breakdown of decommissioning activities for costing; Implementation of the standardised cost structure;

- The standardised structure, as defined, is the **unique platform for harmonisation** in decommissioning costing, at least for presenting the cost.
- The standardised structure was developed as a **hierarchical structure numbered down to the third level**. From this level down, the structure is open and it is possible to add specific levels.
- Implementation of PSL structure means the configuration of elementary decommissioning activities according the PSL numbers by using of the numbered levels and by defining the additional project specific decommissioning activities down the third numbered level.
- This approach **"fixed on top, open downwards"** brings the possibilities of implementation of the standardised structure in principle for any nuclear facility. The nuclear facilities of various types can have its own specific spectrum of decommissioning activities.

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4. Breakdown of decommissioning activities for costing; Implementation of the standardised cost structure;

PSL levels as defined:

- Level "10" - eleven classes are defined numbered as 01 to 11
- Level "100" - sub groups are defined in steps of 100
- Level "1000" - specific activities are defined with the step of 1

Examples of levels "10" to "1000":

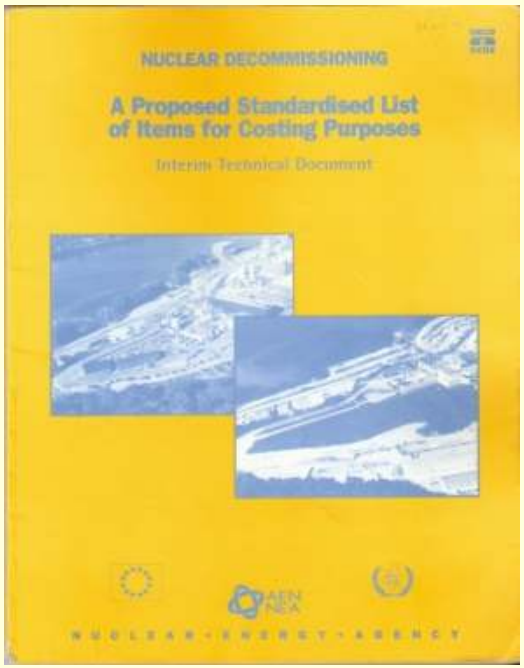
04 Dismantling activities
  04.1300 Removal of primary and auxiliary systems
    04.1301 Removal of primary and auxiliary systems in reactor facilities
    04.1302 Dismantling and removal of contaminated equipment, piping, liners and internal systems in non-reactor nuclear facilities

Extending the PSL structure down the third numbered level

- PSL level "1000.xx" 04.1301.01
- PSL level "1000.xx.xx" 04.1301.01.01
- PSL level "1000.xx.xx.xx" 04.1301.01.01.01
- Etc.

Standardised Cost Items (former cost types):

01 Pre-decommissioning actions
02 Facility shutdown activities
03 Procurement of general equipment and material
04 Dismantling activities
05 Waste processing and disposal
06 Site security, surveillance and maintenance
07 Site restoration, cleanup and landscaping
08 Project management, engineering and site support
09 Research and development
10 Fuel and nuclear material
11 Other costs



The "Yellow Book"

4. Breakdown of decommissioning activities for costing; Implementation of the standardised cost structure, cont.

The approach of adding specific activities down the third numbered level has following advantages:

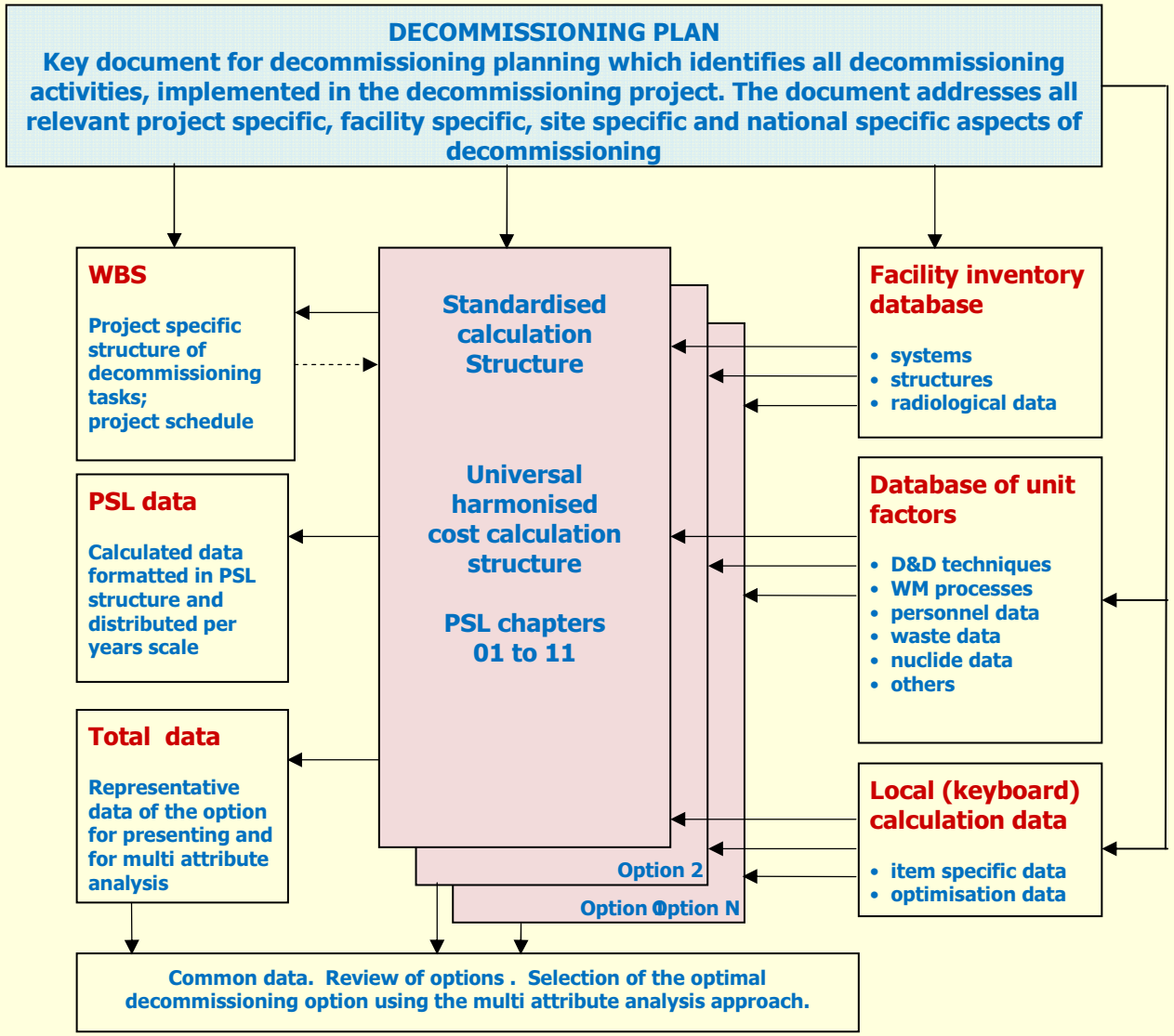
- **One common standardised calculation platform is established which is harmonised to the third numbered level for any calculation case**
- **Any aspects which are specific for a group of nuclear facilities can be easily harmonised at the lower calculation levels. This is for example the case of research rectors.**
- **There are possibilities for development of specific calculation structures for typical complex equipment, e.g. for dismantling of reactors of a given type. The calculation segments can be implemented into any decommissioning case with the standardised calculation structure.**
- **There is no theoretical limitation in numbering the levels downwards. There could be some practical limitations for the level of details of a decommissioning project and limitations related to the software used (e.g. Excel vs. ORACLE).**

4. Breakdown of decommissioning activities for costing; Implementation of the standardised cost structure;

Principal scheme of the standardised analytical cost estimation model.

The model involves current experience in costing methodologies and the principles of implementation of the standardised cost structure

WBS – Work Breakdown Structure



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4. Breakdown of decommissioning activities for costing; Implementation of the standardised cost structure;

- Standardised cost calculation structure which implements the classification of decommissioning activities according the Yellow Book. The calculated data are available directly in the standardised structure.
- WBS – Work Breakdown Structure (schedule) of decommissioning tasks, represents the sequence of individual tasks as defined in the decommissioning plan. Unique linking of items of calculation structure to tasks of WBS is needed for individual cases.
- Facility inventory database. Contains all data of systems and structures needed for calculation of cost and other decommissioning data.
- Database of unit factors for techniques and processes, personnel data and other data defined as common data for all calculation cases and option specific data like waste data.
- Local input calculation data specific to individual calculation items, introduced to the calculation structure as the keyboard data.
- PSL data - calculated data formatted in PSL structure.
- Total data - the data for the option for presenting the overall parameters of the case.
- Common data for the multi attributes analysis for selecting the optimal strategy.

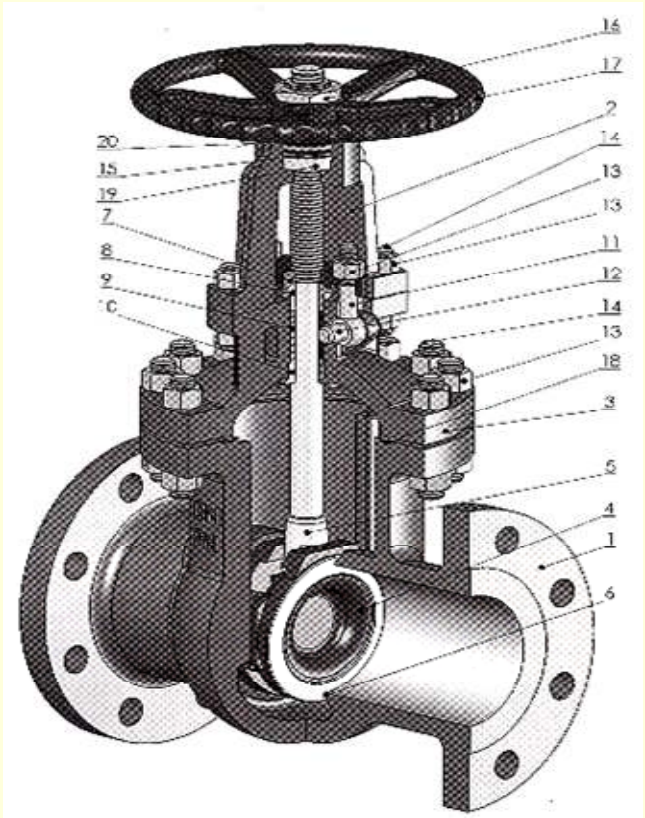
5. Calculation of cost for waste management

The prerequisite for calculation of cost for waste are following:

- **Waste management scheme involving individual techniques for waste types is available**
- **Data for individual techniques – capacity, working groups, consumption of materials and media, secondary waste generation, cost unit factors**
- **Input waste data for individual waste types are defined, derived from the inventory database and from the waste streams**
- **The operational waste in older facilities is a special task – the inventory is required to be elaborated according the intended waste management scheme**

5. Calculation of cost for waste management

- **Example of definition of materials for the waste streams based on inventory data**



	Physical parts	One-material component
1	Body	Carbon steel
2	Clevis	Carbon steel
3	Bonnet	Carbon steel
4	Disc	Carbon steel
5	Disc nut	Stainless steel
6	Seat	Stainless steel
7	Gland	Carbon steel
8	Gland packing	Stainless steel
9	Packing	Graphite
10	Back close	Carbon steel
11	Bolt with snare	Carbon steel
12	Pin	Carbon steel
13	Nut	Carbon steel
14	Bolt	Carbon steel
15	Stem nut	Stainless steel
16	Hand wheel nut	Carbon steel
17	Hand wheel	Carbon steel
18	Seal	Graphite
19	Bearing	Bronze (CM)
20	Washer	Bronze (CM)

Figure 2 Example of the carbon steel valve with its physical parts

5. Calculation of cost for waste management

- **Example of definition of materials for the waste streams based on inventory data**

Index of one-material component	Name of one-material component	Partial Weight [%]	Partial inner surface [%]	Partial inner contamination [%]	Partial outer surface [%]	Partial outer contamination [%]
1	carbon steel	89.5	87	89	97	98
2	stainless steel	9	12.2	9.5	3	2
3	bronze (CM)	1	0.6	1	0	0
4	graphite	0.5	0.2	0.5	0	0

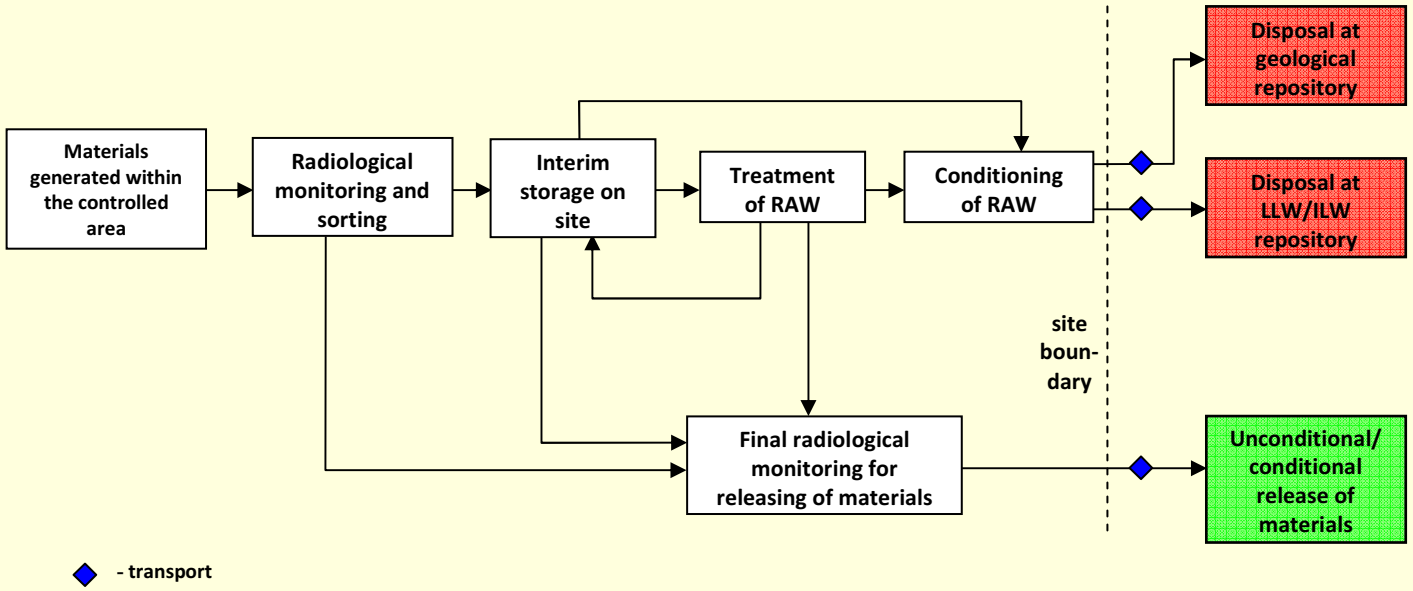
- **Specialised tables which links the individual waste management techniques are used for definition of input variables for individual waste management techniques**

- **The primary and secondary waste items are subject of evaluation**

5. Calculation of cost for waste management

Management of waste from decommissioning in current costing methodologies.

Cost pools are individual techniques, cost drivers are the volumes of input materials



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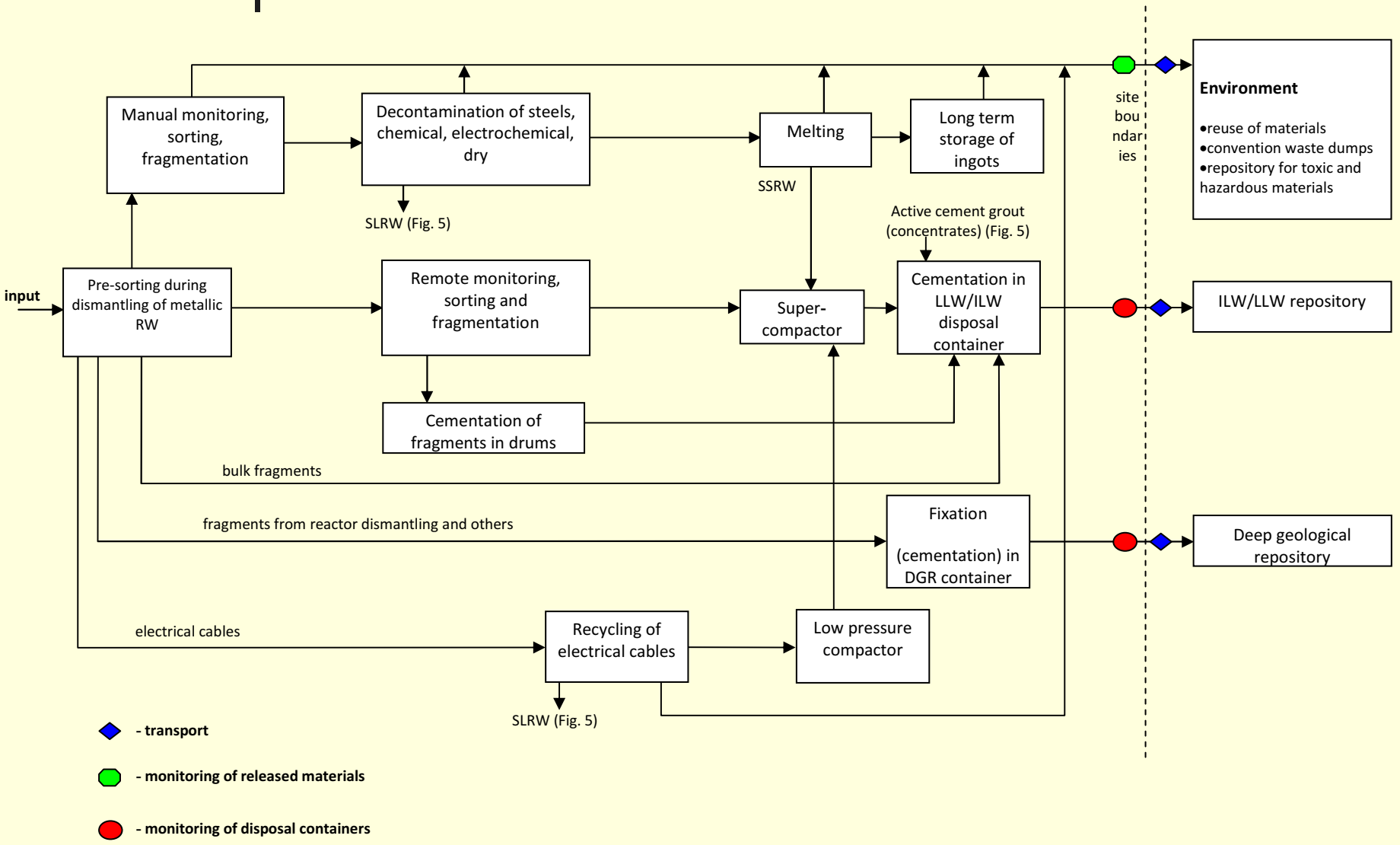
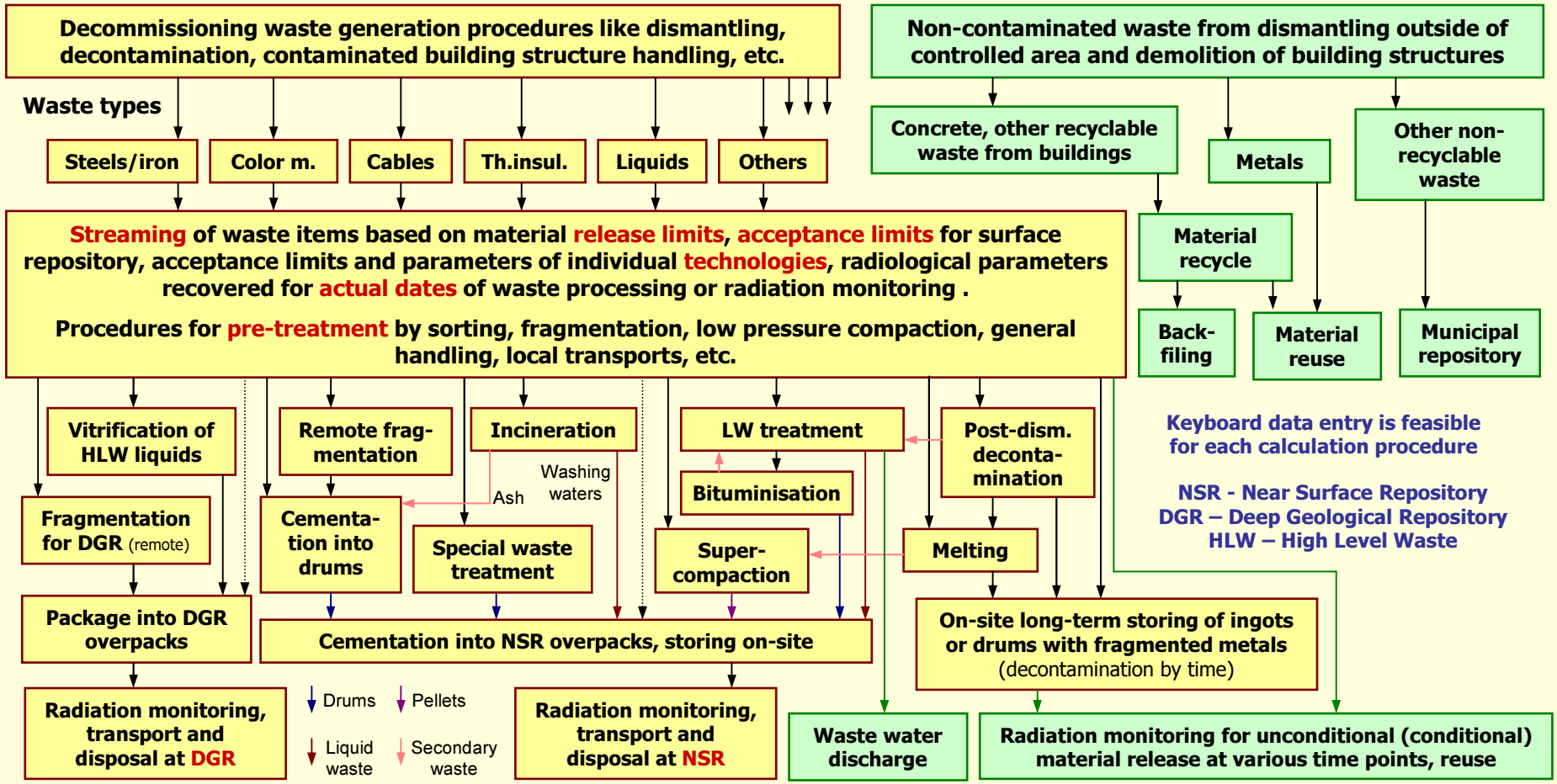
5. Calculation of cost for waste management Example for treatment of metals



5. Calculation of cost for waste management

Review scheme of waste management in OMEGA for decommissioning costing and for general waste management projects optimisation using the keyboard data enter and internal OMEGA tool



6.Calculation approach

- The cost are calculated according the cost groups of the chapter 12 of the PSL which is in line with the recommendations of the IAEA for promoting the PSL structure
- The experience from current decommissioning costing shows that the effective methodology for calculation of cost is the calculation of **manpower components** of individual elementary decommissioning activities at the first step.
- The manpower components are allocated to **individual professions** of the working group and they are the base for calculation of **labor cost** using the labor cost unit factors.
- The costs are completed by **investment cost and by expenses** of techniques and processes involved in the elementary decommissioning activity using the cost unit factors and at the end are completed by **contingency** at the level of individual decommissioning activity.
- Manpower is the **effective indicator** of the size of the project, mostly dependent on facility inventory, on personnel involved (planning, management, support, etc…) and relatively independent on facility or national conditions

6.Calculation approach

- Manpower for hands-on decommissioning activities is calculated as the product of input inventory variable (mass, surface, volume, ...) and the manpower unit factor for the individual decommissioning category. Manpower components are increased for working constraints and for non-productive working time components.

- Manpower for period-dependent activities is calculated as the product of duration and number of personnel of the staff.

- This procedure is used also for calculation of manpower for waste management activities, where the duration is calculated as the product of capacity of the given technological unit and the input variable which is the amount of input waste to be processed.

6.Calculation approach

Cost groups

- The PSL calculation approach implements the calculation of cost groups according the PSL definition at the lowest calculation level. The cost groups defined in the PSL structure are following:

- 12.0000 Total cost (sum of 12.0100 to 12.0400)
- 12.0100 Labour cost
- 12.0200 Capital, equipment and material cost (investment cost)
- 12.0300 Expenses
- 12.0400 Contingency

6.Calculation approach

Labour cost represents costs for staff involved in the evaluated activity.

- **Calculation of labour costs is performed based on calculation of components of manpower for individual professions of the working group multiplied by labour cost unit factors of individual professions of the working group and summed over the professions of the working group.**

- **For activity-dependent cost, the manpower components are calculated from the total manpower proportionally to the composition of the working groups.**

- **For period-dependent costs, the manpower components are calculated from the duration of the elementary activity and number of workers of the working group.**

- **PSL definition: the labour cost unit factors for each profession have three main components:**

  (a) payments to employees
  (b) social security contributions, insurance contributions, social charges
  (c) personal overheads

6.Calculation approach

Capital, equipment and material cost

- Capital, equipment and material cost (investment cost) represent the costs for procurement of equipment or machinery used for dismantling, decontamination, demolition and other activities, cost for technological equipment for processing and conditioning of waste, cost for materials, spare parts of investment character.
- National laws define the limit of cost for items of materials and spare parts for considering them as investment cost.
- Calculation of investment costs is realised by entering the fixed values into the calculation item (keyboard data) or by using cost unit factors which include items like consumption of materials and of spare parts of investment character.
- **PSL definition:**
  - Equipment to be used for a particular cost item
  - Machinery to be used for a particular cost item

6.Calculation approach

Expenses

- Expenses represent the costs for material, media and other cost spent in the process.
- Calculation of consumables is realised on the basis of input variables (weight, surface, volume,...) and specific consumable units factors for general technological media (electricity, water, steam, etc.), for specific media (technical gases, cement, bitumen, etc.), for spare parts of non-investment character. Cost are calculated using the cost unit factors applied for individual consumables and for non-specified expenses
- Other examples of expenses are legal fees, taxes, insurance, consulting fees, rent, office material, utilities, etc. which are related to whole project. The base for calculation of this overheads expenses is the manpower per professions and the expenses cost unit factors related to individual professions. Part of this cost can be identified as investment cost (range 5 - 10 %)
- Care should be taken when defining the cost factors for consumables and overheads expenses to avoid doubling of some cost items

PSL definition

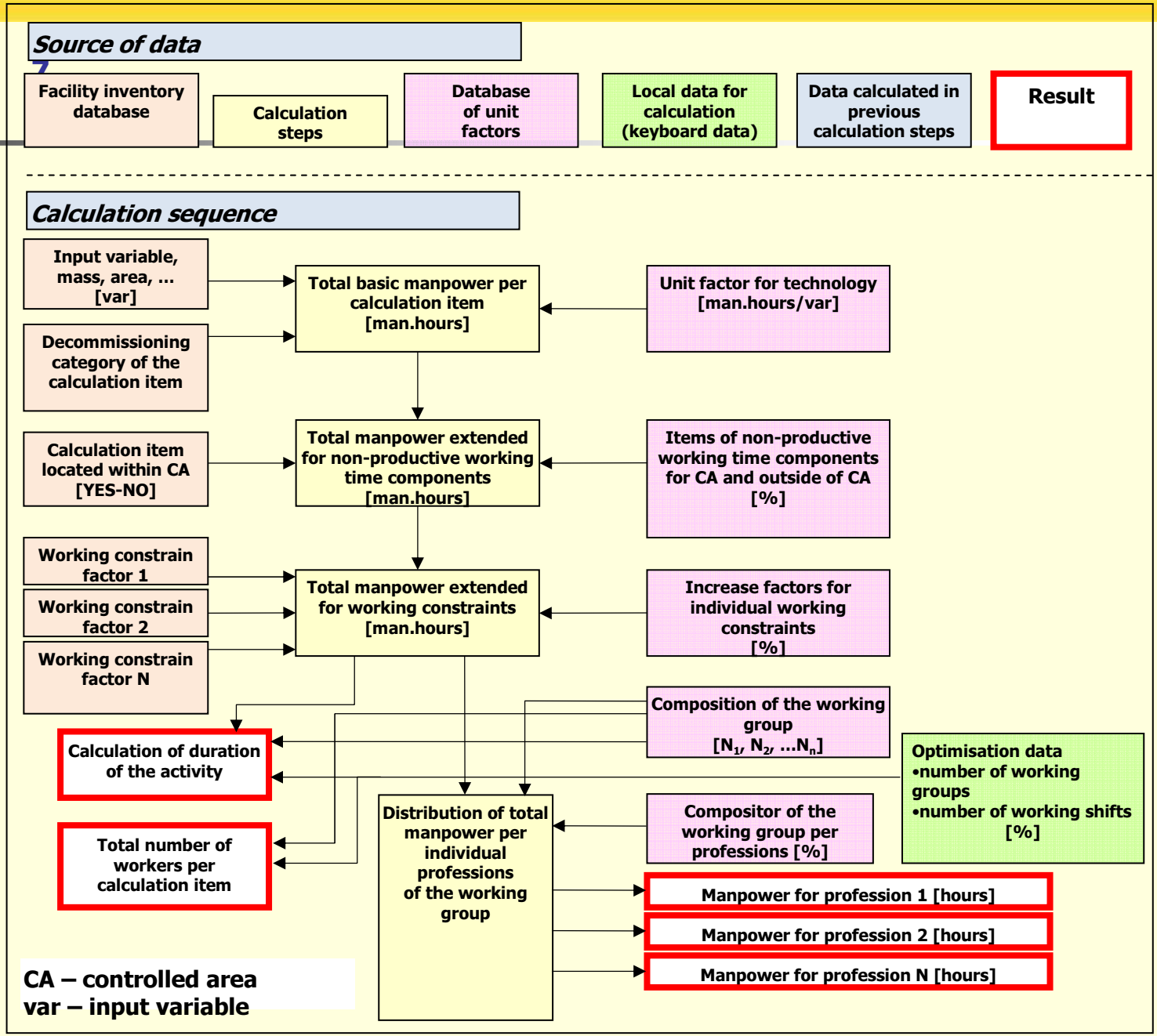
- Consumables
- Spare parts
- Protective clothing
- Travel expenses
- Legal expenses
- Taxes
- Value added tax
- Insurance
- Consultants costs
- Quality assurance costs
- Rents
- Office material
- Heating costs
- Water costs
- Electricity costs
- Computer costs
- Telephone/fax costs
- Cleaning
- Interest
- Public relation
- Licences/patents
- Decommissioning authorisation

6.Calculation approach

Contingency

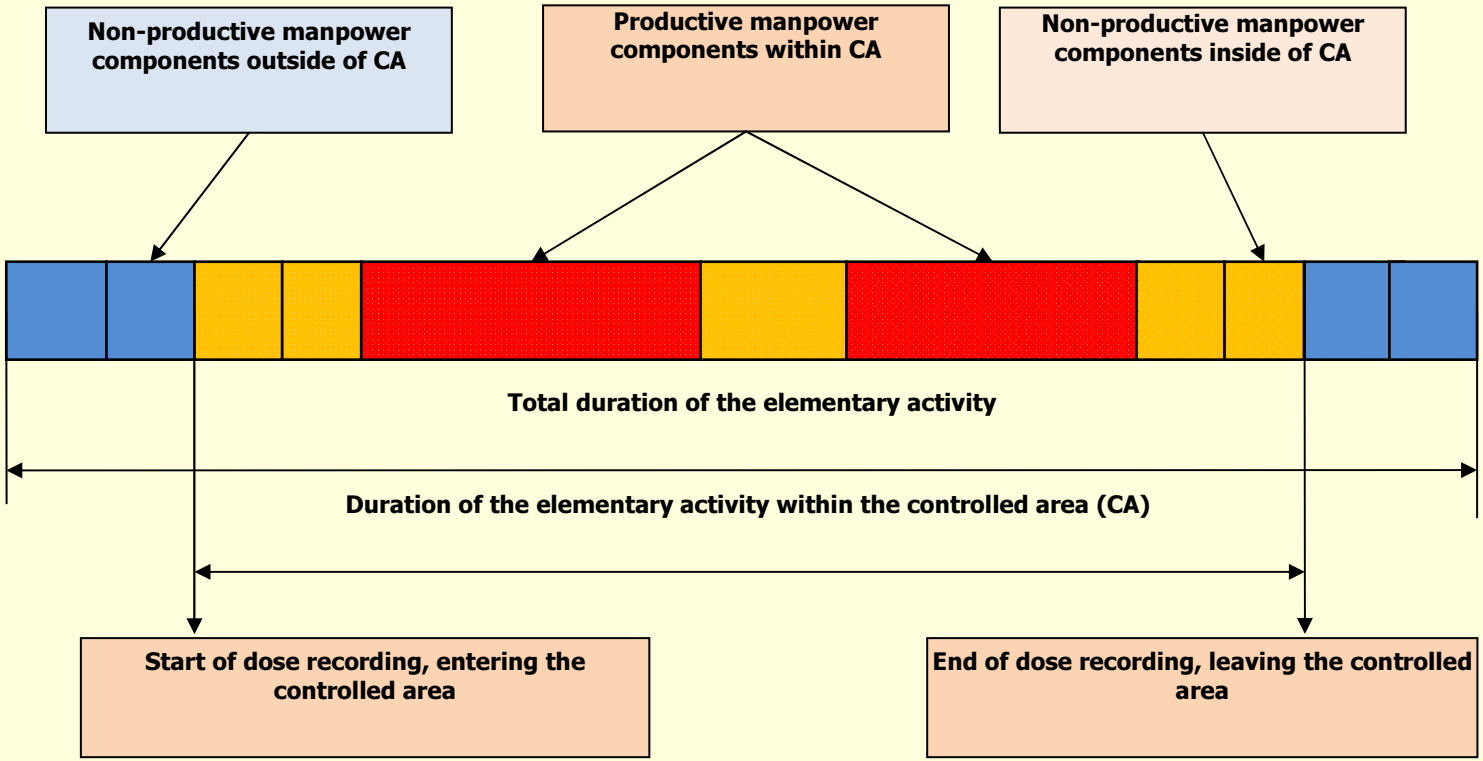
- Contingency is added to calculated cost elements in order to balance the specific provisions for unforeseeable elements of cost **within the defined project scope**.
- Contingency costs are for unforeseen, uncertain and unpredictable conditions typically encountered in decommissioning. In general, all contingency costs are spent as the project progresses, as these unforeseen events occur throughout the project.
- The contingency can be calculated as separate contingency items for labour cost, for investment costs and for expenses) or as one item per calculation item.
- Contingency may be specific for individual calculation items, based on specific character of the evaluated decommissioning activity.
- Standardised structure of cost items for decommissioning [PSL] contains also special items of contingency, which are related to items with generally higher uncertainty in determination of theirs values (chapter 11.0700 of standardised list of cost items).

- **Procedure for calculation of cost for inventory dependent activities**

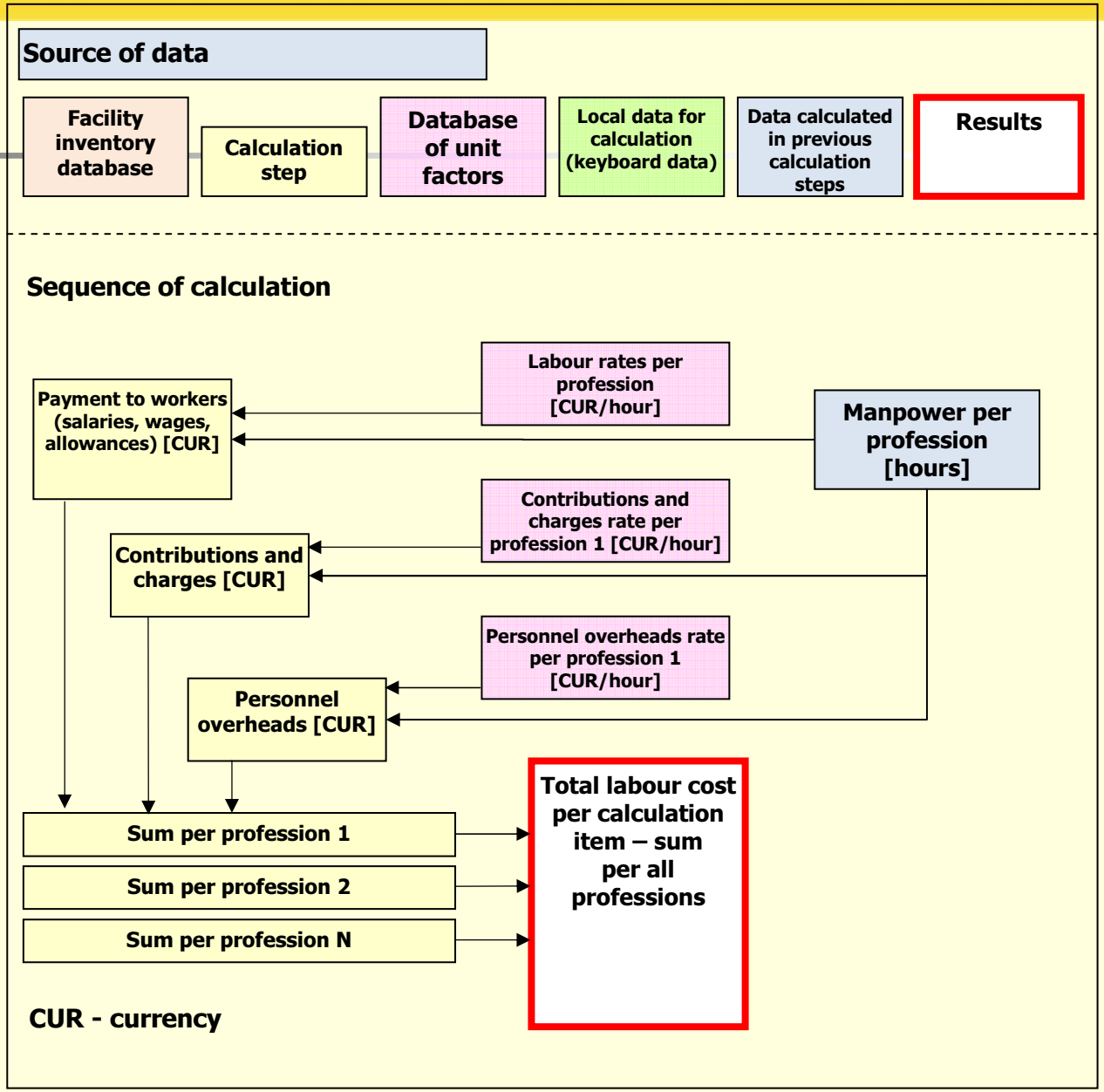


7. Schemes

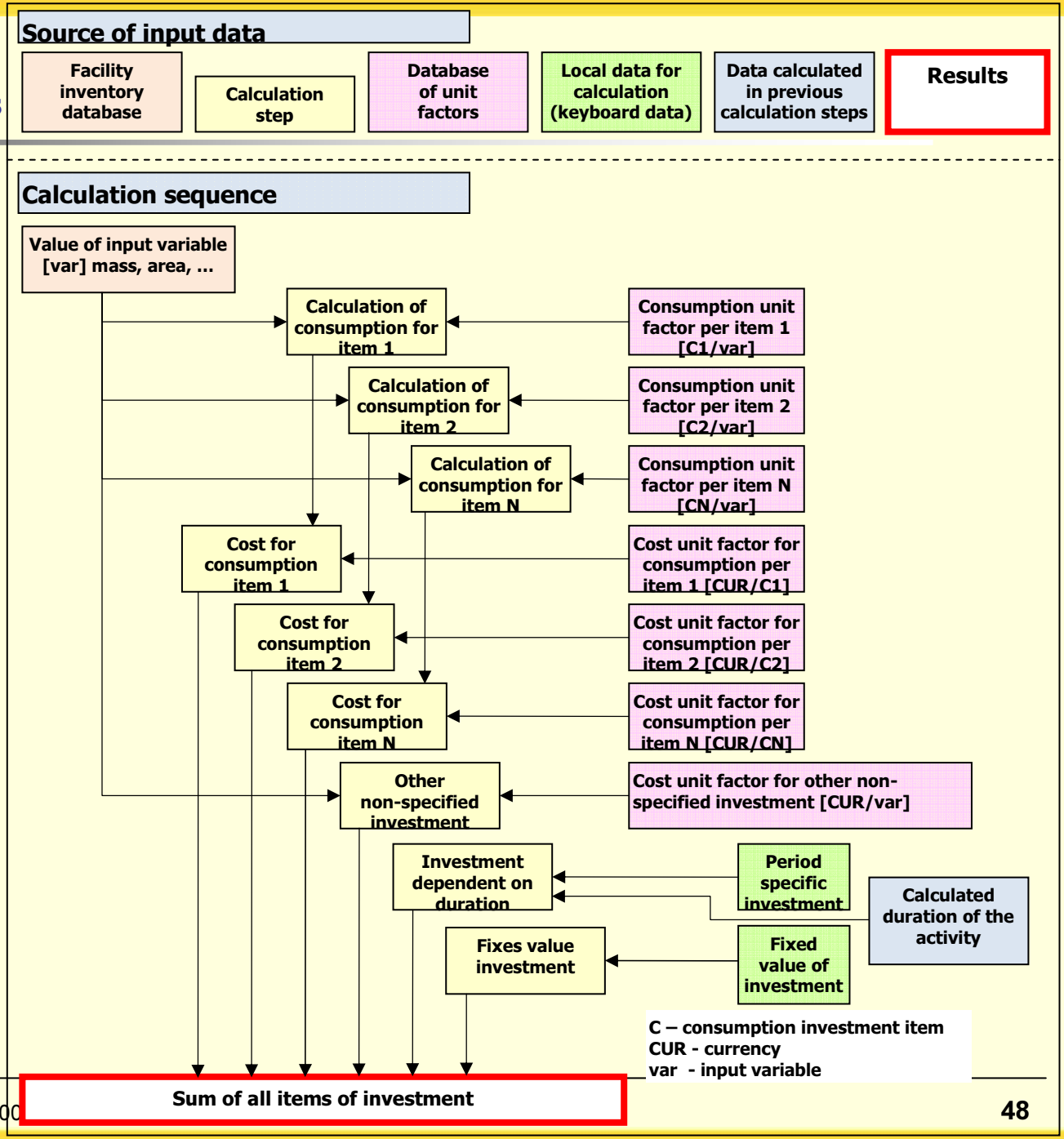
- **Principal structure of time components of a hands on working activity**



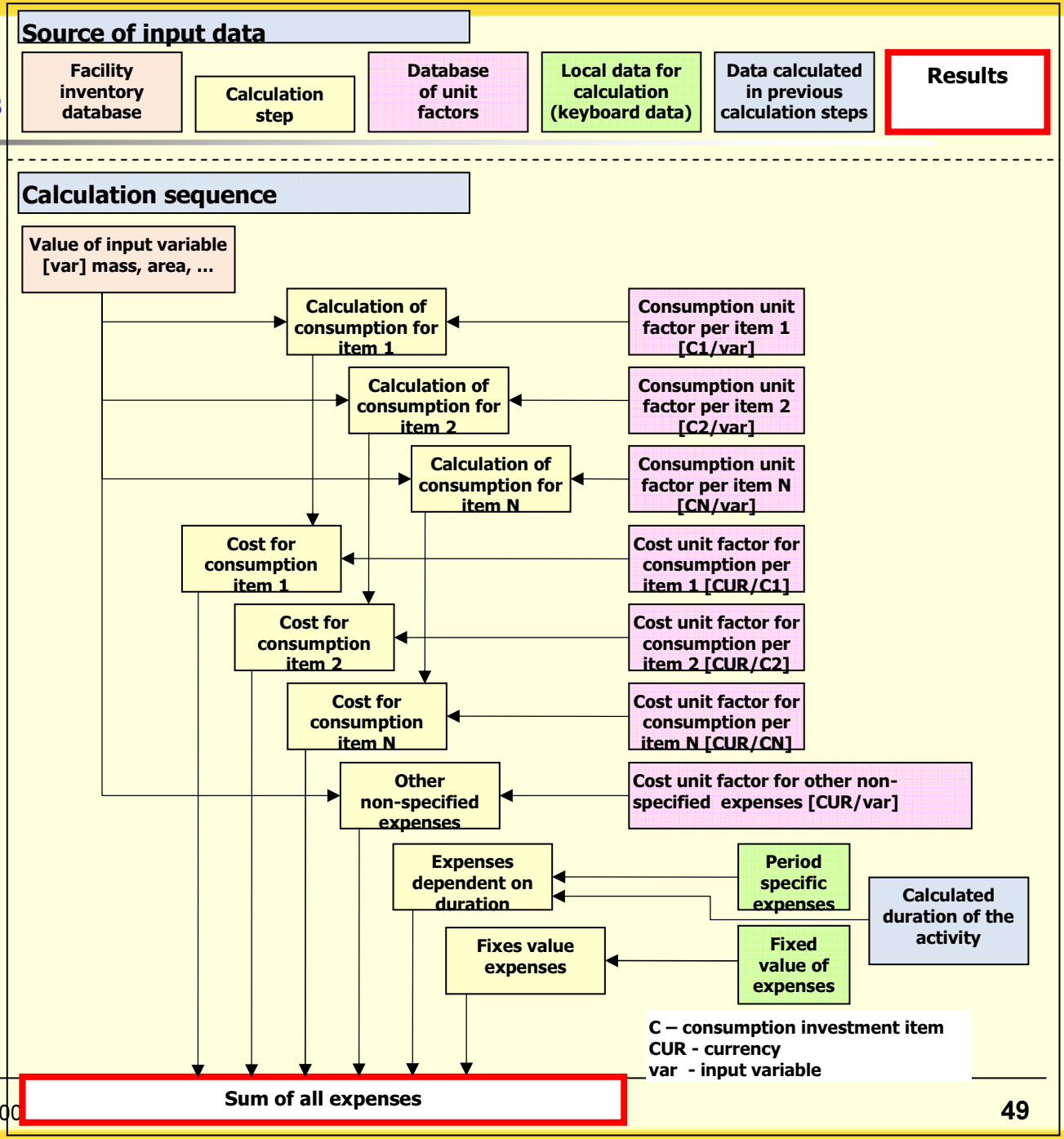
- Procedure for calculation of labour cost
- The same procedure is used for calculation of overheads expenses based on manpower components and overheads cost ratios for professions



- **Procedure for calculation of investment cost**

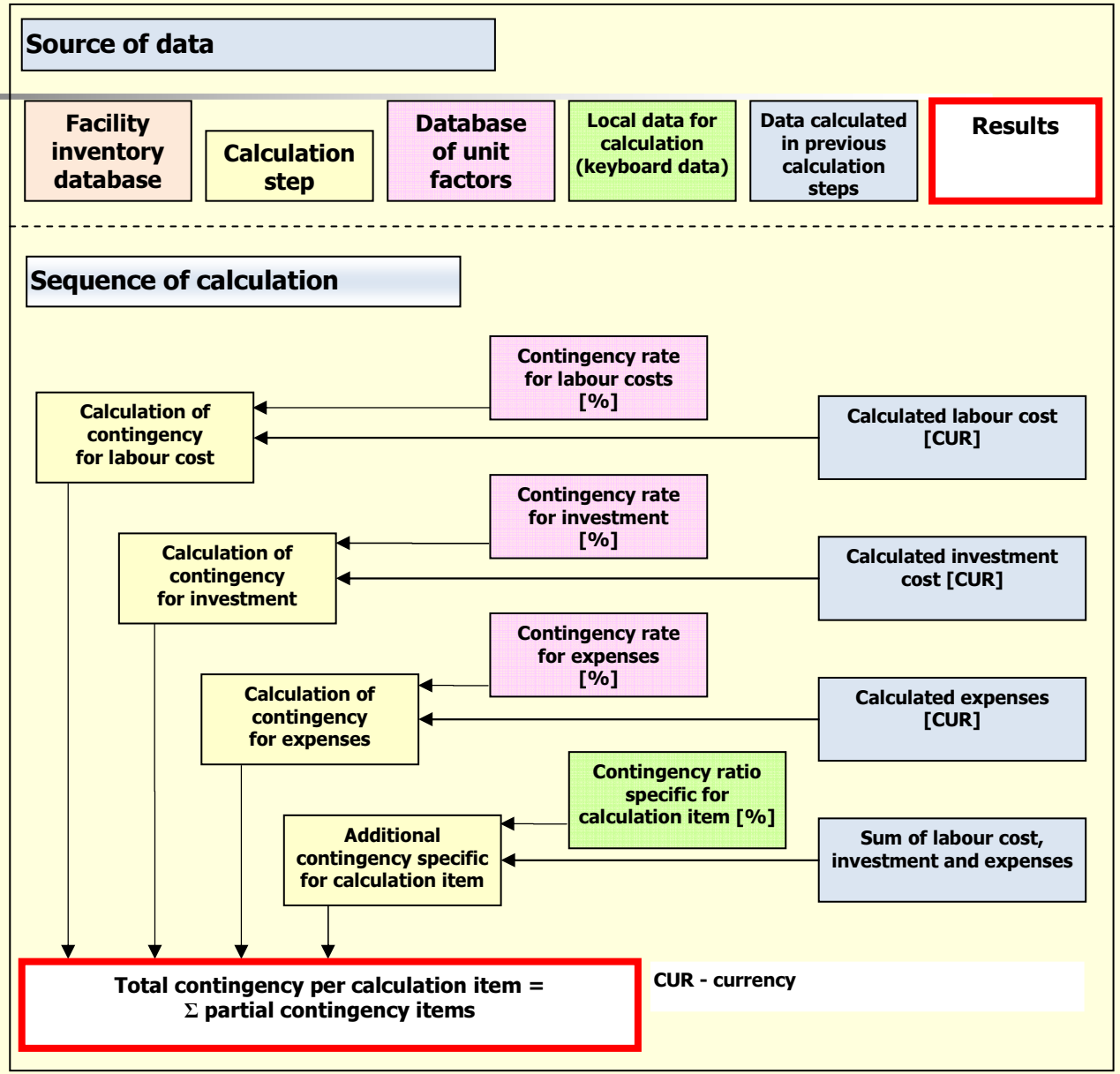


- **Procedure for calculation of expenses**



7. Schemes

- **Procedure for calculation of contingency**



8. Algorithms

- **Calculation algorithms for activity-dependent costs:**

$$y = F_s * x$$

y - calculated parameter of decommissioning [unit of the calculated parameter]
F_s - specific unit factor [unit of the calculated parameter / unit of the variable]
x - input variable (weight, surface, ...) [unit of the variable]

- **Applications:**

Calculation of manpower:

$$y = F_{mp} * x$$

y - calculated manpower [man.hours]
F_{mp} - manpower unit factor [man.hours/ unit of input variable]
x - input variable (mass, surface, ...) [unit of input variable]

- **Manpower for some auxiliary activities especially for room oriented approach is defined as fixed manpower depending on size of the room**

8. Algorithms

- **Consumption items - calculation of material items of consumable or investment character, spare parts, technological media, etc.**

$$y_m = F_{ms} * x$$

y_m - material consumable item of decommissioning (el. energy, steam,...) [unit of material item]
F_{ms} - unit factor [unit of material item / unit of variable]
x - input variable (weight, surface, length, ...) [unit of variable]

- **Cost, specified according to items of consumed materials or media, for calculation of costs on the basis of calculated material items and items of media. Calculation relation is the product of cost unit factor for given material item and already calculated material item of consumable or investment character, spare parts or technological mediums**

$$y_c = F_{cs} * x$$

y_c - decommissioning cost item (costs for el. energy, steam, ...) [currency unit]
F_{cs} - cost unit factor [currency unit / unit of material variable] (e.g. CUR/kWh)
x - input variable (el. energy, steam, ...) [unit of material variable]

8. Algorithms

- **Cost, unspecified, for calculation of consumable or invest costs directly on the basis of input variable. Computing relation is product of cost unit factor for expenses or investment cost, unspecified for individual material item ([currency unit/ unit of input variable])- and input variable**

$$y_n = F_{cn} * x$$

y_n	-	cost decommissioning item [currency unit]
F_{cn}	-	cost unit factor for n^{th} item [currency unit / unit of input variable]
x	-	input variable (weight, surface, length, ...) [unit of variable]

- **Cost for some auxiliary activities like preparatory and finishing activities are defined based on fixed manpower for individual activities**

8. Algorithms

- **Calculation algorithms for period-dependent costs**

$$y = F_t * T$$

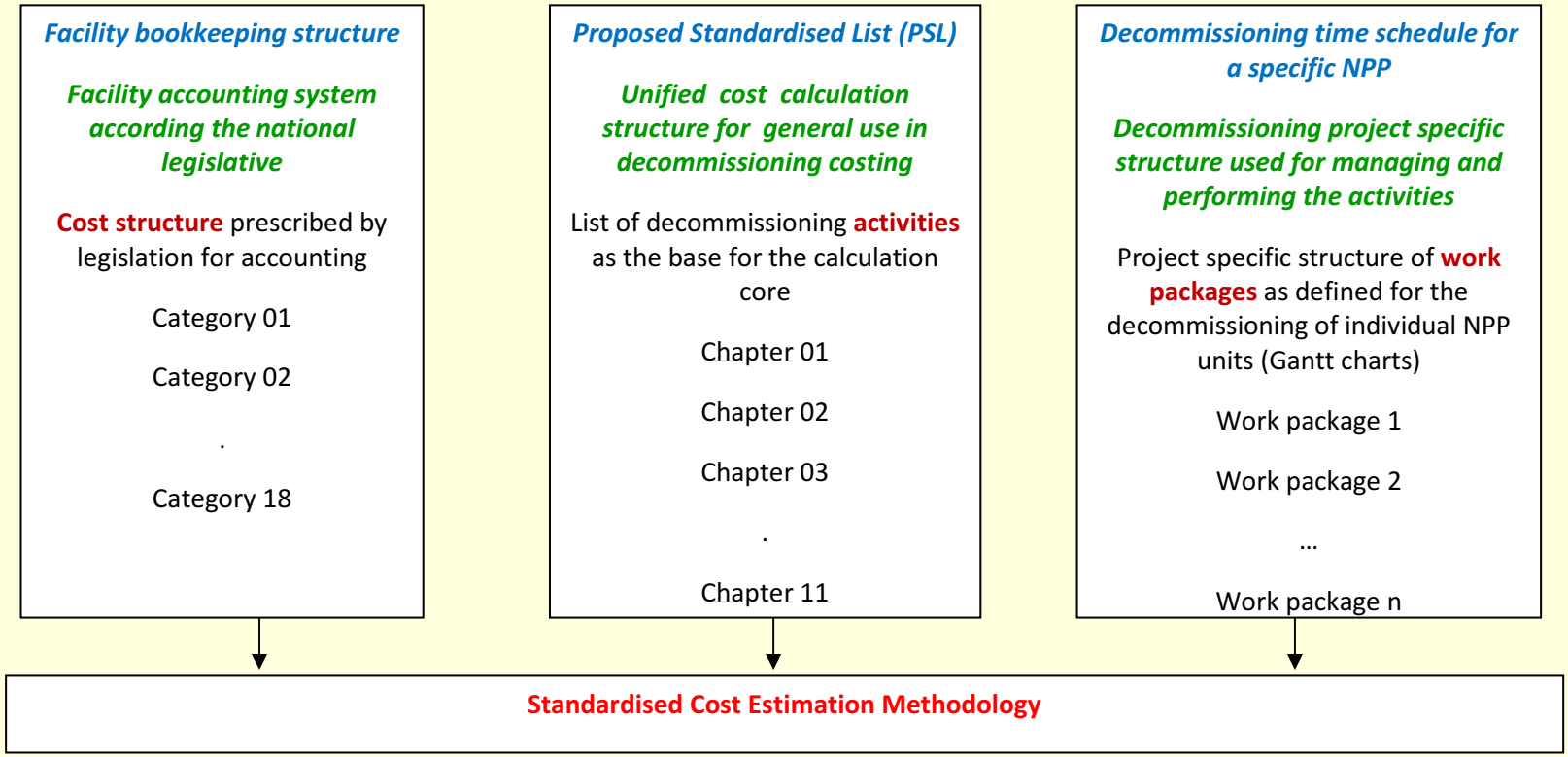
y - calculated parameter of decommissioning [unit of calculated parameter]
F_t - specific period dependent unit factor [unit of calculated parameter / time unit]
T - duration of elementary activity [time unit]

Specific units in presented relation can be:

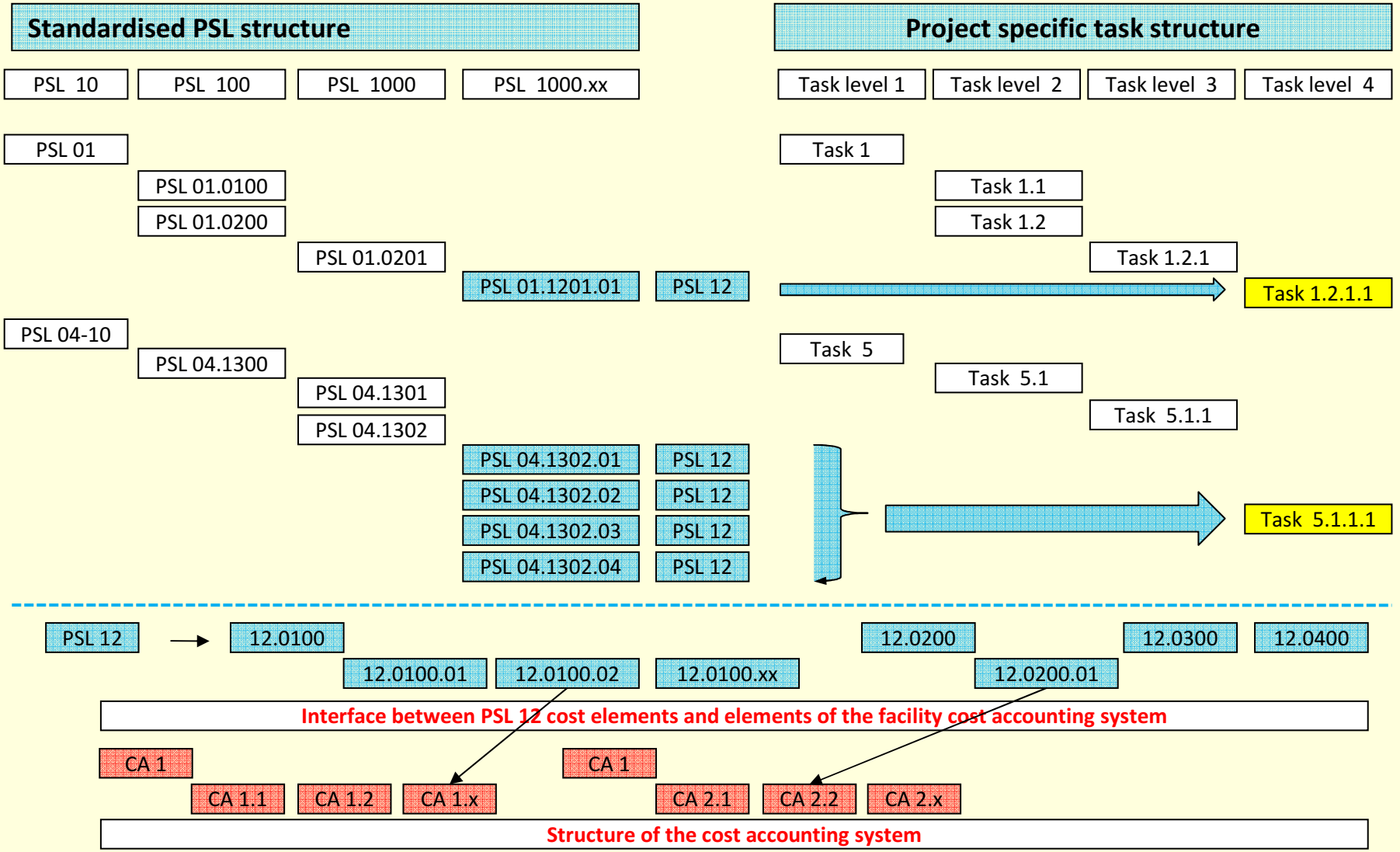
- **Material consumable, for calculation of material items of consumable or investment character, spare parts or technological media. Computing relation is product of material consumable specific unit ([unit of material item / time unit]) and duration of evaluated activity**
- **Cost, unspecified, for calculation of consumable or invest costs. Computing relation is product of cost unit factor for consumable or investment items, unspecified for individual material item ([currency unit/time unit]) and time of duration of evaluated activity**
- **Calculation of manpower for period-dependent activities is the transformation of duration in [hours] into manpower in [man-hours] on the level of individual professions.**

9. Interaction of cost systems

- **Principal scheme for interaction of structures dealing with decommissioning cost**

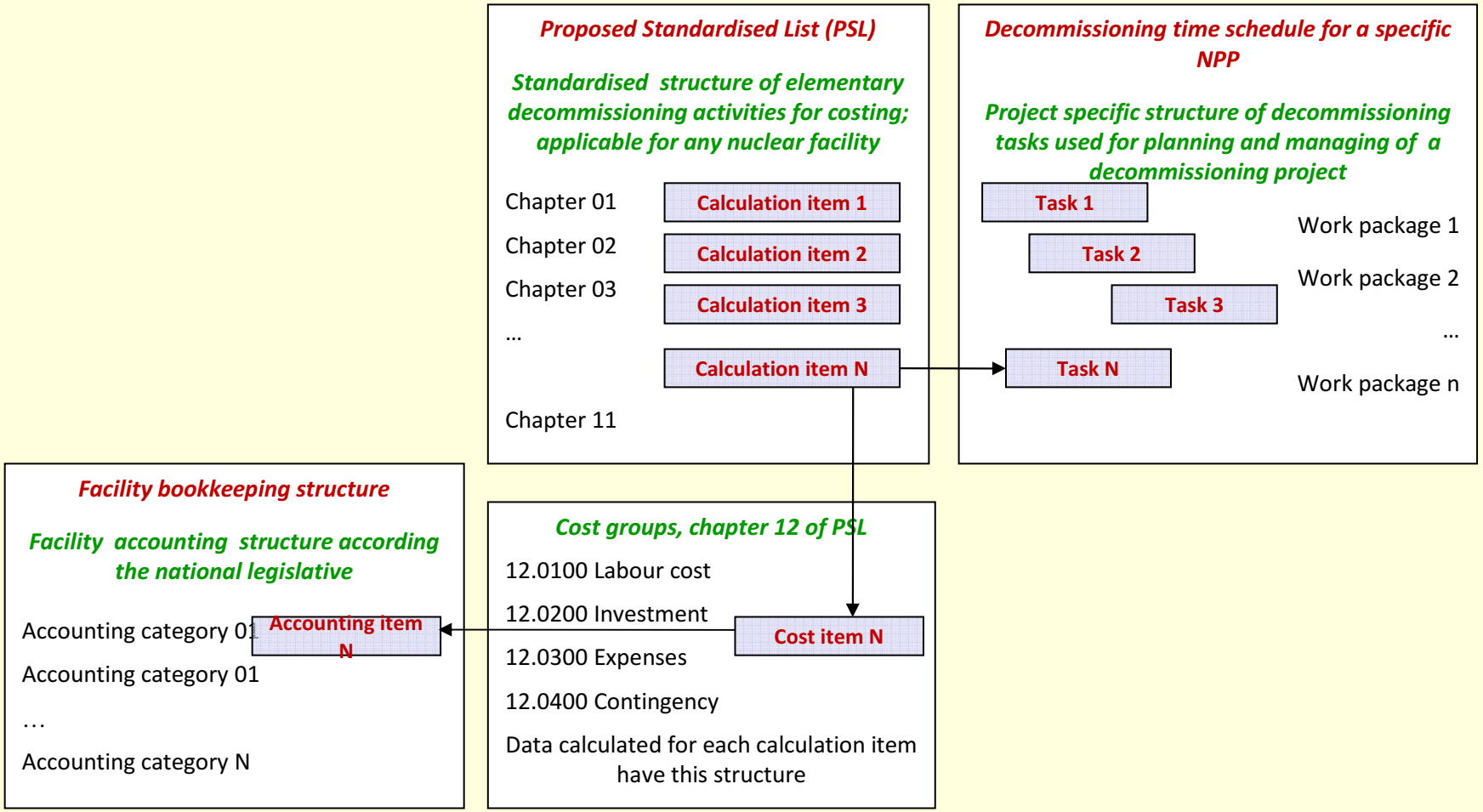


9. Interaction of cost systems



9. Interaction of cost systems

Relations between the standardised structure and specific structures involved in costing



9. Conclusions

The presentation deals with the main elements of decommissioning costing which are following:

- **Input data – facility inventory database , database of calculation parameters**
- **Breakdown of elementary decommissioning activities for which the cost and other decommissioning parameters are calculated**
- **Implementation of standardised cost structure for decommissioning costing is discussed**
- **How to calculate the cost for waste management is briefly discussed**
- **Presented cost calculation approach is based on implementation of the standardised list of items for decommissioning costing, which is in line with recommendation of IAEA**
- **Schemes and algorithms of calculation are presented**
- **IAEA project for robust cost estimation for research reactors was launched for the period 2009 – 2011 which implements the above discussed costing approaches on a simplified level.**