4A. EARLY STAGE COST CALCULATIONS

FOR DECONTAMINATION AND DECOMMISSIONING OF NUCLEAR RESEARCH FACILITIES - 1078

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BACKGROUND

In the fifties and sixties, Sweden had a comprehensive program for utilization of nuclear power including uranium mining, fuel fabrication, reprocessing (not carried out) and domestically developed heavy water reactors.

Only one of these was actually taken in operation, the Ågesta reactor, which generated a thermal power of 65 MW of which 10 MW were for electricity generation and 55 MW for district heating. It was shut down in 1973.

The program also included a materials and fuel testing reactor, R2, with light water and heavily enriched fuel. It has a thermal power of 50 MW and was shut down this year (2005). A hot cell laboratory for post-irradiation investigations still in operation.

The development work described above lead to the present nuclear programme comprising 12 modern light water reactors, ten of which are in operation at present.

THE SYSTEM FOR FINANCING

It has been decided that it is those who benefit from the electricity generated by the modern nuclear power plants who shall pay the costs for the decommissioning, decontamination, dismantling and waste management which is required when the old research facilities are no longer needed.

Thus, the Law on financing of the management of certain radioactive waste e t c (SFS 1988:1597) states (§1) that "fee shall be paid to the Government in accordance with this law as a cost contribution" to amongst other things "decontamination and decommissioning of" … "the Storage for Old Intermediate Level Waste (SOILW)" ... and ... "the Interim Store for Spent Nuclear Fuel (ISSNF)".

The Ordinance (SFS 1988:1598) on financing of the handling of certain radioactive waste e t c states (§4) that the funds collected should be paid to cover the costs incurred. It also states (§4) that "payment will be carried out only for costs which are needed for" the decontamination and decommissioning "and which have been included in the cost estimates" required.

According to the Law on financing of the management of certain radioactive waste e t c (SFS 1988:1597, §5), cost calculations shall be submitted to the Swedish Nuclear Power Inspectorate (SKI) each year. They shall comprise estimates of the total costs as well as the costs expected to be incurred in the future with special emphasis on the subsequent three years.

The SKI has the responsibility (SFS1988:1598, §5) to review the cost estimates and to report to the Government if there is a need to change the level of the fee. The SKI also has the responsibility (SFS 1988:1598, §4) to decide on the payments to be made.

It might be added that according to its instruction (SFS 1988:523, §2) SKI also has the responsibility "in particular … to take initiative to such … research which is needed in order for the Inspectorate to fulfil its obligations".

RATIONALE FOR THE PRESENT WORK

Previous cost calculations rely on data on contamination levels, assumptions on methods to be used and on estimates of various volumes of work and waste based on drawings.

The methodology applied is similar to that used for nuclear power plants and utilizes a summation type of methodology. The experience from such calculations, especially when applied to research facilities, is that the costs estimated increase with the level of detail, and thus escalate as the work progresses and time passes.

However, it is a legal requirement (*cf* above) that the funds collected now must adequately cover all future costs without being superfluous. It is thus necessary to find a methodology with a high precision and which is essentially time and stage invariant.

The purpose of the presently reported work is to identify such methodologies as well as what knowledge might be required in order to apply them.

The scope of the work includes analysis of two reference cases: the Storage for Old Intermediate Level Waste (SOILW) and the Interim Store for Spent Nuclear Fuel (ISSNF). The activities comprised review of reports, site visits and information searches.

Storage for Old Intermediate Level Waste (SOILW)

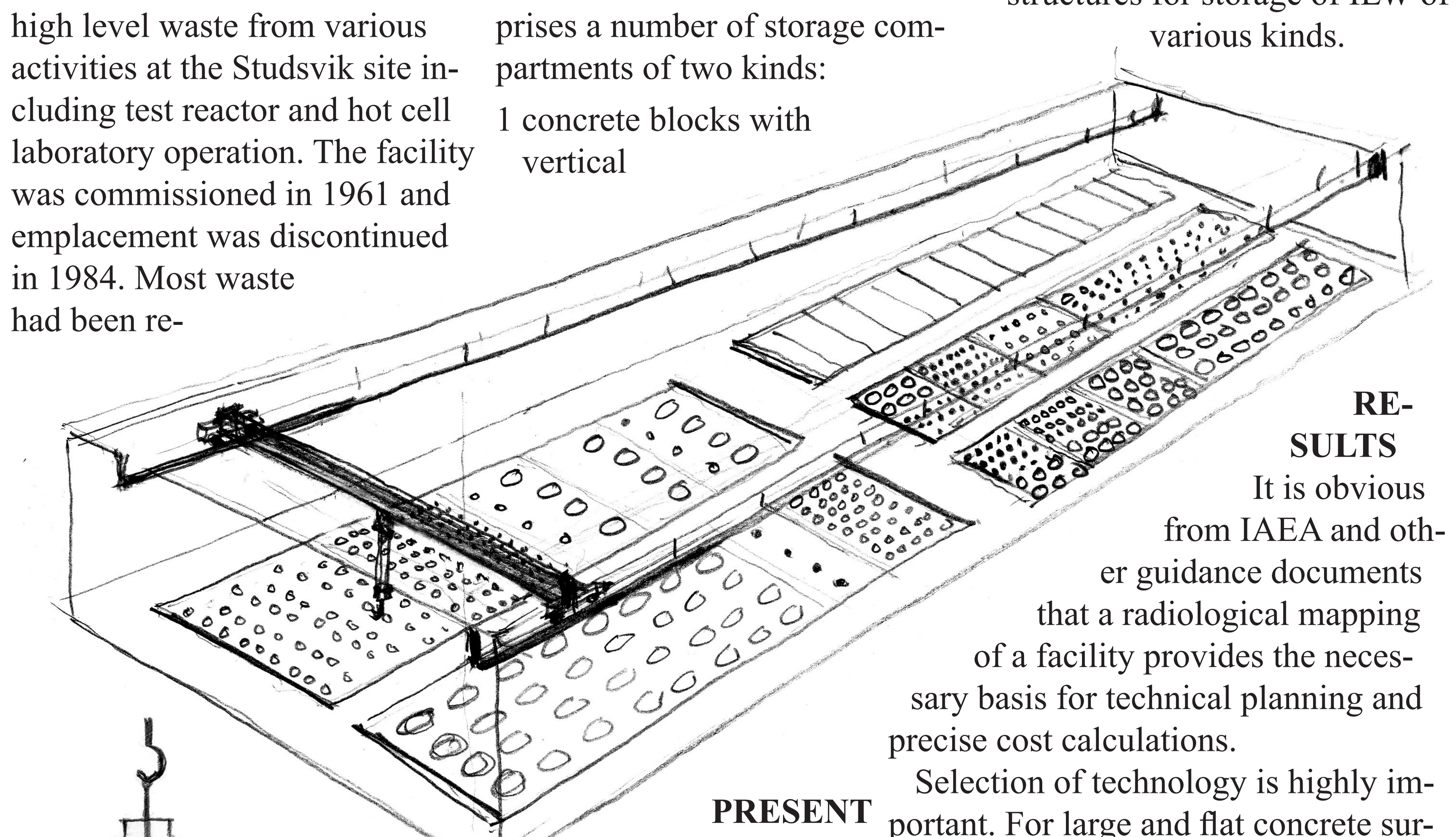
PLANT DESCRIPTION

The SOILW facility is an interim store for intermediate and high level waste from various activities at the Studsvik site including test reactor and hot cell laboratory operation. The facility was commissioned in 1961 and emplacement was discontinued in 1984. Most waste had been removed by 2001.

An overview of the facility is shown below. The SOILW comprises a number of storage compartments of two kinds:

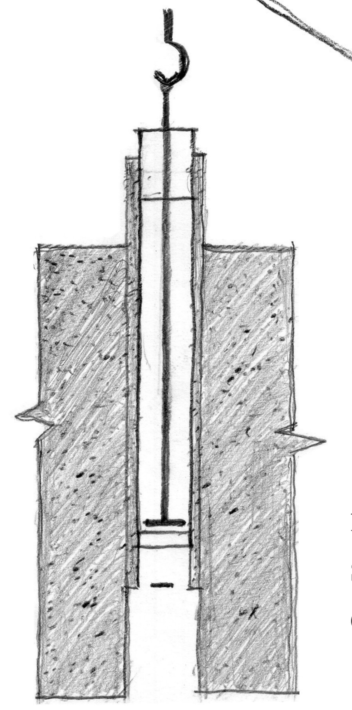
1 concrete blocks with vertical pipes for storage of tins, and

2 compartments with no internal structures for storage of ILW of various kinds.



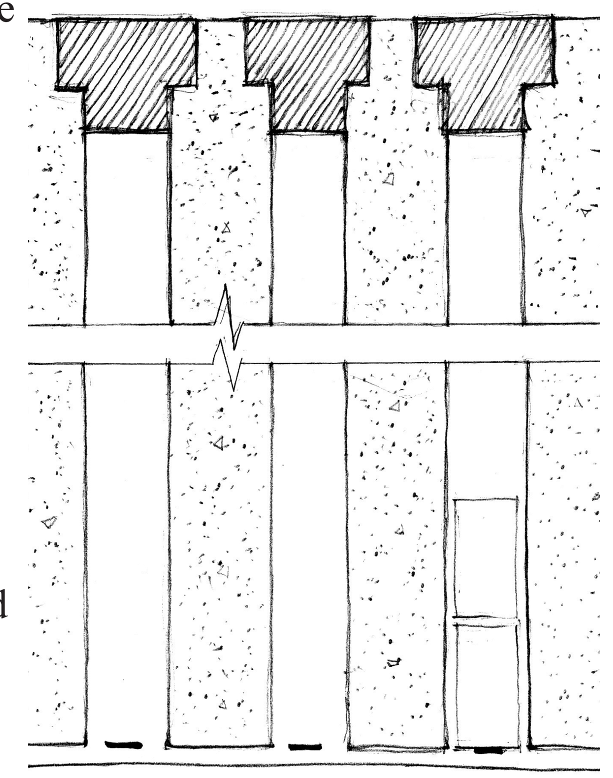
PRESENT PLAN

The insides of the vertical pipes are partially contaminated by leakage from cans containing wet and corrosive high level waste. The plan is to reduce the level of contamination by carbon dioxide jet cleaning. Most of the pipes will still need overcoring using conventional equipment and techniques.



The floor underneath the ventilation space (*cf* figure) is also expected to hold contamination from leaking containers. A first step will be to attempt to remove such activity using e g vacuum cleaning.

The concrete blocks are to be size reduced by means of drilling and mechanical fracturing. They will then be cleaned through manual billing.



RESULTS

It is obvious from IAEA and other guidance documents that a radiological mapping of a facility provides the necessary basis for technical planning and precise cost calculations.

Selection of technology is highly important. For large and flat concrete surfaces remotely controlled billing may be preferential to manual.

The literature survey revealed the existence of a similar but completed project: the *East Map Tube Facility* at *Argonne National Laboratory*. The experience includes the following.

A concrete coring rig was used to cut each pipe from the concrete matrix. Careful control of the coring operation was required to prevent the coring tool from cutting into the pipe or joint.

The pipes were not quite vertical but attempts to angle the coring operation were unsuccessful. Instead a larger diameter drill was employed. Also, a larger drill rig had to be brought in.

Voids as well as incidental objects were encountered and loss of cooling liquid took place at a number of occasions so that fresh concrete had to be injected.

The activity transferred to the drill water slurry was moderate, but the potential for contamination was substantial.

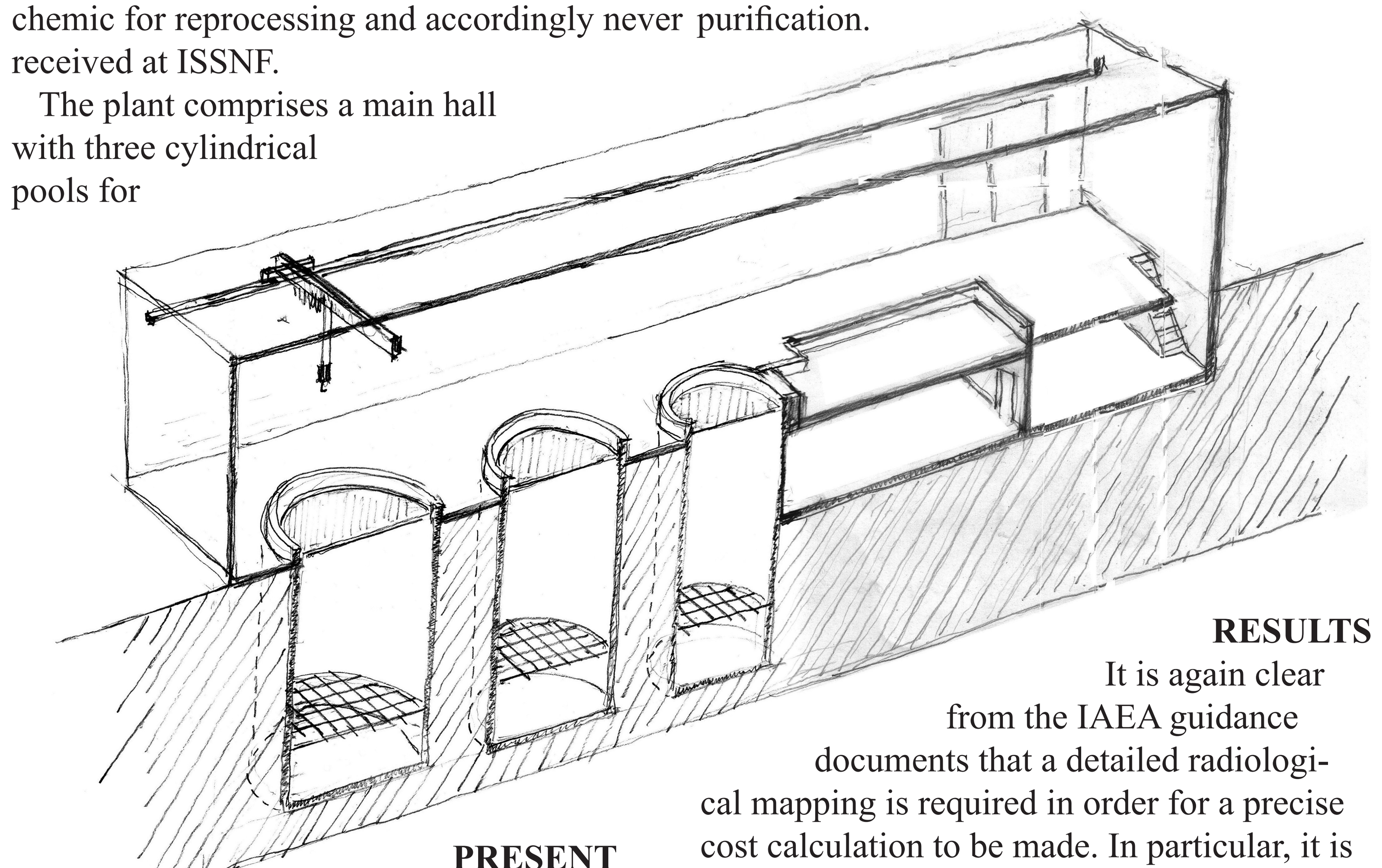
Interim Store for Spent Nuclear Fuel (ISSNF)

PLANT DESCRIPTION

The Interim Store for Spent Nuclear Fuel (ISSNF) was commissioned around 1964 and is still in operation. It has been used for the interim storage of spent fuel from the Ågesta nuclear power plant and the R2 research reactor. The former had incidents of severe fuel damage although it appears that at least some of the most damaged fuel was sent to Eurochemic for reprocessing and accordingly never received at ISSNF.

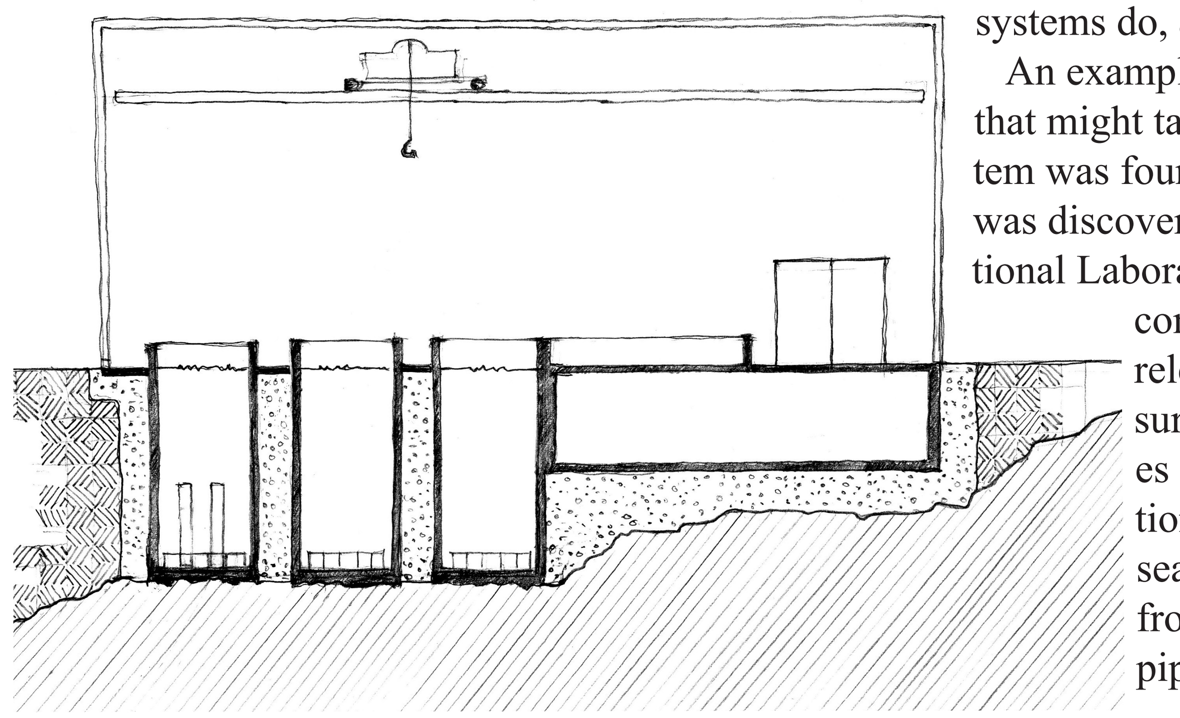
The plant comprises a main hall with three cylindrical pools for spent fuel storage and a drained stainless steel surface for decontamination, see figure below. The insides of the tanks are covered with epoxy impregnated glass fibre which has become deteriorated in patches. The hall also contains an overhead crane and equipment for shielded handling of the fuel.

The basement contains equipment for water management including purification.



PRESENT PLANS

The plans include billing of part of the insides of the concrete tanks. Dismantling of the pipe systems will be based on dose rates on the outsides of the components.



RESULTS

It is again clear from the IAEA guidance documents that a detailed radiological mapping is required in order for a precise cost calculation to be made. In particular, it is important to know the alpha to gamma ratios as well as the presence of any contaminated sludge and deposits in the water system.

Since the pool system is old, it does not have the redundancy of barriers against leakage to the surrounding soil that modern systems do, *cf* figure.

An example the types of events that might take place in an old system was found in the literature. It was discovered at Oak Ridge National Laboratory that potentially contaminated water was released to ground and surface waters. The sources for this were foundation drainage from the Research Reactor and a leak from underground coolant pipes.

DISCUSSION AND CONCLUSIONS

The above examples illustrate the significance of making appropriate radiological mapping as well as technology selection before sufficiently precise cost calculations can be performed.

Actually, it may well be the need for cost calculation precision that dictates the comprehensiveness and timing of such activities, at least in the early stages of planning.

Moreover, uncertainty in cost calculations may occur in a manner similar to that of a hazard. Thus, some sort of risk assessment may be warranted in which conceivable more severe but presumably less likely cases are evaluated.

An example of such a less likely event may be a leak in a fuel storage tank.

Unexpected events do not necessarily have low probabilities, however. In the case of the drilling with overcoring, 10 out of 129 pipe positions had to be temporarily abandoned and grout injected.

Frequently, cost calculations for research facilities are made using calculation tools developed for the case of nuclear power plants.

In research facilities, however, radionuclide distribution and contamination patterns vary and so do the technologies that are suitable to apply.

It should be realized that the precision of cost calculations vary strongly between different types of facilities. It has been found that underestimations are overrepresented in the cases of unusual projects, first of a kind, and research and test facilities.

In conventional cost calculations for new technical facilities, predesign cost estimates are based mainly on comparison and the probable accuracy is typically larger than 30 %. The last stage of calculation is based on summation and the accuracy is perhaps 5 %.

Application of the summation method (as for nuclear power plants) at early stages gives rise to systematic errors which lead to underestimated costs since not all items have been identified.

METHOD FOR "CALIBRATION"

It is desirable to somehow "calibrate" results of early estimates against known costs of already completed projects of similar kind. An example of such an approach may be as follows.

Let the cost for a plant be given by the equation:

$$K^c = \sum_i p_i \qquad (1)$$

Where
K^c = the total calculated cost
p = cost item, and
i = index for cost item

A fit to actual cost K^a for a completed project can be made using the weighing factors w_i and a scaling factor s according to the following equation:

$$K^a - K^c = s \sum_i w_i p_i \qquad (2)$$

The weighing factors may be obtained by assessment of which items should have a small, intermediate, large or very large influence on the difference between calculated and actual values. For instance, a weighing factor can be given one of the values 1, 2, 4 or 8. The scaling factor can then be calculated using the equation:

$$s = (K^a - K^c) / \sum_i w_i p_i \qquad (3)$$

For a plant for which a refined cost calculation is to be made, the cost items can be calculated first, and then the total cost according to the equation (1) above.

After that, an adjusted calculated total cost can be calculated using the equation:

$$K^{adjusted} = \sum_i (1 + s w_i) p_i \qquad (4)$$

where s and w_i have been derived from a similar reference plant and p_i for the plant for which a refined calculation is to be made.

The application of equation (4) implies an improvement compared to a simple over all scaling since differences in the assessed cost structure influences the result.