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ISOE INFORMATION SHEET

ANALYSIS OF THE EVOLUTION OF COLLECTIVE DOSES RELATED TO INSULATION JOBS IN SOME EUROPEAN PWRS

ISOE European Technical Centre - CEPN Information Sheet No. 22

1. Introduction

This information sheet has been elaborated within the framework of the ISOE Working Group on Data Analysis. One of the purposes of this group is to perform studies based on the elements contained in the ISOE Database. The selection of insulation jobs was made following a request from the French Utilities in 1996-1997 on the good practices to reduce occupational exposures related to insulation jobs in PWRs. The answers from 18 different plants belonging to ISOE provided qualitative information on the main actions undertaken by these plants to reduce insulators' exposures (see § 5 below). In order to complete the analysis, a second request asking for quantitative data on the evolution of insulator's doses were sent to the contact person having answered to the initial request. The answers from 8 plants were then completed by an extraction of data from the ISOE 1 database.

The objectives of this information sheet are to present an example of the types of analyses which can be performed with ISOE data, and to point out some problems which may arise from the information contained in the database, as well as the limits but also the interests of such studies.

2. The extraction of data from ISOE 1

Two main tables where used for this analysis:

- Table P: "Collective dose by task and type of personnel" (which contains the collective dose of insulation jobs distributed among outside and plant personnel, or with no breakdown).
- Table Q: "Total collective dose by job and type of personnel" (which is generated from the Table P, and contains only the line "Total" of Table P)

It is important to be careful when extracting data from this type of Table to be sure that all the data are valid. For example, Table P data has to be used to complete Table Q data for the units where the Total of insulation jobs' doses where not reported in the line "total". It is also important to check the "comments" column which may contain information related to the origin of data, or to the way there were distributed among the various tables. In this specific case, it appeared that some plants were not completing Table P because the data where "not available", or "included in Table 13 (scaffolding)", or "inserted into Table R (dose by occupational category)".

The extraction was made on a period of 8 years: from 1990 to 1997. The tables were filled in by 144 PWR's units (in total), which represents approximately 40% of the total number of units in the database. Nearly 30% of these units where then eliminated because only 1 to 3 years of data where provided over the whole period of interest, and it was considered that this was not statistically sufficient. From the remaining units, only those from Europe were finally selected (see Table 1).

Table 1. Distribution of selected units per country

Country	No of units considered in the analysis
Belgium	7
France	53
Germany	8
Hungary	4
Netherlands	1
Spain	7
Sweden	3
Switzerland	2
Total	**85**

In order to better take into account the differences in terms of period duration between two outages in these countries, and the fact that some outages may cover 2 years, all the calculations have been made on the basis of a three years rolling average for each unit. The mean per country, or per unit sister group, has then be determined using the three year average of each unit belonging to the group under consideration.

Finally, before going further in the analysis of the results, it is necessary remember that:

- the data were not available for all units in each country,
- the number of units in each country varies significantly and this has an impact on the mean per country (the standard deviations indicated in the Table 2 in the next paragraph is one of the indicators of the dispersion which can be founded in each country),
- there may be noticeable differences in the way each unit completes the Tables in ISOE, as "insulation jobs" may not always cover the same type of job in different countries or units,

- the design of the various units, which is studied by the intermediate of the sister units groups is only one explanation of the differences between the units.

Therefore, it is important to consider the numbers presented as global trends from which each individual plant can, for example, evaluate its position, or further analyse the database to identify other reasons for differences.

3. Analysis of the evolution of insulation job exposures per country

Except for Hungary and Switzerland, the collective dose due to insulation jobs represents between 5% and 7% of the annual collective dose on the basis of three year average per unit (see Figure 1).In Hungary, the collective dose associated with insulation jobs represented around 20% of the total annual collective dose during the period 93-95 and has decreased to 18%, but is still rather high compared to other countries. In Switzerland, it appears that the percentage of dose associated with insulation jobs is rather low (around 2%). For these two countries, it could be useful to further analyse the situation, and for example, verify if the repartition of doses into insulation job categories is the same than in other countries.

In nearly all countries, insulation jobs represent a relatively stable fraction of the total annual collective dose from the period 90-92 to 95-97. Exception are mainly in Sweden and Hungary, where a noticeable decrease in the percentage can be observed since 93-95.

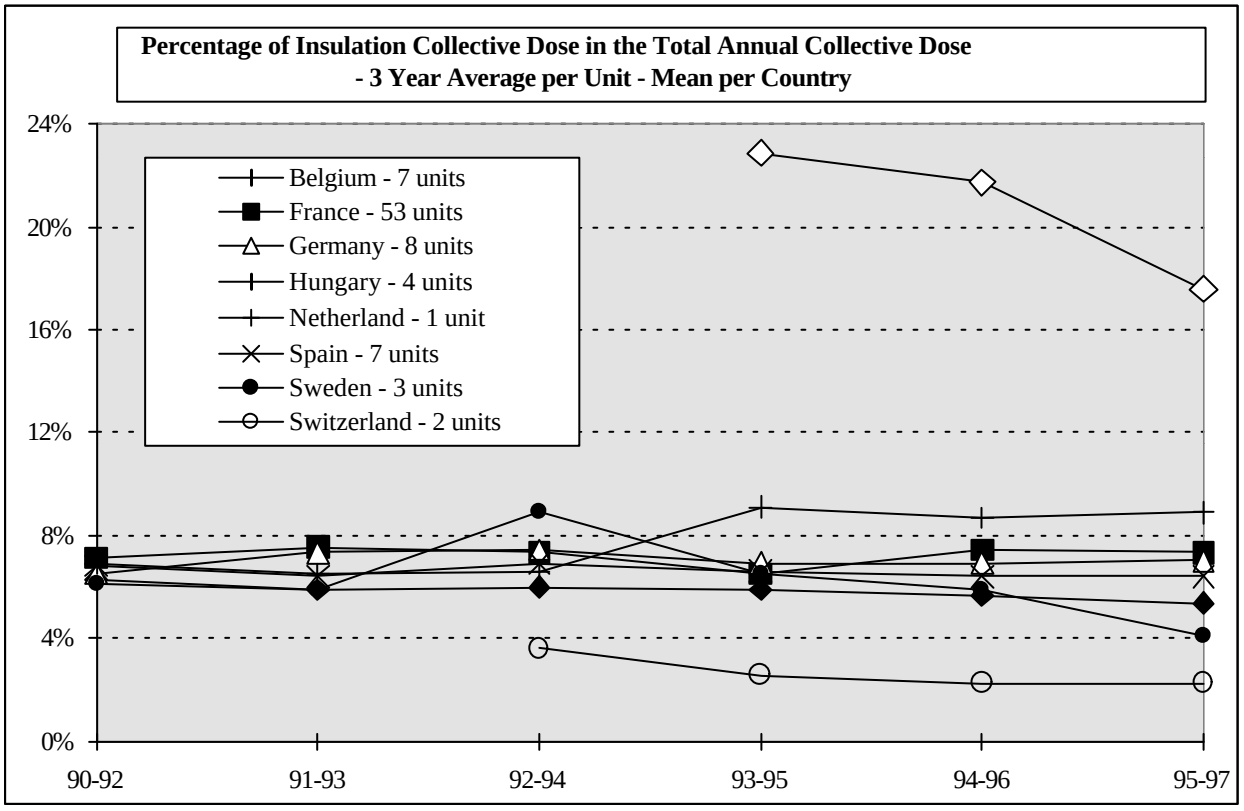

Figure 1. Evolution of the percentage of annual collective dose due to insulation jobs

However, when looking at the quantitative values of the 3 years rolling average of the collective dose due to insulation jobs, it appears that they are decreasing in nearly all countries. Two main groups of countries can be identified (see Figure 2 and Figure 3):

- a first group with Switzerland, Sweden, Germany and Belgium where the level of the 3 year rolling average per country for insulation jobs is situated between 20 and 100 person.mSv in the first period (90-92), and between 20 and 45 person.mSv on the last period (95-97)

- a second group composed of Spain, France, Hungary and Netherlands, where the level of collective doses due to insulation jobs are greater than in the first group: between 120 and 140 person.mSv during the first period, and between 80 and 125 person.mSv) on the last period.

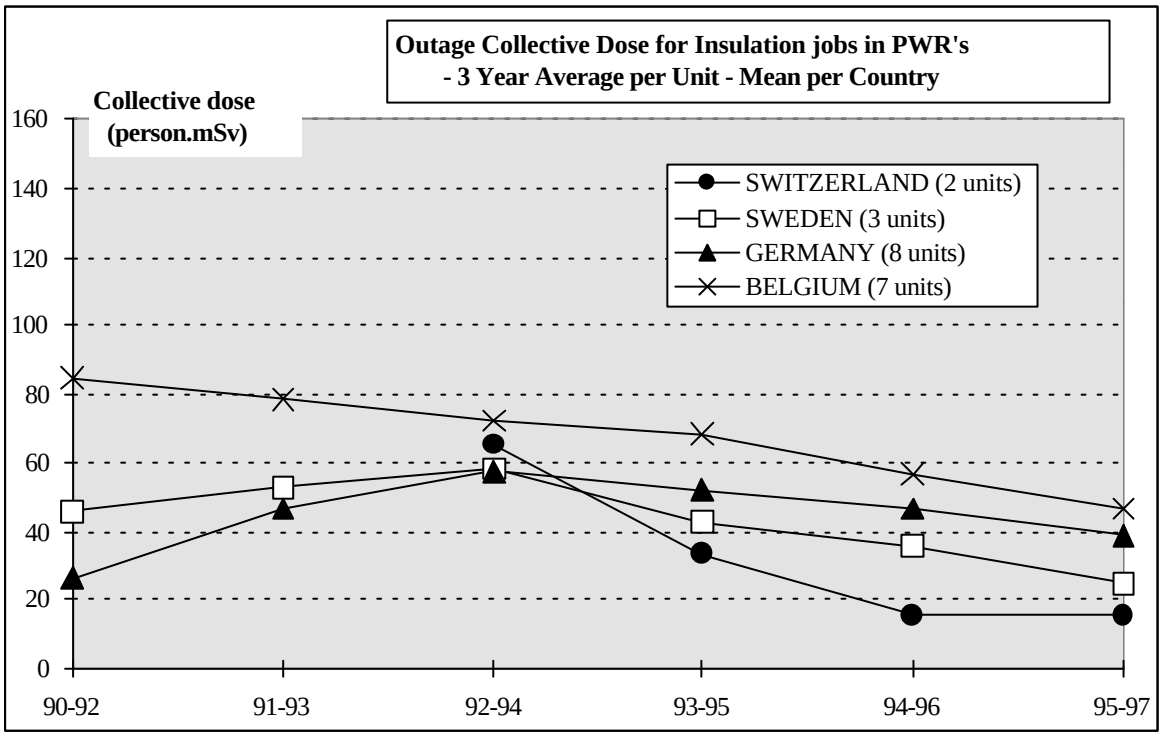

Figure 2. Collective exposure for insulation jobs in Belgium, Germany, Sweden and Switzerland

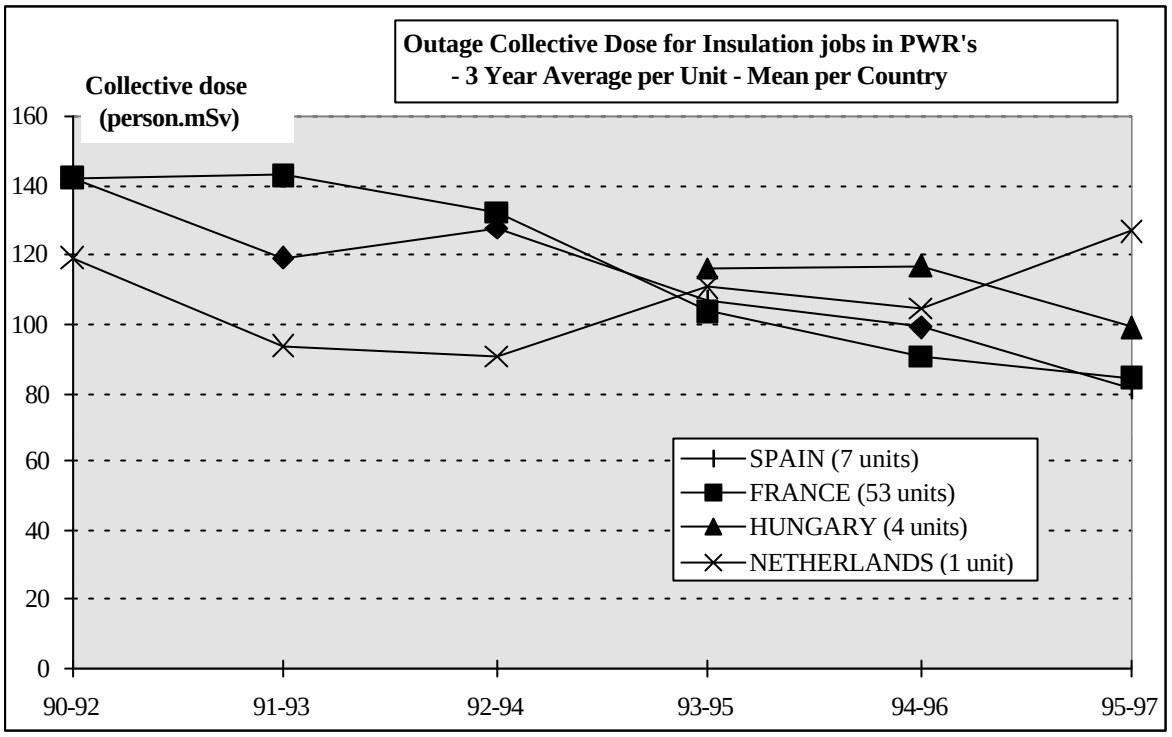

Figure 3. Collective exposure for insulation jobs in France, Hungary, Netherlands and Spain

- in the first group of countries, the best results were obtained in Switzerland, with a decrease of nearly 80%: from 100 person.mSv per year on the period 90-92 to 18 person.mSv on the last period 95-97. In Sweden and Germany, after a increase between 90-92 and 92-94, the mean collective dose of insulation jobs has decreased. But in Germany, the level of the period 95-97 (around 40 person.mSv) is still higher than during the period 90-92 (around 25 person.mSv). In Sweden, the level of the last period (25 person.mSv) corresponds to a decrease of 45% since the first period (45 person.mSv).

- in the second group, an important decrease can be observed in France and Spain, where the mean collective dose has decreased by nearly a factor 2: from 140 person.mSv in 90-92 to 80 person.mSv in 95-97. In Hungary, the collective dose due to insulation jobs was quite stable from 91-93 to 94-96 (around 118 person.mSv per year). A decrease can however be observed during the last period, where the collective dose of insulation jobs is below 100 person.mSv. In the Netherlands, after a significant decrease between 90-92 and 92-94, the collective dose of insulation jobs seems to increase. And the level of the last period 95-97 (125 person.mSv) is above that of the first period (120 person.mSv).

Table 2 shows the mean and the standard deviation between units per country for each period.

Table 2. Collective dose of insulation jobs - Means and standard deviations per country on three years rolling periods

Country		90-92	91-93	92-94	93-95	94-96	95-97
Belgium (7 units)	Mean Collective Dose (person.mSv)	84.38	78.72	72.45	68.57	56.34	46.72
	Standard Deviation	44.24	45.35	40.12	37.35	29.17	24.16
France (53 units)	Mean Collective Dose (person.mSv)	142.51	142.73	131.82	103.35	90.19	84.40
	Standard Deviation	77.60	85.09	80.11	52.28	42.96	52.50
Germany (8 units)	Mean Collective Dose (person.mSv)	26.68	46.83	57.66	51.92	46.72	38.99
	Standard Deviation	38.74	60.95	77.45	68.93	63.37	50.48
Hungary (4 units)	Mean Collective Dose (person.mSv)	-	-	-	116.07	116.78	99.07
	Standard Deviation	-	-	-	25.83	34.38	43.85
Netherlands (1 unit)	Mean Collective Dose (person.mSv)	118.67	93.17	90.17	110.17	104.30	126.63
	Standard Deviation	0.00	0.00	0.00	0.00	0.00	0.00
Spain (7 units)	Mean Collective Dose (person.mSv)	142.24	119.39	127.82	106.53	98.94	80.86
	Standard Deviation	89.92	68.30	83.22	55.66	50.20	36.44
Sweden (3 units)	Mean Collective Dose (person.mSv)	45.44	52.89	57.99	42.36	35.93	25.01
	Standard Deviation	18.53	17.61	37.51	21.30	22.03	14.76
Switzerland (2 units)	Mean Collective Dose (person.mSv)	-	-	64.92	33.17	15.92	15.58
	Standard Deviation	-	-	18.42	6.17	2.58	2.92

4. Analysis of the evolution of insulation job exposures by sister unit group

In order to perform a preliminary analysis of the differences in terms of design between the various plants, the analysis of the collective dose due to insulation jobs has been done for different sister units groups, as they have been defined in ISOE. Table 3 presents the results by sister unit group, as well as the number of units taken into account in each group for this analysis

Table 3. Mean collective dose for insulation jobs per sister unit group

Sister Unit Groups		No. of units considered in the analysis	90-92	91-93	92-94	93-95	94-96	95-97
B22	2 loops - Babcock & Wilcox - Generation 2	1	14.48	6.01	5.97	11.06	7.80	8.26
F31	3 loops - Framatome - Generation 1	6	225.69	170.76	112.39	80.80	76.45	70.88
F32	3 loops - Framatome - Generation 2	28	159.40	178.87	164.96	120.30	106.89	99.67
F42	4 loops - Framatome - Generation 2	19	88.49	80.63	89.12	85.49	71.66	69.38
S21	2 loops - Siemens - Generation 1	2	118.67	136.13	157.02	157.24	148.73	139.30

Table 3. Mean collective dose for insulation jobs per sister unit group (cont.)

Sister Unit Groups		No. of units considered in the analysis	90-92	91-93	92-94	93-95	94-96	95-97
S32	3 loops - Siemens - Generation 2 (pre-Konvoi)	2	79.03	76.90	85.98	72.87	60.32	54.77
S42	4 loops - Siemens - Generation 2 (pre-Konvoi)	2	12.93	20.64	28.88	22.75	19.35	12.79
S43	4 loops - Siemens - Generation 3 (Konvoi)	3	8.36	10.04	8.10	8.97	9.65	11.19
V213	VVER 440-V213	4	-	-	-	116.07	116.78	99.07
W00	1 loop - Westinghouse -	1	53.60	40.30	41.19	46.92	46.92	40.50
W21	2 loops - Westinghouse - Generation 1	2 in 90-91 and 91-93; 4 after 92-94	43.46	34.10	47.04	27.18	16.24	14.42
W31	3 loops - Westinghouse - Generation 1	1	39.00	60.00	42.40	47.33	37.50	45.73
W32	3 loops - Westinghouse - Generation 2	9	129.60	112.14	122.49	103.82	94.91	74.89
X31	3 loops - Acecowen	1	78.97	82.76	72.40	62.65	61.45	54.03
X32	3 loops - Framaceco	2	130.52	124.61	118.28	100.45	73.05	55.16

The Figures 4 to 6 show the evolution of these collective doses for three sub-groups: 2 loop (plus VVER), 3 loop and 4 loop plants. It appears that there is a large dispersion of the collective dose within all 3 sub-groups:

- within the sub-group of 2 loops plants, the Siemens generation 1 have the highest collective dose for insulation jobs, and the trend has been increasing during the first periods, and is slightly decreasing since 93-95, although remaining above the level of 90-92 (with 140 person.mSv in 95-97, against 120 person.mSv in 90-92). The doses related to the VVER are globally stable, a little below the Siemens plants (around 110 person.mSv), with a small tendency to decrease since 94-96. The doses of the Westinghouse first generation plants have noticeably decreased (from 70 person.mSv to 15 person.mSv), and are now closed to the lowest levels within this group, which are the Babcock & Wilcox plants.

- the dispersion within the sub-group of 3 loops plants has been considerably reduced between 90-92 (between 40 person.mSv and 260 person.mSv) and 95-97 (between 40 person.mSv and 100 person.mSv). The most noticeable diminution can be observed within the Framtome first generation plant (from 220 person.mSv to 70 person.mSv, i.e. 70% of reduction) and second generation (from 180 person.mSv to 100 person.mSv, i.e. 45% of reduction).

- the sub-group with 4 loop plant showed a major difference between the Framatome and Siemens designs (with pre-Konvoi and Konvoi plants). There is approximately a factor 7 between the two designs, the Framatome plants being around 70 person.mSv and the Siemens plants around 10 person.mSv).

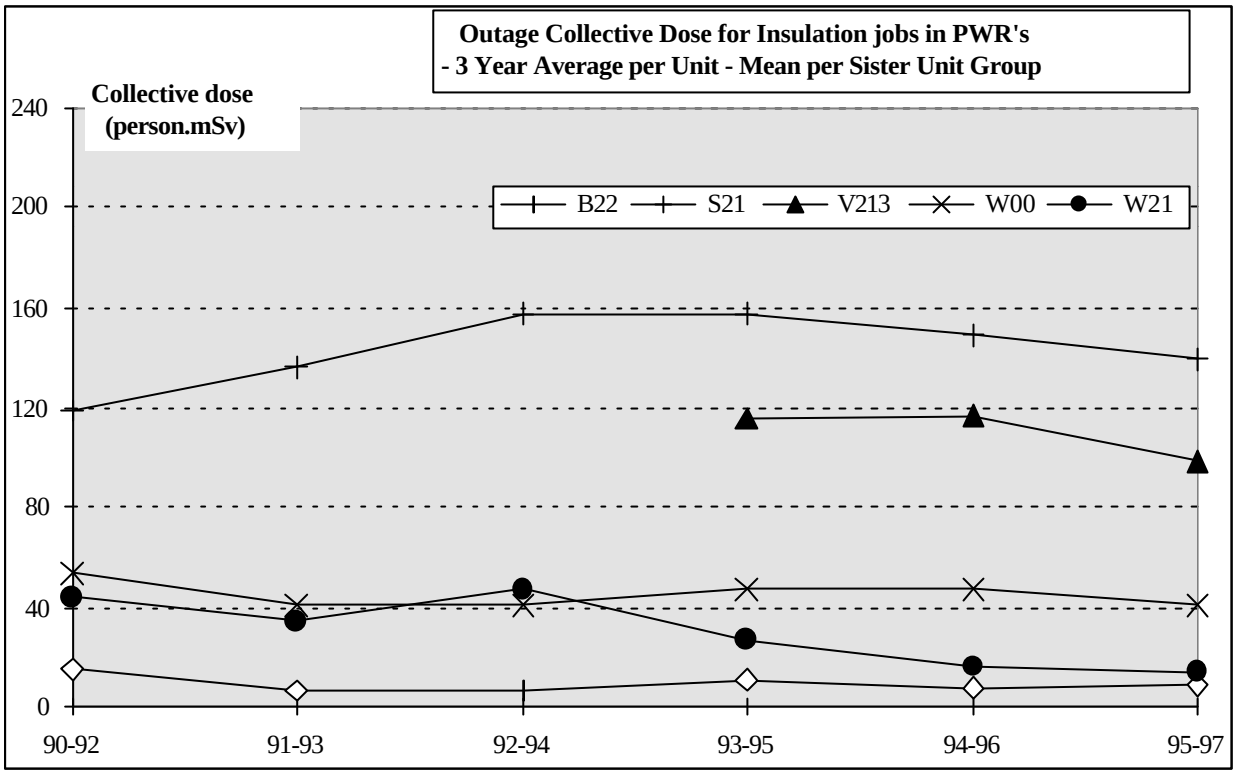

Figure 4. Collective exposure for insulation jobs in 2 loop sister unit groups (plus VVER)

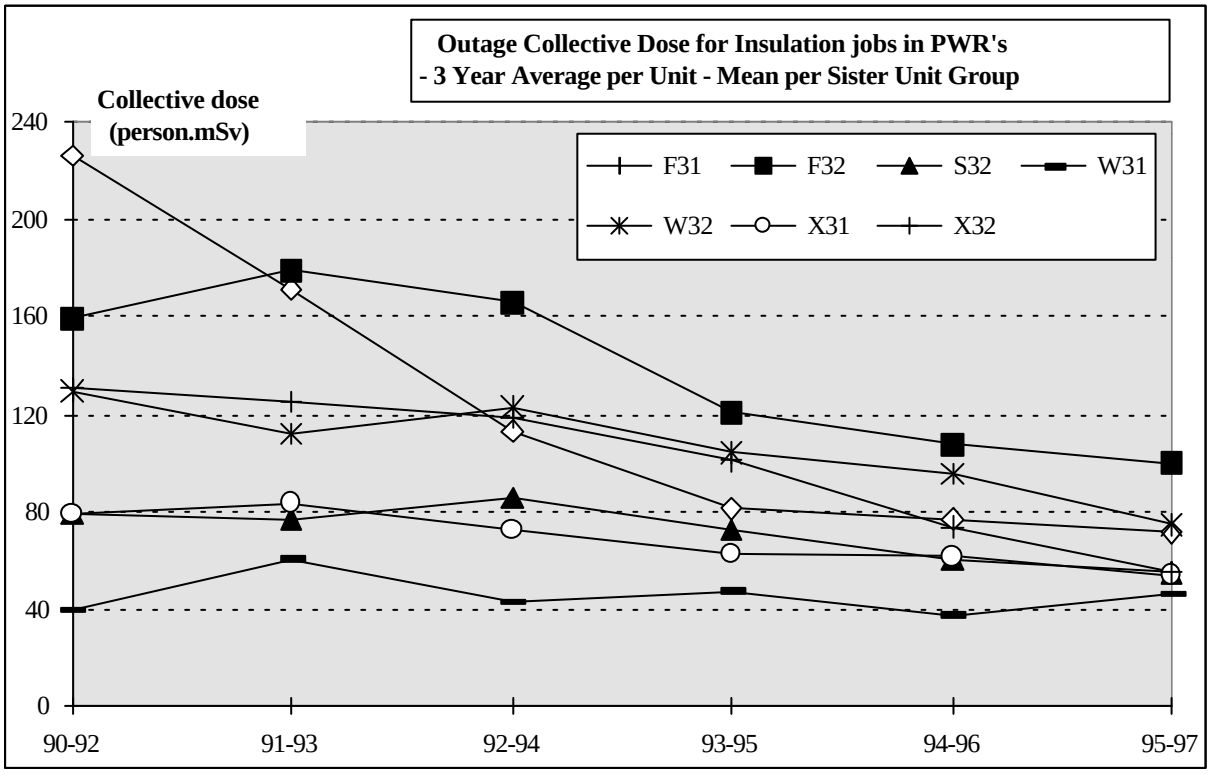

Figure 5. Collective exposure for insulation jobs in 3 loop sister unit groups

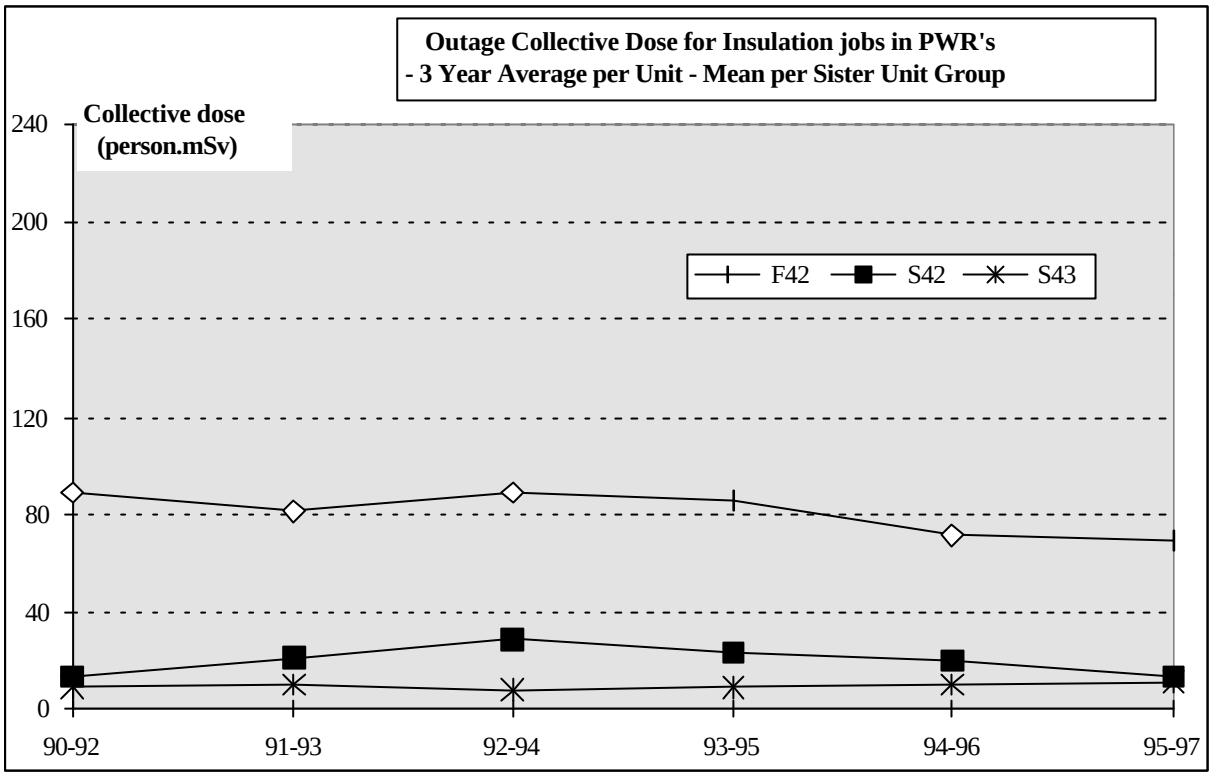

Figure 6. Collective exposure for insulation jobs in 4 loop sister unit groups

It is also interesting to look at the evolution of the collective dose within sister units groups from the same designer, with the change of generations. Figures 7 to 9 presents respectively the Westinghouse 3 loop plants, generations 1 and 2, Framatome 3/4 loop plants, generations 1 to 3 and the Siemens 2/3/4 loop plants, generations 1 to 3.

- the collective doses associated with insulation jobs in 3 loop Westinghouse plants from the first generation are relatively stable over the considered periods: around 50 person.mSv. The plants of the second generation present a level of collective dose higher than the first generation, but this level has been reduced by a factor 2, from 140 person.mSv in 90-92 to 70 person.mSv in 95-97.

- within the three Framatome generations, the level of collective dose due to insulation jobs in the first 3 loop plants has now reached the level of the second generations with 4 loops, around 70 person.mSv. Despite a major reduction, the 3 loop plants of the second generation are still slightly above the others, with a level of 100 person.mSv.

- the four types of Siemens plants present major differences. There is a factor close to 14 between the level of collective dose in the pre-Konvoi and Konvoi plants (around 10 person.mSv) and the first 2 loop generation plants (around 140 person.mSv in 95-97). For the latter, the dose for insulation jobs has in fact increased between 90-92 and 92-94, rising to a level of to 160 person.mSv. It seems that the tendency is now slightly falling. The level of the collective dose for the 3 loop second generation plants has also decreased, and is now close to 50 person.mSv.

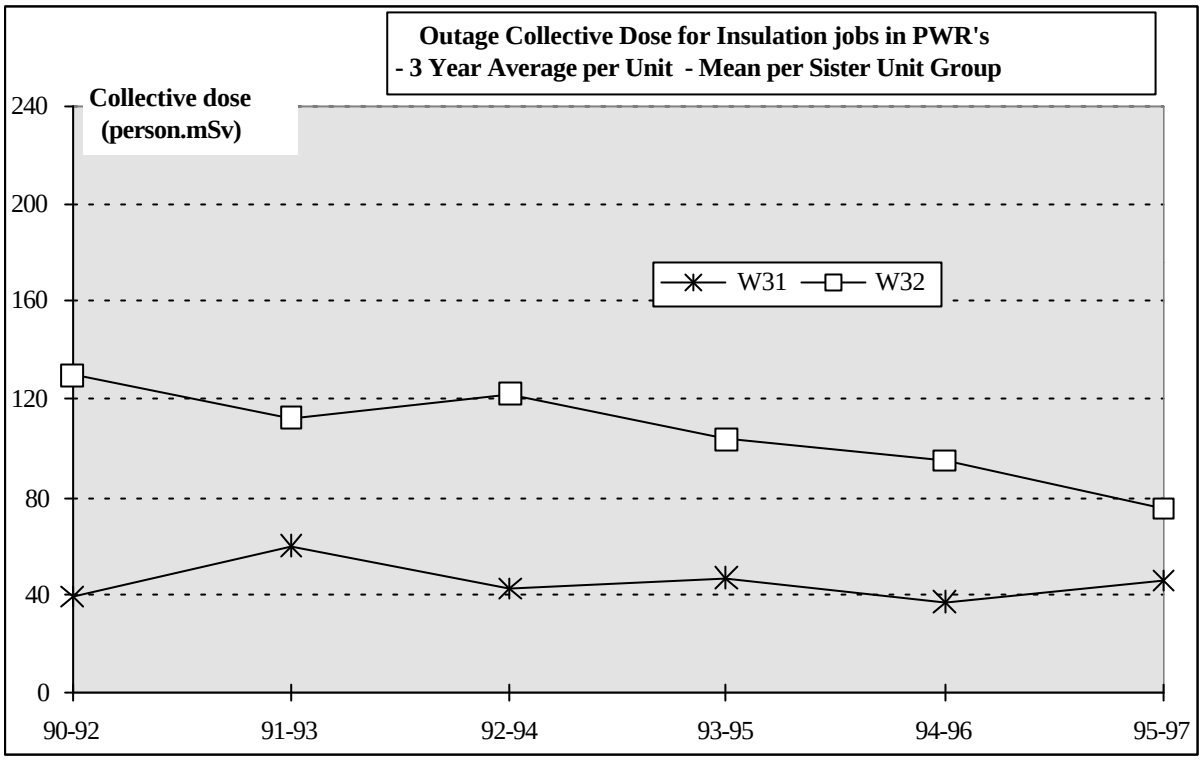

Figure 7. Collective exposure for insulation jobs in Westinghouse plants

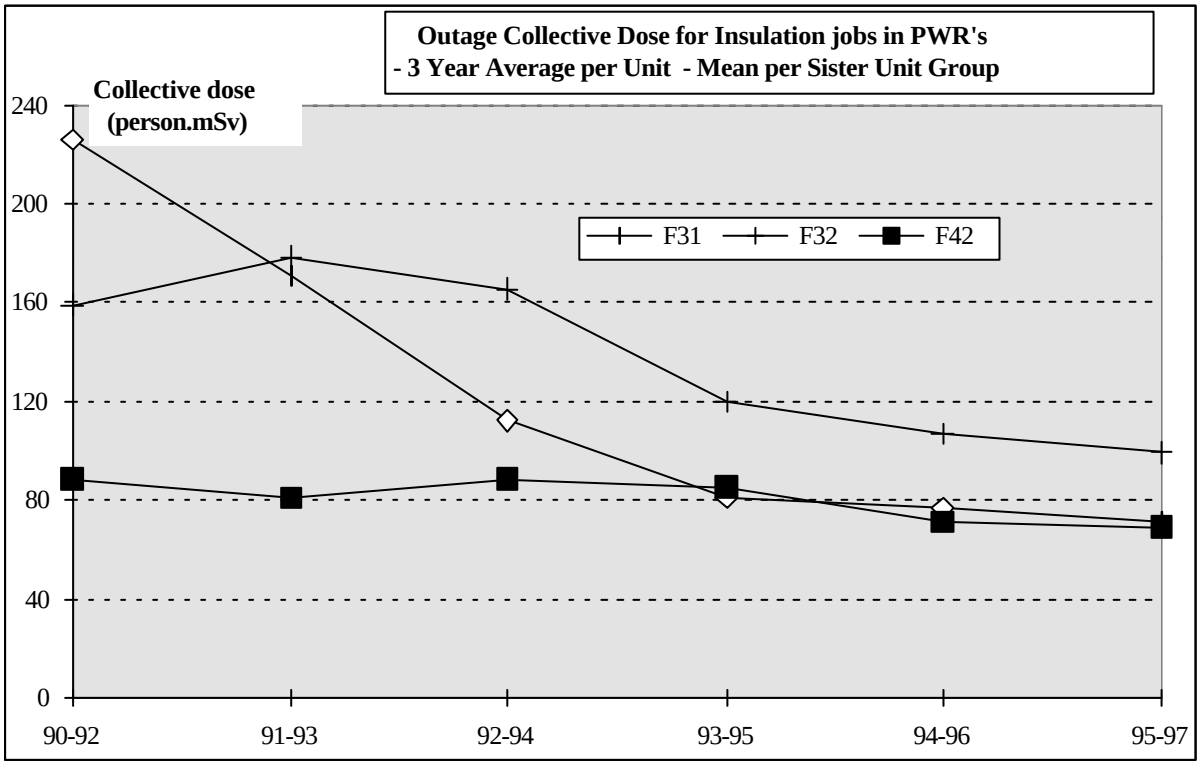

Figure 8. Collective exposure for insulation jobs in Framatome plants

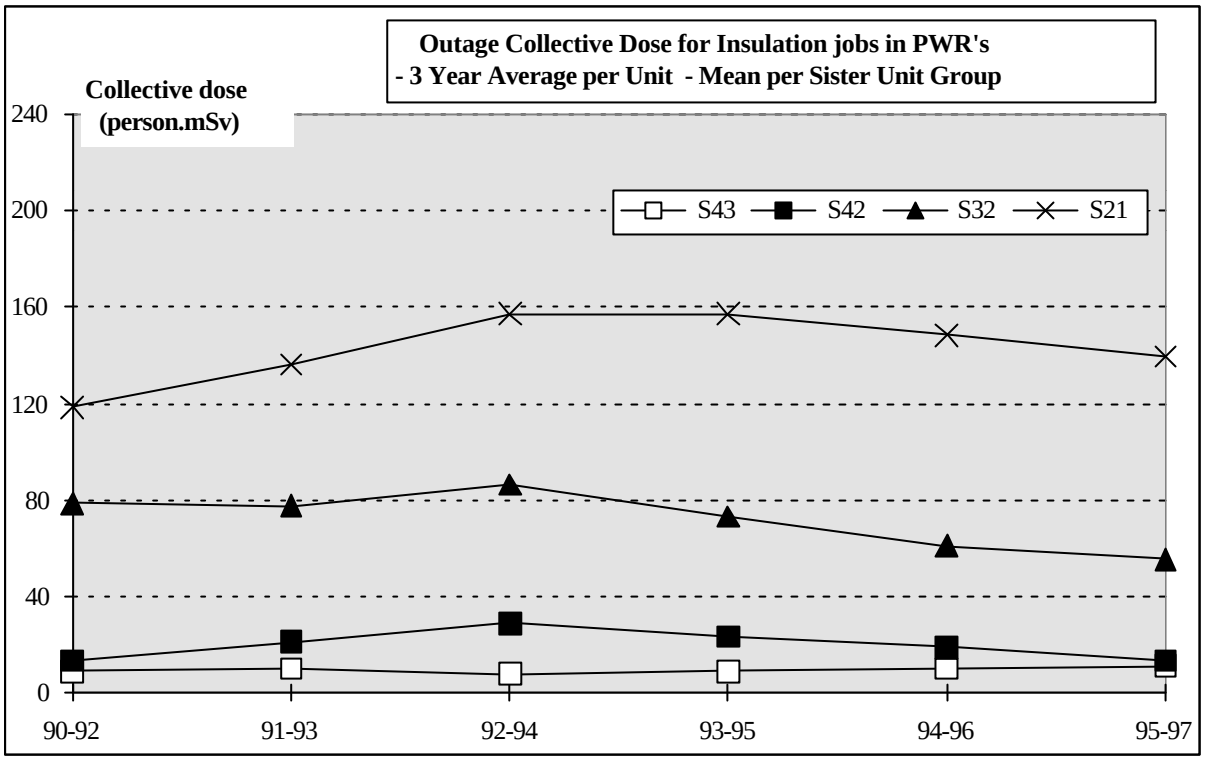

Figure 9. Collective exposure for insulation jobs in Siemens plants

Another type of result which is also interesting, is the evolution of the mean collective exposure for insulation jobs for one sister unit group compared to the mean per country of the units belonging to this group.

Figure 10 shows, for example for the group W21 (Westinghouse, 2 loops, first generation), the position of Swiss and Belgian plants compared to the mean of the 2 countries. It appears that during the earlier periods there was a large difference between the two countries (the Swiss plants being more than twice as high as the Belgian plants). In both countries, the level of collective exposure has then decreased. Since 94-96, they have reached the same level of collective exposure for insulation jobs.

Figure 11 presents the comparison between Spanish, Belgium and Swedish plants belonging to the W32 sister unit group (Westinghouse, 3 loops, second generation). The respective positions of the three countries remains the same over the entire period, with Spain over Belgium over Sweden. In Spain and Sweden, the level of collective exposures due to insulation jobs has significantly decreased: from 180 person.mSv to 100 person.mSv in Spain, and from 50 person.mSv to 20 person.mSv in Sweden. In Belgium, the level is relatively stable over the period.

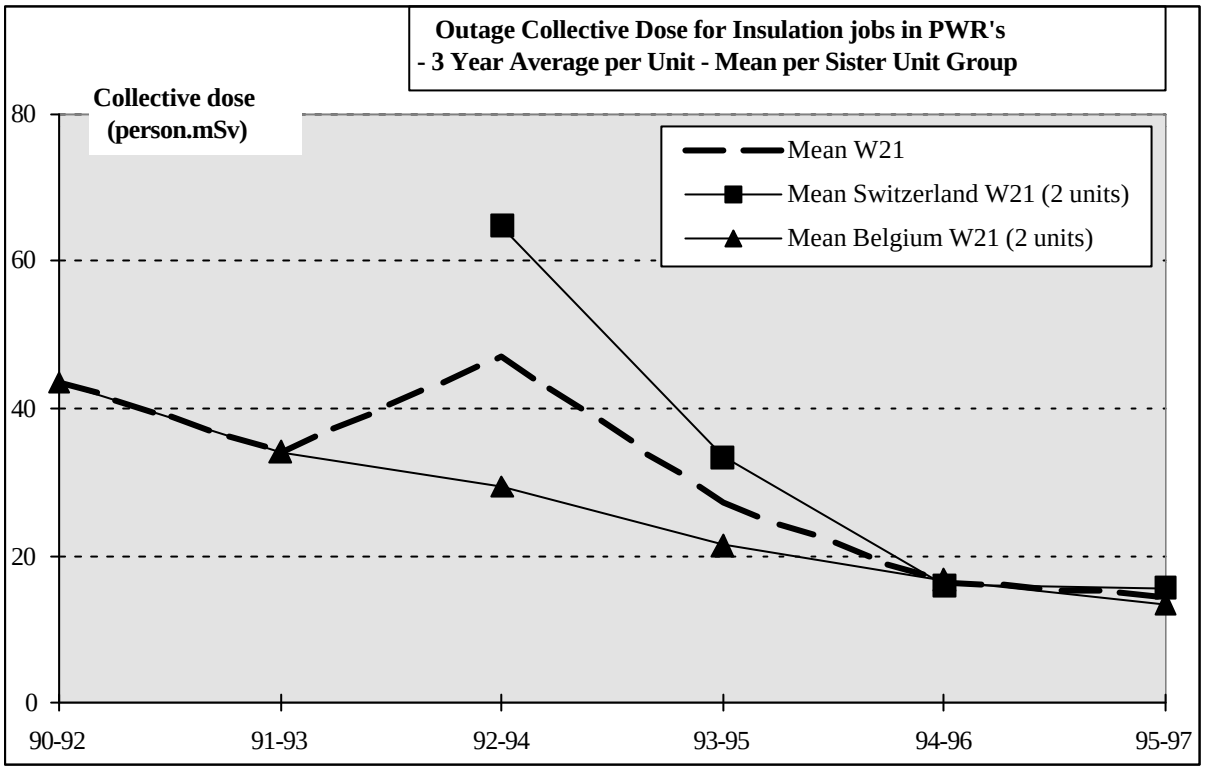

Figure 10. Collective exposure for insulation jobs in Westinghouse W21 plants: comparison between Switzerland and Belgium

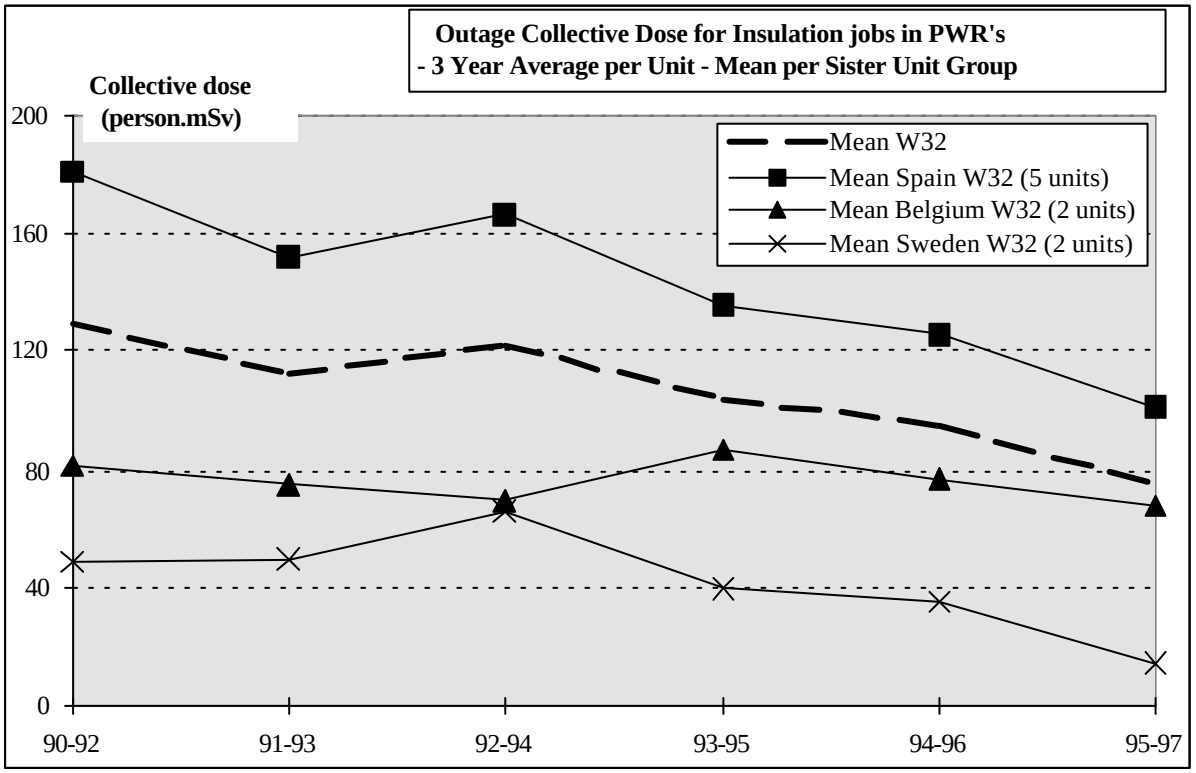

Figure 11. Collective exposure for insulation jobs in Westinghouse's W32 plants: comparison between Belgium, Spain and Switzerland

5. Conclusion

Even if some major differences still exists between countries or the types of units, this study confirms the global trend of decreasing collective doses for insulation jobs in nearly all plants. This trend is most likely linked to the decrease in total collective doses observed in the majority of the countries, and to the implementation and sharing of good practices between plants. The main actions undertaken to reduce insulators exposures, as collected through the ISOE request, are the following:

- replacement of normal insulation by "cassette insulation" (easy to remove and replace - this divides by a factor 2 to 3, at a minimum, the exposure time)
- improvement of scaffoldings (use of quick assembly scaffoldings)
- reduction of the amount of insulation to be removed
- selection of the best work time period in the outage schedule (ex: insulation work planned when the piping is full of water whenever possible)
- specific radiation work permit for insulation work
- improvement of insulation marking just before removal to facilitate the replacement
- improvement of storage to prevent damage
- team management
- specific training on mock-up

This study also shows that it was possible to extract interesting elements from the ISOE 1 data base, allowing the performance of inter-comparison of plants and countries. However, as explained previously, it must be remembered that all the plants contained in the data base where not included in the study, either because the data did not exist, or because the Tables where not completed systematically. It is also important to consider this analysis as a broad picture of global tendencies, rather than an exact description of the behaviour of each plant. In order to complete the study, it could be useful to focus on some types of plants, and to collect more precise information on the contents of the Tables (what are exactly the jobs included as "insulation jobs"), as well as on the various practices of the utilities.