Full-scope EIA Temelin

according to Article V of the Melk Protocol

ensuing from negotiations between the governments of the Czech Republic and the Republic of Austria, led by Prime Minister Zeman and Federal Chancellor Schüssel in the presence of EU Commissioner Verheugen

on 12 December 2000

Report to the Federal Government of Austria

Umweltbundesamt

Federal Environment Agency – Austria

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Preface

The present opinion presented to the Austrian Federal Government concerns the documents put forward by the Czech EIA Commission on 14 April 2001 and additional information given on 20 May 2001 as a result of the request for further material made by Austria.

In as far as issues are dealt with in more than one place, they are also discussed in the respective chapters in the opinion presented to the Federal Government of Austria. By way of example, a result thereof is that the possible impact of severe accidents on the environment is covered in several chapters.

All documents are published on the Temelín homepage provided by the Federal Environment Agency at http://www.ubavie.gv.at. The present opinion as well as the illustrations on the CD-ROM enclosed are also published there.

Should you encounter technical problems, please do not hesitate to contact mailto:Schuh@ubavie.gv.at.

Content

ABRIDGED VERSION

In the Melk Agreement, Federal Chancellor Schüssel and Prime Minister Zeman, in the presence of EC Verheugen, decided upon the implementation of a full-scope EIA for the NPP (Nuclear Power Plant) at Temelín, according to the procedural rules of the European EIA Guidelines, and publicity participation in accordance with the standards of the Espoo Convention.

ALTERNATIVE EXAMINATION (ZERO OPTION)

Based on agreements with the Czech members of the EIA Commission (scoping list), which refers to the EU Guidelines on EIA Procedures, and starting from the documents submitted by the Czech side, an investigation was made, for the present declaration,

- as to whether an alternative existed, which might, with comparable economic profitability, bring with it a lower ecological burden, or lower potential ecological danger, and
- as to whether the project altogether shows an appropriate relationship between economic profitability and any actual as well as potential ecological burden.

To this end, the option of completing and commissioning Temelín, as well as its potential alternatives were examined with a regard to the economic and ecological effects associated therewith.

In this respect it should first be recalled that, considering all the means already invested, the NPP project at Temelín is in any event uneconomic, and has thus already caused economic damage, which in any event will burden the Czech national economy - probably by sharply reduced privatization proceeds (compared with the scenario without the Temelín NPP) - over a longer time-span (cf. the final report of the "expert team for the independent assessment of the project to complete the Temelín NPP", commissioned by the Czech government, January 1999). In current feasibility studies, in which the already invested means ("sunk cost") are not considered, it is simply a matter of "damage limitation", that is to say any option is sought which will lead to an extensive as possible limitation of the damage already caused.

To this end, for the present declaration, comparative economic costings were carried out, which assume the ideal case where the Temelín NPP (block 1) would be operational immediately (that is to say the completion costs which are still due on block 1 and above all are still to be incurred on block 2, for the moment are not considered), and can be operated according to plan (namely at 6,000 full-load hours per annum).

If one makes these assumptions, from an operational point of view - that is the CEZ point of view - the offsetting income which will be generated from the running operation of the plant to cover investment costs and profit expectations, represents the central assessment criterion. The offsetting income for the accounts carried out will thus be defined as follows: earnings (from power sales) less fuel costs and miscellaneous variable costs, as well as the fixed operational costs (management, maintenance and overhaul).

It is thus to be recorded

- that the commissioning of Temelín under current market conditions shows no economic advantage, because no additional offsetting income will be generated;
- that a commissioning of Temelín is not expected to lead to any environmental relief as regards gas emissions and so, from an ecological viewpoint, is to be assessed thus at the

most detrimental; this is because, on economic grounds, as a consequence of the commissioning of Temelín, an obligation will arise to expand sales;

- that through the commissioning of Temelín, environmental relief will only be achieved against the price, that economic performance (in the sense of offsetting income generated) in any event remains behind the scenario of non-commissioning;
- that the commissioning of Temelín at the same time leads to an increase of the nuclear risk.

It is fundamentally to be emphasized that, in the comparative economic costings mentioned, the investments to be effected up to commissioning are not taken into consideration. Furthermore, in the case of a decision in favor of completion and commissioning, a series of significant risks arise, which would not arise in the event of non-commissioning. These specific risks arising on commissioning suggest that, from an economic viewpoint, non-commissioning would additionally be advantageous:

- Risk of further cost overruns until take-up of commercial operation; in relation to the safety equipment alone, based on the previous results of the trialogue on the nuclear safety of the Temelín NPP, modernization requirements were investigated, the costs of which could amount to between 1 billion CZK and 4 billion CZK. And in the mechanical and electronic aspect, test operation brought a series of technical faults to light, the solution of which could prove to be cost-intensive.
- Risk of unreliability in operation, which can in no way be excluded assuming the known operational data concerning the existing WWER-1000.
- Obstacles to expansion of sales which, from an economic viewpoint, appears necessary if Temelín is commissioned, whereby the major obstacles include: expectation of an insignificant rise in domestic demand; limitation of power-line capacities, re-import by distribution companies.
- Risk of price developments on Central European energy markets, since commissioning would only achieve the additional offsetting income if there were considerably higher energy prices (if at the same time there is a sharp expansion of sales, which is necessarily inconsistent with the needed improvement to the delivery price).

In amplification of the comparative economic-ecological costings, the present declaration analyses some fundamental statements in the documents provided by the Czech side (later filings with the Czech Foreign Ministry, May 2001) in detail and shows, in contrast to the lines of argument used therein,

- that the CEZ power station company suffers no loss whatsoever through the non-commissioning of the NPP, but that, on the contrary, it can be assumed that the economic advantage will surpass the loss occasioned by non-commissioning. This is connected in the first place with the fact that under current market conditions a commissioning of Temelín would result in no increase in income for the company, which in other words means that, under these conditions, the investments in the Temelín NPP have no value in an economic sense.
- that on the one hand the entire Temelín investment plan has already considerably reduced the achievable privatization proceeds for CEZ, and that on the other hand it is in no way certain that the privatization proceeds would be higher if Temelín is commissioned than on termination or postponement of the project. This is because, alongside strategic considerations, potential investors look in the first place to the earnings capacity of a company, and because it is highly probable that the commissioning of Temelín will not increase the earnings capacity, but at the same time bring additional risks.
- that the bookkeeping consequences of non-commissioning, which are described in the documents provided by the Czech side (one-off depreciation of invested capital in full either directly or through the creation of a reserve), could be relaxed after a successful privatization.

- that the impact on employment of a commissioning, just like that of non-commissioning would be insignificant from today's viewpoint, but that at the same time the impact on employment of the entire Temelín project will be negative, since the unprofitable project will burden the Czech national economy for several years (probable through reduced privatization proceeds).
- that, from an economic viewpoint, it would not be understandable if the completion and commissioning decision to be taken now were supported by highly uncertain future income from CO_2 business, so long as there are no fundamental prerequisites, since their determination continues at an international level and therefore price assumptions in this connection are pure speculation.
- that assuming economic development on the one hand, and on the other hand the qualitative consequences of the expected accelerating economic growth (technological renewal and structure effect with simultaneous losses of market share in the space-heating market), a forecast annual growth of energy demand of 5% goes without any real foundation. It is much more to be assumed that just such expected economic growth will lead to a gradual reduction of energy intensity. So for the next three to five years a slight increase in energy demand is to be assumed of between 1% and 2%.
- that even with growing demand it can in no way be ensured that CEZ will be able to maintain its present level of sales. This applies in particular to the case of a complete opening of the market, which is closely connected with the EU entry for which the Czech Republic is striving.

The two fundamental questions in the present declaration can therefore be answered as follows:

- There are without doubt alternatives to the commissioning of Temelín, which, with comparable economic profitability produce lower ecological burden or risk;
- An economic advantage potentially only arises - although it is extremely improbable, as shown - when sales can be expanded if possible by the entire volume of energy generated in Temelín. In this case, the ecological burdens and nuclear risks are at their greatest. The extent of potential economic advantage in this scenario - and in particular against the background of the associated technical and market-related risks - does not stand in any appropriate relationship to the additional ecological risk thus caused.

ENVIRONMENT AND HEALTH

The limitation of the assessment of the environmental impact of the Temelín NPP to normal operation is to be described, in the sense of the EU Guidelines on EIA, as not arguable, since under those guidelines a description of the possible environmental effects of the planned project is demanded. At least the environmental effects of fuel production and the disposal of the waste arising from the operation and in due course demolition of the plant should be considered.

The finding of the EIA Commission, that the disposal of spent fuel elements represents no environmental risk whatsoever is not comprehensible, since no corresponding concept in real terms was put forward in this regard.

According to the Espoo Convention, the environmental impact of accidents were also to be considered, and even when the probability of occurrence is low, but the consequences could affect huge areas.

A presentation is not given of the effects of radioactive emissions through the spent air route, in particular the conclusion whereby the exposure limits for the population would be far from reached remains incomprehensible.

Effects of the drawing off of radioactive materials with the spent water in connection with the entry of residual spent water and the spent heat represent a danger to the aquatic ecosystems concerned and through the food chain perhaps also to humans. In this regard, no statement was made by the EIA Commission.

The examination of the effects of the NPP on the state of health of the population is only concerned with the effects of normal operation. Consideration is given exclusively to an area within a radius of 13 kilometers around the Temelín NPP. A fundamental fault of the health studies submitted consists of an absence of data on any illnesses (thyroid cancer, leukemia in children, deformities in new-born children), which can provably be triggered by ionizing rays. It also remains unclear how population health will be observed in the future.

Two of the three EIA documents dated 20 May 2001 examined reference accidents, which as design base accidents have relatively limited radiological effect on the surroundings, but have a frequency of occurrence which is lower than the frequency of severe accidents,

This EIA documentation did not deal with the category, which is significant to Temelín, of design base accidents involving primary or secondary circulation leaks.

And accidents triggered by external events were not dealt with sufficiently in this EIA documentation.

The EIA documentation of 20 Apr. 2001 draws the conclusion, among others, that: "the assessment of the consequences of radiation from selected reference accidents at the Temelín NPP shows that, even using conservative prerequisites, the results exclude the possibility that there could be a danger to the health of the population of the Czech Republic or neighboring Austria and Germany."

In contrast it is to be noted that:

- the term "danger to health" was not clearly defined.
- the respect of dose limits was not proved. There are no comprehensible representations of the assessments in this respect.

Numerous aspects of the disaster plans submitted suggest that the Czech authorities very seriously reckon with the wide-ranging consequences of possible accidents potentially endangering human health.

SEVERE ACCIDENT SCENARIOS IN THE SUJB REPORT (20 MAY 2001)

The documents (Investment Project 2001) submitted by the operator CEZ within the context of the environmental impact assessment contained no statements on severe accidents and their possible consequences, that is to say on accidents which go beyond design base accidents and whereby large releases are possible of radioactivity into the environment.

The information on severe accidents, submitted following demands made by Austria (SUJB, May 2001), does not comply with conventional international standards, or with the requirements of the EU EIA Directive (EC 97/11/EC). Nevertheless, on the basis of the statements contained in these documents on the inventory and the source terms underlying Czech emergency planning, it was possible to make some assessments of the possible effects of that sort of accident on Austria.

According to the probabilistic safety assessment carried out in 1995 on the instructions of the operator, the core damage frequency (CDF) figure for Temelín is above the value of 10^{-5} per annum, wherewith it exceeds the safety target of several EU states and Russia. Furthermore, on account of the high frequency of containment bypass sequences for Temelín, the INSAG safety target of the IAEA is surpassed.

The core damage frequency for Temelín is thus calculated by means of accident sequences, which lead to a containment bypass. This is a definite deviation from practice in EU member states.

Because severe accident risk analyses have not been carried out, or carried out inadequately, above all with regard to the integrity of containment in the event of severe accidents, it cannot be excluded that the probability of severe accidents is still underestimated.

In view of the lack of analysis from an Austrian point of view, the analysis of severe accidents for Temelín on which emergency planning is based is inadequate. If the integrity of containment in the event of severe accidents cannot be ensured, greater releases of radioactivity must be reckoned with than for the accident sequences previously studied in planning for emergencies.

Measures to reduce the frequency and/or measures to reduce the effects of severe accidents are not dealt with within the context of the overall EIA for Temelín and the SUJB documents, although a first pilot study into such measures by the NPP operators was already made. This is not in harmony with the EU EIA Directive, which demands from the operators of a project a "*description of the measures whereby considerable adverse effects are avoided, mitigated and as best possible balanced out.*"

Both with regard to completeness and also content, the treatment of severe accidents within the context of the overall EIA documentation for Temelín (including the documents on severe accidents) is inadequate.

EMERGENCY PLANNING FOR TEMELÍN

The IAEA definitions on the establishment of zones for emergency planning (IAEA Tecdoc 953 1997), which were clearly used for Temelín, allow considerable room for maneuver with regard to actual implementation. For this reason it would be desirable to receive more information on the method employed in establishing the sizes of zone 1 and zone 2 for Temelín. These zones are located at 5 kilometers and 13 kilometers radius, however exclusively on Czech territory. The emergency planning zone 3 (LPZ), which according to verbal information covers the entire Czech Republic, however doubtless extends to Austrian and German territory, and should thus be established in accordance with the recommendations of the IAEA (IAEA Tecdoc 953 1997). Cross-border co-ordination and consultation on emergency planning and emergency protection measures is necessary.

Although the emergency planning zone 3 is defined in the first instance in relation to the long-term effects of radioactive pollution, in view of the restrictive definition of zone 2 and zone 3, the necessity can fundamentally arise for immediate measures to be taken. In the concrete instance, however, this was excluded in the SUJB documents: "*Irradiation of neighboring countries people on dose levels (i.e. for accidents with the probability equal or lower than 10^{-7} / year), for which implementation of the urgent protective measures is justified and reasonable, can not be occurred.*" As a limit for immediate measures, Czech Law provides an effective dose of 10 mSv as a 2-day value. Calculations, which verify that this dose cannot be reached at distances of 50 kilometers and above, and thus support the above statement, were not put forward. In compliance with the EU EIA Directive, it would be necessary for the project promoter to take a critical and earnest look at the possible cross-border effects of its plant.

OWN EXAMINATIONS OF THE EFFECTS OF SEVERE ACCIDENTS

The statement that the necessity of immediate measures is excluded in neighboring countries, is in glaring contradiction to the results of Austrian calculations.

The effects of a severe accident in the Temelín NPP were examined for the present declaration by Austria on the basis of the statements contained in the EIA documentation of 20 May 2001, amplified by internationally accessible meteorological data,.

On the one hand, with the assistance of a so-called particle model, the effects of the severe accident indicated by the SUJB were analyzed for 88 meteorological situations spread equally over the year 1995. The calculations show that the consequences of a major release of radioactive material in the Temelín NPP would not only be limited to the immediate neighborhood of the NPP, but depending on the weather situation could also severely effect more distant regions of Europe.

The probability of occurrence of a severe accident in Temelín is low, but if such an event occurs, by virtue of its geographical situation and meteorological conditions, Austria is extremely likely to be affected, in most cases severely (Cesium deposits of more than 1,500 kBg/m^2). And in most other European countries, including Great Britain, Sweden and Greece for instance, case study results show deposits of more than 185 kBg/m^2.

Alongside these investigations, analyses were also carried out, with the PC-COSYMA program, into the possible effects of a severe accident in Austria. PC-COSYMA is a recognized software package, created with EU support, which can also be used to assist in emergency planning. It offers only limited opportunity to depict complex meteorological processes, but is suitable for making dose calculations for up to 100 kilometers distance.

The scenario employed for the calculations corresponds to the so-called V sequence, the instance given by the Czech authorities with the greatest release of radioactive material (SUJB: May 2001). Since major investigations of severe accident risk at Temelín have not yet been carried out, or have not been carried out adequately, it is not possible to ensure that this accident scenario actually represents the one with the most severe effects.

The calculations carried out show that Cesium 137 deposits of 1,500 kBg/m^2 and over could occur in areas covered by the central section of the radioactive cloud.

For a distance of 40 to 100 kilometers from the Temelín NPP, in the central area of the radioactive cloud, the dose calculations gave an effective dose of more than 100 mSv for two days. Such levels, according to the Austrian provisions (BKA 1991), would correspond to dangerous substance category III in the affected areas. The inhabitants would be required not to go into the open air, and to take cover in protective rooms. Children, young people and also adults (up to 45 years of age) would be required to take potassium iodine tablets.

For the regions affected, the thyroid dose (calculated for two days) could also reach the intervention limit provided in the Czech Radiation Protection Act for the prescription of potassium iodine tablets (100 mSv). It follows that - other than described in the documents from the SUJB dated 20 May 2001 - there could also be a necessity in Austria of immediate measures (see above).

In extreme cases, the analysis of the expected dose for the first year after such an accident shows, for the most severely affected areas, that the dangerous substance category IV could be reached under the framework recommendations of the Austrian Radiation Protection Commission (BKA 1991).

CONSIDERATION OF SEVERE ACCIDENTS IN THE EIA PRACTICE OF OTHER COUNTRIES

As an example of the handling of environmental impact assessments of nuclear power plants in other countries, provisions in the USA, as the county with the greatest experience in this sector, and the Netherlands, as an EU member state which 10 years ago carried out a similar procedure for the nuclear power plants at Borsselle and Dodewaard were the subject of discussion.

The comparison with the overall EIA documentation for Temelín dated 20 Apr. 2001 and May 20 2001 shows that in both examples an extensive risk analysis was carried out for the plant and presented in detail in the EIA documentation, serving as a basis for decision. These analyses include an assessment of core damage frequency for various accident-triggering events, the containment retention capacity in various core damage scenarios, the possible scenarios for the release of radioactivity (source terms), the movement and deposit of the radio nuclides released and finally a dose assessment and with it an estimate of the health risk to be expected.

LEGAL ASPECTS

The “full-scope EIA” goes beyond the Czech national EIA procedure and the existing obligations of the Czech Republic under International Law. Both the Melk Agreement and the joint declaration by Ministers Kavan and Molterer of 12 Feb. 2001 establish that the current environmental impact assessment of 78 project changes will be extended to a full-scope EIA. The Kavan-Molterer Agreement contains the statement, “The technical results of the assessment must be observed and implemented by the relevant bodies of state government in the required administrative and authorization measures in accordance with national law”.

The overall EIA is run by a separate body, the Czech EIA Commission, while the Czech Ministry of the Environment carries out the national EIA under Czech EIA Law.

The EIA Directive and also the Kavan-Molterer Agreement of 12 Feb. 2001, provide that the results of the full-scope EIA should be considered in the approvals still to be issued, especially those under the Building and Federal Nuclear Acts. Such consideration is to be understood as the responsible authorities giving attention to the EIA conclusions (results of the environmental impact assessment documentation and the EIA Commission reports, public interventions, results of the consultations with Austria, of which this opinion is also a part) and, where appropriate, the setting of conditions or refusal of approval.

The question of integrating the Melk process into the national EIA and the national approvals procedure thus remains open. However, when the time comes for approval of the project, the mandatory consideration requirement shall come into its own.

It must further be remembered that under article 7 (4) of the EU EIA Directive the participating member states enter into consultations which among other things are intended to deal with the potential cross-border impact of the project and the measures to be taken in order to mitigate or avoid such effects.

1 INTRODUCTION – ENVIRONMENTAL IMPACT ASSESSMENT IN THE FRAMEWORK OF THE MELK PROCESS

1.1 The EIA for Temelín according to Czech law

The ruling Czech Environmental Impact Assessment Law (EIA Law, No. 244/1992 Slg.) lays down an EIA requirement for nuclear power plants and any modifications to them (§1 in combination with §2 (1) and appendix 11 figure 3.3 EIA Law).

The EIA is to be carried out before the required permissions according to the materials laws and, more particularly, according to the Building Law and the Atom Law can be granted and before the modifications are carried out. It represents a basis for the decision of the relevant authorities.

The Czech authorities had originally taken the viewpoint that an EIA "after the fact" of the nuclear power plant originally approved under building law in 1986, would not be possible and that an EIA for the later modifications (consisting, in particular, of the installation of a new control system) was not required according to Czech EIA Law. The Prague High Court, in a precedence judgment with full force of law and without right of appeal of Feb. 22, 1999, GZ 6 A 82/97-70, made clear that any alteration to a building that, when first erected, would have been subject to an EIA, is to undergo an EIA; and this, whether the alteration was scheduled for the time of erection or after completion.

However, this EIA obligation does not affect administrative procedures that were commenced before the EIA Law came into force on 1 July 1992.

Following on this judgment, environmental impact assessments were carried out for individual changes to the nuclear power plant project compared to the original plans of 1986.

In respect of the EIA documentation handed over to Austria in October 2000 regarding numerous alterations to the building work, a team of Austrian experts concluded:

> *"The original building permission is fundamentally free of any subsequent EIA and just as much so are those parts of the original building project that have remained unchanged. Fundamentally, the environmental impact of a proposal are to be set out in the EIA taking a complete and integrated view and it is required that changes to a project should be examined and assessed in their entirety. The changes are also to be assessed in relation to those elements of the project that are taken over from the original project without modification. In so doing, it can be assumed that from the interplay of the "old" and the "new" components of the power plant, a unified state of security will result that is decisive for the assessment of the nuclear power plant's impact on the environment, in particular, in the event of an accident. The object assessed in the EIA is thus wider than the object of any decision on the authorization of a modification.*
>
> *Whether such an overall assessment has been carried out where such is necessary, cannot be confirmed from knowledge of the EIA documentation made available."* (Umweltbundesamt GmbH [Federal Environment Agency Ltd.], Part UVE II Temelín, Report to the Austrian Federal Government, November 2000, p. 6)

1.2 The Melk Agreement

The criticism expressed by the experts and also by public representatives in Austria, the Czech Republic and Germany that overall assessment which, according to European and International law, characterizes the very essence of the EIA, has not taken place in the part-EIA that has so far been carried out on the basis of Czech law, and the fact that Austria could not take part formally in the procedure, moved the Austrian and Czech heads of governments to negotiate.

In Melk, Lower Austria, on 12 Dec. 2000, Chancellor Schüssel and Prime Minister Zeman agreed, in the presence of Commissioner Verheugen of the European Commission responsible for Enlargement, which a comprehensive general EIA should be carried out for the Temelín nuclear power plant. The relevant article 5 of the Melk Agreement states:

> *"V. Environmental Impact Assessment*
> *The European Commission will assist and monitor the environmental impact assessment of the NPP Temelín. The Czech authorities will voluntarily extend the ongoing environmental impact assessment of 78 design changes into a comprehensive and full-scope environmental impact assessment of the whole plant taking fully into account the expertise that was done up to now. In procedural terms this extension shall be guided by the Council Directive on the assessment of the effects of certain public and private projects on the environment (Council Directive 85/337/EEC as amended by Council Directive 97/11/EC), in particular with regard to the participation of neighboring countries. The extended environmental impact documentation to be released to the public will comprise the project documentation and other reference documents to the extent necessary to understand and assess the conclusions of the environmental impact documentation respecting European standards including criteria of business secrecy."*

From the Austrian point of view, it follows from this Agreement that:

- the EIA now in progress according to Czech law and covering 78 design changes will be extended voluntarily from the Czech side (at least with respect to Austria), to a full-scope EIA.
- the EIA will be comprehensive and carried out in the light of the requirements of the EU EIA Directive (85/337/EEC as amended by 97/11/EU); the documented results of the EIA must, in any event, include such reference material as is necessary for an appreciation of its conclusions. Furthermore, for the scope of the documentation, "European standards" are to be applied, including the European standards of business secrecy (however, Art. 10 of the EU EIA Directive refers, in this regard, to the legal provisions of the individual states and "current legal practice"),
- in the evaluation, efforts should be made to judge according to "European standards",
- in the course of the procedure, the EU EIA Directive will be observed. This includes article 7, which applies the Espoo Convention to cross-border situations (information and participation of the Austrian public, consultation with Austria).

1.3 EIA execution to date according to the Melk Agreement

On 17 Jan. 2001, the Czech Government reached a decision on the institutional and methodological bases of the full-scope EIA (Government Decision No. 65). In this decision, the Minister for Industry is charged with the technical and organizational execution and an EIA Commission is set up with four members, two from the Industry ministry and two from the Environment Ministry. This decision invites Austria and Germany to send one "observer" each and the EU one "representative" to the commission. The Government Decision also identifies, in a very general manner, eight areas of investigation for the EIA.

This government decision represented the basis for further Austrian-Czech negotiations regarding the content and execution of the full-scope EIA, which led, on 12 Feb. 2001, to an agreement between the Austrian Environment Minister Molterer, and the Czech Foreign Minister Kavan on the implementation of the Melk Agreement.

In the spirit of the Melk Agreement, the Austrian side has already presented a document containing its expectations of the EIA ("Scoping List") to the Czechs.

In the "Kavan-Molterer" Agreement of 12 Feb. 2001, it was made clear that, according to Czech law, the full-scope EIA represents a voluntary extension of the EIA of 78 design changes that is currently being carried out. It will be carried out in accordance with the EU EIA Directive and its technical results will be observed and implemented by the responsible Czech authorities in the "required administrative and authorization steps according to national law". The determination of the framework of investigation (Scoping List) was to be set down by the EIA Commission, with special attention being given to the Austrian proposal. Furthermore, this detailed agreement attempts to further define the role of the EIA Commission in that it also has a process control function (Verifying the documentation supplied by the operating company, CEZ, for completeness and comprehensibility, the imposition of further requirements, putting public participation into practice and participation in bilateral consultations).

The EIA held three meetings in which, in accordance with the Kavan-Molterer Agreement, two observers each from Austria, Germany and the European Commission participated.

The third meeting of the Commission finally succeeded in arriving at a jointly agreed and binding Scoping List in which, on Austrian insistence, the tested alternatives from project bidders will be included. The impact of severe accidents, being accidents for which the power plant is not designed and cannot be fully mastered by the installed safety systems, should be discussed in a separate forum and dealt with in a separate document.

In the EIA Commission meetings, agreement was reached with the Austrian observers on a few key points of public participation. The report to be prepared by the EIA Commission should be put on public display for 30 days, and translated into German by Austria and Germany. No agreement was reached regarding the extent of the documents that are to be put on display.

Finally, on 14 April 2001, the report of the EIA Commission ("Assessment of the Environmental Impact of the Temelín Nuclear Power Plant"), in the Czech language, was handed over to Austria. Attached to this report was a summary of the results of a workshop in which Czech and Austrian experts discussed with one another the question of the probability and effects of severe accidents and which was regarded from the Czech side as the agreed separate forum on "severe accidents" (Severe Accident Forum).

In the view of the Austrian side, some of these documents were incomplete and their completion was requested in a diplomatic note. Austria's demands were, essentially,

- completion of the various scenarios by a consideration of the zero option (no start-up), on the one hand, and
- completion of the severe accident documentation in order to allow a reliable estimate to be made of the impact of such accidents on Austrian territory, on the other hand.

As long as the Austrian side does not receive complete documentation and as long as such documentation is not made accessible to the public in English or German by the Czech side, the procedure for public participation cannot be considered begun.

As a result of the further negotiations on the political level, which led to a new agreement between Ministers Kavan and Molterer on 12 May 2001, additional documents were made available from the Czech side regarding the zero option and severe accidents, and also giving information on the current turbine problems. These details, together with the EIA documentation originally made available, represent the material on which this opinion shall be based.

1.4 Legal Assessment of the Melk Process

As already explained in 1, an EIA is being carried out in the Czech Republic according to Czech law. However, according to Czech law, this EIA does not comprehend the entire Temelín nuclear power plant project but only such changes as were made to the project after 1 Jul. 1992 or for which an administrative procedure was initiated after this date. In addition, at the time of the Melk agreement, the Czech Republic had not yet ratified the ECE agreement of 25 Feb. 1991 on environmental impact assessments in cross-border circumstances (Espoo Convention). Under this convention, states affected by possibly significant environmental impacts, in this case Austria, are to be informed of an EIA procedure, their public is to be involved in the same way as the public of the state carrying out the assessment and the affected state has the right to demand consultations regarding the object of the procedure.

In order to close these deficits, Chancellor Schüssel and Prime Minister Zeman concluded the political Melk Agreement in which Austria is assured of a comprehensive EIA for the whole project according to the procedural requirements of the European EIA Directive and of participation in accordance with the Espoo Convention and article 7 of the EIA Directive.

The “Melk EIA” thus goes as much beyond the national EIA procedure as beyond any existing obligations of the Czech Republic under International Law. Both the Melk Agreement and the joint declaration by Ministers Kavan and Molterer of 12 Feb. 2001 establish, however, that the environmental impact assessment of 78 project changes will be extended to a full-scope EIA. The Kavan-Molterer Agreement contains the statement, “The technical results of the assessment must be observed and implemented by the relevant bodies of state government in the required administrative and authorization measures in accordance with national law”. The background to this agreement was apparently, on the one hand, the wish to avoid preparing anew the documentation so far presented in the course of the national EIA and, instead, to be able to integrate it into the full-scope EIA, and on the other hand, the wish to comply with the EU EIA Directive, according to which the results of an EIA must be taken into account in the official approval procedures (article 8).

The EIA Directive and also the Kavan-Molterer Agreement of 12 Feb. 2001, provide that the results of the full-scope EIA should be considered in the approvals still to be issued, especially those under the Building and Federal Nuclear Acts. Such consideration is to be understood as the responsible authorities giving attention to the EIA conclusions (results of the environmental impact assessment documentation and the EIA Commission reports, public interventions, results of the consultations with Austria, of which this opinion is also a part) and, where appropriate, the setting of conditions or refusal of approval.

Austria has received no information from the Czech side as to the way in which this is to be incorporated into the approvals procedure. The question of integrating the Melk process into the national EIA and the national approvals procedure thus remains open. However, when the time comes for approval of the project, the mandatory consideration requirement shall come into its own.

It must further be remembered that under article 7 (4) the participating member states enter into consultations which among other things are intended to deal with the potential cross-border impact of the project and the measures to be taken in order to mitigate or avoid such effects.

Such consultations have already taken place in the course of the Melk process with regard to the extent of the investigations and the EIA procedure. Consultations are now required, on the basis of the full-scope EIA, to consider the cross-border effects of the project and the measures that should be taken in order to mitigate or avoid such effects. It is the responsibility of the parties to the Melk Agreement to set an appropriate time frame for such consultations.

2 ASSESSMENT OF ALTERNATIVES

2.1 Introduction

The Czech members of the Environmental Impact Assessment (EIA) Commission and the Czech Department of Foreign Affairs respectively submitted a set of documents on the assessment of potential alternatives. The main objective of these documents was to provide „an overview of the alternatives analysed by the project operator and the main reasons for the operator‘s decision after having taking into account any possible impacts on the environment“ in accordance with the agreement concluded with the Czech members of the EIA Commission (Scoping List) according to the EU Directive on Environmental Impact Assessment Procedures (article 5, paragraph 3).

In the following chapters the documents on the assessment of possible alternatives provided by the Czech authorities will be commented on by taking into account especially three main aspects:

- Do the documents provided by the Czech authorities present and analyse all realistic – i.e. economically acceptable – alternatives, or were any other possible options excluded from the assessment?
- Do the documents provided by the Czechs authorities consider all relevant – both economic and ecological – system effects which might possibly arise if the Temelín NPP is or is not taken into operation respectively? (Due to the relative size of the project in relation to the overall Czech power supply system, system effects have to be included in the EIA procedures at any rate.)
- Can the conclusions presented in the documents provided by the Czech authorities be substantiated by hard facts?

The starting point for this report is the currently prevailing rule for any EIA procedures according to which the assessment procedures of specific plants – in this case the Temelín NPP – have to investigate

- whether any other possible alternative exists which might entail less harmful ecological impacts and/or ecological threats in spite of comparable economic advantages, and
- whether the entire enterprise bears an appropriate relation to the economic advantages and the actual as well as potential ecological harms.

In the following chapters potential alternatives are assessed, first with respect to their economic and subsequently with respect to their ecological impacts. In the centre of the analysis are the two basic variants, namely the completion and taking into operation of the Temelín NPP on the one hand and the suspension of the project (so-called „zero variant“) on the other hand. In the conclusions probable scenarios of development for the two variants are then compared and assessed.

2.2 Comparison of the Economic and Ecological Effects of Taking or not Taking Temelín into Operation Respectively

2.2.1 Economic Assessment of Potential Alternatives

In the case of an investment option where – as in the case of the Temelín NPP – the investment capital is employed over a longer investment period the **time of economic assessment** is decisive. While the entire (expected) investments costs have to be taken into account before the start of the investment activities, in the case of an economic assessment effected at a later point in time only the respective costs of completion of the project have to be considered. The funds invested and/or tied up definitely at that stage have already incurred at any event („sunk costs“) and therefore do no longer need to be considered.

Hence, the outcome of the economic assessment of the option of completing and taking into operation the Temelín NPP (compared to other potential alternatives) will be more favourable the later the comparative assessment of the plant’s economic efficiency is conducted. Nevertheless this does not alter the fact that such a project as for instance Temelín, which has to be regarded as unprofitable from an overall perspective (i.e. considering the sunk costs) – for details please refer to section 2.2.1.1 – results in an overall economic loss which needs to be settled in one way or the other. Regarded from this perspective, comparative economic assessments undertaken at a later stage – in the case of Temelín for instance at a time when the NPP has nearly been completed – mainly concentrate on „damage limitation“, i.e. finding an option which helps limiting the damage that has already been caused as far as possible.

2.2.1.1 Economic Assessment of the Overall Project

Taking into account the entire capital invested in the project the construction of the Temelín NPP definitely has to be regarded as a misinvestment. It seems impossible that the entire capital invested in the project may ever be refinanced through additional revenues which might possibly be generated if Temelín is taken into operation. This fact has already been mentioned in the final report of the Team of Experts for Independent Evaluation of the Project of Complete Construction of the Temelín Nuclear Power Plant: „The economics of the Temelin NPP with inclusion of sunk cost do not indicate a profitable investment“ (Hrubý 1999, Final Report of the Team of Experts for Independent Evaluation of the Project to Complete Construction of the Temelín Nuclear Power Plant, p. 7)

Is should also be remembered that Austria repeatedly underlined the economic inefficiency of the Temelín project. Especially on the occasion of the first bilateral talks with the Czech Republic on the Temelín NPP at the beginning of 1993, Austria warned of the high risks of exceeding the initially estimated investment costs – which have indeed already been exceeded to a considerable extent. Furthermore, Austria repeatedly – and already at a very early stage of the project where the degree of the damage was not yet as serious as it is at present – presented alternative options of energy management to the Czech authorities which would have entailed not only economic but also ecological advantages.

The costs of the misinvestment – a label which is certainly applicable to the Temelín project – will strain the Czech economy for years to come, the negative effects manifesting themselves in the following manner:

- The revenues from the privatisation of the CEZ will only amount to a trifling sum compared to a scenario where the investment capital employed for the construction of Temelín would have been used for alternative more profitable investments, i.e. to the extent of the lower profit expectations. The decline in profits, which can be ascribed to the Temelín misinvestment (as a total project), ranges between CZK 70 and 150 billion. This shortfall in revenues represents a considerable burden on the Czech budget (for details refer to chapter 2.3.2).

- Charging the customers higher power tariffs is another option of shifting the costs of the Temelín misinvestment (as an overall project) to other economic units. In the currently still price-regulated market this would in principle be feasible.
- If the rapidly advancing liberalisation of the electricity markets continues the costs of the Temelín misinvestment could be passed on to the customers by including parts of the production costs in the system utilisation fees. If and to which degree this option, which is currently practised, will still be available in the case of a completely liberalised market primarily depends on the legal framework conditions and the position of the regulation authorities in practice.

2.2.1.2 Economic Assessment from Today‘s Perspective

The economic assessment of the overall project has to be distinguished clearly from the analysis aimed at identifying the most profitable option from today‘s perspective. The following cost elements do not need to be taken into account for such an analysis:

- investments already effected;
- investment capital already tied up through fixed orders.

For identifying the most profitable option from today‘s view – especially with respect to the decision of whether to complete and take into operation the Temelín NPP or shut down and/or preserve the plant – economic profitability assessments were conducted with the help of the GEMIS model (Global Emission Model for Integrated Systems) for the Czech Republic; the input data and the results will be presented in detail in the following chapters.

Basic Method

The calculations performed for this report aim at identifying the economic advantages that could be expected if Temelín was to be taken into operation in comparison to possible advantages if the plant was not to be taken into operation.

For the sake of simplicity it was assumed that block 1 of the NPP would be ready for operation straight away (i.e. no additional costs incurring for the final completion) and that the plant could operated according to plan (i.e. with 6000 full load hours per year). As it was not possible to take into account investment costs in this scenario, block 2 (which requires higher capital investments) was not included in the calculation. Taking into account block 2 would only corroborate the results.

Departing from these assumptions, the contribution margins generated from the operation of the plant for covering the investment costs and profit expectations represent the central criterion of assessment. The term contribution margin is defined as follows for the calculations undertaken in this document:

	Revenues (from power sales)
minus:	Fuel costs
	Other variable costs
	Fixed operation costs (operation and maintenance)
	Contribution margin

Hence, the main focus of the analysis lies on the economic advantages of the different power plants operated by the CEZ and/or the different plant systems from the view of the Czech utility CEZ. Before the background of a rapidly advancing liberalisation of the Czech electricity market this focus on economic aspects seems appropriate.

The contribution margins are of course also relevant for the Czech economy as valued-added contributions, other economic effects extending beyond this aspect (especially occupation effects and their impacts) remain excluded from this calculation.

Selection of Potential Scenarios of Energy Management

The contribution margin is calculated for different potential scenarios of energy management. From an economic point of view the scenario with the highest contribution margin can be regarded the most advantageous.

“Scenario” always refers to one possible variant which, in principle, would be available to the CEZ for operating its currently existing power plants. Block 1 of the Temelín NPP is counted among the group of already existing capacities ready for operation (for input data and detailed results please refer to appendix 3).

In the following the different scenarios are analysed:

- **Reference scenario:** Maintaining the existing production structure without taking the Temelín NPP into operation *(zero-variant);* production remains at the current level of 48 TWh;
- **Scenario A:** *Taking Temelín into operation (Block 1)* and expanding the export market to the extent of the capacities produced in Temelín; production rises to a level of 54 TWh;
- **Scenario B:** *Taking Temelín into operation (Block 1)* without expanding the market which would result in Temelín replacing the respective share of Czech coal power stations; production remains at the current level of 48 TWh;
- **Scenario C:** *Zero variant:* Temelín is not taken into operation and at the same time production is reduced to the level of demand of the domestic market (no exports and no expansion of domestic market shares); production will be reduced to 39 TWh;
- **Scenario D:** *Zero variant* as in scenario C and at the same time shutting down existing reserves of 1500 MW in order to reduce the block of fixed costs.

All scenarios include the entire power stations currently operated by the CEZ, the different power plants were summed up in the following categories for the sake of simplicity:

- Dukovany NPP (4 blocks with each 440 MW)
- Temelín NPP (1 block with 1000 MW)
- Brown coal-fired power plants (without heat delivery)
- Hard coal-fired power plants (without heat delivery)
- Thermal power plants (brown coal)
- Thermal power plants (hard coal)
- Storage power stations
- Pumped storage power stations.

Basically, the differences between the scenarios lie in the extent to which production is reduced in the Czech coal power stations (either replacing effect if Temelín is taken into operation as in scenario B and/or cutting down the production volume deliberately to domestic demand as in scenario C and D. If production in the Czech coal power stations is cut back this is mainly due to the slightly higher amount of marginal costs in hard coal-fired power stations and also in brown coal-fired power stations. It is assumed that a certain minimum operation time of the plants has to be kept for technical reasons. The full utilisation of the capacities of the Czech hydroelectric power stations and thermal power plants – the latter mainly due to their special operation characteristics of heat delivery – remain unaltered in all scenarios.

Input Data on the Cost and the Revenue Side

Table 1 summarises the different components of the operation costs which are used for the comparative economic assessment.

Table 1: Average Operation Costs in the Czech Power Station Park

Power Plant Categories	**Fuel Costs** CZK/MWh	**Other Variable Costs** CZK/MWh	**Fixed Operating Costs (O&M*)** CZK/kWa	**Operating Costs (6000 Full Load Hours)** CZK(EURO)/MWh
Dukovany NPP	149.11	38	1500	437 (12.9)
Temelín NPP	171.08	38	2000	542 (15.9)
Brown Coal-Fired Power Plants	424.69	65.88	555.22	583 (17.1)
Thermal Power Plants (Brown Coal)	438.29	67.67	560.19	599 (17.6)
Hard Coal-Fired Power Plants	485	62.61	546.15	639 (18.8)
Thermal Power Plants (Hard Coal)	485	62.61	546.15	639 (18.8)
Storage Power Plant	0	180	350	-
Pumped Storage Power Plants	0	180	350	-

** O&M = Operation & Maintenance*

The following data sources were used:

- The input data stem from the documents of the „Commission of Experts for Independent Evaluation of the Project to Complete Construction of the Temelín Nuclear Power Plant" (commissioned by the Czech government) which assessed the option of completing the Temelín NPP between November 1998 and January 1999 and based their findings on a data set provided by the CEZ (Hrubý 1999, Final Report of the Team of Experts for Independent Evaluation of the Project to Complete Construction of the Temelín Nuclear Power Plant);
- The input data sets for all other power plant categories are taken from the data set of the GEMIS model for the Czech Republic.

What is decisive for the calculation of the above scenarios is that in the case of the Temelín NPP the fixed costs during the operation period – i.e. basically the costs for operation and maintenance – are considerably higher than the costs in the Czech coal power plants, while on the contrary the sum of the variable costs is lower. Hence, the entire operation costs per MWH in the Temelín power plant depend to a much greater degree on the number of full load hours than in the case of the coal power plants (see table 1).

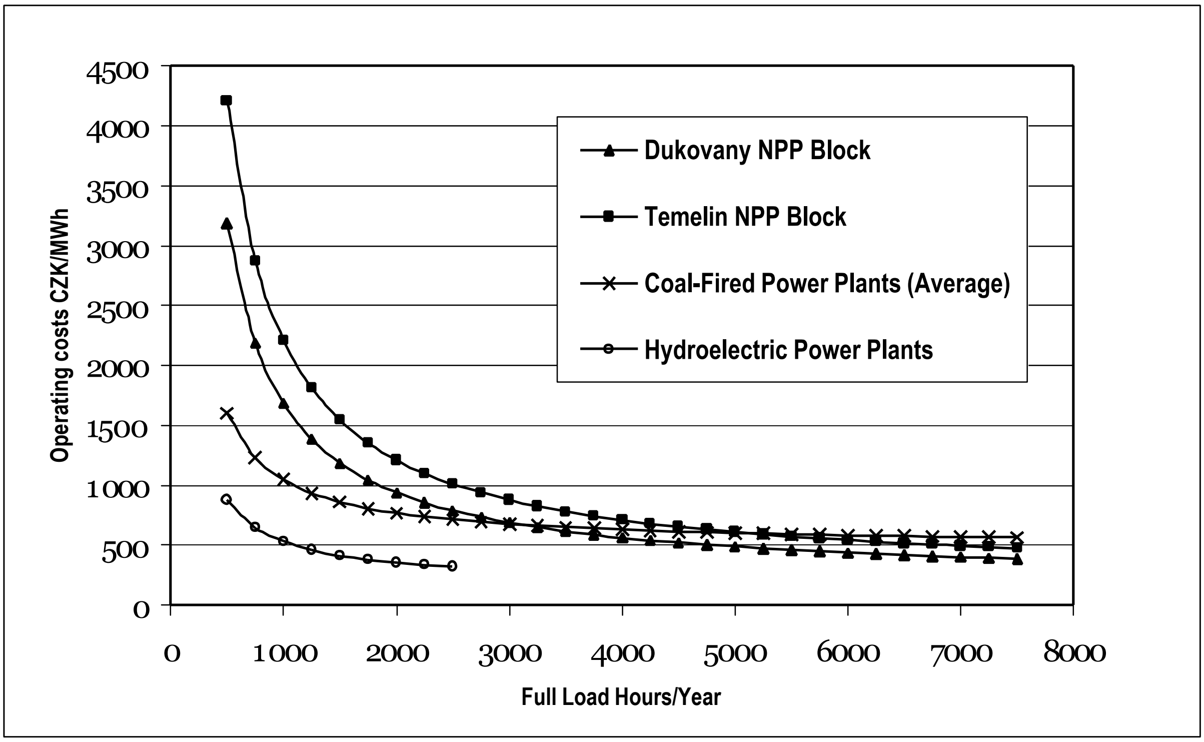

Figure 1: Operating Costs of the Different Categories of Power Plants Depending on the Number of Full Load Hours (Without Investments Costs / Depreciations)

For the revenue side the calculations were based on the following assumptions:

- Domestic sales amount to 1100 CZK/MWh which corresponds to the current price level for power supplies to the distributor companies.
- Export revenues amount to 582 CZK/MWh gross[1]. This corresponds to the revenues the CEZ is currently earning in its export business[2]. This price level at the same time represents the lower margin of the currently prevailing range of prices for the delivery of base load on European markets.

Results

Table 2 summarises the basic results of the calculations of an economically ideal form of operation of the power stations principally available to the CEZ. A central result are – as already described above – the contribution margins which can be generated for the respective scenarios. These contribution margins are employed for covering investment costs (depreciations) and any other fixed costs (administration costs etc.) which are assumed to be at a similar level in all scenarios.

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[1] According to current regulations, the CEZ does not have to pay system utilisation fees for exports, therefore the net revenues tally with the gross revenues. From an economic point of view, this rule is to be objected because, in fact, it represents a cross subsidisation of exports through the domestic customers who have to pay all system costs. In the case of an economic calculation, system utilisation fees would have to be included in the calculations because these costs do in fact incur.

[2] Source: Czech Foreign Trade Statistics 2000; current information indicate a slight decrease of the average export prices ("Hospodarske noviny", dated May 18, 2001) where an export price of 570 CZK/MWh is reported. Lower average prices (540 CZK/MWh) also result from the values indicated in the German Foreign Trade Statistics.

Table 2: Results of the Contribution Margin for the Selected Scenarios

Per Year	Unit	Reference Scenario	Scenario A	Scenario B	Scenario C	Scenario D
Sales CR	TWh	39	39	39	39	39
Export sales	TWh	9	15	9	0	0
Price CR	CZK/MWh	1100	1100	1100	1100	1100
Export price	CZK/MWh	582	582	582	582	582
Revenues CR	Mio. CZK	42900	42900	42900	42900	42900
Revenues export	Mio. CZK	5238	8730	5238	0	0
Fixed costs (O&M)	Mio. CZK	6900	8900	8900	6900	6071
Fuel costs	Mio. CZK	16164	17190	14583	12282	12282
Other variable costs	Mio. CZK	3047	3275	2883	2458	2458
Contribution margins	Mio. CZK	22,026	22,264	21,772	21,260	22,089

The results of the calculations summarised in the table above have to be interpreted as follows:

- Under current market conditions the CEZ does not make any additional contribution margins if Temelín is taken into operation – irrespectively of the fact whether it will be possible to sell the additional capacities produced in Temelín on the export markets or whether the Czech coal power plants will be replaced by the Temelín NPP while exports remain at the current level;
- If Temelín is taken into operation, additional contribution margins can only be expected if the following two conditions can be realised simultaneously:
  - The CEZ succeeds in expanding its export market shares by 6 TWh (scenario A);
  - Distinctly higher revenues than currently possible can be realised on the export markets.
- In the case that the CEZ does not succeed in expanding its market shares, which will automatically lead to the replacement of the Czech coal power plants by the Temelín NPP (Scenario B), we could even expect a slightly lower contribution margin than indicated in the Reference Scenario where Temelín is not taken into operation, independently of the price levels on the export markets. This result can be put down to the fact that the operation of the Temelín NPP, compared to the operation of the Czech coal power plants, will result in a reduction of fuel costs and other variable costs even though this cost reduction will be over-compensated by the increase in fixed costs accruing during the operation period.

The optimum entrepreneurial decision – and the decision if Temelín is to be taken into operation certainly is an entrepreneurial decision – mainly depends on the risks that have to be expected. The following categories, which will be described in detail in the following chapters, need to be taken into consideration:

- Technical risks and resulting costs related to the completion and taking into operation of Temelín.
- Risks (and chances) related to the development of the domestic market and, probably even more important, the export market.

2.2.1.3 Technical Risks

The calculations presented in the above chapters are based on the assumption

- that block 1 of the Temelín power plant is ready for operation straight away without any additional investments, and
- that block 1 of the Temelín power plant can be operated smoothly without any major problems (6000 annual full load operating hours, i.e. almost 70% availability).

These assumptions had to be made in order to be able to identify the ideal type where economic differences between the analysed scenarios do not result from differing investments but merely from divergent operating costs of the different power plant capacities (provided that operation runs smoothly as assumed in this report). It has to be noted that additional investments are necessary for the Temelín power plant; the final sum cannot yet be identified definitely. Smooth operation according to plan can be guaranteed on no account in the case of Temelín. In detail:

- ***Safe investment requirements:*** According to the documents provided by the Czech authorities CZK 2 billion need to be invested until the final completion of the two blocks, provided that the cost estimates can be met. The major part of these investments will go into block 2. According to these information the costs which would only arise in the case of the completion of the project, especially penalty payments and payments in the case of the termination of contracts, amount to almost CZK 1.5 billion. In other words, in the case of a complete termination of the project the savings on the investment side would definitely exceed any additional costs.
- ***Potentials for an increase in costs:*** There is a considerable risk that a series of problems will arise in both blocks, entailing additional costs, until the final operating permit can be obtained, especially as the Temelín power plant is based on an innovative but not yet tested design. This does not only affect the safety concept but also the conventional parts of the power plant, especially as the traditional two sets of turbines commonly used for WWER-1000-reactors were replaced by only one set. Furthermore, this is the first time that the producer company has produced a turbine with the necessary capacity of 1000 MW. Concrete potentials for an increase in costs can be identified in the following areas:
  - With respect to the safety equipment is was agreed in bilateral talks that the Temelín power plant displays a series of both serious faults and lesser defects. One major fault is the fact that necessary analyses are lacking; therefore it cannot be determined definitely which kinds of reconstruction works will be required. Based on a series of expert estimates it can be assumed that the reconstruction costs will range between approx. CZK 1 billion and CZK 4 billion (for block 1; in the case of block 2 it can be assumed that the necessary measures would only amount to 50% of the costs due to the preparation works as well as the analyses that have already been undertaken for block 1). The tremendous difference between the upper and the lower limit in the price range stated above is primarily due to the fact that urgently necessary analyses are not yet available, the results of these determining the costs.
  - As regards the machinery and the electro-technical systems the test run showed a series of technical faults; it has not yet been clarified how much it will cost to repair these faults. If it turns out during subsequent test runs that it is hardly possible or not possible at all to repair the turbine, important components of the turbine would have to be replaced which would cost between CZK 1.6 billion and CZK 2.1 billion (possibly per block), estimates based on current market prices. This does not guarantee, however, that no other problems will arise in the machine systems.
  - Due to the fact that the producer, Škoda, is partially owned by the CEZ (the rest being under state ownership) penalty payments between these two business partners are ineffective. With respect to the completion of Temelín Škoda can be regarded as „prolonged workbench“ of the CEZ.

- Even if both blocks of the power plant will be granted operating permits according to plan and without any additional costs, this does not mean that the actual operation of the plant will be as reliable as planned. One glance in the business statistics of existing WWER-1000-reactors proves that the an average capacity of 6000 full load hours per year (load factor of almost 70%), as planned by the operators and assumed in the above calculations, cannot be taken as a matter of course. In total, only 40% of the currently operated WWER-1000-reactors show an average (accumulated over the operation time) load factor of 65.5% (6000 full load hours) or more. The same number of blocks have load factors of an average of 5000 full load hours or even less. A worse performance (basically indicated by the criterion of the load factor) would have decisive impacts on the plant's economic efficiency if Temelín was to be taken into operation. With the help of the calculation model presented above it can be proven that a load factor of an average of 5000 full load hours per year (under current market conditions) would entail a reduction of the annual contribution margin by approx. CZK 400 million per year.
  Furthermore, an unreliable reactor may entail technical problems related to the fuel rods due to more frequent shut-downs and thus would result in higher fuel costs.

2.2.1.4 Market Analysis

As regards the analysis of the market risks and/or chances of the two scenarios (i.e. Temelín is taken into operation or the project is cancelled respectively) the following two aspects are decisive:

- How realistic is an expansion of sales beyond current levels?
- How realistic are noticeable price rises on the CEZ‘s export markets?

Only if both an expansion of sales – as assumed in scenario A – and the introduction of higher export supply prices are feasible can it be assumed that the operation of Temelín will result in higher contribution margins and the project would thus be economically efficient (cf. 2.2.1.2).

Estimation of the Chances for a Sales Expansion

In this respect the following aspects preventing a rapid and smooth expansion of sales have to be emphasised:

- ***low increase of domestic demand:*** Contrary to the documents provided by the Czech authorities domestic demand will not increase noticeably in the medium term for the following reasons:
  - Since 1996 electricity consumption has decreased for three years in succession in the Czech Republic; only in 2000 as slight increase by approx. 1% was registered which can be put down partially to the weather conditions.
  - Growth effects in the Czech economy, which basically lead to an increase in consumption, go hand in hand with technological innovations and structural effects (shifts from heavy industry to light industry and/or from industry to services sector and other service-related branches). This automatically leads to a reduction of the power intensity of the Czech economy which is approx. four times higher than the EU average.
  - Due to formerly very cost-efficient tariffs electrical current has advanced into the Czech heating market. This resulted in a considerable increase in electricity consumption between 1994 and 1996. The growth potential on this market has by now been fully exploited, and owing to the increasingly unfavourable tariffs it has to be assumed that electricity will continue to lose market shares in the heating market.

- ***Export market with strong price elasticity:*** With respect to the export market it has to be pointed out that the sale of additional capacities primarily depends on the prices offered. On the middle-European market, which in spite of a partial reduction of capacities still shows a surplus, market shares can only be gained through very cost-efficient prices. The CEZ 's export success over the last two years primarily is due to the cheap price conditions offered by the CEZ. As the CEZ needs to offer additional 2000 MW of base load for economic reasons if Temelín is to be taken into operation, it has to be assumed that the CEZ conditions will have to continue to orientate themselves at the lower limit of the price range. This is a stark contradiction with respect to the second condition which needs to be fulfilled if an additional contribution margin is to be generated through the operation of Temelín, namely higher prices (for detailed information see below).
- ***Limited network capacities:*** Another obstacle of a more technical nature for the expansion of export sales are the limited distribution capacities, especially to Germany, which currently prevent the delivery of additional 2000 MW band electricity (even if there was a sufficient customer stock). A few comments on this situation are presented below:
  - The physical energy flows from the Czech Republic to the Federal Republic of Germany amounted to 8,932 GWh in 2000 (sources: UCTE: http://www.ucte.org – Physical Electricity Exchange in 2000). In the statistical data of the federal central dispatcher (analogue system to UCTE) the value indicated for physical electricity exchange with foreign counties corresponds to the actual physical electricity transports and also includes, apart from exports and imports on the basis of long-term contracts and short-term agreements, any other trans-border electricity flows resulting from the operation of high voltage grid with foreign utilities, no matter whether deliveries were supplied against payment or in exchange for other goods.
  - Imports and exports according to the Foreign Trade Statistics of the Austrian Department of Statistics (ÖSTAT – Statistische Nachrichten Feb. 2001, Aussenhandel Jän.-Sept. 2000) and/or the Federal Department of Statistics of the Federal Republic of Germany in Wiesbaden (http://www.statistik-bund.de, http://www.vdew.de – Aussenhandelsbilanz 2000, 26.2.2001) are exclusively exports and imports of electrical energy agreed upon by contract. These exports of electrical energy from the Czech Republic to the Federal Republic of Germany as specified by the Foreign Trade Statistics amount to 1,614 GWh. As the physical flows of energy are higher than the flows agreed upon by contract by a factor of 5, the cross-border transmission lines are strained to an even greater degree.
  - According to ETSO, the Association of European Transmission System Operators, the net transmission capacity[3] of the CENTREL network area (http://www.centrel.org) to Germany is reported to be 2250 MW. According to the UCTE the physical energy flows from Poland and the Czech Republic (CENTREL network area) to Germany, for instance on December 15, 2000, at 11:00 p.m. (CENTREL network area) amounted to 1990 MW which is close to the net transmission capacity.
  - In fact, according to information of the UCTE, there are already shortcomings in the CENTREL network areas due to auctions. For 2001, on the occasion of an auction for the transmission of 682 MW from the Czech Republic to Germany a price of 4380 €/MW was obtained (corresponding to 5000 hours in approx. 30 to 40 CZK/MWh). These costs incur in addition to the 30 CZK/MWh which have to be paid as import fees in Germany.

  By way of summarising it can be concluded that even at present there are certain limits with respect to the supply capacities which result in a considerable increase in costs for the import companies (increase of approx. 20%). A noticeably increased amount of deliveries from the Czech Republic to Germany does not seem to be feasible due to network

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[3] Net transmission capacity means the maximum level of transmission between two network areas; main precondition is that the safety standards are met in both areas and technical uncertainties with respect to future network conditions are taken into account.

restrictions. It can be excluded at any rate, that the production capacity of one single Temelín block could be fully exploited for export purposes. Therefore, Czech operators have already introduced plans to expand the network capacities for deliveries to Germany. In this respect it has to be mentioned that the construction of additional supply capacities, which would not be necessary if Temelín was not taken into operation, would have to be counted among the additional costs for the Temelín NPP from an economic point of view.

- ***Re-Imports:*** Under current market conditions, the most decisive obstacle for an expansion of sales through additional exports is the problem of re-imports; thus the CEZ will gain market shares abroad but at the same time will run the risk of losing these shares again on the domestic market. Such re-imports are possible only because electricity exports have been liberalised whereas domestic prices in the Czech Republic are self-regulatory. Due to the fact that distributor companies obtain a cheaper price for supplies from abroad than for the CEZ deliveries (approx. 1100 CZK/MWh) it is possible that these deliveries in fact do not leave the country but are re-sold by the recipient to the Czech distributor company upon payment of an additional fee. The winner is the „importer“ abroad and the respective distributor company, while the CEZ is the loser. Apart from an expansion of industrial domestic supply systems, the problem of re-imports was the main reason why the CEZ’s market share in the Czech Republic has decreased from 80% to 65% between 1996 and 2001[4]. In principle, there are two ways of preventing re-imports:
  - By regulating the electricity exports, especially by prohibiting electricity imports under such conditions: Such a regulation would not comply with EU laws and thus would only have a limited life span;
  - By effecting a comprehensive liberalisation of the domestic electricity market: This would result in an adaptation of the domestic price level to the levels of the middle-European electricity market which would lead to a reduction of the domestic price levels under current market conditions – with the effect of a reduction of sales for the CEZ.

Estimation of the Price Development on the Middle-European Electricity Markets

Currently, the range of prices for the delivery of base load on the European markets – depending on „quality“ of the delivery (especially with respect to the time between the conclusion of the contract and the delivery) – ranges between 600 CZK/MWH and 860 CZK/MWh; at this level no or only minor additional contribution margins could be generated (after deduction of the Czech system utilisation fees) if Temelín was to be taken into operation as proved by the above calculations.

In the last few months a slight increase of the level of electricity prices could be observed due to higher costs for fossil sources of energy; principally there is the chance that if Temelín is taken into operation – provided the entire production of Temelín could be sold – it would be possible to earn additional contribution margins on the medium term which, from an economic point of view, would be preferable to cancelling the project.

However, it has to be objected that:

- Experts agree[5] that a series of factors prove that (at least on the medium term) a stabilisation at the current level, possibly entailing further price increase for fossil sources of energy, would only result in a slight increase of the electricity prices, especially for the delivery of base load. This includes:

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[4] Source: CEZ Business reports 1996-2001: www.cez.cz

[5] e.g.: European Commission: European Energy Outlook to 2020, November 1999, Cambridge Energy Research Associates: The CERA Study, Paris 2000; Kreuzberg, M.: Spotpreise und Handelsflüsse auf dem europäischen Strommarkt, ZfE, 1/99; Riechmann, Ch.: Preisentwicklung in einem liberalisierten Strommarkt, ZfE, 1/99

  - further considerable surplus capacities (part of the capacity reductions will be compensated by enforcing international network relations and reducing the prescribed reserves);
  - further potentials for liberalisation in important electricity markets such as France and Italy;
  - expected intensification of the electricity trade due to the termination of long-term supply contracts, through the establishment of cross-border fees and the establishment of additional electricity stock exchanges;
  - impending liberalisation of the natural gas sector which plays an important role for electricity production and, together with the increasing emancipation of natural gas prices from oil prices, has a weakening effect for price development.
- Even if a more rapid increase of the electricity prices for the delivery of base load would occur than could be expected by market analyses it should be considered
  - that the CEZ will not be in a position to increase the prices for its own deliveries to the full extent because it is obliged to acquire greater market shares;
  - that price increases will also result in an increase in competition on the market; though on a widely liberalised market the competitiveness of Temelín will be limited, especially compared to other more flexible power plants located close to the customer (especially in the industry).

2.2.2 Ecological Impacts of the Different Scenarios

Apart from the economic effects of the different scenarios, their ecological impacts have to be taken into account as well in a comprehensive EIA. Only after having compared the respective economic and ecological effects will it be possible to draw conclusions for the assessment of alternative options.

For that reason, the most import environmental impacts were investigated for the scenarios presented above – again with the help of the GEMIS model for the Czech Republic. Table 3 summarises the results.

Table 3: Important Environmental Impacts of the Analysed Scenarios

Per Year	Unit	Reference Scenario	Scenario A	Scenario B	Scenario C	Scenario D
SO_2-equivalent	t	84,113	84,313	69,452	61,836	61,836
CO_2-equivalent	Mio. t	39	39	32	29	29
Radioactive waste	t	54	78	78	54	54

As was to be expected scenario A (Temelín is taken into operation and the market share is expanded) is the least favourable scenario from an ecological point of view due to the fact that in this case radioactive waste will be generated but the level of air pollution and CO_2 emissions would not be reduced. In scenario B the levels of air pollution and/or CO_2 emissions will be reduced at the cost of higher amounts of nuclear waste; from an ecological point of view, however, scenario C and D (reducing production to domestic demand levels) would be even more favourable. It has to be pointed out that scenario D (reducing the block of fixed costs by shutting down reserve capacities which are not necessary in this scenario) provides the same economic advantages at present market conditions as scenario A which seems feasible only if the best possible availability is expected.

2.2.3 Conclusions from the Economic-Ecological Analysis

If Temelín is taken into operation the CEZ has to pursue a strategy of sales expansion for economic reasons. If it succeeds in doing so – which will meet with considerable obstacles as described in section 2.2.1.4 – this scenario will be the most disadvantageous from an ecological view. It will not be possible to secure an economic advantage over the reference scenario (current production structure) or a scenario of reducing the production to the level of domestic demand as the increase of the price levels on the export markets necessary for such a development cannot be guaranteed from today‘s view.

If an expansion of sales cannot be guaranteed, which would lead to a replacement of the Czech coal power stations, we have to expect serious economic disadvantages if Temelín is taken into operation (even if the considerable technical and market-related risks are neglected) both in comparison to the reference scenario (existing production structure) and the scenario of production linked to domestic demand.

In spite of the fact that the overall project of the Temelín power plant (including all investment costs) is a very unprofitable project which will continue to be a burden on the Czech economy for a long time, it has to be pointed out

- that taking Temelín into operation will not secure any economic advantages under the current market situation because no additional contribution margins will be generated;
- that this option shows considerable technical and market-related risks compared to the „zero variant“;
- that if Temelín is taken into operation air pollution will not be reduced (and if, only at the cost of a deterioration of economic performance); hence taking Temelín into operation has to be regarded as the least favourable option from an ecological point of view;
- that this option also increases the nuclear risks.

The EIA documents presented in April partially also present similar conclusions even though these conclusions were neither described in detail or in a transparent fashion nor were they corroborated with facts.

2.3 Detailed Criticism of Different Aspects of the Documents Presented

In the following sections several assertions on the assessment of alternatives presented by the Czech authorities will be investigated in detail. We will concentrate on statements presented in the documents on power consumption development in the Czech Republic, on the amount of losses if Temelín is not taken into operation, on privatisation revenues, on occupation effects and the expected CO_2 trade.

2.3.1 Costs and Benefits if Temelín Does not Go Into Operation

2.3.1.1 Direct Amount of Loss

In the documents provided by the Czech authorities (handed in later by the Czech Ministry of Foreign Affairs) it is indicated that a damage at the amount of CZK 117.4 billion would arise for the power plant operator CZK if Temelín is not taken into operation; according to these documents the damage would include the following elements:

1. Investments already realised at the amount of CZK 91.7 billion;
2. Orders already taken (investments currently in progress) at the amount of CZK 4.9 billion;

3. Fuels, operating resources and spare parts etc. already purchased at the amount of CZK 6.5 billion (for the nuclear fuels alone approx. CZK 4.7 billion)
4. Special payments/costs which will only become effective if Temelín is not taken into operation at the total amount of CZK 14.4 billion[6], including in detail:
    - Liquidation of the building site equipment: CZK 2.2 billion
    - Dismantling of already active parts of the power plant, i.e. the entire block 1: almost CZK 8 billion;
    - Costs arising from the non-fulfilment of contracts, cancellations etc.: almost CZK 1.5 billion;
    - Transformer station and lines constructed for the Temelín plant: CZK 2.7 billion

Based on the results of the comparative economic assessment of taking (or not taking) Temelín into operation (cf. 2.2.1.2) it has to be pointed out with respect to this cost overview:

- Any costs related to the investment and the subsequent operation of the plant (also the costs indicated above under points 1 to 3) are economically valuable only if they generate additional contribution margins (if Temelín goes into operation). As has already been indicated it is not very probable and linked with great risks that additional contribution margins will indeed be generated if Temelín is taken into operation. To put it blankly: Damage has already incurred not matter whether Temelín is taken into operation or not! As it is not very probable that the conditions necessary for generating positive economic effects if Temelín goes into operation can in fact be achieved, the funds that have already been invested and are already tied up must not be regarded as damage which would arise if Temelín was not to be taken into operation.
- With respect to the cost elements indicated under point 4, it is important to distinguish in detail:
    - The liquidation of the building site equipment is part of the investment costs[7]. These costs would arise at any rate, no matter whether Temelín is taken into operation or not, and thus cannot be regarded as „damage“ which would arise if Temelín was not to be taken into operation.
    - The dismantling costs will arise in any case. In absolute values it has to be assumed that the dismantling of the Temelín power plant in its present state, i.e. with only low activity, is much more cost-efficient that the dismantling of a power plant which has already been in operation for several years. In this respect it is important to take into account the time of the dismantling. Dismantling the plant at the present point in time (and costs at the amount of almost CZK 8 billion can only be interpreted as costs for an immediate dismantling) would be less favourable from an economic point of view than a dismantling at the end of the technical life time of the Temelín plant. It is not necessary to dismantle the already active parts immediately after the plant is shut down. This would not be advisable because the level of radioactivity in the reactor decreases over the time and the dismantling would be much easier from a technical view and thus, also much more cost-efficient if it would take place at a later point in time. In practice, the Temelín power plant would remain an industrial object for some time if it was decided that the plant is not to be taken into operation and/ or preserved – such as is planned for the closure of the

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[6] In the documents provided by the Czech authorities costs at the amount of CZK 11.6 billion are indicated for this position; this amount, however, does not tally with the values indicated for the different cost factors.

[7] It does not shed a very positive light on the quality of the calculation of the investment costs if this cost factor was obviously ignored.

plant at the end of its technical life time[8]. For that reason it is not admissible to declare the dismantling costs as a damage arising only if Temelín does not go into operation.

  - Both the transformer station and the lines constructed for the Temelín plant can be used in the medium term no matter whether Temelín does or does not go into operation. For that reason no damage will arise from not taking Temelín into operation.
  - Hence, if Temelín does not go into operation merely those costs, which would arise only in that case, can be regarded as potential damage. These are the costs for penalty payments and cancellation payments at the amount of almost CZK 1.5 billion. It has to be pointed out that the amount of these costs still has to be determined in detail.

By way of conclusion it can be assumed that the economic damage of not taking Temelín into operation – i.e. the sum of all costs and/or declines of earnings arising only if Temelín does not go into operation – will probably amount to a maximum of CZK 1.5 billion.

2.3.1.2 Benefits of Not Taking Temelín into Operation

By comparison, the following benefits are to be expected if Temelín does not go into operation:

- According to the documents presented by the Czech authorities, costs of CZK 2 billion in outstanding (i.e. not yet booked) investments would be saved if Temelín did not go into operation.
- In addition, there would be no risk of further cost overruns with regard to the completion of the project; such a risk can currently not be excluded, given the need for safety upgradings and the fact that in the conventional part, additional costs might incur in particular when upgrading the turbine (for details, see 2.2.1.3).
- Furthermore, considerable revenues could be achieved by selling production facilities (or, to a limited extent, by selling parts of the system) – unless, of course, a decision is made to conserve the plant.[9]

2.3.1.3 Conclusions

By way of conclusion, one can say that – in contrast to the line of argumentation followed in the documents presented by the Czech authorities – the utility CEZ should not have to expect any losses if Temelín does not go into operation. On the contrary, it can be expected in this case, that the economic benefits would surpass any losses. This is above all attributable to the fact that, given current market conditions, the power plant operator's earnings would not grow if Temelín went into operation, which means, in other words, that under these conditions investments in the NPP Temelín are of no value. They would only be of value in one of the specified scenarios, if the following two conditions were met at the same time (and this potential value would then correspond to the extent of the economic loss which would have to be expected if the plant did not go into operation under these circumstances):

- the CEZ expands its sales in equal proportion to its power production in Temelín and
- at the same time sharply drives up electricity prices.

As we have already demonstrated, it is very improbable that one of these two conditions is met, which makes it all the more unlikely that both conditions – which even contradict each

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[8] In this respect the documents provided by the Czech authorities refer to a study approved by the SUJB entitled „Outline of the Form of Shutting Down the Temelin Power Plant and Estimation of Costs“ (Energoprojek Prag, 1999).

[9] In this context, revenues will certainly be generated from spare parts already procured and from operating media. Fuels for the NPP Temelín have a special configuration. It cannot be excluded, however, that buyers may even be found for these special fuels.

other to a certain degree – should be met at the same time (for details, see 2.2.1.2). Aside from this crucial aspect, also according to the documents presented by the Czech authorities, other costs, which would only be accrued if the plant does not go into operation (above all contractual penalties, payments connected to dismissals) will be lower than the cost savings and/or additional revenues which would result if the project was terminated.

2.3.2 Privatisation Revenues

The documents provided by the Czech authorities (which were handed in later via the Czech Foreign Ministry) state that the value of the CEZ would decrease dramatically if Temelín did not go into operation.

In this context, one must point out that the entire Temelín investment project has already substantially decreased any to-be-expected privatisation revenues for the CEZ. As it is very unlikely to expect additional contribution margins if Temelín goes into operation, the currently possible privatisation revenues – compared to a scenario where Temelín would not have been constructed at all – have already been reduced, on principle, by the funds invested in Temelín. It would even have been possible that the CEZ had invested these funds in a profitable way, which would have created a clearly more favourable situation for the privatisation of the CEZ. All in all, one can assume that the construction of Temelín has generated costs for the Czech government of between CZK 70 billion and CZK 150 billion, via a reduction of privatisation revenues (this amount roughly corresponds to the forecast for the 2001 budgetary deficit).[10]

Even if these actual losses are not taken into consideration, it is – from a current point of view – by no means certain that privatisation revenues would be higher if Temelín went into operation than if the project was conserved or terminated. Apart from business strategy aspects, the purchase price of an enterprise – as seen by the investor – is determined above all by the earning capacity value, i.e. by the future earnings expected for the respective enterprise. The book value only plays a minor role.

As we have been able to show that taking Temelín into operation under the current market conditions would not improve the profitability of the CEZ (see 2.2.1.2), there is no reason to assume that privatisation revenues would be higher if Temelín went into operation than if it did not. In fact, one must assume that, in the case of the CEZ, the level of privatisation revenues will mainly depend on the strategic considerations of potential investors (market development, synergies with the investor's existing mix of power plants, etc.)

It is even likely that if Temelín went into operation too fast, investors would make deductions from the purchase price due to potential risk, as it is them, after all, who would have to take over the reliability-related technical risks as well as the risks of potentially necessary technical/safety upgradings. All these risks do not exist for the investor if Temelín does not go into operation in the first place.

It must be pointed out in this context that the accounting-related consequences of not taking Temelín into operation, according to the documents presented by the Czech authorities (one-time write-off of total capital invested, either directly or via setting up a liability reserve) could be solved after successful privatisation. As a matter of fact the book value of the enterprise by far exceeds the actual market value, as the book value continues to include the unprofitable investments made in Temelín. As one must assume – as we have shown – that no additional cash flow would be produced for the enterprise if Temelín went into operation, the accounting measures described above (one-time write-off) only serve to reduce the enter-

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[10] The lower of these two values results from the fact that the attractiveness of entering the Czech market compensates, in part, the unprofitable investments made in Temelín (strategic consideration); the higher value is base on a comparison with a scenario where the CEZ would have used its funds with high profitability.

prise's excessive book value to an adequate level. A "depreciation" in terms of accounting would be necessary in any case. One can assume that potential buyers of the CEZ are aware of this fact and will consider it in their bids.

2.3.3 Impact on the Employment Situation

The documents submitted by the Czech authorities (which were handed in later via the Czech Foreign Ministry) state that

- 5000 persons would lose their jobs if the Temelín project was discontinued (of which 1500 currently employed by the CEZ and the remaining 3500 employed by manufacturers and suppliers);
- a possible "replacement effect" – i.e. a decrease in the utilisation of coal power plants once Temelín will take up operation – would make around 3500 to 6000 persons jobless in the region of northern Bohemia; and that
- at the same time, however, additional infrastructure measures (road construction, renovation of panel buildings, etc.) would create around 8500 new jobs in northern Bohemia.

From an economic point of view, this line of argumentation contains a series of inconsistencies. Its basic errors are the following:

- As – at least according to the documents presented by the Czech authorities – the NPP Temelín is close to being completed, the chances that a discontinuation of the project might have a negative effect on employment are extremely marginal. If Temelín does not go into operation, this would have consequences only for part of the CEZ's staff.
- If the infrastructure measures planned for the region of northern Bohemia are seen in direct relation to the negative effects on employment that are expected if Temelín goes into operation – as suggested in the documents submitted by the Czech authorities – the costs of these infrastructure measures – set off against the expected benefits, of course – would have to be attributed to the fact that Temelín takes up operation. No direct relation can be assumed, however, between the implementation of the infrastructure measures mentioned above and the question whether Temelín goes into operation or not. In fact, from the point of view of economic policy, it would be absolutely inappropriate to link these measures, if they turn out to be useful on principle, to the question of whether Temelín goes into operation or not.

As a matter of fact, one must assume that, according to the values contained in the documents presented by the Czech authorities, a serious effect on employment can neither be expected in either of the two scenarios. If Temelín takes up operation, the actual effect on employment depends, above all, on the question of whether this would lead to a replacement of coal power plants. If sales expand accordingly, however, this might not be the case, as this would even have a slightly positive effect on the employment situation, creating around 1500 additional jobs (compared to the reference scenario of the current production structure). If sales do not expand, however, the contrary effect would have to be expected: 2000 to 4500 jobs would be lost.

It is essential, however, to point out that the entire Temelín investment project will certainly have a negative overall effect on employment. It is one of the basic findings of macroeconomics that government interventions which contribute to the realisation of otherwise unprofitable projects may, in the short term, create jobs under certain circumstances, but will in the long and medium term represent a burden on the economy, causing employment to contract permanently.

2.3.4 Sale of Emission Credits

The documents submitted by the Czech authorities (which were handed in later via the Czech Foreign Ministry), state in several passages that

- taking Temelín into operation would contribute essentially to reaching the Kyoto objective defined for the Czech Republic; and that
- as soon as Temelín will be in operation, considerable income might be generated from emission trading (in concrete terms, possible income is estimated at CZK 2 billion per year).

This line of argumentation must be commented as follows:

- Should this argumentation refer to the project-related Kyoto instruments ("Joint Implementation" in the case of the Czech Republic) one must point out, in addition, that international negotiations have reached a relatively broad consensus, stating that joint implementation projects are not admissible for nuclear power plants.
- Regarding the possibility of emission trading provided for in the Kyoto Protocol, one must point out that not even the most fundamental concrete framework conditions have been established so far. This is true at the EU level, where a Green Paper is currently being discussed, but all the more so at the international level. As the framework conditions for emission trading are therefore still completely uncertain, any assumptions on the possible future value of CO_2 emissions must, for the time being, be considered pure speculation.
- If Temelín goes into operation, this does by no means automatically imply that the Czech Republic would be able to reach its Kyoto objective:
    - As for the power supply system itself, we have shown that the only scenario in which the operation of Temelín would potentially – even with a strongly limited probability – have a positive economic impact would be the one where sales would expand in direct proportion to Temelín's entire power generation (scenario A, see details in chapter 2.2). In this scenario, CO_2 emissions would not be reduced vis-à-vis the reference scenario.
    - In contrast, reducing production to the domestic demand level (scenarios C and D) would reduce CO_2 emissions almost to the same extent as assumed in scenario B (replacement of coal power plants by Temelín, in this case calculated for both blocks, for details see 2.2.2).
    - What is even more important is that any emission-reducing effects which are based on a fuel switch (such as in scenario B, where coal might be replaced by nuclear fuels) will quickly be exhausted by growth effects. This refers not as much to possible – even if currently not very probable – growth effects in electricity consumption (for details see 2.3.5) as to real consumption growth, in particular in transportation and also, to a lesser extent, with regard to buildings.

With regard to the argumentation contained in the documents presented by the Czech authorities on the question of income on CO_2 tradings we may can summarise that owing to the complete lack of framework conditions one cannot find a good reason, from an economic point of view, to explain why a current decision for completing Temelín and taking it into operation should be based on a highly uncertain source of income (both in terms of time and volume). In addition, let us point out once again that a cost-efficient climate protection policy – as a basis for possible future CO_2 tradings – must first of all be positioned on the demand side, as emission-reducing effects caused by fuel switch measures do not have a permanent impact. However, particularly in the Czech Republic, there is still enough room for manoeuvre on the demand side, as becomes obvious when considering the current values reported in energy intensity in general and electricity intensity in particular (for details see 2.3.5).

2.3.5 Developments in Electricity Consumption

The documents submitted by the Czech authorities (handed in in May 2001 via the Czech Foreign Ministry) state that the annual growth in domestic power demand will amount to around 5% by 2005, which corresponds to a rise by around 10 TWh (production in the two Temelín blocks comes to around 12 TWh according to plan). This is to show that excess production in Temelín would quickly be absorbed by a rise in domestic demand.

Aside from being in contrast to the statements given in the above-mentioned documents, which forecast that the environmental burden caused by air pollutants and CO_2 emissions would be reduced if Temelín goes into operation as coal power plants would be replaced, this argumentation must be criticised for two reasons:

- On the one hand, it seems to be highly improbable for a number of reasons that domestic power demand will grow to the extent mentioned in these documents.
- On the other hand, in a market which is being liberalised (and this also holds true for the Czech market at the moment), domestic electricity demand will no longer play the same role as in a monopolised market. Instead, the market growth of the entire region (in this case of the central European electricity market) and the supplier's competitiveness are more important market parameters. In a liberalised electricity market it is therefore by no means certain whether CEZ deliveries will be able to cover any additional demands occurring in the Czech Republic.

2.3.5.1 Realistic Development of Electricity Consumption in the Czech Republic

Economic Growth

The only reason for the expected annual 5% rise in electricity consumption (as of 2001) given in the documents presented by the Czech authorities is the expected development of the Czech economy. It is true that the Czech economy, after three years of recession, again posted a positive growth in 2000. The main pillar of its 3.1% growth (in real terms) were lively investment activities (with gross fixed capital formations, which in turn were mainly supported by foreign direct investment, going up 5.2%). In contrast to the worldwide trend of slowing growth, it is expected in general that economic growth in the Czech Republic will accelerate slightly this year and in 2002. The OECD, the Czech Ministry of Finance, and foreign banks expect a rise by between 3% to 4% over the next three years (see table 4).

Publicly available economic forecasts all show growth rates of below 4% for the next two years. The Czech Ministry of Finance published growth rates of just under 4% in its Economic Outlook for the period up to 2004.

Table 4: GDP Growth and GDP Forecast

	1998	1999	2000	2001*	2002*	2003*	2004*
OECD (May 2001)	-2.2	-0.5	3.1	3	3.5		
WIIW (Feb 2001)		-0.8	2.7	3	3.5		
Czech Ministry of Finance (2001)	-2.2	-0.8	3.1	3.5	3.8	3.8	4
Bank Austria (Mai 2001)	-2.2	-0.2	3.1	3.3	3.8		
				Forecast*			

Source: OECD 2001, WIIW 2001, Czech Ministry of Finance 2001, Bank Austria 2001

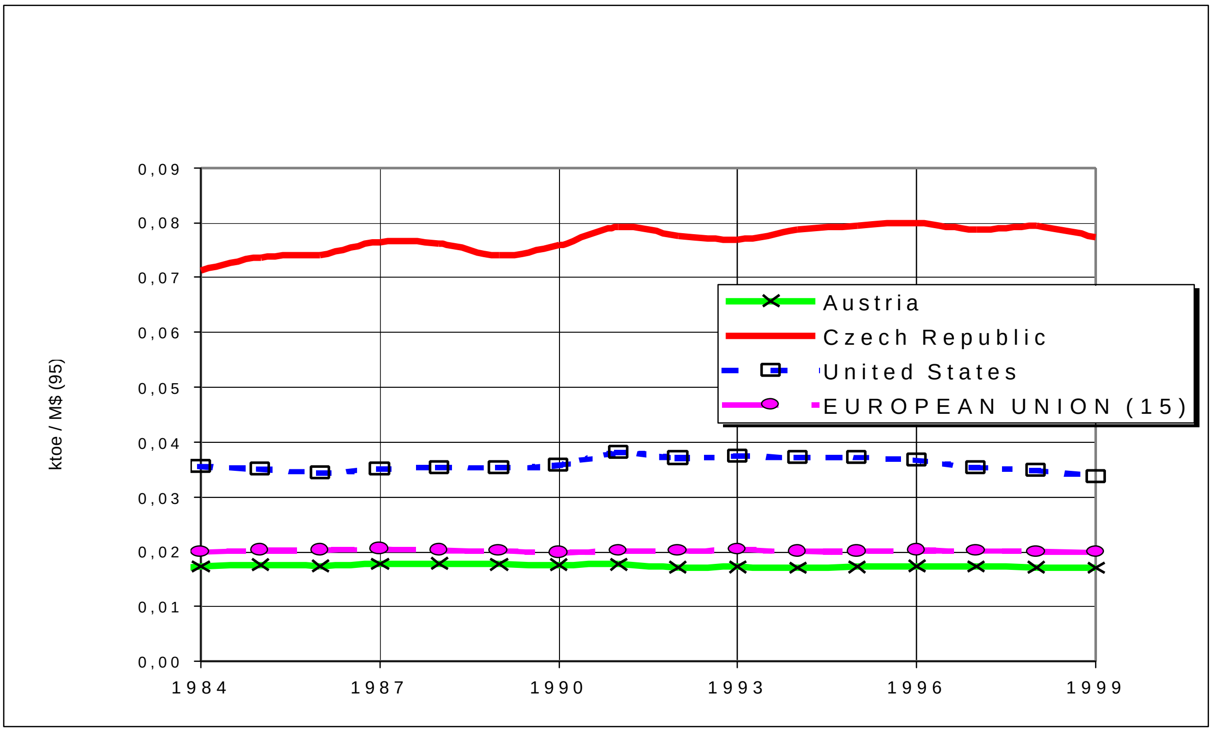
Based on the available economic forecasts and in connection with the forecasts on electricity demand presented by the Czech authorities we may, in a first step, make the following observations:

- Even if the growth rates in electricity consumption develop in parallel to GDP growth rates – which would mean, in fact, that a highly improbable growth scenario without structural effects would be realised –, it is not possible that electricity consumption will grow by the factor of 5% as stated in these documents.
- Long-term GDP forecasts, as suggested in the documents presented by the Czech authorities, do not exist in reality. Even a 4-year forecast, as the one by the Czech Ministry of Finance, produces extremely uncertain results. Let us just recall, in this context, that no GDP forecast from the mid-90s predicted the subsequent recession. Currently, the Czech economy is characterised by a number of risk elements that might have a sustained negative effect on growth. One of these factors is, in particular, the dramatic growth of the public deficit over recent years. The unprofitable investment in Temelín represents a considerable additional burden on the public household (as it reduces privatisation revenues).

Structural Effects

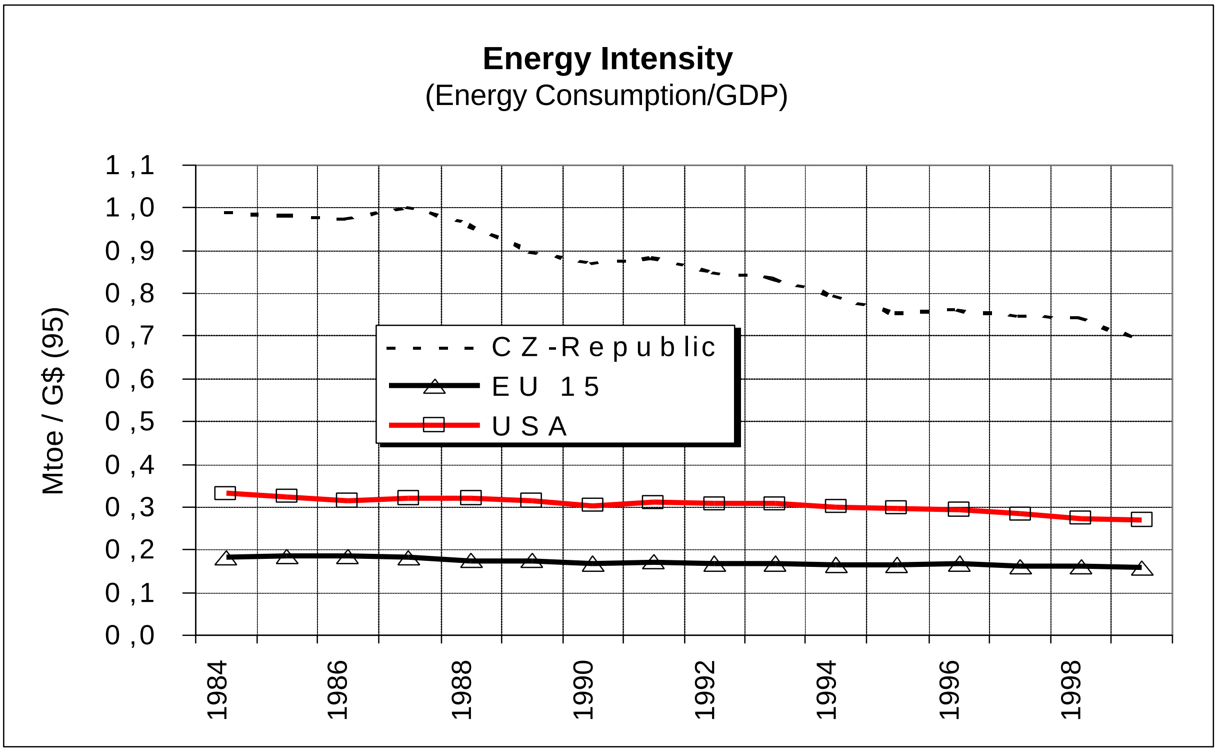
The electricity consumption forecast presented by the Czech authorities becomes entirely implausible if, aside from the quantitative aspect of economic growth, we include in our analysis the qualitative aspects of new technological innovation and structural effects, which will both be accelerated in particular by economic growth.

In this case, we can assume that electricity intensity (electricity consumption/GDP) in the Czech economy is considerably higher than the EU average. Since the beginning of the 1990s, electricity consumption in relation to economic performance has been three times higher in the Czech Republic than the EU average. Furthermore, this trend does not seem to be changing significantly, which is in contrast to the development of overall energy intensity (total energy consumption/GDP) (see figure 2 and figure 3).



Source: Enerdata s.a.- World Energy Database, Grenoble 2001

Figure 2: Development of Electricity Intensity in the Czech Republic



Source: Enerdata s.a.- World Energy Database, Grenoble 2001

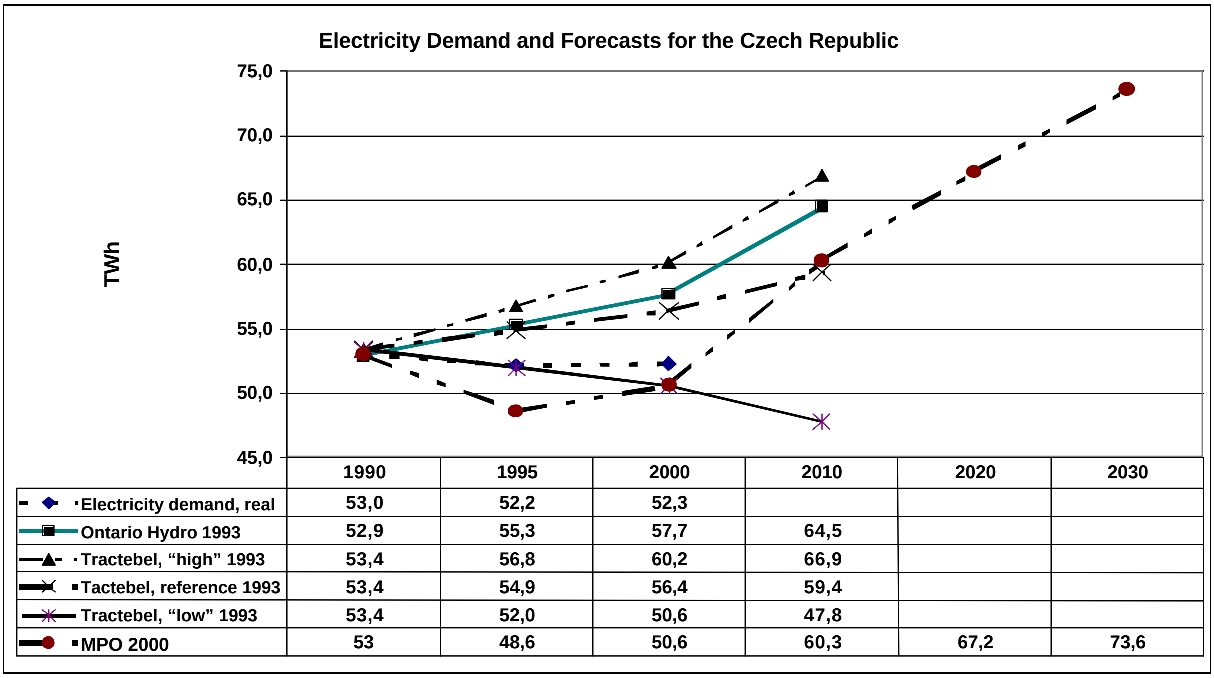
Figure 3: Development of Overall Energy Intensity in the Czech Republic

The continuously high values in electricity intensity largely result from the fact that electric heating systems are extremely widespread in the Czech Republic (a particular uptrend has been observed in the second half of the 1990s). The dominant strategy of Czech utilities, in cooperation with the CEZ, has been to counterbalance the slump in power demand in trade and industry by widely promoting the use of inexpensive electric heating systems. However, the growth potential in the space heating market has meanwhile been exhausted. As tariffs are constantly rising – for economic reasons, it was not possible to maintain the cheap "market introduction tariffs" for long – one must, in fact, assume that electricity has begun and will continue to lose market shares in the Czech space heating market.

In combination with technological innovations brought about by investment activities and with structural effects (shifts from heavy industry to light industry, and from industry to services and services-related branches) the expected losses in space heating market shares will cause the development of electricity consumption to considerably lag behind the economic development itself, which means that developments in electricity intensity will gradually adapt to the pattern observed in the development of overall energy intensity.

Frequency of Accurate Electricity Consumption Forecasts in the Past

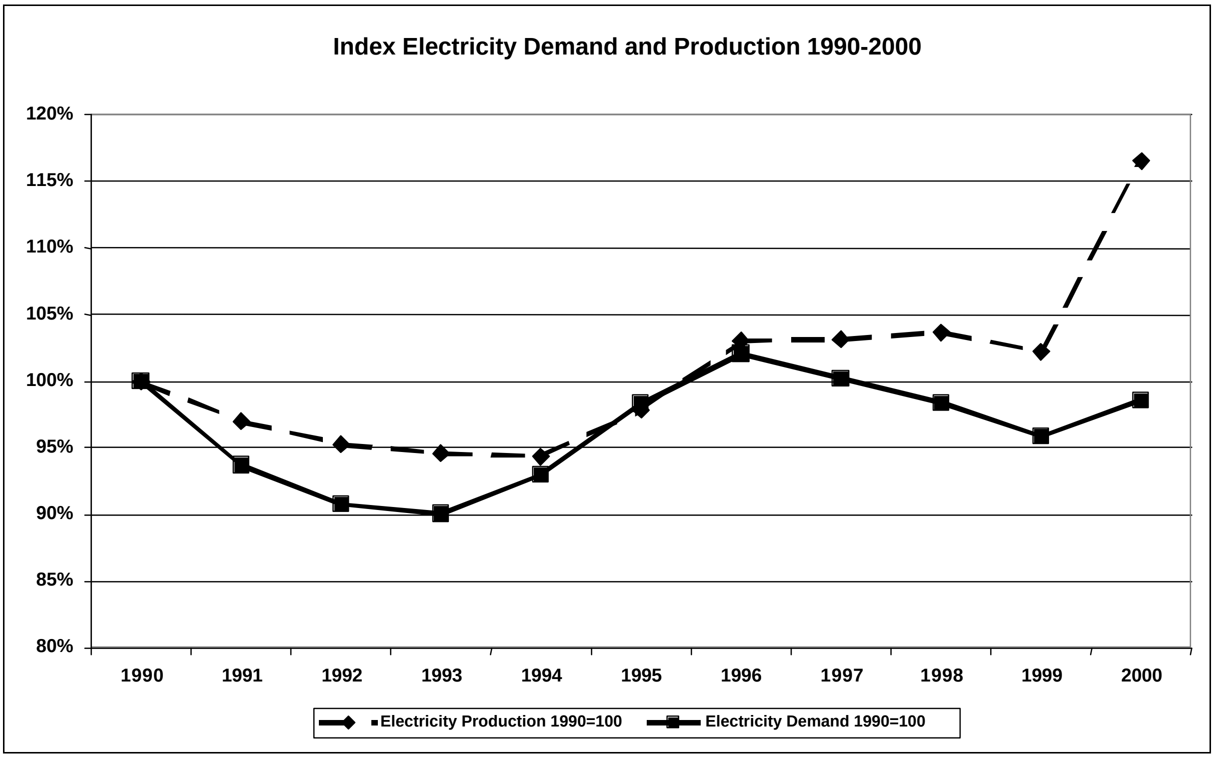
Since the beginning of the 1990s, relevant electricity consumption forecasts have been available for the Czech Republic. For instance the Canadian company Ontario Hydro compiled a forecast of electricity consumption in the Czech Republic until 2010, based on an electricity forecast by the Belgian company Tractebel. The deviation rate of Ontario Hydro's forecast from the reference scenario established by Tractebel is below 1%. The forecasting value for electricity consumption in 2010 is 10% lower than the scenario "high" (72 TWh) and 22% higher than the scenario "low" (53 TWh) provided by Tractebel. The forecasts by both companies were used to justify the completion of the NPP Temelín in the beginning of the 1990s (see figure 4).



	1990	1995	2000	2010	2020	2030
Electricity demand, real	53,0	52,2	52,3			
Ontario Hydro 1993	52,9	55,3	57,7	64,5		
Tractebel, “high” 1993	53,4	56,8	60,2	66,9		
Tractebel, reference 1993	53,4	54,9	56,4	59,4		
Tractebel, “low” 1993	53,4	52,0	50,6	47,8		
MPO 2000	53	48,6	50,6	60,3	67,2	73,6

Source: Czech Ministry for Industry and Commerce (MPO) 2001, EVA 1994

Figure 4: Electricity Consumption Forecast for the Czech Republic as of the Beginning of the 1990s



Source: Czech Ministry of Industry and Commerce 2001

Figure 5: Development of Electricity Demands and Electricity Production in the Czech Republic

In reality, electricity demand in 2000 almost reached the 1990 value, thus corresponding best to the low demand scenario put forward by Tractebel. Real developments therefore prove that the electricity forecasts from the early 1990s, which were used as major arguments to support the completion of the NPP Temelín, were in fact incorrect.

In spite of a stagnating demand, production has been constantly going up since the end of the 1990s, which is basically due to a dramatic rise in electricity exports (see figure 5).

Conclusions for a Realistic Development of Electricity Consumption

Based on the one hand on the expected economic development and, on the other, on the qualitative consequences of the expected acceleration in the economic upturn (technological innovations and structural effects, accompanied by a loss in market shares in the space heating market, which up to now sufficed to compensate the reduced consumption in industry and trade), it must be pointed out that an annual growth in electricity consumption by 5%, as mentioned in the documents presented by the Czech authorities, is totally unrealistic. In fact, it must be assumed that in particular the expected development of economic growth will gradually reduce electricity intensity. This means that in the next few years, we may very likely expect a slight rise in electricity consumption (by 1% to 2%). It cannot be excluded, however, that the period of zero growth in electricity demand is going to continue.

2.3.5.2 The Role of Electricity Consumption Forecasts in Liberalised Markets

The importance which is in general attributed to country-specific electricity consumption forecasts is based on monopolised markets, where single providers must meet the demand at the lowest possible cost. It must be pointed out, however, that given the ongoing liberalisation and opening of electricity markets, country-specific electricity consumption forecasts are becoming less and less important as a basis for investment and operating decisions. Instead, market analyses for larger regions (in this case, the central European electricity market) and analyses on the competitiveness of certain suppliers will play a more important role.

In other words: Even if there is a high increase in electricity demand in the Czech Republic, this does not automatically mean that, given completely open markets, sales by the CEZ would go up proportionally. The past three years have already shown that – even in an only moderately liberalised electricity market – the CEZ continuously lost market shares in the Czech Republic (1996: 80%, 2000: 65%; see figure 6). An essential reason for these losses are rising imports by distribution companies. Until a few years ago, these companies purchased their electricity exclusively from the CEZ. Owing to the partial liberalisation of the Czech electricity market, it has become more profitable for those companies which are partly owned by foreign electricity utilities, to cover major parts of their electricity procurements via imports rather than buying electricity directly from the CEZ. The loss in domestic market shares has significantly reduced the CEZ's revenues (for details see 2.2.1.4)[11].

In a completely liberalised electricity market, one may therefore not exclude the possibility that the CEZ might have to face further losses in domestic market shares, which will be difficult to compensate by gaining shares in foreign markets. In this context, the following aspects are of importance:

- A complete liberalisation of electricity markets would relatively quickly cause the currently regulated prices in the domestic market to adapt to the price level dictated by electricity exports. This will cause revenues for the CEZ to go down considerably, which is going to make it more and more difficult to continue the cross-subsidisation of foreign trade via revenues accrued on the domestic market. This will weaken the position of the CEZ in export trade.

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[11] Aside from the CEZ, the Czechpol company is also entitled to import and export electricity.

- At the same time, the pressure exercised on the Czech market by foreign producers is going to rise. One must not forget that considerable surplus capacities exist in central European electricity markets.
- Additional competition is to be expected from additional capacities placed on the market by independent producers in case of a transparent market opening. In this context, CHP plants will be serious competitors in industry and trade and, to a lesser extent, also in the district heating supply. If compared directly to the CEZ in general and to the Temelín power plant in particular, in completely liberalised markets these decentral CHP plants offer a number of competitive advantages:
    - Decentral CHP plants are positioned directly near the end-consumer: once the costs for network utilisation have become more transparent due to liberalisation, network tariffs for their own consumption will be lower for this type of plants. This corresponds to a rise in project revenues by around 7 to 14 €/MWh (according to the actual level of network tariffs in the Czech Republic).
    - Not only full cost, but also variable costs are important for price competition – which is to be expected in a liberalised market in particular for large-scale customers. In this context, CHP plants are in a clearly favourable competitive position (upon deduction of heat revenues).
    - CHP plants are far more flexible than nuclear power plants, which are only able to produce base load (i.e. electricity of the lowest quality and at the lowest price level). Depending on the type of plant, CHP plants are also able to produce electricity in the medium and, in part, peak load range, thus achieving higher average revenues.

Altogether, it is by no means certain that the CEZ will be able to maintain its current sales level in a liberalised market. For this reason, the government has over the past two years introduced a series of measures to counteract liberalisation, aimed at stabilising the sales and revenues situation of the CEZ. Among these measures are the vertical integration of the CEZ and a majority of distributors, the collection of highly excessive network tariffs (which are, via default liability fees, mainly used to support the CEZ) and the creation of legal barriers to limit imports. The majority of the related regulations, however, will lose their legal basis if the Czech Republic becomes a member of the EU.[12]

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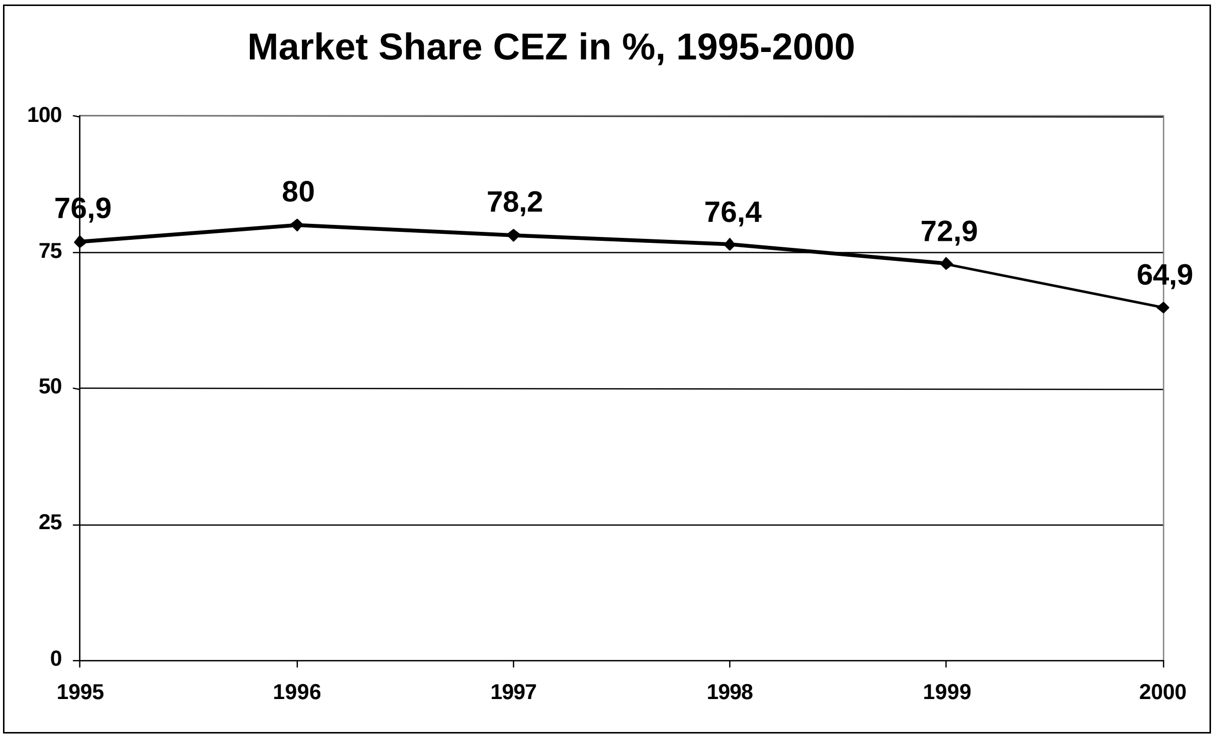
[12] In this context, the current draft of the annual OECD country report on the Czech Republic comes to the following conclusion, "While the stratey being pursued in the energy sector might have the benefit of maximising short-term privatisation revenues, but it appears short-sighted and is unlikely to provide consumers and firms with the lowest possible energy prices. The choice to create a dominant player in the electricity sector is especially unfortunate because it fails to take advantage of the substantial efforts, that have been made to create a legal framework capable of supporting a more competitive-friendly sector. By recreating dominant and vertically-integrated electricity and gas providers it is likely to reduce substantially the benefits that would have accrued to consumers by the creation of a competitive sector."



Source: CEZ Annual Reports 1996-2000

Figure 6: Development of Market Shares Held by the CEZ in the Czech Republic

2.4 Summary and Conclusion

Based on the agreements with the Czech members of the EIA Commission (Scoping List), which refers to the EU directive on EIA procedures, as well as on the documents presented by the Czech authorities, this opinion examines

- whether there is an alternative combining comparable economic advantages with reduced ecological burdens and/or a lower potential risk for the environment, and
- whether the project altogether offers an appropriate balance between economic advantages and the actual and potential burdens on the environment.

For this purpose, the options of completing Temelín and taking the plant into operation on the one hand, and of potential alternatives on the other, were examined as to their economic and related ecological impact.

In this context, one must point out first of all that, **if all funds already invested are included in the calculation, the Temelín project is in any case uneconomical** and therefore has already caused an economic loss which will, in any case – and most likely via a strong reduction in privatisation revenues (compared to a scenario without Temelín) – constitute a longer-term burden on the Czech economy (see the Final Report of the Team of Experts for Independent Evaluation of the Project to Complete Construction of the Temelín Nuclear Power Plant, installed by the Czech government, January 1999). Current economic feasibility studies, which need not take into account any funds already invested ("Sunk Cost") therefore only deal with a "limitation of damages," i.e. with finding an option which guarantees the greatest possible limitation of damages that have already occurred.

For this purpose, **comparative economic calculations** have been carried out for this opinion. These were based on the ideal assumption that the NPP Temelín (block 1) would go into operation immediately (i.e. discounting, for the time being, any completion costs still outstanding for block 1 or completion costs yet to be estimated for block 2) and that the plant could be operated according to plan (i.e. at 6000 full load hours per year).

Based on these assumptions, from a business management point of view, i.e. from the point of view of the CEZ, the **contribution margins** gained during operation of the facilities for covering investment costs and meeting profit expectations constitute the **crucial assessment criterion**. For the calculations carried out in this context, contribution margins have been defined as follows: revenues (from electricity sales) less fuel costs, other variable costs, and fixed cost during operation (in particular plant management, maintenance and repair).

Based essentially on cost data already confirmed by the CEZ in the course of the assessment carried out by the above-mentioned Team of Experts for Independent Evaluation of the Project to Complete Construction of the Temelín Nuclear Power Plant, the following scenarios have been calculated both for the annual contribution margins – i.e. the economic advantage – and for the related ecological impact (above all air pollutants, CO_2 emissions and nuclear waste):

- **reference scenario:** continuation of currently existing production structure without taking Temelín into operation *(zero variant);* production remains at the current level of 48 TWh;
- **scenario A:** *taking Temelín into operation (block 1)* and expanding the export market in direct proportion to Temelín-based power generation; production rises to a level of 54 TWh;
- **scenario B:** *taking Temelín into operation (block 1)* without expanding the market, leading to a corresponding replacement of coal power plants; production remains at the current level of 48 TWh;
- **scenario C:** *zero variant* without taking Temelín into operation, while currently reducing production to the level of the domestic market (no exports and no gains in domestic market shares); production goes down to 39 TWh;
- **scenario D:** *zero variant* like in scenario C, but at the same time abandoning reserves of 1500 MW existing in this case in order to reduce the block of fixed costs.

All these scenarios comprise all power plants currently operated by the CEZ, combining single plants in individual categories (NPP Dukovany, NPP Temelín, brown coal and lignite coal power plants with and without cogeneration, hydroelectric power plants) for reasons of simplicity.

Table 5 provides a summary of the **results** of these calculations.

Table 5: Results of the Comparative Economic/Ecological Calculations

Per year	Unit	Reference scenario	Scenario A	Scenario B	Scenario C	Scenario D
Economic effects						
Sales CR	TWh	39	39	39	39	39
Export sales	TWh	9	15	9	0	0
Prices CR	CZK/MWh	1100	1100	1100	1100	1100
Export prices	CZK/MWh	582	582	582	582	582
Revenues CR	CZK million	42900	42900	42900	42900	42900
Export revenues	CZK million	5238	8730	5238	0	0
Fixed costs (O&M)	CZK million	6900	8900	8900	6900	6071
Fuel costs	CZK million	16164	17190	14583	12282	12282
Other variable costs	CZK million	3047	3275	2883	2458	2458
Contribution margin	CZK million	22026	22264	21772	21260	22089
Ecological Effects						
SO_2 equivalent	t	84113	84313	69452	61836	61836
CO_2 equivalent	million t	39	39	32	29	29
Radio-active waste	t	54	78	78	54	54

One can therefore conclude that

- given the current market situation, taking Temelín into operation does not entail any economic advantages as no additional contribution margins can be gained;
- taking Temelín into operation is unlikely to reduce the burden on the environment as far as the emission of air pollutants is concerned and that it must therefore be assessed negatively from the ecological point of view; this negative assessment is based on the assumption that, for economic reasons, sales would have to be expanded if Temelín went into operation;
- if Temelín goes into operation, the burden on the environment could only be reduced if economic performance (in terms of contribution margins gained) remained in any case behind the non-operation scenarios;
- taking Temelín into operation goes hand in hand with an increased nuclear risk.

The essential point in this context is that the presented comparative calculation does not take into account any investments which are still required before Temelín can go into operation. In addition, a possible decision to complete Temelín and to take the plant into operation entails a series of grave risks, which would not exist if the plant did not go into operation. The following **specific operation-induced risks** add to the attractiveness of deciding against the operation of Temelín:

- **risk of further cost overruns,** likely to occur until the start of commercial operation: the required upgrades of the technical and safety systems (calculated on the basis of previous results of trilateral negotiations) alone would cost between CZK 1 billion and CZK 4 billion (for block 1; the big gap between the two ends of this price spread is above all attributable to the fact that necessary safety technology analyses are not yet available and that the results of these analyses are crucial in determining costs). In addition, a number of technical problems (regarding both mechanical and electronic engineering) have occurred during the trial operation and might require a cost-intensive solution.

- **risk of unreliable operation**, which according to available operation data of existing WWER-1000 reactors can by no means be excluded. In this case, a reduction of average annual full load hours from 6000 (as planned) to merely 5000 under current market conditions would cause annual contribution margins to decrease by around CZK 400 million.
- **barriers preventing an expansion of sales**, which seems necessary from an economic point of view if Temelín is taken into operation The main barriers are: low expected increase in domestic demand; limited capacity of power lines; re-imports by distributors.
- **risk of being exposed to price developments in central European electricity markets**, as the operation of Temelín would only produce additional contribution margins if electricity prices were raised considerably (and if at the same time, sales would be expanded heavily, which in a way contradicts the necessary improvement of delivery prices). Experts[13] agree that a series of factors suggest that at least in the medium term a stabilisation of prices at the current level can be expected and that, if prices for fossil fuels continue to rise, electricity prices – in particular for delivery of base load – will only rise slightly.

By way of complementing the described comparative economic/ecological calculation, this opinion also contains a detailed analysis of some crucial statements given in the documents submitted by the Czech authorities (which were handed in later via the Czech Foreign Ministry). This analysis proves that, in contrast to the line of argumentation used in said documents

- no losses will result for the utility CEZ if Temelín does not go into operation; on the contrary, the economic benefits will most likely exceed the expected losses. This is above all attributable to the fact that under present market conditions, taking Temelín into operation would not cause the company's revenues to rise, which, in other words, means that investments in the NPP Temelín would have no economic value;
- on the one hand, the entire Temelín investment project has already considerably reduced potential privatisation revenues for the CEZ, while it is by no means certain, on the other hand, whether privatisation revenues would be higher if Temelín went into operation than if the project was discontinued or conserved. This is owing to the fact that potential investors (aside from strategic considerations) mainly focus on the earning capacity value of an enterprise as well as to the fact that taking Temelín into operation would most likely not increase the earning capacity value, but at the same time entail additional risks;
- it will be possible to solve the consequences in terms of accounting which would result from not taking Temelín into operation – discussed in detail in the documents presented by the Czech authorities (one-time write-off of the entire invested capital, either directly or by establishing liability reserves) – after privatisation;
- the effect on employment would, from the current perspective, be immaterial in both cases, while the employment effect of the Temelín project as a whole will, at the same time, be negative owing to its unprofitability, which will represent a burden on the Czech economy over the next few years (most likely via a reduction in privatisation revenues);
- given the complete lack of adequate framework conditions and the fact that it is uncertain how long it would take to establish such conditions at the international level and that therefore, any price assumptions made in this context are pure speculation, one cannot find a good reason why, from an economic point of view, a current decision on whether to complete Temelín and take the plant into operation should be based on highly uncertain potential incomes to be gained from CO_2 tradings;
- based on the one hand on the expected economic development and on the other hand on the qualitative consequences of the expected swift economic uptrend (technological inno-

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[13] e.g. European Commission: European Energy Outlook to 2020, November 1999, Cambridge Energy Research Associates: The CERA Study, Paris 2000; Kreuzberg, M.: Spotpreise und Handelsflüsse auf dem europäischen Strommarkt, ZfE, 1/99; Riechmann, Ch.: Preisentwicklung in einem liberalisierten Strommarkt, ZfE, 1/99

vation and structural effects in combination with losses in market shares and the space heating market), the forecast annual 5% growth in electricity consumption is highly unrealistic. In fact, one must assume that the expected economic growth leads to a gradual reduction in electricity intensity. Therefore, electricity consumption is expected to grow by no more than 1% to 2% over the next 3 to 5 years;

- even if demand is going up, this does not guarantee that the CEZ will be able to maintain its current level of sales. This is true in particular if complete market liberalisation is achieved – a development closely connected to the Czech Republic's possible accession to the EU.

By way of a summary, the two principal questions dealt with in this opinion can be answered as follows:

- There are certainly alternatives to taking Temelín into operation which offer lower ecological burdens or risks in combination with comparable economic advantages (in particular scenario D and, within limits, also the reference scenario).
- An economic advantage will, potentially (even if we have demonstrated that this is highly unlikely), only occur if sales can be expanded widely, if possible in direct proportion to the entire production by the NPP Temelín. In this case, ecological burdens and risks would be highest. The extent of the potential economic advantage provided by this scenario – in particular against the backdrop of related technical and market risks – is in no adequate relation to the resulting excess burden on the environment.

2.5 Literature

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3 HEALTH AND ENVIRONMENT

SUMMARY

The limitation of the assessment of the environmental impact of the Temelin NPP to normal operation is not reasonable for the purposes of the Council Directive 97/11/EC, which requires a description of the likely significant effects of the proposed project on the environment. According to this directive, it is necessary that at least the environmental impact of fuel production and disposal of the waste generated in the course of the plant operation and prospective demolition of the facility be considered.

Due to the fact that no appropriate concrete concept has been presented, the statement of the EIA Commission that the disposal of spent fuel is not an environmental threat cannot be confirmed.

According to the EU directive on EIA, the environmental impact of accidents must be considered as well, even for cases in which the probability of incidence may be low but the consequences might affect large areas.

The representation of the impact of radioactive substances discharged through the waste air system is missing and the conclusion that the exposure of the population will be significantly lower than the exposure limits cannot be proven.

The impact of radioactive substances discharged through sewage combined with the impact of other effluents and the waste heat have a negative influence on the affected aquatic ecosystems and - via the food change - probably also on humans. The EIA Commission made no statement in this respect.

The assessment of the impact of the NPP on the health of the population refers only to the impact of normal plant operation. Only a zone with a radius of 13km from the Temelin NPP is taken into account. The presented health study does not contain any data referring to conditions (thyroid cancer, pediatric leukemia, anomalies in newborns) that may demonstrably be caused by ionizing radiation, which is a major failure of the health study. It also remains unclear how the future physical condition of the population should be monitored.

The Temelin NPP shows a lack of safety that greatly interferes with the effectiveness and reliability of the "Defence in Depth" concept (INSAG-3, INSAG-12). According to valid European practices, the operation of the facility would not be possible considering the current lack of safety. The documentation does not contain a *"a description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment"*, as required by the Council Directive 97/11/EC.

The value of 2.6E-5 per reactor year presented in the EIA documentation in regard to the risk of incidence of severe accidents in the Temelin NPP cannot be confirmed and is inconsistent with the results of the Probabilistic Safety Assessment (PSA) of the Temelin NPP completed in 1995 and the information contained in the documentation (SUJB May 2001) provided by the State Office for Nuclear Safety (SUJB) regarding severe accidents. According to the results of the PSA from 1995, Temelin does not meet the quantitative safety goals for existing facilities set forth by the International Atomic Energy Agency (INSAG-12).

The EIA documentation from April 14th, 2001 does purposely not mention any accidents with radiological consequences that might affect large areas (due to the low probability of occurrence) but it mentions Reference Accidents:

Three reference accidents that have as design accidents a relatively minor radiological impact on the environs were examined. Two of these three reference accidents show a probability of incidence that is smaller than the probability of incidence of severe accidents.

This EIA documentation does not consider a category of design base accidents that is very important for Temelin, namely design base accidents with leakage from the primary to the secondary circuit.

Also accidents caused by external events are not treated by the EIA documentation in a sufficient manner.

Important information needed for the confirmation of the estimate of radiological consequences of the two reference accidents causing emissions to the atmosphere is missing.

As far as the reference accidents are concerned, information about expected doses at the national border with Germany and Austria was provided. As far as severe accidents are concerned, information pertaining to Temelin and its possible impact on neighboring countries has been requested repeatedly. (See Chapter 3 of this Statement.)

The presented EIA documentation comes to this conclusion: “The evaluation of the radiation impacts of the selected reference accidents of the Temelin nuclear power plant showed that even when making conservative assumptions, the results do not indicate that any danger to the health of the population in the Czech Republic or in the neighboring countries – Austria and Germany – could arise.”

Many aspects of the presented emergency planning indicate that the Czech authorities in fact do assume possible consequences of accidents that might have an impact on large areas and pose potential threat to the health of the population.

3.1 Introduction

The statement for the Chapter “Health and Environment” is based on the following documentation:

- Assessment of Impacts of Temelin Nuclear Power Plant on the Environment, Submitted in Connection with the Voluntary And Above-Standard Procedure According to Part V of the Melk Protocol. Documentation for Public Assessment And Use by Affected Authorities Pursuant to Article 6 of the European Commission Directive No. 97/11/EC. Drawn up by the Commission for Overall Assessment of the Impact of Temelin Nuclear Power Plant on the Environment, Prague, April 2001 (Commission 2001).
- Documents for Environmental Impact Assessment Temelin NPP. Invest Project, March 2001, 372 pages, (Invest Project 2001).
- Temelin NPP – Documents for Environmental Impact Assessment, Supplementary information (1), Radiological Impacts of selected reference accidents. Compiled by Ing. Radek Svoboda. Invest Project, (Svoboda 2001).
- Principles and methods of emergency planning and response at NPP Temelin including assessment of beyond design and severe accidents consequences. Presented during the workshop organised by SUJB on 4 April 2001 in Prague, (SUJB April 2001).
- Assessment of beyond design and severe accidents consequences, principles and methods of emergency planning and response at NPP Temelin. State Office for Nuclear Safety, Praha, May 2001, (SUJB May 2001).

3.2 Atmosphere and Climate

3.2.1 Emissions during Normal Operation

The presentation of the background contamination by conventional pollutants is satisfactory. However, a comparable presentation of the pre-existing contamination by radioactive substances is missing.

The documentation obtained in the course of this process (Invest Project 2001) mentions the same values of annual emissions during normal operation as the documentation for EIA II – Project Changes (UBA Nov. 2000). These values are similar to the projected emissions that are also listed for other VVER 1000 reactors. A comparison with the Overall Assessment of the Impact of the Nuclear Power Plants Rovno/Khmelnitsky on the Environment (K2/R4 1998) shows that the overall activity discharged through the waste air system is the same. However, the presented list of nuclides is in comparison to Rovno/Khmelnitsky much shorter; moreover, essential radionuclides, such as strontium 90, are missing.

The present report assumes that the forecast values listed in the documentation (Invest Project 2001) “are greatly exaggerated” and that judging from experience with the Dukovany NPP, *“the real discharges can be expected up to three orders of magnitude lower compared to these values.”* (Commission 2001, Chapter 2.1.1.5.1)

Limiting values for emissions were not set directly, as is obvious from the documentation. However, they were set indirectly through the determination of a limiting value for the calculated immission (annual effective dose). This mode of calculation cannot be confirmed, as the necessary information has not been provided. In this context, only a legal amendment is mentioned, which is supposed to be in compliance with an IAEA recommendation not described in greater detail. (Commission 2001, Chapter 2.1.1.4.1)

The dose is not specified in Appendix 3 of Invest Project 2001[1] either. According to US rules, the risk is calculated directly from the concentration of activity (air, food, soil). However, calculations based on the Czech regulation on radiological protection consider only doses from inhalation and ingestion (irradiation from the contaminated ground and direct irradiation from the radioactive cloud are missing).

The study of the dispersion of airborne radioactive effluents in normal conditions emphasizes that these effluents are released to the atmosphere via three separate ventilation chimneys, which are 160 – 242m apart from each other, and that these chimneys are handled as a one point source for the purpose of the calculation. Due to the fact that additional information, such as the heat flow of waste air, necessary for such calculation of dispersion is not considered, this assumption is not justified. In addition, no explanation is provided why the heat flow of waste air is different for the individual chimneys (difference waste treatment in hot bituminizing plant – waste air from NPP). This information is necessary, in order to decide whether summing up the chimneys to a point source represents a conservative suggestion or not.

The program serving as the basis for the calculations of dispersion (RDETE) is not described in greater detail, the dose calculation, exposure paths considered, and meteorologic input data are not treated. The source rates used as the basis for the calculations are not provided. The characterization of the critical group of people as individuals living within the distance of 5km from the power plant is too vague. Are the numbers of persons added and averaged? In which distance and direction does the maximum load of the effective dose occur? The geographic distribution of the dose in normal operation is not covered by the documentation provided.

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[1] Evaluation of Health Risk

This procedure is in clear contradiction to the EU directive (EU 97/11/EC) as well as to the Espoo Convention (Espoo 1991). The latter requires *“an explicit indication of predictive methods and underlying assumptions as well as the relevant environmental data used…”* and *“an identification of gaps in knowledge and uncertainties encountered in compiling the required information...”* (Espoo 1991, Appendix II, f, g)

The method of determination of the limits for the discharge of radioactive substances is not clear: While the limits for the discharge of radionuclides to the atmosphere are set by the effective dose, the limits for the discharge of radionuclides to the sewage are set by annual limits of the total activity (tritium, overall beta activity).

“The discharge is carried out solely by three chimneys (reactor building of the 1st block, reactor building of the 2nd block, auxiliary active equipment building).” (Commission 2001, Chapter 2.1.1.5.3). “This layout is resistant against any defect.” (Commission 2001, Chapter 2.1.1.5.5)

The aforementioned statement that airborne radioactive substances are discharged solely through ventilation chimneys is neither true for Temelin, nor for any other NPP. At best, this might be true for the planned discharge of airborne radionuclides from the reactor buildings and the waste treatment during trouble-free operation.

This statement is also qualified by the following quotation: *“The fundamental attention must be paid to the ventilation and outlet of the air in the containment, where in case of a defect the escape of active substances can happen from the damaged tightness of the primary circuit to the containment area.”* (Commission 2001, Chapter 2.1.1.5.3).

Equally, due to lack of evidence, it is impossible to confirm the suggestion quoted above that the layout cannot be destroyed by any defect.

The control of the discharge of contaminated air from the containment in case of an accident (e.g., for the purpose of pressure reduction within the containment) is not described in greater detail. It is only mentioned that the control will be conducted under the supervision of the SUJB. Moreover, it is neglected that the containment has a certain rate of leakage as well and that a slow (uncontrollable!) release of radioactive air is to be expected. Nevertheless, only two short paragraphs further down in the report, the assertion is made that the system is self-contained:

“During any accident all the area of the containment is hermetically closed and from this area no airborne effluent is not released to the outside environment nor it can escape from there.” (Commission 2001, Chapter 2.1.1.5.5).

This assertion is not true for:

- Containment by-pass accidents, regardless whether these accidents are design accidents with ruptures of the steam generator (see Chapter 3.10) or severe accidents with core melt-through (see Chapters 4.1, 4.2, 4.5),
- severe accidents for which the integrity of the containment may not be ensured, regardless whether due to hydrogen detonations or a melt-through of the containment base plate, etc.,
- severe accidents for which the normal rate of containment leakage was assumed 0.1% of the volume activity per day and for which according to the SUJB documentation (SUJB, May 2001), at stability class F, a two day dose of 10mSv within the distance of 5km to the plant is to be expected.

As far as severe accidents are concerned, the PSA completed for Temelin indicates that on the one hand, the probability of incidence is dominated by containment by-pass accidents (contribution of more than 60%) and on the other hand, important studies in regard to the integrity of the containment in case of severe accidents are missing (see Chapters 4.1, 4.5).

"Outside the containment, i.e. in the enclosure and in the auxiliary equipment building a sudden release of airborne radioactive effluents cannot happen in such a volume and activity to be able to influence the environment in more important way including the health risks for people, because no such substances are found there." (Commission 2001, Chapter 2.1.1.5.3)

The auxiliary equipment building must be seen separately, as far as the content of radioactive substances is concerned, and the relevant danger - which is by far smaller than with severe accidents - is not the release of airborne effluents but the release of effluents contained in the sewage. (See Report to the Austrian Government regarding the partial EIA of Temelin, UBA March 2000)

3.2.2 Note About the Outline of Alternatives

This section emphasizes that Temelin is a source of energy that does not discharge any significant pollutants and that the amount of radioactive emissions is basically negligible. Furthermore, the statement is made that Temelin does not produce any greenhouse gases and does not use any oxygen.

In this context, we must point out that an NPP must not be evaluated as an isolated facility in this respect but rather the production and treatment of fuel, which have a major impact on the environment, must be analyzed as well. The note about the use of oxygen is deceiving, as there are no industrial processes with a major impact on the oxygen economy of the atmosphere and thus, any potential alternatives might claim the same "advantage."

In one of the further paragraphs, the necessary treatment and storage of radioactive waste is referred to as a disadvantage of Temelin. However, the negative impact of the production of nuclear fuel is not mentioned.

The present documentation does not exclude possible reprocessing of irradiated fuel. Consequently, a discussion of the impact of the considerable release of radioactive inert gases due to the chemical treatment and the possible contribution of the ionizing activity of the released inert gases to the greenhouse effect is necessary.

The commissioning of the NPP may have a positive effect on emissions of CO_2 only if the major emitters are removed from the network and not if the electricity is exported (e.g., to Germany) and used instead of the electricity from power plants with comparably high environmental standards.

3.2.3 Monitoring

"The only potentially possible source of irradiation of the inhabitants in the locality of power plants are airborne and liquid effluents." (Commission 2001, Chapter 2.1.1.6.1)

This must be commented as follows:

1. These effluents are not <u>potential</u> but <u>real</u> sources.
2. The radioactive waste of the NPP is also a (potential) source of irradiation of the environs.
3. The risk resulting from the transportation of radioactive waste, in particular the transportation of spent fuel rods, is not limited to the environs of the NPP.

A current measurement of irradiation of 0.001µSv/a for part of 2000 is listed in (Commission 2001, Chapter 2.1.1.6), Table no. 7. This value is compared to the irradiation limit of 40µSv for individuals from the population. The representation does not explain how the measurement was obtained. It remains unclear at which location the measurement was taken and why this location was considered the location with the highest irradiation. Moreover, a measurement probably only refers to the external gamma radiation, whereas the effective dose load of an individual must also take inhalation and ingestion into account.

Further down, it is said that the Dukovany NPP is very similar to the Temelin NPP in regard to technology of operation and output. This assertion is only partly true. It is true that both NPPs feature a pressurized water reactor. However, there is a great difference between the two facilities, as far as important details in regard to the output of the individual reactor units, the containment structure (Dukovany has only a “confinement” for pressure reduction and no “containment”), and the waste treatment technology are concerned.

The effluents of Dukovany NPP shown in the tables and graphs in (Commission 2001, Chapter 2.1.1.6.1) are characterized by a two-year-cycle. The liquid effluents vary by a factor of approximately 10, the airborne effluents by a factor of approximately 3. This remarkable phenomenon is not mentioned, let alone explained in greater detail. The tables and graphs are not accompanied by expressive legends.

For example, Table no. 8: *“Nuclear Power Plant Dukovany – the real discharges in comparison with the limit.”* The table does neither explain which substances were measured nor which medium was considered.

The legend of Graph no. 7 is completely insufficient as well – neither the absciss nor the ordinate shows information about the represented values, the information provided by the legend is too vague.

The average total effective dose produced by natural sources for the inhabitants of the emergency planning zone is estimated at approximately 4mSv (Commission 2001, Chapter 2.4). However, the average dose in the Czech Republic is only 1.8mSv. The question arises why this specific location with more than twice as high a pre-existing irradiation was chosen as the site of an NPP in the first place.

The EIA directive (EU 97/11/EC) and the Espoo Convention require *“…a description of mitigation measures to keep adverse environmental impact to a minimum…”* (Espoo 1991, Appendix II e) and *“…a description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment”* (EU 97/11/EC, Annex IV, 5)

We may assume that the alarm and intervention levels (Commission 2001, Chapter 2.1.1.6.3) are part of these measures. However, the actual process remains unclear:

“As regards airborne radioactive effluents, in accordance with the document ‘Limits andconditions’ and decision of the State Office for Nuclear Safety, the activity of radionuclides arising in the nuclear power plant and discharged by ventilation chimneys to the atmosphere in the course of one calendar year cannot cause to an individual from the population 50-year load of the effective dose higher than 40 µSv during the operation of two units. The conversion of the radioactivity to the doses must be carried out in the way authorised by the State Office for Nuclear Safety. If such a limit value was reached, the reactor must be put out of operation within one hour and next operation can only be started after the issue of a new permit by the State Office for Nuclear Safety.” (Commission 2001, Chapter 2.1.1.6.3)

Judging from this explanation, we may expect that the operation of the plant will only be stopped when the admissible annual dose limit is exceeded. Although the title of this chapter mentions alarm and intervention levels, neither the manual nor the automatic alarm and intervention levels are described.

Consequently, we come to the conclusion that as far as air pollution by radioactive emissions is concerned, the description of the mitigation measures to reduce adverse environmental impact is not as detailed as required by (EU 97/11/EC) and (Espoo 1991).

The description of the climate in (Commission 2001, Chapter 2.1.2) is all in all a suitable rough outline of the climate of the Temelin area. However, it is surprising that the analysis of maximum gusts is based on values measured at the Prague-Ruzyne station and what is more, the orographic situation of this station is not compared to the knoll situation of Temelin. Table no. 19, which lists the frequency of wind directions, does not contain information regarding the frequency of calms. Moreover, it must be noted that the climate characteristics presented in the documentation do by no means qualify as a sufficient basis for calculations of dispersion. It is true that the background documentation (Invest Project, 2001) contains much more detailed information (especially complete two-dimensional wind distributions by direction and velocity), but the combination with different kinds of precipitation, which would be absolutely necessary for the calculation of doses in normal operation, is missing in this documentation as well. Information regarding sea levels at which mixing occurs is not provided either.

3.2.4 Radioactive Discharges to Atmosphere from other Sources

As far as the closed down Mydlovary uranium ore processing site is concerned, primarily radon emissions and secondarily radioactive aerosols (dust) are to be expected.

The description in (Commission 2001, Chapter 2.1.1.7) does not contribute to a better understanding of the approval practices, as it refers to the fact that the SUJB approved an annual release of radionuclides to the environment of up to 250 µSv for the population of Mydlovary and Olesnik.

What is more significant than airborne effluents are the radioactive substances washed out of the former mud tanks into nearby fish ponds, rivers and into groundwater.

It is not discussed whether the radioactive emissions of Mydlovary and the radioactive emissions of Temelin might have a cumulative effect, nor which part of the population would be affected.

3.2.5 Conclusions

One might only come to the conclusion that the impact of the Temelin NPP on the atmosphere is largely insignificant if solely the normal operation of the plant is taken into account.

This modification is not compliant with the Espoo Convention, which requires *“a description of the* *__potential__* *environmental impact of the proposed activity.”* (Espoo 1991).

In any case, the processes of fuel production and waste disposal must be included in the assessment of the environmental impact as well.

Potential environmental impact might even be an impact with a low probability of incidence.

The presented data cannot be proved, as the documentation provided is insufficient. Above all, detailed information regarding the calculation model used and meteorological input parameters is missing.

The question of the impact of low doses is not handled.

3.3 Water

3.3.1 Hydrological and Hydrogeological Situation

The areas listed in the scoping list - water consumption (drinking and industrial water), sewage water, contaminations and possible effects on water economy – are discussed on 46 pages of the EIA documentation (Commission 2001) and also some problems are pointed out. However, the results of the geologic and hydrogeologic research (technically pertaining to the chapter dealing with waste) that have to date been obtained in the course of the selection of a final storage for radioactive waste are missing.

This topic is handled in greater detail by the assessment team than the area of soil and rock environment. It must be noted that contrary to the section dealing with seismic activity, some existing risks are not only not denied decidedly but even uncertainties are regretted and possible cumulative effects are mentioned in this section. This might be due to the fact that an essential possible contamination path leads via the surface water and groundwater to the Vltava river and that the drinking water supply down the river (Prague) might be affected in case of an accident.

The existence of only one drinking water supply facility is listed as a major problem. There is danger that in case of an accident, accumulation of radioactivity will occur in river sedimentation. Contamination of the shallow groundwater level is considered the greatest threat to the hydrosphere. (See also 3.3.2.1.)

Only a few studies have been made regarding the possible contamination of lower groundwater levels (crevasse water in the granite or in lower sedimentation layers of the sedimentation basins affected by recent tectonic movements); in this context, optimistic assumptions are prevalent. However, this does not only refer to the Temelin NPP site as such but also to the closely connected topic of waste, i.e., the tectonic and hydrogeological situation of a final storage of radioactive waste, for which preliminary studies have already been conducted in multiple steps. However, advanced studies of the geological structure were only performed in one granite massif and were limited to quarry measurements. In other countries (Switzerland, Sweden, France), rock laboratories have been conducting studies necessary for the selection of a final storage for years. The possible impact on the hydrosphere and environment of the Dukovany NPP is classified as a little bit more severe than the one of Temelin.

3.3.1.1 Conclusions

According to the Czech EIA Commission, major questions remain open as far as the potential contamination paths via crevasse water are concerned. In case of an accident, the particles bound in river sedimentation might be remobilized by erosion and thus pose a renewed threat to drinking water supplies.

3.3.2 Sewage

"The aim of processing technology and treatment of liquid radioactive waste is to minimise the final amount, i.e. to return the maximum amount of water back to the technological circuits of the power plant or after screening discharge to the receiving stream and concentrate the remaining activity to the smallest volume." (Commission 2001, Chapter 2.2.1.3)

Sewage not reaching the limits may be fed into the receiving stream.

The admissible value for tritium is 20TBq per year per unit. Consequently, the tritium activity in the Vltava river will rise by 13Bq/l at an average water regime and by 66Bq/l at low water compared to normal tritium activity of 1.5Bq/l.

The discharge of liquid effluents will probably be much closer to the limits than the discharge of airborne effluents. The expected annual emission of tritium is 30TBq/a for both reactors (Commission 2001,Chapter 2.2.1.3.2).

According to the information in (Commission 2001, Chapter 2.2.1.3.5), the overall beta activity (excluding tritium) will not exceed 1Gba/year with two NPP units in operation.

The permissible discharge of activity in sewage water is set as follows: The effective dose ($H_{50,L}$) load of a person whose yearly requirement of drinking water of 700 liters is exclusively met by the water from the Vltava river may not be equal to or higher than 0.32µSv for tritium and 0.006µSv for other radionuclides. The consumption of radionuclides via the food chain (fish) is not handled, nor are the consequences of external irradiation by swimming or staying at the bank of the receiving stream. The limits for the admissible emissions of the NPP are considerably lower than the limit of 50µSv set by the regulation on radiological protection.

The annual overall activity of the sewage discharge amounts to 1GBq during routine operation assumed by design (Table 34 in Commission 2001, Chapter 2.2.1.3.5 or Table 32 in Invest Project 2001, Part B II 5). This includes 1MBq Cs-137, but also iodine isotopes and strontium, with a discharge of 3000m³ of contaminated sewage.

The impact of radionuclides on the aquatic ecosystems of the reservoir is not treated in the report, although the statement is made that *“mass activity of certain radionuclides (e.g. caesium 137, or strontium) will persist in sedimentation and other environmental compounds for a very long time and will interfere with the impact of Temelín power plant operation.”* (Commission 2001, Chapter 2.2.1.3.4).

(Commission 2001, Chapter 2.2.1.3.5) refers to the final report of the work of Justýn et al from 1992, which has not been submitted to us. The following statement is made: *“On the basis of findings about the effect of the impact of radioactive material on water biocoenosis, … according to appendix No. 3 of government decree No. 82/1999 Coll., no harmful effects of radionuclides arise…”*

It is clear from the aforementioned balance that approximately half of the cesium activity discharged to the reservoir actually stays in the reservoir. Due to its long half-life (approx. 30 years), the cesium that can be found in sedimentation (214Bq/kg in 1990; 104Bq/kg in 1999) and probably also the cesium in water plants degrades very slowly. Similar processes are also to be expected in respect to the effluents originating from Temelin.

The authors of the Commission agree that these processes must be at least observed.

The sewage of the NPP does not only pass radioactive substances to the reservoir, but also waste heat. At low water, the temperature is as high as 90% of the limit. The heat stimulates the growth of water plants; consequently, large numbers of fish are attracted. Fishing might cause radioactive substances to enter the food change. (Commission 2001, Chapter 2.2.1.3.5)

According to the EU directive, an EIA must contain *“a description of the likely significant effects of the proposed project on the environment resulting from …the emission of pollutants, the creation of nuisances and the elimination of waste”*… as well as *“the description by the developer of the forecasting methods used to assess the effects on the environment.”* (EU 97/11/EC, Annex IV)

The present report gives the impression that despite of several studies, there are still considerable doubts in regard to the impact of the NPP operation on the hydrosphere.

“At the present time there is no criterion available, which would define the boundaries of seriousness of the impact of Temelín NPP on the hydrosphere. The problem is examinedfrom a number of isolated points of view with awareness of the fact that the impact ofTemelín NPP on the hydrosphere is many-sided.” (Commission 2001, Chapter 2.2.3)

"The viewpoint of testing the impact of radioactive irradiation to humans and ecological systems acting directly or through the medium of the hydrosphere has priority. The second in line is the viewpoint of testing the impact of thermal contamination on the environment. An unforgettable parameter is the establishment of quantitative claims on available sources of water, i.e. pre-defined off-take." (Commission 2001, Chapter 2.2.3)

Even in dry periods, no problems caused by an insufficient water regime of the Vltava are expected for the operation of the NPP. However, due to the fact that the rise in temperature is greater and the eutrophication and concentration of pollutants are higher in dry periods, we can only endorse the following recommendation by the Commission:

"For verification of conclusions from the survey, especially in the area of the impact of Temelín NPP on the hydrosphere, it has been shown as effective to provide independent and continuous control of the impacts of operation of the Temelín power plant from the period of starting unit 1 to a period of 3 years after starting unit 2." (Commission 2001, Chapter 2.2.4.3.) However, in order to verify long-term environmental effects, a longer observation period should be selected.

3.3.2.1 Conclusions

As far as water is concerned, the present EIA lists the following key problems:

"(A) drinking water security and quality

(B) service water security and quality

(C) risk of radioactive contamination of the receiving stream owing to the discharge of tritium water" (2.2.4.3)

However, it is necessary to draw attention to the following questions:

1. The discharge of tritium water during normal operation of the facility as well as the discharge of certain activities of other radionuclides are part of the license for the operation of the NPP. This has – especially in combination with other waste waters and the waste heat – an adverse impact on the aquatic ecosystems affected and via the food chain possibly even on humans.
2. If the supply of the NPP with cooling water from the receiving stream has priority over environmental protection, environmental problems will arise in times of low water due to waste heat.

The restriction to the aforementioned key problems originates from the neglect of the synergetic effect of different influences and is in contradiction to the environmental priorities listed in the very report.

The conclusion made by the Commission that the *"impact of Temelín nuclear power plant on the hydrosphere is negligible and acceptable."* (Commission 2001, Chapter 2.2.4.3) cannot be confirmed from our point of view. Even the Czech EIA Commission believes that this conclusion can only proved by a several year long observation of the operation.

3.4 Earthquake Hazard (Seismicity and Tectonics)

The evaluation commission's view on agricultural usage, geology, geomorphology, soil, potential environmental effects and seismic threat fills 22 pages of the documentation. Unlike the preceding chapters such as Atmosphere and Climate or Hydrology, this chapter is not concluded by a tabular overview of the key problems and recommendations. The earthquake hazard assessment table is badly arranged.

The bibliographic references provided cannot be followed, as the corresponding quotations are missing from the bibliography (References) (e.g., ASCR, Energoprojekt, Rudajev, Masopust).

Chapter 2.3.4 (Commission 2001) starts with a description of the individual tectonic fault zones. Despite the evidence of microquakes at single faults and the reference to neoid tectonic movements mentioned by several Czech examiners, the study talks about *"unproved seismic activity"* or says that *"no neoid movements were proved."* Furthermore, the survey results allegedly show that no movements have occurred for the past 0.78 million years. However, no advanced paleoseismologic studies have been conducted, nor have datings of tectonic shifts been presented.

The significant tectonic line running NE-SW heavily fractured and weathered in the area of the cooling towers, which is already mentioned in Chapter 2.3.2 (Commission 2001), is not considered in detail. An assessment of this fault zone cannot be made without the information contained in the undoubtedly extensive geotechnical material.

The evaluation by the Czech ministry of environment emphasizes that most of the hazard estimates for the "operation basic earthquake" (OBE) showed an intensity of 5.5ºMSK and for the "safe shutdown earthquake" (SSE) an intensity of equal to or less than 6ºMSK. This is supposed to be the prove for the correctness and conservatism of the OBE value of 6ºMSK and for the SSE value of 6.5ºMSK, although these values do not correspond to the minimum recommendation of 7ºMSK by the IAEA (IAEA, 1991).

Several times, the value for the "safe shutdown earthquake" (SSE) is specified as 6ºMSK or 6.5ºMSK. This is in contradiction to the requirement of the IAEA, according to which this value should be increased to the minimum value of 7ºMSK set by the IAEA as the value of intensity not leading to any damages in aseismic areas, which is effective worldwide.

As far as the below listed observations are concerned, it is necessary to point out the distinction between the greatest intensity I_o (in the epicenter) measured and the weaker intensity I occurring in more distant localities (e.g., the Temelin site).

A maximum earthquake of I_o = 10ºMSK must be assumed for the seismogene zone of the historical high intensity earthquake of Neulengbach. The expansion of this zone varies significantly from one author to the other. If the smallest possible expansion of this seismic zone is assumed, the intensity for the area of Temelin will amount to I = 7ºMSK due to the known weakening of intensity of East Alpine earthquakes. However, if the zone reaches as far as 100km close to Temelin (see GRÜNTHAL et al., 1998), the intensity affecting Temelin must be expected to equal I = 8ºMSK, while in case of a distance of 30km between the aforementioned zone and Temelin (see LENHARDT, 1995), an intensity between I = 8.5ºMSK and 9ºMSK is to be expected. In usual international practice, 1º is added to the greatest earthquake recorded for the purpose of specifying the maximum possible earthquake. This means I = 9ºMSK + 1º = 10ºMSK for Temelin.

The maximum historical intensity of I = 6ºMSK specified for the village of Sobeslav is attributed to local soil conditions by the present EIA. However, sufficient evidence is not furnished (microzoning). In this respect, we must point out that this intensity was not only reached in Sobeslav but also in other cities of Bohemia and Moravia, some of which were farther away than Temelin, at the occasion of this historical high intensity earthquake (see isoseist map in GUTDEUTSCH et al., 1987), so that Sobeslav may not necessarily be considered a local exception.

At the end of the chapter on seismology, a comparison of different model variations can be found in the report by the Czech EIA Commission for the first time. The maximum value of intensity (SSE) is mostly assumed I = 5.5º or 6ºMSK by the different studies (the text falsely speaks of "magnitude" when referring to the MSK scale).

Solely the result of the Energoprojekt study (1998) reaches a value of 6.5ºMSK. The earthquake hazard assessment table is incomplete. The actual valid values (intensities, accelerations) are not unmistakably obvious from this table. In addition, ground acceleration values of civil buildings are compared to ground acceleration values of nuclear facilities. The studies conducted by foreign authors (LENHARDT, 1995, GRÜNTHAL et al., 1995, GRÜNTHAL, 1998) are either completely neglected in the Temelin earthquake hazard assessment table or the table lists very low intensities or ground accelerations (g values), which widely differ from the values presented in KOHLBECK's study (2000, statement about UVE I, UBA, 2000 a). It has not been explained where the present values are derived from.

We can only make extensive comments on these assumptions after more detailed material containing the reasons for these assumptions that appear to be too low has been submitted and studied. Unfortunately, like in the Invest report, many of the quotations mentioned in the Commission's assessment are missing from the bibliography (e.g., ASCR, Energoprojekt, Rudajev, Masopust).

It would be advisable to combine the findings and evaluations of tectonic faults made by the different disciplines (geotechnics, hydrogeology, and seismology), in order to follow the current scientific approach to the consideration of active movements.

The possible threat and its effects caused by the combination of an earthquake and an accident is not treated.

The information exchange through direct talks with experts proposed at the end of this chapter is to be marked as a good suggestion.

3.4.1 Conclusions

The present evaluation by the EIA Commission of the Czech government for the first time contains a comparison of different earthquake hazard assessments. However, the acceleration values effective for civil buildings are compared to the requirements of NPPs, which is not acceptable.

Most of the Czech authors consider an intensity value of 5.5º to 6ºMSK-64 adequate for the SSE (safe shutdown earthquake), which is supposed to be the proof that the value of 6.5ºMSK-64 set for the SSE is enough conservative ("to be on the safe side"). However, the damage brought about by the greatest historical high intensity earthquake known that has had a substantial impact on this region (Neulengbach, 1590, epicenter intensity 9ºMSK-64) indicates that the aforementioned intensity values have already been reached in southern Bohemia.

However, the greatest earthquake recorded is not necessarily equal to the maximum earthquake possible. The strongest earthquake measured in the vicinity of Neulengbach had an intensity of I_0 = 9ºMSK. Consequently, the maximum earthquake possible in the zone of Neulengbach is to be assumed I = 9ºMSK + 1º = 10ºMSK.

Moreover, the assumption that no tectonic activity has occurred for 780,000 years has not been proved by any advanced research method (paleoseismology, datings). A decade of continuous monitoring of microquakes tells nothing about potential high intensity earthquakes, which may occur every few hundred or thousand years.

Consequently, the value of 6.5ºMSK-64 set for the SSE in Temelin is not adequate and it also does not meet the IAEA recommendation of 7ºMSK-64.

3.5 Health Effects of Irradiation

In the paragraph dealing with collective doses, *"the collective dose expressed as a product of the average doses and the number of inhabitants that the researcher decides to use for the calculation (in this context, the question of how many inhabitants living in the NPP vicinity should be included in the collective dose calculation, is irrelevant; other methods may be used)"* is considered *"a suitable indicator"* (Commission 2001, Chapter 2.4).

The calculation of the "average dose" implies that the dose for each inhabitant and thus in fact the collective dose must have already been determined. Usually, the collective dose is the sum of all individual doses. It is completely inconceivable why the question of the area included in the calculation of the collective dose is considered irrelevant. On the contrary, the geographic distribution of the collective dose and in particular, the question which part of it falls on foreign countries, is especially interesting.

It says in Chapter 2.4.3.1.5.1 (Commission 2001) that computations were made for the distances of 667m, 1,667m, 5333m, and 10,667m. However, these values do not define the parameters of the calculations, as the directions are not specified. The question arises whether the program NORMAL takes the local climatology, e.g., the distribution of wind directions, into account if the direction seemingly does not play a role. Just in one of the calculations mentioned subsequently it is stated that it was made for the "north-east direction." However, computations for the other directions are important as well.

As far as the dose calculations are concerned in general, it seems strange that a male adult reference person is supposed to be a *"very conservative"* approach. Other groups of the population, such as children, old and ill people, or pregnant women are usually more severely affected by radioactivity than adult men.

As for sections 2.4.3.1-4 (basis for the dose computations), other chapters of the documentation are referred to, although these chapters do not handle these topics in a manner that would be sufficient for the subject matter of dose computation. The section 2.4.5.1 deals with the contamination of surface water by the sewage originating from the NPP. In this respect, tritium is the most relevant factor. The concentration of tritium in the receiving streams will be multiplied by the operation of the NPP, in extreme cases even to a factor of more than 360 for short periods. While percentile and graphic comparisons with natural irradiation are made for air contamination and the doses resulting from it, the aforementioned unfavorable result for the NPP is not presented in such a clear manner.

Furthermore, no estimates are made in regard to the individual or collective doses resulting from the discharge of tritium, nor is any information given about the fact that the tritium will be passed to Germany by means of the Vltava and Labe rivers and that at least to some extent, it will ultimately (half-life: 12 years) be distributed in the whole global water cycle.

Section 2.4.6 treats the calculation of effective doses at the border with Germany and Austria for two design accidents and makes a reference to the supplement of the documentation (Svoboda 2001). The summary of this report is inadequate. It is not explained what a Design Base Accident is and that much more severe accidents are also under discussion. The expression "wind intensity of F category" is not appropriate, as the dispersion classes A-F do not refer to wind conditions but to turbulence conditions. It is also surprising that this section is found in the context of normal operation and not under 2.7 (Possibility of Occurrence of Accidents). As far as the evaluation of the document (Svoboda 2001) as such is concerned, see Chapter 4.7 of this Statement.

It says in Section 2.4.7 that the table used for the computation of the effective dose load based on the intake of activities is comprised of 45 pages and thus is too long to be included in the documentation (as this probably refers to the dose factors listed in Annex 3 of the Czech regulation on radiological protection, it would have been sufficient if a reference to these dose factors had been made). The calculations should be part of the background documentation and it should be ensured that at least the effective doses resulting from the most important nuclides be presented.

In Chapter 2.4.7.1 (Commission 2001) External Radiation Monitoring, a reference is made to the existing measuring sites. However, no information is provided about how these measuring stations are positioned to the NPP. Same applies to the monitoring of air contamination, Chapter 2.4.7.2 (Commission 2001).

3.5.1 Assessment of the Existing Health Situation

This subject matter is treated in Chapter 2.4 (Commission 2001). In addition, an extensive study has been presented by the operator – CEZ (Invest Project 2001, Chapter C III, p. 187 – 203). The latter contains an assessment of the current health situation of the people living within a radius of 13km from the NPP. This "Health Study" considers exclusively the effects of normal operation.

„This study did not consider the possibility of an accident, as it is impossible to predict the size and location of the potentially affected area".

This statement is in contradiction to the assumption that the effects of an accident will be limited to the 13km zone.

Large cities (e.g., Ceske Budejovice) are located just in the area within the 30km zone. An evaluation of the health situation of these groups of population would be very important, in order to be able to record the effects of the NPP operation.

The "Health Study" was elaborated, in order to serve as a basis for the assessment of future effects of the NPP. However, exactly the diseases that are of particular significance in this context – thyroid cancer and pediatric leukemia – which may demonstrably be caused by ionizing radiation, were not identified separately in the course of the evaluation of the current health situation. The question arises how a potential increase in thyroid cancer and pediatric leukemia may be proved based on these data.

Moreover, the analysis of the number of malformations is missing.

The control group necessary for this kind of study was selected from neighboring regions. In case of an accident with effects reaching beyond the 13km zone, these regions would not be suitable for the selection of control groups any longer. The question arises which groups should be compared in such case.

It is not obvious from the information provided in Chapter 2.4.2.2 (Commission 2001) how the health situation of the population and the changes should be monitored and shown in the future. Three possibilities are suggested but no variant is defined as final. Consequently, it is impossible to comment on this either.

The impact of ionizing beams on the health of the population is discussed in Chapter 2.4.2.2 (Commission 2001). Right at the beginning of this chapter, the statement is made that the possible effects upon health are of key importance in the EIA process.

"This relationship has not yet been proven for the human populations, however, based on the experimental animal studies, it is regarded as an existing relationship."

This statement is in contradiction to many international studies and findings made even before Tchernobyl. Alone the works of ICRP and UNSCEAR show that ionizing radiation may cause genetic disorders in humans as well.

3.5.2 Assessment of Risk for the Population Caused by Normal Operation of the NPP

The potential health risks attributed to normal operation were examined as part of a model study (Invest Project 2001, Chapter CIII with Annex), (Commission 2001, Chapter 2.4.2.2).

The basis of these models is comprised of the volume activities of the 15 most important radionuclides in the air for different distances.

It is interesting that the dispersion of nuclides was calculated for a distance of up to 17.3km, which is in contradiction to the assumption that no effects may be expected beyond 13km (Invest Project, Chapter CIII, p. 198). However, as far as risk assessment is concerned, only a dispersion up to 10.7km was considered.

The health risk has been computed by two methods. Based on the computation made in compliance with the method used by the American health agency EPA (EPA 1999), the additional overall lifetime risk of death from cancer lies between $2.9*10^{-6}$ and $9.7*10^{-7}$ for 30 years of NPP operation. For morbidity, a risk between $4.3*10^{-6}$ to $6.2*10^{-7}$ is assumed.

As far as the calculation according to EPA is concerned, it must be stressed that only men were considered, no risk has been computed for women or children. However, the EPA also lists risk factors for children and women, which have obviously been ignored by the present EIA. This is a major failure, as specifically for children the risk is higher.

The value of $1*10^{-6}$ is considered the risk of both mortality and morbidity (additional lifetime risk) accepted internationally. The source for this internationally accepted value is not listed. Furthermore, several risk values exceed the risk of $1*10^{-6}$.

The reasons for the conclusion that the value of e.g., $4*10^{-6}$ is too conservative and thus may be compared to the internationally accepted value of $1*10^{-6}$ are in our view insufficient.

In addition, a comparison of the overall effective doses from natural and artificial radiation is made. A percentile representation shows that the Temelin dose amounts to just a fraction of the overall dose. This result is compared to countries such as Iran or parts of Norway, where the overall lifetime dose from natural sources comes to several hundred mSv. Allegedly, no increase in morbidity has been observed in these regions.

This representation is misleading. For example, certain areas in Byelorussia have received a much lower overall lifetime dose[2] from the accident in Tchernobyl than the aforementioned areas in Iran and still the incidence of thyroid cancer has risen unmistakably and considerably.

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[2] In 1996, the IAEA predicted that by the year 2056, the total accumulated dose would reach 160mSv in the areas contaminated the most. [IAEA Bulletin 1996]

3.5.3 Conclusions

The assessment of the impact of the NPP on the health situation of the population deals exclusively with the effects of normal operation. Solely a radius of 13km from the NPP is considered.

Contrary to all other EIA articles, the health study does not exclude possible effects of accidents reaching beyond this radius. However, due to the fact that no predictions can be made in regard to the affected regions, these effects are not analyzed.

Large cities are located exactly in the area within the 30km zone. An assessment of the health situation of these groups of population would be essential, in order to be able to record the long-term effects of the NPP operation. Thus, the assessment is not sufficient in this respect. One of the major failures of the health study is the lack of information regarding the diseases (thyroid cancer, pediatric leukemia, malformations in newborns) that may demonstrably be caused by ionizing radiation.

It remains to be answered, how the health situation of the population is supposed to be monitored in the future.

It is impossible to prove whether the dose computations for design base accidents or normal operation are true.

It seems that although health agencies are willing to observe potential effects of the NPP operation on the population, the Commission believes that this is not necessary.

3.6 Nature and Landscape

Chapter 2.5.2.1.2 (Commission 2001) deals with the effects of water vapor emissions from the cooling towers of the NPP. A comparison of the water discharge by the cooling towers with evapotranspiration would be reasonable. However, the existence of cooling tower plume (occurrence of shading and possibly drizzle or snow dust precipitation) is not mentioned, let alone discussed.

3.7 Waste/spent fuel

3.7.1 Radioactive waste from the NPPs

The Austrian position papers on EIA I - Building Annexes (UBA 2000 a) and EIA II - Construction Alterations (UBA 2000 b) discussed in detail the entire range of problems that relate to the treatment, storage and transportation of the different types of radioactive waste produced from operation of NPPs. Neither the overall EIA report of the investment project (Invest Projekt 2001), nor the EIA committee (Kommission 2001), however, contains any reference to the issues and areas of ambiguity they raised.

This report did nevertheless discuss the advantages and disadvantages of the bituminisation technology used in relation to fluid waste for the first time, and also recognized that "*the essential disadvantage of bituminisation technology is its increased fire risk*."

3.7.2 Spent fuel

3.7.2.1 Disposal

In Chapter 1.2 (Kommission 2001) during the discussion on *alternative solutions*, the problems surrounding disposal are mentioned twice:

- In 1998, although an international panel of experts *found that there were no serious problems in terms of environmental impact, it did once again uncover what were already well-known complications, such as the problem of final storage and the associated risks.*
- When listing the effects of the commissioning of the Temelin NPP, they concluded that there was only one negative effect: *the annual consumption of 40– 50 t of nuclear fuel creates a corresponding need to treat radioactive waste, as well as ensure its long-term storage.*

In chapter 2.6 Waste, a very simplistic picture is presented of the problems surrounding disposal:

"The treatment of spent fuel, i.e. storage, transportation and underground storage, presents no unsolvable technical or technological difficulties, and also no significant environmental risks."

In Chapter 3 Non-technical summary, it is even claimed that: *"spent fuel is not just waste that that we don't know where to. Rather, it is a potentially valuable energy source; and it is this way of thinking that determines policy in the majority of countries that use nuclear energy."*

In this regard, unsecured waste is just one of many reasons underlying the global slump in, or flight from, nuclear energy. Decades after the start of nuclear energy's commercial use, the problem of what to do with the nuclear fuel or radioactive waste (HAW) arising from reprocessing has not been solved anywhere in the world. Indeed, although the international technical community has assumed the inherent feasibility of creating final disposal that is secure in the long-term for this range of waste products, there is so far no evidence of the existence of any specific plant capable of doing this successfully. In fact, nowhere in the world is there an approved final disposal site for spent fuel elements and HAW. Nor is any likely to be constructed in the near future. Hence, continued production of spent fuel elements and HAW amounts to taking out a mortgage on the future, a mortgage whose repayments we have no way of knowing how we will meet.

At the present time, it looks like the revenues from spent fuel elements and HAW must be limited as much as possible for this reason. Also, as much as possible, we need to avoid creating new amounts of these waste products. This is one of the reasons that Germany took the decision to terminate its use of nuclear energy as rapidly as possible and to thrash out once again a national disposal plan for nuclear waste. In this context, it is intended that a panel of experts will come up with a suggested acceptable set of procedures, drawing on the current national and international state of knowledge on the subject; and this suggested plan will be implemented during the time final disposal locations are being selected.

The key suitability factor of a potential final storage site would be its demonstrable long-term security. In spite of more than three decades of ongoing research, there remains an intensive international debate regarding concepts and methods in this area. The latest research results from the Radioactive Waste Management Committee (RWMC) of the OECD/NEA on the security of final storage and methodology (OECD/NEA 1999) showed that an iterative methodology is what is needed to resolve once and for all long-term security issues.

At the same time, these results also point to issues that have been the subject of renewed the international debate in recent times, such as recoverability, use of safety indicators (IAEA 1999) and timeframes. Further, a circular issued by the European Commission in 1999 on the disposal of radioactive waste (EC 1999) contained an extensive chapter on the safety aspects of final storage. In this regard, particular attention was paid to an assessment of the long-term behavior of final disposal sites, recoverability, the interaction with human factors and the institutional control of final disposal sites. The definition of critical groups and biospheres, and also the inclusion of possible human factors affecting final storage sites (ICRP 2000) are just two of the areas being investigated by an International Committee for Radiological Protection (ICRP) Working Group, handling basic issues and criteria for the final storage of radioactive waste.

3.7.2.2 Storage in wet storage reservoirs

The reports mentioned do not deal in detail with the safety of wet storage of spent fuel. The problems surrounding wet storage of discussed in detail in the EIA II (UBA 2000 a) position paper.

3.7.2.3 Temporary storage of spent fuel

The report does not make clear where the spent fuel is to be transported to at the end of its cooling period in the reservoir, nor where the storage area for spent fuel is located. In the case of a storage area situated on the grounds of the Temelin NPP, a detailed environmental impact assessment would also need to be carried out.

3.7.2.4 Transportation of spent fuel

This topic has been dealt with very inadequately and only general comments have been made, such as: *"No accessible, relevant documents are available to assist in any assessment of the transportation of spent fuel. Therefore, this study is based on assumptions pertaining to generally applied procedures and rules, as well as on current legislation, and experiences gained from transportation projects already carried out, both in the Czech Republic and Slovakia (transportation of spent fuel from the Slovak NPP at Bohunice to the spent fuel storage area at Dukovany and also transportation abroad)."*

3.7.3 Conclusions

The general EIA documentation within Invest Projekt fails to address the issues and areas of ambiguity regarding waste disposal problems raised in the Austrian reports on EIA I and EIA II.

As regards bituminisation technology used in relation to fluid waste, the committee's documentation for the first time discusses the respective advantages and disadvantages of the technology; and specifically recognizes that *"the disadvantage of bituminisation technology is the increased fire hazard that it creates."*

Their final comment on spent nuclear fuel is:

"The treatment of spent fuel, i.e. storage, transportation and underground storage, presents no unsolvable technical or technological difficulties, and also no significant environmental risks." In this regard, unsecured waste is just one of many reasons underlying the global slump in, or flight, from nuclear energy. Decades after the start of nuclear energy's commercial use, the problem of what to do with the nuclear fuel or radioactive waste (HAW) arising from reprocessing has still not been solved anywhere in the world.

3.8 Accident prevention and design fault-related breakdowns

3.8.1 Accident prevention - the addition of safety features

Measures intended to prevent accident prevention are a major topic area addressed in Chapter 4 of the General EIA Report (Kommission 2001) on the project. (This issue is dealt with under Topic Area 07 "*possible occurrence of accidents*" contained in the assessment table.

The Austrian draft of the Scoping List refers to: *"measures designed to avoid, reduce and as far as possible compensate for, the severe negative impact of the project on the environment during construction, operation and/or failures"*. In the final version of the Scoping List, this topic area of possible accidents is also addressed (in Chapter 2.7, item 2.7.1): *"accident prevention, limits and conditions of safe operation".*

The Council of the European Union's EIA Directive 97/11/EG of March 1997, article 6 (3) and Schedule IV (EU 97/11/EC) requests the project operators to submit a report to the Austrian government in relation to the general EIA at Temelin by June 2001, describing "*the measures designed to avoid, reduce and as far as possible compensate for the plant's severe negative effects".*

This topic area is dealt with in chapter 2.7.1 (Accident Prevention) and also in Chapter 2.7.2 (Limits and Conditions of Safe Operation) of the General Environmental Impact Assessment Report for Temelin (Kommission 2001):

Specific deficits:

This chapter does not state what accident prevention measures have already been implemented at the present time, or will be in the near future. Nor does this chapter contain a summary of the status quo regarding the implementation of safety relevant additional equipment at the plant, as demanded for Temelin in 1996 by the International Atomic Energy Authority, among others.

Further, the safety issues raised -- which to date are still unresolved -- in the context of the Trialog trial, a process running in parallel to the Temelin general EIA investigation were not addressed, either. Based on the Melk Treaty, 29 potentially safety relevant problem areas were dealt with in the course of this process. (See UBA home page).

3.8.1.1 IAEA safety faults in WWER-1000/320 reactors

In 1996, the International Atomic Energy Authority identified 84 safety relevant problem areas in relation to the WWER-1000/320 reactor type, classifying them in categories I-IV, according to their degree of safety relevance (IAEA 1996a).

- Category IV: *„Issues in Category IV are of the highest safety concern. Defence in depth is unacceptable. Immediate action is required to overcome the issue. Compensatory measures have to be established until the safety problems are resolved."*
- Category III: *„Issues in Category III are of high safety concern. Defense in depth is insufficient. Immediate corrective action is necessary. Interim measures might also be necessary."*
- Category II: *„Issues in Category II are of safety concern. Defense in depth is degraded. Action is required to resolve the issue."*
- Category I: *„Issues in Category I reflect a departure from recognized international practices. It may be appropriate to address them as part of actions to resolve higher priority issues."*

In this context, 11 safety faults fall within category III, 38 within category II and 22 within category I. 13 safety deficiencies relating to plant operations were not categorized at all.

Table 1: Safety faults in WWER-1000/320 reactors and their categorization (IAEA 1996a)

Category	I	II	III	IV	unclassified
Design					
General	-	2	1	-	
Reactor core	-	2	1	-	
Integrity of components	-	2	4	-	
Systems	4	9	2	-	
Regulation and management technology	4	6	1	-	
Electricity supply	4	1	1	-	
Containment	-	1	-	-	
Internal hazards	1	6	1	-	
External hazards	1	2	-	-	
Accident analysis	8	7	-	-	
Subtotal	22	38	11	-	
Operation					
Operation regulations	-	-	-	-	3
Management	-	-	-	-	4
NPP operation	-	-	-	-	3
Radiation shielding	-	-	-	-	1
Training	-	-	-	-	1
Disaster management planning	-	-	-	-	1
Subtotal	-	-	-	-	13
Total	**22**	**38**	**11**	**-**	**13**

In 1996, based on the safety faults identified generally for the WWER-1000/320 reactor type, the IAEA produced a list of recommendations for additional safety features to be installed at Temelin (IAEA 1996b).

The general EIA documentation contains no information on the status of additional safety features at Temelin, intended to remedy these safety faults.

3.8.1.2 Unresolved safety problems at the Temelin NPP

Based on various documents (WENRA, 2000; GRS, 2000; IAEA 1996a und b; KUJAL, 1997; IAEA, 1998) and information provided by experts participated in the "severe accident forum" workshop in Prague (See also Chapter 2 - Introduction), the following major safety problems can be identified; and further, no evidence has been produced showing that these safety problems have been resolved by installing additional safety features.

Essentially, these topic areas relate to be reliability of barriers protecting against the release of radioactivity from the Temelin NPP under all conceivable conditions. They deal with the integrity of physical barriers, such as reactor pressure vessels and general containment, and their effectiveness. They also deal with the adequacy of the Emergency Zones and Action

Plan advocated as part of the Five Stage Barrier Plan for the plant (INSAG-3, INSAG-12). Further, there are the unresolved topics of the qualification of components and earthquake hazards.

Topic area: Primary cycle barrier

- Reactor pressure vessel cracking and shock loading under temperature and pressure stresses (PTS).

  The necessity of performing appropriate inspections to verify the integrity of the reactor pressure vessel throughout a reactor's entire lifespan is now generally accepted (IAEA 1996a). Current European practice demands that this inspection takes place before a reactor is commissioned, in order to verify early on whether the reactor pressure vessel is capable of withstanding cracking throughout its planned lifespan. Potentially necessary safety features can then be installed before commissioning (IAEA 1996a).

  However, the Czech side would like to carry out the study on Blocks 1 and 2 sometime in the next five years.

  Nevertheless, the integrity of the reactor pressure vessel is of the highest importance, if only because no safety system is capable of compensating for its sudden failure.

- Destruction-free checks (NDT)

  The necessity of undertaking corresponding material checks to safety relevant components is also generally accepted (IAEA 1996a). In contrast to general international practice, these checks were not carried out at Temelin before the plant was commissioned. Not only that, but both the scope of the checks and the methods used when the checks were finally carried out do not conform to international practice.

Topic Area: Containment, integrity and bypass components

- Containment: design and arrangement

  In contrast to western plants, the containment in the WWER 1000 (and therefore in Temelin) is located in a suspended position, rather than on the ground (IAEA 1998). It also includes further good-sized rooms, the layout of which does not correspond to a containment (IAEA 1998). In the scenario of an accidental core meltdown leading to a melt through of the flooring panels, these areas could function as a conduit for a major release of radioactivity into the environment (SUJB May 2001) (Kujal 1997). Chapter 4.5 contains a discussion of the measures necessary to prevent this from happening.

- Controlling Hydrogen release

  In the case of an accidental core meltdown, considerable amounts of hydrogen could be created within the containment. At Temelin, it is not yet been ensured that the recombination units are capable of preventing hydrogen explosions (Kujal 1997). Corresponding studies and the implementation of the measures that those studies might advocate to control this problem (as is standard European practice) are urgently necessary.

  There is a greater than two-thirds probability that containment bypass and accidents involving transfer from the primary to the secondary circulations (and also failures due to the loss of cooling agent resulting in a bypass of the containment (all this caused in turn by leaks in a steam production vessel)) would contribute to a reactor core meltdown (Mlady 1999). European standards dictate, however, that these kinds of failures must not be the major factor contributing to the likelihood of an accident. Appropriate countermeasures designed both to reduce the influence of these factors to a markedly lower level, and to diminish the consequences of any release, if that were to occur, are necessary.

- Evidence of the qualification of safety and release valves in the secondary circulation.

  Cooling water leaks from the primary to the secondary side, due to the failure of internal steam production components, can result in a two-phase steam/water assault on secondary-side safety and release valves (IAEA 1996 a). At Temelin, following nuclear commissioning, the qualification of the relevant valves in relation to the stated set of conditions remains pending (WENRA 2000). The approval authority should have been required to demand that the said valves were qualified, and that the corresponding documentation was in order and in place, before commissioning actually occurred; all of which is standard European practice.

- Rupture of the fresh steam and water feed piping (28.8 m high platform)

  At the Temelin NPP, the high energy fresh steam and water feed pipes have been laid between the containment and the powerhouse, on the same level as the 28.8 m high platform located in the auxiliary building; and they do not benefit from any separating bulkheads or breakout prevention arrangements. Thus, in the case of a ruptured pipe, an event that the safety systems would need to bring under control, consequential damage to other pipes and components could result; and this in turn could lead to accidents that are not capable of being controlled at all. Both the German Society for Reactor Safety (GRS 2000) and WENRA (WENRA 2000), an informal international organization of supervisory authorities in the countries that operate nuclear power plants, have assessed this issue as unresolved in the case of Temelin.

A study encompassing all conceivable failures, including any associated consequential damage, right up to multiple failures in piping, and dealing also with construction and renovation actions designed to avoid them, is necessary.

Topic Area: Emergency measures and zones

- Accident procedures (EOPs) and emergency measures (SAMGs)

  Internal plant emergency measures intended to prevent failures that exceed design parameters, and action Directives in the case of reactor core meltdown accidents, together form the final barrier in the multiple barrier plan devised for NPPs (INSAG-3, INSAG-12). As far as Temelin is concerned, these aspects have still not been fully worked out or implemented (SUJB April 2001). Completion of these works, taking into account recent studies of failures that exceed design parameters, is necessary.

- Technical basis for defining Emergency Planning Zones (EPZs)

  When establishing Emergency Planning Zones, a more extensive information interchange regarding the fundamental assumptions and methodology used would be desirable. It is necessary to include nearby Austrian border areas when defining these zones; and also to undertake coordination of emergency prevention measures across the national borders concerned. (This topic is dealt with in more detail in chapter 4.3 of this report.)

Topic Area: Seismology

The assessment made of seismic hazards to the Temelin site is based on analytical methods that are outdated in terms of the current state of technology, and there are certain indications that the risk in this regard has been underestimated. (See also Section 3.4.)

Although the IAEA ordered the upgrading of the plant’s earthquake proofing to a value of 0.1 g in 1991, it is unclear whether or not this requirement has been implemented. A review and redefinition of the strength of the plant's designed earthquake tolerance and its actual seismic qualification are now necessary.

Evidence of the qualification of plant components

According to general European practice, a reactor may only be operated if all of its safety relevant equipment is qualified for all conceivable operating conditions (including failure scenarios, earthquakes, etc.); and also if the associated documentation is also up to standard in this regard. At Temelin, this precondition is only partially fulfilled, because the qualification process has not yet been completed. (See, for example, the valves mentioned above.)

3.8.1.3 Conclusions

As far as Temelin is concerned, there are safety deficits with a major negative impact on both the effectiveness and reliability of the multiple barrier plan ("Defence in Depth“ (INSAG-3, INSAG-12)) devised for this NPP.

Under general European practice, operation of this plant with the safety deficits mentioned would be prohibited.

The deficits mentioned also need to be viewed in terms of the General Environmental Impact Assessment for Temelin. European Directive (Environmental Impact Assessment Council Directive 97/11/EC of March 1997, Article 6 (3) and Schedule IV (EU 97/11/EC) requires a project's operators to *"describe the measures used to prevent, reduce and as far as possible rectify major negative impacts"*.

3.8.2 Temelin and international safety objectives

In the documentation pertaining to Temelin's general Environmental Impact Assessment (Kommission, 2001), Chapter 1.2 makes the following finding regarding the likelihood of major accidents:

"The risk of major accidents occurring at the Temelin NPP is very small and is in the area of 2.6E-5/Ra (The IAEA's safety objective is 10-4/Ra, whereby at that value no measures need be implemented at all.)"

The stated value of *"2.6E-5/Ra" (*Ra = for reactor and year) cannot be checked. No reasons are given as underlying this value, nor can it be found in any documentation made available to date, nor is it contained in any reference to other literature.

The probability of the nuclear accidents occurring stated in the Probability Safety Analysis (PSA) carried out in 1995 does not agree with the value stated, being higher by a factor of approximately 4 (Mlady 1999). A PSA update has been in course of preparation since the end of January 2001. However, this is not expected to be completed before 2002. (See Chapter, Major Accidents: 4 .5).

The value of 2.6E-5/Ra for the *"risk of major accidents occurring in the Temelin NPP"*, as stated in the general Environmental Impact Assessment Report (Kommission 2001) also contradicts the data contained in the papers on major accidents drafted by SUJB (SUJB, May 2001). In these, the probability of a core meltdown occurring due to untoward events taking place within the plant is given as 8.95x10-5/reactor and year.

Comparison of the Probability Safety Analysis (PSA) for Temelin carried out in 1995 with the IAEA's safety objectives:

The Temelin PSA carried out in 1995 came to the conclusion that the probability of a nuclear accident (CDF) occurring at the reactor is 1.1×10 -4 per year (Mlady 1999). The results contained in this report also indicated that at Temelin, the likelihood of the early major release of radioactivity (due to containment bypass and other contributing factors) is almost as high, namely 9.3×10 -5 per year. This means that, according to the PSA carried out for Temelin, virtually every major accident that causes a core meltdown will also lead to an early release of major amounts of radioactivity.

1998 was the first year that the International Atomic Energy Authority's (IAEA) International Nuclear Safety Advisory Group (INSAG) formulated quantitative safety objectives for reactors in both current and future operation (INSAG-3 1988). The INSAG-3 safety objectives were summarized in a publication issued by the German Federal Office for Radiation Safety (BfS 1996) in the following way:

- *"As far as existing plants are concerned, the likelihood of severe nuclear accidents occurring should not exceed 10-4 per year, and for plants that have not yet been constructed, this upper limit is set at 10-5 per year; and*
- *the likelihood of major radiation releases taking place and causing significant damage in the vicinity should actually be lower than this by at least a factor of 10, after the emergency protection systems in place inside the plant are taken into account".*

This view was essentially adopted in the update to this report issued in 1999 (INSAG-12 1999).

A comparison of this data with the PSA results for Temelin shows that the likelihood of severe nuclear accident damage occurring is situated roughly at the INSAG-3 limit, although the likelihood of a major release of radioactivity is greater than the INSAG limit by an approximate factor of 1. The

With regard to a comparison of the likelihood of a major accident at Temelin with the safety objectives being used in other EU countries, the reader is referred to Chapter 4.5 and the material on major accidents contained in this report.

Possible changes in the update to the Temelin Probability Safety Analysis

The 1995 PSA has a number of shortcomings. An update has been expected since January 2001. Chapter 4.5 of this report contains a discussion of our own estimate of the expected reduction in the probability of a core meltdown (CDF), based on safety improvements carried out the plant so far and also improved estimates undertaken within the PSA update. However, our conclusion is that the safety objective contained in INSAG-12 continues to be overshot in relation to the probability of major releases of radioactivity.

3.8.2.1 Conclusions

The value of 2.6E-5/Ra stated in the Environmental Impact Assessment Report in relation to the *"risk of major nuclear accidents occurring at the Temelin NPP"* cannot be checked. Further, it contradicts the Probability Safety Analysis completed for the plant in 1995, as well as the data contained in the SUJB report on major accidents (SUJB, May 2001).

When judged in accordance with the results of the 1995 Probability Safety Analysis, Temelin does not meet the quantitative safety objectives set by the International Atomic Energy Authority for nuclear plants that are already in operation (INSAG-12).

3.8.3 Design-related failures

Chapter 2.7.2 of the Temelin General Environmental Impact Assessment Report (Kommission 2001) contains a brief summary of the design-related failures stated within the precommissioning safety report. The background documentation contained in CEZ (Invest Projekt 2001) deals with this chapter in more detail.

The three reference accidents selected in the Temelin General Environmental Impact Assessment Report can only be partially checked. Thus, this documentation fails to deal with, for example, the leak that occurred from the primary circulation to the secondary circulation (as caused by either fractured steam production pipes or steam production collector leaks).

Accidents caused by extreme events, however, have been addressed. In spite of this, the treatment of external events looked at, such as breaks in the gas pipeline, the impact of crashing aircraft and earthquakes, is limited to one brief paragraph.

With regard to the evaluation of the radiological consequences of the reference accidents mentioned (and this includes the associated atmospheric releases of radioactivity); although these were discussed in more detail, the following information allowing them to be followed up and verified was not supplied:

- Data on radioactive releases (source terms, level of release, release duration, etc.)
- Data regarding the various meteorological scenarios affecting calculations of the geographical spread of any releases: for example, how much has precipitation been taken into account?
- Data regarding the methods used to assess doses/dose models.

The General Environmental Impact Assessment Report (Kommission 2001) discussed the following design-related failures in more detail, in terms of reference accidents:

Reference accidents entailing releases of radioactivity into the atmosphere

- Major failure involving loss of cooling agent (2F rupture, maximum design-related failure)
- Rupture to the feed system pipework in the primary circulation, with subsequent loss of cooling agent and containment bypass.

1 Reference accident involving the release of radioactivity into watercourses:

- Leaks of concentrated fluid radioactive waste from storage tanks (See Temelin Environmental Impact Assessment Report Part 1 (UBA 2000 a).

The various design-related failures are classified in four categories, according to respective probability (Kommission 2001):

Category I: Normal operation and transient operational states

Category II: Events with moderate frequency of occurrence

Category III: Events with low frequency of occurrence

Category IV: Limit (accident) events

According to the General Environmental Impact Assessment Report (Kommission 2001), the three reference accidents selected fall within categories III and IV.

Distinction: major accidents versus design-related failures:

The General Environmental Impact Assessment Report (Kommission 2001) only discusses what it refers to as ‘design-related failures’, either in general or as reference accidents. The following paragraphs are intended to clarify the distinction between major accidents, as dealt with separately in the SUJB reports (SUJB, May 2001), and the reference design-related failures referred to in the Temelin Environmental Impact Assessment Report.

In general, major accidents are regarded as being core meltdowns, i.e. destruction of the reactor core (Pershagen 1989); and also as situations where large quantities of radioactivity -- primarily fission products -- are released from exposed nuclear fuel material. However, these events would not always involve the release of large amounts of radioactivity into the environment itself, because various retention systems (such as containment) are meant to be in place within the plant. Thus, the massive destruction of the reactor core (core meltdown) is what distinguishes major accidents from the said "design-related failures": the latter have, in fact, far less potential for releasing radioactivity into the environment.

Thus, the consensus report issued by the Council of the European Union regarding the safety of European light water reactors (EUR 16803 EN 1995) makes the following distinction: major accidents are accidents, for which the potential of a radiation release into the atmosphere is significantly higher than is the case for the radiation releases that can be expected from design-related failures. It makes good sense that a nuclear power plant should be designed in a way that major accidents would occur far less frequently than any design-related failures, the latter being regarded as intrinsic to the individual design of the nuclear power plant concerned. (NUREG-1555)

Selection of reference failures (= design-related failures):

Chapters 2.7.2.3 and 2.7.2.3.3 (Kommission 2001) of the Environmental Impact Assessment Report contain information on the probability of occurrence of the various design-related failures:

- Failure involving major loss of cooling agent: *"a type LB LOCA accident caused by a sudden, complete break to 850 mm diameter pipework of the primary circulation -- commonly referred to as a guillotine break -- is generally regarded as the maximum size design-related failure. Its probability of occurrence is assessed at* ***10^{-4} to 10^{-5} per year.****"*
- Leak from concentrated radioactive waste storage tanks: *"This option is based on the fact that this type of accident signifies the greatest risk for the release of radioactive materials into the hydrosphere. In spite of this, the total probability of this scenario actually taking place is just* ***10^{-6} per reactor year.“***
- The Temelin General Environmental Impact Assessment Report (Kommission 2001) has not stated any probability for a reference failure occurring due to a break in the feed system pipe work.

Comparison with the results of the 1995 Probability Safety Analysis show that the likelihood of major accidents occurring at Temelin is greater than at least two of the reference design-related failures investigated here. As far as the operational reactor at Temelin is concerned, the overall probability of a reactor core meltdown due to internal and external events (See Chapter 4.5 of this report) is 1.1x10- 4/reactor year. Alone, major accidents caused by leaks from the primary to the secondary circulation make up over 60% of the total probability of all serious accidents (6.5x10-5 per reactor year).

Leaks from the primary to the secondary circulation analysed as a failure group

The German Society for Reactor Safety has published a study (GRS 2000) into the failure analyses carried out at Temelin, as contained in the pre-commissioning safety report. It also examined the inherent quality of these analyses by means of "spot checks".

At Temelin, as regards the failure group consisting of leaks from the primary to the secondary circulation (caused by defects in the steam production unit, and assessed with a probability of occurrence of between 2x10-2 und 10-3, See Chapter 4.5), the General Environmental Impact Assessment Report available does not contain any further comments; and the following result was achieved:

The GRS makes the following comment in relation to the assumptions on which the analysis of this failure group is based: "Further, it is never envisaged that one of these valves might get stuck in an open position. No reasons are given for this, nor is any adequate probability-based evidence supplied relating to this area -- something that is not compatible with the deterministic specifications expected from an analysis of design-related failures." (GRS 2000)

The pre-commissioning report states specific limits for radiological effects that have to be complied with in the case of design-related failures. They are the following (Committee 2001):

- Category II (extraordinary conditions) -- 12.5 mSv over 50 years,
- Category IV (accidents) -- 12.5 mSv over 50 years.

Further, it remains unclear (and has not been investigated) whether the maximum dose limit of 50 mSv (in 50 years) can be complied with, in a scenario where the fresh steam release vents and safety vents get stuck in an open position.

3.8.3.1 Conclusions

Two of the three reference accidents investigated (and these, as design-related failures, would have a relatively limited radiological impact on the vicinity) are assessed as being less likely to occur than major accidents.

The Environmental Impact Assessment Report fails to deal at all with the design-related failures involving leaks from the primary to the secondary circulation, a category that is significant in the context of Temelin.

In general, the Environmental Impact Assessment Report deals inadequately with accidents triggered by external events.

3.8.4 Radiological consequences

Section 2.7.4.1 (Kommission 2001) deals with releases into the atmosphere, including the calculation model used and the resulting doses.

Calculations were carried out using the *Herald* software program, although no documentation or any additional literature was presented to clarify its usage. Another report (Svoboda 2001) contains a rather more detailed description of this software, some additional information and also some calculation results. Clearly, these reports were not coordinated with each other, and neither refers to the other. They are therefore commented on separately, below.

The description: *"is solved using the normal diffusion model (Gauss model), with the addition of ‘Box’ or ‘Semi-box’ methodology"* (Kommission 2001) is hardly an appropriate or adequate way of describing the model used. The term ‘semi box methodology’ is, in fact, totally unknown in both the German language and English-language technical literature on the subject. Interestingly, the model includes a modified version of dry deposition due to topography, something that completely exceeds the generally used standard. In spite of this, no further information is offered regarding the nature and effect of this modification. Further, although distribution varies according to direction, it is clear that only one wind direction has been assumed (22.5 degrees). No reason is given for this choice of direction.

Except in relation to the diffusion category, *none of the input data used to calculate distribution* has been presented. (The following are absent: source term, wind speed, precipitation, mixture level, and also coefficients and parameters used in the model.) Thus, neither the calculations and nor any claims based on them can be checked.

It is claimed that *category F is a conservative estimate*. Category F describes a meteorological situation involving very slight turbulence, i.e. a slight thinning of the hazardous material. Except where the sources are very low, this is not necessarily the most unfavorable situation for the immediately surrounding area. Although no original level is given, it can be assumed that the 100 m ventilation stack, or at least the 60 m high building, is used as the point of exit for scenarios involving design-related failure. In the case of less stable categories, a higher dose than one occurring with category F can be expected in the immediate vicinity.

Further, the meteorological situations described in relation to simplifying categories A to F are not necessarily the most unfavorable ones. If the radioactive cloud were, for example, to drift into a populated area under conditions of slight breeze, and if the lack of wind were then to cause it to remain stationary, even higher doses can be expected than were calculated for Category F using a wind speed scenario of 2 m/s.

For this reason, there is no justification for empirically classifying category F as relating to a wind speed scenario of 2 m/s.

Both the calculation of the *collective dose* and its analysis are, in fact, questionable. It is unclear what meteorological situations were used as the basis for this calculation or were identified as a conservative situation. The phrase "wind direction calculated for each sector" suggests that the existence of stationary and uniform meteorological conditions was assumed. If this was indeed the case, then this is totally inadequate for calculations meant to cover the entire territory of the Czech Republic.

Finally, no proof whatever is offered to support the claim that the collective doses occurring in neighboring countries would be "several levels lower" than "in the Czech Republic". In fact, given the form in which this statement is presented, namely without any reference to underlying meteorological conditions, it is totally meaningless.

From a meteorological standpoint, it should be stated in relation to this section that the doses and their geographical distribution are both heavily dependent on the *appearance of precipitation*. In spite of this, the EIA Report does not deal with this fact at all, and does not even state whether or not the existence of any precipitation was assumed when the calculations were being made.

Section 2.7.4.2 (Kommission 2001) discusses the consequences of releases into receiving watercourses occurring due to accidents (the river Moldau). At this point, a surprising sentence appears: *"No risk is posed to the populations of neighboring countries in the scenario, because the location is sited in an area that drains into the North Sea."*

Why the fact that the Moldau drains via the Elbe into the North Sea means that there is no risk for the German downstream areas on the Elbe is mystifying.

Just before the start of Section 2.7.3 (Kommission 2001), there is an illustration with the caption *"Dependence of the dose on distance with reference accidents at the Temelin NPP (West South West direction)"*. There is no explanation or discussion of this caption. Clearly, it relates to the two major accidents subsequently identified as forming the standard basis for disaster planning. It is surprising that no continuous reduction of the dose occurs with increasing distance in the context of "MPN - LOCA within the containment". In fact, a number of secondary maximum limits appear; whereby an absolute minimum is presented at approx 35 km, and then after that, a gentle increase can be seen up to the calculated upper limit of 60 km. No verifiable reasons are given for the *establishment of the first two emergency planning zones* by the supervisory authority (5 km and 13 km), as discussed in Section 2.7.3.2 (Kommission 2001).

Contrariwise, this paragraph speaks of calculations "for categories D and F", which suggests a deterministic calculation method. Equally, further up in the paragraph there is a problematic definition of both zones (i.e. in a median climate, 90% and 99% of serious health consequences within both zones, respectively). As has been stated above, in this context the appearance of precipitation is extremely significant, and the fact that this issue has clearly not been paid any attention at all is a very serious error.

The sentence "*When compared to general European practice, both of these zones are sufficiently conservative."* has been expressed in a very unclear way, and with no supporting evidence whatever.

Also, in this section one of the statements we read on the issue of the SUJB supervisory authority's responsibility is: *"Analysis and prediction of accident consequences affecting the territory of the Czech Republic, and perhaps also other countries".* Unfortunately, there is a total absence of any more detailed data governing how this analysis and prediction are meant to be carried out. Given the fact that the responsible authorities are not obviously in a position, during the plant approval process, to investigate the potential distribution of radioactivity in the event of major accidents, it is questionable whether this task could be carried out under the pressure of a recent catastrophic accident.

In any case, the actual formulation of this task underlines the statements made above stating that measures undertaken within the second zones (location of shelters, administration of prophylactic iodine, possible evacuation) *"could, in the case of major accidents, extend beyond this area's borders ".* It follows from this that within the third zone, and therefore over a greater distance, such as including territory within Austria or Germany, it can be expected that taking short-term protective actions (administration of prophylactic iodine, location of shelters) will be necessary.

The concluding summary claims: *"Analysis of the radiological consequences from the reference accidents selected at the Temelin NPP demonstrates that, according to the analysis results obtained, even if conservative parameters are assumed, the health of population of the Czech Republic or of the neighboring countries of Austria and Germany will not be endangered".* The recommendation made contains calculations that are set too conservatively, and this suggests that the calculation carried out was actually just a "best estimate".

In this context, it should also be noted that:

- The concept of "endangerment to health" has not been defined clearly.
- No evidence has been presented that the dose limits (which seem to have been set arbitrarily) have been kept to. The only result of the dose calculations stated consists of the diagram already referred to, which the text does not discuss at all. There are no verifiable presentations of the calculations underlying the curves shown in this diagram; and there is also no indication given that these curves in fact amount to conservative estimates. Against this background, the call contained in the report's conclusions section for less conservative calculations to be made is both scurrilous and counter-productive.
- Numerous aspects of the disaster planning described suggest that, in reality, the Czech authorities are probably envisaging far more extensive consequences of a nuclear accident, involving scenarios that would be potentially more hazardous to human health.

Additional information has been made available in Svoboda 2001, a document that was supplied separately. As already stated, neither report was coordinated with the other. There now follows a discussion of the content of Svoboda 2001:

The description of the model used is in fact more detailed than the one contained in the other report (Kommission 2001). Thus, the meaning of "box model" is actually stated. However, the meaning of "semi-box model" is still not explained. Also, nothing is said about which of the model variants forms the foundation for the calculations made, and why. It is apparent from the description that radioactivity is not regarded as being deposited on the ground while a cloud is passing over, but rather as occurring just after a cloud has passed. In fact, this is a factor in the general underestimate of radiation doses.

It is claimed that meteorological conditions have been selected conservatively. Further on, it is explained that only four different meteorological scenarios were investigated: Distribution Categories A and B without precipitation, and Distribution Category D with precipitation of 10 mm/h.

The source height is stated as 10 m without thermal elevation, and no information given about what allowance has been made for the effects of buildings. (We can assume that these effects were not taken into account, since they are not mentioned in the descriptive accounts of the models used.) No data regarding wind speed, mixture level and source term (all essential information with regard to verifiability and the analysis of essential data) has been supplied.

It can be noted that the meteorological conditions throughout the distribution categories (at least, in the immediate vicinity, where it would be justified to assume the existence of stationery and uniform conditions) are described in a "realistic" and not in a "conservative" way. This is the case if we mean by "conservative" the systematic assumption of the existence of the most unfavorable preconditions (even if those conditions couldn't actually occur in that combination in nature).

In fact, what is probably meant is "the most unfavorable" meteorological conditions. In order to find these, it would be necessary to include in any research the variation range of all meteorological parameters; (in this case, wind direction, wind speed, distribution category and at least a minimum mixture level per distribution category). However, the only parameter that has been fully investigated is the one that clearly has the least impact, namely wind direction. It appears that no variation at all in wind speed has been considered, and of the variety of possible precipitation rates, just 0 und 10 mm/h (the latter in relation to one distribution category only) were considered.

This methodology does not enable the most unfavorable situation to be identified. The writer's own experiences suggest that weaker precipitation can lead to an even more unfavorable situation. Further, even in stable situations, precipitation can fall (a warm front, a concealed cold front).

Fundamentally, a model that allows precipitation to fall uniformly over the entire area dealt with is totally inappropriate when it comes to assessing the potential doses of radioactivity that would occur on the Austria and German borders in the most unfavorable scenario. The most unfavorable scenario occurring in relation to more distant emission points is, of course, one in which, at first, no precipitation falls; but then appears later on, once a cloud passes the emission point. In addition, it should be noted that a source height of 10 m with no thermic elevation will lead to a relatively strong, dry deposit and therefore favor distant areas in relative terms. Thus, the question arises, which regions should the assumed accident scenarios, together with the associated peripheral conditions (release height, heat) actually be qualified for?

3.8.4.1 Conclusions

As far as the verifiability of the estimates carried out for the radiological consequences of the two accidents involving atmospheric release is concerned, significant data is absent (such as exact source terms).

Information has been presented, however, regarding the doses of radiation to be expected on the international borders with Germany and Austria, in the event of the reference accidents looked at actually occurring. Although data specific to Temelin on the possible impact on neighboring countries of these scenarios has been requested a number of times, none has so far been provided. (See Chapter 4.3.)

The *concluding summary claims: "Analysis of the radiological consequences from the reference accidents selected at the Temelin NPP demonstrates that, according to the analysis results obtained, even if conservative parameters are assumed, the health of population of the Czech Republic or of the neighboring countries of Austria and Germany would not be endangered".* The recommendation made contains calculations that are set too conservatively, and this suggests that the calculation carried out was actually just a "best estimate". But:

The concept of "endangerment to health" has not been defined clearly.

No evidence has been presented that the dose limits (which seem to have been set arbitrarily) have been kept to. The only result of dose calculations stated consists of the diagram already referred to, which the text does not discuss at all. There are no verifiable presentations of the calculations underlying the curves shown in this diagram; and there is also no indication given that these curves in fact amount to conservative estimates.

Numerous aspects of the disaster planning described suggest that in reality the Czech authorities are probably envisaging far more extensive consequences of a nuclear accident, involving scenarios that would potentially be more hazardous to human health.

3.9 Non-technical summary

The non-technical summary is inadequate. Topics appear in the summary that have not been addressed elsewhere previously in the EIA, such as construction differences between the Temelin NPP and the Chernobyl NPP (an issue that has nothing to do with the environmental safety of the Temelin NPP), a discussion of turbine problems, a theoretical discussion of handling major accidents, and issues regarding the reprocessing of spent fuel. The accidents themselves are discussed in a totally inadequate way. It is not made clear what the consequences of a major accident occurring at Temelin might actually be.

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4 SEVERE ACCIDENTS AND THEIR CONSEQUENCES

SUMMARY

Severe accident scenarios in the SUJB-report

The documents that were at first submitted as part of the Environmental Impact Assessment did not contain any data on severe accidents and their consequences, i.e. on accidents that exceed design basis accidents and can lead to large radioactive releases into the environment.

The documents that were submitted later due to Austrian demands for supplementary information (SUJB, April 2001 and SUJB May 2001) did not comply with international practice or with the demands of the EU-EIA directive (EC 97/11/EC). However, it was possible to conduct own estimates of possible consequences of these accidents for Austria. These estimates are based on the data from the inventory and the source term used for the Czech emergency planning, contained in these documents.

The core damage frequency (CDF) is according to the Probabilistic Safety Assessment, which was performed (ordered) by the operator in 1995, above 10^{-5} per year. This is above the safety objectives of several EU member states and Russia.

The CDF for Temelin is dominated by accident sequences leading to containment bypass. This deviates clearly from practice in other EU member states.

Moreover, such high frequency for containment bypass sequences exceeds the INSAG safety target set by the IAEA, as well as the safety objectives for large releases in several EU member states and Russia.

Because the severe accident analyses were not conducted, or not adequately conducted, mainly concerning the containment integrity, it cannot be excluded that the severe accident frequency is underestimated.

From an Austrian perspective, the analysis on which the emergency planning for Temelin is based on is insufficient because of missing analyses.

If the containment integrity during severe accidents cannot be guaranteed, we have to expect radioactive releases larger than for the accidents sequences used for the emergency planning.

Measures for reducing the frequency and/or measures for mitigating severe accident consequences are not being discussed in the framework of the Comprehensive Temelin EIA and the SUJB – documents. This despite that a pilot study has already been conducted by the operator and a high number of these measures are discussed in publications. This does not comply with the EU-EIA directive (EC 97/11/EC), which asks the operator to provide *"A description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment."*

The treatment of severe accidents in the framework of the Temelin comprehensive EIA documentation (including the documents on severe accidents) are concerning completeness as well as content, inadequate.

Emergency planning for Temelin

The IAEA definition for the determination of the zones (IAEA TECDOC-953), which was apparently used for Temelin, leaves significant room to manoeuvre concerning the concrete implementation. For this reason it would be desirable to obtain more information about the method for determining the sizes of zone 1 and 2 for Temelin. The zones, however, with their radius of 5 km and 13 km respectively, lie only within Czech territory. The emergency planning zone 3 (LPZ), which according to oral information, includes the whole Czech Republic, beyond doubt also includes Austrian and German territory and should be set for these countries according to the IAEA recommendations (IAEA TECDOC-953). Cross border coordination of emergency planning and emergency measures is necessary.

Although emergency planning zone 3 is mainly defined concerning long-term consequences of radioactive exposure, the necessity of immediate measures can occur due to the restrictive determination of zone 2 and zone 3. However, the SUJB documents exclude this in the concrete case (SUJB, May 2001): "*Irradiation of neighbouring countries people on dose levels (i.e. for accidents with the probability equal or lower than 10^{-7}/year), for which implementation of the urgent protective measures is justified and reasonable, can not be occurred*". Czech law foresees an effective dose of 10 mSv for 2 days as the limit for urgent protective measures. Calculations that would prove that this dose cannot be reached in a distance of up to 50 km and more and therefore would support the above-mentioned statement, were not provided. The EU EIA directive (EC 97/11/EC) suggests that the project developer seriously considers the potential cross border impacts of his installation.

The statement that the necessity of urgent protective measures in neighbouring countries can be excluded stands in strong contradiction to the results of Austrian calculations.

Own analysis of severe accident consequences

Based on data contained in the documents and internationally available meteorological data, the impacts of a severe accident in Temelin were examined.

The probability of a severe accident in Temelin is low. But if it occurs, Austria is going to be affected by it with a relatively high probability due to its geographic situation and meteorological conditions. In most cases Austria is going to be strongly affected (Cs137 deposition over 1500 kBq/m^2). The probability that Austria will be affected by an accident at Temelin lies according to the performed case studies at approximately 60%. In more than half of these cases (36%), Austria would be strongly affected (Cs137 contamination over 185 kBq/m^2). Furthermore, because of the Alps, the probability of being effected is higher for Austria than for other European states. However, also in other states, including for example Great Britain, Sweden or Greece, deposition reach in most case studies over 185 kBq/m^2.

Apart from these examinations we also undertook analyses with the program PC-COSYMA regarding possible impacts of severe accidents on Austria. PC- COSYMA, a renowned software package produced with EU support, can also be used for emergency planning. Although it offers only limited possibilities for the description of complex meteorological processes, it is suitable for calculating doses for up to 100km away from the accident site.

The accident scenario we used corresponds with the so-called V - sequence, which was defined by the Czech Nuclear authority as the accident with the largest release of radioactive material (SUJB, May 2001). Because important examinations of severe accidents for Temelin have not been done yet, or at least not adequately, it is however not guaranteed that this accident scenario is actually the one with the most severe consequences.

The conducted calculations show that a Cs137 deposition of 1500 kBq/m^2 and more can occur in areas where the centre of the radioactive cloud passes over.

The dose calculations showed for a distance between 40 to 100 km from the NPP Temelin an effective dose over 100 mSv in the central part of the radioactive cloud during 2 days. According to Austrian regulations (BKA, 1991), in this case danger level III would be announced in the affected areas. The inhabitants would be urged not to stay outside and rather stay in buildings for protection. Children and teenagers, but also adults (up to 45 years of age) would be asked to take iodine tablets.

The thyroid gland dose (calculated for 2 days) could in the affected regions even exceed the intervention level that the Czech radiation protection law foresees for administering iodine tablets (100 mSv). This leads to the conclusion that – in contradiction to SUJB´s statement – it could be necessary to apply urgent protective measures also in Austria (see above).

Looking at the expected dose for the first year after a severe accident we have to consider severe damage for agriculture in the most affected areas. The worst case could also lead to considerations whether inhabitants have to be resettled (danger level IV; according to BKA, 1991).

These considerations show clearly that the risk posed by the operation of NPP Temelin would oblige Austria to prepare measures for dose reduction in case of an accident.

Treatment of severe accidents in the EIA practice in other countries

As an example for the handling of EIA for NPP in other countries we discuss the rules in the US, as the country most experienced in this sector, and the Netherlands, as a EU member state that conducted such a procedure for the NPP Borselle and Dodewaard approximately 10 years ago.

The comparison with the Temelin Comprehensive EIA shows that the significant difference is that in both cases a comprehensive risk analysis was performed for the respective installation, which is described in detail in the EIA documentation and served as a basis for decision taking. This analysis included the assessment of core damage frequency for several accident initiating events, the retention capacity of the containment for several core melt down scenarios, the possible radioactive release (source term) scenarios, transport and deposition of released radionuclides and finally a dose assessment and therefore an assessment of the expected health risk.

The EIA does not mention any preventive measures for severe accidents (severe accident mitigation alternatives, SAMAs).

4.1 Severe accident scenarios in the SUJB report

4.1.1 Summary

The documents first submitted as part of the Environmental Impact Assessment did not contain any data on severe accidents and their consequences. The documents that were submitted later due to Austrian demands for supplementary information did not comply with internationally accustomed descriptions. However, it was possible to conduct own estimates of possible consequences of these accidents for Austria.

The release rates for the accident, which was addressed by the Czech side as the most severe accident – the so called V – sequence, comply with the postulated release in the frame of precision for this type of data on this type of accident. Also without the assumption of failure of all safety systems at once, the release rates for this accident release probably stay in this order of magnitude. But then the accident probability is higher than the 10^{-7} as demanded by Czech law.

The core damage frequency (CDF) is according to the Probabilistic Safety Assessment, which was ordered by the operator in 1995, above 10^{-5} per year. This is above the safety objectives of several EU member states and Russia.

The CDF for Temelin is dominated by accident sequences leading to containment bypass. This deviates clearly from practice in other EU member states.

The analysis on which the emergency planning for Temelin is based on is insufficient because of missing analyses. If the containment integrity during severe accidents cannot be guaranteed and an early containment failure cannot be excluded, we have to under certain circumstances expect radioactive releases larger than for the accidents sequences used for the emergency planning.

Measures for reducing the frequency and/or measures for mitigating severe accident consequences are not being discussed in the framework of the Comprehensive Temelin EIA and the SUJB – documents. This despite that a pilot study has already been conducted by the operator and a high number of these measures are discussed in publications. This does not comply with the EU-EIA directive (EC 97/11/EC), which asks the operator to provide a "*A description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment.*"

The treatment of severe accidents in the framework of the Temelin comprehensive EIA documentation (including the documents on severe accidents) are concerning completeness as well as content, inadequate.

4.1.2 Completeness of documents

After the submission of the SUJB documentation on severe accidents, "*Principles and methods of emergency planning and response at NPP Temelin including assessment of beyond design and severe accidents consequences, presented during the workshop organised by SUJB on 4 April 2001 in Prague*" (SUJB, April 2001), the following information on severe accidents was additionally demanded within the framework of the Comprehensive Temelin EIA:

- Data on the radioactive inventory of the reactor (for the radiologically important radionuclides) and on the potential release of radioactivity (source term, release height, chronological release, released energy) for the analysed accident scenarios.
- Detailed description of containment behaviour at Temelin for the analysed severe accident scenarios.

- List and analyses of accident scenarios when the reactor is at low power and zero power output, as well as for the burned fuel pool.
- Data on planned or already implemented upgrading measures and severe accident management measures, which are leading to reduction in frequency and/or in accident impacts. These were addressed at the workshop organised by the Czech Nuclear Authority in Prague on April 4 2001.

This set of additional requests was only partially answered (see SUJB, May 2001). The additionally submitted information on source term and radioactive inventory of the reactor does not comply with internationally accustomed descriptions:

- Instead of the usual 7 to 9 radionuclide groups for the source term only 3 were given.
- On the question of the radioactive inventory only data of a typical German pressurized water reactor with 1300 MW output was submitted. Several radionuclides are missing.

The documents on severe accidents (SUJB, May 2001) do not contain a discussion of measures for the reduction of frequency and/or impacts of severe accidents. This is demanded by the European directive on EIA or part of the EIA documentation in the US (see Chapter 4.4 and Annex A1). The EU EIA directive (EC 97/11/EC) demands in Annex IV a *“description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment.*

This means that the EIA documentation should also describe measures for the reduction of frequency and/or impacts of severe accidents.

Comparison between the updated SUJB documents (SUJB, May 2001) and the earlier version (SUJB, April 2001)

These two documents ”*Principles and methods of emergency planning and response at NPP Temelin including assessment of beyond design and severe accidents consequences, presented during the workshop organised by SUJB on 4 April 2001 in Prague”* (SUJB, May 2001), and *“Assessment of beyond design and severe accidents consequences, Principles and methods of emergency planning and response at NPP Temelin”* (SUJB, April 2001) are to a large extent of identical content.

This document (SUJB, May 2001) contains the following additional information:

- Sequence 5 was added to the list of accident sequences in section 4.
- A table assigning the mixing heights to the dispersion categories was introduced in the same section.
- In section 6 the paragraph on LPZ was significantly extended.
- At the end of the main part of the document two “notes” were added concerning (1) accidents with a frequency under 10^{-7} and very large releases and (2) countermeasures in neighbouring countries for design basis accidents.
- To the discourse about accident sequences AB_01 and V, which is now located in Annex 2, data on the source term was added.
- The document was extended by two documents of the German Ministry for environment: nature protection and reactor safety. One document is concerning released activity, which can lead to an effective dose of 10 mSv in 7 days in a distance of 100 km and 300 km, and the other with a reactor inventory of a 1300 MW PWR.

4.1.3 Comments on the content

4.1.3.1 Selection of severe accident scenarios which should be taken into consideration for emergency planning in Temelin

For defining the emergency planning zones in Temelin according to the SUJB report (SUJB, May 2001) the two most severe accidents at Temelin were included:

- AB – sequence (large Loss of Coolant Accident with station blackout)
- V – sequence (large primary-to-secondary leakage also combined with station blackout)

Because of the underlying assumptions that a station blackout occurs in addition to the leakage and therefore several safety systems are not available, the accident course is faster and more dramatic. The amount of released radionuclides probably increases only slightly. At the same time this accident sequence also becomes extremely unlikely.

In 1999, the "*Decree of the Government of the Czech Republic No. 11/1999 on the Accident Planning Zone*" entered into force. According to this decree, the definition of emergency planning zones has to take into consideration all severe accident scenarios (accident sequences) with a frequency of 10^{-7} or higher 10^{-7} per installation/per year.

Based on the Probabilistic Safety Assessment, which was finished for NPP Temelin in 1995, the following accident sequences with frequency of $>10^{-7}$ were analysed:

- Large leak from primary into the secondary circuit and;
- Large Loss of Coolant Accident

Five more accident sequences exceeding the frequency of 10^{-7} were also considered. Among them are also accident scenarios that are caused by a fire in the installation.

Both scenarios – large leak from primary into the secondary circuit and Large Loss of Coolant Accident – are according to the PSA the most probable and comply according to the SUJB report (SUJB, May 2001) with the AB and V already used earlier – sequences with a slower course of the accident.

4.1.3.2 Release of radioactivity (source term)

According to the SUJB report (SUJB, May 2001), the calculated radioactive releases are largest for the AB-sequence and the V-sequence. All other accident sequences have smaller source terms. One reason for this is the slower course of the accident. The data for these two sequences are:

Released fraction of core initial inventory for **V-sequence:**

"The most important leakage of FP is realised during in-vessel phase of accident (from 35 th to 90 th minute): Noble gases : » 0.78, Aerosols – volatile FP : < 0.19, Aerosols – non-volatile: < 0.01"

Released fraction of core initial inventory for **AB sequence (AB_01)**

"Noble gases: < 4.0E-3, Aerosols – volatile FP: < 8.0E-5
Aerosols – non-volatile: from 2.0E-6 up to 6.0E-5"

These release rates comply with release rates expected for this type of accidents.

Source terms for other accident sequences with a frequency of 10^{-7} were not submitted.

4.1.3.3 Severe accident analyses for NPP Temelin:

The SUJB documents (SUJB, May 2001) do not discuss more severe containment accidents: ”*For the accidents with probability lower than 10 -7 the very large releases of radionuclides are possible only in connection with accident sequences, which lead to early global containment failure, i.e. during high- or low-pressure core meltdown with the subsequent a hydrogen detonation or a steam explosion. Both possibilities, however, are so improbable that they are not considered”.*

However, the severe accident analyses for Temelin currently available are not complete. The important analyses of severe accidents were not yet or not adequately – according to state of the art – performed. We have to assume that the following issue, where all of them can lead to containment failure, are still open (a detailed description is in Annex A1):

- Accident with Containment Bypass,
- Hydrogen detonation
- High Pressure Core Melt Ejection
- Reactor Cavity Melt-Through
- Late Overpressure Failure of the Containment due to continued pressurisation of the containment.

Accidents with containment failure can therefore not be excluded from consideration. Since these accidents are not taken into consideration, it is currently not possible to guarantee that the severe accident sequences “AB – sequence” and “V-sequence” in the SUJB report really are the accidents with the largest impact on the surroundings of the installation. For severe accidents where the containment integrity cannot be guaranteed, it is necessary to assume higher radioactive releases into the environment than was done for the V-sequence. As an example, the German risk study (GRS, 1990) contains data about possible radioactive releases in case of an early large containment failure above the ground desk caused for example by a hydrogen detonation. In this case, the release rates for the important nuclide groups are higher than in the case of the most severe accident given for Temelin (Table 1) by a factor of 4 (for barium and strontium even factor 30-40).

Table 1: Comparison of the release share for a severe accident with containment failure according to the German risk study (GRS, 1990) and the V – and AB-sequences in Temelin (SUJB, 2001)

	Kr-Xe	J	Cs	Te	Sr	Ru	La	Ce	Ba
Risk study	1.0		0.5 to 0.9		4 E-1	1 E-5	2 E-2	4 E-2	3 E-1
V-Sequence	0.78		< 0.19		*< 0.01*	*< 0.01*	*< 0.01*	*< 0.01*	*< 0.01*
AB-Sequence	0.40		< 8 E-5		*2 E-6 - 6 E-5*	*2 E-6 - 6 E-5*	*2 E-6 - 6 E-5*	*2 E-6 - 6 E-5*	*2 E-6 - 6 E-5*

Although the PSA 1995 results indicate that the severe accident frequency for the reactor at shutdown, and due to the loss of coolant in the spent fuel pool, is higher than 10^{-7}, they are not mentioned in the SUJB documents. Therefore, it is not clear whether they were taken into consideration for defining the planning measures for severe accidents. Annex A1 discusses in detail both accident scenarios and their treatment in the framework of the PSA.

A comparison between core melt down frequency at Temelin according to the PSA from 1995 and international safety targets and the European practice is undertaken in Chapter 3.3 and Annex A1. This leads to the following conclusions:

- The core damage frequency (CDF) is according to the Probabilistic Safety Assessment, which was performed (ordered) by the operator in 1995, above 10^{-5} per year. This is above the safety objectives of several EU member states and Russia.
- The CDF for Temelin is dominated by accident sequences leading to containment bypass. This deviates clearly from practice in other EU member states

4.1.3.4 Discussion of measures for reducing the frequency of severe accidents

As mentioned earlier, the discussion of preventive measures for reducing the frequency of severe accidents and/or mitigating measures for reducing the impacts of severe accidents is missing in the Temelin Comprehensive EIA and the SUJB documents on severe accidents (SUJB, April 2001; SUJB, May 2001). On the other hand, it is shown in Annex A1 that plenty of literature and experience exists and that several measures are being considered or are already implemented in other EU countries.

In Chapter 4.4 we discuss examples referring to consideration and discussion of such measures in EIA in the US and the Netherlands.

4.2 Emergency planning for Temelin

4.2.1 Summary

The IAEA definition for setting the zones (IAEA TECDOC-953), which was apparently used for Temelin, leaves significant room to manoeuvre concerning the concrete implementation. For this reason, it would be desirable to obtain more information about the method for defining the size of zone 1 and 2 for Temelin.

The emergency planning zone 3 (LPZ) is not explicitly defined, but it seems that the whole Czech Republic is included in this zone. However, according to the IAEA recommendations, this zone also has to be defined for countries abroad because emergency-planning zones cannot stop at state borders. Cross border coordination of emergency planning and emergency measures are necessary.

SUJB denies that neighbouring states could be affected to such an extent that urgent protective measures might become necessary. This is done by using an accident frequency of over 10^{-7}/year. But SUJB did not submit any calculation results that would support this claim. On the other hand, tables referring to this issue show the maximum distance of the 10 mSv zone (intervention level for urgent protective measures) at > 40km. Calculations using the source term given by SUJB for the V – sequence show results of dose values of 90 to 300 mSv as a 2 day dose in 60 km distance.

The EU EIA directive states that the project developer should seriously consider the potential cross border impacts of his installation.

4.2.2 Completeness of documents

Apart from the documents on severe accident scenarios in Temelin mentioned in section 4.1.1, we also asked for documents that would address expected impact of severe accidents and the methods used for obtaining these:

- Description of the meteorological dispersion model (RTARC), used for estimating the accident consequences.
- Analyses of potential consequences of severe accidents (acute, mid-term and long-term consequences, like e.g. contaminated soil and food stuff) on neighbouring countries.

This additionally requested information was only partially delivered. We obtained a list of publications about the dispersion model (RTARC). However, none of these articles were published in the standard, easily available publications and could therefore not be obtained up to now. Concerning the analyses of potential consequences of severe accidents for Austrian territory, the Czech side only referred to a German study that was written for the German Ministry of the Environment in 2000. From this it can be concluded that the results of the study are seen as applicable.

The method used for defining and setting the different emergency planning zones for Temelin has been described in the documents on severe accidents. However, several questions remain open:

- How were the radius of 5 km and 13 km for the emergency planning zones defined in concrete terms?
- How much significance was given to the different accident scenarios (V-sequence, AB-sequence, etc. see (SUJB, May 2001) that were taken into consideration for defining the emergency planning zones?
- How were different meteorological scenarios taken account of?

4.2.3 Comments on the content

4.2.3.1 Determination of emergency planning zones

The different emergency planning zones for Temelin were obviously (see SUJB, April 2001 and SUJB, May 2001) defined in accordance with the IAEA recommendations (IAEA-TECDOC-953). The relevant IAEA documents (IAEA-TECDOC-953 and IAEA-TECDOC-955) set the following criteria for defining the emergency planning zones:

Zone 1 (Precautionary Action Zone - PAZ):

- The size of this zone should be based on a realistic estimate of impacts of the most severe accident.
- Urgent protective measures (like evacuation, seeking out buildings for protection, prophylactic administration of iodine) should be introduced shortly before or immediately after the radioactive release in the whole zone area.
- The size of zone 1 should be determined in such a way that in the case of radioactive release into the atmosphere around 90% of the risk of serious direct health impacts are contained in this zone under “average“ meteorological conditions.

Zone 2 (Urgent Protective Action Zone - UPZ):

- In case of a severe accident in this zone should be measures prepared already in advance. This ensures that on basis of radioactivity monitoring it would be possible to implement short term and effective urgent protective measures (like evacuation, seeking out buildings for protection, prophylactic administration of iodine)

- The size of zone 2 should be determined in such a way that in the case of radioactive release into the atmosphere around 99% of the risk of serious direct health impacts are contained in this zone under “average“ meteorological conditions.

Zone 3 (Long Term Planning Zone - LPZ):

- Measures in this area should be prepared in advance. These measures would enable an effective implementation of protective measures in case of an accident. The measures should reduce the risk of direct and late health consequences (stochastic consequences), which can be caused by long-term exposure to radioactive deposition and ingestion of contaminated foodstuff.
- The size of zone 3 should be determined in such a way that about 90% of the risk is being contained, which exceeds the Generic Intervention Levels.

Figure 1 shows the determining of the emergency planning zones in Temelin (see Temelin: http://www.cez.cz/jete/INFO).

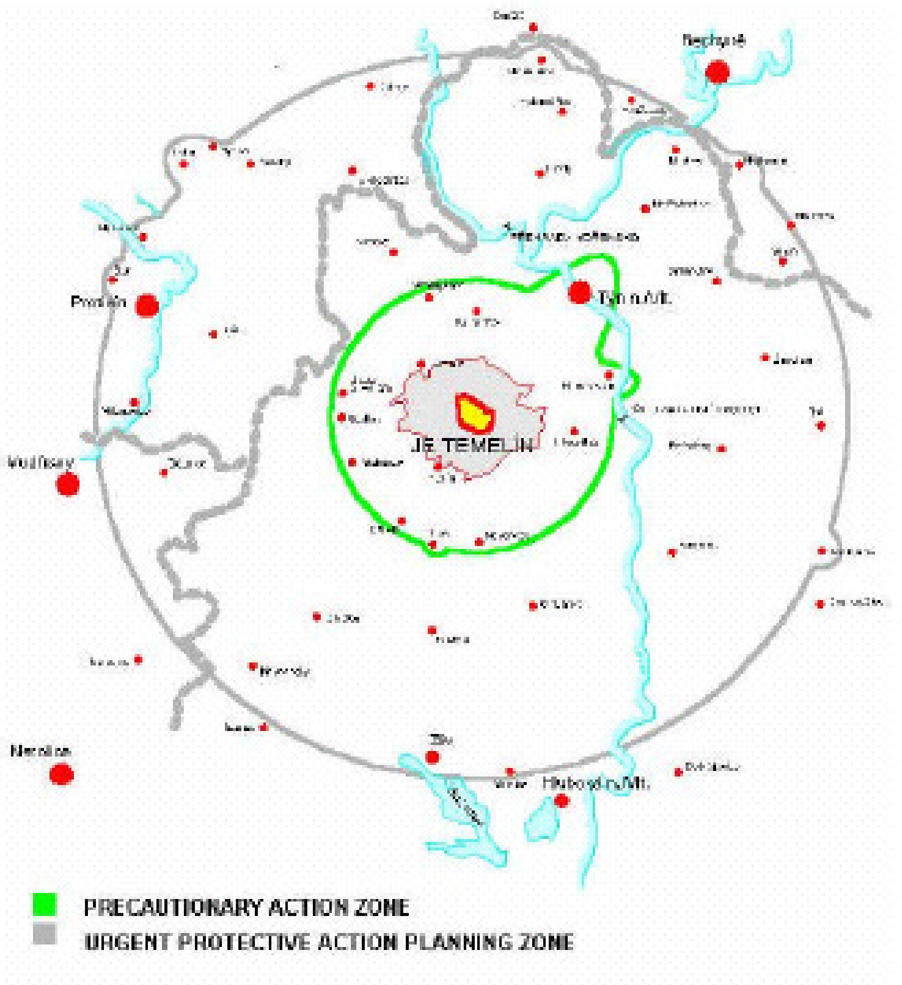

Figure 1: Temelin Emergency Planning Zones Delineation

The IAEA definition for determination of the zones leaves significant room to manoeuvre concerning the concrete implementation. For this reason, it would be desirable to obtain more information about the method for determining the size of zone 1 and 2 for Temelin.

4.2.3.2 Dispersion calculation and dose estimate for determining the Zones

The dispersion calculations in the SUJB documents are not conservative concerning the meteorological conditions taken into account (see section 4.3 and 3.5).

The data for the meteorological assumptions were broadened for the conducted dispersion and dose calculations compared to the documents (Commission, 2001) and (Svoboda, 2001). With this the mixing height, dispersion categories and wind speeds are known for the calculations of severe accidents.

As opposed to the document (Svoboda, 2001) on the consequences of design basis accidents, here were instead of meagre 4 only 2 different meteorological situations considered. However, precipitation can cause strong contamination at significantly higher distances than under dry weather conditions. Dose calculation without adequate consideration of the influence of precipitation is insufficient for the determination of emergency planning zones. As far as it is possible to judge from the available documents, this approach violates Czech laws, which demand a specification of potential accident consequences (Commission, 2001, Chapter 2.7.3.2).

In (SUJB, May 2001) the distance, up to which the effective dose of 10 mSv is exceeded in 2 days, is given for the sequence ST_V and dispersion category F at 2m/s wind speed with ">40" (see Table 2). Obviously, the calculations were conducted only up to the distance of 40 km. We have to assume that the values would exceed this limit also in a distance of 50 km at the Austrian border if the calculations were not stopped before. However, this situation is being ignored.

Table 2: Maximum distances, up to which the given dose is reached for different accident scenarios (from: SUJB, May 2001)

Stability class F						
Sequence	**2 days** **Intervention Level**			**7 days** **Intervention Level**		
	5 mSv	**10 mSv**	**50 mSv**	**50 mSv**	**100 mSv**	**500 mSv**
AB_01	8 km	5 km	-	1 km	-	-
AB_02	14 km	8 km	2 km	2 km	1 km	-
AB_03	18 km	11 km	3 km	4 km	2 km	-
AB_04	16 km	9 km	1 km	2 km	-	-
ST_V	>40 km	>40 km	-	-	-	-
ST 1*	35 km	23 km	2 km	3 km	2 km	2 km
ST 1**	35 km	17 km	5 km	5 km	3 km	2 km
ST 2	-	-	-	-	-	-
ST 3*	27 km	19 km	2 km	2 km	2 km	-
ST 3**	21 km	14 km	2 km	3 km	2 km	-
ST 4	-	-	-	-	-	-
ST 5	5 km	2 km	-	-	-	-

Note: ST 1 and ST 3* – calculations for real terrain, direction Týn nad Vltavou*
*ST 1** and ST 3** –calculations for real terrain, direction Ceské Budejovice*

The presented results of the dispersion calculations are being shown as the dose limits 5 mSv to 500 mSv, although these values do not comply with the criterion for emergency planning zones (serious deterministic health consequences occur at dose values starting at 1000 mSv).

It is also surprising that only a table with threshold values and distances is shown, while no graphic figure shows dose in relation to the distance.

The documents do not explain why two different programmes, HERALD and RTARC, are used for the calculation of dispersion and dose. It is also not explained what the differences between the programmes are and how these differences influence the results.

The question of support for the emergency planning through real-time simulators is only shortly discussed in the SUJB documents. A comparison with standards and practice in other countries, for example the EU, is missing.

4.2.3.3 Cross border determination of zone 3

While the first two zone for Temelin were determined with a radius of 5 km and 13 km, zone 3 (Long Term Planning Zone) was not set according to the EIA documentation. This does not comply with the recommendations of the IAEA-TECDOC-953.

The Comprehensive EIA documentation says in chapter 2.7.3.2. (Commission, 2001): *"the zone of subsequent measures - was not defined"* and in (SUJB, April 2001): *"Similarly as for the Dukovany NPP, the Long Term Protective Action Planning Zone (LPZ) was not determined. In case of radiation accident, depending on its course, extent, the long-term protective measures will be realised, based on the radiation monitoring results."*

In (SUJB, Mai 2001) it is explained that the priori geographic definition is not necessary, because of the early warning radiation system in the CR and the in general prepared crisis management. According to oral information given during the workshop on severe accidents in Prague this has to be understood, that the whole CR is the LPZ.

Die IAEA recommends to determine the emergency planning zones as a cross border zone: "*It is important to note that the zones do not stop at national borders."* (IAEA TECDOC-953, page 11). This is apparent also in Figure 2 (IAEA-TECDOC-953, page 11) describing the concept of emergency planning zones.

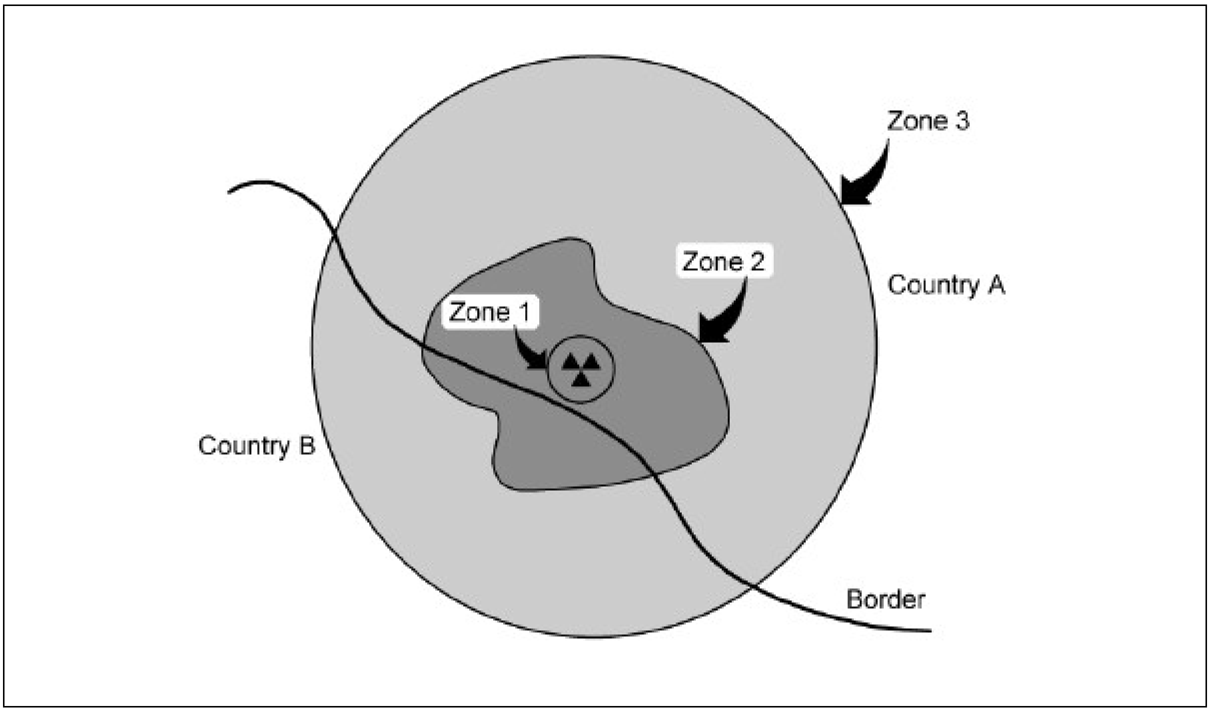

Figure 2: Cross border character of emergency planning zones (see IAEA-TECDOC-953, page 11)

The guideline given for the radius of zone 3 (LPZ) is a distance of 50-100 km from the NPP. According to this recommendation also Austrian territory would be part of zone 3, because the shortest distance between the NPP Temelin and the Austrian is border is ~50 km. The fact, that the LPZ should include also Austrian and German territory was confirmed by Czech experts during the discussion at the above mentioned workshop in Prague.

Die SUJB documents (SUJB, April 2001; SUJB, May 2001) and Comprehensive EIA documentation (Commission, 2001) do not contain any indication, that the LPZ was calculated for the neighbouring countries or was determined in a cross border fashion.

According to the IAEA-TECDOC-953 recommendation it would be necessary to prepare measures in advance in zone III. This ensures a fast and immediate implementation of measures, which would reduce the long term dose caused by external exposure and deposition as well as internal contamination via ingestion. This requires also cross border harmonisation and coordination of protective measures. On this issue the EIA documentation does not contain any indications or proposals.

4.2.3.4 Cross border consequences of severe accidents

In the SUJB report (SUJB, May 2001) the following is said about the impacts of severe accidents:

"*Irradiation of neighbouring countries people on dose levels (i.e. for accidents with the probability equal or lower than* 10^{-7}*/year), for which implementation of the urgent protective measures is justified and reasonable, can not be occurred*"

The IAEA TECDOC-955 (page 101) on the other hand states estimates that: "*The generic assessment procedures for determining protective actions during reactor accident*" that in case of a severe accident urgent protective measures like evacuation, seeking out buildings for protection, prophylactic administration of iodine, are necessary at least up to 50 km distance from the site. The considered accident with core melt down is a case with containment bypass vie a dry defect steam generator with leakage rate 100% per up to 100% per hour.

Our own calculations with the PC-Cosyma programme (see Chapter 4.3) are based on the data given by SUJB (SUJB, May 2001) on radioactive release for the V-sequence. They also showed that urgent protective measures are also needed outside the Czech Republic. The dose values of the axis of the trajectory of the radioactive plume are in Table 3.

Table 3: Effective dose after 2 days at a distance of 60 and 100 km from Temelin for 3 different meteorological situations

	Effective dose after 2 d (mSv)	
	distance 60 km	distance 100 km
Neutral dispersion category (D), dry	90	50
Stable dispersion category (F), dry	200	100
Neutral dispersion category (D), 0.5 mm/h precipitation	300	~140

Even the calculations in the SUJB documentation (SUJB April 2001; SUJB, May 2001) show, that for V-sequence an effective dose of 10 mSv for distances >40 km is reached under very stable meteorological conditions (stability category F). While for the reference design basis accidents in the framework of the EIA documentation (Commission, 2001) dose estimates on the border to neighbouring countries is given, these data are missing for severe accidents.

This lack of "*any available information on its possible transboundary impact" of severe accidents at Temelin does not comply with the EU directive* EC 97/11/EC, which requests: *"(1) Where a Member State is aware that a project is likely to have significant effects on the environment in another Member State or where a Member State likely to be significantly affected so requests, the Member State in whose territory the project is intended to be carried out shall send to the affected Member State as soon as possible and no later than when informing its own public,*

(a) a description of the project, together with any available information on its possible transboundary impact;

(b) information on the nature of the decision which may be taken,

...

4.3 Own examinations of severe accident consequences

4.3.1 Summary

With the support of a so-called particle model (FLEXPART) we calculated the impacts of the severe accident given by SUJB for 88 meteorological situations, spread evenly over the year 1995. The calculations show that the consequences of a large release at NPP Temelin are not limited only to the closest surroundings, but could concern also parts of Europe, depending on the weather situation.

The probability of a severe accident at Temelin is low. However, if it occurs, Austria is going to be affected by it with a relatively high probability (approximately 60%) due to its geographic situation and meteorological conditions. In most cases (36%) even strongly affected (Cs137 contamination over 1500 kBq/m^2). Depositions over 185 kBq/m^2 can occur in most European countries, e.g. in Great Britain, Sweden or Greece.

Apart from the simulations with FLEXPART, we also undertook analyses with the program PC-COSYMA on possible impacts of severe accidents on Austria. PC- COSYMA is a renowned software package produced with EU support that also can be used for emergency planning. Although it offers only limited possibilities for the description of complex meteorological processes, it is suitable for dose calculation.

The accident scenario we used corresponds with the so called V - sequence, which was defined by the Czech Nuclear Authority in its study "*Assessment of beyond design and severe accidents consequences, Principles and methods of emergency planning and response at NPP Temelin* ", State Office for Nuclear Safety, Praha, Czech Republic, May 2001.

However, because important examinations of severe accidents for Temelin have not been done yet or not adequately, it cannot be guaranteed that this accident scenario is actually the one with the most severe consequences.

The conducted calculations show that Cs137 deposition of 1500 kBq/m^2 and more can occur in areas where the centre of the radioactive cloud passes over.

The dose calculations showed for a distance between 40 to 100 km from the NPP Temelin an effective dose over 100 mSv in the central part of the radioactive cloud during 2 days. According to Austrian regulations (BKA, 1991), in this case danger level III would be announced in the affected areas. The inhabitants would be urged not to stay outside and rather stay in buildings for protection. Children and teenagers, but also adults (up to 45 years of age) would be asked to take iodine tablets.

The thyroid gland dose (calculated for 2 days) could in the affected regions even exceed the intervention level that the Czech radiation protection law foresees for administering iodine tablets (100 mSv).

Looking at the expected dose for the first year after such a severe accident, we have to consider severe damage for agriculture in the most affected areas. The worst case could also lead to considerations whether inhabitants have to be resettled (danger level IV; according Austrian "Recommendations for the protection of the population from ionizing radiation in case of extensive radioactive contamination").

These calculations show clearly that the risk posed by the operation of NPP Temelin would oblige Austria to prepare measures for dose reduction in case of an accident.

4.3.2 Overview and objectives

Potential consequences of severe accidents at NPP Temelin for Austria and other countries were at first not even described in the documents presented by the Czech side. Also in the latest submitted documents (SUJB, May 2001) this topic is not discussed sufficiently. On the other hand, it is exactly this question that leads the Republic of Austria, the territorial authorities and also the people in Austria to their critical stance towards putting Temelin into operation. In order to introduce a scientific basis into the discussion, it was necessary to conduct our own calculations. These calculations take into consideration, whenever possible, the information and the documents that were presented by the Czech side. Because they are incomplete and some were submitted very late, own research and considerations also play an important role.

Among the comments raised by Austrian experts referring to EIA II (78 project changes), analyses about potential impacts of severe accidents on Austria were already made. They proved the Austrians' concerns in such a case. Data from literature on release parameters had to be used for these analyses. Under the process of the Melk Protocol, Austria received for the first time documents describing an accident scenario at NPP Temelin. This data was included in the following calculations.

4.3.3 Examined accident scenarios and radioactive release

Two similar severe accident scenarios were considered as the starting point for the meteorological dispersion calculation and dose estimate, which are to found in Chapter 4.3.3-4.3.5 of this report.

Accident scenario 1 and the relevant radioactive release (described through release ST1) are mostly based on the Probabilistic Safety Assessment for Temelin, which was finished in 1995.

Accident scenario 2 is based on information submitted by the Czech Nuclear Authority SUJB (SUJB, May 2001) under the process of submitting additional documents for the Comprehensive EIA documents on May 20th 2001.

Scenario 1:

Due to a large leak in the steam generator (simultaneous rupture of several steam generator tubes or leaks in the steam generator collector) primary into secondary leakage occurs. Additionally occurring mistakes (e.g. wrong manipulations) lead in the long term to coolant loss in the primary circuit and consequentially to core melt down. For this accident type, it is typical that at least in the first phase after the core melt down has started, the function of the containment as the last retention barrier of radioactive substances is not fulfilled. The reason is that the containment is being bypassed because of the leak in the steam generator (Containment-bypass). The release of large amounts of radioactivity directly into the atmosphere is e.g. possible through an open, not any more closeable atmospheric dump valve at the height of approximately 50 m.

According to the PSA, this type of accident dominates the severe accident frequency with an approximately 75% contribution to CDF caused by internal events and an approximately 60% contribution to overall CDF (Mladý, 1999).

For these severe accidents, the radioactive releases can be deducted by referring to the risk studies by the US Nuclear Authority (NUREG-1150 and NUREG-1465). This approach can be called conservative because it does not assume any retention of radioactive substances in the primary circuit and the defect steam generator. On the other hand, only the first phase of the severe accident is being considered and the long-term releases are being ignored. However, it was modified according to the reactor output in Temelin (1000 MWe).

As opposed to the described reactor Biblis B, a 4-year fuel cycle (Commission, 2001) with a higher burn up (maximum burn up 60 MWd/kg (Investprojekt, page 37) is planned for Temelin. For short lived radionuclides (like I-131), this does not make a difference. But the inventory of long lived radionuclides (like Cs-137) can be underestimated by a difference of up to 50% (the order of magnitude stems from a comparison of Biblis B with a reactor with a 42,7 MWd/kg burn up (Dutton, 1995)).

Scenario 2:

The second scenario was taken out of a study submitted by the Czech Nuclear Authority: *"Assessment of Beyond Design and Severe Accidents Consequences, Principles and Methods of Emergency Planning and Response at NPP Temelin, State Office for Nuclear Safety, Praha, Czech Republic, May 2001"* (SUJB, Mai 2001).

The so called V – sequence, which was used for the emergency planning in Temelin, is according to the SUJB study one of the two most severe accident scenarios (see also section 4.1.2). The accident was caused, as in scenario 1, by a large leak in the steam generator. The fast acceleration of the accident course is caused by the underlying assumption that additionally a total loss of power occurs and therefore several safety systems are not available. The largest fraction of the release occurs between minute 35 and 90 (after the emergency reactor scram). The release fraction is 78% for noble gases, up to 19% for fission products in the form of volatile aerosols and up to 1% for fission products in the form of non-volatile aerosols. Based on this data, the release for the second accident (ST2) was defined (Table 4).

A comparison with other source term studies shows that due to the imprecise data on the source term giving only 3 radionuclide groups the Tellur group fraction was probably overestimated compared to the other volatile aerosols. Also the release fraction of other non-volatile radionuclides seems to be overestimated.

In Table 4 both scenarios are being compared. There it becomes apparent that both scenarios concerning the important nuclides release fractions are very similar.

Table 4: Release parameters for two accident scenarios in Temelin

	Scenario 1 (ST1)	Scenario 2 (ST2)
Time between shut down of reactor and start of release (h)	4	1
Time of release (h)	1	1
Release height	50 m	50 m
Released energy	10 MW	10 MW
Release fractions		
Noble gases (Xe, Kr)	1	0.78
Halogens (I, Br)	0.40	0.19
Alkali metals (Cs, Rb)	0.30	0.19
Tellur group (Te, Sb, Se)	0.05	0.19
Barium-Strontium-Group (Ba, Sr)	0.02	0.01
Precious metals (Co, Ru)	0.0025	0.01
Cerium group (Ce, Pu, Np)	0.0005	0.01
Lantanides (La, Am)	0.0002	0.01

The radioactive inventory of NPP Temelin was not submitted. The fact, that the inventory of a German 1300 MWe PWR was in the Annex of the SUJB documents, can without doubt be understood as a hint, that this inventory comes close to the actual inventory. In this overview, however, not all radiologically important radionuclides are included. This inventory was used for the model calculation for ST2. Because of the higher output of the reactor, but the lower fuel burn up compared to Temelin, the inventory of short lived radionuclides (like I 131) is being slightly overestimated (~20%). Long lived radionuclides (like Cs 137) however, are underestimated by the same order of magnitude. These figures again stem from a comparison. This time it is the comparison between the inventory of a typical German 1300 Mwe PWR, as was mentioned in the SUJB documents (SUJB, May 2001) and a reactor with 42.7 MWd/kg burn up (Dutton, 1995). Both are relating to the same output.

Comparison with other severe accident studies:

Analyses of steam generator tube rupture in a Siemens Konvoy reactor (quoted in Dutton, 1995) calculated with several source term programmes, showed 15 – 60 % releases of the cesium and iodine inventory. This indicated insecurities in the calculations. Further, the calculations showed that 10 – 15 % of the cesium and iodine inventory were released in the first phase of the accident, approximately 30 % after one day and 50 – 60 % after 5 days.

The analyses performed for the German risk study (GRS, 1990) for a similar accident with a smaller leak in the steam generator showed the following radioactive release:

Groups	Kr-Xe	J	Cs	Te	Sr	Ru	La	Ce	Ba
Release fractions	0.17	0.15	0.15	0.05	6.7 E-5	8.8 E-8	7 E-9	--	1.4 E-3

It is apparent that the releases of the two scenarios ST 1 and ST2 – considering the different preconditions – correspond fairly well with the releases taken out of literature.

4.3.4 Used dispersion and dose models

PC-COSYMA

PC-COSYMA is a combined dispersion and dose calculation model developed by the National Radiological Protection Board in the UK and the Nuclear Research Center Karlsruhe with financial support from the European Commission. It is used for accident consequence assessment and emergency planning in many European countries. In this case, version 2.0 (Jones et al., 1994; EC, 1995) was used.

The dispersion part of PC-COSYMA is based on the Segmented Plume approach. The input consists of hourly data on wind speed and wind direction, dispersion category, and mixing height and precipitation rate at a station. This data was used for the whole calculation area limiting the radius for which this model can be meaningfully applied. However, this approach is superior to a simple GAUSS model, which can describe only stationary meteorological situations.

From a meteorological point of view, this model can be used in three different ways:
1. Deterministic calculation with constant meteorological conditions.
2. Deterministic calculation with pre-set time range of the meteorological conditions.
3. Probabilistic calculation based on a selection of episodes from a preset time range of a period of one year.

Apart the transport with the average wind and the turbulent mixing (maximum up to the mixing height) also thermal plume rise, the influence of buildings, dry and wet deposits and radioactive decay is included. The source term is based on data for the reactor inventory, which can be divided into nuclide groups according to their volatility. For every nuclide group the release can be given in fractions of the inventory. The release takes place in hourly intervals and each interval can be specified separately. Additionally, the time between the ceasing of the chain reaction and the start of the release (in full hours) has to be given. The output is calculated for a selectable grid of polar coordinates.

The dose part calculates the short term (more than 1 day to 365 days) and long-term (50 years) dose. It calculates the organ absorbed dose and the effective dose, cloud radiation, soil radiation; inhalation and ingestion were used as exposure pathways. Re-suspension effects, several transfer processes into human food and activity wash off from the surface are taken into consideration. Moreover, the protective effect due to stay in buildings, the so called “location factors“, can be taken into consideration.

The program makes also the simulation of dose reducing measures, the calculation of health risks and the economic damage possible. These options were not used for the calculation presented here.

FLEXPART

FLEXPART is a universally applicable Lagrangian particle dispersion model, designed mainly for usage on a regional and a global scale. The model is freely available.[1] It is tested for several different long-range time dependent 3-dimensional fields of wind direction and wind speed (including vertical movement), temperature and humidity, as well as 2- dimensional fields of convective and greater area precipitation. It simulates average and turbulent transport, dry and wet deposits and radioactive decay. The output takes place through a select-

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[1] http://www.forst.tu-muenchen.de/EXT/LST/METEO/stohl/flexpart.html. This website shows the documentation, source code and refers to publications about the model.

able grid in geographic coordinates. Here a modified form of version 2 of the program was used.

Compared to PC-COSYMA, the program has the advantage that it can – being a numeric model – conduct a much more realistic description of the transport and the pollutant dilution, taking into account the adequate space-time variations of the meteorological fields, which makes it suited for the simulation of spreading via any great distance. On the other hand, FLEXPART is purely a spreading program and does not perform any dose calculation.

4.3.5 Meteorological scenarios, model configuration and input

4.3.5.1 PC-COSYMA calculations

With PC-COSYMA we calculated:

1. Several scenarios with constant meteorological conditions to compare with similar calculations in the Czech documents and to get a simple assessment of the possible consequences. The selected meteorological scenarios are represented in Table 5.
2. A realistic weather scenario, that actually occurred. As an example, a release on 20.3.1995 at 20h UTC was chosen.

Table 5: Used meteorological scenarios for calculation with constant meteorological conditions

Scenario	dispersion category	Wind speed	Mixing height	Rate of precipitation
1– neutral, dry	D (neutral)	5 m/s	560 m	0 mm/h
2– stable, dry	F (very stable)	2 m/s	200 m	0 mm/h
3– neutral, rain	D (neutral)	5 m/s	560 m	0.5 mm/h

A grid with 72 sectors (5° resolution) and 20 distance areas was used, with the outermost grid point being 102 km away. The position of the concentric circles in the centre of the distance areas is represented in Table 6. In the simple scenarios the value (deposition and dose) is shown in the axis of wind direction, i.e. in the axis of the trajectory of the radioactive cloud.

Table 6: Radius on which the grid points lie (corresponds with the distance of the centre point of the drawn circle rings)

km	0,25	1	2	3	4	5	7,5	12	17	23	29	34	39	45	52	60	68	78	90	102

Further, the following specifications were used:

- No protection by staying inside of buildings (location factors = 1). This corresponds with the assumptions in the Czech calculations.
- Source height 50 m.
- Building dimension 50 m.
- Heat flux 10 MW.
- Other source values see section on source term
- Sigma-parameter set for rough terrain.

- Effective dose model according to ICRP-26
- ÖKOSYS was used in the dose model.
- The short-term dose was calculated for 2 days and 365 days respectively. No ingestion is included in the short-term dose.
- For all other parameters the standard values of PC-COSYMA were used.

Because the Czech side submitted, in spite of repeated requests, only climatological statistics, we had to obtain meteorological data for actually occurred meteorological situations in a different manner. The synoptic data from the station Temelin (since 1995 hourly for disposition), distributed via GTS, were used. The spreading categories (the measure of dilution due to turbulences) was calculated on the basis of ÖNORM M9440 (ON, 1996), Tables 4, 5 and 6, based on wind speed, cloudiness and altitude of the sun, the Austrian categories 2-6 were assigned to the Pasquill- category used in PC-COSYMA (see Table 7). Spreading class 1 (Austrian), resp. A (Pasquill) according to ÖNORM does not occur in the climate of the analysed area. The very stable spreading class 7 does not exist in PC-COSYMA. It was replaced with spreading class 6 (F) with mixing altitude reduced to 100m. Since the precipitation sums were given only in 6 hourly intervals, they had to be distributed evenly in the attributed time interval.

Table 7: Standard mixing altitude in dependence on the dispersion category in PC-COSYMA

Dispersion category	A	B	C	D	E	F
Mixing altitude in m	1600 m	1200	800	560	320	200

4.3.5.2 FLEXPART calculations

The program FLEXPART was used for simulating the dispersion and deposition of cesium 137 for a representative number of real meteorological situations in Europe in case of a hypothetic severe accident (ST2) in Temelin. Here, the same 88 starting dates from the year 1995 were used, which were also used in project RISKMAP (Andreev et al., Hofer et al., 2000). The year 1995 proved to be representative for the climatological trend dispersion in Central Europe. The 88 dates were spread evenly over all seasons of the year and times of the day.

The date 20.3.1995, 20 UTC, for which the realistic COSYMA scenario was calculated, is one of these 88 dates. This makes it possible to compare the results of the two models.

For each date the radioactive model was monitored for 10 days, or rather until it left the area of calculation. It concerns ECMWF data with 1º horizontal and 3 hours time dissolution and 31 layers. The area of calculation includes the whole of Europe. The cesium 137 deposition (summed over one calculation respectively) was given in two different output grids:

1. Rough grid with 1º resolution all over Europe.
2. Fine grid with ca. 15 km dissolution only over CR with surroundings (from 10ºE to 20ºE and 46ºN to 51.4ºN)

Since FLEXPART cannot take into account thermal uplift during release, we assumed that the particles will be evenly emitted 50 m to 100 m above ground. Since these calculations included only cesium 137, this can be easily converted into another source term by scaling the deposition values accordingly.

4.3.6 Results

4.3.6.1 Comparison of different scenarios for severe accidents

The first step was to analyse to what extent the differences between the source term (ST1) we used and the finally obtained data (ST2) will be reflected in the calculations. This comparison was conducted with the program PC-COSYMA using the scenarios with constant meteorological conditions. Deposition and doses were compared.

Concerning the deposition of Cs137 the new accident scenario ST2 shows slightly lower values (i.e. 83%) than previously assumed with ST1 (Fig. 3). The dose calculation also leads in both cases to very similar results (Fig. 4). For this reason we show only the results for scenario ST2 in the following section.

4.3.6.2 Consequences for Austria:

Simple calculation with PC-COSYMA

Again we first looked at the simple cases with constant meteorological conditions. These simplified analyses with PC/COSYMA moreover served as a comparison of the results with the analyses and conclusions as presented in the Czech documents. These analyses excluded a significant exposition to the population in Austria. The following description of the situation after the release of radionuclides according to the scenario ST2, which was presented by the Czech side, refutes these assertions, as the figures 5 and 6 show:

A deposition of 1500 kBq/m^2 Cs137 is being exceeded in all cases up to a distance of 100 km (partially even further than that), and during precipitation this value is being exceeded even in a distance of 100 km from the plant (Fig. 5). This refers to the values in direction wind, i.e. along an idealized transport path of the radioactive cloud.

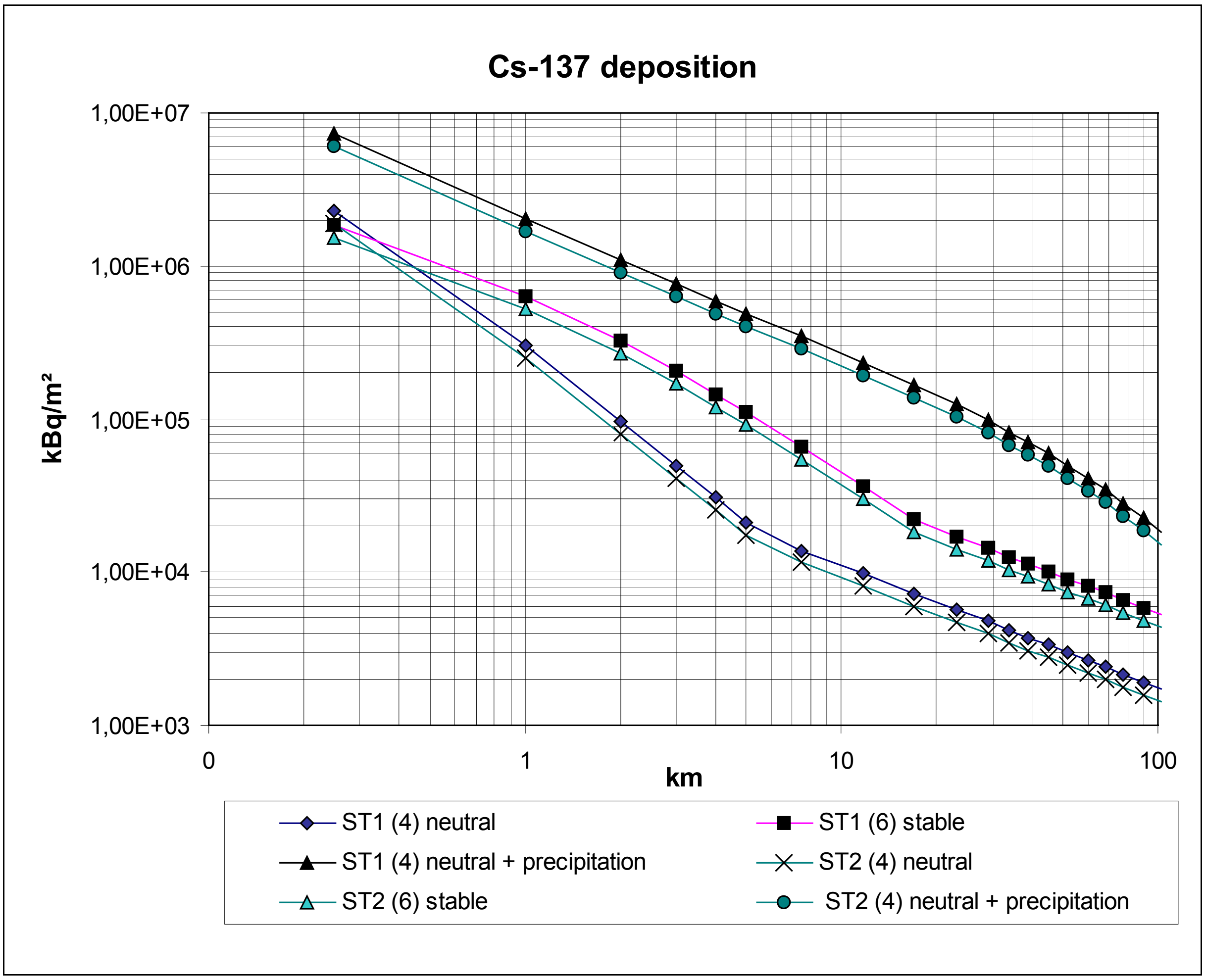


Figure 3: Cs-deposition along the wind direction axis after a severe accident, comparison between two scenarios: ST1 (PSA) and ST2 (new)

Up to a distance of over 70 km at all layers effective doses over 100 mSv (Fig. 6) can occur. This would exceed also the Czech intervention levels. The thyroid gland doses would exceed 100 mSv along the whole distance up to 100 km (Fig. 7).

The calculations show the clear influence of precipitation on the result. With precipitation a clearly higher deposition of Cs137 (by ca. the factor 10) and a higher radiation exposure (by ca. factor 2) has to be assumed. This despite that we calculated with a relatively low precipitation rate (0.5 mm/h). Assuming strong precipitation evenly for the whole area (i.e. also in the close surrounding of the NPP), as it was done in the Czech documents, regions further away are going to have an advantage because the activity has already been washed out of the atmosphere.

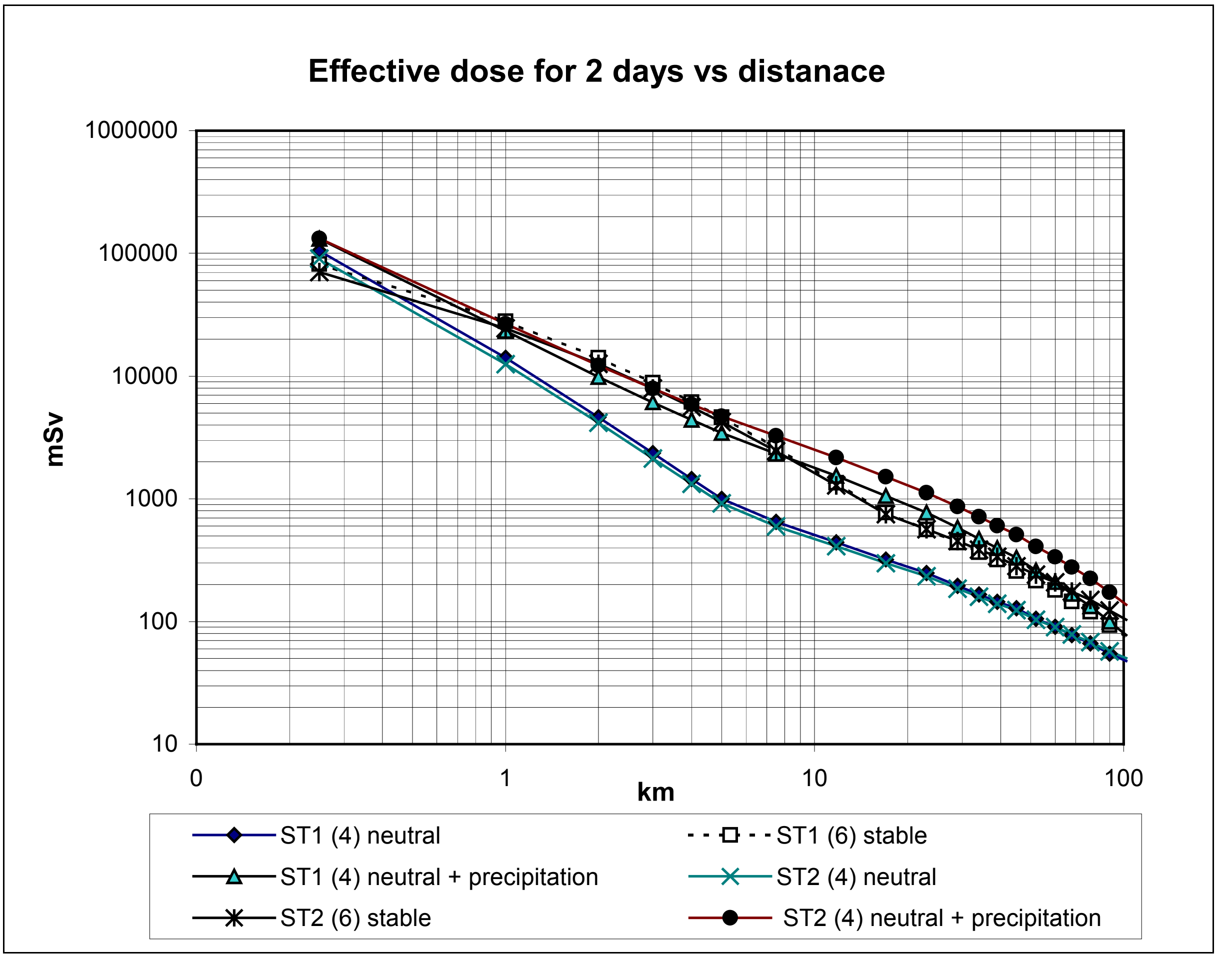


Figure 4: The 2 day effective dose along the axis of the wind direction after a severe accident; comparison of two scenarios: ST1 (PSA) and ST2 (new)

Case study with PC-COSYMA

As explained above, among the simple calculations we also analysed a realistic scenario with PC-COSYMA. We assumed the release of the radioactive cloud on 20.3.1995 at 8 p.m. Contrary to the earlier assumptions, this time the radioactive cloud is not carried in a straight line but is being first moved to the north-west and later in a south-east direction due to a wind change. The presentation of the results does not only include the value in the centre of the cloud but also the horizontal expansion. We calculated the deposition of Cs137 (Fig. 8) and the resulting warning level for Austria (Fig. 9) according to the recommendations for the protection of the population against ionizing radiation (BKA, 1991) applied in Austria. The warning level was assessed on the basis of the 2-day dose, which was calculated with PC-COSYMA. The danger level was based on the dose for 365 days without protection measures, but also without ingestion. The definition of the warning levels and the relevant danger level that can be expected are shown in Table 8. Apart from the entire body dose, also the expected thyroid gland dose (2 days dose) was calculated (Fig. 10).

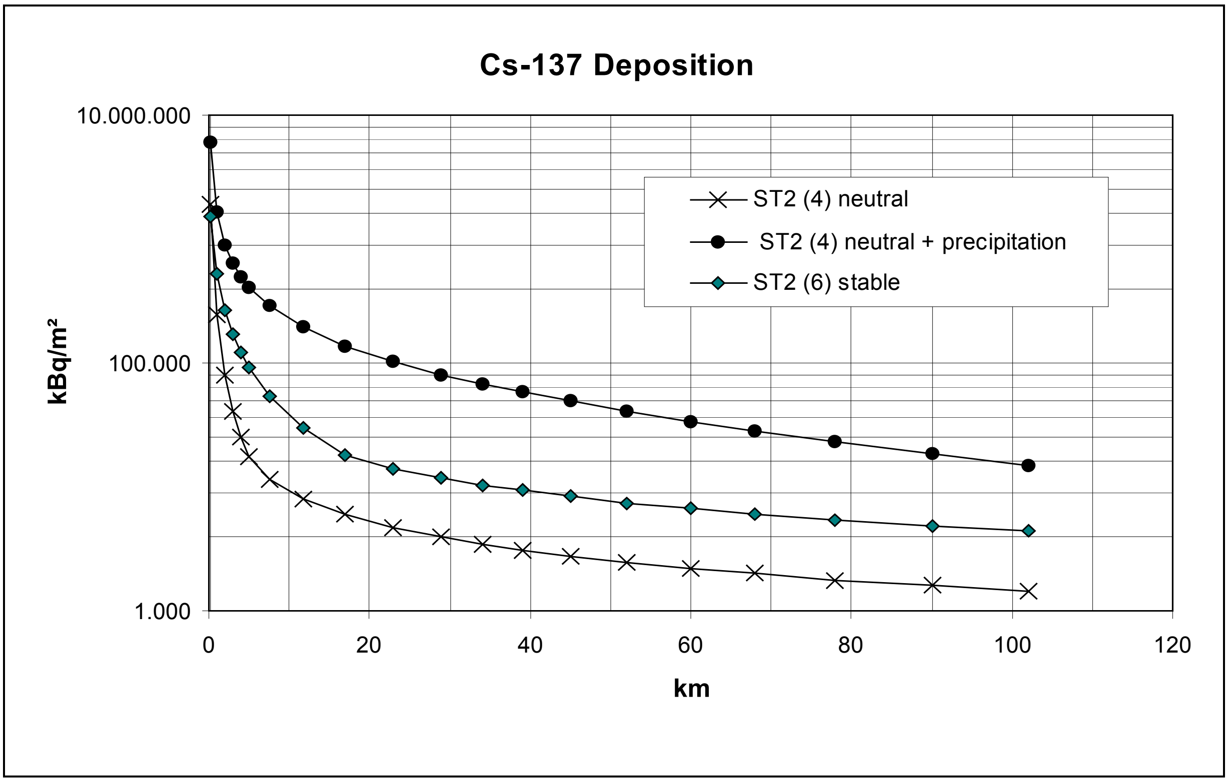


Figure 5: Cs-137 Deposition along wind direction axis according to scenario ST2 lager distances from the NPP (maximum 108 km), calculated with PC-COSYMA.

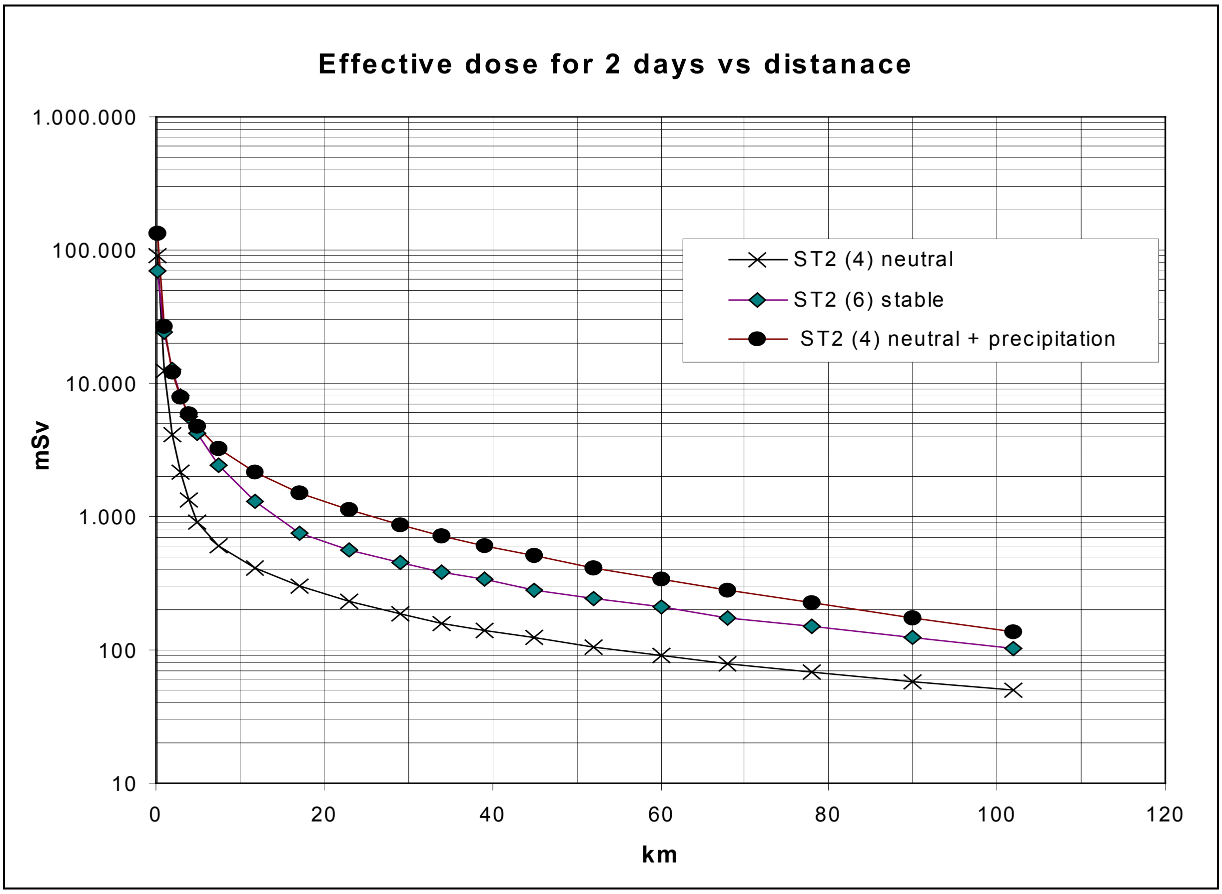


Figure 6: 2 day effective dose according to scenario ST2 in larger distances from the NPP (Maximum 108 km), calculated with PC-COSYMA.

Table 8: Connection between dose, warning level and danger levels (Source: (Rahmenempfehlungen (BKA, 1991))

Dosisleistung	Sv/h	Warning level	Danger category	Expected dose (mSv)
Up to0,03 µSv/h	= $3*10^{-8}$	2	I	0,5-2,5
Up to 1 µSv/h	= $1*10^{-6}$	3	II	2,5 – 25
Up to 10 µSv/h	= $1*10^{-5}$	4	III	25 – 250
Up to0,1 mSv/h	= $1*10^{-4}$	5	III	
Up to 1 mSv/h	= $1*10^{-3}$	6	IV	>250
Up to30 mSv/h	= $3*10^{-2}$	7	IV	
> 300 mSv/h	= $3*10^{-1}$	8	IV	

First, the comparison of the descriptions of Cs137 deposition – calculated with PC COSYMA and FLEXPART (Fig. 8 and 11) – show that the results comply well enough in the overlapping part. Certain differences have to expected because the PC-COSYMA calculation was done only with the data from a weather station and only with ground data (without taking into account the upper winds). This means that the model results are less and less realistic the further away from Temelin they are. The position of the maximum, however, is being described very well also by PC-COSYMA.

Figure 9 (warning level) shows that in this scenario, in the centre of the affected regions in Austria, warning level 4-5 is reached. In this case, danger level III would be announced. The inhabitants would be urged not to be outside but stay in buildings for protection. Children and teenagers, but also adults (up to 45 years of age) would be asked to take iodine tablets.

The necessity of using iodine tablets is being confirmed by the calculation of the thyroid gland dose (Fig. 10). The intervention level foreseen in the Czech radiation protection law for administering iodine tablets (100 mSv) is being exceeded in Austria as well. Because the Austrian Rahmenempfehlungen (BKA, 1991) set the dose factor for calculating the exposition of the thyroid gland approximately two times higher than for adults, the intervention value shall be 50 mSv. Both limits are visible in the figure.

During the following course it cannot be excluded that danger level IV is going to be reached.

In Table 9 the calculated dose value of this case study for the distances 40, 60 and 100 km are put together. It is visible that the Czech intervention level of 100 mSv would be exceeded everywhere. The effective dose after one year is over 250 mSv, on the lower limit of the Austrian danger level IV. However, these doses are calculated without assuming any measures, as was described earlier. In practice, the exposition exposure is reduced already by seeking out a building. Nevertheless, it would be necessary to realize measures for reducing the exposure.

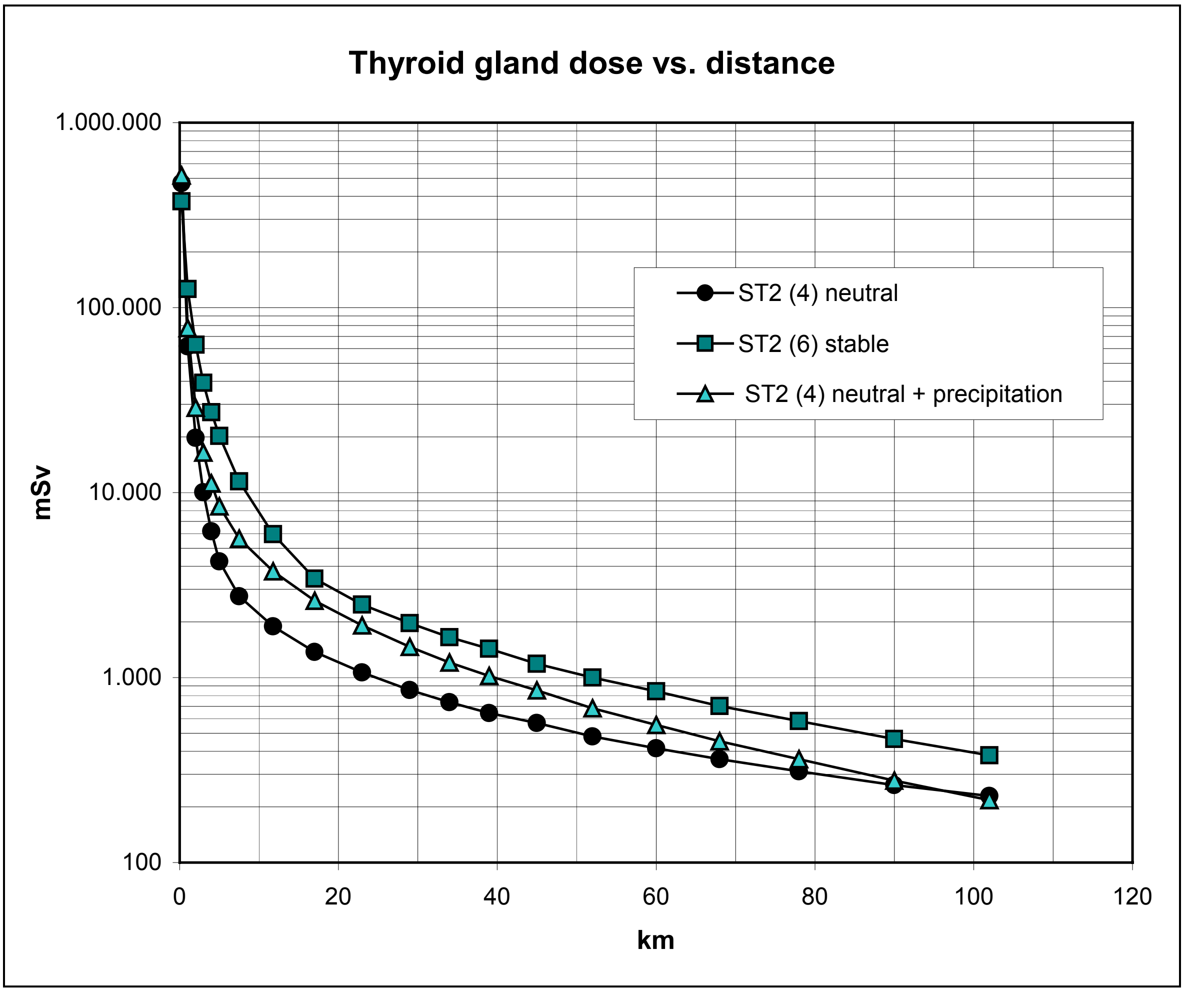


Figure 7: 2 day thyroid gland dose according to scenario ST2 in the greatest distance from the NPP (maximum 108 km), calculated with PC-COSYMA.

Table 9: Result of the dose calculation to scenario ST2 on 20.3.1995, calculated with PC – COSYMA.

Distance from Temelin in km	Effective dose (2 days) in mSv	Effective dose (365 days) in mSv
40	186	1605
60	138	1263
80	113	1055
100	103	976

4.3.6.3 Risks for neighbouring countries

For consideration exceeding the distance of 100 km from Temelin it is necessary to look at the FLEXPART calculations. An example of the calculation results is given in Fig. 11. The Cs137 deposition is in kBq/m^2.

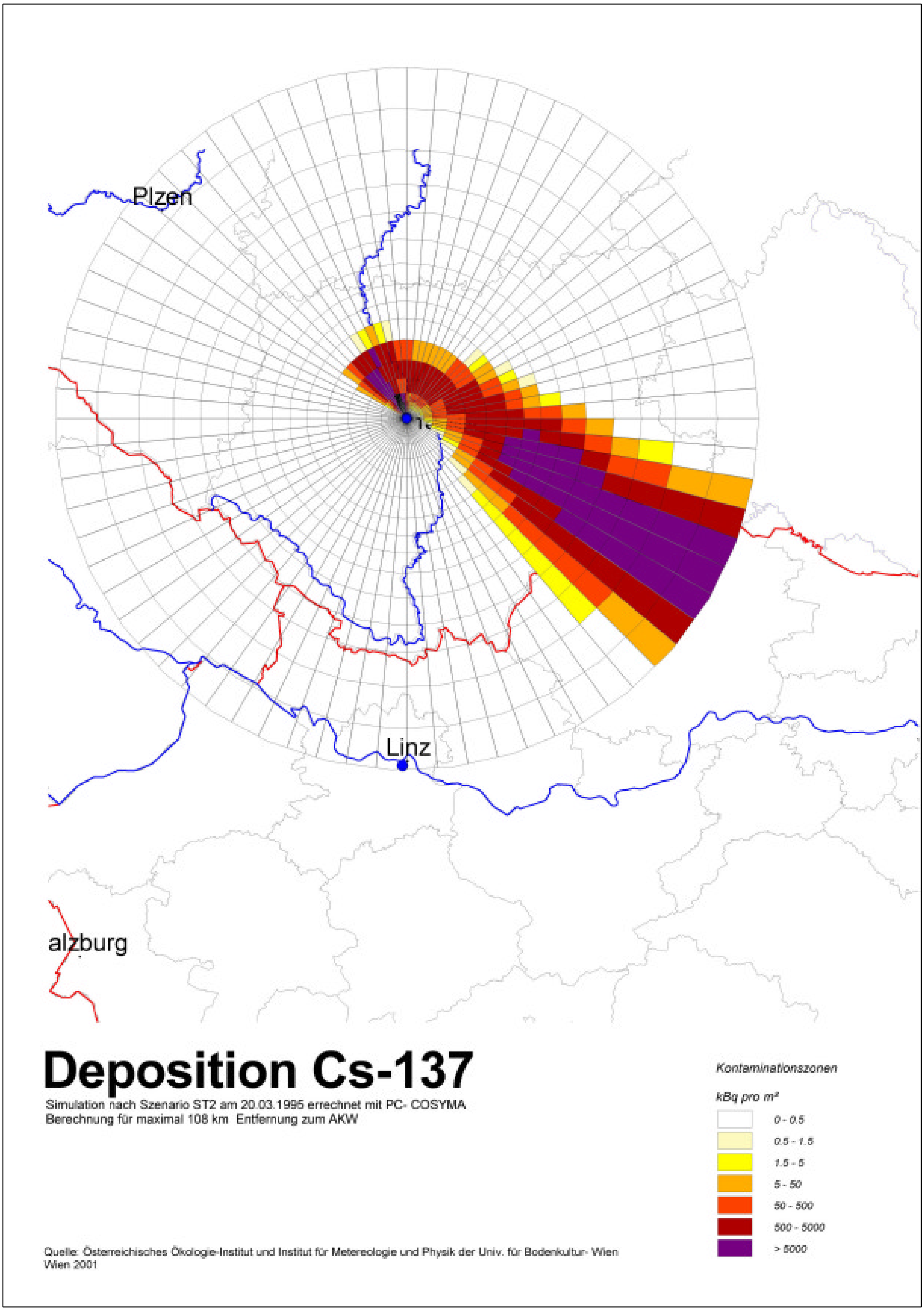
Annex A2 and the enclosed CD-Rom contain the description of all 88 cases in a section that is reproduced in Fig. 11 as well as in a larger section (see Fig. 12). At this scale, it becomes clear that the consequences of a large release at NPP Temelin are not constricted only to the closest surroundings but could concern also states that are further away, depending on the weather situation. According the spreading of precipitation, the affected area is a closed area or it is made up of separated areas – partially far away from each other.

Based on the 88 case studies, a statistic of affected areas of selected states with a Cs137 contamination of 185-1500 kBq/m^2, or over 1500 kBq/m^2 was drawn up. The results are shown in Table 10. The probability that Austria is going to be affected by a deposition of over 185 kBq/m^2 lies according to this (limited) statistic at 36% and therefore higher than for any other neighbour of the Czech Republic. In all, a radioactive cloud will pass over Austria in approximately 60% of all cases. This is due to the geographic situation, the wide range situation of air currents and the orography.

Mainly the lower contamination levels are in these case studies also going to be reached in other European countries, including for example Great Britain, Sweden or Greece.

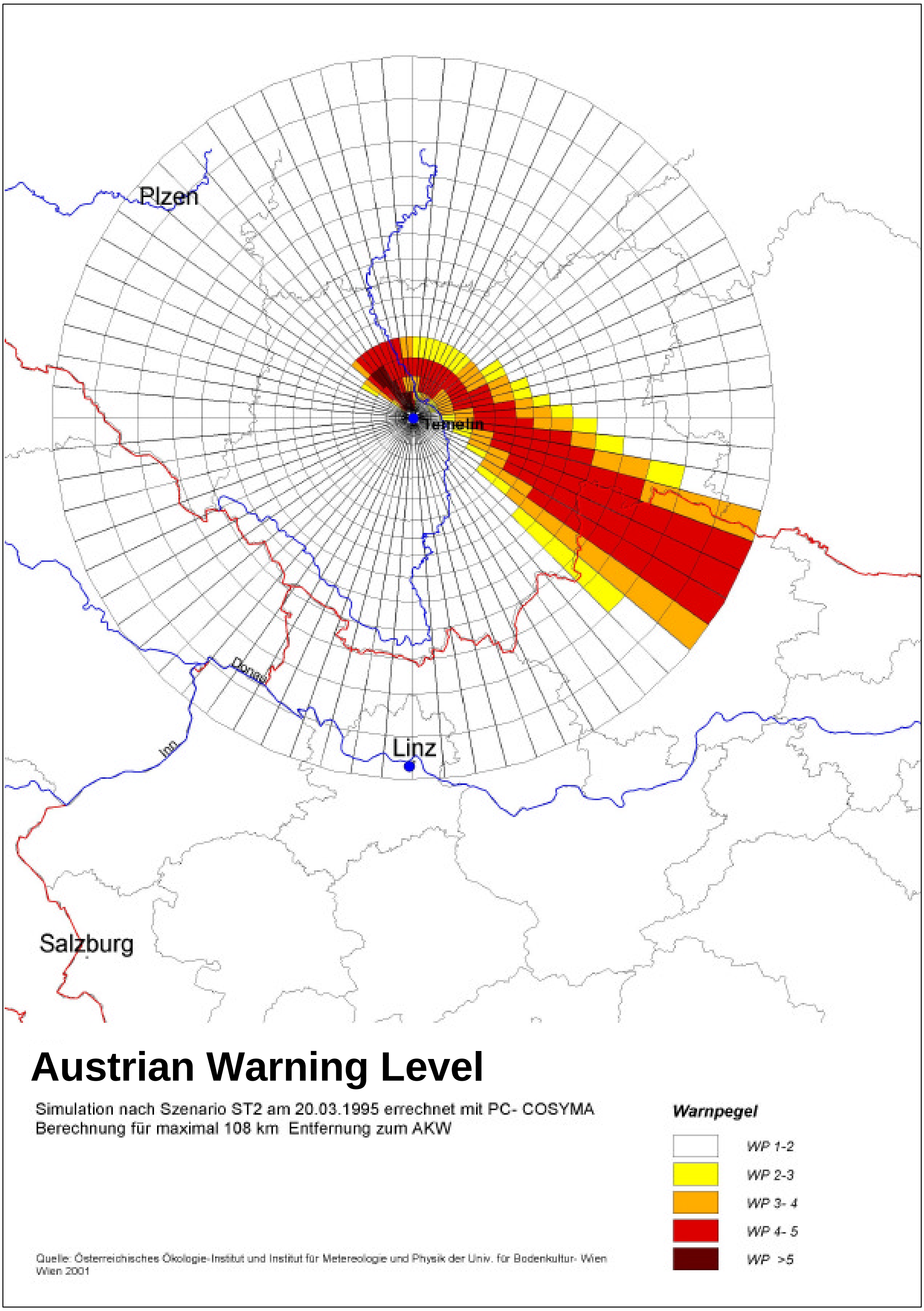
Table 10: Absolute and relative frequency of cases, under which in the 88 analysed case studies in the named countries Cs137 contamination of over 185 or over 1500 kBq/m^2 occur. Overall number of cases: 88.

Country	Frequency (affected)			
	Maximum deposition 185 -1500 kBq/m^2		Maximum deposition > 1500 kBq/m^2	
CZ	37	42%	35	40%
AUT	16	18%	16	18%
GER	17	19%	5	6%
SK	7	8%	1	1%
POL	11	13%	1	1%
HUN	12	13%	-	
SLO	6	7%	-	
ITA	5	6%	-	



Quelle: Österreichisches Ökologie-Institut und Institut für Metereologie und Physik der Univ. für Bodenkultur- Wien
Wien 2001

Figure 8 Cs137 deposition according to scenario ST2 on 20.3.1995, calculated with PC-COSYMA

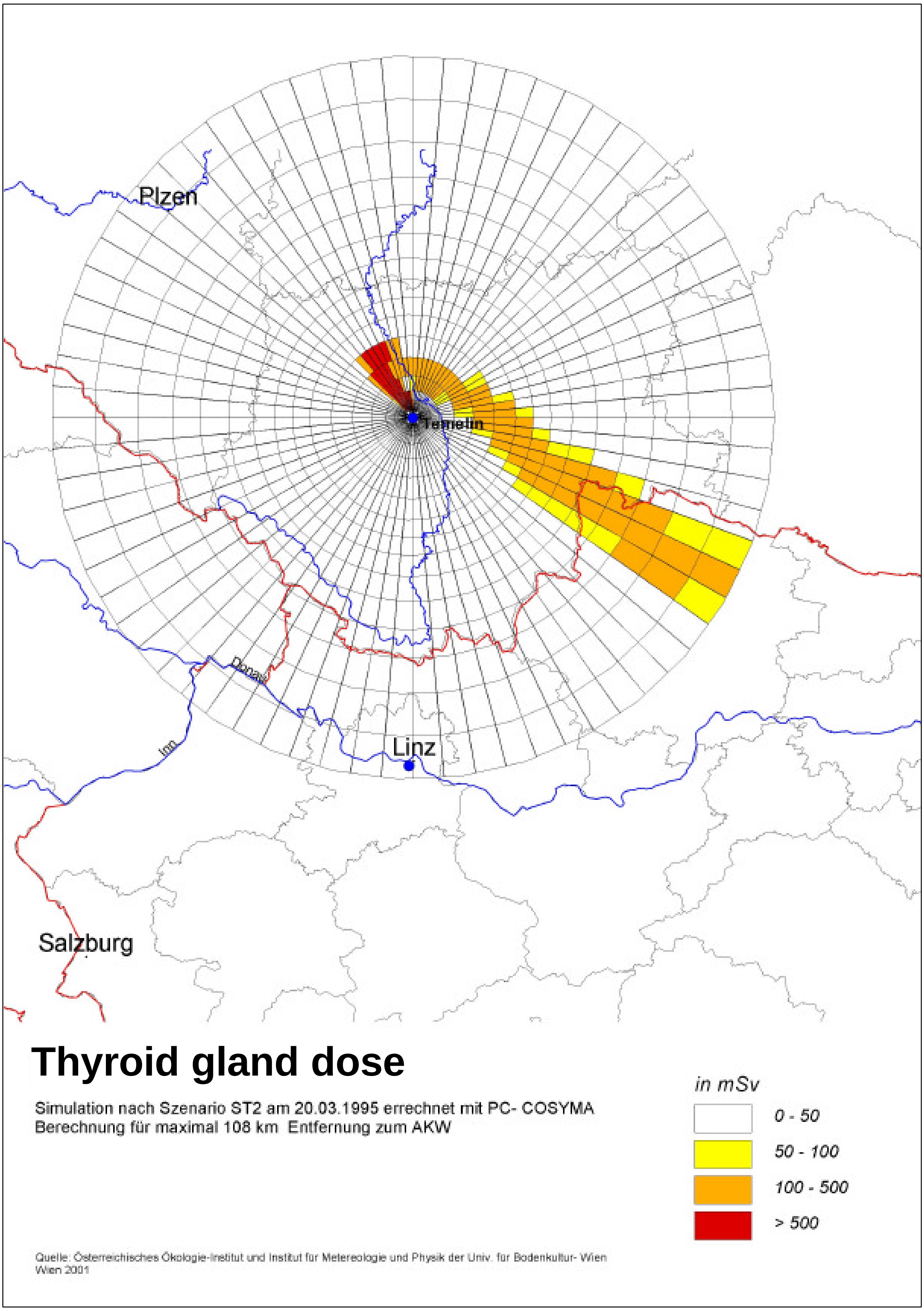


Austrian Warning Level

Simulation nach Szenario ST2 am 20.03.1995 errechnet mit PC- COSYMA
Berechnung für maximal 108 km Entfernung zum AKW

Quelle: Österreichisches Ökologie-Institut und Institut für Metereologie und Physik der Univ. für Bodenkultur- Wien
Wien 2001

Figure 9: Austrian warning level according to scenario ST2 on 20.3.1995, calculated with PC-COSYMA, maximum distance to the NPP 108 km



Thyroid gland dose

Simulation nach Szenario ST2 am 20.03.1995 errechnet mit PC- COSYMA
Berechnung für maximal 108 km Entfernung zum AKW

in mSv

- ⬜ *0 - 50*
- 🟨 *50 - 100*
- 🟧 *100 - 500*
- 🟥 *> 500*

Quelle: Österreichisches Ökologie-Institut und Institut für Metereologie und Physik der Univ. für Bodenkultur- Wien
Wien 2001

Figure 10: Thyroid gland dose in Austria according to scenario ST2 on 20.3.1995, calculated with PC-COSYMA, maximum distance to the NPP 108 km

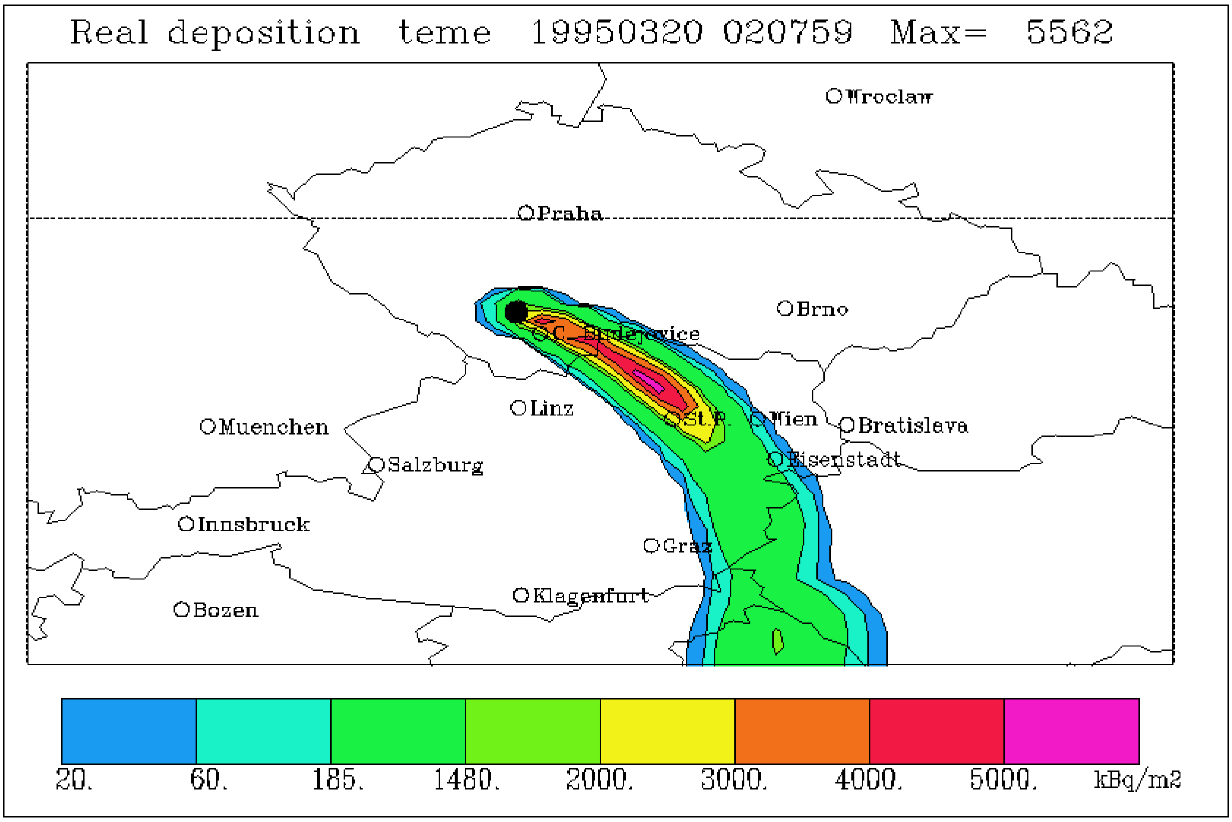


Figure 11: Cs deposition according to scenario ST2; FLEXPART calculation, section Austria

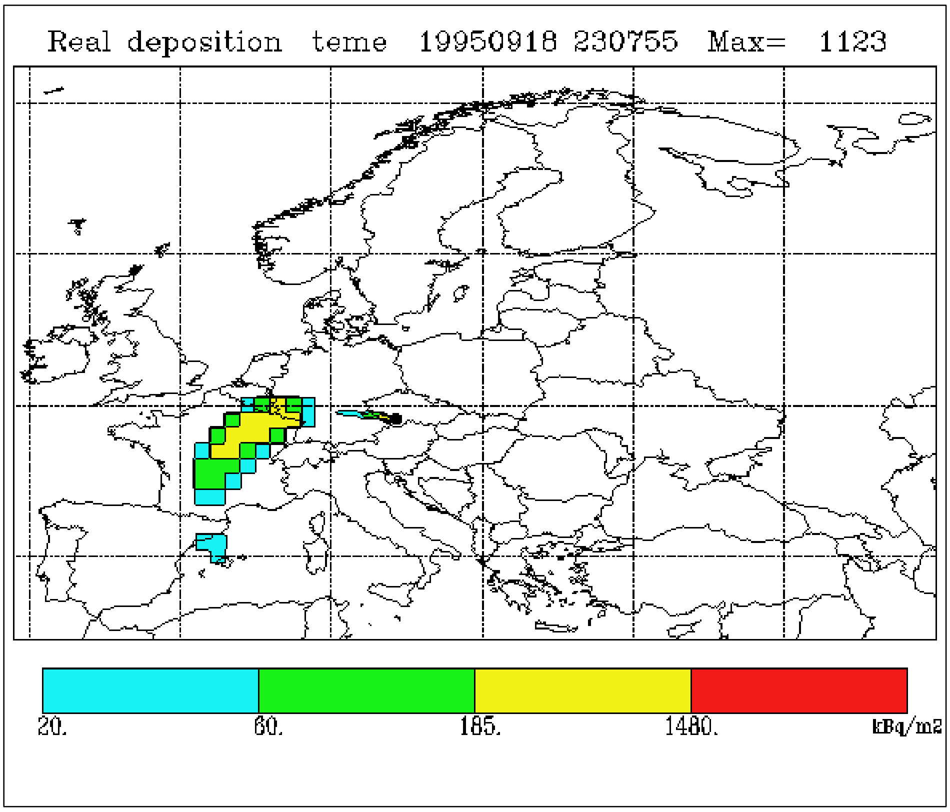


Figure 12: Cs deposition according to scenario ST2; FLEXPART calculation, section Europe

4.4 Treatment of severe accidents in the EIA practice in other countries

In the following section we want to give two examples from the practice of treating severe accidents in the framework of Environmental Impact Assessments for nuclear power plants. On the one hand we chose the US, because the EIA culture has been established there for a long time and because the US nuclear authority (NRC) probably has the most experience with licensing nuclear power plants worldwide. Further, we describe the procedure in the Netherlands because the Netherlands work within the framework of the EU EIA directive and they conducted an EIA process for the NPPs Borselle and Dodewaard in the early 90ies. Both states apply high demands for their EIA.

4.4.1 Summary

As an example for the handling of EIA for NPPs in other countries we discuss the rules in the US, as the country most experienced in this sector, and the Netherlands, as a EU member state that conducted such a procedure for the NPPs Borselle and Dodewaard approximately 10 years ago.

The comparison with the Temelin GESAMT EIA shows differences in the following areas:

- Performing of a full scope Level 3 risk analysis for the respective installations in the US and the Netherlands, which is described in detail and served as a basis for decision taking. This analysis included the assessment of core damage frequency for several accident initiating events, the retention capacity of the containment for several core melt down scenarios, the possible radioactive release (source term) scenarios, transport and deposition of released radionuclides and finally a dose assessment. It is therefore an assessment of the expected health risk.
- Detailed description of prevention and mitigation measures for severe accidents as part of the EIA. In the US this also included a cost/benefit analysis for the individual measures.
- Comparison of the environmental risk of severe accidents and the risk caused by emission during normal operation.

4.4.2 USA

In 1999, the US nuclear authority (NRC) developed new guidelines for setting up site specific Environmental Impact Declarations for NPPs, the “Environmental Standard Review Plan” (NUREG-1555). The Environmental Impact Declaration, which is being prepared according to these guidelines, is a prerequisite for the site authorization and the operational license. The annex of NUREG-1555 also describes the guidelines for the preparation of an Environmental Impact Declaration as a precondition for renewing the operational license of an installation.

According to the “Environmental Standard Review Plan”, an Environmental Impact Declaration for the licensing of NPP should contain a chapter named “accidents”, which covers the following topics:

- Design basis accidents
- Severe accidents
- Alternative for the prevention of severe accidents
- Transport accidents

The chapter concerning **severe accidents** of an installations' Environmental Impact Declaration should contain the following information:

- Sum-up of the radioactive releases into the atmosphere for different severe accident sequences (including the accident sequence (course of the accident) or sequence group, the probability (frequency) of the accident sequence per reactor and year and the share of the reactor inventory that is going to be released by this accident)
- Summary of the environmental consequences and their probabilities (this includes the probability per reactor and year, number of people exposed to a dose of >2 Sv, number of people exposed to a dose of >0.25 Sv, the number of expected latent cancer cases and the cost of the measures for combating the accident consequences)
- Summary of the anticipated number of anticipated short term death toll and the frequency (probability per reactor and year)
- Average value of the environmental risk of severe accidents per reactor and year
- Comparison of the environmental risk of severe accidents with the risk caused by emission during normal operation.

The chapter concerning alternatives for the prevention of severe accidents should contain the following:

- Description and examination of design alternatives, which significantly reduces the radiological risk of severe accidents by either preventing core melt down or the release of large amount of radioactivity during a severe accident.
- For all design alternatives and other measures for the prevention of severe accidents, assessments in relation to the costs of the measures and the implementation of the measures and the achieved benefit should be discussed.
- The reduction of the risk of the installation should be described.

4.4.3 Netherlands

According to the country report in the framework of the Convention on Nuclear Safety (Netherlands, 1998), the **"Environmental Protection Act"** (in compliance with the EU directive EC 97/11/EC) says the following about the treatment of severe accidents in an EIA:

During the licensing of a nuclear power plant the operator has to provide an EIA documentation (Environmental Impact Declaration). This EID also has to be performed for certain modifications of an already licensed installation (change of the nuclear fuel, certain design modifications at the installation, changes of the emissions). Moreover, an independent Commission for the evaluation of the EID has to be established.

The EIA should deliberately stimulate a public discussion: *"Environmental impact assessments are often used by the public and interest groups as a means of commenting on and raising objections to decisions on nuclear activities. This clearly demonstrates the value of these documents for public debate and involvement."*

In 1989, an upgrading program was started for both NPP Borssele and Dodewaard in the Netherlands. Later it turned out that both installations needed a new operational license because of the modifications of the installations. As part of this licensing procedure an EIA had to be conducted. An important part of the EID was a full scope Level 3 Probabilistic Safety Assessment ("full scope", i.e. including all internal and external threats, Level 3 means that everything was considered from the probability of a severe accident to the radioactive release to dispersion and deposition and the caused health damage of the surrounding population). The influence of the changes of the installation on the overall risk of the installations were examined and described as well.

Between 1986 and 1999, the concept of Risk Management and Risk Assessment in the field of environmental policy was developed. The Ministry of the environment set objectives (risk criteria) for the acceptability of risks from normal operation and from severe accidents at NPPs.

For the normal operation of one installation, a maximum individual dose of 0,1 mSv was decided.

For the prevention of severe accidents, a maximum limit was set for the individual mortality risk (caused by acute and delayed health consequences) with 10^{-5} per year and 10^{-6} per year for the individual installation.

For proof that the risk criteria are being met, only the usual emergency measures for mitigation of the impacts (e.g. fire-brigades, medical care,) can be considered. Emergency measures, like evacuation, prophylactic administration of iodine or seeking out protective rooms, cannot be considered.

For this reason, a large part of the EIA documentation, which is part of the licensing procedure, is dedicated to comparing the results of the Level-3 PSA with the above mentioned risk criteria.

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Annex 1: Severe accident risks posed by the Temelín Nuclear Power Plant and preventive and mitigation measures

Chapter 4.1 points out in several places that the environmental impact assessment lacks significant data on the analysis of severe accidents and does not address potential severe accident mitigation alternatives for the reduction of accident risk or the mitigation of their effect. The following is the attempt to bridge these gaps, in as much as this is necessary for the evaluation of the Temelín nuclear power plant, using different available documents, and, above all, the information gained during the workshop on severe accidents in Prague, as well as own estimations. The major results of these considerations are already contained in Chapter 4.1.

Annex 2: Illustration of case study calculation results

Annex A1

SEVERE ACCIDENT RISKS POSED BY THE TEMELIN NUCLEAR POWER PLANT AND SEVERE ACCIDENT MITIGATION ALTERNATIVES[1]

1.1 Summary and Conclusions

- The Temelín core damage frequency (CDF) is above 10-5 per year, which is the safety target for NPPs in a number of EU member states as well as the Russian Federation.
- The CDF is dominated by containment bypass sequences, contrary to EU member states' practice. In addition, the containment bypass sequences have a frequency in excess of the INSAG safety target and well in excess of "large release" safety targets for member states of the EU and the Russian Federation.
- The environmental impact assessment does not address severe accident mitigation alternatives at all, even though a preliminary study of some such alternatives has been done for the operating utility, and a wide variety of potential severe accident mitigation alternatives is described in the literature.
- The environmental impact assessment's treatment of severe accidents is inadequate in both scope and detail.

1.2 Introduction

In any environmental impact assessment concerning the proposed operation of a commercial nuclear power plant — and especially one prepared in the opening decade of a new century, 15 years after the Chornobyl Unit 4 accident and 22 years after the Three Mile Island Unit 2 accident — one would have thought it plainly obvious that a key matter for analysis and extended discussion is the issue of the risks posed by severe accidents and alternative plant configurations to reduce those risks. Indeed, it has been standard practice to include such an analysis in environmental impact assessments in the United States for more than a decade, and it is the practice in a number of other countries as well (e.g. Finland and the Netherlands). Worldwide, severe accident issues are part and parcel of the regulatory process except — as strenuously pointed out by representatives of the Czech regulatory authority (SÚJB) on several occasions — in the Czech Republic. [2]

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[1] The author had been given access to the PSA 1995 for Temelin NPP by the Czech side. For the purposes of publication within the EIA, numbers and considerations from the PSA that are not generally known or published elsewhere were eliminated by the editor. Insertions by the editor are marked by italics.

[2] SÚJB is well outside the mainstream in forswearing the use of risk methods in regulation (INSC 1998; Colin 1997; IAEA 2001; NEA 1992; NEA 1996a; Campbell 1993). Within the EU, for example, regulatory authorities in Finland, Sweden, and the United Kingdom make broad use of risk methods. Of course, the use of risk methods by the USNRC — which is moving to risk-informed regulation and has issued safety goals and a PSA policy statement — is well known internationally (ORNL 1996).

SÚJB is even behind the times in the use of risk methods in regulation compared with nuclear regulatory authorities in central and eastern Europe and the former Soviet Union. For example, the nuclear regulatory authority in Ukraine required the performance of probabilistic safety assessments (PSAs) for VVER-440/213 and VVER-1000 NPPs in that country in 1995 (ANL 1999).

A Level 2 probabilistic safety assessment (PSA) of Unit 1 of the Temelín nuclear power plant (NPP) was completed for CEZ a.s. in late 1995. The Level 1 (core damage frequency, or CDF) scope of the analysis included accidents involving the reactor core at power and during shutdown, caused by internal events and external man-made and natural phenomena hazards. The analysis scope also included some consideration of accidents involving the spent fuel pool (frequency of boiling down the pool water level to the top of the stored fuel). The Level 2 analysis (accident progression, containment integrity assessment, and source term estimates) considered only accidents initiated at power.

The PSA provides a basis for assessing the risks posed by the Temelín NPP, and for assessing the risk reduction benefit afforded by a variety of potential severe accident mitigation measures. Indeed, the PSA itself cites these as two purposes for performing the analysis in the first instance. The failure of the Temelín environmental impact assessment (EIA) to address severe accidents — except to cite a core damage frequency a factor of more than three lower than the PSA estimated and claim that this result meets INSAG CDF targets — is therefore striking indeed.

The purposes of this section of the review of the Temelín EIA are the following:

- To provide a discussion on treatment of severe accident risks in the member states of the European Union and internationally, providing a framework for the information which follows below.
- To provide information on the results of the Temelín PSA.
- To compare the Temelín PSA results with safety targets used internationally and within the member states of the European Union.
- To provide an appraisal of containment integrity and containment bypass for Temelín under severe accident conditions.
- To identify potential severe accident mitigation alternatives, which were not at all discussed in the Czech EIA report.

1.3 Treatment of Severe Accident Risk in the Member States of the EU and Internationally

1.3.1 General Severe Accident Framework

Nuclear power plants (NPPs), including Temelín Units 1 and 2, are generally designed in accordance with defense-in-depth principles to respond — with considerable margin — to a variety of accident conditions. Accidents which are within the envelope of equipment failures, environmental conditions, and human response for which the NPP is designed are referred to as "design basis accidents" or DBAs.

Of course, the design of an NPP is not without bounds, and there can occur conditions or combinations of failures and erroneous or untimely human actions which can place the NPP outside its design basis and in risk of severe damage to the reactor core. Thus, at some frequency of occurrence, conditions more significant than those envisioned in the design can occur.

Such conditions, if they lead to severe damage to the reactor core, are referred to as "severe accidents". Consistent with the 1995 EC consensus document, a severe accident is regarded as one with the potential to release to the environment significantly more radioactivity than the levels predicted for design basis accidents (EC 1996:21).

Severe accidents which do not result in containment bypass or an impairment or failure of containment integrity do not have the potential for health effects or contamination offsite. Such accidents are of considerable economic consequence however:

- Large amounts of money must be spent in stabilizing the plant in a safe condition, and then cleaning up the contamination in plant buildings.
- Large amounts of money must be spent on either purchasing replacement power, refurbishing an existing facility and restoring it to operation, constructing a new facility, or some other means or combination of means of making up for the lost power production of the unit which experienced the accident.
- Construction loans remaining on the damaged unit must be paid without revenues from the damaged plant, and this perhaps has consequences for the utility's continued financial viability and/or for the continued maintenance of the utility's other units (including, possibly, other nuclear units).

Severe accidents in which containment bypass or containment integrity impairment occur, however, have effects offsite and, depending on circumstances, can have such effects at a considerable distance. Thus arises the potential for transboundary impacts. Such transboundary impacts are the issue of greatest concern to Austria as regards the operation of Temelín Units 1 and 2.

Containment bypass accidents potentially affecting Temelín include the following:

- Interfacing loss-of-coolant-accident (LOCA), in which the boundary between the primary coolant system and systems which penetrate the containment is lost, and the pressure boundary outside the containment cannot be maintained, resulting in a loss of coolant outside the containment and eventual release of radioactive materials during core degradation which bypasses the containment into the reactor building. This is the so-called PWR "V" sequence identified in the WASH-1400 Reactor Safety Study in 1975.
- Steam generator tube rupture (SGTR), which results in the loss of primary coolant into the secondary side of the steam generator. Such coolant cannot be recycled back into the reactor, so that this initiating event can only be managed by reducing pressure to stop the flow through the broken tube, and then placing the plant in cold shutdown for repairs. If this is not done, the primary system inventory is lost and the core is damaged, during which process radioactive materials are released to the secondary side of the plant and into the environment.
- Steam generator collector leakage (SGCL), in which the collector head lifts, which also results in primary to secondary leakage similar to — but at a much higher leak rate — a steam generator tube rupture.

Threats to containment integrity at Temelín apart from containment bypass include the following:

- Failure of containment isolation.
- Hydrogen combustion, including deflagration, deflagration-to-detonation-transition (DDT), and detonation.
- Direct containment heating (DCH) resulting from expulsion of core debris from the reactor vessel with the primary system at pressure above 2 MPa.
- Core debris contact with the containment liner at the floor/cylinder junction, resulting in liner failure and excessive containment leakage in the short term and possible containment wall failure due to concrete ablation in the long term.
- Overpressure failure of the containment in the long term due to steam (in case of containment heat removal failure) and noncondensable gases
- Failure of containment penetrations due to high temperature or other causes.

- Melt-through of the reactor cavity due to molten core/concrete interactions (MCCI) and failure of the cavity due to its inability to support the weight of structures above.
- Failure due to missile impacts resulting from steam explosions and from locally generated missiles (such as the reactor cavity doors, expelled at high velocity due to cavity overpressurization from high pressure melt ejection and DCH).

1.3.2 Relevant History of Temelín Design & Construction

In 1980, a decision was taken in the former Czechoslovakia to construct four VVER-1000/320 units at the Temelín site. Site preparation began in 1983, and actual construction began in 1987. In 1990, the government of the former Czech and Slovak Federal Republic decided to complete only the first two units. Between 1990 and 1992, several evaluations of the plant design were made, and numerous recommendations were made for improvements. In March 1993, the government of the Czech Republic determined that completion of Units 1 and 2 should proceed.

An Association Agreement between the European Communities, the Member States, and the Czech Republic was signed in October 1993, and entered into force in February 1995. The Czech Republic formally applied for membership in the European Union on 17 January 1996. Accession negotiations were formally initiated on 31 March 1998 with the Czech Republic and five other countries.

Table 1 provides a chronology which places some of these events into historical perspective with the development of regulatory treatment of severe accident issues.

1.4 Temelin PSA Results

1.4.1 Level 1 PSA Results at Power

The Level 1 PSA results for accidents occurring at power are provided in a published conference paper from 1999. The total core damage frequency from all causes, as well as the CDF from the various contributors, is provided in Table 2.

Table 1: Chronology of Temelín Design & Construction and Developments Worldwide in the Regulatory Treatment of Severe Accident Issues

DATE	EVENT
1971-07-XX	US federal court issues the Calvert Cliffs decision, requiring the federal government to prepare environmental impact assessments on NPP licensing decisions
1975-10-XX	WASH-1400, Reactor Safety Study, published; first large-scale PSA of two nuclear power plants
1979-03-28	Three Mile Island Unit 2 accident in United States
1980-XX-XX	Czechoslovakia decides to construct four VVER-1000 units at Temelín
1983-XX-XX	Site preparation work begins at Temelín
1984-07-XX	USNRC issues ATWS rule requirements
1985-08-XX	USNRC issues Severe Accident Policy Statement
1986-04-26	Chornobyl Unit 4 accident in Ukraine
1986-08-04	USNRC issues the policy statement on Safety Goals for Nuclear Power Plants
1986-11-XX	Temelin construction permit issued
1987-02-XX	Physical construction begins at Temelín
1988-07-XX	USNRC issues station blackout rule
1988-11-23	USNRC issues Generic Letter 88-20 concerning the IPE program
1989-XX-XX	Gosatomnadzor (GAN) issues OPB-88 (PNAE G-1-011-89) USNRC required by Federal Appeals Court to consider severe accident mitigation alternatives (SAMAs) in NPP environmental impact assessments
1990-XX-XX	Czech and Slovak Federal Republic decision to stop construction of Units 3 and 4
1990-12-XX	USNRC publishes NUREG-1150, 5-plant risk assessment study
1991-06-28	USNRC issues Supplement to Generic Letter 88-20 extending IPE program to external events (IPEEE)
1993-03-XX	Czech government decision to complete Temelín Units 1 and 2
1993-10-XX	Association agreement signed between the European Union and the Czech Republic
1994-08-12	USNRC issues the policy statement on Use of PSA Methods in Nuclear Regulatory Activities
1995-02-XX	Association agreement, signed between the European Union and the Czech Republic, entered into force
1995-08-XX	USNRC issued policy statement on use of PSA in NPP regulatory activities
1996-01-17	Czech government formally applies for membership in the European Union
1997-04-03	USNRC issues a PSA implementation plan
1998-03-31	Accession negotiations formally begin between the European Union and the Czech Republic
2000-07-06	Start of fuel loading at Temelín Unit 1
2000-10-11	Initial criticality at Temelín Unit 1
2000-11-02	Power operation (Mode 1) achieved at Temelín Unit 1
2000-12-21	First electricity generated at Temelín Unit 1

It is notable that 6.76×10^{-5} per year — representing about 62% of the at power CDF — consists of events that bypass the containment. Most of this comes from steam generator collector head leaks and steam generator tube rupture accidents. The PSA itself acknowledges that this result is about one to two orders of magnitude above the results in US PWR PSA studies. There are three main reasons for this outcome:

- The initiating event frequency for steam generator tube rupture (SGTR) is about a factor of 20 higher for VVER-1000 reactors than for PWRs generally (4.4×10^{-2} per year in the Temelín PSA, versus a value of 2×10^{-3} per year for PWRs generally[3]). Allowing for updated VVER-1000 operating experience through the end of last year, the SGTR initiating event frequency would be 2.1×10^{-2} per year (six events in 282 reactor-years of operation).
- Steam generator collector head leakage is a unique VVER contributor — it does not exist for western PWRs.

Automatic system response to both events, in the long term, is contrary to recovery and safe shutdown before core damage occurs (IAEA 2000). Thus, the CDF from SGTR and steam generator collector leak events is dependent on operator actions to take control room the automatic systems, depressurize the primary system to stop the leakage to the secondary side, and place the reactor on long-term shutdown cooling. This must be accomplished before the inventory of the emergency core cooling systems (in the containment sump) is lost to the secondary side of the plant and out into the environment, where it is unavailable for continuous core cooling. If this is not done, core damage under containment bypass conditions ensue.

The Temelín PSA manager asserts in a published paper that the results for the steam generator collector leakage are conservative because the steam generators are of the latest design and include improvements that will reduce the likelihood of the initiating event. It is suggested as a result that the CDF from steam generator collector leakage will drop from 4.33×10^{-5} per year to somewhere in the range of 5.0×10^{-6} to 1.0×10^{-5} per year (Mladý 1999). We disagree for the following reasons:

- Substantial decrease in steam generator collector leakage based on steam generator design changes is not justified. Apart from one specific change (installation of flow limiters on the collector head, which is fully reflected in the PSA which models a leak size of 40 mm instead of 100 mm as in the original design), the design changes were intended to address steam generator collector failure, not leakage. These changes are fully reflected in the PSA, which already does not include steam generator collector failure as an initiating event.
- Consideration of additional VVER operating experience between when the PSA was performed and the end of the year 2000 would allow a drop in initiating event frequency for steam generator collector leakage of about a factor of 2 to 1.3×10^{-3} per year.

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[3] This is based on the historical number of non-VVER SGTR events divided by the number of reactor-years of experience of non-VVER PWRs. A collection of PWR PSA studies reviewed as part of an EU project found SGTR initiating event frequencies in the range of 1.4×10^{-3} per year and 6.0×10^{-3} per year (Enconet 1999).

Table 2: Core Damage Frequency Results for Temelín Unit 1 (Mladý 1999)

Initiating Events		Initiating Event CDF Contribution	Total CDF Contribution
Internal Initiating Events			**8.96×10^{-5}**
T9	Steam Generator Collector Leakage	4.33×10^{-5}	
T8	Steam Generator Tube Rupture	2.27×10^{-5}	
S2	Large LOCA	7.87×10^{-6}	
S4	Small LOCA	4.01×10^{-6}	
TS	Anticipated Transients Without Scram (ATWS)	2.70×10^{-6}	
T6	Loss of Offsite Power	2.68×10^{-6}	
S5	Very Small LOCA	1.94×10^{-6}	
T4	Reactor Trip with Main Feedwater Unavailable	8.73×10^{-7}	
T1	Reactor Trip with All Systems Available	8.73×10^{-7}	
S3	Medium LOCA	4.61×10^{-7}	
S1	Reactor Vessel Rupture	2.71×10^{-7}	
T5	Reactor Trip, Loss of Main & Auxiliary Feedwater	2.13×10^{-7}	
TV2	Loss of Two Trains of Essential Service Water	1.95×10^{-7}	
V	Interfacing Systems LOCA	1.60×10^{-7}	
TV	Complete Loss of Essential Service Water	5.23×10^{-9}	
T7	Unisolable Steamline & Feedwater Line Breaks	$<10^{-9}$	
External Initiating Events			**2.03×10^{-5}**
Internal Fires		1.8×10^{-5}	
Internal Flooding		2.3×10^{-6}	
TOTAL CDF FROM ALL CAUSES			**1.1×10^{-4}**

- The frequency of the T9 initiating event is not meant only to reflect steam generator collector leakage. It is also intended to represent multiple SGTR events. It is frequently stated that no multiple SGTR events have occurred to date. <u>This is not correct.</u> The 1982 R.E. Ginna SGTR event in the US resulted in failure of an adjacent tube; fortuitously, the adjacent tube had previously been plugged, which is why this aspect of the Ginna event has not been widely appreciated. Estimates of the frequency of multiple SGTR as an initiating event range from 1.1×10^{-4} per year for Loviisa to 4.4×10^{-3} per year in the French 900 MWe PSA, compared with the steam generator collector head leakage frequency in the Temelín PSA of 2.5×10^{-3} per year. (A strictly historical perspective is one event — Ginna in 1982 — divided by 8000 reactor years of PWR experience, yielding a frequency for multiple SGTRs of 1.3×10^{-4} per year.)
- Human response to steam generator collector leakage is an important factor in steam generator collector leak and SGTR CDF results. We do not foresee a substantial decrease in human error rates responding to these two initiating events because this response oc-

curs under time constraints and high stress conditions. [4] Furthermore, the Temelín PSA has already included the effects of switching to symptom-oriented emergency operating procedures and the use of computer-aided emergency procedures (COMPRO) in the PSA. A sensitivity study contained in the PSA reduced human error rates across-the-board — without any regard to the type of error — by factors of 2, 5, and 20 and then recalculated internal events CDF. The base case CDF result is 8.96×10^{-5} per year for internal events. Factors of 2, 5, and 20 reduction in human error rates yield CDF results of 5×10^{-5} per year, 3×10^{-5} per year, and 2×10^{-5} per year. That is, a 20-fold reduction in human error rates yields a CDF reduction of a factor of less than 5. We do not believe that a factor of 20 reduction, or even a factor of 5 reduction, could be credibly justified.

So, where does this leave us? SGTR contribution to CDF could drop by a factor of 2.1 and the steam generator collector leakage could drop by a factor of 2, both based on updated initiating event frequency data. Thus, the internal events CDF could drop from 8.96×10^{-5} per year to 5.24×10^{-5} per year as shown in Table 3.

Even with this revised result, containment bypass sequences represent 3.27×10^{-5} per year — still 62% of the internal events CDF and about 46% of the total at power CDF of 7.27×10^{-5} per year. The Czech EIA cites a CDF value — unsubstantiated by any documented calculation or citation — of 2.6×10^{-5} per year. No indication is given of the contributors to the CDF value (i.e., what fraction of this value is containment bypass?).

Table 3: Reassessment of Internal Events CDF Results

Initiating Event	1995 PSA Result	2001 Coarse Recalculation
Steam generator tube rupture	2.27×10^{-5}	1.08×10^{-5}
Steam generator collector leak	4.33×10^{-5}	2.17×10^{-5}
All other events	2.36×10^{-5}	1.99×10^{-5} (see footnote) [5]
Internal Initiating Event Total	8.96×10^{-5}	5.24×10^{-5}

The PSA Level 1 update was started recently (January 2001)[6], and is expected to take 15 months (Hezoucky 2000), thus the PSA revision results would not be available until about March 2002. The Austrian *experts* (…)were told repeatedly that there are no new results yet from this study, and this is consistent with the timing just discussed. Thus, the CDF value cited in the EIA cannot be taken seriously without an indication of how it was calculated, the nature of its contributing accident scenarios, and whether the analysis was — consistent with practice internationally and within the European Union — subject to a peer review.

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[4] We are not alone in asserting short response times and high stress levels for operators responding to SGTR and STCL accidents. This issue has been raised in the South Ukraine Unit 1 PSA (Kot 1999:9). The PSA is being performed by Ukrainian organizations, with Scientech, Inc. in a technical assistance role. Scientech is company which now owns the former NUS group which performed the Temelín PSA.

[5] The reduction here reflects the dropping of a sequence (large LOCA with failure of accumulators but success of low pressure injection) which should not have been kept as a core damage sequence. Its inclusion in the 1995 PSA was excessively conservative.

[6] This date was cited in discussions during the expert meeting in Prague on 4 April 2001 as part of the Melk Protocol Trialogue process.

1.4.2 Level 1 PSA Results at Shutdown

The PSA scope included an assessment of the frequency of the loss of residual heat removal during shutdown conditions, resulting in failure to cool the reactor core.

From this – based on the more detailed knowledge of the PSA and a number of additional considerations – a shutdown CDF of 3.0×10^{-5} *per year is assumed.*

(….)

No Level 2 analysis was presented for shutdown accidents involving the reactor core. It has to be noted, however, that containment integrity requirements for shutdown conditions are different than at full power, and there is a greater potential for the containment to be unisolated at the time of an accident during shutdown. In addition, the requirements on equipment availability are less strict during shutdown, so it cannot be presumed that the same system containment isolation reliability values apply during shutdown accidents.

1.4.3 Level 1 PSA Results for Spent Fuel Pool

(...)

Contribution of Spent Fuel Pool severe accidents have not been fully analysed for Temelin. Studies of American PWRs even show a considerable potential for spent fuel pool severe accidents when the reactor core is in the reactor. Regardless of whether one takes as an indication of spent fuel pool accident risks a maximum value of 7×10^{-5} *per year or a value reduced by a factor of 10 or 100, none of these values is so low as to justify exclusion of spent fuel pool severe accidents from the scope of the environmental impact assessment. Some considerations from published literature show this clearly.*

A recent OECD/NEA report could not find any detailed analysis of spent fuel degradation and radionuclide release involving fuel in the spent fuel pool in VVER-1000 NPPs (NEA 2000a:21). Such analyses have, however, been carried out for PWR NPPs in the United States. These analyses have found that under some circumstances severe spent fuel pool accidents can occur which result in fuel heatup, cladding degradation, metal-water reaction producing large quantities of hydrogen, and possible radionuclide release from the fuel under oxidizing conditions (BNL 1987; INEL 1996; USNRC 1989a; USNRC 2000a; USNRC 2000b).

The potential for a cladding fire are sensitive to fuel assembly geometry and spent fuel pool racking configuration (USNRC 2000b:2-1). The USNRC latest study, completed last fall, found the spent fuel cladding fires remain an issue, and also stated that the consequences of such a fire are so severe that the USNRC's large release frequency safety target for risk-informed regulation should apply (i.e., $<10^{-5}$ per year) (USNRC 2000b:1-2), and the report discusses accident management measures for spent fuel pool accidents. [7]

A severe accident in a VVER-1000/320 NPP can essentially preclude access to the reactor building surrounding and underlying the containment (especially in the case of reactor cavity melt-through). The spent fuel pool cooling system equipment is located in the reactor building, and any equipment failures that would require repairs could be precluded by high radia-

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[7] It is important to recognize, in the contact of the USNRC studies, that spent fuel pools in PWRs in the US are located outside containment. In the VVER-1000/320 design implemented at Temelín, the spent fuel pool is inside containment. Under these conditions, for a VVER-1000 a severe spent fuel pool accident could release large quantities of hydrogen into the containment, far larger than the amounts released in a severe accident involving the reactor core. In addition, boiloff of the pool water inventory into steam, if not condensed by containment spray (and this is almost a non-sequitor since if the spray system was available it would be used for pool inventory makeup), is approximately sufficient to cause containment overpressure failure. The pool has an area of about 43 m^2 and a depth of about 8 m, so the volume is 344 m^2. According to the PSA, 300 m^3 of water boiled to steam will take the containment to the median failure pressure.

tion dose fields. Any spent fuel pool severe accident that would follow a severe reactor accident could, if the containment is not already failed, add additional containment loads (pressure, hydrogen). If the containment is already failed, the radioactivity release from such an accident could result in additional contamination offsite.

Similarly, if a severe reactor accident occurs, it is very likely that the reactor building will have to be abandoned (due to leakage of the containment into the building due to containment liner failure; due to melt-through of the reactor cavity into the reactor building). The spent fuel pool cooling system is located in the reactor building, as is the containment spray system. If these systems fail, loss of spent fuel pool cooling is possible because access to the cooling system will not be possible due to high radiation doses. Thus, a loss of spent fuel pool cooling accident could lead to a spent fuel pool severe accident. As regards emergency makeup to the spent fuel pool from the containment spray system after a severe reactor accident, it has to be observed that the dominant severe accident scenarios involve unavailability of containment spray system because the inventory for the pumps is lost to the atmosphere due to primary to secondary leakage accidents and/or the system fails due to other causes. Thus, it is unlikely that containment spray would be available to recover the situation.

(…)

It must also be noted that the capacity of the spent fuel pool is for about ten years of storage. Since it is anticipated that the Temelín NPP will operate for 30 years or more, it is clear that some additional means of spent fuel storage or disposal will need to be implemented in this time frame. Although a final decision is not yet made, at least a scoping assessment of alternative spent fuel storage risks should be presented in the EIA, covering the range of possible storage/disposal options. This should include construction of additional pool storage, construction of a dry storage facility at Temelín (or at Dukovany or at Skalkar), and consideration of spent fuel transportation risks as well.

1.4.4 Level 2 PSA Results at Power

The Level 2 analysis tracks accident progression (core melt progression, reactor vessel failure, phenomena in containment such as hydrogen deflagration, interactions between molten core debris and containment structures, etc.) and estimates source terms for releases to the environment. The Temelín PSA Level 2 analysis was performed using containment event trees and "decomposition event trees" which allowed quantification of event sequences.

This effort was aided by severe accident progression calculations carried out using the USNRC-sponsored "Source Term Code Package" (STCP) computer model, which served as part of the basis for similar calculations in the NUREG-1150 study completed in 1990. The STCP code does not model all relevant phenomena, however, and it was necessary for the Level 2 PSA analysts to use expert judgment and analogies based on detailed calculations for other types of PWR NPPs in order to quantify the Level 2 analysis. Not surprisingly, later detailed calculations carried out with more modern codes show some important differences.

Setting aside those differences, for the moment, Table 4 provides the Level 2 PSA results from the Temelín PSA in terms of containment integrity and containment bypass.

Section 4, below, provides a more current perspective of containment failure modes and frequencies of occurrence.

1.5 Containment integrity and Containment By-pass at Temelin

1.5.1 Contrast With Temelín PSA Results

The Temelín Level 2 results reflect understandings of the time frame of the early 1990s, and are based substantially on assumptions concerning the similarity of behavior of the Temelín plant with the behavior of other PWR designs. Limited code calculations were carried out with the STCP code, but in essence the containment event tree was quantified using expert judgment (this is always the case, but there is a large gap from one study to another in terms of the amount of explanation, and the assumptions and code calculations used to justify the expert judgments). In contrast to the NUREG-1150 study, however, the expert judgment process was not a formal expert elicitation[8] .

(….)

Newer calculations, both specific to Temelín or to VVER-1000 NPPs as well as generic calculations, cast doubt on some of the important judgments reflected in the Temelín PSA Level 2 results. These key judgments are presented below with a short discussion to illustrate the issues involved:

- **Direct Containment Heating**

  Direct containment heating (DCH) occurs when the reactor vessel fails with the primary coolant system above a pressure of about 1 MPa (SNL 1996:14), and is especially severe when the pressure is near the setpoint of the primary relief valves. Under such conditions, core debris is expelled from the reactor vessel due to a local failure, overpressurizing the reactor cavity area and failing the cavity doors. Then the debris is blown into the containment atmosphere, where it can give up its heat, react with oxygen creating still more heat, and result in hydrogen combustion. In addition, if a debris pathway is available, the core debris can be blown into containment structures, including the containment liner along the containment cylinder/floor junction.

Table 4: Temelín PSA Level 2 Results (as presented in the PSA)[9]

Containment Failure Mode	Frequency per Year	Discussion
Containment bypass	6.62×10^{-5}	This is due mostly to steam generator tube rupture and steam generator collector failure sequences, with a small contribution from interfacing LOCA (at a frequency of 1.6×10^{-7} per year)
Large early release	(...)	This is entirely due to core debris penetration of the bottom of the containment
No failure	(...)	The containment remains intact, and leaks at the design basis leak rate (0.4% per day by volume)
Temperature failure	(...)	Failure of the containment liner due to high temperature (e.g., due to contact of the containment wall with core melt debris)
Pressure failure	(...)	Reflects overpressure failure due to steam as well as late hydrogen combustion events
Missiles	(...)	Puncture of the containment liner and wall/dome by missiles due to in-vessel steam explosion or due to expulsion of the reactor cavity doors under high pressure due to failure of the reactor vessel under high primary system pressure
TOTAL	(...)	Sum total of above results

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[8] Expert elicitation methods are well developed and described in NUREG-1150 (USNRC 1990) as well as in a report from Los Alamos National Laboratory (LANL 1990a). A shorter report describing the problems with informal expert elicitation processes is also available from LANL (LANL 1990b).

[9] see footnote 1)

In the Temelín PSA Level 2 analysis, it was assumed, based on analogy to work conducted in the US on Westinghouse PWRs, that (…) DCH and any resulting phenomena were unimportant.

(...)

As discussed at the technical meeting on 4 April 2001 in Prague in connection with the Melk Protocol Trialogue process, calculations specific to Temelín now show that primary system failure by high temperature and creep failure in fact are not expected to occur under high primary system pressure conditions. This is a complete reversal of outcome from that predicted in the PSA, and so all subsequent containment event tree estimates for such sequences are necessarily incorrect. This has a major impact on the question of containment integrity due to the geometry of the Temelín containment.

The reactor vessel bottom head, upon failure, will release core debris to the reactor cavity area. This is a small room from which there is only one exit, via a pair of doors into the lower containment area. In the case of primary system failure at high pressure, high pressure ejection of the core melt will rapidly overpressurize the reactor cavity volume, failing the doors and expelling the core debris through the opening. The opening is aimed directly at the containment cylinder/floor junction.

This geometry — which is unlike most PWRs — presents the possibility that a rather large quantity of core debris (of the order of hundreds to thousands of kilograms) will impinge on the containment liner at the containment cylinder/floor junction. Such an outcome would rapidly result in liner failure, and following this the containment leak rate would increase to levels substantially in excess of normal design leakage (far in excess of simple multiples of the normal leak rate). Such a high leak rate would occur precisely at a time when the containment atmosphere — as a result of the pressurized melt ejection and resulting mechanical and chemical reactions in the containment atmosphere — is rich in volatile and non-volatile radioactive species. Thus, the resulting source term will be far from negligible. This is a containment failure mode which was not evaluated in detail in the Temelín PSA nor in subsequent work (as evidenced by the discussion at the 4 April 2001 technical meeting).

It appears to us that this will be a major source of early radioactivity release to the environment in the event of a severe accident at Temelín in which primary system pressure is high at the time of vessel failure. It has to be noted that this will consist of a large fraction of the total core damage frequency, and it will represent a second, additional early release pathway for steam generator tube rupture and steam generator collector leakage scenarios, both of which are associated with sufficiently high primary system pressure at the time of vessel failure to result in DCH. [10]

The DCH issue is considered by the USNRC to be resolved for all large dry containment PWRs in the US (SNL 1996). However, one of the principal reasons for containment loads in US PWRs being lower than the containment failure pressure is that the primary coolant system of these PWRs is unlikely to be at high pressure when vessel failure occurs due to a combination of factors including hot leg or pressurizer surge line failure at elevated temperature, failure of reactor coolant pumps seals, and stuck open pressurizer relief valves (BNL 1995).

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[10] Early containment failure due to melt/containment liner & wall contact is predicted in some other PWR PSA studies. The PSA (IPE) study for the Davis-Besse PWR in the US predicted such a failure mode, even though the steel shell containment is protected by concrete curb 0.75 meters high and 0.46 meters thick. In addition, IPE studies for the Sequoyah and Watts Bar PWRs (ice condenser containment PWRs) found such a failure mode (USNRC 1997a:4-33, 4-39).

- **Melt-Through of the Reactor Cavity Into the Reactor Building Above Ground**

  The Level 2 PSA results are driven by plant-specific design differences between Temelín's VVER-1000 containment and other PWR containments. The Temelín containment is a prestressed concrete containment with a steel liner, a general design type used around the world for PWR NPPs. However, the Temelín geometry is different from that of nearly all PWRs in the world in one important respect.

  The bottom of the Temelín containment is about 10 meters above local ground elevation, supported by the reactor building lower elevations. There are two reactor building elevations above ground and one below ground, all underneath the Temelín containment. In nearly all other PWR designs (except for VVER-1000 NPPs and, according to the Czech government, the Koeberg PWRs in South Africa), the bottom of the containment consists of a 3 to 7 meter thick reinforced concrete plate that is located underground by several meters to tens of meters.

  If core debris melts through the containment bottom in such plants, the release of radioactivity to the environment is delayed and much attenuated by the ground. In NUREG-1150, calculations were performed for conditions in which a PWR basemat melts through into the surrounding soil for the Surry PWR. The retention factors (that is, the factor by which the source term is reduced by the soil "filtration" before reaching the environment) were estimated as follows (NNC 1995:46):

  - Noble gases & organic iodine = 3
  - Elemental iodine = 250
  - Molybdenum group = 250
  - Antimony & tellurium groups = 300
  - Lanthanum, cerium & uranium groups = 400
  - Cesium & barium groups = 600

  In contrast, analysts from the Nuclear Research Institute Rež reported at a technical meeting in Prague on 4 April 2001 (in connection with the Melk Protocol Trialogue process) that the attenuation factor for the reactor building, into which core debris would be released when the bottom of the containment melts through, is a factor of 10. We regard this as an upper bound and believe the true value could be less because the calculations which yielded the factor of 10 reduction used very coarse nodalization (that is, a low level of detail) of the plant structures, and because there are phenomena which were not apparently considered (e.g., hydrogen combustion in the reactor building, the effect on structural integrity of the reactor building of releasing high containment pressure into the reactor building). Based on other studies of reactor buildings surrounding containment structures, an attenuation factor of more than 2 or 3 is suspected as being optimistic.

  Finally, it should be noted that melt-through of the reactor cavity is predicted to occur much sooner for Temelín than for most other PWRs. Typical basemat penetration timing for PWRs is in the range of 3-5 days or more. Note, however, that these basemats are supported underneath by solid rock or compacted soil. Temelín is not so supported. Even though the reactor cavity is 3.53 meters deep, there is a 0.6 meter deep (0.75 meter wide) sump just under the reactor vessel. In addition, since the bottom of the containment is not supported over its entire surface, and since there is a very large mass above the location where the melt-through can occur, weakening of the cavity floor will result in cavity failure before the entire thickness is ablated by core debris interactions. At the 4 April 2001 meeting, experts from the Czech Nuclear Research Institute indicated that the cavity would fail when the remaining thickness is one meter. Thus, the cavity is — effectively — 1.93

meters thick, and this thickness can be ablated by core debris much more quickly than can 3.53 meters. [11]

As a result of the above considerations, reactor cavity melt-through accidents at Temelín are a much more serious matter in terms of radiological release potential than they are at nearly all other PWRs in the world. Finding some means of ensuring debris spreading and cooling, so that melt-through of the cavity is avoided, is clearly a high priority task for the Temelín containment design.

- **Hydrogen Detonation**

  It is well recognized internationally that containments which are extensively compartmentalized can result in non-uniform hydrogen distribution, with an attendant higher likelihood of deflagration to detonation transition (DDT). Hydrogen detonations are unlike hydrogen deflagrations. Deflagrations produce a slower pressure rise and quasi-static loads on the containment. DDT and detonation events produce very fast pressure rise times and impulsive shock loading on the containment, threatening containment integrity (NNC 1995:17). The possible vulnerability of Temelín to DDT due to its geometry was acknowledged in 1997 by two researchers from Nuclear Research Institute Rež, and further more detailed calculations were recommended (Kujal 1997), who stated, "The complex internal design of containment building (above all the lower part of it) makes favourable conditions for the transition from hydrogen deflagration to detonation."

  The latest results reported in April 2001 at a technical meeting in Prague under the Melk Protocol Trialogue process show that calculations have been performed with MELCOR 1.8.3, with only 1, 2, 5, or 16 nodes used to represent the containment. This is insufficient as a basis for thermalhydraulic input into detonation calculations for so complex a geometry as the Temelín containment. Even hydrogen deflagration calculations for containment geometries have required 80-120 nodes in previous work sponsored by OECD's Nuclear Energy Agency (NEA 2000b). Thus, even the most recent results cannot be taken as adequately representing Temelín, and they certainly do not provide a basis for excluding early containment failure due to hydrogen detonation.

- **Late Overpressure Failure**

  If short-term containment integrity is maintained, then a shift to longer-term containment integrity issues must be considered. Ultimately, if no containment bypass or heat removal occur, the containment could pressurize to a point where it fails due to static or quasi-static overpressure failure due to steam pressure. In most PWR NPPs in the European Union (more than 75% of the units), this failure mode of the containment is avoided by a filtered containment venting system. No such system exists for Temelín.

  Late overpressure failure would be a concern in the time-frame of a few days(Temelín PSA makes clear, by way of the quantified containment event tree, that much of *the non bypass internal events CDF* involves accident sequences in which the containment spray system is not available. (…) That is, no water to attenuate the source term either by sprays or by covering the melt with water. At the very least, this portion of the core damage frequency could go to late overpressure failure if there is no other earlier failure mode.

A revised view of the containment failure probabilities for Temelín should take into account the above perspectives.

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[11] A US PWR with a reactor cavity 1.52 meters thick was characterized as having a "*relatively thin basemat*" and had a high potential for basemat melt-through. Most US PWRs were characterized as having basemats 3 meters thick (USNRC 1997:4-33, 4-39). Thus, the expectation for comparatively early reactor cavity failure for Temelín, with an effective cavity thickness only 1.93 meters thick, is scarcely a remarkable insight. And this expectation is confirmed by calculations reported at the 4 April 2001 expert meeting which indicate reactor cavity failure as soon as 18 hours.

1.5.2 Rebaselining of the Temelín PSA Results

This section of the report provides a provisional rebaselining of the Temelín PSA results at the Level 2 (containment failure assessment) scope. The rebaselining is of course judgmental, but it is based on more recent information and perspectives than the 1995 PSA. It is felt to provide a more current view of the situation regarding Temelín. Better information will have to await an formal update of the Level 2 PSA, and this will not occur until after the Level 1 update is complete in about March 2002. Much work remains to be done at that point, since entirely new code calculations capable of accurately modeling the response of the plant to severe accident conditions will need to be done. One cannot rationally base a reassessment of the Level 2 results on a severe accident code using 2, 6, or even 16 nodes; this is simply inadequate for the task, and represents the state-of-the-art in the early 1990s — not in 2001. A current state-of-the-art assessment is required.

The next subsections will deal with particular containment failure modes, and apportion the CDF among the containment failure modes. The last subsection provides a wrapup of this assessment in a format which can be compared with the results from the 1995 PSA provided in Table 4, above.

1.5.2.1 Containment Bypass Scenarios

There are three containment bypass scenarios for Temelín:

- Interfacing LOCA — 1.6×10^{-7} per year
- Steam Generator Tube Rupture (SGTR) —1.08×10^{-5} per year
- Steam Generator Collector Leakage (SGCL) — 2.17×10^{-5} per year

The total containment bypass frequency is the sum of the frequencies of these scenarios, or 3.27×10^{-5} per year.

1.5.2.2 Pressurized Melt Ejection & Direct Containment Heating (DCH)

If the reactor vessel fails in a severe accident while the reactor coolant system is at high pressure, core debris can be expelled from the vessel rather than simply flowing under gravity. Under these conditions, containment pressurization can occur very quickly. Bottom head failure under high pressure conditions would be followed by melt expulsion, blowdown of the primary coolant system, and entrainment of molten core debris into the blowdown gases. This is called high pressure melt ejection.

A number of sources cite a pressure of 2 MPa as the pressure below which, if the primary system is depressurized, melt ejection and DCH cannot occur; see for example (NEA 1996b:31). The most recent assessment of this issue, prepared for the USNRC, suggests that this critical pressure is lower than 1 MPa (based on experiments which showed the onset of core debris dispersal from the cavity at pressures higher than this) (SNL 1996:14). It is unknown whether the capacity of the pressurizer relief valves and primary system vent valves at Temelín is sufficient to reduce the primary system pressure below 1 MPa under severe accident conditions.

In contrast with the Temelín PSA assumption that the primary system will fail before vessel failure and "automatically" depressurize the system to avoid DCH, more recent calculations reported at the expert meeting in Praha on 4 April 2001 indicate that this is not the case. Thus, instead of 98% of the high pressure sequences transferring to low pressure, essentially all of the high pressure sequences remain at high pressure up to the time of vessel failure.

As a result of the configuration of the VVER-1000 design, it is likely that doors in the reactor cavity passage to the containment will be blown open early in the melt ejection, and core debris will be swept out into the containment oriented at 90 degrees from the vertical. No debris will be forced out along the vessel since this very small gap is expected to be closed under severe accident conditions due to thermal swelling of the vessel. The only pressure relief is out of the cavity via the cavity passage to the lower part of the containment. This will bring multi-ton quantities of core debris into contact with the containment liner at the side wall/floor junction (the much finer debris will be lifted into the containment).

Direct containment heating *per se* is judged to be unlikely to result in overpressure failure of the containment. This judgment is based on an extensive series of analyses for Westinghouse PWRs in the US, consideration of the margin to failure exhibited in those analyses, and the strength of the Temelín containment against overpressure failure (the median failure pressure is estimated in the PSA to be 1.1 MPa, which is similar to the Westinghouse PWR containments). In the analysis of Westinghouse PWRs, the mean conditional probability of containment failure is less than 0.01 given a high pressure core damage sequence (with the exception of one plant which has a comparatively weak containment). The Temelín containment failure pressure is not consistent with a "weak containment", so it is more reasonable to expect that DCH-related overpressure failure is unlikely. For the purposes of this assessment, without more detailed plant-specific calculations, we assess the conditional probability of overpressure failure due to DCH at 0.01 per high pressure core melt, yielding a frequency of 1.48×10^{-6} per year.

Even if early containment failure does not occur, however, it is clear that there is a very high potential for core debris to be expelled from the reactor cavity. The only pathway for this to occur is through the cavity passage which, as noted above, brings the core debris into contact with the containment liner at the wall/floor junction. The liner is judged to fail very promptly due to a combination of stress and thermal loads from the hot core debris. The failure of the liner would result in a very large containment leak rate, well in excess design leak rates. The actual size of the leak could not be specified except as a range and only then following calculations which are not possible here. For high pressure core melt sequences in which no other containment failure mechanism occurs, we consider that this failure mode will occur with high likelihood. Thus, we bin 90% of the remaining high pressure core melt frequency into this early liner failure mode, and the remaining 10% into the "no failure" bin. This yields results of 1.14×10^{-5} per year for early liner failure and 1.26×10^{-6} as an additional contribution to no containment failure. [12]

1.5.2.3 Hydrogen Phenomena

Hydrogen phenomena can be considered to involve hydrogen deflagration (a hydrogen burn resulting in quasi-static loading on the containment), hydrogen detonation (a hydrogen combustion phenomenon resulting in impulsive "shock" loading on the containment), and phenomena involving flame acceleration and deflagration-to-detonation transition (DDT).

The highly compartmentalized geometry of the Temelín containment is such as to favor flame acceleration and DDT. Analyses of hydrogen combustion phenomena at Temelín have used codes and containment nodalization schemes wholly unsuited to hydrogen combustion analyses. The most recent analyses have used MELCOR 1.8.3 with 2, 5, or 16 nodes (mostly with 5 nodes). Such nodalization is not consistent with the state-of-the-art; indeed,

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[12] Similar conditions, leading to large leakage rates from containment, have been identified for a few PWRs in the US (USNRC 1997a:4-33, 4-39). Basically, rapid heatup of the steel liner occurs, while heat flow to the concrete behind the liner is limited due to differences in conductivity of the steel liner and the concrete. Large temperature differences between the involved liner areas (connnected by studs to the wall) and the concrete wall will cause localized expansion of the liner and considerable thermal stress. Under these conditions, failure of the liner cannot be excluded.

the now 11-year old German Risk Study analysis for Biblis B (Siemens PWR) used 24 nodes to represent the primary containment (GRS 1990:618-619).

The nodalization of the free volume of the containment with only 5 thermalhydraulic balance volumes is not suited to properly predict natural convection processes in a 70,000 m^3 containment. This is well known from the results of several analyses for gas distribution experiments, in particular from some blind pre-test predictions performed within the frame of International Standard Problems (NEA 1993; NEA 1995; De Boeck 1997b:7). Even a simplified combustion analysis would require the preduction of initial thermalhydraulic conditions with a nodalisation concept with 80 up to 120 nodes to take into account natural flow convection within a containment with 70,000 m^3 free volume (NEA 2000a).

In order to reasonably calculate hydrogen detonation potential and consequences, it is necessary first to have accurate gas distribution calculations in order to have the initial conditions for subsequent combustion processes. Boundaries between deflagration, flame acceleration, and DDT are characterized by narrow bands of concentration and are heavily influenced by the presence of turbulence generated by obstacles. Lumped parameter codes like MELCOR 1.8.3 are, at their present state of development, unable to satisfy the demands for three dimensional accuracy needed for coupling to hydrogen combustion codes for assessment of detonation risks (NEA 1999a:11). [13] This is particularly critical in the case of Temelín, which as a VVER-1000/320 NPP has the potential for generating considerably more hydrogen then other PWRs of comparable thermal power level.

Thus, the potential vulnerability of the Temelín containment to hydrogen combustion phenomena is difficult to completely assess. Given the containment strength, it seems unlikely that early containment failure due to hydrogen deflagration could occur. However, given the quantities of hydrogen potentially available and given the geometry of the containment which favors flame acceleration and DDT, early containment failure due to detonation phenomena cannot be excluded on the basis of existing analyses.

Quantification under these circumstances is entirely judgmental. We regard the assessment in the 1995 PSA as far too optimistic and the value (…) for early overpressure failure as not credible. The low pressure core melt scenarios will be accompanied by significant steam inerting which will not be altered in the early phase of such accidents. Early hydrogen detonations under these conditions do not appear to be likely. High pressure core melt sequences will likely result in containment failure due to high leakage resulting from core debris/containment wall/floor junction interaction in any event. It is only necessary to distinguish large early failures which could result from hydrogen detonations from such sequences. The PSA results suggest that sprays will more than likely be unavailable for the relevant sequences (high pressure sequences, due to small LOCAs and transient initiators). If the sprays are unavailable, there will be considerable steam inerting and stratification of the containment atmosphere. Detonation under these circumstances is not considered to be likely. It is also necessary to consider the performance of the passive autocatalytic igniters in depleting the hydrogen source term. Hydrogen detonation would have to occur early (i.e., within the first hours after core damage), otherwise the recombiners would reduce the available hydrogen source available for detonation.

The PSA results identify the CDF contributions for small LOCAs, very small LOCAs, and transient sequences with sprays available. Considering the potential for an ignition source being available (e.g., a valve changing position, etc.) within the required time period, and the

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[13] The organization representing the technical support organizations of the EC nuclear countries ("Technical Support Organization Group") has questioned the use of MELCOR and other codes for "mechanistic" evaluations, stating that MELCOR is not suitable suitable for mechanistic evaluations (AVN 1997:48). The TSO Group includes IPSN (France), GRS (Germany), AEA-Technology (UK), AVN (Belgium), CIEMAT (Spain), and ANPA (Italy). Similarly, an OECD Nuclear Energy Agency (NEA) workshop on this issue in 1996 generally concluded that lumped parameter models (such as MELCOR) are limited to slow combustion modes (NEA 1996c:11).

conditional probability of flame acceleration or DDT given an ignition, it seems unlikely that the conditional probability of a detonation would exceed 0.1. We will use this value as representative of conditions in which hydrogen detonation may cause early large containment failure. Thus, we estimate a frequency of 6.8×10^{-7} per year.

1.5.2.4 Reactor Cavity Melt-Through

Only low pressure core melt sequences present a risk of reactor cavity melt-through. As discussed in Section 4.2.2 above, high pressure sequences will be accompanied by pressurized melt ejection from the reactor cavity, spreading the core debris such that bulk melt-through of the reactor cavity should not occur.

Only LOCA sequences with large leak rates will depressurize sufficiently to avoid pressurized melt ejection and present a possibility of melting through the reactor cavity. These sequences are those initiated by large LOCAs, medium LOCAs, and reactor vessel rupture. *The PSA includes a CDF contributor that in fact would not result in core damage. an Thus, the frequency of low pressure core melt sequences would to be lower than supposed in the PSA. It is estimated to be* 4.9×10^{-6} *per year.* (….)

For low pressure sequences, the PSA assigns a 10% probability to the potential for core debris to spread out of the reactor cavity. We do not regard this as reasonable. However, recovery and prevention of this outcome is expected to occur after vessel failure in the case of reactor vessel rupture. Vessel rupture (…) contributes part of the "no containment failure" frequency. Containment spray cannot recover low pressure scenarios where the core debris remains in the reactor cavity because the sprays do not reach this area. In any event, in some of the low pressure scenarios the containment spray system is not operable.

1.5.2.5 Late Overpressure Failure

Late overpressure failure is a possibility in a core melt accident sequence in which no early failure has occurred and no containment heat removal is available. At most, in this assessment, this could involve some fraction of the "no containment failure" bin in Table 5 (some of the frequency here is associated with sequences in which the containment sprays are working, and in which it is therefore very unlikely that the containment can overpressurize). Since the frequency of this bin is less than 3% of the at power core damage frequency, we have not differentiated between those scenarios in which late overpressure failure occurs and those in which it does not.

1.5.2.6 Revised Containment Failure Mode Assessment

Based on the above discussion, Table 5 provides a summary of the revised containment failure mode assessment. Table 6 provides a comparison of these results with the 1995 PSA results. Note that the 1995 PSA results include fires and internal flooding; the current results include only internal events. (It is expected that the fire and flooding sequences would bin into early liner failure and early overpressure failure due to DCH. At most, if all of the frequency of about 2×10^{-5} were binned to the early liner failure frequency, it would increase it by a factor of 2-3, and this would not dramatically alter the risk perspective.)

The numbers presented in the table show two significant figures solely for actuarial reasons; the second significant figure should not be taken seriously.

Table 5: Revised Temelín Level 2 Results

Containment Failure Mode	Frequency per Year	Discussion
Containment Bypass	3.27×10^{-5}	This is due mostly to SGTR and SGCL sequences (less than 1% of this frequency is from interfacing LOCA); it must be noted that these accidents — which result in a potential for a large release of radioactivity bypassing the containment — could also be accompanied by containment failure after vessel failure due to pressurized melt ejection
Early Liner Failure	1.14×10^{-5}	Containment liner failure at the wall/floor junction due to high pressure melt ejection and contact of hot core debris with the containment liner at this location
Reactor Cavity Melt-Through	4.63×10^{-6}	Large and medium LOCA scenarios where the core debris remains in the reactor cavity and there is no water available to cool the debris
No Containment Failure or Late Overpressure Failure	1.53×10^{-6}	Reactor vessel rupture with continued coolant injection after vessel failure (…) and high pressure sequences in which the containment does not fail early (…).
Early Overpressure Failure	1.48×10^{-6}	Due to direct containment heating
Early Hydrogen Detonation Failure	6.8×10^{-7}	Associated with small and very small LOCAs and transient sequences with containment sprays operating

Table 6: Comparison of 1995 PSA With Rebaselined Results

Containment Failure Mode	1995 Result	2001 Rebaselined Result
Containment Bypass	6.62×10^{-5}	3.27×10^{-5}
Early Structural Failure	(...)	2.16×10^{-6}
Early Liner Failure	(...)	1.14×10^{-5}
Early Reactor Cavity Melt-Through	(...)	not credible
Late Reactor-Cavity Melt-Through	(...)	4.63×10^{-6}
No Failure or Late Failure	(...)	1.53×10^{-6}

1.6 Comparison of Temelin PSA Results with Safety Targets used in the Member States of the European Union and Internationally, and Comparison with PWR PSA Results for NPPs in the EC and Switzerland

1.6.1 Comparison of 1995 Temelín PSA Results With INSAG-12

The Temelín PSA, as issued in 1995, estimates an at-power core damage frequency (CDF) value of 1.1×10^{-4} per year. In addition, the results suggest a large early release frequency (which we take here as the sum of the containment bypass frequency, large early release frequency, and missile failure frequency*) of the same order of magnitude (containment bypass alone: 6.6 10^{-5} per year)*. (….)

The IAEA's International Nuclear Safety Advisory Group (INSAG), which is an advisory group reporting to the Director-General of the agency, established quantitative safety targets in 1992 (INSAG 1992) which were essentially reaffirmed in 1999 (INSAG 1999). The CDF target, for existing nuclear power plants, is a core damage frequency less than 10^{-4} per year. INSAG also states that containment and severe accident management measures could reduce by at least a factor of 10 the likelihood of large off-site releases requiring short term off-site response (INSAG 1999:11). Essentially, this equates to a large release frequency of less than 1×10^{-5} per year. [14]

From the 1995 PSA results, the CDF target can be seen to be straddled or, essentially met. However, the safety target for large release frequency is exceeded by a wide margin (nearly an order of magnitude). Indeed, the large release frequency is nearly 85% of the CDF — which is another way of saying that the containment is very ineffective in protecting against large releases in severe accidents.

1.6.2 Comparison of Updated Result from Section 3.1 With INSAG-12

In Section 3.1 of this report, we estimated a reduce CDF and containment bypass frequency. The CDF value estimated in Section 3.1 is about a factor of two under the INSAG-12 safety target. However, ignoring any possibility for large release except containment bypass sequences, the large release frequency of 3.3×10^{-5} is still well above the large release safety target. Containment bypass still remains a significant fraction of the CDF (not quite two-thirds of the CDF),

1.6.3 Comparison of EIA Result With INSAG-12

The Czech EIA reports an accident frequency of 2.6×10^{-5} per year. No indication is given of the contributors to the CDF value, and no basis is provided for the CDF number. It is known that the result is not from the PSA update, since the PSA update is in its earliest stages and will not be complete until 2002. The EIA value is simply offered "whole cloth" without any explanation, calculation, or citation whatsoever. Given this situation, a comparison with INSAG-12 safety targets is not warranted.

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[14] Actually, the INSAG target may be substantially more stringent than we have used it. For a 1200 MWe PWR, a dose of 100 mSv at the plant boundary is produced under Pasquill Stability category F with a release fraction of 10^{-6} for cesium and iodine (NNC 1995:3). It is noted that 100 mSv dose projection would, under the Temelín EPZ approach under Czech law, result in immediate sheltering and iodine prophylaxis or possibly evacuation (SÚJB 2001:12, 19). Such circumstances would seem to meet the INSAG criterion, and would involve a release much lower than those for which we show a frequency above.

1.6.4 Comparison of Rebaselined Containment Failure Frequency from Section 4 With INSAG-12

Table 5 shows clearly that the containment bypass events are above the INSAG-12 safety target.

1.6.5 Comparison With Safety Targets Used in the European Union and Internationally

The following quantitative safety targets for core damage frequency (CDF) and large release frequency (LRF) are in use in member states of the European Union:

- FINLAND (STUK 1996a)
  - CDF $<10^{-5}$ per year
  - LRF $<5\times10^{-7}$ per year (for release of 100 TBq or more of Cs-137 or its equivalent)
  - Addressing severe accident risks according to the "SAHARA" principle (safety as high as reasonably achievable)
- FRANCE (Colin 1997)
  - Frequency of "unacceptable consequences" $<10^{-6}$ per year
- GERMANY (INSC 1998)
  - LRF $<10^{-6}$ per year (core damage plus containment failure)
- RUSSIAN FEDERATION (IAEA 1994b; GAN 1989)
  - Core damage frequency $<10^{-5}$ per year
  - Offsite release requiring offsite emergency response $<10^{-7}$ per year
- SWEDEN (SKI 1998:37)
  - Swedish utilities have established a CDF target of $<10^{-5}$ per year
  - Swedish utilities have established a frequency of $<10^{-7}$ per year for a release of more than 0.1% of the core inventory (excluding noble gases)
- UNITED KINGDOM (NSD 2000)
  - Basic safety objective for a release of more than 10,000 TBq of Iodine-131 (0.4% of the Sizewell B core inventory) of $<10^{-7}$ per year
  - Basic safety objective for a dose of 1 Sv at 1 km from the reactor of $>10^{-6}$ per year
  - Basic safety objective for severe accident of $<10^{-5}$ per year
- UNITED STATES (ANL 1996:20)
  - Containment bypass frequency $<10^{-6}$ per year
  - Core damage frequency $<10^{-4}$ per year

1.6.6 Comparison of Temelín PSA Results With PWR NPPs in the EU and Switzerland

A comparison with the PSA results for the Gösgen NPP in Switzerland (HSK 1999) is illuminating. The Gösgen PWR is a 3002 MWt Siemens KWU PWR which began operation in late 1979. A comparison of the PSA results is provided in Table 7.

The at-power CDF result for Temelín is a factor of 40 higher than Gösgen. This outcome is understandable given the bunkered decay heat removal system at Gösgen. More importantly, however, the containment bypass frequencies differ even more dramatically. For Gösgen, the containment bypass accident frequency is 2.1×10^{-7} per year. For Temelín, the rebaselined value is 3.2×10^{-5} per year — a factor of more than 150 greater than Gösgen.

Table 7: Comparison of Gösgen & Rebaselined Temelín PSA Results

Contributor	Temelín	Gösgen
Internal Events	**5.1×10^{-5}**	**9.7×10^{-7}**
LOCAs	1.1×10^{-5}	6.4×10^{-7}
Interfacing LOCA	1.6×10^{-7}	1.9×10^{-7}
SGTR & SGCL	3.2×10^{-5}	2.1×10^{-8}
Transients	7.3×10^{-6}	1.2×10^{-7}
External Events	**2.1×10^{-5}**	**2.9×10^{-7}**
Fire	1.8×10^{-5}	1.8×10^{-7}
Loss of Service Water	2.0×10^{-7}	7.2×10^{-8}
Aircraft Crash	$<1.0 \times 10^{-7}$	2.1×10^{-8}
Flooding	2.3×10^{-6}	1.1×10^{-8}
Seismic	$<1.0 \times 10^{-7}$	not included
Total at power CDF	**7.2×10^{-5}** **(includes seismic estimate, but seismic hazard estimate is considered to be extremely optimistic)**	**1.8×10^{-6}** **(does not include seismic)**

1.7 Temelin Severe Accident Mitigation Alternatives

The EIA for Temelín does not include any assessment of measures to reduce risk from severe accidents, so called severe accident mitigation alternatives (SAMAs). It is known from a conference paper from 1997 that at least some SAMAs were investigated for Temelín (Kujal 1997), but the EIA report is silent on the matter. The measures considered, at least provisionally for Temelín, included (Kujal 1997):

- A feasibility study of a filtered venting system to prevent containment overpressurization and mitigate consequences during melt-through of the reactor cavity.
- Improvements in catalytic recombiners to make them effective for severe accident conditions.
- Primary circuit depressurization to avoid DCH phenomena.
- External cooling of the reactor pressure vessel by cavity flooding to prevent vessel failure.
- Plugging of vertical gauge channels with concrete to prevent early core debris penetration of the reactor cavity.
- Provision for core debris spreading and cooling with water.
- Draining core debris onto the reactor building foundation mat for debris cooling and improvement of leaktightness of the reactor building.

The issue of SAMAs for PWRs more generally has been widely addressed in the United States. [15] SAMA evaluations have been performed for the Comanche Peak (USNRC 1989b) and Watts Bar PWRs (USNRC 1995) as part of environmental impact assessments related to initial licensing of these facilities. SAMA evaluations have also been performed as part of license renewal environmental impact assessments for the Calvert Cliffs (USNRC 1999a), Oconee (USNRC 1999b), and Arkansas Nuclear One Unit 1 (USNRC 2000c) facilities. And, as part of the design certification process, SAMA evaluations were performed for the Westinghouse AP600 (USNRC 1999c) and ABB/CE System 80$^+$ PWRs (USNRC 1997). Utility or vendor submittals relating to SAMA evaluations, and the USNRC staff environmental impact statements provide a wealth of information about SAMA possibilities. The range of SAMA possibilities considered ranged from a low of 26 measures (Calivert Cliffs) to a high of 169 measures (Arkansas Nuclear One, Unit 1).

Evaluations of severe accident risk reduction alternatives have also been carried out for Sizewell B in the UK. However, both the Temelín specific information and the broader literature on SAMA possibilities for PWRs has been totally ignored by the Czech EIA on Temelín.

Among the SAMA possibilities cited in these documents, for PWR NPPs, are:

- Cross-tying power supplies of adjacent units (note that this has been done for Temelín, and contributes to the low CDF from station blackout accidents).
- Automation of high pressure recirculation (change from manual switchover).
- Addition of extra diesel generators or small battery-charging diesels.
- Provision of a portable battery charger.
- Installation of an AC-power independent coolant injection system.
- Installation of improved main coolant pump seals.
- Installation of an independent main coolant pump seal cooling system.
- Installation of a hydrogen ignition system.
- Installation of a reactor cavity flooding system.
- Installation of a containment filtered venting system.
- Installation of a core debris retention device or system.
- Installation of a containment inerting system.
- Installation of additional instrumentation to improve human response to containment bypass accidents.
- Installation of a dedicated primary coolant depressurization system to avoid DCH.
- Installation of an independent containment spray system.
- Implementation of a large water tank, with the inventory available for emergency coolant injection, containment spray, and other purposes.
- Improvements in temporary arrangements for heating, ventilation, and air conditioning (HVAC) system for the control room.
- Installation of nitrogen accumulators to allow valve alignments in station blackout (for valves such as primary PORV, AFW flow and pressure control valves, etc.).

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[15] There is a legal requirement in USNRC regulations to consider severe accident mitigation alternatives in operating license renewal, located in the regulations at 10CFR§51.53(c)(3)(ii)(L). The Nuclear Energy Institute, on behalf of the commercial nuclear industry, petitioned the USNRC on July 13, 1999 to delete this requirement. The USNRC declined to do so, citing a US Circuit Court of Appeals ruling in 1989 (*Limerick Ecology Action v. NRC*, 867 F.2d 719, 3d Cir., 1989). There is also a legal requirement in USNRC's regulations concerning consideration of severe accident mitigation alternatives for design certification and for new NPPs at 10CFR§50.34(f)(1)(i).

- Installation of motor-generator set trip breakers in the main control room to provide additional ATWS protection.
- Improvements in depressurization capabilities to terminate releases to the environment in non-isolable steam generator tube rupture sequences.
- Design changes to allow the use of fire water system pumps as a backup source of pump cooling in the event of failure of service water or component cooling water.
- Addition of a non-safety containment spray system as a backup for the existing safety-related system, or installation of a passive containment spray system.
- Upgrade the charging system to accommodate small and intermediate size LOCAs.
- Connection of charging pump suction to the ECCS water supply (in Temelín, this is the containment sump).
- Direct steam from atmospheric steam dump (BRU-A in the Temelín design) and the main steam safety valves to the sump to condense the steam and avoid containment bypass releases to the environment in case of primary-to-secondary leak accidents.
- Installation of a passive heat removal system to the steam generator shell side.
- Installation of a secondary containment filtered ventilation system (at Temelín, the analogous situation would involve a filtered venting system for the reactor building).
- Increase in the containment design pressure to very high level (20 bar) with a passive containment cooling system.
- Increase in reliability of a diverse safety features actuation system (in Temelín, this would correspond to the Diverse Protection System or DPS).
- Incorporation of self-actuating containment isolation valves into the containment design.
- Installation of a backup system for refilling the ECCS water supply (containment sump at Temelín).
- Increase in the height of flood barriers to reduce flood CDF.
- Addition of independent feedwater system to reduce the likelihood of induced steam generator tube rupture during high pressure core melt sequences.
- Modification of service water systems so that the backup pumps automatically start if the operating pump fails.
- Use of a fire protection water system to provide alternate cooling for the RHR heat exchangers, safety injection pumps, and main coolant pump seals.
- Use of the fire protection water system as an alternate source of water for containment spray.
- Provide additional batteries to extend the time to loss of DC power following station blackout.
- Implementation of automatic crossties between power supplies of multi-unit NPPs.
- Increase in capacity of diesel generator day tanks.
- Installation of water tight doors to reduce flood CDF.
- Increase in capacity of water supply to emergency feedwater system.
- Automation of demineralized water makeup to emergency feedwater system tanks.
- Use of fuel cells as DC power supply instead of batteries.
- Installation of gas turbine generators for emergency power supply.
- Use of fire protection water system as a backup source for cooling water for diesel generators.

- Automatic flooding of steam generator prior to core damage for steam generator tube rupture sequences.
- Use of a hydro test pump for main coolant pump seal injection backup capacity.
- Implementation of leak rate testing capabilities for valves in the interfacing LOCA leak paths.
- Addition of a component cooling water pump.
- Improvements in reactor water level monitoring during shutdown to avoid loss of RHR in shutdown when in mid-loop condition.
- Use of fire protection water system as a backup source of water for the spent fuel pool.

Additional SAMA changes are identified in other reports:

- Installation of a lead oxide/boron oxide chemical core catcher, which forms a molten glass upon contact with core debris, which more easily spreads into a coolable layer than core debris alone (Forsberg 1997).
- Bunkered safety system buildings (AVN 1993; NEA 1997; Germany 1998).

1.8 Severe Accident Mitigation Alternatives implemented within the European Union

Since the 1980s, following severe accidents at Three Mile Island and Chornobyl, and following the completion of plant-specific and generic PSAs on numerous NPPs, severe accident mitigation alternatives have been implemented at many NPPs within the member states of the European Union. A summary of these measures is provided in Table 8 in order to provide a point of comparison with Temelín. Similarly, Table 9 provides a list of SAMA measures implemented at NPPs outside the European Union.

Table 8: Severe Accident Mitigation Alternatives Implemented at PWR Nuclear PowerPlants in the Member States of the European Union

Country	Affected NPPs	Severe Accident Mitigation Alternative Measure Implemented
BELGIUM	Doel 1-4 Tihange 1-3	Installation of system to flush and decontaminate containment spray system and low pressure injection system and dispose of the water into the containment, to allow repairs & maintenance after severe accidents (AVN 1993:12)
		Qualification of electrical connections inside containment for post-accident conditions (AVN 1993:11)
		Installation of passive autocatalytic recombiners (PARs) (AVN 1997:9-11; SKI 1995:149)
	Tihange 1	Seismic upgrade from 0.1g to 0.17g (AVN 1993:8-9)
FINLAND	Loviisa 1-2	Double containment with annulus filtration system
		External containment spray system spraying on steel shell containment to reduce internal temperature and pressure
		Filtered venting system (for severe accidents) for annulus between primary and secondary containment
		Installation of passive autocatalytic recombiners (PARs)
		Four diesel generators per unit; connection to hydroelectric station via 20 kV overhead line
		Piping connected to the primary coolant system must be able to withstand full primary system pressure without failure, irrespective of isolation valve provisions (STUK 1996a)
		Containment melt-through in a severe accident must be avoided by design with high certainty (STUK 1996a)
		Containment design must cope with 100% metal-water reaction (STUK 1996b)
		Containment integrity must be maintained in both high and low pressure core melts (STUK 1996c)
		Modifications to reduce CDF: (a) provision of emergency pressurizer spray from high pressure injection system; (b) improvements to main control room HVAC systems; (c) installation of 1000 m^3 water tank for response to primary to secondary leakage accidents; (d) new protection signal to close the feedwater isolation valve and stop the main coolant pump in a loop with high steam generator level; (e) improvements in high pressure injection reliability; and (f) improvements in protection against internal flooding and fires (STUK 1998; IAEA 1994a)

Table 8 (cont.): *Severe Accident Mitigation Alternatives Implemented at PWR Nuclear PowerPlants in the Member States of the European Union*

Country	**Affected NPPs**	**Severe Accident Mitigation Alternative Measure Implemented**
FRANCE	All PWRs (58)	Filtered venting system (sand bed filter on top of auxiliary building, with decontamination factors of 100 for aerosols and 10 for elemental iodine); actuated manually at containment pressure of 5 bar (NEA 2000a:91-92; Colin 1997)
		Ultimate accident management procedures implemented, including use of portable pumps and emergency power supplies for high pressure injection and containment spray (Colin 1997)
		Systematic use of water addition to the steam generators to limit the risk of bypass in the event of tube rupture or other primary to secondary leaks (SKI 1995:35)
		Opening and maintaining open the pressurizer relief valves to maintain primary system pressure at low levels and avoid direct containment heating (SKI 1995:35)
		Special U2 procedure to localize and repair leaking penetrations (SKI 1995:35)
		Installation of passive autocatalytic recombiners (PARs) (Colin 1997)
GERMANY	All PWRs (13)	Double containment with annulus filtration system
		Filtered venting system (SKI 1995:112)
		Installation of passive autocatalytic recombiners (PARs)
		Bunkered safety system building, including capability for reactor shutdown, emergency feedwater, and residual heat removal independent of the main control room, designed for external events (including disruptive actions or interference by third parties) (Germany 1998:53)
		Implementation of automatic control system response to steam generator tube rupture (Germany 1998:52)
		Installation of an underground emergency power supply connection, protected against external events (Germany 1998:52, 66)
		Installation of 2-hour capacity batteries (Germany 1998:118)
		Implementation of secondary feed and bleed (Germany 1998:65)
		Implementation of passive autocatalytic recombiners (PARs) capable of removing hydrogen from 100% zirconium oxidation within 24 hours and keep the temperature of the recombiners below 600º C (SKI 1995:112-113)
		Plant-specific review of high/low pressure interfaces performed, with fixes on a plant-specific basis; implementation of improved isolation valve design (Germany 1998:66)
	1st & 2nd Generation PWRs	Additional diesel generators added (Germany: 51, 118)
	3rd & 4th Generation PWRs	Four additional diesels added (Germany: 51, 118)

Table 8 (cont.): Severe Accident Mitigation Alternatives Implemented at PWR Nuclear PowerPlants in the Member States of the European Union

Country	Affected NPPs	Severe Accident Mitigation Alternative Measure Implemented
NETHER-LANDS	Borssele	Double containment with annulus filtration system
		Filtered venting system (venturi scrubber and metal filter with decontamination factors of 1000 for aerosols, 100 for elemental iodine, and 10 for organic iodide
		Performance of a Level 3 PSA including shutdown (Netherlands 1998:62-63)
		Installation of passive autocatalytic recombiners (PARs)
		Bunkered safety system complex qualified for seismic events and external explosion (AVN 1993:7-8); includes: (a) two additional borated water tanks of 243 m^3 and 262 m^3 capacity (additional to the existing 712 m^3 capacity); (b) two reserve charging pumps with a capacity of 18.8 m^3 per hour each; (c) two reserve emergency feedwater pumps and two additional demineralized water tanks of 496 m^3 and 469 m^3 capacity; and (d) a reserve RHR system including a pump and a diverse heat exchanger (Netherlands 1998:76-79, 85-86)
		Installed three new SEBIM safety/relief valves (Netherlands 1998:76-79, 85-86)
		Implementation of the capability to pump emergency decay heat removal water inventory from a deep well (Netherlands 1998:76-79, 85-86)
		Separation of component cooling water trains and addition of a fourth train (Netherlands 1998:76-79, 85-86)
		Connection of bunkered reserve injection charging pumps to pressurizer spray to permit pressure decrease in case of SGTR (Netherlands 1998:76-79, 85-86)
		Replacement of diesel generators with larger engines with a greater output (Netherlands 1998:76-79, 85-86)
		Replacement of main steam and feedwater lines inside containment and in the annulus between the primary and secondary containment, and partially in the turbine hall, with qualified "leak before break" piping and inclusion of a steam flow limiter at the containment penetration (Netherlands 1998:76-79, 85-86)
		Installation of guard pipes on steam and feedwater lines in the auxiliary building (Netherlands 1998:76-79, 85-86)
		Replacement of the main control room with a digital system, installation of a second control room in an external event-hardened building, and replacement of reactor protection system (Netherlands 1998:76-79, 85-86)
		Replacement of turbine-driven emergency feedwater system with a motor-driven system (Netherlands 1998:76-79, 85-86)
		Installation of new check valves on the low pressure ECCS lines (Netherlands 1998:76-79, 85-86)

Table 8 (cont.): Severe Accident Mitigation Alternatives Implemented at PWR Nuclear PowerPlants in the Member States of the European Union

Country	Affected NPPs	Severe Accident Mitigation Alternative Measure Implemented
SPAIN	Trillo	Double containment with annulus filtration system
SWEDEN	Ringhals 2-4	Filtered venting system (multi-venturi scrubber with decontamination factor of 500 for aerosols) (NEA 2000a:95; SKI 1998:16)
		Special precautions taken to prevent clogging of cooling water intakes by marine plants and organisms (SKI 1998:148)
		Spray systems installed to clean switchyards from salt deposits during storms (SKI 1998:148)
		Severe accident management measures implemented to ensure that core debris is covered by water and cooled, and with the containment depressurized and with containment integrity preserved (SKI 1998:153)
UNITED KINGDOM	Sizewell B	Partial double containment above annular auxiliary building, with filtration system between the containment buildings
		Package of measures to reduce CDF by a factor of 40 over the original design, prior to operation: (a) diverse secondary protection systeml (b) diverse emergency boration system; (c) diverse and redundant emergency feedwater system; (d) diverse and redundant steam-turbine driven emergency charging system; (e) replacement of PORVs with SEBIM safety/relief valves; (f) addition of two battery charging diesels; and (g) additional diverse containment isolation provisions for the containment mini-purge system (NEA 1997:120-128)
		Four-train safety system, with each train in its own auxiliary building

Table 9: Severe Accident Mitigation Alternatives Implemented at PWR Nuclear PowerPlants Outside the European Union

Country	**Affected NPPs**	**Severe Accident Mitigation Alternative Measure Implemented**
JAPAN	Genkai 1-4 Ikata 1-3 Mihama 1-3 Ohi 1-4 Sendai 1-2 Takahama 1-4 Tomari 1-2 Tsuruga 2	Primary system depressurization to at least 2 MPa to avoid DCH (SKI 1995:87)
		Injection of fire protection water into the containment to condense steam and quench core debris (to prevent reactor cavity melt-through) (SKI 1995:87)
SWITZERLAND	Beznau 1-2	Installation of a NANO bunkered safety system complex, including: (a) additional trains of emergency feedwater and ECCS recirculation, (b) installation of an emergency main coolant pump seal injection system, (c) movement of a high pressure injection train to the bunker to protect it against external events, (d) replacement of PORVs & safety valves with three tandems of combined safety & relief valves, (e) installation of an additional diesel generator, (f) installation of an additional cooling water pump, and (g) installation of a separate control room and I&C system for the NANO bunker systems. Reduced CDF by a factor of 30 (NEA 1997:110-112).
		Filtered vented containment system installed (NEA 2000a:83-110).; filtered venting system found particularly effective for core damage sequences where containment sprays are unavailable (SKI 1995:68)
	Beznau 1-2 Gösgen	Manual depressurization of the primary system using the pressurizer relief valves to avoid DCH (SKI 1995:70)
		Addition of fire protection system water to the secondary side of a damaged steam generator in order to reduce the source term (SKI 1995:71)
		Addition of fire protection system water to the reactor cavity area to reduce the source term from core-concrete interactions (SKI 1995:71)
		Alignment of fire protection water system to containment sprays (SKI 1995:72)

1.9 References

ANL 1996	Argonne National Laboratory, Overview of Steam Generator Tube Degradation and Integrity Issues, ANL/ET/CP-91433 (Argonne, IL USA), October 1996.
ANL 1999	Argonne National Laboratory, The Role of PRA in the Safety Assessment of VVER Nuclear Power Plants in Ukraine, ANL/RE/CP-97672 (Argonne, IL USA), 1999.
AVN 1993	AIB Vinçotte Nuclear, Periodic Safety Reviews in Belgium, AVN-93/012 (Brussels, Belgium), 1993.
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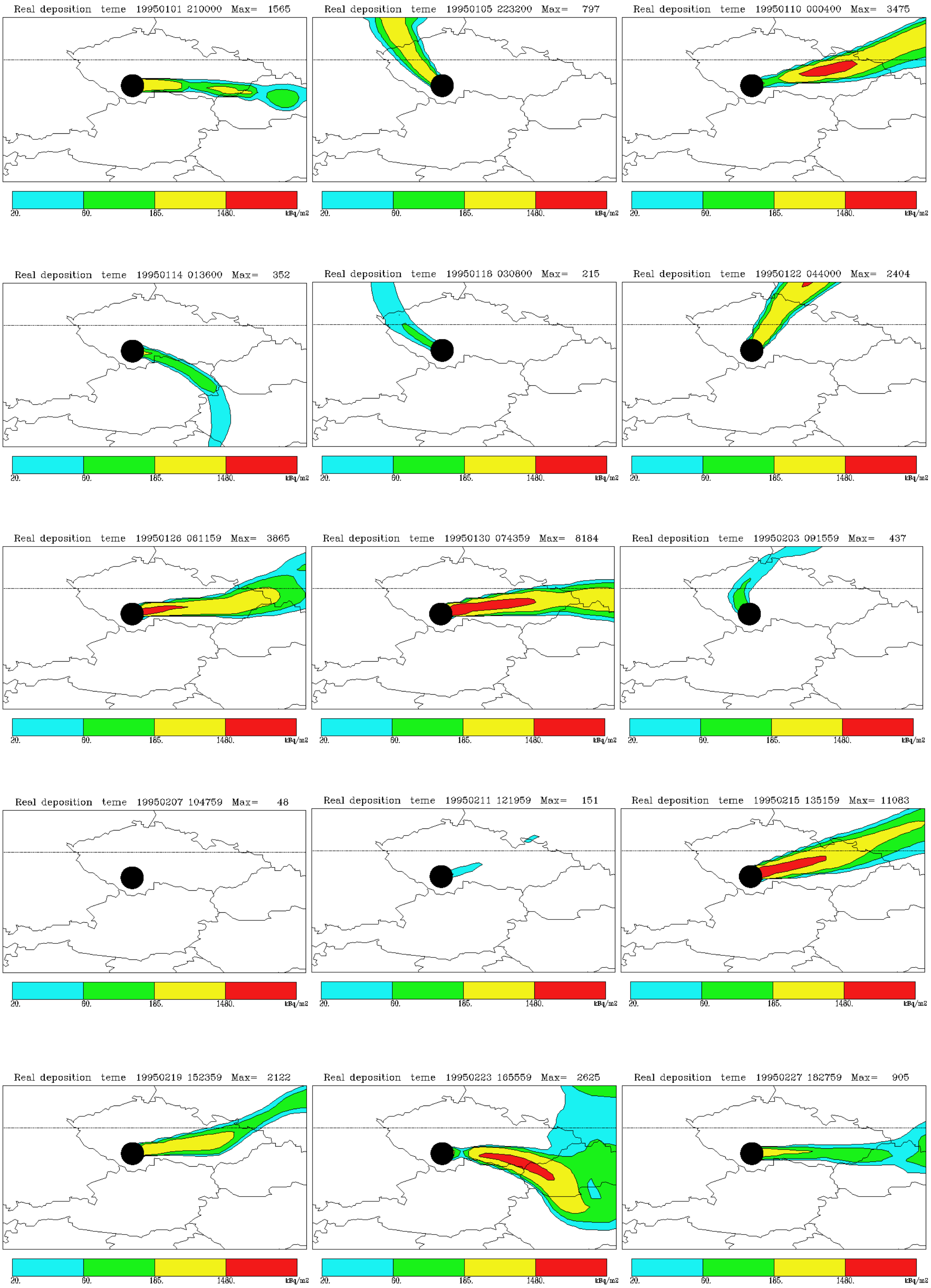
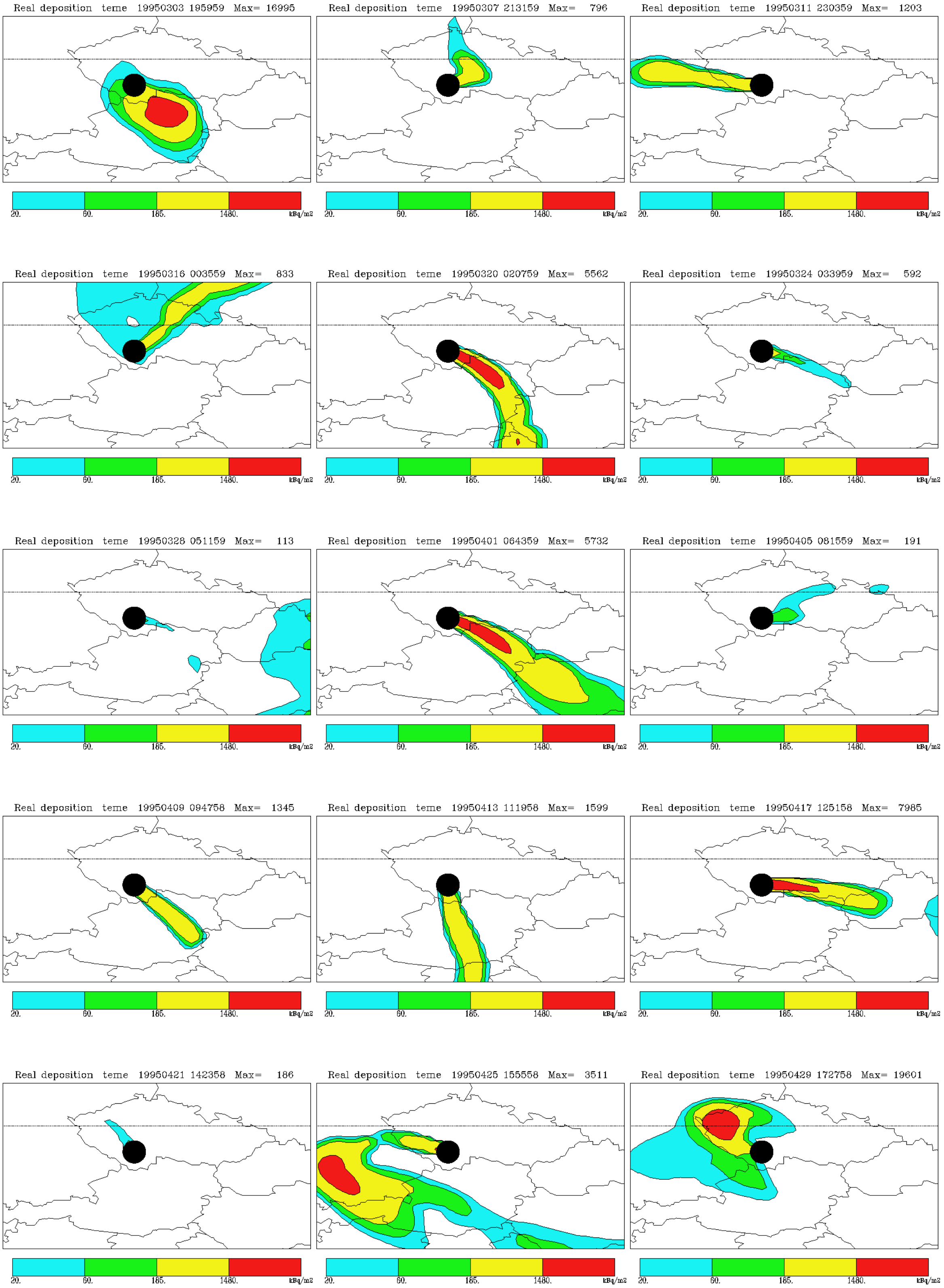
Annex A2

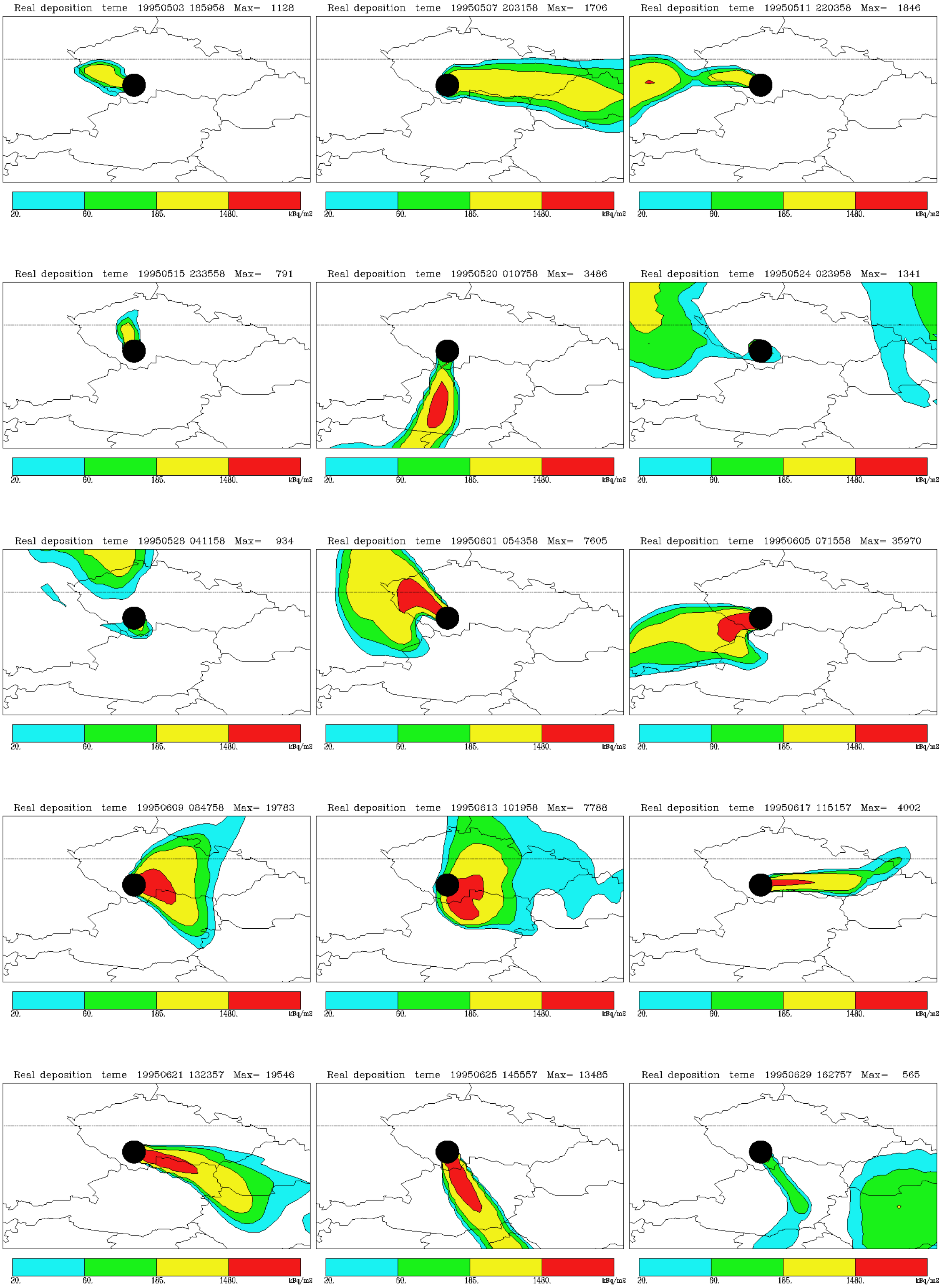
ILLUSTRATION OF CASE STUDY CALCULATION RESULTS



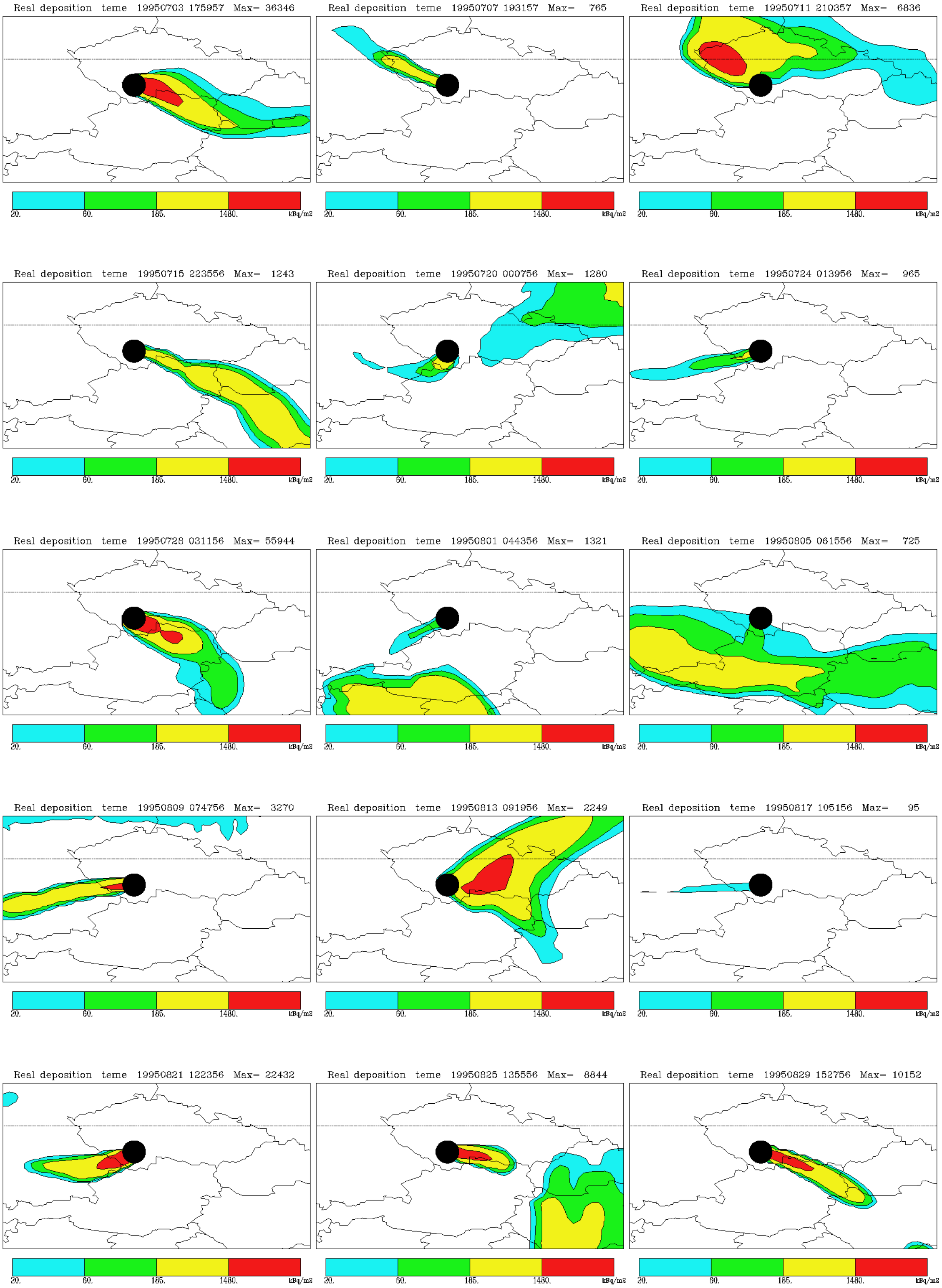
Cs-137 depositions after 10 days for the Flexpart case studies 0-14, area detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3



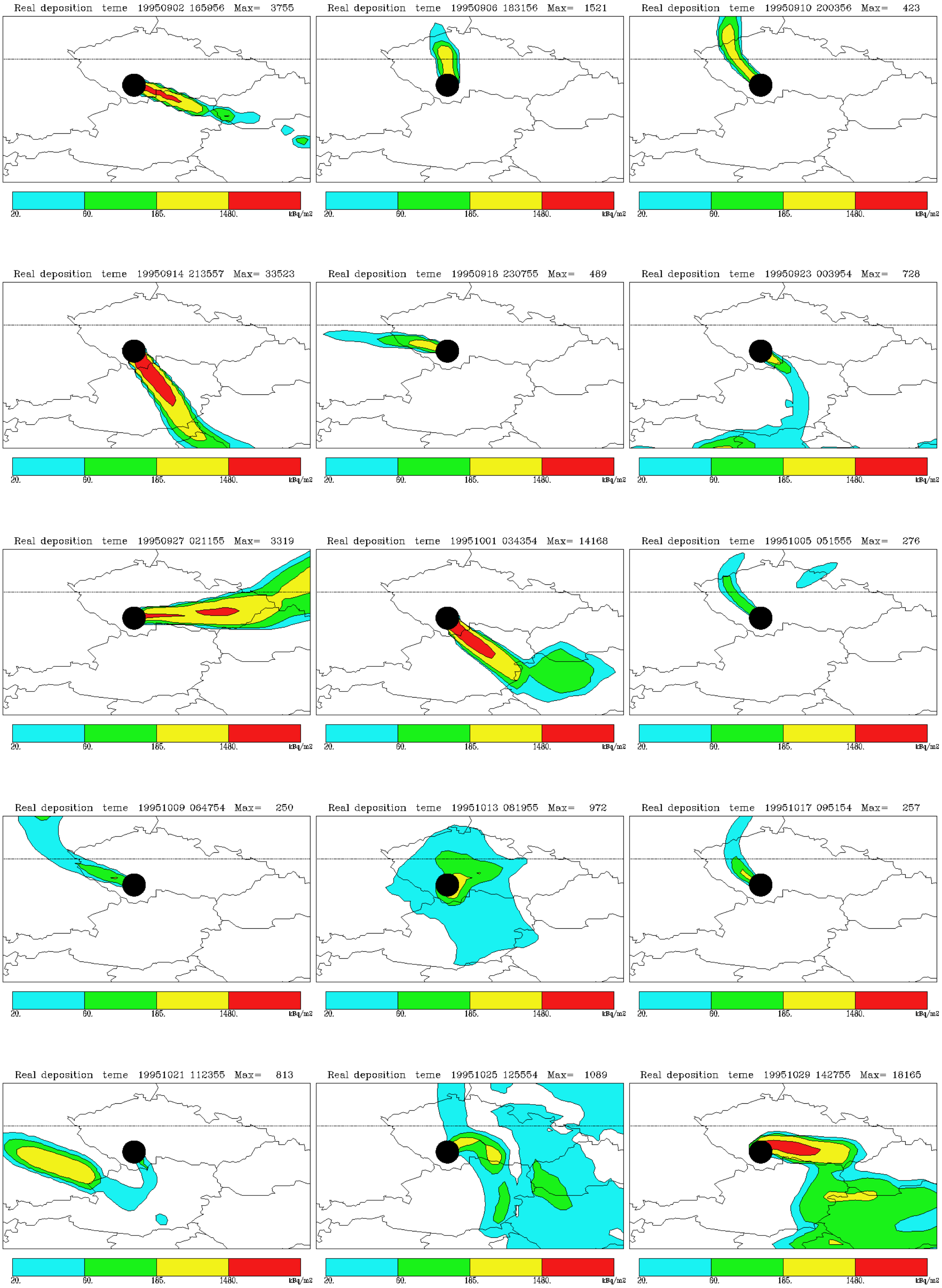
Cs-137 depositions after 10 days for the Flexpart case studies 15-29, area detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3



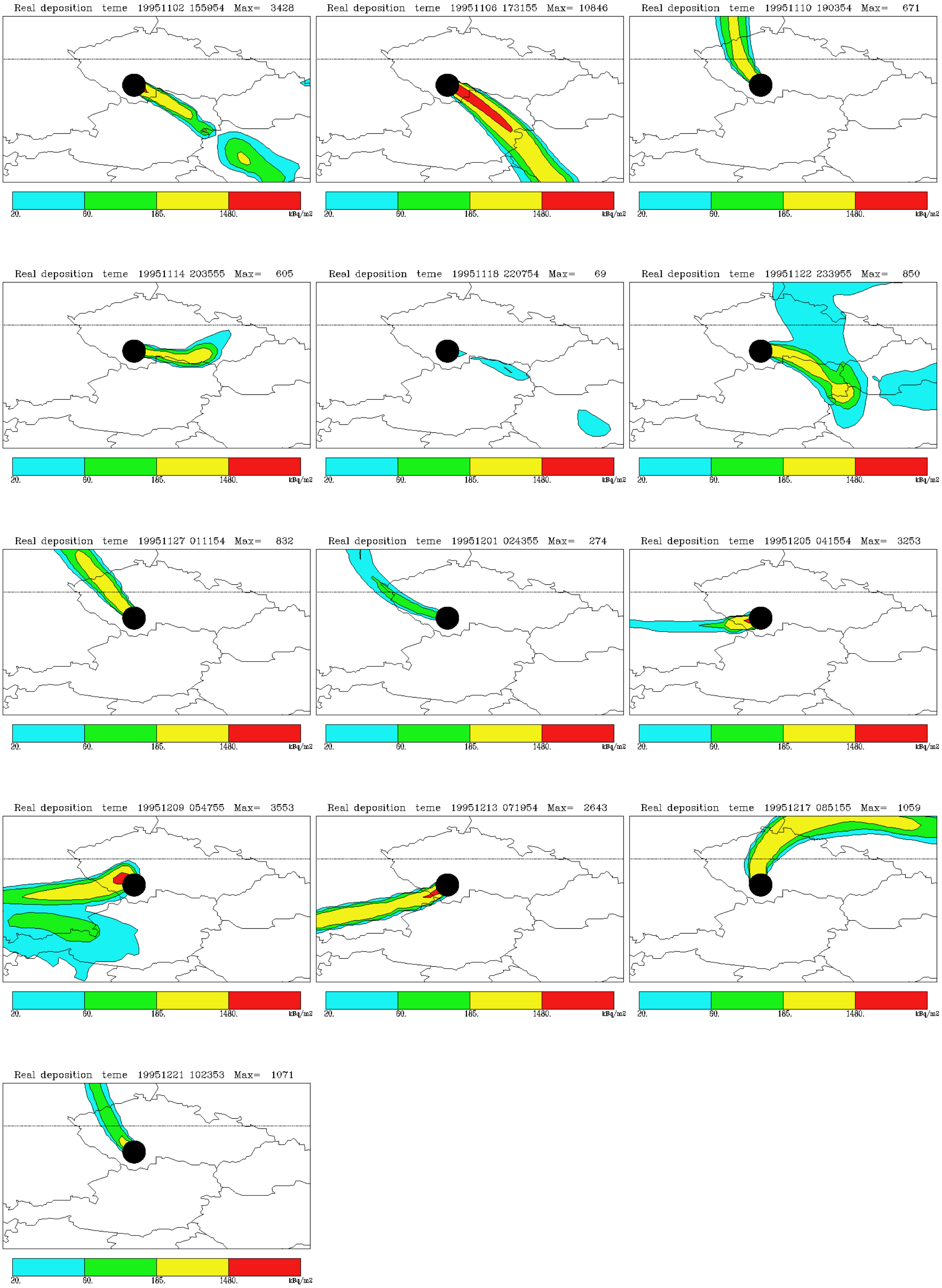
Cs-137 depositions after 10 days for the Flexpart case studies 30-44, area detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3



Cs-137 depositions after 10 days for the Flexpart case studies 45-59, area detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3



Cs-137 depositions after 10 days for the Flexpart case studies 60-74, area detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3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Real deposition teme 19951110 190354 Max= 671

Real deposition teme 19951114 203555 Max= 605

Real deposition teme 19951118 220754 Max= 69

Real deposition teme 19951122 233955 Max= 850

Real deposition teme 19951127 011154 Max= 832

Real deposition teme 19951201 024355 Max= 274

Real deposition teme 19951205 041554 Max= 3253

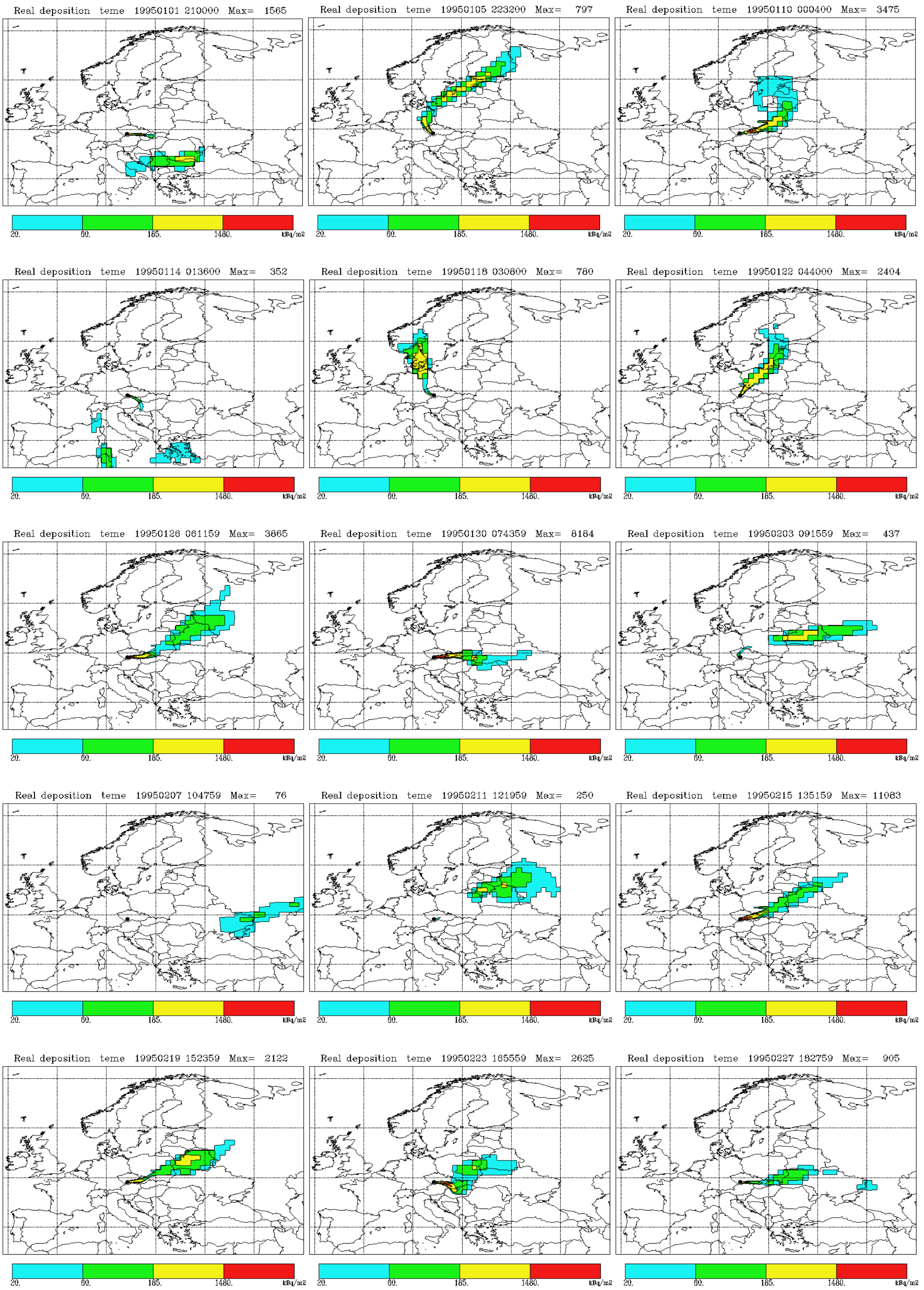
Real deposition teme 19951209 054755 Max= 3553

Real deposition teme 19951213 071954 Max= 2643

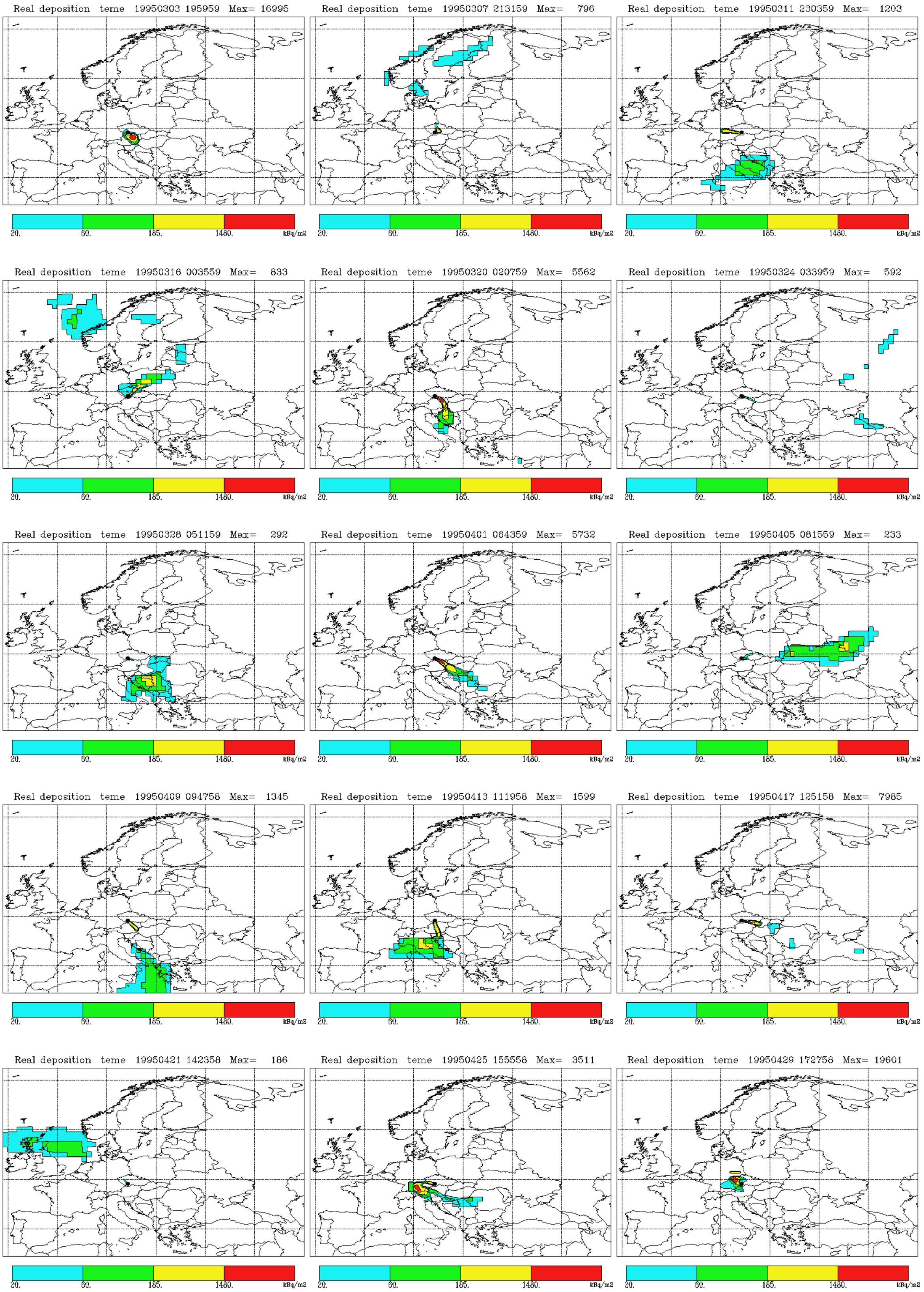
Real deposition teme 19951217 085155 Max= 1059

Real deposition teme 19951221 102353 Max= 1071

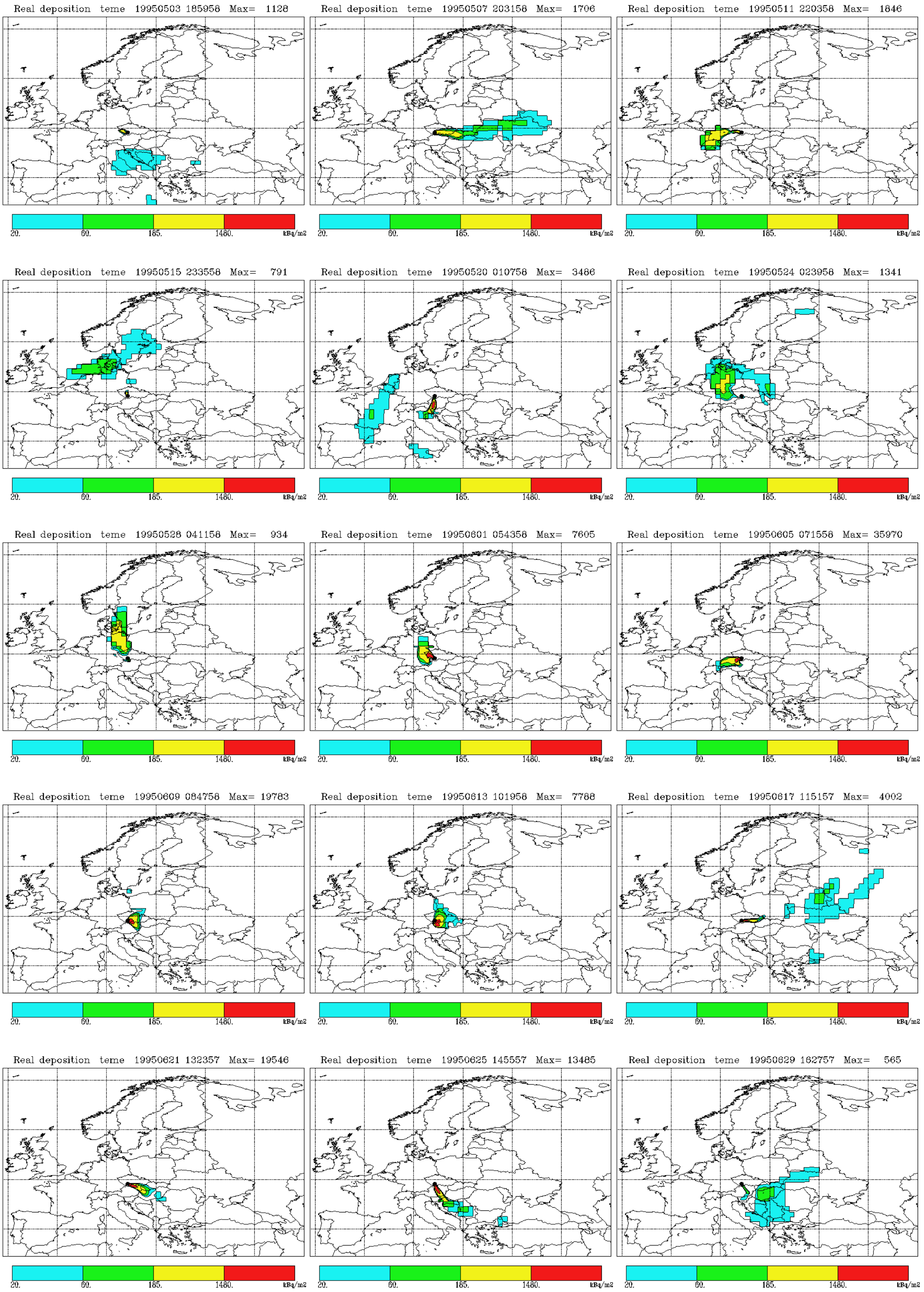
Cs-137 depositions after 10 days for the Flexpart case studies 75-87, area detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3



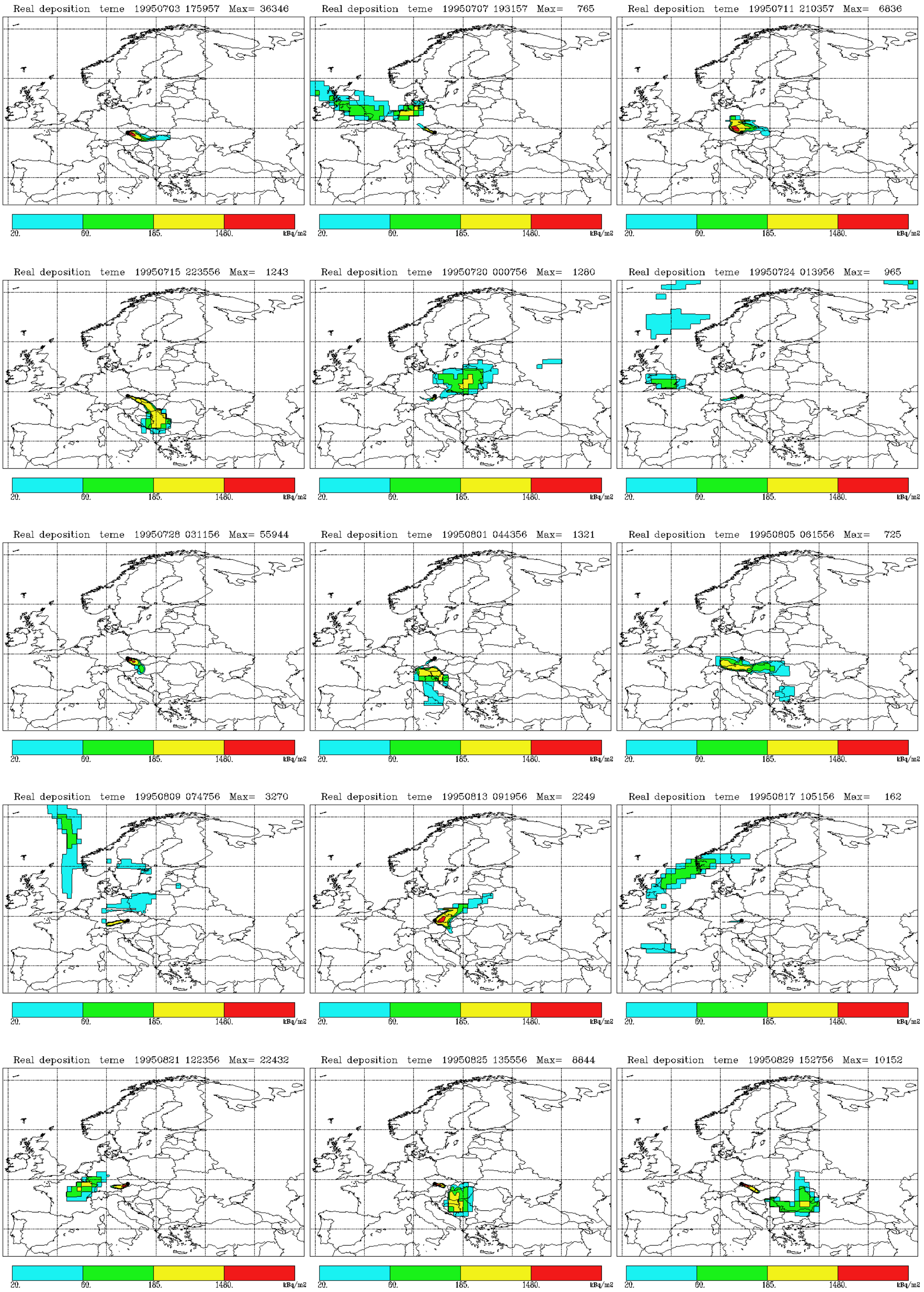
Cs-137 depositions after 10 days for the Flexpart case studies 0-14, Europe detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3



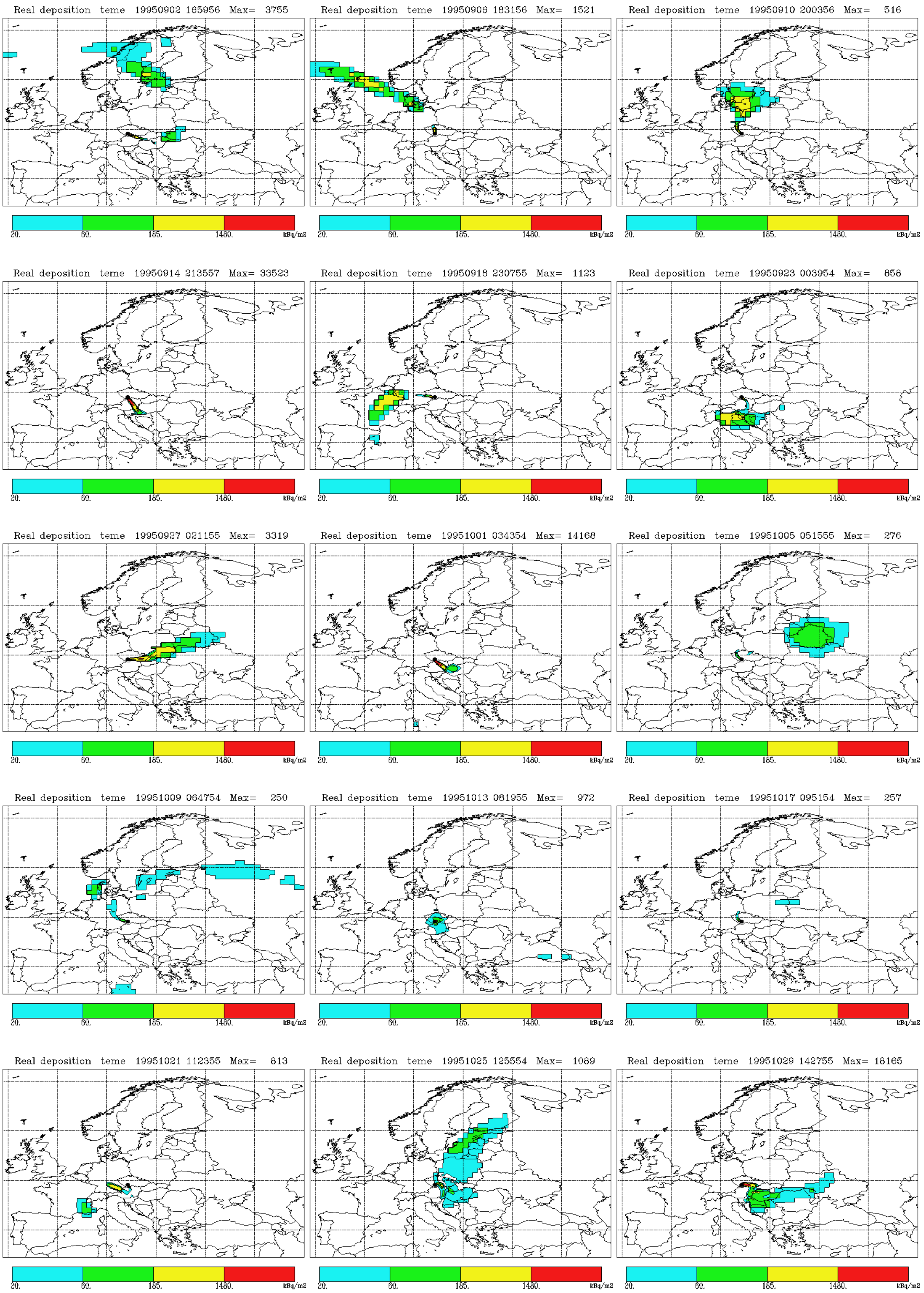
Cs-137 depositions after 10 days for the Flexpart case studies 15-29, Europe detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3



Cs-137 depositions after 10 days for the Flexpart case studies 30-44, Europe detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3



Cs-137 depositions after 10 days for the Flexpart case studies 45-59, Europe detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3



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Real deposition teme 19950910 200356 Max= 516

Real deposition teme 19950914 213557 Max= 33523

Real deposition teme 19950918 230755 Max= 1123

Real deposition teme 19950923 003954 Max= 858

Real deposition teme 19950927 021155 Max= 3319

Real deposition teme 19951001 034354 Max= 14168

Real deposition teme 19951005 051555 Max= 276

Real deposition teme 19951009 064754 Max= 250

Real deposition teme 19951013 081955 Max= 972

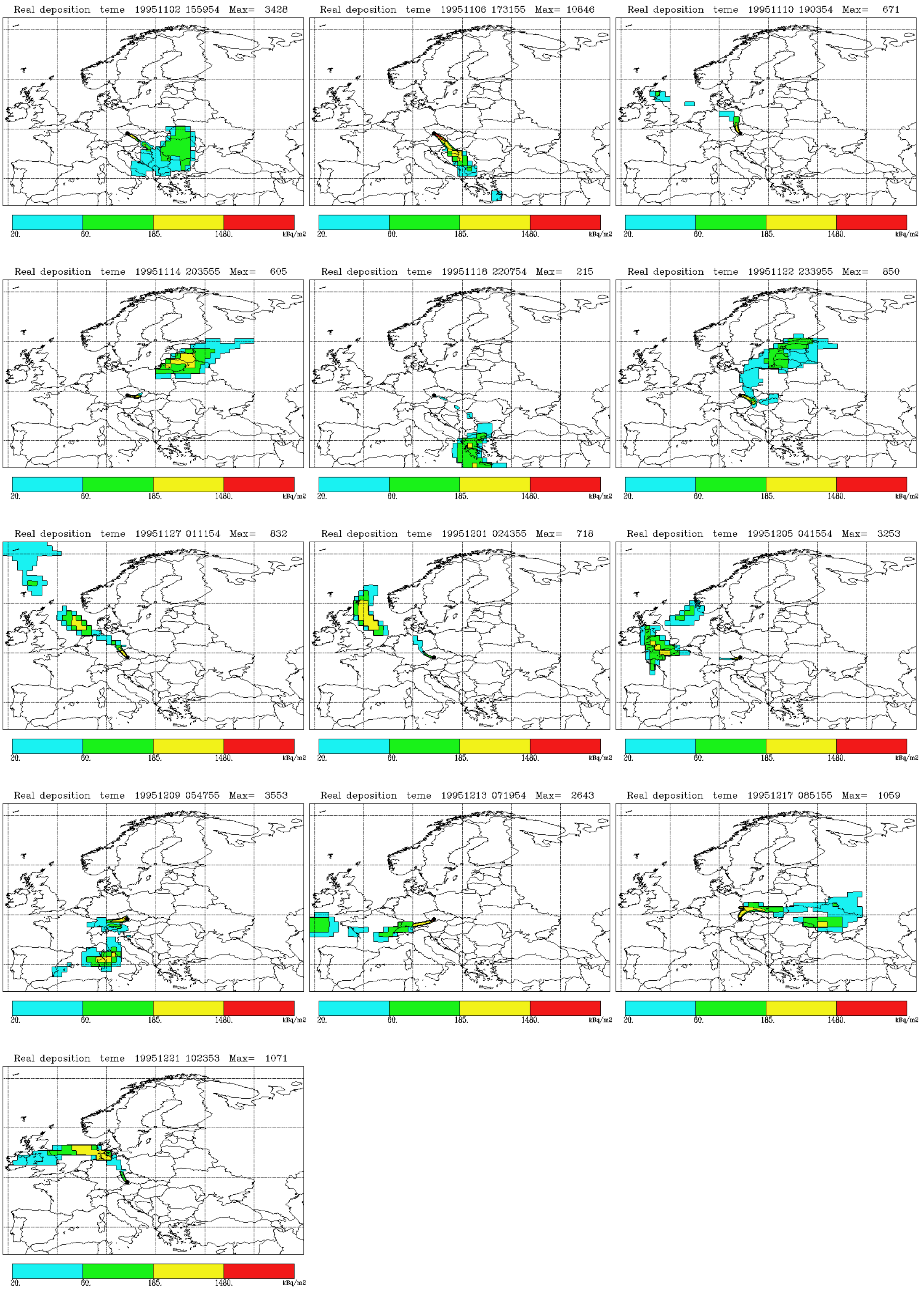
Real deposition teme 19951017 095154 Max= 257

Real deposition teme 19951021 112355 Max= 813

Real deposition teme 19951025 125554 Max= 1089

Real deposition teme 19951029 142755 Max= 18165

Cs-137 depositions after 10 days for the Flexpart case studies 60-74, Europe detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3



Cs-137 depositions after 10 days for the Flexpart case studies 75-87, Europe detail. Release date and maximum deposition in kBq/m^2 shown at top of each illustration. Color scale lower limits: blue 20, green 60, yellow 185, red 1480 kBq/m^2. Closer description: see chapter 4.3

Annex A3

CALCULATIONS ON ECONOMIC-ECOLOGICAL COMPARISONS

3.1 Untersuchte Szenarien

Referenzszenario: Fortführung der bestehenden Erzeugungsstruktur ohne Inbetriebnahme Temelíns *(Nullvariante);* die Erzeugung verbleibt auf dem gegenwärtigen Niveau von 48 TWh;

Szenario A: *Inbetriebnahme Temelíns (Block 1)* und Marktausweitung im Export im Ausmaß der Erzeugung in Temelín; damit steigt die Erzeugung auf eine Niveau von 54 TWh;

Szenario A‘: *Inbetriebnahme Temelíns (Block 1)* und Marktausweitung im Export im Ausmaß der Erzeugung in Temelín; Allerdings lediglich 5000 Jahresvollaststunden in Temelín (anstelle von 6000 im Szenario A)

Szenario B: *Inbetriebnahme Temelíns (Block 1)* jedoch ohne Marktausweitung, was zu einer Verdrängung des entsprechenden Anteils in Kohlekraftwerken führt; die Erzeugung verbleibt auf dem heutigen Niveau von 48 TWh;

Szenario C: *Nullvariante* ohne Inbetriebnahme von Temelín bei gleichzeitiger Reduktion der Erzeugung auf das Niveau des Heimmarktes (kein Export sowie keine Marktanteilszugewinne im Inland); damit reduziert sich die Erzeugung auf 39 TWh;

Szenario D: *Nullvariante* wie Szenario C jedoch mit gleichzeitiger Außerbetriebnahme von in diesem Fall bestehenden Reserven in der Höhe von 1500 MW, um den Fixkostenblock zu reduzieren.

3.2 Detaillierte Inputdaten zur Definition der unsuchten Szenarien

Definition des Referenzszenarios

Kraftwerkskategorie	Summe el. Leistung MW	Vollaststunden h/a	Erzeugung GWh/a
KKW Dukovany	1760	7500	13200
KKW Temelín	0	6500	0
Braunkohlekraftwerke	3314	6039	20014
Heizkraftwerke Braunkohle	2217	4007	8883
Steinkohlekraftwerke	800	3730	2984
Heizkraftwerke Steinkohle	165	4443	733
Speicherkraftwerk	720	2300	1656
Pumpspeicherkraftwerke	1140	465	530
Gesamt	**10116**	**4745**	**48000**

Definition des Szenario A

Kraftwerkskategorie	Summe el. Leistung MW	Vollaststunden h/a	Erzeugung GWh/a
KKW Dukovany	1760	7500	13200
KKW Temelín	1000	6000	6000
Braunkohlekraftwerke	3314	6039	20014
Heizkraftwerke Braunkohle	2217	4007	8883
Steinkohlekraftwerke	800	3730	2984
Heizkraftwerke Steinkohle	165	4443	733
Speicherkraftwerk	720	2300	1656
Pumpspeicherkraftwerke	1140	465	530
Gesamt	**11116**	**4858**	**54000**

Definition des Szenario A‘

Kraftwerkskategorie	Summe el. Leistung MW	Vollaststunden h/a	Erzeugung GWh/a
KKW Dukovany	1760	7500	13200
KKW Temelín	1000	5000	5000
Braunkohlekraftwerke	3314	6039	20014
Heizkraftwerke Braunkohle	2217	4007	8883
Steinkohlekraftwerke	800	3730	2984
Heizkraftwerke Steinkohle	165	4443	733
Speicherkraftwerk	720	2300	1656
Pumpspeicherkraftwerke	1140	465	530
Gesamt	**11116**	**4858**	**53000**

Definition des Szenario B

Kraftwerkskategorie	Summe el. Leistung MW	Vollaststunden h/a	Erzeugung GWh/a
KKW Dukovany	1760	7500	13200
KKW Temelín	1000	6000	6000
Braunkohlekraftwerke	3314	4525	14998
Heizkraftwerke Braunkohle	2217	4007	8883
Steinkohlekraftwerke	800	2500	2000
Heizkraftwerke Steinkohle	165	4443	733
Speicherkraftwerk	720	2300	1656
Pumpspeicherkraftwerke	1140	465	530
Gesamt	**11116**	**4318**	**48000**

Definition des Szenario C

Kraftwerkskategorie	Summe el. Leistung MW	Vollaststunden h/a	Erzeugung GWh/a
KKW Dukovany	1760	7500	13200
KKW Temelín	0	6500	0
Braunkohlekraftwerke	3314	3620	11998
Heizkraftwerke Braunkohle	2217	4007	8883
Steinkohlekraftwerke	800	2500	2000
Heizkraftwerke Steinkohle	165	4443	733
Speicherkraftwerk	720	2300	1656
Pumpspeicherkraftwerke	1140	465	530
Gesamt	**10116**		**39000**

Definition des Szenario D

Kraftwerkskategorie	Summe el. Leistung MW	Vollaststunden h/a	Erzeugung GWh/a
KKW Dukovany	1760	7500	13200
KKW Temelín	0	6500	0
Braunkohlekraftwerke	2214	5430	11998
Heizkraftwerke Braunkohle	2217	4007	8883
Steinkohlekraftwerke	400	5000	2000
Heizkraftwerke Steinkohle	165	4443	733
Speicherkraftwerk	720	2300	1656
Pumpspeicherkraftwerke	1140	465	530
Gesamt	**8616**		**39000**

3.3 Umweltauswirkungen

Die Umweltauswirkungen der Szeanrien wurden berechnet mit dem GEMIS-Modell für Tschechien

Emissionen für SO_2, NO_x und für SO_2-Äquivalente

Tonnen pro Jahr	SO_2	NO_x	SO_2-Äquivalent
Referenzszenario	44227	56620	84113
Szenario A	44341	56740	84313
Szenario A‘	44341	56740	84313
Szenario B	36551	46695	69452
Szenario C, D	32546	41575	61836

Emissioen Staub, CO und Kohlenwasserstoffe (ohne Methan)

Tonnen pro Jahr	Staub	CO	NMVOC
Referenzszenario	2570	14256	582
Szenario A	2589	14307	585
Szenario A‘	2589	14307	585
Szenario B	2173	11808	484
Szenario C, D	1953	10516	431

Emissionen von Asche, Nebenprodukten der Entschewefelung, Abraum

Tonnen pro Jahr	Asche	REA-Reststoff	Abraum
Referenzszenario	2974000	2209000	240800000
Szenario A	2979000	2213000	241400000
Szenario A‘	2979000	2213000	241400000
Szenario B	2442000	1834000	201000000
Szenario C, D	2172000	1618000	176800000

Radioaktive Abfälle

Tonnen pro Jahr	radioakt. Abfälle
Referenzszenario	54
Szenario A	78
Szenario A‘	74
Szenario B	78
Szenario C, D	54

Emissionen CO_2 und CO_2-Äquivalent

tsd. Tonnen pro Jahr	CO_2	CO_2-Äquivalent
Referenzszenario	38010	38900
Szenario A	38120	39010
Szenario A‘	38120	39010
Szenario B	31470	32170
Szenario C, D	28030	28700

3.4 Detaillierte Ergebnisse der ökonomischen Analyse

Referenzszenario

	Fixko (O&M)	sonst. var.Kosten	Brennstoff-kosten	Gesamt	Erzeu-gungs-kosten	Grenz kosten
	tsd. CZK	tsd. CZK	tsd. CZK	tsd. CZK	CZK/MWh	CZK/MWh
KKW Dukovany	2640000	501600	1968252	5109852	387	187
KKW Temelín						
Braunkohlekraftwerke	1840132	1318516	8499703	11658351	583	491
Heizkraftwerke Braunk.	1241908	601131	3893452	5736491	646	506
Steinkohlekraftwerke	436920	186805	1447062	2070787	694	548
Heizkraftwerke Steinkohle	90115	45899	355551	491565	671	548
Speicherkraftwerk	252000	298080	0	550080	332	180
Pumpspeicherkraftwerke	399000	95418	0	494418	933	180
Gesamt	**6900075**	**3047449**	**16164020**	**26111544**	**544**	

Szenario A

	Fixko (O&M)	sonst. var.Kosten	Brennstoff-kosten	Gesamt	Erzeu-gungs-kosten	Grenz kosten
	tsd. CZK	tsd. CZK	tsd. CZK	tsd. CZK	CZK/MWh	CZK/MWh
KKW Dukovany	2640000	501600	1968252	5109852	387	187
KKW Temelín	2000000	228000	1026480	3254480	542	209
Braunkohlekraftwerke	1840132	1318516	8499703	11658351	583	491
Heizkraftwerke Braunk.	1241908	601131	3893452	5736491	646	506
Steinkohlekraftwerke	436920	186805	1447062	2070787	694	548
Heizkraftwerke Steinkohle	90115	45899	355551	491565	671	548
Speicherkraftwerk	252000	298080	0	550080	332	180
Pumpspeicherkraftwerke	399000	95418	0	494418	933	180
Gesamt	**8900075**	**3275449**	**17190500**	**29366024**	**544**	

Szenario A‘

	Fixko (O&M)	sonst. var.Kosten	Brennstoff-kosten	Gesamt	Erzeugungs-kosten	Grenz kosten
	tsd. CZK	tsd. CZK	tsd. CZK	tsd. CZK	CZK/MWh	CZK/MWh
KKW Dukovany	2640000	501600	1968252	5109852	387	187
KKW Temelín	2000000	190000	855400	3045400	609	209
Braunkohlekraftwerke	1840132	1318516	8499703	11658351	583	491
Heizkraftwerke Braunk.	1241908	601131	3893452	5736491	646	506
Steinkohlekraftwerke	436920	186805	1447062	2070787	694	548
Heizkraftwerke Steinkohle	90115	45899	355551	491565	671	548
Speicherkraftwerk	252000	298080	0	550080	332	180
Pumpspeicherkraftwerke	399000	95418	0	494418	933	180
Gesamt	**8900075**	**3237449**	**17019420**	**29156944**	**540**	

Szenario B

	Fixko (O&M)	sonst. var.Kosten	Brennstoff-kosten	Gesamt	Erzeugungs-kosten	Grenz kosten
	tsd. CZK	tsd. CZK	tsd. CZK	tsd. CZK	CZK/MWh	CZK/MWh
KKW Dukovany	2640000	501600	1968252	5109852	387	187
KKW Temelín	2000000	228000	1026480	3254480	542	209
Braunkohlekraftwerke	1840132	988037	6369302	9197472	613	491
Heizkraftwerke Braunk.	1241908	601131	3893452	5736491	646	506
Steinkohlekraftwerke	436920	125220	970000	1532140	766	548
Heizkraftwerke Steinkohle	90115	45899	355551	491565	671	548
Speicherkraftwerk	252000	298080	0	550080	332	180
Pumpspeicherkraftwerke	399000	95418	0	494418	933	180
Gesamt	**8900075**	**2883386**	**14583037**	**26366498**	**549**	

Szenario C

	Fixko (O&M)	sonst. var.Kosten	Brennstoff-kosten	Gesamt	Erzeugungs-kosten	Grenz kosten
	tsd. CZK	tsd. CZK	tsd. CZK	tsd. CZK	CZK/MWh	CZK/MWh
KKW Dukovany	2640000	501600	1968252	5109852	387	187
KKW Temelín						
Braunkohlekraftwerke	1840132	790396	5095225	7725754	644	491
Heizkraftwerke Braunk.	1241908	601131	3893452	5736491	646	506
Steinkohlekraftwerke	436920	125220	970000	1532140	766	548
Heizkraftwerke Steinkohle	90115	45899	355551	491565	671	548
Speicherkraftwerk	252000	298080	0	550080	332	180
Pumpspeicherkraftwerke	399000	95418	0	494418	933	180
Gesamt	**6900075**	**2457745**	**12282480**	**21640300**	**555**	

Szenario D

	Fixko (O&M)	sonst. var.Kosten	Brennstoff-kosten	Gesamt	Erzeu-gungs-kosten	Grenz kosten
	tsd. CZK	tsd. CZK	tsd. CZK	tsd. CZK	CZK/MWh	CZK/MWh
KKW Dukovany	2640000	501600	1968252	5109852	387	187
KKW Temelín						
Braunkohlekraftwerke	1229531	790396	5095225	7115152	593	491
Heizkraftwerke Braunk.	1241908	601131	3893452	5736491	646	506
Steinkohlekraftwerke	218460	125220	970000	1313680	657	548
Heizkraftwerke Steinkohle	90115	45899	355551	491565	671	548
Speicherkraftwerk	252000	298080	0	550080	332	180
Pumpspeicherkraftwerke	399000	95418	0	494418	933	180
Gesamt	**6071013**	**2457745**	**12282480**	**20811238**	**534**	

3.5 Sensitivitätsanalyse: Abhängigkeit des Deckungsbeitrags vom durchschnittlichen Exportpreis

Exportpreis CZK/MWh	Deckungsbeitrag (Mio. CZK/a)					
	Referenzsz.	Szenario A	Szenario A’	Szenario B	Szenario C	Szenario D
500	21288	21034	20743	21034	21260	22089
600	22188	22534	22143	21934	21260	22089
700	23088	24034	23543	22834	21260	22089
800	23988	25534	24943	23734	21260	22089
900	24888	27034	26343	24634	21260	22089
1000	25788	28534	27743	25534	21260	22089
1100	26688	30034	29143	26434	21260	22089

3.6 Analyse der Effekte eines offenen Außenhandels und eines regulierten Heimmarktes (Effekt der Re-Importe)

		Szenario E
Verkauf CZ	TWh	33
Verkauf Export	TWh	15
Preis CZ	CZK/MWh	1100
Preis Export	CZK/MWh	582
Umsatz CZ	mil.CZK	36300
Umsatz Export	mil.CZK	8730
Fixkosten (O&M)	mil.CZK	8900
sonst. var. Kosten	mil.CZK	2883
Brennstoffkosten	mil.CZK	14583
Umsatz gesamt	mil.CZK	45030
Erzeugungskosten	mil.CZK	26366
Deckungsbeitrag	mil.CZK	18664

3.7 Abhängigkeit des Effekts der Reimporte vom Exportpreis

Exportpreis CZK/MWh	Deckungsbeitrag (Mio. CZK/a)						
	Referenzsz.	Sz. A	Sz. A'	Sz. B	Sz. C	Sz. D	Sz. E
500	21288	21034	20743	21034	21260	22089	17434
600	22188	22534	22143	21934	21260	22089	18934
700	23088	24034	23543	22834	21260	22089	20434
800	23988	25534	24943	23734	21260	22089	21934
900	24888	27034	26343	24634	21260	22089	23434
1000	25788	28534	27743	25534	21260	22089	24934
1100	26688	30034	29143	26434	21260	22089	26434

3.8 Abhängigkeit des Deckungsbeitrags vom Strompreis bei vollständiger Liberalisierung

Exportpreis CZK/MWh	**Deckungsbeitrag (Mio. CZK/a)**					
	Referenzsz.	**Szenario A**	**Szenario A'**	**Szenario B**	**Szenario C**	**Szenario D**
500	-2112	-2366	-2657	-2366	-2140	-1311
600	2688	3034	2643	2434	1760	2589
700	7488	8434	7943	7234	5660	6489
800	12288	13834	13243	12034	9560	10389
900	17088	19234	18543	16834	13460	14289
1000	21888	24634	23843	21634	17360	18189
1100	26688	30034	29143	26434	21260	22089

Annex A4

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