WMO

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

NATIONAL GREENHOUSE GAS INVENTORIES PROGRAMME

UNEP

ESTABLISHING A DATABASE

ON

GREENHOUSE GAS EMISSION FACTORS

Meeting Report

New Delhi, India

24-25 July 2000

IPCC National Greenhouse Gas Inventories Programme and its Technical Support Unit

The World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) jointly established the Intergovernmental Panel on Climate Change (IPCC) in 1988 to:

(i) Make periodic assessments of the science, the impacts, the economics and the options for the mitigation of/adaptation to climate change;
(ii) Assess, and develop as necessary, methods such as the IPCC Guidelines for National Greenhouse Gas Inventories;
(iii) Provide, on request, scientific/technical/socio-economic advice to the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP/UN FCCC) and its bodies.

The IPCC, at its 14th session in October 1998, established a Task Force on National Greenhouse Gas Inventories (TFI). The TFI was to have a Task Force Bureau (TFB) to provide guidance on the management of the IPCC National Greenhouse Gas Inventories Programme (IPCC-NGGIP).

In accordance with a decision taken by the IPCC at its 14th session and an offer of funding by the Government of Japan, a Technical Support Unit (TSU) for the Programme was set up in 1999 at the Institute for Global Environmental Strategies (IGES) in Hayama, Japan. The TSU took over the technical support for the NGGIP which had been managed by IPCC Working Group I since 1991, in close collaboration with the Organisation for Economic Co-operation and Development (OECD) and the International Energy Agency (IEA).

The objectives of the IPCC-NGGIP are:

- To develop and refine an internationally-agreed methodology and software including good practice guidance for the calculation and reporting of national GHG emissions and removals;
- To encourage the widespread use of this methodology and guidance by countries participating in the IPCC and by signatories of the United Nations Framework Convention on Climate Change (UNFCCC);
- To facilitate the compilation of national greenhouse gas inventories.

The primary function of the TSU which is responsible to the TFB through its two Co-chairs is to serve the needs of the NGGIP.

The TSU undertakes scientific and technological duties as part of the Programme including:

- Improving technical support for countries engaged in estimating GHG emissions and removals related to fuel use, industrial sources, waste disposal, agricultural activities and land use, land-use change, and forestry;
- Collecting, managing and disseminating information related to GHG inventories;
- Organising international meetings of experts to take up scientific and technical issues in the various sectors to assist parties compile more reliable GHG inventories;
- Responding to specific requests from parties on issues relating to GHG inventories.

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Japan

ACKNOWLEDGEMENTS

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PART 1 – OVERVIEW

PURPOSE OF A DATABASE AND MEETING

Parties to the United Nations Framework Convention on Climate Change develop, periodically update and publish a national inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol (hereinafter referred to as greenhouse gas (GHG) inventories).

For Parties mentioned in Annex B to the Kyoto Protocol, these GHG inventories will facilitate determination of compliance with quantified emission limitation and reduction commitments.

Emissions of GHGs can be estimated either by direct measurements or by calculations[1]. In practice, most emissions are estimated by calculations using activity data and emission factors for reasons of cost effectiveness. Therefore, the quality of GHG inventories depends substantially on the reliability of the relevant parameters and in particular on the selection of the emission factors.

Although it is preferable to use emission factors that reflect the national circumstances, emission factor development is expensive, time consuming and requires a wide range of expertise. The *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the *IPCC Guidelines*) and the recently published *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as the *Good Practice Report*) provide default emission factors for the majority of source and sink categories. Some of these default emission factors are region or country specific, but in general not all regions or countries are covered. Sharing of research information would enable countries to use or develop emission factors that are more reliable and better applicable than the IPCC default emission factors without having to bear the associated research cost.

For this reason, many countries have indicated (e.g. in the Expert Group Meeting on National Feedback on the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Cuba, 1998) that an easily accessible public database on GHG emission factors with supporting scientific information would help improve the quality of GHG inventories in a cost-effective way.

A database on GHG emission factors with supporting scientific information would also support the future review and update of the *IPCC Guidelines* under the IPCC National Greenhouse Gas Inventories Programme.

Although collections of GHG emission factors have been prepared by various organisations, they do not generally cover all world regions or all emission source categories. Examples are:

- AP-42 from the US Environmental Protection Agency;
- Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook;

[1] For example, to estimate methane emissions from cars, one can:

- Perform direct measurements at the tail pipe of every single car; or
- Multiply litres of gasoline consumed by an emission factor.

In the latter case, the result expresses the average emissions in grams of methane per litre of gasoline. The latter solution is more practical and cheaper than the former one.

- Database of Phare Topic Link on Air Emissions (focuses on Eastern European countries);
- Database of the Japanese National Institute for Agro-Environmental Studies (focuses on agriculture);
- OLADE database of emission factors (Latin America)

Extensive coverage of all IPCC source/sink categories and all world regions would be the longer term goal of the new database.

Against this background an IPCC expert meeting was convened to:

- Develop a work plan to construct a database of emission factors with wide regional and sectoral coverage;
- Discuss ways of operating and maintaining the database;
- Determine a preliminary set of user requirements.

PARTICIPANTS

The meeting, held in New Delhi, India on 24-25 July, 2000 was attended by 27 participants from 17 countries (Belgium, Brazil, Canada, China, Cuba, Germany, India, Italy, Netherlands, Poland, Republic of Uzbekistan, Russian Federation, Slovak Republic, Sudan, United Kingdom, United States and Zimbabwe), as well as from the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), the Task Force Bureau of the IPCC National Greenhouse Gas Inventories Programme (IPCC-NGGIP/TFB), the Technical Support Unit of the IPCC National Greenhouse Gas Inventories Programme (IPCC-NGGIP/TSU) and the Organización Latinoamericana de Energía (OLADE). The meeting was co-chaired by Tinus Pulles from the Netherlands and Katarina Mareckova of the Slovak Republic.

The Tata Energy Research Institute hosted the meeting.

SUMMARY OF RESULTS

The discussions resulted in a first outline of user requirements, including quality aspects and a proposed work plan to construct a prototype database on the Internet and CD-ROM by the end of 2001.

The workshop participants proposed a work plan that would require two more expert meetings:

1 A meeting to discuss and finalise the functional design of the system (by March 2001);

2 A meeting to review and discuss the populated prototype (by December 2001).

After the completion of the prototype database, regular meetings of emission factor experts, organised by source category, would help data collection and assessment. Currently, no budget is available for such meetings. Organising them back-to-back with other related meetings could reduce the costs of such meetings while at the same time facilitating the participation of the limited number of experts in the field worldwide.

The meeting requested the TSU to consult the Task Force Bureau on National Greenhouse Gas Inventories or the IPCC Bureau to see if additional funds could be made available.

A major issue was the large amount of work involved in collecting, reviewing and processing research information on emission factors to be incorporated in an emission factors database. It is clear that the Technical Support Unit of the IPCC National Greenhouse Gas Inventories Programme cannot undertake this task alone[2]. The project depends on collaboration with outside organisations and national governments. Collaborative mechanisms need to be devised and partners identified. The meeting proposed to organise populating the database by means of an editorial and reviewing board, limiting the effort required by the system and database managers to distributing proposed entries to members of the editorial and reviewing board and following up on their decisions.

[2] As a comparison, the USEPA FIRE emission factors database was developed by 10 persons working full-time for 1.5 years.

PART 2 – PROCEEDINGS

PRESENTATIONS

A number of presentations that provided background information and facilitated the discussions were made by the following participants.

- Tinus Pulles: “Establishing a database on GHG emission factors”;
- Leandro Buendia: “Database on methane emissions from rice fields”;
- Wanda Pazdan: “Achievements of Phare Topic Link on Air Emissions in the field of emission factors”;
- Mike Woodfield: “Experiences of the UNECE Task Force on Emission Inventories”;
- Stelios Pesmajoglou: “Activities of the UNFCCC in relation to GHG inventories and views on the IPCC emission factors database”;
- Jeroen Meijer: “Activity data collection mechanism of the International Energy Agency for its CO_2 emissions database – relevant highlights”;
- Uma Rajarathnam: “Emission factors for GHGs from small scale combustion”;
- Gabriel Hernandez: “OLADE statistics on GHG emissions from Energy”.

Overhead slides of these presentations are available separately. Information about some of the speakers and their respective organisations are as follows.

Tinus Pulles has been involved in various emissions estimation projects of the European Environmental Agency and was responsible for the emissions inventory software of the EEA.

Leandro Buendia works for the Technical Support Unit of the IPCC National Greenhouse Gas Inventories Programme. Previously he was involved in emission factor research at the International Rice Research Institute.

Wanda Pazdan works for the Phare Topic Link on Air Emissions and is currently constructing a database of emission factors for 10 Eastern-European countries.

Mike Woodfield is the co-chairman of the UNECE Task Force on Emission Inventories. He has been involved in the production of the EMEP/CORINAIR Atmospheric Emission Inventory Guidebook.

Stelios Pesmajoglou is working as a Program Officer at the secretariat of the United Nations Framework Convention on Climate Change.

Jeroen Meijer works for the Technical Support Unit of the IPCC National Greenhouse Gas Inventories Programme. Previously he worked at the International Energy Agency.

Uma Rajarathnam has been involved in research on emission factors for small-scale combustion and works for TERI.

Gabriel Hernandez is responsible for OLADE's calculations of GHG emissions from energy use in Latin America. Emission factors come from the *IPCC Guidelines* and other sources.

DISCUSSION

Discussions were structured along a list of topics outlined in the paper prepared for the workshop. This structure has been retained below.

A OBJECTIVES AND USERS OF THE DATABASE

1 Main objectives

The main objective of the database is the storage and exchange of information on and details of emission factors (including collection methods and classification) and other parameters needed to estimate GHG emissions. The database to be developed will:

- Provide inventory compilers a wider choice of emission factors and other relevant parameters (including background information) than currently available in the *IPCC Guidelines*;
- Facilitate the selection of the most appropriate emission factors through comparisons of the underlying information;
- Serve as a starting point for additional emission factor research programmes;
- Improve the quality and reliability of GHG inventories;
- Increase the transparency of GHG inventories;
- Provide a valuable input to assessment, review and future updates of the *IPCC Guidelines*.

2 Users

Priority 1:

- Inventory compilers (inventory agencies);
- IPCC (future update of *IPCC Guidelines*, starting in 2002).

Priority 2:

- Inventory review teams;
- Project developers, involved in e.g. the Clean Development Mechanism and Joint Implementation;
- Corporations and others who engage in emissions trading;
- Scientists;
- General public and NGOs;
- Consultants involved in GHG inventories work.

B CONTENT AND STRUCTURE OF THE DATABASE

3 Content

Which gases to include?

The workshop participants agreed that it would be most appropriate to include emission factors and emission estimation parameters on four "single" gases, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and sulfur hexafluoride (SF_6), and on each of the hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) mentioned in Table 1 of the Common Reporting Format of the UNFCCC (see UNFCCC document FCCC/CP/1999/7). Indirect greenhouse gases will not be included in the database during the initial development stage, but the system could be designed to allow including them at some future date.

Which emission factors to include?

Options are:

- All default emission factors from the *IPCC Guidelines* and the *Good Practice Report*; plus
- Only country-specific emission factors that are different from the default IPCC emission factors;

  or
- For each country, all emission factors used, even if some or all of them are the same as the default IPCC emission factors;

  or
- Two data sets of factors:
  - set 1 includes all the emission factors used in estimating emissions;
  - set 2 includes only high quality emissions factors with margin of standard error and background literature that describes the source and how the emission factors were estimated.

Implied emission factors, as defined in the UNFCCC Common Reporting Format, in most cases are time-dependent and weighted averages of the underlying emission factors used in the calculation of GHG emissions. They could be included as a second priority with a clear indication that they should not be used for inventory calculations directly, but may serve as an order of magnitude check.

Which other parameters to include?

It is preferable that all parameters that are required by different methods listed in the *IPCC Guidelines* and the *Good Practice Report* be included in the database, for example:

- Biological oxygen demand (BOD) in waste water;
- Average milk production.

4 Structure

The workshop participants agreed that the database should be structured according to the source/sink categories of the *IPCC Guidelines* and the *Good Practice Report*, taking into account the UNFCCC Common Reporting Format. Within source/sink categories, the structure should follow estimation tiers. (Later in this paper, suggestions are made for database fields.)

The workshop participants also agreed that the structure should be flexible to allow for the following elements:

- Changing demands on the database;
- Incorporation of data from other databases in the future or link to relevant database for greater detail on emission factors;
- Inclusion of source/sink categories that are not considered in the *IPCC Guidelines*/the *Good Practice Report*/ the UNFCCC Common Reporting Format, that could be introduced in Non-Annex I countries[3];
- Introduction of new methods to estimate GHG emissions in the future.

There could be different types of sector classifications in a database to provide a link to different inventory methods (e.g. CORINAIR) with an indication of the IPCC source/sink category. 'Look-up' facilities should translate one classification system to another. Consideration should be given to include categories below the most detailed IPCC level to allow for different estimation or classification practices in different countries.

Other parameters required in an estimation method may not fit neatly in a simple structure of source/sink category and gas. Additional knowledge is required to show how this information may be used in GHG emissions estimations. The database structure should be able to accommodate this knowledge.

Another issue is the inclusion or exclusion of expert systems or mathematical models that can be used to calculate emission factors as a function of various parameters.

Advantages of inclusion:

- A better match of emission factors to local circumstances would be allowed.
- Emission factor information would be available in one software package, compared to the situation where internet links to the modelling software would be required. This is an important consideration in developing a database that would ensure direct and simple access to data.

Disadvantages:

- It is technically complicated to build a mathematical model into a database.
- It requires extra person-time to fully understand the mathematical models and to include them in the database.
- Stand-alone modelling software will offer more modelling features. These features will be absent in the EF database.

However, it should be noted that including complex and detailed models in a database of emission factors would lie beyond the scope of such a database.

4 (a) Data fields

The information in the emission factors database will be organised in data records. Each data record will

[3] For example, biomass fuel such as sugar cane baggasse for power generation and ethanol as fuel for road transportation.

contain information about one emission factor or emission estimation parameter. The information in a data record is subdivided in separate pieces, the so-called data fields. Each data record will be uniquely identified through the use of information stored in data fields.

The following is a preliminary list of data fields that would contain the information that users expect to find in the database. The final list will depend to a certain extent on the database structure and technology chosen.

- Gas that will be estimated with the parameter or emission factor;
- Descriptive name of the parameter or emission factor;
- (Sub-) source category or activity definition, according to the source/sink categories of the *IPCC Guidelines*/the *Good Practice Report* and taking into account the UNFCCC Common Reporting Format [4];
- Value of the emission factor or parameter;
- Measurement unit [5];
- Upper and lower boundaries (confidence limits) at the 95 % confidence interval;
- IPCC worksheet number if applicable;
- Influencing factors (e.g. technology, fuel, abatement technology, region, latitude, longitude, altitude, humidity or feeding practices) [6];
- The equation used for estimating the emission;
- Reference or source of the information (e.g. country, organisation, researcher(s), where published);
- Data quality rating [7];
- Description of measurement techniques;
- Amount and frequency of measurements;
- Date of measurements;
- Other information relevant to a determination of the quality of the measurements.

Several participants in the meeting raised the point that 'country' is often not a good parameter on its own to explain emission factor variations. More important are parameters like technology, climatic conditions, altitude, animal or vegetation type, etc. Care should be taken not to omit this information. Experience from the EMEP/CORINAIR project shows that emission factors vary considerably, even at a very disaggregated classification level.

A confidence interval or a data quality rating for an emission factor may not be of practical use without

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[4] There could be different types of sector classifications simultaneously in a database, to provide a link to different inventory methods (e.g. CORINAIR). There should always be an indication of the IPCC source/sink category. IPCC source/sink category should be the primary identification field to be used for quick/easy search and retrieval of emission factors.

[5] Units should preferably be those identified in the *IPCC Guidelines*/the *Good Practice Report* or in the UNFCCC Common Reporting Format.

[6] The type and amount of influencing factors will differ among IPCC source categories.

[7] Workshop participants preferred to leave it to the supplier of the information to choose a system, e.g. UNECE/CORINAIR, USEPA, DARS, etc. This avoids re-evaluation or re-coding of existing quality ratings. Information on the data source itself could also be considered as an indicator of data quality

knowing what the factor will be used for. Application of one emission factor to different situations (e.g. combustion conditions, climatic zones or water management regimes) may reveal that the uncertainty is low in one situation and high in another. A confidence interval or a data quality rating is not universally valid. The factors influencing the value of the emission factor should be clearly indicated.

An indication of the quality of the parameter or emission factor could be provided by the data quality rating, the 95% confidence interval, the reference (peer reviewed scientific journal), a description of the measurement techniques and the factors influencing the emissions.

Another question raised during the discussions was whether it was useful to include emission factors in the database that were related to activity data that were not available in national statistical publications. The workshop participants did not reach any conclusion on this question.

4 (b) Data sources

Data source options include:

- The *IPCC Guidelines* and the *Good Practice Report*;
- UNFCCC secretariat (Information on emission factors and other estimation parameters, officially submitted to UNFCCC secretariat);
- Scientific literature;
- National greenhouse gas inventory agencies [8];
- Existing (partial) databases or inventory guidelines from other organisations [9].

C DEVELOPMENT OF THE DATABASE

5 Selection of computer software

The database should probably use a relational structure. Furthermore, an object-oriented structure may be necessary to allow for different information requirements (represented by database fields) in different IPCC source/sink categories.

The database should be user friendly and have sorting tools built in. The user should be able to extract any selection of emission factors and to export these to:

- A widely used commercial spreadsheet format (e.g. Excel);
- A widely used simple database format (e.g. dBase IV);
- A comma separated text file;
- A fixed length text file;

[8] Inventory agencies may have contracted research to develop country-specific emission factors. The results may not have been published.

[9] Several organisations have developed databases on GHG emission factors for one or more IPCC source categories. Examples are IRRI, USEPA and EMEP/CORINAIR. Modalities of collaboration, such as establishing linkages (to the specific database via the internet) or agreements on mutual reproduction of data, need to be considered.

– Paper.

It seems best to use a database that can be downloaded from the internet or can be made available on a CD-ROM, and not an online web-based database. Many countries do not have cheap, reliable high-speed internet connection lines. Working with an online database would be too slow and costly. Web-based software could be considered in the future, paying due consideration to its cost-effectiveness.

It was suggested to connect to (XML)[10] developments to facilitate data transfer.

6 Proposed work plan for the development of the database

The workshop participants drafted a preliminary work plan with a tentative time schedule as follows.

1. Planning for the development of the database. This meeting fulfils this function.
2. Implementation on a task by task basis.

Task	Activity	Team	End date
Functional design	Draft the information structure, subject to the functions the information is to fulfil. This functional design is independent of the actual software to be used.	Structure designers	January 2001
Technical design	Implement functional design into technical design. This technical design is software-dependent.	Structure designers and software designers	March 2001 First expert meeting
Prototype construction	Computer programming	Software designers	September 2001
Partial population of the database for test purposes	Data screening and import	Data Managers	December 2001
Database beta test	Data retrieval and manipulation	Users	December 2001 Second expert meeting
Implementation of procedures for maintenance, operation, updating		Data suppliers, data editors, data managers	

[10] The Extensible Markup Language (XML) is the universal format for structured documents and data on the internet. XML is a set of rules or guidelines to design text formats in a way that produces files that are easy to generate and read by a computer. The format allows for inclusion of meta-information, facilitating exchange of information between different applications.

D LONG TERM ASSESSMENT OF THE DATABASE

7 Hosting and sustainability

The Technical Support Unit of the IPCC National Greenhouse Gas Inventories Programme could host the prototype database. The TSU would have to cooperate with a network of institutions and scientists. IPCC Working Groups I and III have a web site hosted by an outside organisation. So not all IPCC Working Groups host their own web site.

8 Data collection procedures

A wide range of partners, specified through an agreed procedure (e.g. national inventory compilers or scientists), could be allowed to propose emission factors in a standard format, for inclusion into the database. This would require some information pre-processing by the data supplier and would reduce the workload of the database host. Data could be submitted using an Electronic Discussion Group or by email. Special encoding protocols such as XML may be helpful.

Countries could be asked to nominate experts who will participate in the database project, either at the stage of database development or of database population.

Regular meetings of emission factor experts, organised by source category, would help data collection. Currently, no budget is available for such meetings. The TSU should consult the Task Force Bureau for the National Greenhouse Gas Inventories Programme or the IPCC Bureau to see if additional funds could be made available.

The UNECE representative explained that the UNECE uses expert panels for the collection of emission factors in Europe. About 50 people per expert panel meet once a year to assess progress and agree on a work plan for the next period. The expert panels are organised by source category, such as combustion & industry, transport, agriculture and nature. These expert panels work during the year and are co-ordinated via e-mail by the panel leader. Small groups meet if the need arises and resources are available.

The USEPA used 10 people full-time for 1.5 years to create the FIRE emission factor database. This effort represented data retrieval directly from readily available references such as AP-42 and a search through test reports and literature. The effort did not include design and conduct of emission factor experiments. They found it unproductive to process emission factor research reports.

The information provided in the Atmospheric Emission Inventory Guidebook (EMEP/CORINAIR) is very extensive. It is available on the internet. The information has been made available in text not database format. Copying emission factors plus scientific background information into the emissions factors database proposed here may necessitate a considerable amount of person-hours, which would require special institutional arrangements. It needs to be investigated as to whether or not the information can be copied in an automated manner.

The database needs to be advertised and certain capacity building efforts will be required to promote population and use of the database.

9 Quality control: options for inclusion of information and peer review

The workshop participants considered the following options:

- Including emission factors from every possible source. Low quality information is preferred to no information. Only un-referenced data should be excluded.
- Include data from all possible sources, and indicate in a field whether or not data has been submitted through official channels
- Carefully screen information through regular expert meetings, organised by source category. These teams could work in anticipation of the revision of the *IPCC Guidelines*. This is obviously ideal, but might require significant financial and institutional resources that are not currently available. The practical implementation of this needs further discussion.
- Submit data through a limited number of data providers, who would pre-screen the data, in order to maintain quality control. Emission factors could , for example, be submitted through governments.

One participant raised the question of whether a database of, say, one million emission factors could be transparent.

10 Funding

Costs include:

- Functional design of the database;
- Technical design of the database;
- Computer programming; (may be a minor cost element if standard software is used)
- Data research;
- Data peer review;
- Data input;
- Workshops (venue, travel);
- Maintenance of database (server);
- Dissemination of results (sending out CD-ROMs).

Cost scenarios depend on the division of work between partners. Potential partners are:

- The Technical Support Unit of the IPCC National Greenhouse Gas Inventories Programme [11];
- National governments;
- Regional institutions or international organisations;
- Universities.

Organisations that could provide data to the database could be requested to supply the data in a standard format.

The USEPA would look into the possibility of making a database programmer available to the project.

[11] TSU will provide a time-limited in kind contribution. The workshop participants suggested that the TSU could host the prototype database.

If the work programme envisages a high quality product, it will be easier to find funds or generate interest from other parties.

11 Copyright/intellectual property restrictions

All information within the database will be freely available to all users. Copyright matters arising when obtaining information for the database need to be dealt with on a case-by-case basis. In particular,

- Scientific journals: if necessary ask permission to copy emission factor information.
- National greenhouse gas inventory agencies: if necessary ask permission to copy emission factor information.
- Existing (partial) databases: negotiate with the compilers of the databases the terms on which information could be shared.

12 Distribution of the database

- Internet.
- For users without access to Internet: CD-ROM or diskettes possibly split per sector.

13 Working language

English should be the working language. Workshop participants agreed that some provisions should be made for submission of information in other UN languages. They also agreed that this issue should be discussed further.

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ANNEXES

Presentations:

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