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Working Group on Strategies and Review

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Item 3 of the provisional agenda

PREPARATORY WORK FOR THE NEGOTIATION OF A REVISED GOTHENBURG PROTOCOL

TECHNO-ECONOMIC ISSUES

Report by the Co-Chairs of the Expert Group on Techno-economic Issues

1. This report presents the results of the thirteenth meeting of the Expert Group on Techno-economic Issues, held on 29 April 2008 in Stockholm in accordance with item 1.6. of the 2008 workplan for the implementation of the Convention (ECE/EB.AIR/91/Add.2) adopted by the Executive Body at its twenty-fifth session. In addition, the main outcomes on work of the Expert Group's subgroup on emerging technologies for large combustion plants (LCPs), which met on 28 April 2008, are summarized in the annex to the present report.

2. The Expert Group reviewed progress achieved in implementing the workplan, focusing on the work assigned by the Working Group on Strategies and Review at its forty-first session for to the possible revision of the annexes IV, V, VI and VIII to the 1999 Protocol to Abate

Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol) as well as for the revision of the guidance documents on sulphur dioxide (SO_2), nitrogen oxides (NO_x) and volatile organic compounds (VOCs) associated with the Protocol, including also proposals for addressing particulate matter (PM) in the annexes and the guidance documents. In addition the Expert Group reviewed progress made on emerging technologies for LCPs and the revision of the Expert Group's methodology and the background document on LCPs, and considered studies on small combustion installations. Presentations from both meetings are available online at: http://www.citepa.org/forums/egtei/egtei_meetings.htm#Steeringgroup13.

3. Experts from the following Parties to the Convention attended the meeting of the Expert Group: Austria, Belgium, Czech Republic, Finland, France, Germany, Italy, the Netherlands, Sweden and the United Kingdom of Great Britain and Northern Ireland. Also present were industry experts from the European Association of Internal Combustion Engine Manufacturers (EUROMOT) and the French Technical Association of Industries of Hydraulic Binders (L'Association Technique de l'Industrie des Liants Hydrauliques (ATILH)). The French-German Institute for Environmental Research (IFARE), the French Inter-professional Technical Centre for Studies on Atmospheric Pollution (CITEPA) and the French Agency of Environment and Energy Management (ADEME) were also represented. A member of the Convention secretariat also attended.

4. Ms. Eva Smith, Director of the Climate Change Department of the Swedish Environmental Protection Agency, opened the meeting and welcomed the participants. Mr. J.-G. Bartaire (France) and Mr. T. Pignatelli (Italy) co-chaired the meeting, which was hosted by Sweden.

I. ITEMS FOR INFORMATION

5. A representative of the secretariat presented updated information on Convention activities and summarized the relevant outcomes of the twenty-fifth session of the Executive Body (10–13 December 2007) and the forty-first session of the Working Group on Strategies and Review (14–17 April 2008), drawing attention to the time schedule and expected deliverables for the revision of the Gothenburg Protocol and its annexes.

6. The Co-Chairs reviewed the conclusions from the twelfth meeting of the Expert Group (Angers, France, 2 October 2007[1]) and also presented the work ahead, highlighting in particular the extensive contributions that the Expert Group was expected to deliver for the revision of the

[1] See the report of the twelfth meeting by the Co-chairs of the Expert Group on Techno-economic Issues (ECE/EB.AIR/WG.5/2008/2).

annexes and guidance documents of the Gothenburg Protocol. In addition, the meeting was informed that the preparations for a workshop on abatement technologies in the fields of energy production, refineries and cement production in Almaty, Kazakhstan, had been completed to the extent possible, but that in absence of an official confirmation from the Kazakh authorities, it had not been possible to set a date for the event. The Co-Chairs explained that if a workshop in Kazakhstan turned out not to be feasible, another possibility would be to hold it in the Russian Federation.

7. Mr. Bartaire informed the Expert Group about the latest developments in the revision of the European Community (EC) National Emission Ceilings (NEC) Directive, explaining that the final proposal of the revised Directive was expected by the end of June 2008.

II. PROGRESS OF THE EXPERT GROUP

A. Emerging technologies for large combustion plants

8. Mr. N. Thybaud (France) reported on the outcomes of the third, fourth and fifth meetings of the Expert Group's subgroup of experts on emerging technologies for LCPs, held on 25 January 2008 in Brussels, on 17 March 2008 in Paris and on 28 April 2008 in Stockholm, respectively. The subgroup had provided technical and economical information for modelling purposes on emerging or improved technologies and abatement techniques of NO_x, SO_2, PM and the reduction of greenhouse gases for LCPs exceeding 500 MWth up to 2030.

9. The main outcomes of this work are summarized in the annex to this report for consideration by the Working Group on Strategies and Review at its forty-second session. A full technical report is available at: http://www.citepa.org/forums/egtei.

B. Revision of the methodology and background document on large combustion plants

10. Ms. D. Rostal (IFARE) reported on the progress made in revising the Expert Group's methodology and the background document for LCP >500 MWth. Following the incorporation of the feedback from the Czech Republic, France and Sweden that had tested the methodology at the national level, experts from Belgium, Czech Republic, Finland, France and Sweden as well as representatives from EDF and EURELECTRIC had met to discuss how to improve the methodology and the background document further.

11. In view of the likely revision of the EC LCP Directive in the future, the experts had concluded that the methodology should use reference installations based on best available techniques (BAT), instead of referring to the regulatory classes provided by the Directive, and

should provide for abatement measures that allowed reaching BAT levels as a minimum. The reference installation approach used in the methodology would distinguish between the starting year, operating hours, boiler type and fuel type. Furthermore, the experts concluded that in the future the methodology would cover boilers greater than 300 MWth (instead of >500 MWth).

12. The improvement of the background document would be finalized in time for its presentation at the next meeting of the Expert Group. In addition, a short guide to the background document was being finalized to assist the national experts in collecting the technical information.

C. Emission limit values for nitrogen oxides from stationary engines

13. Ms. K. Saarinen (Finland) and Mr. P. Daskalopoulos (EUROMOT) reported on progress in preparing options for new limit values for NO_x emissions for new stationary engines in view of the possible revision of the (table IV of) annex V to the Gothenburg Protocol. The need for this work had been raised by a number of Parties during the review of the Protocol and of its technical annexes, due to the difficulties these Parties had experienced for complying with these values when ratifying the Protocol. On 28 February 2008, a number of national experts from Belgium, Finland, France, Germany, Greece, the Netherlands and the United Kingdom, as well as representatives of industry and engine manufacturers had met in Frankfurt, Germany, at the premises of EUROMOT to exchange information, better define the stationary engines and discuss the internationally available regulations on stationary engines as well as the conditions that have to be fulfilled to achieve the lowest emissions.

14. A second technical meeting would be held in June 2008 in Helsinki to review the two sets of data collected on: (a) country specific legislation; (b) emission limit values (ELVs); and (c) the share of the new stationary engines in national NO_x emissions as well as stationary engines. On the basis of the data collected, the meeting would prepare proposals for revising the limit values for NO_x. All experts were encouraged to contribute to this work by submitting relevant data and to take part at the meeting in Helsinki. According to Ms. Saarinen, the preliminary results of the work indicated that some of the problems with the current ELVs resulted from an error in copying the values to the final text of the Protocol. Further information is available at: http://www.citepa.org/forums/egtei/egtei_Stationary_engines.htm.

D. Work on small combustion plants

15. The Expert Group considered the outcomes of two studies on small combustion plants, including from the view of using this information for the revision of the guidance documents associated with the Gothenburg Protocol, in particular as regards PM from stationary sources.

16. Ms. A. Behnke (German Federal Environment Agency) informed the Expert Group of the outcomes of the German study on the average emission factors for small combustion units in households and the tertiary sector. The study aimed at calculating sectoral emission factors and improving data for several reporting obligations. The study covered approximately 30 million small and medium combustion installations in use by households, the consumer sector and the armed forces, focusing on, inter alia, appliance-specific energy consumption, total fuel consumption and the share of the total consumption for each type of installation, emission measurements for each mode of operation (i.e. the share of full load and part load),and age structure. The types of installations included those operating with light fuel oil, natural gas, coke from hard coal, hard coal briquettes, brown coal briquettes, untreated wood, wood waste pellets, wood chips and straw.

17. The outcomes of the study indicated the highest sectoral carbon monoxide (CO) emission factors from hard coal. For sectoral NO_x and polycyclic aromatic hydrocarbons (PAHs) emission factors, the highest emissions were derived from solid fuels and the lowest from natural gas. The outcomes showed furthermore that even small combustion installations not used regularly by households had a considerable impact on the pollutants emitted, being accountable for example of over 90 per cent of the PAHs emissions. Comparison with the data from 1995 indicated that NO_x emission factors from natural gas had declined mainly due to improvements in the installations. A full report on the outcomes of the study would be available in German. Their English summary could be accessed from the website of the Expert Group.

18. Mr. S. Casarini (Environmental Protection Agency of Lombardy, Italy) presented a study carried out in Italy to better understand the contribution and impact of wood burning within domestic sector to the emissions of air pollutants and the air quality. The study had confirmed that wood combustion was a key source of primary PM_{10} emissions, including in urban areas, while it contributed less to the NO_x and SO_2 emissions. Its results had showed that the emission factors were highly dependent on the type of appliance used, presenting the following percentage shares: open fireplace (45%), traditional stove (28%), closed fireplace (20%), innovative stove (4%) and automatic pellets (3%). The study concluded that regulations limiting emissions of PM produced by small devices burning biomass were increasing; including detailed regulations by type of sampling (cold or hot, regimen or transitory). It had also highlighted the existence of interesting new procedures relating to test certificates, controls, verification and the manufacturer’s registry. On the negative side, the study was able to flag that regulations setting limits did not clearly distinguish between various types of appliances (e.g. open fireplaces, inserts, stoves, pellets). In addition the fixed limits appeared to be too high for small plants with respect to technologies available, in particular for automatic stoves. Furthermore, limits for centralized plants (i.e. 150 mg/m^3, 74 g/GJ) seemed overly high and

not to take into account the abatement systems already available for plants of a certain size. Overall, the study indicated the need for better control systems for PM, PAHs and VOCs.

E. Preparatory work of the revision of the Gothenburg Protocol

19. Ms. N. Allemand presented in detail the work assigned to the Expert Group and the time frame for delivering the expected outputs, in accordance with the work plan for the revision of the Gothenburg Protocol that was adopted by the Working Group on Strategies and Review at its forty-first session (ECE/EB.AIR/WG.5/2008/13). This work would involve:

(a) Proposals to revise the annexes IV, V and VI to the Protocol, specifying limit values for sulphur, NO_x and VOCs for stationary sources, as well as of annex VIII, which sets limit values for mobile sources. In addition to revising annex VI, preparatory technical work would be needed to address the requirement in article 3, paragraph 7, of the Protocol to consider limit values for the VOCs content of products not included in annexes VI or VIII, with a view to adopting an annex. Furthermore, the Expert Group was invited to draft an annex on limit values for emissions of PM ($PM_{2.5}$ and PM_{10}) from stationary sources.

(b) Secondly, the Expert Group was invited to revise the guidance documents associated with the Protocol on sulphur, NO_x and VOCs, and adding PM to them. The Expert Group could cooperate with the Expert Group on PM and the Task Force on Heavy Metals to update the guidance documents on stationary sources for PM.

20. The work for revising of the annexes should be presented to the forty-third session of the Working Group on Strategies and Review in April 2009 and finalized for the forty-fourth session of the Working Group in September 2009 for negotiation and agreement. The updated guidance documents should be presented to the Working Group in September 2009 for agreement.

21. The Expert Group discussed the division of labour, the contributions needed from experts outside the Expert Group, the methods of work and the time schedule for the deliverables. The main conclusions are outlined in paragraph 28 below.

III. CONCLUSIONS

22. The Expert Group:

(a) Took note of the information provided on the:

(i) Workplan and time schedule for the possible revision of the Gothenburg Protocol;

(ii) Revision of the EC NEC Directive;

(b) Welcomed the outcomes of the three last meetings of the Expert Group's subgroup on emerging technologies for LCP (Brussels, 25 January 2008; Paris, 17 March 2008; and Stockholm, 28 April 2008); agreed that the summary of the outcomes be made available by the beginning of June 2008 for incorporation into the Expert Group's report to the Working Group on Strategies and Review at its forty-second session in September 2008; and invited the subgroup to circulate and the full technical report and make it available online at the end of June 2008.

(c) Took note of the outcomes presented by IFARE on the technical meetings held in fall 2007 for the improvement of the methodology and background document on LCPs, including through preparation of a guidance document for national experts to be finalized by September 2008;

(d) Welcomed the work by Finland and EUROMOT to review the limit values for NO_x emissions for new stationary engines in table IV of annex V to the Gothenburg Protocol, involving: (i) holding a meeting bringing together experts from national administration and industry to exchange information, to define stationary engines and to compare internationally available legislation on stationary engines; (ii) collecting information on country-specific legislation, the share of ELVs in national NO_x emissions and data on stationary engines; and (iii) holding a second meeting in Helsinki in June to elaborate a proposal for revising the ELVs in the Protocol;

23. On the work for the negotiation of a revised Gothenburg Protocol**,** the Expert Group:

(a) Agreed that CITEPA and IFARE would divide the responsibility for leading the work in line with their respective experience, as follows;

(i) CITEPA: draft guidance document and technical annexes on SO_2 and VOCs (with solvent contents in products);

(ii) IFARE: draft guidance document and technical annexes on PM and NO_x;

(iii) CITEPA: draft technical annex VIII;

(b) Emphasized the need for inputs from experts representing national administrations, industries, the Expert Group on PM and the Task Force on Heavy Metals for carrying out the work;

(c) Agreed on the following methodology for the work:

(i) Maintain the existing structure of the guidance documents and the annexes;

(ii) Update and complete them as needed and provide an explanation for the proposed changes;

(iii) Provide options for limit values or other means for reducing emissions, for the Working Group on Strategies and Review to consider and to provide a basis for the negotiation by the Parties;

(d) Agreed on a provisional time schedule for the work as follows:

(i) Invite all Parties as well as task forces and expert groups under the Convention and in other relevant forums (the European Union (EU), industry, etc.) to provide relevant recent information to CITEPA by 20 May 2008;

(ii) From October 2008 to March 2009, exchange information among experts (invite comments and information from administrations); Hold expert meetings if necessary (e.g. sector specific meetings);

(iii) By January 2009, submit a document to the Working Group at its forty-third session, to inform it of the progress made;

(iv) Between January 2009 and mid May 2009, submit (revised) proposals to experts for consideration and finalization;

(v) By June 2009, submit finalized proposals for revising the guidance documents and technical annexes to Working Group at its forty-fourth session (in September 2009)

24. The Expert Group agreed to hold its fourteenth meeting on 13 and 14 October 2008 in Sorrento, Italy.

Annex

WORK ON EMERGING TECNOLOGIES AND TECHNIQUES ON LARGE COMBUSTION PLANTS >500 MWTH UP TO 2030

1. This document presents work that the Expert Group on Techno-economic Issues was mandated to carry out, in line with the workplan of the Convention (ECE/EB.AIR/2007/9) on emerging technologies to assess what could be done technically and economically to reduce emissions into the air in the future. The report has been prepared by the Expert Group's ad hoc expert subgroup (LCP2030 subgroup), which was set up to explore emerging technologies and techniques and possibilities for improving existing technologies and techniques until 2030. The work focuses as a priority on the energy sector, in particular the large combustion plants (LCP) > 500 MWth.

2. Emerging technologies could be considered within different scenarios (such as the business as usual (BAU) or optimization scenario). For example, the application of emerging technologies could contribute to lowering of the emissions of the so-called maximum technically feasible reductions (MTFR) scenario and thereby reduce the gap still present between the effect level obtained with the MTFR scenario and the no-emissions effect level. The shift from the RAINS to GAINS models for emissions impacts offers the opportunity to improve assessment of the impacts and costs of emerging technologies on emission reduction over time. A significant improvement in the modelling could be achieved by replacing the current assumption, that the efficiency of abatement techniques is constant over time, with information from the technical improvements of existing technologies and abatement techniques.

I. SCOPE AND OBJECTIVE

3. The scope of the work covers emerging technologies, emerging abatement techniques, emerging applications of existing abatement techniques, improvement of existing technologies and improvement of existing abatement techniques. Techniques or technologies that are not yet commercialised or those that are in a early stages of commercialization would be considered as "emerging". The emissions considered include SO_2, NO_x, PM and carbon dioxide (CO_2).

4. The main objective of this work is to characterize the emerging techniques and technologies considered both technically and economically (ie. provide techno-economic information on them), for example as regards their emission reduction potential and costs

II. METHODOLOGY

5. As a first step, a list of potential technologies/techniques was drawn up, on the basis of IPPC BREF[2] document on LCPs and the EU-project “Assessment of the air emissions impact of emerging technologies” carried out by IFARE and UBA Vienna with a participation of ITA and CITEPA, for the European Commission in the period 2003–2004. As a next step, the full list was reviewed to identify technologies/techniques to be analysed as a priority.

6. The experts in LCP2030 subgroup collected information on the priority technologies/techniques, including through inviting inputs from other relevant experts.

III. MAIN VIEWS AND FINDINGS

A. Development of emerging technologies

7. On the basis of the expert views and the available data, the following emerging technologies were identified as priorities: integrated gasification combined cycle (IGCC) and oxy-combustion, two technologies which could benefit from the deployment of CO_2 capture and storage (CCS).

Integrated gasification combined cycle

8. The net efficiency for existing IGCC plants operating on coal is around 43%(LHV basis). IGCC could reach 50% efficiency (LHV basis) around 2015.

9. Investment cost is estimated at 1 and 1.5 M€/MWth (demonstration plant). A study of the International Energy Agency (IEA) considers than the specific investment cost of IGCC is about 20% higher than that of pulverised combustion. There is, however, more uncertainty in IGCC costs, as there are no recently built coal IGCC plants and the existing ones were constructed as demonstrations. Suppliers have plans to bring the capital cost to within 10% of that of pulverized coal combustion.

[2] Integrated Pollution Prevention and Control (IPPC) BAT reference (BREF).

10. The challenges of IGCC relate to its reliability, availability and investments needed. According to expert views, IGCC technologies could be commercially available around 2020 with CCS.

Oxy-combustion

11. Oxy-combustion enables the capture of CO_2 by direct compression of the flue gas without further chemical capture or separation.

12. Optimizing the competitiveness of the oxy-combustion process for power generation would require several developments, such as:

(a) Adaptation of cryogenic air separation unit for more energy-efficient utilization and operability for use in large oxy-fuel power plants or development of new technologies of oxy-combustion such as chemical looping combustion;

(b) Adaptation of combustion technologies to oxygen firing;

(c) Safe operation under enhanced oxygen firing and CO_2-related safety issues;

(d) Optimization of heat transfer in the boiler;

(e) Optimization of steam cycle in order to compensate efficiency loss due to CCS;

(f) Optimization of the flue-gas recirculation

13. Several 10 to 50 MW demonstrations worldwide are planned up to 2010, with 100 to 500 MW demonstrations possible around 2015. Oxy-combustion technologies could be commercially available around 2020.

14. The reduction of NOx emissions (on mass emissions basis) in oxy-combustion process is mainly due to the very low concentration of nitrogen gas (N_2) from air in the combustor. The decrease of NOx formation is then the result of the recirculation of flue-gas (interactions between recycled NOx, fuel-N and hydrocarbons released from fuel).

B. <u>Improvement of existing technologies</u>

15. One of the ways of reducing CO_2 emissions from fossil fuel-fired power plants is to improve the overall efficiency of plants. Furthermore, because of the penalty of CO_2 capture,

CCS makes sense only for highly efficient plants. The following sections outline the main views of the experts on the improvement of existing technologies.

Coal-fired power plant

16. A study from IEA, “Fossil fuel-fired power generation – case studies of recently constructed coal and gas-fired plants”, provides much information on the performance and costs of proven technology available today to show what has been achieved to date in modern plants in different parts of the world.

17. Currently, subcritical coal-fired power plants can achieve efficiencies of up to 40% and supercritical and ultrasupercritical of up to 45%. From 2020, coal-fired power plants with advanced steam cycle (350 bar, 700°C) could reach efficiency of above 50%. The challenge is the development of materials. These steam cycle conditions would be allowed by the use of nickel-based alloys.

Combined cycle gas turbine

18. Nowadays, the average efficiency of a 400 MWe combined cycle gas turbine (CCGT) is about 58%. In 2008, CCGT with an efficiency of 59.4% are commercially available. In 2015, it is possible to consider that an efficiency of 62% could be commercially available. According to experts, in 2035 CCGT should be able to reach commercially an efficiency of 70% by improving the component efficiencies and by using new materials. The efficiencies of CCGT should reach a ceiling of about 72% towards 2050.

19. The increase of efficiency will follow the increase of the capacity of units. At present, the CCGT units (F technology) have a capacity of 430 MWe (in CCGT configuration). Technology of the H generation has a capacity of 530 MWe. Experts assess that the CCGT units could reach capacities of 600 to 700 MWe in the future.

20. A natural gas-fired combined cycle is more efficient and less expensive than systems based on coal. The investment is shared in ratios of one third for the gas turbine and in two thirds for the steam cycle. Roughly two thirds of the operation costs come from the gas turbine and one third from the steam cycle.

21. The most recently build plants are able to reach 20 mg/Nm^3 (based on a daily average, standard conditions and an O_2 level of 15 %) without selective catalytic reduction.

C. Emerging abatement techniques

22. According to the expert views and the available data, the following emerging abatement techniques were considered by the LCP2030 subgroup as most promising:

(a) Flow Pac for SO_2 abatement;

(b) Fine particle abatement techniques;

(c) CO_2 abatement techniques

(d) Oxygen-enhanced low-NOx technology and oxy-combustion for NOx abatement. (For the moment, it has not been possible to draw conclusions on the basis of the data collected for NOx abatement techniques.)

Flowpac (Alstom)

23. Flowpac is a promising end-of-pipe desulphurization (wet FGD[3]) technology using a bubbling technology instead of circulation pumps. Difficulties and power consumption are minimised by the suppression of recycle pumps, spray nozzles, headers, separate oxidation tanks and thickeners. The electrical consumption is lower in the Flowpac (1.3% of the power capacity) than in the classical wet FGD (1.7/1.75%).

24. The process has a compact design and achieves high desulphurisation rates (> 99%) with high sulphur content fuels (> 1.5%). The sulphur trioxide (SO_3) abatement efficiency is around 60 to 70%.

25. Flowpac presents a low capital cost due to elimination of spray pumps and associated equipment.

26. The system is currently implemented in oil-fired plants (< 340 MWe) and needs to be demonstrated with coal-fired plants.

[3] Flue gas desulphurization.

Fine particles abatement techniques

27. COHPAC and TOXECON technologies have been developed in the United States to capture emissions such as PM, mercury and dioxins. COHPAC in combination with TOXECON offers the ability to significantly reduce mercury, sulphur dioxide and other toxic (dioxins) emissions at a lower investment.

28. The Indigo Agglomerator, developed in the United States, agglomerates fine particles with heavy particles to better capture them. The particles are then easily collected in an electrostatic precipitator. A reduction of the fine particles emissions by a factor 10 is achieved. It seems that the Agglomerator is only used in plants not equipped with wet FGD.

CO_2 abatement techniques

29. CO_2 emissions of fossil fuel-fired power plants can be reduced by energy-efficiency improvement or capture of CO_2 that is released and then stored underground.

30. CO_2 capture processes lead to an efficiency loss of the power plants estimated to be 8 to 12 percentage points for existing coal power plants. Due to efficiency drop with CO_2 capture, increase of efficiency of fossil-fuel fired power plants is the first step. In parallel, a priority is the improvement of energy efficiency of CO_2 capture processes and optimization of the steam cycle for the heat demands for CO_2 capture.

31. There are three types of CO_2 capture processes:

(a) The post-combustion process, which consists of extracting the CO_2 that is diluted in the combustion flue-gas. The post-combustion process is the most advanced technology today. The solvents for CO_2 post-combustion capture can be physical, chemical or intermediate. Chemical solvents such as amines are most likely to be used. The other post-combustion capture solutions are absorption (new solvents, chilled ammonia), adsorption, antisublimation and membranes;

(b) The oxy-combustion process, which consists of burning a fuel in oxygen and recycled flue gas. The gases produced by the oxy-combustion process are mainly water and CO_2, from which the CO_2 can easily be removed at the end of the process;

(c) The pre-combustion process, which consists in a conversion (gasification or partial oxidation) of a fuel into a synthesis gas (carbon monoxide and hydrogen), which is then reacted with steam in a shift reactor to convert CO into CO_2. The process produces highly concentrated CO_2, which is readily removable by physical absorbents. Hydrogen (H_2) can then be burned in a gas turbine. For the moment, none of the existing coal-fired IGCC plants includes shift conversion with CO_2 capture.

32. The level and nature of impurities in the CO_2 stream can affect its transport and storage. The CO_2 purity level will impact the choice of pollutant abatement techniques.

33. Some CO_2 processes are also sensitive to pollutants. For example, NO_2 and SO_2 from the flue-gas react with the amine (post-combustion capture) to form stable, non-regenerable salts and so cause a loss of the part of the amine. With amine, SO_2 specification is usually set as < 40 mg/Nm^3 and nitrogen dioxide (NO_2) specification as < 50 mg/Nm^3 (based on a daily average, standard conditions and an O_2 level of 6 %).

34. Limits for SOx can be achieved by some FGD technologies. Experience from CASTOR pilot (post-combustion capture with amine) showed that limestone gypsum FGD plants can be designed to reduce SO_2 emissions down to 10 mg/Nm^3 with an increase of capital costs by up about 7% and 27% of operating costs.

35. Limits for NOx are technically achievable by the use of low NOx burners and SCR.

36. A field of CCS technology is available, but it is not of a mature enough status for application to LCPs. CO_2 capture and storage in power plants is being demonstrated in a few small-scale pilot plants. Large-scale demonstration plants with CCS are planned for around 2015, with the objective of developing CCS by 2020.

37. CCS costs are highly project-specific. Many techno-economic studies give information on performance and costs. Nevertheless, data on large-scale CO_2 capture implementation are not available. The objective is to reduce CCS costs to below 25€/t CO_2 avoided by 2030.

38. There is no consensus on which option (post, pre or oxy-combustion) will cost least in the future, each has pros and cons and the costs appear to be comparable.

D. Improvement of abatement techniques

39. No significant improvements of existing abatement techniques have been identified compared to the information already available in the European BREF document on LCPs. The IEA study on fossil fuel-fired power generation reports some very low emissions for a few recent constructed coal power plants.

40. In order to compare existing data with the modelling data and to update them, costs and performances of abatement techniques of existing installations have been provided by the experts.

Emerging applications of existing abatement techniques

41. Only SO_3 injection was identified as an emerging application of an existing abatement technique to reduce PM emissions.

Other information

42. The increasing of cost in relation with net efficiency of power plants and the increasing of costs of plants and emissions abatement systems have been mentioned by the experts.

Main conclusions and future work

43. The efficiency penalties of CO_2 capture will become lower for future power plants as the trend to higher efficiencies continues, with efficiencies above 50% now in sight.

44. Some technologies/techniques (e.g. catalytic combustion), were considered as outside the scope of the LCP2030 subgroup, which considered only power plants with capacities higher than 500 MWth. Future work of the subgroup could consider lower capacities of LCPs (e.g. > 100 MWth).
