C3 - 00

SPECIAL REPORT FOR SC C3
(System Environmental Performance)

Special Reporters

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Introduction

The main mission of SC C3, created in 2002, is to present unbiased positions and produce approaches on power system environmental performance and impacts and their implications for management, operation and investment decisions.
While the environmental issues related to power system planning and to component and sub-system design and operation are dealt with inside other specific study committees, SC C3 is focused on "system" aspects.
The study committee activities are focussed on the following main Technical Directions:

TD1. Power systems development/operation and environment
TD2. Global environmental changes and power system
TD3. Public acceptance of plants and infrastructure, stakeholder engagement and communication
TD4. Power sector efficiency and environment.

The evolution of modern power systems has been mainly shaped by the key objective to supply electric energy with the highest degree of reliability and security of supply. Recently the need for a more efficient operation of the system, with the aim to reduce prices and increase the quality of service, has led to the unbundling of the vertically integrated power utilities and the liberalization of electricity generation, distribution and sales, while the growing concerns for environmental impacts have stimulated the wide integration of renewable energy sources and dispersed generation in the power system.

Social and sustainable development considerations are also a key driver in the broad context of system environmental performance.
Sustainable development is a very wide concept that affects the entire value chain of the electric sector. The three pillars of sustainability are:

- People: affordable and accessible power
- Planet: acceptable impacts on a global, regional and local scale
- Profit: reliable power for the development, adequate investments and returns.

The great challenge that electric power systems have to face today is how to incorporate sustainable development concepts and practices into the system planning and development, on one side, and into day-to-day plant operation and maintenance on the other. Secondly, energy storage technologies are very "hot" nowadays in our sector. Storage is also very important for increasing sustainability, especially in the case of connecting wind, solar and water energy to

our customers. Last but not least, it should be noted that communication and stakeholder consultation and engagement (aiming for better awareness and participation) are still crucial issues for the development and operation of power systems, particularly near urban areas. That is why we have the following preferential subjects for our group discussion meeting in the Paris 2014 session:

P.S.1: Environmental implications of energy storage technologies
P.S.2: Integrated sustainable approaches for T&D development
P.S.3: Acceptance of high voltage transmission assets near urban areas

A total of 20 papers have been selected for the 2014 session, divided over the three Preferential Subjects: two for P.S.1, twelve for P.S 2 and six for P.S.3.

1. P.S.1 - Environmental implications of energy storage technologies

1.1 General

The development of renewable and intermittent sources for electricity generation drives a renewed interest in energy storage solutions to help the balancing of load and consumption in the power system. The future power system with a large share of renewables will mix grid solutions which help to mutualise energy sources and take advantage of long distance power exchange, with flexibility solutions including demand side response and energy storage.
The latest is more crucial for isolated systems, such as islands, which cannot take benefits of a large scale interconnected system.
Any case, new infrastructures have to be developed, some of them on a dispersed basis (for example, battery storage) or for large scale power (for example, pumped hydro storage). Being able to compare different strategies on an economical basis, as well as their environmental implications, is essential to achieve the most sustainable choice and explain it. Each technology has specific functional characteristics (ratio between power and energy, storage duration, losses, dynamic behaviour) and environmental implications. A set of methods should be shared in the coming years to evaluate the environmental implications from a system perspective, and compare the different technological alternatives, taking into account social acceptance. The Cigré C3 work will help in this task and the preferential subject develops the first building block which can be further developed with increasing shared experience on a variety of cases.

1.2 Papers description and discussion

C3-101: In Brazil, the electric energy production and transmission National Interconnected System is characterized as hydrothermal, with hydropower plants being complemented by thermal and other generation sources. To keep its efficiency requires the development of a range of projects with hydraulic reservoirs, for accumulation and/or balancing of electricity flows.
In the meantime the environmental licensing process for hydropower has been increasingly complex in Brazil, particularly in the case of reservoirs and dams because of the environmental and social acceptance issues.
The lack of new projects capable of regulation and accumulation create serious consequences for the operation of the Brazilian power system: therefore the reservoirs are important not only for its ability to stabilize the waterways in which they are located, but also to provide

flexibility for the National Operator of the System, minimising thermal dispatch, and also facilitating integration with new renewable sources such as wind.
This systemic configuration offers adverse consequences such as the inability to control floods and greater requirements on the power plants that have regulating capacity, requiring higher thermal dispatch due to the need to meet seasonal supply load.
Developing reservoirs helps to improve the strength of the system, for the improvement with institution, contributes to consolidating security and operational flexibility of the National Integrated System, showing clearly and objectively that the environmental issue, if properly crafted, may make full use of the national energy potential.

C3-102: In the Italians islands (mainly Sicily and Sardinia) during some parts of the day where renewable generation exceeds the local load, and cannot be valorised in the national network because of limitation in the transmission system.
Marine Pumped Energy Storage (MPES), where the upper reservoir is located on top of a steep shoreline and the lower reservoir is the sea, is more and more being considered as a viable alternative for energy storage, especially for islands and coastal areas with significant density of non-dispatchable RES generation.
RSE, in the theme of the nationally-funded "Electric Power System R&D" Program, developed a MPES project for a site in south-western Sardinia. The site was chosen according to the character of the coastal area (e.g. enough steep cost profile, flat or gently rolling area on the top) and the presence of wind power parks in the surroundings.
In the environmental assessment phase, all the environmental constraints (e.g. protected areas, etc.) and territorial constraints (e.g. landscape issues, historical building presence, etc) have been examined and evaluated. Particular attention has been devoted to carefully choose the proper location and the size of the reservoir, in order to optimize the balance between excavation of material and its movement and therefore to minimize both the visual impact and the need of material disposal.
Finally, the construction phase impacts were analysed and the appropriate mitigation measures identified.

The experience gained by RSE in instructing the marine pumped hydro project in Sicilia highlights the importance of choice of site to get a good balance between environmental impacts and global environmental benefits, mostly through the better efficiency in RES integration. Among other factors to be considered, the location relative to the transmission network, the impact on human activity, biodiversity preservation and other environmental implications have to be mitigated with adequate geological factors. Respecting this, Marine Pumped Hydro technology can offer a good solution to facilitate RES resources and valorisation in weakly interconnected power systems.

1.3 Questions

Question 1.1
Both papers highlight the advantages of hydraulic reservoirs or marine pumped hydro storage to balance intermittency of renewable energy, compared to equivalent thermal dispatch. What is the evaluation of the greenhouse gases emission relative to the development of the reservoir in the forest area? (This could include methane emission from to organic matter decomposition, reduction of the forest surface which decreases the absorption of CO_2, load losses along the transmission network, etc.) Or marine pumped hydro compared to an equivalent thermal dispatch solution**?**

Question 1.2
The projects in both papers address acceptance issues: getting social acceptance, when the local population do not get direct benefits from the project, is always challenging. What are the initiatives to solve this contradiction? What are the impacts of the project on local economic activity (fishery, settlement, agriculture, maintenance, etc.)?

Question 1.3
Both papers relate to high power storage equipment, with potentially high environmental impacts and which could also have problems of public acceptance. Dispersed storage solutions, such as batteries, seem to be more acceptable to population. Impact of each component is light because of their size, but what about the environmental impact of the whole set? What is the method to assess it?

2. P.S. 2 - Integrated sustainable approaches for T&D development

2.1 General

This preferential subject speaks about integrated sustainable approach. What does that mean? "Integrated", according to the dictionary, means making complete, to become a unit, look at the whole system. If we look at the 12 papers, we can say that overall most of the topics concerning our sustainable approach are dealt with. Some papers deal with the whole chain of T&D development, as they are looking at life cycle assessment for the whole company, or performance indicators to determine the effects on the grid.
Other papers write about parts of the system like magnetic fields and interferences, acceptance of our work by stakeholders, advice about declining CO_2 footprint, environmental effects of a new line/cable, bird collisions and so on. Together they cover nearly the system's entire field.
At the end we can conclude that all the papers together will give a nearly complete overview of all the aspects concerning the integration of approaches.

There are several definitions of sustainability. But most of us working with sustainability agree that sustainability is about the three P's: people, planet, profit. Roughly speaking, we can conclude that half of the papers are dealing with "planet" and the other half with "profit". There is no single paper that specifically writes about "people". It seems that more often, sustainability forgets the aspect of "people". Some papers are dealing with public acceptance. One can say that this is about the "people" aspect, but I dare to say that measurements and behaviour to increase public acceptance is more belonging to the "profit" factor. In the questions this aspect will be addressed.

2.2 Papers' description and discussion

In this preferential subject, twelve papers have been selected. All of the papers give some interesting insights that allow us to have a good discussion at our technical meeting. The main topics are:

- Integration of RES is a main driver for many papers.
- Life cycle assessment (LCA) is written about in several papers, and all authors are enthusiastic about this instrument.

- The sustainable approach is highlighted at several levels; some for high and some for low voltage lines (you can say for transmission and distribution systems), some are dealing with the whole system, some are focussing on parts of the system.
- There are several papers which describe some new innovative solutions, in order to increase sustainability.

The papers have been classified into three main groups:

1. Papers, focussed at one part of the chain
2. Papers, focussed on the whole chain
3. One paper that is "meta-integrated", a paper that describe one part of the system, but the main message is not the part itself, but gaining opportunities to allow more RES and dispersed generation into the grid.

2.2.1 Focussed at one part of the chain

The first group of papers deals with parts of the system. There are papers about magnetic fields, about eco-designed switchgear, about a sustainable substation and about bird collisions (C3-201 from Argentina, C3-203 & C3-205 from France, C3-210 from Romania and C3-212 from Korea). All these papers present a focussed and specific point of view and describe some new or recent inventions.

Paper C3-201: It is well known that substations, power lines, cables and transformers in the energy system generate both power frequency and high frequency electromagnetic fields in their vicinity. In particular power frequency magnetic fields have gained much interest lately and have led to specific limitations in various countries in the world. This paper describes some methods to damp the magnetic field from transformers and cables close to the source of the field. The use of metallic screens, both single and multiple, was investigated in laboratory measurements and in practice in transformer stations. The report shows that a considerable attenuation can be obtained.

Paper C3-203 writes about the study to make substations more eco-designed. In order to find the best measurements and the optimum design rules, LCA was used to determine the best practices. There are 18 environmental indicators investigated in this LCA, like global warming, freshwater eutrophication and urban land occupation. The paper describes the process of four steps (definition of goal and scope, collecting data, impact assessment and interpretation of results). Next, the LCA methodology is applied for two examples.

Paper C3-205 is the second paper to describe how to achieve a more sustainable substation. The goal was to build a new substation that has less environmental effects and can be used as a "showroom". The focus was mostly on reducing the CO_2 footprint, especially of the layout/ construction of the substation: the different assets of the substation were not included in the investigation. It resulted in several innovative solutions for substation level equipment.

Paper C3-210 is about bird collisions. The paper describes the three most important effects that overhead lines will have on birds; reduction of land/habitat, collision with ground wire or conductor, and electrocution. Besides planning the new route of an overhead line in a proper way (like bundling the overhead line next to a main road), the paper gives an overview of some technical solutions (another type of tower, using other colours) and of some nearly new devices like bird flight diverters.

Paper C3-212: High frequency fields may be the source of disturbances and may cause mal-operation or even damage in particular to low voltage equipment not only in the substations themselves, but also in close vicinity of the energy system. This paper describes a simple method to reduce the effect of transient voltages on the DC feeding connections to protection relays. A ferrite tubular ring is placed around the wires that attenuate the disturbances to a level that no longer causes mal-operation. The development is supported by measurements on actual equipment

2.2.2 Focussed on the whole chain

The second group of papers is about the whole system of transmission or distribution. Some of them look at the system as a whole (C3-202 from China, C3-209 from Japan, C3-211 from Iceland), while others are looking at all the different individual aspects, but added, it also gives a nearly complete, integrated overview of all aspects concerning the whole system (C3-204 from France, C3-207 & C3-208 from Spain).

Paper C3-202 describes the efforts that take place in China, to increase the awareness of the public about welfare of the grid and the environmental protection made by the enterprises. In order to do so, it was decided that a complete system of environmental performance indicators should be established. The paper describes several methods which can be used to determine the effects of the grid on the environment. The paper refers to four different kinds of indicators: management and operational performance indicators, energy saving indicators and environmental indicators.

Paper C3-209 is about the use of life cycle assessment (LCA). The authors are pointing out that LCA is a powerful tool to give information about how to reduce the environmental effects of the electric system. LCA can be used on the different devices within the system, but also for a holistic overview of the best ways to make the system more sustainable. Looking at individual apparatus, makes it possible to determine the dominant factors of environmental effects, but by applying the individual results to the whole system, helps to design the most optimal power system as well.

Paper C3-211 also describes the use of LCA. In Iceland, LCA was, on the one hand, used to determine the environmental effects of transportation of 1 kWh during the whole life cycle, and on the other hand LCA was used to determine where in the whole life cycle the most important environmental effects are taking place. As in paper C3-209, the authors emphasize the importance of LCA as a powerful tool for the decision making process. Most important in this study is the line itself and the transportation losses.

Paper C3-204 is focused mostly on the acceptation of new overhead lines by different stakeholders. The authors distinguish four groups of stakeholders; local residents, all other local stakeholders, (managers of the) TSOs and the regulator. For all of these groups, they defined the most important topics. Where the only topic of the regulator is cost, the other stakeholders are involved with more topics, although they differ from each other. TSOs are mostly concerned with safety, technical issues and economics; the residents are mostly interested in issues concerning their individual health, like visual impact, noise and EMF, while other local stakeholders are mostly focussing on the bigger issues for the local community, like town planning, quality of electricity, biodiversity and so on. The end of the paper describes an example of how all the different stakeholders are involved in an actual

project. Stakeholders have had the opportunity to influence the shape and the track of the new overhead line. The project is still going on, but the results until now are promising.

Paper C3-207 presents an overview of the technical and environmental aspects of the construction of a new interconnection between Spain and France, from which a part is built as a cable. All the aspects belonging to the construction of a new overhead line and divided in several accessories, like the converter substation, an overhead line and a cable. Also the defining of the route is discussed. Finally, the paper also gives some insights on the difficulties with an interconnection, relating to different laws in both countries, not only laws about the electrical system, but also about environmental issues.

Paper C3-208 describes the usefulness of 3D geodesign for the planning of new electricity networks. The authors give examples of the use of 3D geodesign in every phase of the design, construction and building of a new grid, also including the use of 3D for communication and negotiation. 3D seems to achieve some good results in the administrative process, in increasing productivity and in reducing costs and time of the process.

2.2.3 "Meta-integrated"

Paper C3-206 from Germany is the only paper in this group. After reading this paper the first time, it seemed to describe one small particle of the whole system. But in fact, the description of this new invented solution (voltage regulated distribution transformers, VRDT), allows companies to increase the grid integration capacity for renewable energy sources and dispersed generation. The VRDT itself is not a solution for negative environmental effects, but in this way a small solution for a small part of the system, will make the whole system more sustainable for a longer time.

2.3 Questions

Question 2.1
As written in the general comments, sustainability is about the three Ps: people, planet and profit.
Not one of the papers is really focused on the aspect of people. So the question is for all the authors: can you explain why you did not pay attention to this aspect? Can you give us more information about the attention your company gives to this aspect? The papers are all written from a technical point of view, but do you have the impression that your company also gives enough attention to the "people" aspect? If not, can you give some recommendations about how to improve this?

Question 2.2
Some papers (C3-201, C3-205, C3-207, C3-208, and C3-210) describe a newly invented or innovative contribution for improving sustainability. Are there any experiences around the world that comes close to your innovative solution and what are the differences we can learn from?

Question 2.3
Papers C3-203, C3-209 and C3-211 all speak about LCA and all authors explain that LCA is a powerful tool. But all the papers describe another situation and another use of LCA. Can you give us some recommendations about how and in which situations the use of LCA would

be preferred and otherwise in which specific situations the use of LCA will not be of any help?

Question 2.4
Paper C3-203 shows us in figure 4 the comparative LCA between the former and the new 252 kV GIS. In the text under this figure, the authors write that "this reduction has been mainly achieved thanks to the reduction of the Joules losses during the use phase…" Can the authors explain this more, because the statement can't be read from figure 4?

Question 2.5
Paper C3-204 presents an example of how all the different stakeholders are involved in an actual project. Stakeholders have had the opportunity to influence the shape and the route of the new overhead line, by responding to the three designs of new tower. It is stated in the paper that "Rte acquired three designs of a high tower …" Can you give us more information about how Rte decided that it should be these three new designs, how the new designs are acquired and in which way the public was involved in these selection of these three designs?

Question 2.6
Paper C3-202 refers to four different kind of indicators; management and operational performance indicators, energy saving indicators and environmental indicators. Can the authors give some indication about how and when the use of these different indicators is most convenient? When can companies use the one indicator and in which situations is another indicator better? Cigré published a technical brochure in 2008 about sustainable performance indicators (WG C3-02). Is this brochure taken into account in this paper?

Question 2.7
Papers C3-201, C3-203 and C3-210 are giving us information about a small part of the system, focused on one example. Do the authors believe if it is possible to expand their solutions to other situations? In other words, is it possible to use the results by other companies? If the answer is yes, what conditions are needed to do so?

Question 2.8
Paper C3-201 describes several methods to damp the magnetic field. Do other utilities and power station owners use similar methods to reduce the magnetic field near transformer stations? And if so, have similar results been obtained?

Question 2.9
Paper C3-212 describes a method to reduce the effect of transient voltages on DC feeding connections to protection relays. Have similar solutions been developed by other companies? And could the use of more sophisticated filters consisting of reactors and capacitors lead to even more reduction of the disturbances?

Question 2.10
The solution described in paper C3-206 is applicable for low voltage networks. But, like in Germany, more countries and regions are facing the same problem of connecting renewable energy on to the grid. And often renewable energy is connected to the high voltage grid (for example, connecting big wind farms off shore to the national 380 kV grid). Is your described invention of VRDT also applicable for the high voltage network?
The paper also says that a benefit of VRDT is that it allows companies/ utilities to delay the expansion of the grid. Can you give us any indication about how long the delay can be? Or, in

other words: VRDT facilitates a bigger quantity of PV-systems, then without this technology. But how much more is this?

P.S.3 – Acceptance of high voltage transmission assets near urban areas

3.1 General

This Preferential Subject is very closely related to the work being undertaken by JWG C3/B1/B2.13. The Joint Working Group is examining two key questions:

- How do transmission organisations route new lines near urban areas?
- How do transmission organisations deal with proposals for new built development near existing lines?

The public acceptance of transmission assets is becoming a bigger and more difficult issue to manage. Many communities throughout the world no longer see electricity provision as simply a benefit to their wellbeing and economy: now they often say, why do we have to have this power line or substation near us, and how do we know it is not going to damage our health, affect the value of our land or property, and how do we know it is not harmful to the environment. These issues become even more prominent near densely populated areas, where often the route of a high voltage line (either existing or proposed) has the twin constraints of nearby population and environmental designations.

3.2 Papers description and discussion

These issues are the themes behind the six papers submitted under P.S.3. Papers C3-301 from Belgium, C3-303 from Egypt and C3-305 from Korea all consider issues around new transmission line proposals. While the Egyptian paper considers environmental impact assessment (EIA), both the papers from Belgium and Korea consider issues of public acceptance for new high voltage proposals. C3-301 highlights the key issues which prevail throughout this Preferential Subject. They are:

- visual impact,
- EMF and
- compensation and / or possible loss of property value.

These three key issues are addressed – either singly or together – in all six papers. Each is considered in turn below.

3.2.1Visual impact

C3-306 focuses entirely on landscape and visual impact, but from the point of view of substations. The authors point out that for many people and in the opinion of many authors, the main impacts of a structure are those which can be seen, i.e. visual impact. They state that visual impact depends on

- the quality of the original landscape
- the external appearance of the structure being designed
- the extent of area that the structure can be seen from, and the frequency of which it can be seen
- the time when it is evaluated

- the sensitivity of the observers.

They say that the need to conserve the landscape is a product of society appreciating it. The paper goes on to say that as there are 1,260 different landscape types in Spain, it is unfeasible to design a substation model for each type. They describe a methodology for integrating substations into the environment using 12 substation models, which deals with the external appearance of substations. The paper includes many useful references.

While the theoretical aspects of visual impact are dealt with well in C-306, public perception and opinion regarding visual impact are covered in the papers C3-301 from Belgium and C3-305 from Korea. The TSOs of both countries are proposing major new high voltage transmission lines – a 765kV route in Korea and a 380kV route in Belgium. Both routes pass by or through areas of population, and both are subject to much public comment which needs to be addressed by both TSOs.

C-301 shows that visual impact for the Belgium project was addressed at SEA, EIA, planning and permitting processes. Zones of influence and visibility analysis were undertaken. Route selection is key to the mitigation of visual impact: the project uses existing lower voltage corridors (including undergrounding the existing lower voltage line), and bundles additional circuits in existing routes, so minimising the need for new towers on a new route. Interestingly, some undergrounding is proposed near the city of Bruges, but the paper states that this is because of a European environmental designation (Special Protection Area under EU Natura 2000), rather than visual impact on its own.

In addition to routeing, C-301 discusses the use of insulated cross-arms on towers, bringing the phase bundles together, and so giving the proposed 380kV double circuit towers the same height as the existing conventional 150kV towers.

While C3-305 states that visual impact is an issue for the Korean project, the paper focuses on other issues being raised by the public (discussed below).

The issues are different for the Egyptian project (C3-303), as 90% of the 252 km double circuit 500kV overhead line crosses desert area. The project would connect wind resource at the Red Sea to the more developed Nile area. The impacts mostly relate to effects on the 10% of the route through agricultural areas, and social effects, rather than visual impact which is not regarded as an issue.

3.2.2 EMF

Papers C3-301 (Belgium), C3-302 (Brazil), C3-304 (South Africa) and C3-305 (Korea) all deal with EMF.

Brazil (C3-302), in particular seems to have a very severe potential problem with EMF, because a legal challenge to the Brazilian law on EMF could potentially succeed in reducing magnetic field exposure from the ICNIRP guidelines of 83.3 µT, and 416.7 µT at the edge of the right of way, to a level of 1 µT. The judgement has now been appealed to the Brazilian Supreme Court.

Clearly, if the 1 µT level has to be introduced, then it will have very severe cost implications to the Brazilian TSOs and to consumer bills, as either option to comply – increasing the width

of the right of way or increasing tower height - are extremely expensive for the whole network. Costs are estimated of US$ 38 to 79bn and of US$ 17.7 to 23.0bn respectively to comply. Many people in the industry would believe that the cost of implementing these onerous magnetic field provisions clearly outweigh any benefit they would bring. The level would also go against the guidance produced by the WHO which states that 'policies based on the adoption of arbitrary low exposure limits are not warranted.'

As mentioned above, Korea (C3-305) is investigating EMF issues related to the proposed 765kV overhead line. A 2-year research programme including a test line was set up to investigate these issues. The Korean government has set its own guidelines for magnetic field in law and these are set at 83.3 μT. In addition to this the TO has sought to reduce magnetic fields according to WHO's factsheet guidance.

In addition, KEPCO through their research programme have developed two mitigation techniques for reducing magnetic fields:

- Shielding using passive currents in a wire loop - essentially a magnetic field is induced in the loop which partially cancels the magnetic field from the overhead line. Computer simulations were used to find the optimum reduction in magnetic field. By increasing the passive loops capacitance a reduction in the magnetic field of 67% was achieved. These passive loops introduce additional wires below the bottom cross arm.
- Magnetic shielding with soft magnetic materials. Two different materials of 0.35mm were used to shield the ceiling and windows of a building directly under the overhead line. The magnetic field was reduced between 55 to 67%, reducing a 5 μT to 2.2 μT

The costs of each method were assessed for a single span. These were passive loop US$ 4000m and magnetic shielding US$ 3000m. However the higher costs of the passive loop were due to tower development and the costs of these would be lower long term.

In Belgium (C3-301), in relation to the proposed 380kV line, the public have expressed concerns relating to health, specifically in regard to childhood leukaemia and the IARC classification of magnetic fields as 'possibly carcinogenic to humans' Group 2B. The paper explains that the TSO's approach was to calculate the number of children who would be exposed to 0.4 μT (the level of exposure associated with an increased risk of leukaemia) along the route both before and after the new connection is fully commissioned. They found that the number of children along the route exposed to 0.4 μT or above decreased from 193 to 82 children as a result of the project because of the proposed decommissioning of an existing 150 kV line. Careful routeing was employed to reduce the number of inhabitants to 0.4 μT.

C3-304 considers EMF from a dosimetry perspective. Dosimetry is essentially a computer based model of the human body including organs, nerves, bones etc in order to calculate what level of induced current or electric field is present when standing in EMFs of various strengths. Over the years this area has advanced significantly, with better models and advanced computing meaning that we can be more accurate about the how strong the field has to be to reach the basic restriction. There is very large safety factors applied to the numbers so they are very conservative.

In South Africa a plan to upgrade of an existing 88 kV single circuit line to a new 132 kV double circuit, has resulted in the public questioning the health implications of the upgrade. The TO has undertaken an assessment of the EMF which would be produced and compared

this to Guidelines produced by ICNIRP (1998 and 2002) and the guidance from the International Committee for Electromagnetic Safety (ICES) 2002. Both the ICNIRP and ICES exposure guidelines have limits based on limiting the induced currents (IC) or electric fields (EF) within the central nervous system. However this is not practical to measure in real terms, so they provided electric and magnetic field strength, derived from dosimetry computer based anatomical models, which ensure these induced currents are not exceeded.

The South African TSO decided to perform their own dosimetry rather than using the external field strengths provided by ICNIRP or ICES. The new South African development is fully compliant with all the noted exposure guidelines. The paper highlights that a number of factors including anatomical model used, tissue conductivity values, body position, voxel size etc., can all lead to large variations in results

3.2.3 Possible loss of property value

Perceived loss of value of houses or other land or buildings, either because of proximity to an overhead line or because building is prevented below conductors, is an issue to be considered in many countries. Many countries compensate land or property owners whose land is taken by the right of way, and increasingly some countries are considering some form of compensation or benefit for those outside the right of way, but who may still be impacted.

C3-305 considers the issue of building under overhead lines. In the past in Korea, building under lines was forbidden by law, but with the proposed use of 765kV lines, this restriction was relaxed in 2013 to help with property values. A research project is underway in Korea to establish safe limits to building under these lines. It will examine rise of earth potential, electrostatic and electromagnetic induction, EMF, audible noise, and radio and TV interference. It is also considering risks to the line from fires in buildings below.

C3-303 from Egypt describes that compensation is payable to farmers for loss of agricultural production and restricted land use. Farmers can opt to sell the land for the right of way to the TSO, or to keep the land and accept compensation for restricted use of the land (no buildings, permanent structures or tall trees). All farmers chose the second option. Compensation is negotiable and corresponds to between about 50% and 100% of the value of purchasing the land.

In addition to compensation and ‘right-to-build’ below the line, Korea is also considering the introduction of compensation to private land owners on a ‘sliding scale’ out to 1000m on each side of the 765kV line.

Belgium (C3-301) similarly is considering compensation to owners beyond the right-of-way, up to a distance of 100m. Again it is on a sliding scale of payment, but relates to property value.

3.3 Questions

Question 3.1
A question for all the authors: how has stakeholder involvement shaped either the project or the topic of the paper? For instance, for C-304, did the public or stakeholders request that

dosimetry studies be undertaken? And for C-301, has public involvement been part of the decision to opt for an insulated cross-arm tower design?

Question 3.2
C3-301 and C3-305. Would an alternative proposal to underground the planned transmission line (perhaps more circuits at lower voltages) have benefited the project in terms of cost and programme? Would the additional cost of undergrounding outweigh the costs of delay caused by stakeholder objection, and the efforts needed (e.g. research projects) to respond to their complaints and concerns?

Question 3.3
Can the authors of C3-303, C3-305 and C3-306 explain whether (and how) the impacts on ecology, biodiversity or cultural heritage have been considered in their projects?

Question 3.4
C3-301, C3-303 and C3-305. Have compensation arrangements reduced the number of stakeholder and public objections to projects?
C3-306. Has the landscape methodology you developed reduced the number of stakeholder and public objections to projects?

Question 3.5
Question for C3-301. Does the Flanders 'stand-still' principle, of not creating a net increase in the length of overhead lines, cause a great difficulty in planning and designing new overhead line routes? On the face of it, such a principle seems an attractive proposition for other Governments or Municipalities: do you see it being widely used elsewhere? Are there good arguments to oppose such a principle?

Question 3.6
C3-301, C3-302 and C3-304. Why are health concerns such a major issue for the public in some countries? Is it due to journalist/press coverage, poor communication about risk by electricity organisations, unwillingness to accept any change, or a genuine concern?

Question 3.7
Health concerns regarding overhead lines are often a major topic in deciding whether overhead line projects should be permitted. Can the authors of C3-301, C3-302 and C3-304 give their views on the best ways of communicating about EMF and giving reassurance to the public about health issues? Why are EMF exposure guidelines set by ICNIRP or other international bodies not always accepted by communities or by Governments? What more can Cigré members do to reassure the public?