

# Chemical Disarmament: Current Problems in Implementing the Chemical Weapons Convention

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The Chemical Weapons Convention (CWC) is briefly characterised by stressing its main pillars, such as verified destruction of CW stockpiles and destruction/conversion of CW production facilities (CWPFs), verified non-production of CW by the chemical industries, assistance and protection), and international cooperation. The CWC's leading principle in defining the CW (protecting it generally against scientific and technological development, i. e. so called *General Purpose Criterion*) is thoroughly elucidated showing its relation to the CWC's sophisticated verification system. Status of implementation (as of August 2005) shows main data obligatory declared by the States Parties (SP), among them 6 possessors of CW stockpiles (Russia, USA, India, South Korea, Albania and Libya). From the declared 71 373 agent-tons, 12 889 have been destroyed, from the declared 8 679 M items of munitions (containers), 2 420 have been destroyed, which means that the anticipated 10 years deadline for CW destruction (after entry into force – EIF) will be not managed. For Russia and USA the allowed extension by another 5 years has been already agreed. From the 64 CWPFs (operational after 1946), declared by 12 SPs, 53 have been certified as destroyed/converted. The Organisation for the Prohibition of Chemical Weapons (OPCW) is briefly presented and main results of the First Review Conference (2003) analysed on the base of the adopted principal documents. Future problems of implementing the CWC are connected in the first line with its universality, because among 16 non-SPs, several countries (located mainly in the Near East and on the Korean peninsula) are presumed to be CW-possessors. Special emphasis is laid on both, threats and benefits of the scientific and technological development for current implementing the CWC as well as of its implementation in future after all CW stockpiles have been destroyed.

Keywords: *Chemical weapons (CW), Chemical Weapons Convention (CWC), Organisation for the Prohibition of Chemical Weapons (OPCW), 1st Review Conference, Scientific & technological development*

## Introduction

Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction, shortly depicted as Convention on general and comprehensive prohibition of chemical weapons, or Chemical Weapons Convention (CWC), was adopted in 1992 after complex negotiations on the soil of the Conference on Disarmament (and previous multilateral negotiating fora in Geneva), lasting for nearly a quarter of a century. The reason was not only then proceeding East-West confrontation and the Cold War but mainly difficulties given by the worldwide spread of chemical industry and relatively easy possibility of clandestine synthesis of chemical warfare agents in militarily relevant quantities. This and also bad experience with previously adopted Convention on the Prohibition of Development, Production and Stockpiling Bacteriological (Biological) and Toxin Weapons and of Their Destruction (BTWC) opened for signature in 1972, entering into force in 1975, lacking in the first line any objective verification mechanisms, has been reflected in very careful definitions and criteria, defining purposes not prohi-

bited by the Convention and mainly very complex and sophisticated verification system. The CWC is by no doubt the best elaborated disarmament document, totally outlawing one important and very dangerous kind of weapons of mass annihilation, committing the States Parties (SP) to destruction of the chemical weapons (CW) stockpiles and production facilities (CWPF). Ten years after opening for signature and six years after entry into force (EIF), the First Conference of the SPs reviewing operations of the CWC has been convened in The Hague, stating generally good acceptance by the international community, showing positive results of implementing the CWC, and defining the course for future.

## Chemical Weapons Convention – basic facts

Chemical Weapons Convention (CWC), opened for signature in Paris, on January 13, 1993, entered into force on April 29, 1997. Its complexity is reflected in almost 200 pages of text, containing Preamble, 24 Articles, and 3 Annexes: On Chemicals (6 p), On Implementation & Verifi-

cation (105 p), and On Protection of Confidential Information (5 p).<sup>1</sup>

The genie of this Convention lies mainly in the mood of defining the scope of the prohibition. The CWC is rather by purpose than compound oriented. This means that it is nothing like the list of prohibited compounds as some less informed people mostly expect. The CWC's leading principle, which is often reported as General Purpose Criterion (GPC) is contained in the wording of Article II, para 1, defining the purposes of the CWC among "Chemical Weapons":

*Article II DEFINITIONS AND CRITERIA*

*For the purposes of this Convention:*

1. "Chemical Weapons" means the following, together or separately:

(a) Toxic chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes;

(b) Munitions and devices, specifically designed to cause.....;

(c) Any equipment specifically designed for use.....;

Toxic chemicals are further defined in Article II, para 2 as meaning:

"Any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans and animals. This includes all such chemicals, regardless of their origin or of their method of production and regardless of whether they are produced in facilities, in munitions or elsewhere".

Purposes, not prohibited under the Convention are listed in Article II, para 9 as meaning:

(a) Industrial, agricultural, research, medical, pharmaceutical or other peaceful purposes;

(b) Protective purposes, namely those purposes, directly related to protection against toxic chemicals and to protection against chemical weapons;

(c) Military purposes not connected with the use of chemical weapons and not dependent on the use of the toxic properties of chemicals as a method of warfare;

(d) Law enforcement including domestic riot control purposes.

From this explanations, quoting relevant articles of the CWC is evident, consistently with the mentioned GPC, that the Convention:

a) is nothing like a list of prohibited compounds,

b) covers any toxic chemical intended to be used for chemical warfare (and therefore developed, produced and stockpiled), pursuant to Article II, para 1 (a) and para 2, this means even those not yet synthesised. This means that the CWC is actually open-ended and the prohibition covers any scientific and technological development.

The CWC lists (as the verification instrument) the most important toxic chemicals and their precursors, endangering the CWC within Three Schedules, constituted according to

the risk the chemicals pose for the Convention. Schedule 1 contains super-toxic lethal chemicals and key precursors that have no peaceful uses, Schedule 2 contains less dangerous toxic chemicals and precursors produced in small quantities, and Schedule 3 lists toxic industrial chemicals (that were in the former history used for chemical warfare) and precursors produced on mass scale. A frequent misunderstanding occurs considering the Schedules as the lists of "prohibited compounds", although, it is clearly stated in the CWC that "Schedules do not constitute a definition of CW". The open-ended prohibition, however, does not mean that new toxic chemicals (other than those contained in Schedules) cannot appear on battlefields being used by non States Parties or less possibly by SPs, breaching the CWC or more possibly by the terrorist groups. That is why the scientific and technological development is to be very cautiously watched, international verification measures extended, national authorities and operation systems established, and respective legislation adopted in order to enable prevention and adequate response in real time (repression, protection, rescue and recovery) in cases of emergency.

### **Status of implementation of the Chemical Weapons Convention (If it is not otherwise stated, the data are reported as of March, 2006)**

– At present, there are altogether 178 States Parties to the Convention. Important is the membership of all P-5 members of UN Security Council and vast majority of states with declarable CWC facilities.

– Six SPs (Russia, USA, India, South Korea, Albania and Libya) declared possession of CW.

– Among SPs, there are 12 possessors of former (after 1946) CW production facilities (CWPFs), i. e. Russia, USA, India, South Korea, Libya, France, UK, China, Iran, Japan, Bosnia & Hercegovina, and Serbia & Montenegro (last two SPs declared the same former CWPF).

– The CWC implementation & verification regime now covers more than 90 % of world's population, but what is more important, 98 % of world's chemical industry.

Reviewing the figure on the number of SPs, it is also important to note that there are 8 signatory states that have not yet ratified (*inter alia* Israel) and altogether 8 countries that have not even signed. Beside not very important states, it is necessary to note D. P. R. of Korea and the neighbours of Israel (Egypt, Iraq, Lebanon and Syria) bounding their signature on the Israel's withdrawal from its nuclear weapons programme. Significant breakthrough in this scheme was accession of Libya to the CWC in February, 2004. Important is also, that all above explicitly named states are SPs to the Geneva Protocol (1925), prohibiting use in war of chemical weapons (and of bacteriological methods of warfare).

Assessing the CWC's universality (requirement of the 1st Review Conference), one can come to interesting results comparing the CWC with other agreements on weapons of mass destruction (WMD) as can be shown by Table 1. It seems that one could be satisfied with relatively high number of SPs, 9 years after EIF in comparison with other main

arms-control/disarmament agreements (NPT – Treaty on non-proliferation of nuclear weapons). Nevertheless, for the full assurance in preventing any use of CW, it is necessary to reach higher number of SPs, mainly, because most of the above mentioned important non-SPs concentrated in Near and Middle East and on Korean peninsula are supposed nearly certainly to be possessors of CW (not to speak on possession of other WMD like in the case of Israel).

Table 1 – *Universality: CWC compared with other main agreements on WMD*

Tablica 1 – *Univerzalnost: Usporedba CWC s Konvencijama o drugim oružjima za masovno uništavanje (WMD)*

Treaty	Entry into force	SPs	Other signatories	Non-signatories
NPT	1970	187	–	7
BTWC	1975	155	16	23
CWC	1997	178	8	8

The worldwide status of CWC implementation is witnessed by another important data:

- 161 initial declarations (on possession / non-possession of CW) were obtained from the SPs,
- 151 national authorities were established in the SPs.

Especially the latter number is evidently still insufficient, taking into consideration the tasks of such governmental office in the national implementation measures, starting with the respective legislation and then supervision of the domestic chemical industry and any cooperative activities

Table 2 – *Important data from the declarations by the SPs*

Tablica 2 – *Važni podaci iz deklaracija zemalja-članica*

Subject	Declaring SPs <sup>a</sup>	Declared sites
CW Storage Facilities (CWSFs)	6	35
CW Destruction Facilities (CWDFs)	6	43
CW Production Facilities (CWPFs)	12	64 <sup>b</sup>
Abandoned CW	3	16
Old CW	12	46
<i>Industrial Production:</i>		
Schedule 1 Chemicals	21	27
Schedule 2 Chemicals	35	437
Schedule 3 Chemicals	32	476
Discrete Organic Chemicals	76	4887

<sup>a</sup> Altogether 72 SPs have been inspected

<sup>b</sup> Of the 64 reported former (after 1946) CWPFs, 51 have been destroyed & converted

with the Organisation for the Prohibition of Chemical Weapons (OPCW). What is more alarming, only 108 SPs (i. e. 61 %) have adopted implementation legislation and respective comprehensive legislation has been adopted only in 61 SPs (i. e. 34 %) till now.

The most important data from the declarations of SPs (see Table 2) show the worldwide problems with possession, storage, former production of CW as well as with the spread of chemical industry as the point of outcome, not only for the destruction of CW at present and in the near future, but for monitoring the non-production of CW in chemical industry in future. The total number of declared sites (6003) which are to be regularly or randomly inspected shows the high burden of expected verification activities. At this stage of implementation, the verification activities have been obviously concentrated on storage and destruction, and in industry on facilities producing scheduled chemicals.

At present, the most important activity in implementing the CWC is obviously destruction of CW:

- Declared chemical agents 71 373 tonnes  
Destroyed (January 31, 2006) 12 889 tonnes
- Declared munitions (containers) 8 679 M items  
Destroyed (January 31, 2006) 2 420 M items

As expected, the destruction is proceeding asymmetrically, meeting domestic financial and technological problems with construction of destruction facilities. It is therefore expected, that the scheduled 10 years term for total CW destruction according to the CWC will not be managed and the allowed exemption to extend the destruction period for another 5 years (for technological and / or financial reasons) has been already agreed at both major possessors, i. e. Russia and the USA.

### Organisation for the Prohibition of Chemical Weapons – OPCW

Pursuant to the CWC, after its signature, the Preparatory Commission was founded and after EIF the Organisation for the Prohibition of Chemical Weapons (OPCW) with the seat in The Hague (Johan de Wittlaan 32, 2517 JR Den Haag) was established. For more information see <http://www.opcw.org>.

The Organisation consists of three main elements:

- Conference of the State Parties (all SPs meets regularly once a year), present Chair: H. E. Amb. Mr. Krzysztof Paturrej (Poland)
- Executive Council (41 members distributed among the SPs on a regional, rotating base for 2 years term, meets regularly 4 times a year), present Chair: H. E. Amb. Mr. Alfonso Dastis Quecedo (Spain)
- Technical Secretariat (about 520 staff members, of them about 200 inspectors), Director General: H. E. Amb. Rogelio Pfirter (Argentina),

There are also three subsidiary bodies: Scientific Advisory Board (25 independent experts), Confidentiality Commission, and Advisory Board on Administrative and Financial Matters.

## The First Review Conference

The character and tasks for the Conference were determined as follows:

- Review operations of the Convention,
- Take account of scientific and technological development,
- Lessons learned and recommendations for future implementation,
- Not an amendment (revision) conference.

The attendance represented 113 (then) SPs, 2 signatory states (Haiti, Israel), 2 non-signatory states (Libya, Angola), 5 International Organisations (ESA, ICRC, PCA, CTBTO, UNIDIR), 22 NGOs and 6 Industry Associations. The Conference did not result in radical change of direction for the OPCW or in substantive decisions on crucial, still outstanding issues (e. g. so called “non-lethal” agents, riot control agents, “law enforcement”, nil declarations in respect of OCPF, and like. A number of priorities have, however been clearly recognised.

To those priorities belong:

- Universality of the Convention,
- National implementation measures,
- International Cooperation and Assistance,
- Verification regime for the chemical industry
- Optimisation of verification measures
- Scientific and technological development and
- Functioning of the OPCW.

The detailed explanation goes beyond the frame of this paper. For further information see the adopted documents. This is in the first line the Political declaration containing 23 paras<sup>2</sup> and the main written result, i. e. the Review document with 134 paras.<sup>3</sup> Except many statements, mostly general only, the programme did not go too deep into the problems of impact of scientific & technological development on the CWC that are obviously associated with its future implementation. This problem was analysed in the document prepared by the OPCW Scientific Advisory Board introduced in the Note by the Director General.<sup>4</sup> It was generally expected that this would influence future activities of the OPCW. This process, i. e. joint assessment of OPCW SAB findings and recommendations by the Governmental experts and SPs to establish further strategy, has been already commenced.

## Main pillars of the Convention and impact of the scientific and technological development

To the main pillars of the CWC belong:

- Verified destruction of chemical weapons (CW) and of CW production facilities (CWPF), i. e. disarmament,
- Verified non-production of CW, i. e. non-proliferation,
- Assistance and Protection,
- International Cooperation.

It is obvious that scientific and technological development may have both positive and negative impact on the CWC and its implementation. The positive impact is connected

with destruction technologies, utilisation of sophisticated Hi-Tech analytical equipment and methodologies for all objective verification activities and in all branches of equipment, measures and know-how connected with assistance and protection. On the other hand, the scientific and technological development poses threats in rapid pace of synthesis of both scheduled and unscheduled chemicals that are, as a matter of fact, prohibited according to the GPC principle which does not mean that they cannot appear on battlefields or elsewhere, being used by non-SPs or by SPs breaching the CWC or at terrorist strikes. Various aspects of the impact of scientific and technological development on the CWC were discussed on an IUPAC workshop recently.<sup>5</sup> This problem is also matter of a review article.<sup>6</sup>

## Threats of scientific and technological development for potential proliferation of chemical weapons

One threat lies already now in the inconsistency of the CWC regarding the riot-control agents. Even if law enforcement and domestic riot control are explicitly named among purposes non prohibited by the Convention (as mentioned above), the particular part of the wording (Article I,5), dealing with prohibition of using riot-control agents as a method of warfare is generally considered as *ipso facto* exempting these agents from the definition of toxic chemicals (for the purposes of the CWC) and thus also from the routine verification regime, because these agents are unscheduled. This seems to be a significant loophole, allowing circumvention of the CWC, because R & D and production of this class of chemicals are out of stringent verification measures, typical for this disarmament document. One can therefore imagine legitimate search for new effective and safe (how safe?) irritants and incapacitants for police purposes but also temptations for uncontrolled production of chemicals that might once occur on the battlefield. This is an actually existing problem of present very dangerous orientation on the so called “non-lethal” agents. Every toxicologist knows, however, that any toxic effect or response of organism (including lethal) is dose- (exposition-) dependent. This means that something like non-lethal agents do not exist at all. Safety index of irritants (incapacitants of all kind) depends on the difference between (statistically determined) doses (concentration and exposition time) with intolerable effect and that causing death.

This index should be as big as possible at the riot-control agents but it is in the nature that it cannot be unlimited; that is why the thesis on “non-lethality” is an actual mystification if not cheating.

Future threats are mainly given by the changing face of synthetic and manufacturing methods for producing both scheduled and unscheduled chemicals. It is mainly rapid pace of development in biomolecular science (e. g. genomics and proteomics) and in synthesis (i. e. combinatorial chemistry) giving rise to appearing of new toxic chemicals for potential misuse. These methods enable to synthesise whole series with “tailored” structures (i. e. with theoretically predicted structures) very quickly. Group syntheses, lasting

months to years in the half of 20<sup>th</sup> century, can be achieved within weeks now.

We are now faced also with considerably changed character of chemical industries. Many parts of chemical industry operate with multipurpose batch facilities, which can readily be switched from one product to another. The potential of producing toxic chemicals is considerably enhanced by the use of micro-reactors producing large volumes in small plants. Globalisation of this industry needs thus reviewing verification regime of so called "other chemical production facilities" (OCPF), producing discrete organic chemicals. The ever-growing range of toxic chemicals and new processes of small-scale syntheses increase also a threat of chemical terrorism.

### **Benefits of scientific and technological development for the destruction of chemical weapons**

The destruction and disposal methods, applied for elimination of obsolete chemical weaponry (used on the mass scale for elimination of the captured German and Japanese chemical arsenals after WW-II), such as sea dumping, earth burial, open-pit burning, and exceptionally also blasting, were routinely used till the 1970s. The last known event of this art was operation CHASE, when the US dumped commissioned munitions filled with nerve agents in the Caribic. Such procedures became gradually unacceptable due to environmental awareness and respective domestic legislation. Therefore, R&D on new destruction/disposal technologies started in the 1970s in connection with upgrading chemical arsenals, long before destruction pursuant to the CWC and even its drafting had commenced. It is obvious, that the most common technology for destruction of waste chemicals by incineration was the principal technological orientation. During negotiating the CWC, there were attempts to prescribe the concrete destruction technique but final text of the CWC leaves it to the responsibility of the SPs, of course requiring completeness and irreversibility of destruction to solid non toxic remnants and scrap metal under strict parallel requirements on workplace safety and environmental protection. At present, about 15 basic technologies of destruction have been suggested (some of them having up to 6 various modifications), including some very curious ones like underground nuclear explosion, or simultaneous destruction with burning demilitarised missile engine and like. For the overview, see e. g.,<sup>6</sup> while their practical assessment from various aspects is a matter of other review publications.<sup>7,8</sup>

### **Benefits of scientific and technological development for verification of implementing the CWC**

Main benefit of scientific and technological development for verifying provisions of the CWC is given by the possibility of using objective analytical methods and Hi-Tech instrumentation. Many up-to-date separation methods (such as GC and HPLC) coupled with identification techniques (such as MS) and other spectrophotometric methods (e. g. FT-IR) with computerised data libraries accessible on-line

have been introduced in the OPCW – designated accredited laboratories and the most modern portable GC-MS instrumentation and validated database (OCAD); containing data on several thousand chemicals is routinely used by OPCW inspection teams in on-site verification. The problem is follow-up of the development of toxic chemicals (mainly those unscheduled), technical upgrading of equipment, analysis of toxins and biomedical samples, conservation and transportation of samples for off-site analysis and like. It is also desirable to introduce automatic analytical techniques including remote (off-site) methods with automated data transmission and processing in real time to enable decreasing the burden of prescribed continuous on-site presence of inspectors at CW destruction. This should enable to shift the inspection effort to verifying non-production by the chemical industries of potential CW, i. e. future non-proliferation.

### **Contribution of scientific and technological development to Assistance and Protection**

Incorporating Article X (Assistance and Protection) into the CWC was very important. Threats of CW use still exists from the non-SPs, SPs till the CW arsenals have been destroyed, exceptionally from old and abandoned CW, not to speak about terrorist use of toxic chemicals. Protective equipment will be needed also on the battlefields not only following use of CW and other WMD. Even destroyed industrial and social infrastructures of modern societies, releasing toxic, inflammable, liquefied, explosive, radioactive and infectious materials on landscape, densely populated with such infrastructures after strikes only with conventional warfare, need protective equipment; similarly like at events occurring in the peacetime as a result of accidents and disasters caused by personal, material or system failure or by terrorist strikes.

Assistance and protection according to Article X envisages providing equipment and know-how (in the area of detection, identification and monitoring, decontamination, personal protection and treatment) by the OPCW and by higher developed SPs to those less developed or even without adequate protection. For the detailed overview of some technical issues under Article X and of an example for providing assistance and protection by a SP, see.<sup>9</sup>

### **Other challenges of scientific and technological development**

Among other challenges that the scientific and technological developments pose, it is possible to name mainly those for the OPCW Technical Secretariat (TS), as well as those associated with education and outreach.

Rapid pace of development of new unscheduled chemicals and new production processes of, both, scheduled and unscheduled chemicals as mentioned above needs the TS to be kept up to date. This needs to continuously review relevant scientific and technological development. In this connection, it seems reasonable to further work on recommendations of the Scientific Advisory Board (SAB)<sup>4</sup> with special emphasis on the problems of verification.

Not only future scientific and technological developments, but in the first line the CWC as such and its profound knowledge and correct interpretation, should be matter of education and outreach to scientific and engineering communities as well as to decision-makers in SPs, SSs and nSSs. It is necessary to extend cooperation with relevant national and international professional organisations, academia, universities, industry associations including NGOs representing concerned engineers and scientists, mainly those, having heavily contributed when the CWC was negotiated.

## Conclusions

Operations of the Chemical Weapons Convention are proceeding satisfactory judging according to the status of its implementation by 178 States Parties and verification by the Organisation for Prohibition of the Chemical Weapons in The Hague nine years after entry into force. The First Review Conference stressed the importance of achieving worldwide universality in order to totally eliminate the heredity of past chemical arsenals once forever, prevent threats, and utilise benefits of the scientific and technological development for the CWC implementation in the foreseeable future. Even, if the CWC is open-ended and thus envisages the scientific technological development, it is necessary to reflect possible threats in the general approach of OPCW and national authorities, mainly in continuous updating the verification regime and in adopting respective responsibility of national authorities and comprehensive legislation in the States Parties.

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## SAŽETAK

### Kemijsko razoružanje: tekući problemi u primjeni Konvencije o kemijskom oružju

J. Matoušek

Kratko je opisana Konvencija o kemijskom oružju (Chemical Weapons Convention, CWC), naglašavajući glavne stavke, kao što je verificirano uništavanje zaliha kemijskog oružja i uništavanje ili prenamijena postrojenja za proizvodnju, verifikacija prestanka proizvodnje kemijskog oružja u kemijskim industrijama, pomoć i zaštita, te međunarodna suradnja. Vodeće načelo Konvencije o kemijskom oružju u definiranju kemijskog oružja (štiteći ga općenito od znanstvenog i tehnološkog napretka) je tzv. *Kriterij opće namjene* koji je potpuno razjašnjen te se pokazuje njegov odnos prema sofisticiranom sustavu verifikacije CWC-a. Stanje primjene Konvencije (od kolovoza 2005.) pokazuje osnovne glavne podatke koje su kao obvezu dostavile države članice, a među njima je šest država koje imaju zalihe kemijskog oružja (Rusija, SAD, Indija, Južna Koreja, Albanija i Libija). Od deklariranih 71 373 tona agensa, 12 889 je uništeno; od deklariranih 8,679 milijuna komada streljiva (kontejnera) 2420 je uništeno, što znači da se predviđenih deset godina kao krajnji rok za uništavanje kemijskog oružja (od početka primjene Konvencije), neće moći održati. Za Rusiju i SAD je već dogovoreno produljenje od daljnjih pet godina. Od 64 postrojenja za proizvodnju bojnih otrova (operativnih poslije 1946.) koje je deklariralo 12 država članica, 53 je verificirano kao uništeno odnosno prenamijenjeno. Kratko je predstavljena Organizacija za zabranu kemijskog oružja (Organisation for the Prohibition of Chemical Weapons, OPCW), a glavni rezultati Prve pregledne konferencije (održane 2003.) su analizirani na temelju prihvaćenih osnovnih dokumenata. Budući problemi primjene CWC povezani su u prvom redu s njezinom univerzalnošću, s obzirom na to da je među 18 nečlanica i nekoliko zemalja (lociranih uglavnom na Bliskom istoku i Korejskom poluotoku) za koje se pretpostavlja da posjeduju kemijsko oružje. Posebni naglasak stavljen je na prijetnje i koristi od znanstvenog i tehnološkog razvoja na tekuće primjene Konvencije kao i njezine primjene u budućnosti nakon što sve zalihe kemijskog oružja budu uništene.

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