Semester 1 2022/2023
Sistem Pengawasan Nuklir (RN6086)
FMIPA ITB

Sistem Pengawasan Nuklir (RN6086)

Konsep 3S dan konsep dasar keamanan (security) dan Seifgar (Safeguard)

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Sistem Pengawasan Nuklir

1. tekait tema pengawasan, juga tema keselamatan atau safety dan juga keamanan atau security fasilitas nuklir

2. Sinergitas konsep 3S safety, secuarity dan safeguard proses dan implementasinya,

3. konsep dasar depence in depth dari safety dan safeguard,

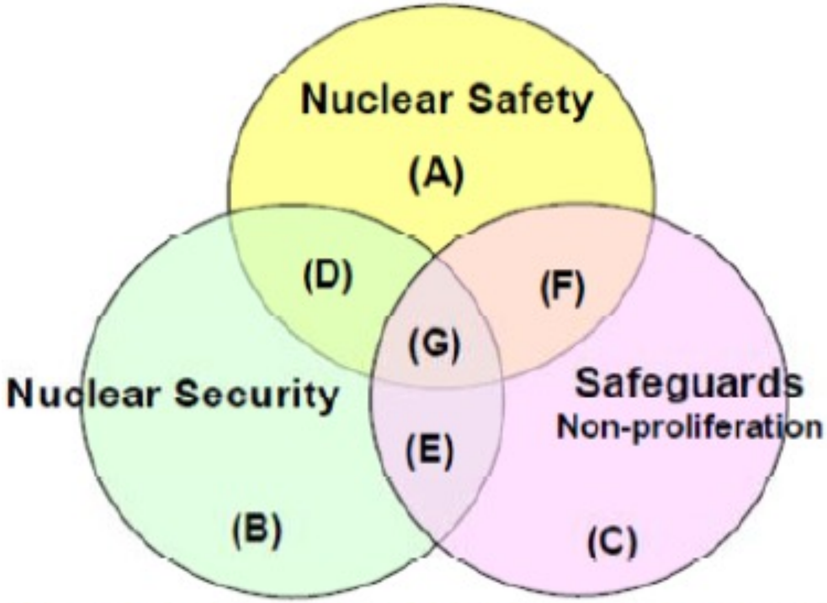
4. analisa desain basis dari konsep safety dan safeguard by design

5. material nuklir terkait daur ulang bahan bakar, kuantitas materil nuklir terkait data

6. pelaporan khusunya material nuklir terkait uranium dan plutonium

7. konsep non proliferasi nuklir, pengetahuan mengenai protected plutonium proliferation

8. Konsep material attractiveness,



(A) Emergency core cooling system for nuclear power plant, (B) Barrier at the facility entrance, (C) Authenticated apparatus
(D) Double-entry doors to keep negative pressure and prevent radioactive release
(E) Management of nuclear material using containment and surveillance and remote monitoring camera
(F) Management of nuclear material for criticality and accounting control
(G) Possible monitoring camera for multipurpose use, such as joint use of equipment

Figure 1 - A Venn diagram depiction of potential synergies among the 3Ss, with examples. (Courtesy of the IAEA, via blanket permission, from Suzuki et al., 2010)

Nuclear Security Science & Policy Institute
A Division of the Texas Engineering Experiment Station

SAFETY, SAFEGUARDS AND SECURITY IN INDIAN CIVIL NUCLEAR FACILITIES

Sinergisasi Konsep 3 S

B. Keselamatan, Keamanan dan *Safeguards*

16. Apakah itu keselamatan nuklir?

Keselamatan nuklir merupakan suatu tindakan untuk pencapaian kondisi operasi yang tepat suatu reaktor nuklir sesuai desain, untuk pencegahan terjadinya kecelakaan atau mitigasi konsekuensi kecelakaan, untuk melindungi pekerja, masyarakat dan lingkungan dari bahaya radiasi yang tidak semestinya, dan termasuk untuk proteksi radiologi.

17. Apakah itu keamanan nuklir?

Keamanan nuklir merupakan tindakan pencegahan, deteksi. dan respons terhadap pencurian, sabotase, akses dan transfer ilegal atau tindakan berbahaya lainnya terhadap bahan nuklir dan zat radioaktif yang berhubungan dengan reaktor nuklir fasilitas terkait.

18. Apakah itu *safeguards* nuklir?

Safeguards nuklir merupakan sarana yang diterapkan untuk verifikasi kepatuhan suatu negara untuk menerima kesepakatan *safeguards* IAEA terhadap semua bahan nuklir dalam semua kegiatan nuklir untuk tujuan damai dan untuk verifikasi bahwa bahan nuklir tersebut tidak dialihkan ke senjata nuklir atau alat peledak nuklir lainnya.

Safeguards didesain terutama untuk dua tujuan yaitu: 1) untuk mendeteksi kegiatan proliferasi yang melibatkan pengalihan bahan dari siklus bahan bakar nuklir sipil, dan 2) untuk memberikan peringatan dari setiap kejadian tersebut kepada forum internasional secara tepat.

Sinergisasi Konsep 3 S

B. Keselamatan, Keamanan dan *Safeguards*

19. Apakah tujuan umum keselamatan, keamanan dan *safeguards*?

Tujuan umum dari keselamatan nuklir, keamanan nuklir dan *safeguards* adalah untuk melindungi manusia dan lingkungan dari efek radiasi pengion yang ditimbulkan oleh fasilitas dan kegiatan pemanfaatan nuklir. Tujuan keselamatan nuklir diarahkan lebih ke arah mengendalikan risiko yang melekat dalam mengoperasikan peralatan nuklir dan fasilitas atau transportasi bahan radioaktif. Tujuan keamanan nuklir ditargetkan untuk memberikan perlindungan terhadap tindakan berbahaya yang dapat menyebabkan lepasan radiologi atau efek menghancurkan yang dihasilkan dari penggunaan zat radioaktif atau bahan nuklir. Sedangkan tujuan dari *safeguards* adalah untuk memastikan bahwa penggunaan bahan nuklir untuk tujuan damai tidak membuat senjata atau bahan peledak nuklir.

Sinergisasi Konsep 3 S

B. Keselamatan, Keamanan dan *Safeguards*

20. Apakah persyaratan keselamatan nuklir?

Persyaratan keselamatan nuklir reaktor nuklir dan fasilitas nuklir lainnya harus memenuhi dua persyaratan keselamatan utama yaitu:

a. Persyaratan keselamatan nuklir untuk fasilitas tersebut selamat untuk dioperasikan dengan probabilitas kecelakaan sangat kecil; dan

b. Persyaratan keselamatan radiasi bahwa paparan radiasi dalam operasi normal berada di bawah batas yang ditetapkan untuk personil, anggota masyarakat dan lingkungan.

21. Apakah yang harus dilakukan untuk mencapai keselamatan reaktor nuklir?

Pemohon izin terkait reaktor nuklir harus melakukan upaya keselamatan dan memenuhi ketentuan yang diberikan oleh badan pengawas (di Indonesia, badan pengawas tenaga nuklir/BAPETEN). Selain itu desain reaktor nuklir harus menerapkan pertahanan berlapis.

Sinergisasi Konsep 3 S

D. Pengawasan Reaktor Nuklir

33. Apakah dasar hukum/peraturan pengawasan nuklir?

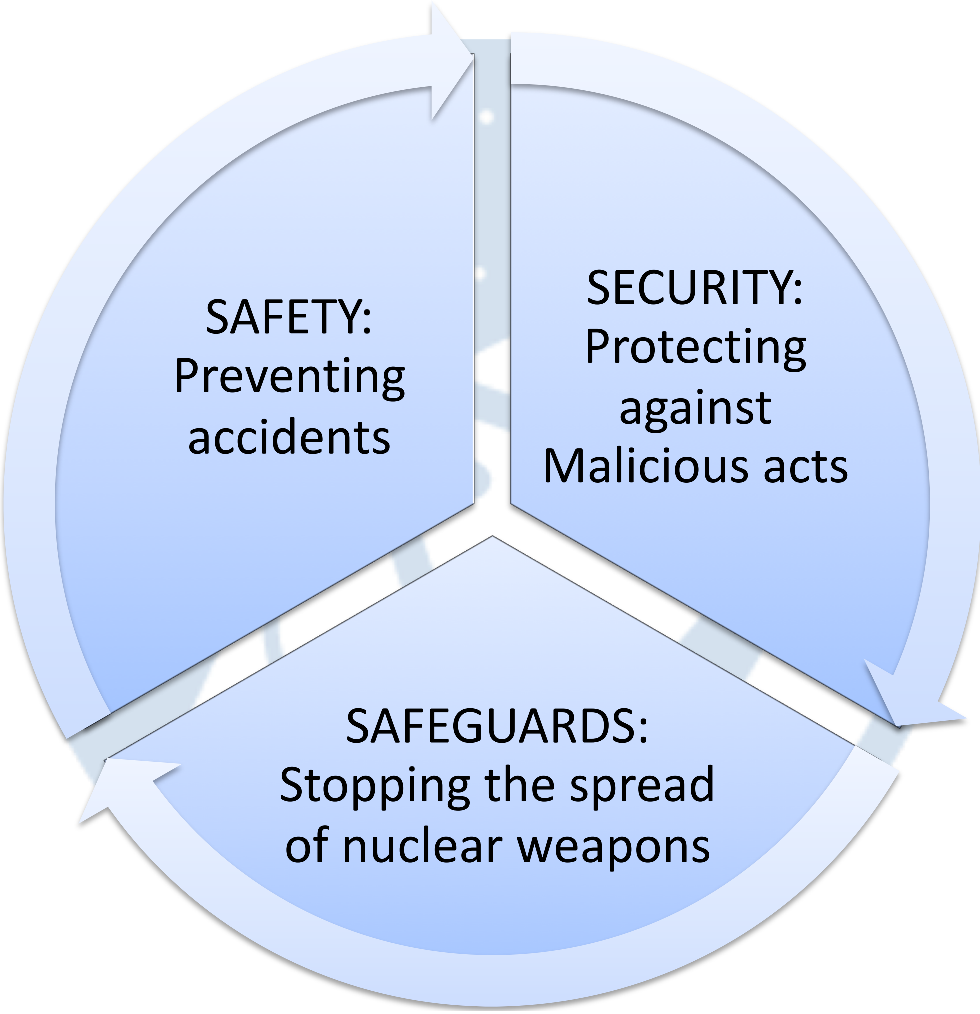
a. Pembukaan Undang-Undang Dasar 1945.
b. Undang-Undang (UU) No.8 Tahun 1978 tentang Pengesahan Perjanjian Mengenai Pencegahan Penyebaran Senjata Nuklir.
c. UU No. 9 Tahun 1997 tentang Pengesahan *Treaty on the Souteast Asia Nuclear Weapon Free Zone*.
d. UU No. 10 Tahun 1997 tentang Ketenaganukliran.
e. UU No. 1 Tahun 2012 tentang Pengesahan Traktat Pelarangan Menyeluruh Uji Coba Nuklir.
f. UU No. 10 Tahun 2014 tentang Pengesahan *Inter-national Convention for Suppresion of Acts of Nuclear Terorism*.
g. Keputusan Presiden (Keppres) No.81 Tahun 1993 tentang Pengesahan *Convention on Early Notification of Nuclear Accident*.
h. Keppres No. 82 Tahun 1993 tentang Pengesahan *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency*.
i. Keppres No.106 Tahun 2001 tentang Pengesahan *Convention On Nuclear Safety*.
j. Perpres No 46 Tahun 2006 tentang Pengesahan *Convention on Physical Protection of Nuclear Material*.
k. Perpres No.84 Tahun 2010 tentang Pengesahan *joint convention on the safety of fuel Management and The safety of Spent Fuel Management*.
l. Perpres No.74 Tahun 2012 tentang Pertanggungja-waban Kerugian Nuklir.

Konsep 3 S Nuklir

- Safety, Security, Safeguards as policy areas: forms of governance developed to manage risks connected to the use of nuclear technology.
- Action at different levels:

– Facility: Management, internal rules, practices – National: Policies, regulatory framework

– International: treaties, cooperation agreeements, trade control regimes, IAEA



Sumber : Alberto Muti , **Nuclear Safety, Security and Safeguards, VERTIC**

Nuclear Safety

"The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards."

IAEA Nuclear Safety Glossary

Nuclear Safety – International

Key International Agreements on Nuclear Safety:

- Convention on Nuclear Safety(1994)
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (1997)
- Convention on Early Notification of a Nuclear Accident (1986)
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1986)
- IAEA supports the implementation of these treaties and encourages ratification
  – IAEA acts as coordination body for the implementation of these treaties
- IAEA supports improvements in Nuclear Safety in Member States
- IAEA Action Plan on Nuclear Safety (2011)
- IAEA Assistance

Sumber : Alberto Muti , **Nuclear Safety, Security and Safeguards, VERTIC**

Nuclear Security

"The prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities."

IAEA Nuclear Safety Glossary

Nuclear Security

• The youngest of the "Three S"
• Energised by changes in the international environment:
– Disgregation of the former Soviet Union
– 9/11 Attacks and "War on Terror"
• Since then, it has risen to prominence in international agenda – and profoundly changed as a concept
• Nuclear Security is a responsibility of the state
• "Original" nuclear security was physical protection: guards, gates and guns
– Principles such as "Defence in Depth" and "Deter, Detect, Delay, Respond, Recover"
• Over time, the concept expanded to include the human elements of security:
– Insider Threat
– "Security Culture" among facility staff

Sumber : Alberto Muti , **Nuclear Safety, Security and Safeguards, VERTIC**

Nuclear Security – International

Key International initiatives on Nuclear Security:

- Cooperative Threat Reduction Programmes (1990s onwards)
- Global Partnership (G7-backed, 31 members, 2002)
- Nuclear Security Summits (2010-2016)
- US Partnership for Nuclear Security
- EU CBRN Centres of Excellence
- Convention on the Physical Protection of Nuclear Material (1980) + 2005 Amendment
- Code of Conduct on the Safety and Security of Radioactive Sources
- International Convention for the Suppression of Acts of Nuclear Terrorism (2007)
- UN Security Council Resolutions:

– 1373 (2001)
– 1540 (2004)

- Not all these instruments relate back to the IAEA – the international framework is more fragmented
- The IAEA has stepped up to provide a coordination and support role on nuclear security after 2001
- Key documents: Nuclear Security Plans, starting in 2003. Current plan is 2018-2021

Sumber : Alberto Muti , **Nuclear Safety, Security and Safeguards, VERTIC**

Nuclear Safeguards

"A set of technical measures applied by the IAEA on nuclear material and activities, through which the Agency seeks to independently verify that nuclear facilities are not misused and nuclear material not diverted from peaceful uses."

IAEA

Nuclear Safeguards

•Item-specific Safeguards (1960s) were created as a confidence-building measure
•With the NPT (1970), Safeguards became the key instrument to verify adherence to non-proliferation commitments
•Established through Bilateral treaties between the IAEA and Member States
•IAEA's role is to verify compliance

Goals of Safeguards:

•Detect the diversion of nuclear material to the manufacture of nuclear weapons
•Deter the diversion of nuclear material by risk of early detection
•Ensure that all nuclear activity a state undertakes is for peaceful purposes and that a state is not engaging in illicit nuclear activiti

Sumber : Alberto Muti , **Nuclear Safety, Security and Safeguards, VERTIC**

Konsep Seifgard (Safeguard)

Nuclear Safeguards

Key approaches in Safeguards:

- Creation of a State System for Accountancy and Control (SSAC) of Nuclear Material at the state level
- Submission of regular reports on nuclear material and activities to the IAEA
- IAEA inspection of nuclear facilities to verify reports and prove compliance
- Nuclear Material: Uranium, Plutonium, Thorium "of a composition and purity suitable for fuel fabrication or for being isotopically enriched"
- Amount, composition and chemical form of material measured :
- – When passing through "Key Measurement Points"
- – When held in "Material Balance Areas"
- A "Facility" for safeguards: fuel cycle facility or location where a certain material is stored

• State Authorities collect information from operators and compile regular reports to the IAEA, including:

– Inventory holdings of material

– Operations – including transformation of composition and form of material (e.g. enrichment, fuel fabrication)

– Transfers of material between facilities in the same country

– Imports and exports

– Losses and Material Unaccounted

Sumber : Alberto Muti , **Nuclear Safety, Security and Safeguards, VERTIC**

Nuclear Safeguards

IAEA Inspectors verify correctness of reports through a number of approaches:

- Visual observation
- Non-destructive assay (radiation detection,
- neutron counting)
- Destructive assay (samples) and environmental sampling
- Use of tamper-indicating devices (seals, tags) and remote monitoring systems (cameras, alarms)

Nuclear Safeguards

Key Safeguards Agreements:

- Comprehensive Safeguards Agreement (INFCIRC/153)
- Small Quantities Protocols
- Additional Protocols (INFCIRC/540)

Additional Protocol

- Introduced in 1996
- Expands reach of safeguards to verify that there is no undeclared activities
- Gives IAEA inspectors new forms of access
- Voluntary measure (subject to fierce international debate)

Sumber : Alberto Muti , **Nuclear Safety, Security and Safeguards, VERTIC**

Safeguards Obligations : why?

NPT preamble (extract)

- "Considering the devastation that would be visited upon all mankind by a nuclear war and the consequent need to make every effort to avert the danger of such a war and to take measures to safeguard the security of peoples"

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

Safeguards Obligations : why?

In other words:

A legal framework

An historical background

A technical challenge

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

Objectives of National Verification

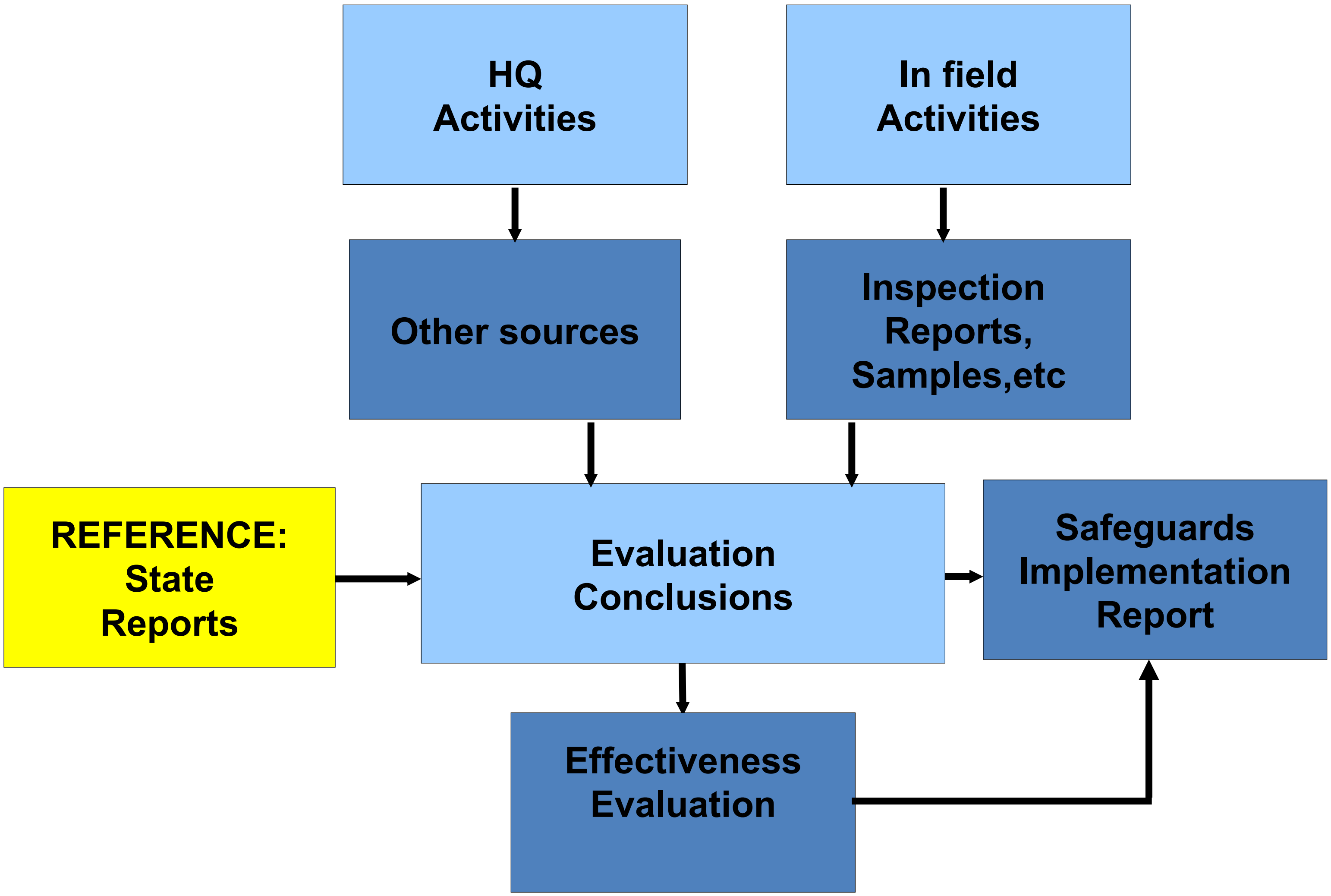
SSAC obligation:

- account for and control of nuclear material
- collect and maintain information on nuclear and related activities
- provide information to IAEA (reports, declarations)

Safety Standards Acknowledgement and Consent (**SSAC**)

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

International Safeguards Implementation



Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

Bridging International and National Safeguards

Compliance with NPT through Safeguards Agreements imposes a very accurate knowledge of the entire industrial, research and commercial status and its evolution within the state, not to mention an adequate knowledge of the conditions offered to the IAEA inspectors to perform their duty.

This can only be achieved with a well informed and powerful state body.

In other words, such a body is the first element of a **continuous chain** for successfully fulfilling national and international commitment towards non proliferation.

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

Preparing for a Nuclear Power Industry – Legislation

- **Is the national safeguards legislation and regulation suitable for implementing and regulating safeguards for a nuclear power industry?**
  - **some safeguards legislations may be tailored to low level of nuclear activities or e.g. to research reactors, and will need amending**
  - **Legal framework between operator and regulator is a key issue**
- **Does the national safeguards legislation cover all nuclear materials and activities in the state?**
- **Legislative independence: accepted international standard for national safeguards authorities is to be independent of operations of facilities**

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

Konsep Seifgard (Safeguard)

Capacity Building : Synergies

Domestic “safeguards” verification activities may build on or contribute toother domestic control regimes:

- control of radioactive materials
- radiation safety
- physical protection
- export/import control system

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

Capacity Building : Safeguards and National Infrastructure

Three-floor building:

Policy makers :
Reference and Objective, Law, Resources, Vision

Managerial level :
Organization, Allotment of resources, Regulations, Control

Technical/Working level :
Collecting/Processing/Reporting information

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

SSAC’s Skills, Knowledge and Abilities

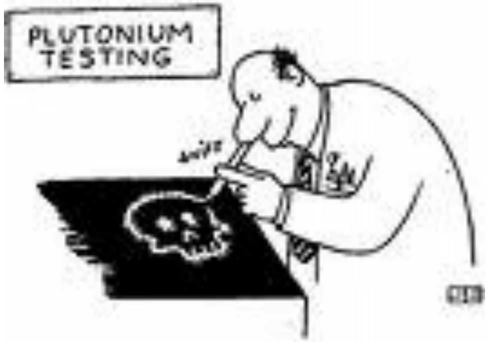
LEGAL

ACTIVITIES

REPORTING

ACCESS

SSAC



NM MEASUREMENT

EXPORT

NMAC

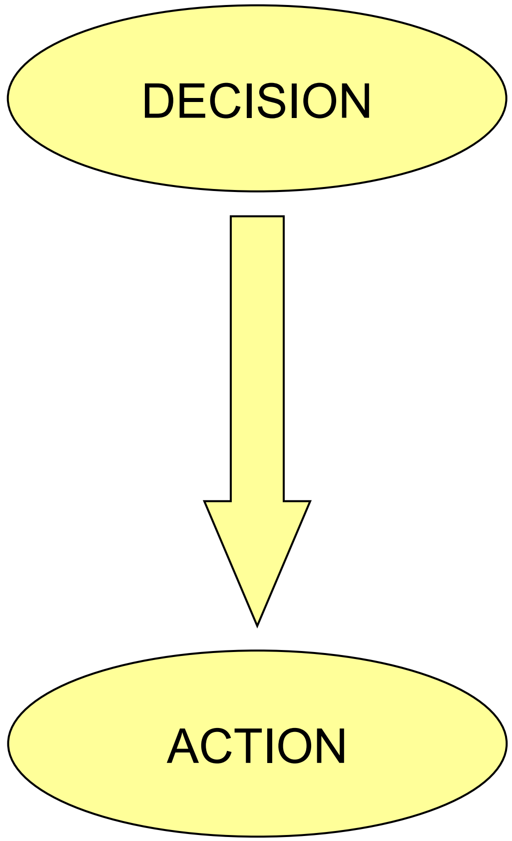
1st Pu core

Safety Standards Acknowledgement and Consent (**SSAC**)

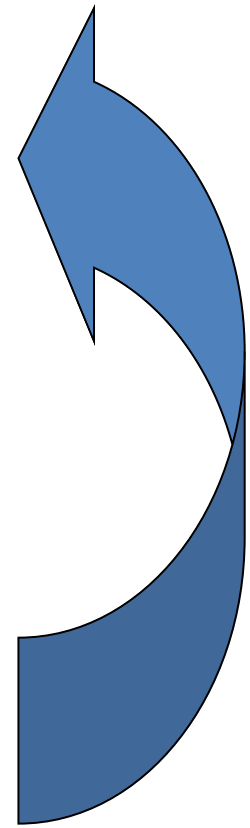
Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

Three Sets of Skills, Knowledge, Abilities

Expertise



Decision making and action line



Control loop

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

As a Summary

- **Safeguards have to be considered**
  - For international purpose
  - As well as for national purpose
- **The sooner the better**
  - Safety and Security of course, but also Safeguards. Take advantage of synergies (e.g. NMAC requirements, safety design of fuel handling system)
  - Currently safeguards are often introduced after a facility's design has been frozen which results in costly redesign and project delays
- **Without starting from scratch:**
  - Radioactive sources management is a sound basis
  - Collecting existing information (e.g. customs or operators data) rather than duplicating or overlapping

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

IAEA safeguards – a sense of scale

- 1,314 facilities or other locations in 179 states, ~150,000 tons of nuclear material (>183,000 significant quantities) under safeguards (as of end of 2012)
- ≈10,000 person-days of inspection/yr, €146.7M IAEA safeguards budget in 2012 (~same as Vienna police department)
- Primarily implemented in non-nuclear-weapon states; a few facilities in weapon states under "voluntary offer"; some facilities in non-NPT states safeguarded when supplier required it
- NPT member states have repeatedly expressed confidence that IAEA safeguards verify states are complying

Sumber : How IAEA Safeguards Work, Matthew Bunn IGA-232, Controlling the World's Most Dangerous Weapons, 20 September 2013, belfercenter.org/mta

5 paths past safeguards to the bomb

- No non-weapons obligation, material produced in dedicated military facilities with no safeguards
  - All 5 NPT weapon states, India, Pakistan, Israel (though some non-verified peaceful use assurances in latter cases)
- Join NPT, accept safeguards, build needed facilities, then withdraw and expel inspectors
  - N. Korea (sort of -- never had full safeguards) -- Iran in the future?
- Join NPT, accept safeguards, divert material from declared, safeguarded facility
  - This is *only* path traditional IAEA safeguards designed to detect
- Join NPT, accept safeguards, build covert facilities
  - Iraq, N. Korea (U program), Libya, Syria -- Iran???
  - Additional Protocol designed to help detect
- Purchase or steal weapon or weapon material

Sumber : How IAEA Safeguards Work, Matthew Bunn IGA-232, Controlling the World's Most Dangerous Weapons, 20 September 2013, belfercenter.org/mta

2 paths are focus of safeguards

- *Divert nuclear material from declared facility*
  - Focus of traditional safeguards
  - Additional Protocol measures (e.g., complementary access, environmental sampling) also help

- *Produce nuclear material at covert facility*
  - Not addressed effectively by traditional safeguards
  - Additional Protocol measures offer *some* potential (especially combined with information supplied by national intelligence agencies)
  - Not high confidence – but overall, no state has ever come close to nuclear weapons capability without detection (yet)
  - IAEA: without Additional Protocol, "the Agency does not have sufficient tools to offer credible assurance regarding the absence of undeclared nuclear material"

Sumber : How IAEA Safeguards Work, Matthew Bunn IGA-232, Controlling the World's Most Dangerous Weapons, 20 September 2013, belfercenter.org/mta

Traditional safeguards

- Traditional safeguards use "material accountancy" and "containment and surveillance" to provide *timely detection* of diversion of *significant quantities* of nuclear material, and to *deter* such diversion by the *risk of detection*
- Significant quantities:
  - Pu or U233: 8 kg
  - HEU: 25 kg contained U-235
  - *Bombs can be made with less -- a key issue*
- Timeliness goal:
  - 1 month for unirradiated Pu or HEU (incl. MOX)
  - *Longer than estimated conversion time – another key issue*

Sumber : How IAEA Safeguards Work, Matthew Bunn IGA-232, Controlling the World's Most Dangerous Weapons, 20 September 2013, belfercenter.org/mta

Material accountancy

MUF (*M*aterial *U*naccounted *F*or) =

Beginning inventory + Additions to inventory - Ending inventory - Removals from inventory

- Because of measurement uncertainties, all bulk facilities have some MUF – but does it mean a real loss?
  - **σMUF** -- standard deviation of MUF -- is measurement precision
  - If MUF > than some threshold level -- usually 3 σMUF -- IAEA rejects the hypothesis that real MUF is zero, investigates possibility that diversion has occurred
- For item facility (e.g., LWR), MUF=0 unless something is missing

These days MUF sometimes called "inventory difference" or ID

Sumber : How IAEA Safeguards Work, Matthew Bunn IGA-232, Controlling the World's Most Dangerous Weapons, 20 September 2013, belfercenter.org/mta

International accountancy standards

Facility Type	Relative STD (%)
Uranium enrichment	0.2
Uranium fabrication	0.3
Plutonium reprocessing	1.0
Plutonium fabrication	0.5
Scrap store	4.0
Waste store	25.0

Source: IAEA Inspector Training Course

Sumber : How IAEA Safeguards Work, Matthew Bunn IGA-232, Controlling the World's Most Dangerous Weapons, 20 September 2013, belfercenter.org/mta

Containment and surveillance

- Containment and surveillance complements material accountancy by (a) detecting unusual activities, (b) confirming there has been no removal of material from measured, sealed containers
- Typical measures include:
  - Surveillance cameras
  - Tamper-resistant seals (which will be broken if sealed item is opened)
  - Tamper-resistant tags (uniquely identify particular measured items)
- What happens when cameras go out, seals break? Often, re-inspection required
- Clearly, containment and surveillance contribute to safeguards confidence – but no one has come up with a way to measure how much better accountancy is with containment and surveillance added

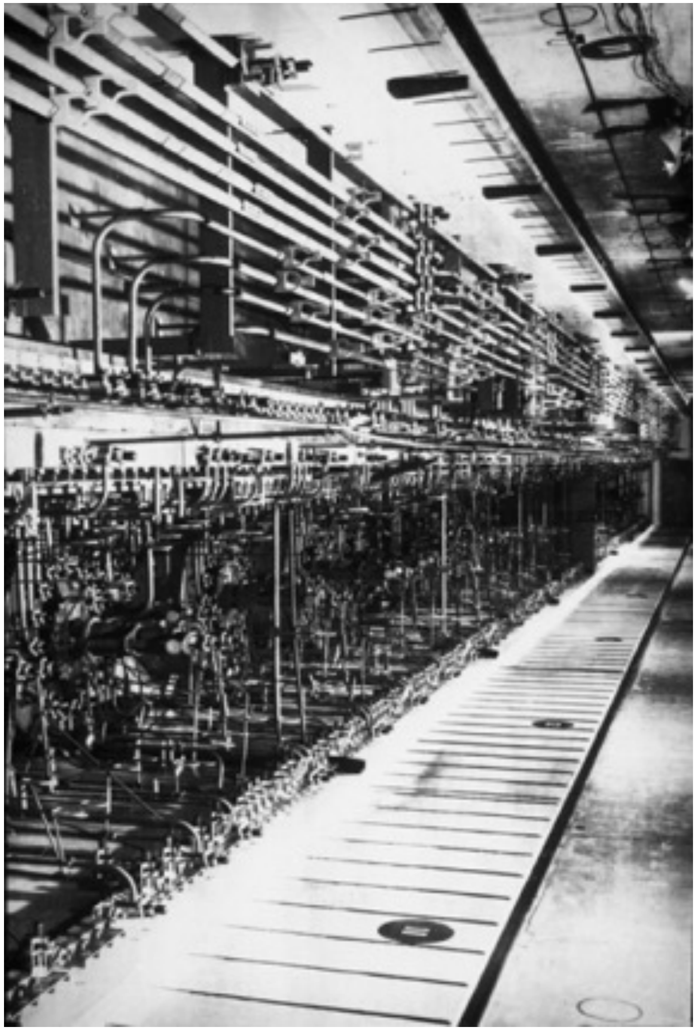
Sumber : How IAEA Safeguards Work, Matthew Bunn IGA-232, Controlling the World's Most Dangerous Weapons, 20 September 2013, belfercenter.org/mta

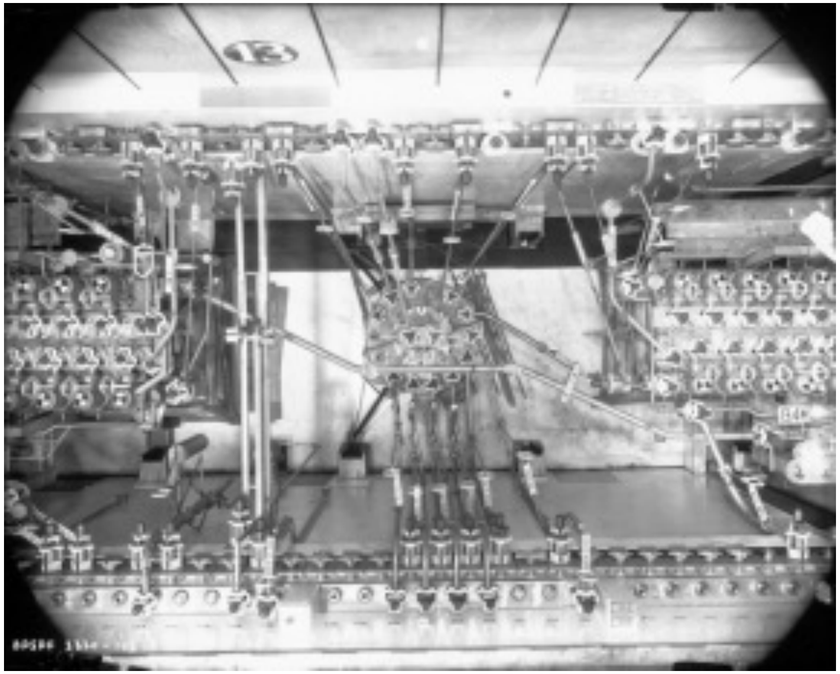
Safeguarding a reprocessing plant

- Large commercial plant: 800 MTHM/yr, ~8 tPu/yr
- 1 close-out for measured inventory/yr
- 1% uncertainty ≈ 80 kg Pu
- If only challenge if MUF>3 σMUF ⍰ 240 kg Pu
- Also, can't meet timeliness goal with 1 inventory/yr
- Partial solutions:
  - Comprehensive transparency and containment and surveillance throughout plant – monitor all flows, detect all unusual activity
  - Near-real-time accountancy – much more frequent partial measurements of material in process, with statistical models designed to detect both abrupt and protracted diversions

Sumber : How IAEA Safeguards Work, Matthew Bunn IGA-232, Controlling the World's Most Dangerous Weapons, 20 September 2013, belfercenter.org/mta

Reprocessing plant piping





Sources: DOE

Sumber : How IAEA Safeguards Work, Matthew Bunn IGA-232, Controlling the World's Most Dangerous Weapons, 20 September 2013, belfercenter.org/mta

Example: some failures in Iran

- 18-year centrifuge program undeclared, undetected by traditional safeguards
- Iran imported 100s of kgs of U from China without reporting it – no detection for > a decade
- Iran converted 100s of kgs of U to metal – no reporting, no detection, for years
- Iran conducted centrifuge tests with UF6, lied to the IAEA in saying it had not done so, was detected years later
- Traditional safeguards only designed to monitor *declared* activities – little capability to address *secret* activities
- *However,* once *other* sources informed IAEA of what was happening, IAEA has done a very professional job at peeling back successive layers of Iranian lies

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

Safeguards technologies: A wide range

TABLE 7: VERIFICATION MEASUREMENT METHODS FOR ON-SITE IAEA ANALYTICAL LABORATORIES

PROCESS AREA	SAMPLING POINT	INSTRUMENT OR METHOD	CONCENTRATION MEASUREMENT	SAMPLE FRACTION	GOAL ACCURACY
HEAD END	INPUT TANK	HYBRID K-EDGE DENSITOMETER (HKEDG)	Pu U	100 % 50 %	≤ 1 % ≤ 0.5 %
SEPARATION	BUFFER/FEED TANKS	ISOTOPE DILUTION MASS SPECTRO-METRY (IDMS)	Pu U	25 % 2 %	≤ 0.2 % 0.2 %
SEPARATION	SCRUB AND WASTE TANKS	Pu(VI) SPECTRO-PHOTOMETRY	Pu	< 20 %	≤ 25 %
Pu PURIFICATION	COLLECTION AND FEED TANKS	HKEDG IDMS	Pu Pu	50 % ≤ 10 %	1 % ≤ 0.2 %
	PuN TANKS	KEDG IDMS	Pu Pu	25 - 100 % 10 - 90 %	0.2 % 0.1 %
	WASTE TANKS	Pu(VI) SPECTRO-PHOTOMETRY	Pu	< 10 %	≤ 25 %
U PURIFICATION	UN TANKS	K-EDGE DENSITOM-ETER (KEDGG)	U	≤ 10 %	0.2 %
	UO_3 CANS UO_3 CANNING	NDA (MEASURE-MENTS MADE IN PLANT) KEDG	U U	≤ 10 % 1 %	< 5 % 0.2 %
MOX CONVERSION	U, Pu N TANKS	KEDG	U Pu	< 10 % 50 %	0.2 % 0.2 %
		IDMS	Pu	20 %	≤ 0.2 %
	MOX CANISTERS	NDA (MEASURE-MENTS MADE IN PLANT)	Pu	100 %	1 %
	MOX CANNING		Pu	25 %	≤ 0.2 %
		KEDG			

Source: Shea et al., "Safeguarding Reprocessing Plants," JNMM, 1993

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

Different steps, different safeguards

Fuel cycle step	Current safeguards	Future safeguards?
U mining and milling	Essentially none	Declarations +
U conversion	Covered; limited accountancy	Full accountancy
Enrichment	In-depth safeguards	Flow monitoring
LEU fuel fabrication	Covered; limited effort	Covered; limited effort
Power reactor operation	Covered; limited effort	Neutrino detection
Research reactors	Covered; limited effort	Increased effort
Spent fuel storage -- pool	Covered; limited effort	Remote monitoring
Spent fuel storage -- cask	Covered; v. limited effort	Remote monitoring
Reprocessing	In-depth safeguards--challenge	Still a challenge
Pu storage	In-depth safeguards	Remote monitoring
MOX fuel fabrication	In-depth safeguards--chalenge	Still a challenge
Spent fuel disposal	Not operational	Unmanned monitors
HLW disposal	Termination of safeguards	Termination of safeguards

Sumber : **Capacity Building For Safeguards : Some Perspectives,** MANAGING THE DEVELOPMENT OF NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER Vienna 9 - 12 February 2010

The Threat Is Real

- Terrorists have stated their desire to use nuclear weapons.
- Acquiring weapons-useable nuclear material is the key step in constructing a nuclear weapon.
- Weapons-usable nuclear material exists at hundreds of sites in 25 countries.
- Not all sites are well secured against terrorists or criminals and nuclear security is only as strong as the weakest link.
- Once a terrorist has acquired weapons-useable nuclear materials, countermeasures have limited effectiveness

Sumber : Introduction to Nuclear Security https://www.nti.org

Security Lapses Continue

• Overthelast20years,therehavebeen1000sof nuclear smuggling incidents, of which ~ 20 involved highly enriched uranium or plutonium.
• It'slikelythatmanymorecaseswereundetected.
• Therehavebeennumerouslapsesinsecurity that, under different circumstances, could have been catastrophic:
– Y-12 (U.S.) security breach (2012)
– Pelindaba (South Africa) break-in (2007)
– Kurchatov Institute (Russia) accounting problem (2001)

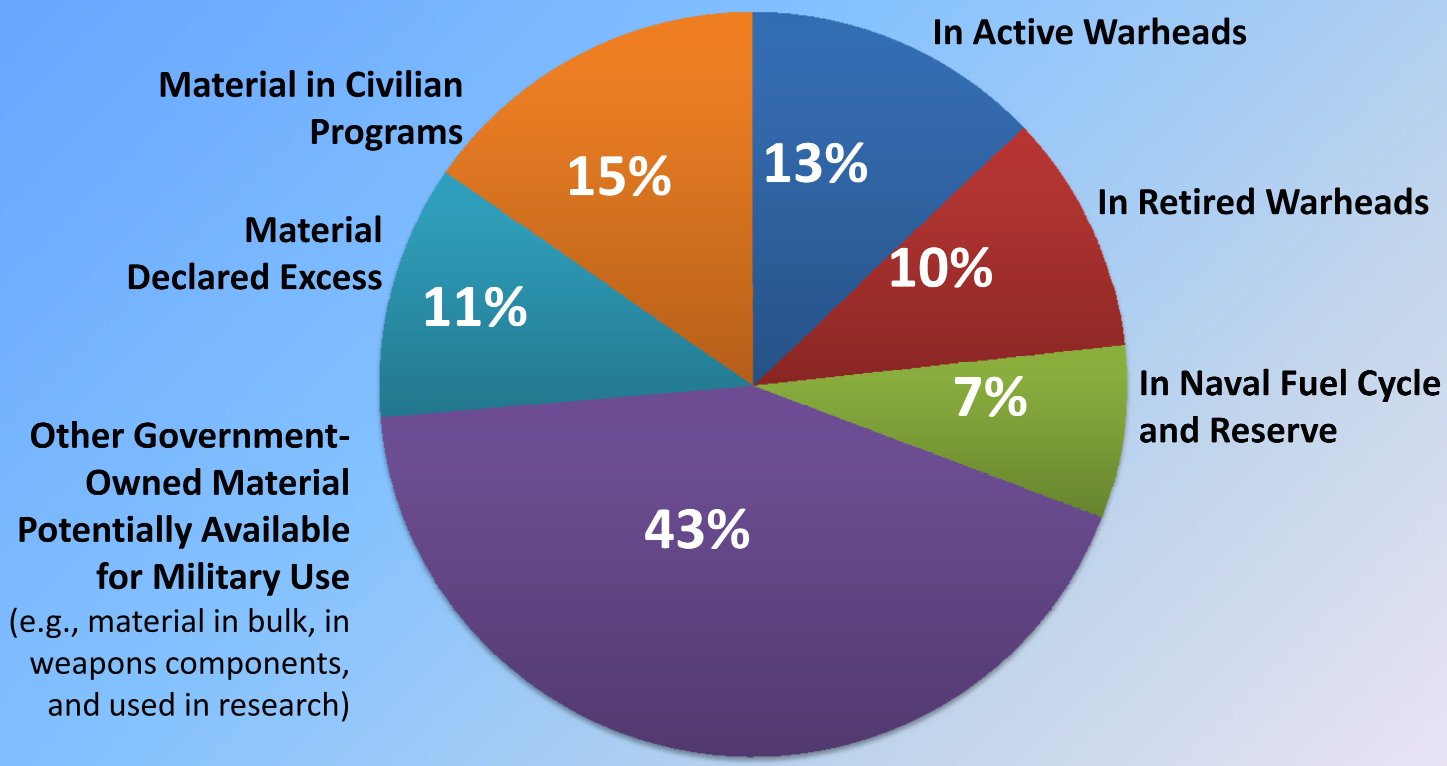
Global Nuclear Security System

• Nuclear security is historically viewed as the sovereign responsibility of individual states.
• Each country's regulatory systems were often developed independently.
– Often variable
• There is no comprehensive global system for tracking, protecting, and managing nuclear materials in a way that builds confidence.
– The existing international system is a patchwork of agreements, guidelines, and multilateral engagement mechanisms.
– It encompasses only civilian materials (15% of total weapons- useable nuclear materials).

Sumber : Introduction to Nuclear Security https://www.nti.org

Konsep Keamanan (Security)

Categories of Weapons-Usable Nuclear Materials Globally (Estimated Percentages)



Note: The total weapons-usable nuclear material inventory is estimated at 1,440 metric tons of HEU and 495 metric tons of separated plutonium. Of this, 1,400 metric tons of HEU and 240 metric tons of plutonium are estimated to be outside of civilian programs. The estimated range of uncertainty regarding the total quantity of materials is +/- 140 metric tons.

Sources: Material quantities are estimates based on *Global Fissile Material Report 2011: Nuclear Weapon and Fissile Material Stockpiles and Production—Sixth Annual Report of the International Panel on Fissile Material* (Princeton, NJ: IPFM, 2012), 2–3.

Sumber : Introduction to Nuclear Security https://www.nti.org

IAEA's Security Role

- The principle objective is to"accelerate and enlarge the contribution of atomic energy..."
- It administers a *safeguards* system to detect diversion for military purposes.
- Nuclear *security* is a relatively new mission.
- IAEA develops nuclear security guidelines and provides numerous nuclear security advisory services.
- The scope of responsibility is *civilian* materials, largely outside the five nuclear weapons states

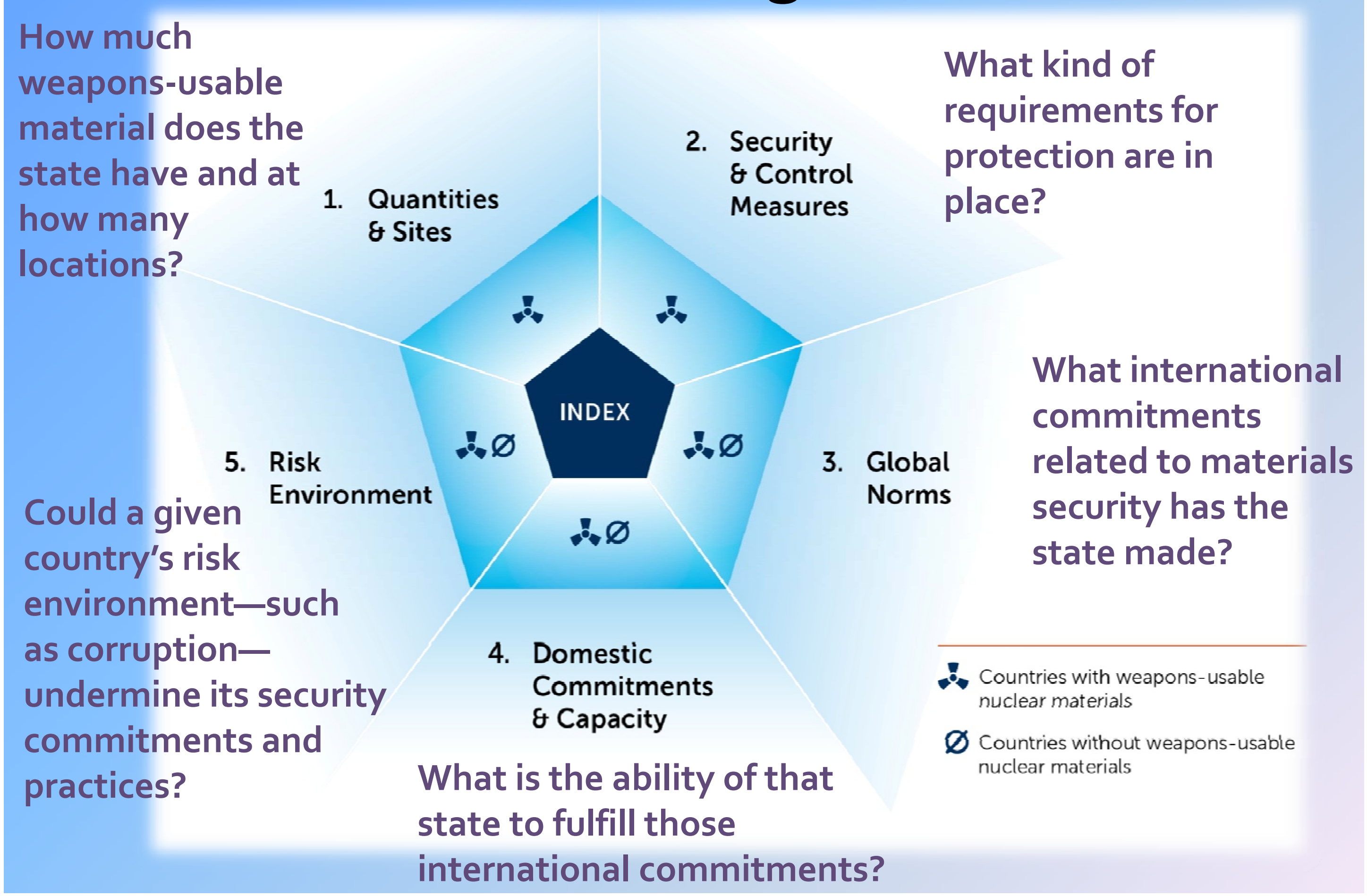
Summary and Discussion

- Nuclear security is a cornerstone of preventing nuclear terrorism.
- An attack anywhere would be an attack everywhere.
- Currently, nuclear materials security largely depends on actions by individual states.
- A comprehensive global system is needed to provide confidence in each state's materials security.

Sumber : Introduction to Nuclear Security https://www.nti.org

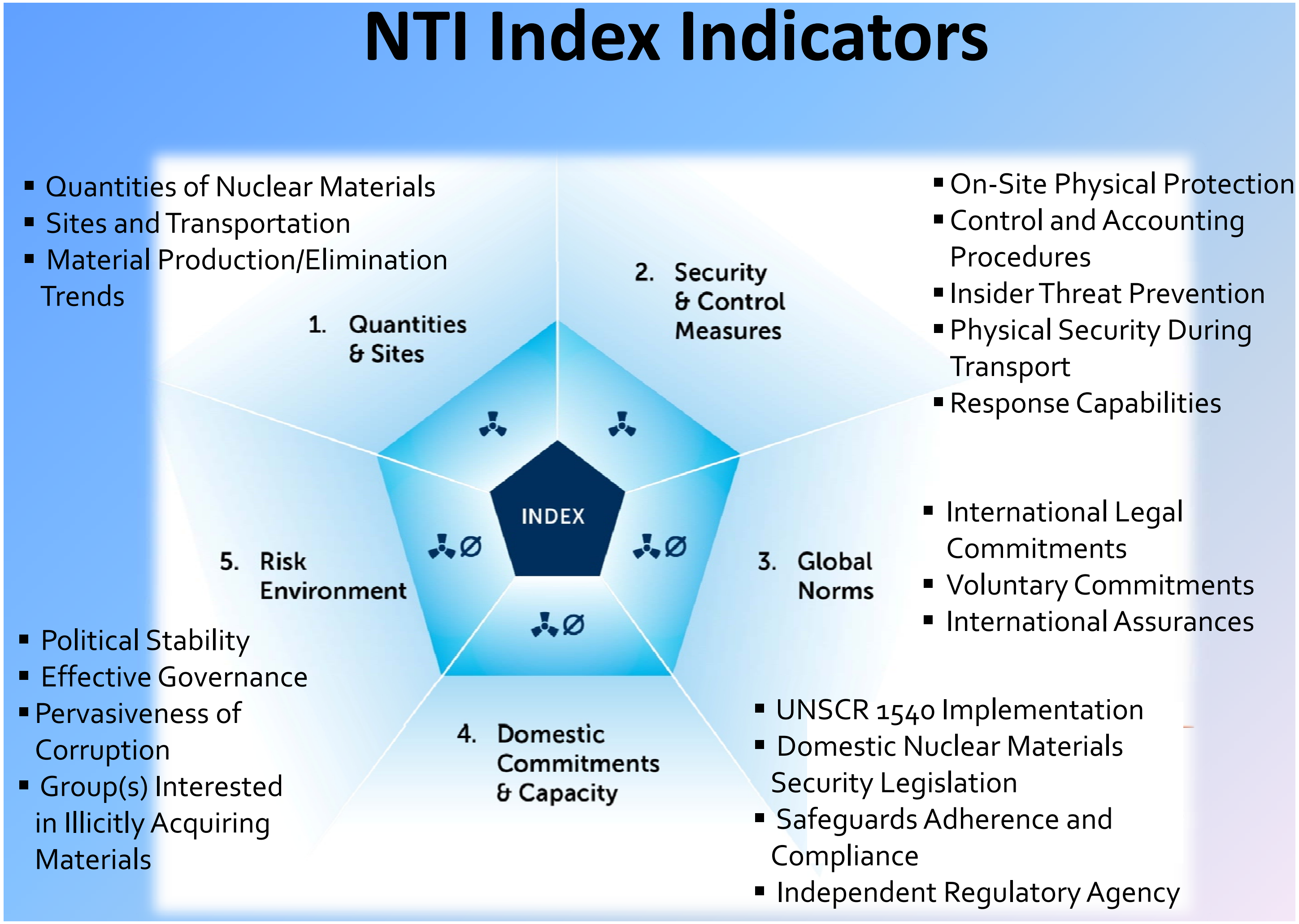
NTI Nuclear Materials Security Index (NTI Index)

The NTI Index Framework Has Five Categories



Sumber : Alberto Muti , **Nuclear Safety, Security and Safeguards, VERTIC**

NTI Nuclear Materials Security Index (NTI Index)



Sumber : Alberto Muti , **Nuclear Safety, Security and Safeguards, VERTIC**

Konsep Keamanan (Security)

NTI Nuclear Materials Security Index (NTI Index)

Country Scores and Rankings (2014)

OVERALL SCORE

Rank / 25		Score / 100	Δ
1	Australia	92	+2
2	Canada	88	+6
3	Switzerland	87	–
4	Germany	85	+3
5	Norway	83	+1
6	Poland	82	+1
=7	France	81	+2
=7	Netherlands	81	–
9	Belarus	80	+5
10	Belgium	79	+7
=11	United Kingdom	77	-1
=11	United States	77	-1
=13	Argentina	76	+4
=13	Japan	76	+6
15	Kazakhstan	73	–
16	South Africa	71	-1
17	Italy	70	-1
=18	Russia	66	–
=18	Uzbekistan	66	+5
20	China	64	+1
21	Israel	57	+2
22	Pakistan	46	+3
23	India	41	+1
24	Iran	39	–
25	North Korea	30	–

1) QUANTITIES AND SITES

Rank / 25		Score / 100	Δ
=1	Argentina	100	+5
=1	Australia	100	+5
3	Uzbekistan	95	+5
4	Iran	89	–
=5	Belarus	84	–
=5	Poland	84	+6
7	Norway	83	-5
8	South Africa	79	+6
9	Italy	73	–
10	Switzerland	72	–
11	Canada	67	–
=12	Belgium	62	+6
=12	Germany	62	–
=12	Netherlands	62	-5
15	North Korea	60	–
16	Kazakhstan	57	-6
17	Israel	44	–
=18	China	34	–
=18	France	34	–
=20	Russia	23	–
=20	United States	23	–
=22	India	22	–
=22	Japan	22	–
=22	Pakistan	22	–
25	United Kingdom	11	–

2) SECURITY AND CONTROL MEASURES

Rank / 25		Score / 100	Δ
1	United States	98	–
=2	Canada	93	+10
=2	United Kingdom	93	–
=4	Belarus	90	+12
=4	France	90	–
=6	Germany	88	+10
=6	Switzerland	88	–
8	Australia	86	–
=9	Kazakhstan	80	–
=9	Russia	80	–
11	Japan	79	+3
12	Netherlands	78	+5
13	Poland	74	–
14	Belgium	73	+17
15	China	72	–
16	Italy	68	–
17	Norway	67	–
18	South Africa	64	–
=19	Argentina	59	–
=19	Israel	59	–
21	Uzbekistan	51	+4
22	North Korea	43	–
=23	Iran	40	–
=23	Pakistan	40	+9
25	India	37	–

3) GLOBAL NORMS

Rank / 25		Score / 100	Δ
=1	Australia	100	+8
=1	France	100	+17
=1	Russia	100	–
=1	United Kingdom	100	–
=5	Canada	94	+17
=5	Germany	94	–
=7	Belgium	88	+9
=7	China	88	+5
=7	Kazakhstan	88	+6
=7	Netherlands	88	–
=7	Switzerland	88	–
12	Japan	85	–
13	United States	83	–
=14	Poland	82	–
=14	Uzbekistan	82	+14
16	Argentina	80	+22
17	Norway	73	–
18	India	71	+6
19	Belarus	68	–
20	Pakistan	63	–
21	Italy	58	–
22	South Africa	57	-5
23	Israel	55	+8
24	Iran	18	–
25	North Korea	0	–

4) DOMESTIC COMMITMENTS AND CAPACITY

Rank / 25		Score / 100	Δ
=1	Australia	100	–
=1	Belgium	100	–
=1	Germany	100	–
=1	Italy	100	–
=1	Japan	100	+27
=1	Netherlands	100	–
=1	Norway	100	–
=1	Poland	100	–
=1	South Africa	100	–
=1	Switzerland	100	–
=11	Canada	96	–
=11	France	96	–
=11	Kazakhstan	96	–
=11	United Kingdom	96	–
=15	Argentina	92	–
=15	Belarus	92	–
=17	Russia	89	–
=17	United States	89	-3
19	Uzbekistan	88	–
20	Pakistan	85	–
21	China	81	–
22	Israel	66	–
23	India	47	–
24	Iran	19	–
25	North Korea	4	–

5) RISK ENVIRONMENT

Rank / 25		Score / 100	Δ
1	Norway	100	+13
2	Japan	86	-1
3	Canada	83	–
4	Switzerland	82	+1
5	Australia	79	–
6	Netherlands	78	–
7	Germany	77	+1
=8	Belgium	75	–
=8	France	75	-1
=10	Poland	74	–
=10	United States	74	–
12	United Kingdom	69	-2
13	Argentina	61	–
=14	Belarus	58	+6
=14	South Africa	58	-2
16	Israel	55	–
17	Italy	51	-1
18	North Korea	42	–
19	China	38	+2
20	Kazakhstan	37	–
21	Iran	35	+1
22	India	32	–
23	Uzbekistan	24	–
24	Russia	21	–
25	Pakistan	19	+6

Sumber : Alberto Muti , **Nuclear Safety, Security and Safeguards, VERTIC**

NTI Nuclear Materials Security Index (NTI Index)

Example Country Profile: Netherlands

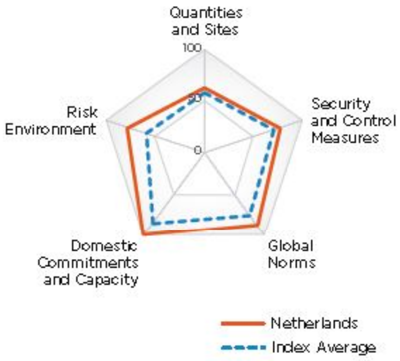
NETHERLANDS

	Score / 100	Δ Score	Rank / 25
OVERALL SCORE	81	-	=7
Quantities and Sites	62	5	=12
Security and Control Measures	78	+5	12
Global Norms	88		=7
Domestic Commitments and Capacity	100		=1
Risk Environment	78		6

= denotes tie in rank

Δ denotes change in score between 2012 and 2014

Scores are normalized (0-100, where 100=most favorable nuclear materials security conditions)



ABOVE AVERAGE (Indicator scores greater than 66)

Quantities and Sites
- Sites and Transportation
- Material Production / Elimination Trends

Security and Control Measures
- On site Physical Protection
- Control and Accounting Procedures
- Response Capabilities

Global Norms
- International Legal Commitments
- Voluntary Commitments

Domestic Commitments and Capacity
- UNSCR 1540 Implementation
- Domestic Nuclear Materials Security Legislation
- Safeguards Adherence and Compliance
- Independent Regulatory Agency

Risk Environment
- Political Stability
- Effective Governance
- Pervasiveness of Corruption

AVERAGE (Indicator scores between 34 and 66)

Quantities and Sites
- Quantities of Nuclear Materials

Security and Control Measures
- Insider Threat Prevention
- Physical Security During Transport

Global Norms
- International Assurances

Risk Environment
- Group(s) Interested in Illicitly Acquiring Materials

BELOW AVERAGE (Indicator scores less than 34)

Synopsis:

Overall excellence—biggest challenges is materials quantities.

Opportunities to improve in:

- Security during transport
- Insider threat prevention
- International assurances
- Reducing materials quantities

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NTI Nuclear Materials Security Index (NTI Index)

Key Index Findings

- Governments are more aware of the threat and are engaged.
- The consensus on priorities is lacking.
- The lack of openness impedes confidence and accountability.
- Several states are more vulnerable to insider threats.
- Stocks of weapons-usable nuclear materials continue to increase.
- More states could eliminate their stocks.
- Many states lag on joining international agreements

Sumber : Alberto Muti , **Nuclear Safety, Security and Safeguards, VERTIC**

Semester 1 2022/2023
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