Introduction to Nuclear Security

Outline

- The threat
- Nuclear 101
- Nuclear security
  - Current status
  - The global system: challenges and opportunities
- Reactions and discussion

The Threat Is Real

- **Theft**
  - Terrorists have stated their desire to use nuclear weapons
  - Acquiring nuclear material is hardest step in making a nuclear weapon
  - Not all sites are well-secured against terrorists or criminals
  - No effective countermeasures once material obtained by terrorists
- **Sabotage of nuclear facilities**
  - Could cause a catastrophic radiation release, similar in scale to the Chernobyl accident
  - Many developing countries lack sufficient protection measures from sabotage

Nuclear security is only as strong as the weakest link

Nuclear 101

Watch short tutorial video:

https://www.youtube.com/watch?v=7FXtqCKEYgo&feature=youtu.be

Key Concepts

- Nuclear *fission* is the breakup of a heavy nucleus, such as uranium, into two medium-weight nuclei. Fission is usually accompanied by emission of a few neutrons and γ-rays.
- Under certain conditions chain reactions can occur and lead to enormous amounts of energy being released
- Nuclear technology is dual use:
  - Nuclear reactor=controlled energy release
  - Nuclear bomb=uncontrolled energy release

Nuclear Fission Videos

https://www.youtube.com/watch?v=mBdVK4cqiFs

http://www.youtube.com/watch?v=0v8i4v1mieU

Fissile Materials

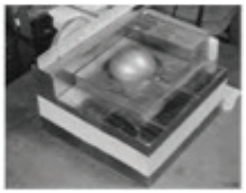
Uranium

- < 20% U-235: Low enriched uranium (LEU)
- Nuclear reactors use 3-5% U-235
- >=20% U-235: Highly enriched uranium (HEU)
- Can in principle be used to make weapons
- >=90% U-235: "Weapons-grade"

Plutonium

- Produced in nuclear reactors
- Plutonium separated with chemical processes (i.e. reprocessing)

The amount of HEU needed to build a nuclear weapon could fit in a 5lb bag of sugar.



The amount of weapons-grade plutonium needed to build a bomb is roughly the size of a grapefruit

US Department of Energy

Types of Nuclear Weapons

	Plutonium	HEU	Yield	Example
IAEA Significant Quantity (SQ)	8 kg	25 kg*		
1st-generation gun-type weapon	n/a	50–60 kg	20 kt	Hiroshima
1st-generation implosion-type weapon	5–6 kg	15–18 kg	20 kt	Nagasaki (6 kg Pu)
2nd-generation single-stage weapon	4–5 kg	12 kg	40–80 kt	(levitated or boosted pit)
Two-stage low-yield weapon	3–4 kg Pu and 4–7 kg HEU		100–160 kt	W76
Two-stage medium-yield weapon	3–4 kg Pu and 15–25 kg HEU		300–500 kt	W87/W88
Two-stage high-yield weapon	3–4 kg Pu and 50+ kg HEU		1–10 MT	B83

Table A.1. Nuclear weapon generations and estimated respective fissile material quantities. Warhead types are U.S. warhead-designations. The estimates assume about 18 kt per kilogram of nuclear material fissioned, a fission-fraction of 50% for a 2nd-generation and two-stage weapon, and a yield fraction of 50% in the secondary from fission in the two-stage weapon. *The significant quantity specifies uranium-235 contained in highly enriched uranium.

Source: International Panel on Fissile Materials *Global Fissile Material Report 2015*

Nuclear Weapons Effects

- **Blast** – causes shock waves
- **Thermal radiation** – generates heat
- **Nuclear radiation** – causes short and long-term biological effects
- **Electromagnetic pulse** – disrupts and damages electronics and infrastructure

Photo: XX-34 BADGER atmospheric nuclear test performed by the United States in April 1953.
Photo Credit: NNSA

Countries with Nuclear Weapons

Country	Date of first nuclear test	Current nuclear warheads
United States	1945	~7200, of which about 2500 are awaiting dismantlement
Russia	1949	~7500, with a large fraction awaiting dismantlement
United Kingdom	1952	215
France	1960	Fewer than 300
China	1964	~260
India	1974	110 – 120
Israel	1979*	80
Pakistan	1998	120 – 130
North Korea	2006	fewer than 10

Table 1. Date of first nuclear test and estimated total nuclear-weapon stockpiles as of 2015.
Source: Federation of American Scientists, Status of World Nuclear Forces, updated September 2015.

* Possible nuclear test by Israel in the Southern Indian Ocean on 22 September 1979.

Source: International Panel on Fissile Materials *Global Fissile Material Report 2015*

Nuclear Security

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).

Current Status

- >100 incidents of theft and other unauthorized activities involving nuclear and radioactive material reported by IAEA each year
- Likely that many more cases are undetected
- Ongoing lapses in security
  - US Y-12 security breach (2012)

Nuclear Security System

- Historically viewed as the responsibility of individual countries
- Each country's regulatory systems were often developed independently
- Existing international system is a patchwork of agreements, guidelines, and multilateral engagement mechanisms
- There is no comprehensive system for tracking, protecting, and managing nuclear materials in a way that builds confidence

Existing Nuclear Security System

AGREEMENTS AND GUIDELINES

- CPPNM
  - 2005 Amendment
- UNSCR 1540 & 1373
- ICSANT
- INFCIRC/225/Rev. 5
- IAEA Fundamental Principles
- Safeguards and accounting
- Nuclear Suppliers Group
- NPT

MULTILATERAL ENGAGEMENT MECHANISMS

- Nuclear Security Summits
- G8 Global Partnership
- GICNT
- Centers of Excellence and Nuclear Security Training
- Proliferation Security Initiative (PSI)

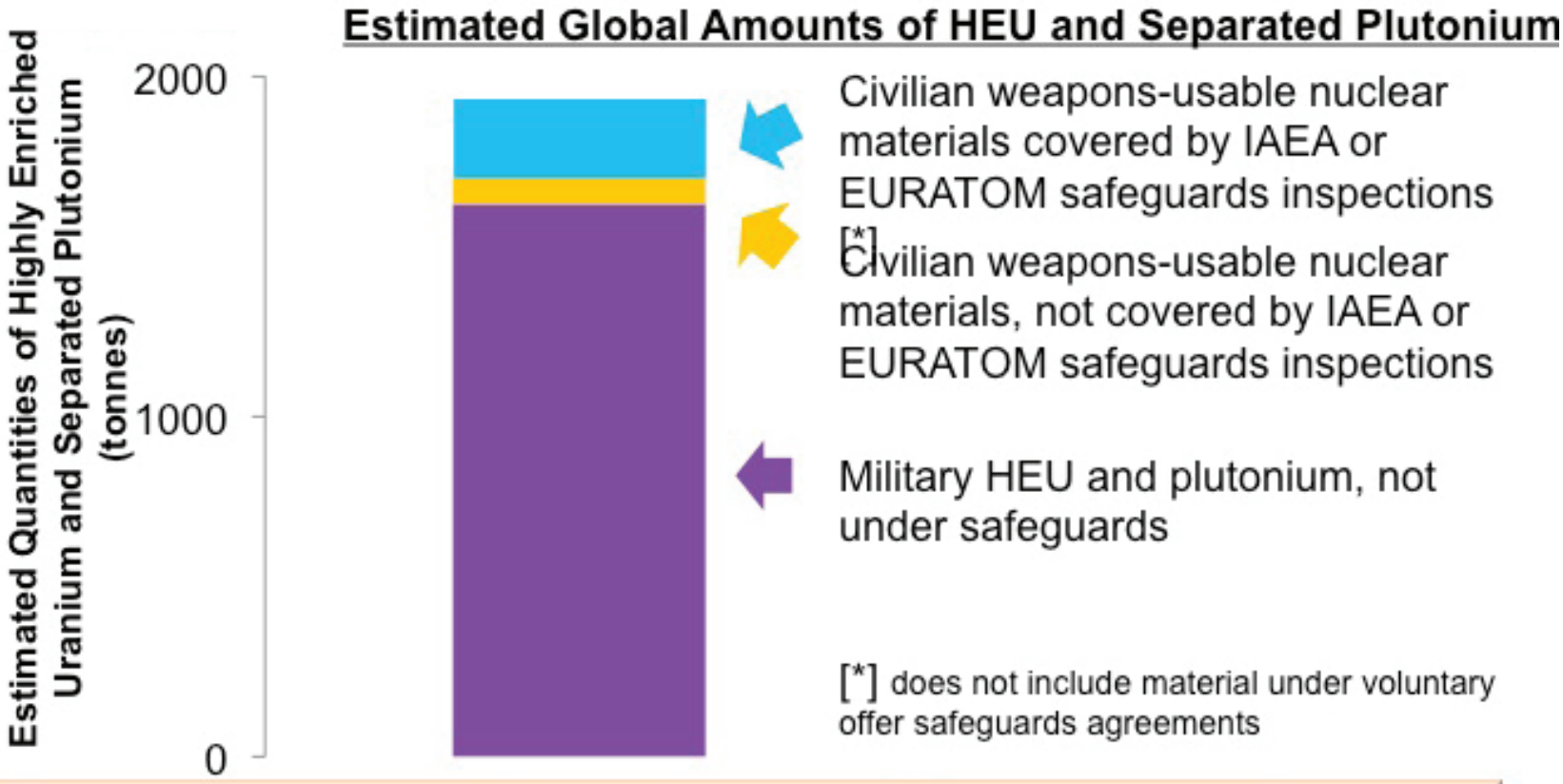
IMPLEMENTATION MECHANISMS

- IAEA Advisory Services
  - IPPAS
  - INSServ
  - Others
- World Institute for Nuclear Security (WINS)
- Global Threat Reduction Initiative

IAEA's Security Role

- Principle objective is to ***"accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world"***
- Administers safeguards system to detect diversion for military purposes
- Develops nuclear security guidelines and provides a number of nuclear security advisory services
  - Nuclear security is a relatively new mission
- Scope of responsibility is *civilian* materials largely outside the five nuclear weapons states

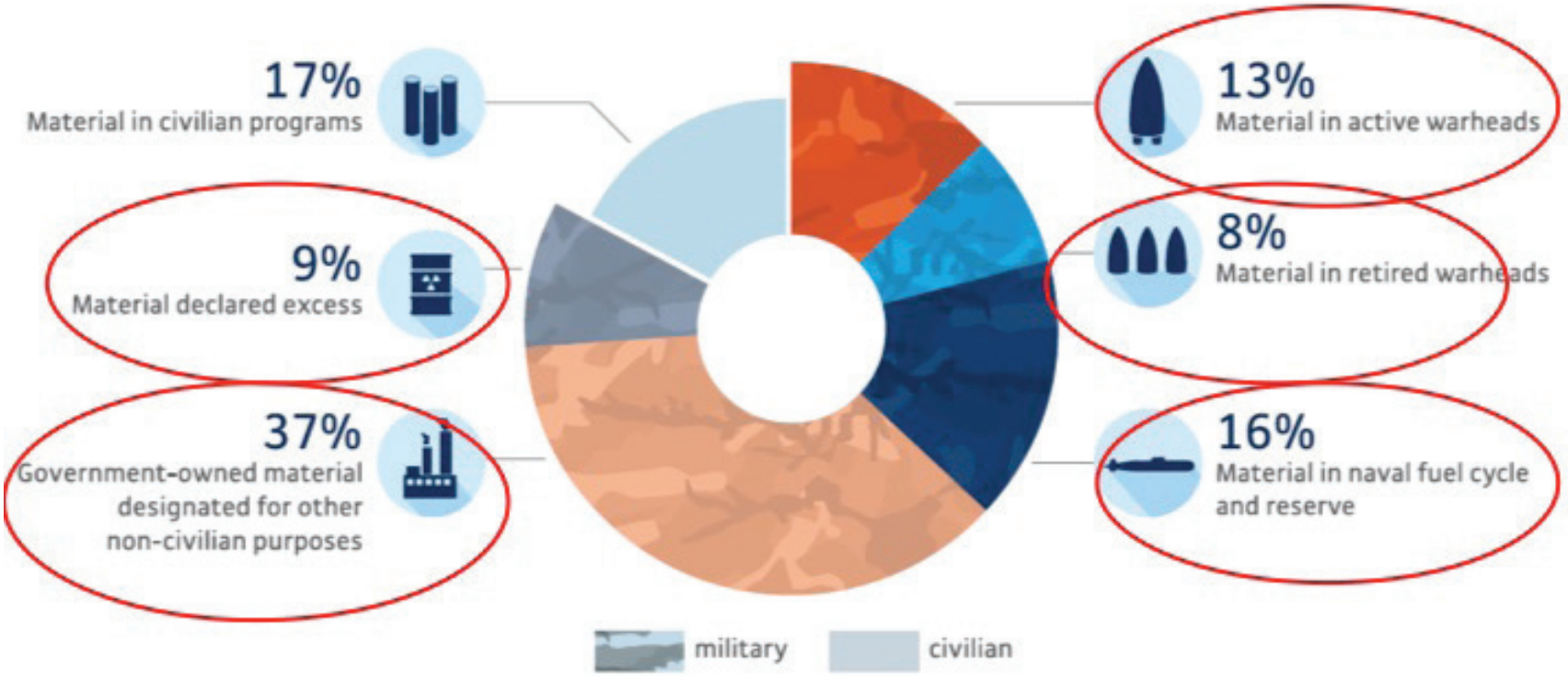
Scope of the Existing System



Most weapons-usable nuclear materials are not subject to international agreements, security guidelines and are not under international safeguards

Source: *International Panel on Fissile Material 2011;* Estimates do not include spent HEU fuel or Pu in spent fuel

Military Materials



=83%

Nuclear Security Summits

- Focused high-level attention on the issue
- Products include a non-binding communiqué, a work plan, and commitments by states and groups of states

- Nuclear Security Summits were held in Washington, DC (2010); Seoul South Korea (2012); The Hague, Netherlands (2014)
- Fourth and final in Washington, DC in 2016

Summary

- Nuclear security is a cornerstone of preventing nuclear terrorism
- The current system largely depends on actions by individual states
- The global system is insufficient and needs to be strengthened

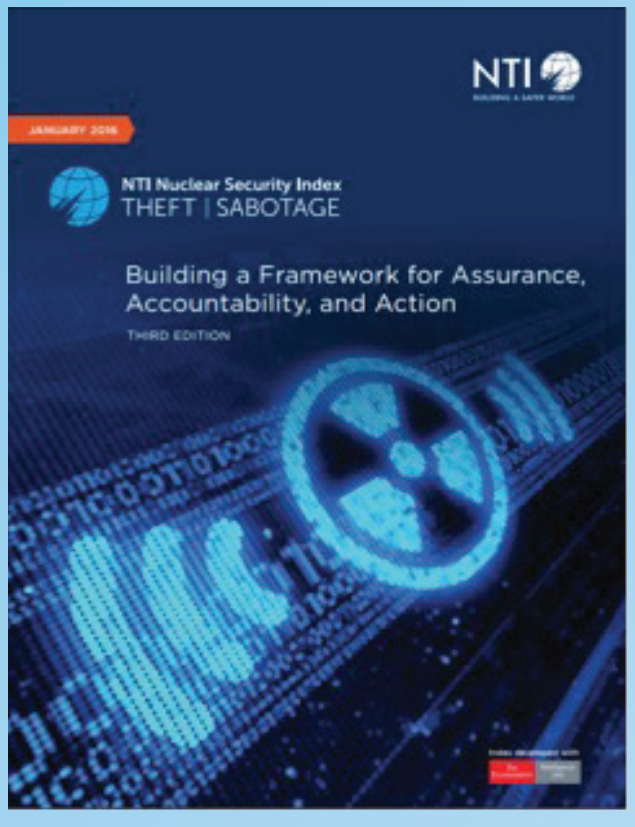
NTI Created an Index to Assess Nuclear Materials Security Conditions

- **An index is a structured way of assessing country actions and enables tracking over time**
  - Simplifies complex issues
  - Provides a framework for discussion
  - Permits objective, standardized evaluation

- **The NTI index has several characteristics**
  - Broad framework
  - International perspective
  - Transparent

The NTI Index Has Several Important Goals

- **Provide a country-by-country assessment of global nuclear materials security conditions**
  - Identify needed improvements and track progress
  - Promote action to improve nuclear materials security
  - Serve as a basis for dialogue on priorities for preventing theft of nuclear materials



Released in January 2016
Available at ntiindex.org

Key Characteristics

indicator score = Σ individual subindicators

category score = Σ weighted individual indicators

$x = (x - \text{Min}(x)) / (\text{Max}(x) - \text{Min}(x))$,

Rigorous Analysis

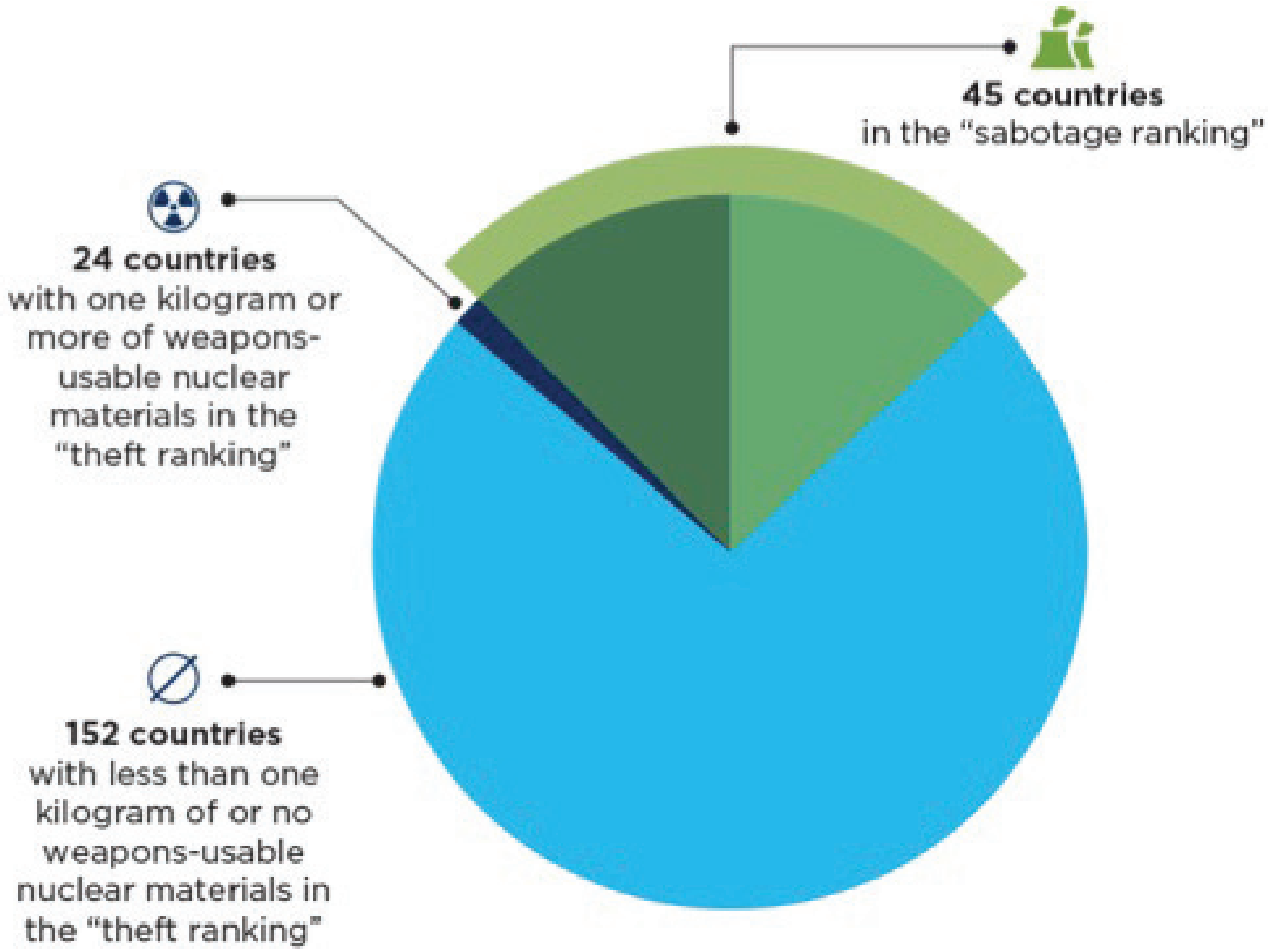
International Perspective

Transparent Process

Scope and Constraints

- **Provide a country-by-country assessment of global nuclear materials security conditions**
  - Theft: evaluates nuclear materials security conditions
    - 24 countries with >= 1 kg of nuclear material
    - 152 countries with <1 kg or no nuclear materials
  - Sabotage: evaluates nuclear security conditions at nuclear facilities
    - 45 countries with nuclear facilities
- **Constraints:**
  - Uses publically available information
  - Assessment at the country, not facility level
  - Assesses nuclear security, not nuclear safety

Features Theft and Sabotage Rankings



Theft Indicators

Sabotage Indicators

Cybersecurity Is An Emerging Issue

Theft

Physical Protection, Control & Accounting

Sabotage

Safety & Operations

Nuclear Command & Control

Satellite Systems & Communications

Cybersecurity at Nuclear Facilities

- **NTI Index includes basic cybersecurity measures**
  - Is cybersecurity required at nuclear facilities?
  - Must critical digital assets be protected?
  - Must cyber threat be included in overall threat assessment?
  - Is cybersecurity assessed in a performance-based program?

- **Same indicator used for both theft and sabotage rankings**

Country Scores and Rankings: Theft (2016)

OVERALL SCORE				
			Change since	
Rank / 24		Score / 100	2014	2012
1	Australia	93	0	+3
2	Switzerland	91	+2	+4
3	Canada	87	+2	+8
4	Poland	84	+3	+7
=5	Belgium	83	+3	+13
=5	Germany	83	+1	+6
=5	Norway	83	+2	+5
=8	Belarus	81	0	+7
=8	France	81	+1	+3
10	United States	80	+3	+2

Score simulator demonstration:

What could North Korea do to get a score of 83?

http://ntiindex.org/data-results/score-simulator/

Example Country Profile: Netherlands, Theft

NETHERLANDS

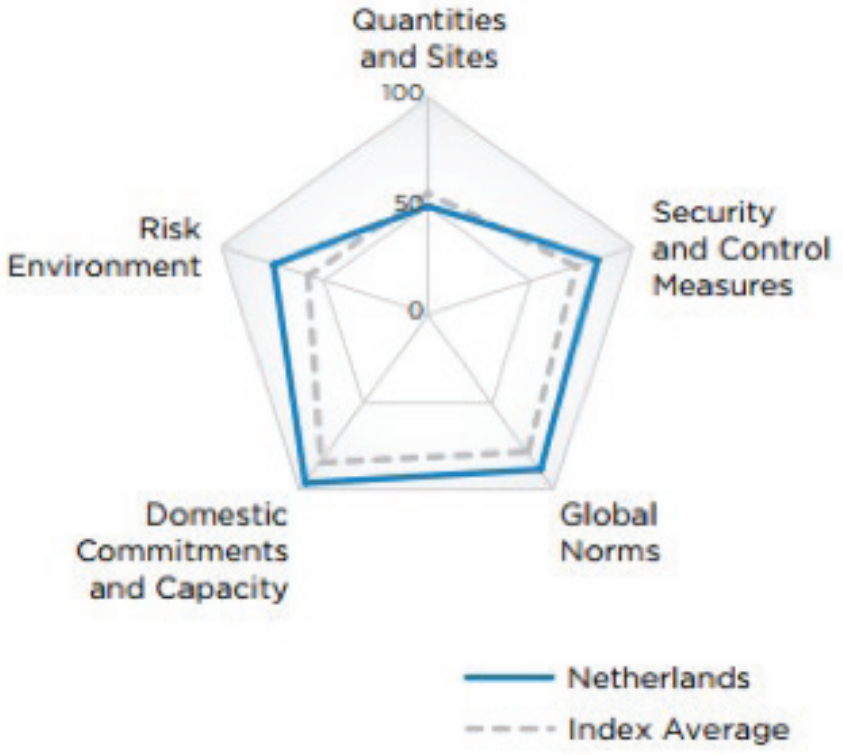
	2016 Score	Δ Score	Rank / 24
OVERALL SCORE	**79**	**-1**	**11**
Quantities and Sites	50	-22	14
Security and Control Measures	82	+10	=9
Global Norms	88	-	=9
Domestic Commitments and Capacity	96	-	=7
Risk Environment	75	-	7

= denotes tie in rank

Δ denotes change in score between 2014 and 2016

– denotes no change between 2014 and 2016

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



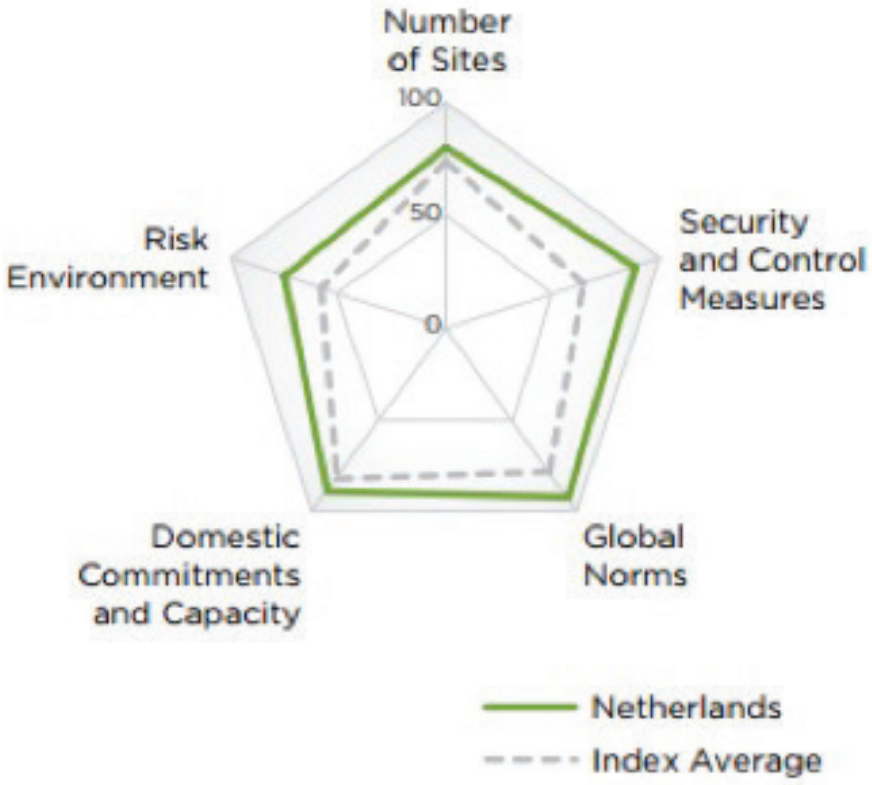
Example Country Profile: Netherlands, Sabotage

NETHERLANDS

	2016 Score	Rank / 45
OVERALL SCORE	**86**	**=10**
Number of Sites	80	=15
Security and Control Measures	88	=10
Global Norms	92	=14
Domestic Commitments and Capacity	89	=22
Risk Environment	75	12

= denotes tie in rank

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



Selected 2016 Observations

- Summits played valuable role; significant progress has been made
- Progress securing and eliminating materials has slowed
- Countries are ill-prepared for emerging cyber threat
- Some countries considering nuclear power programs do not have robust regulatory systems in place
- Still no comprehensive, effective global system

Selected Recommendations

- **Global actions**
  - Build an effective global nuclear security system
  - Strengthen and build confidence in security of military materials
  - Bolster legal foundation

- **State actions**
  - Stop increasing stocks of weapons-usable nuclear materials
  - Bring all civilian production facilities under international safeguards

- **Sustainability**
  - Core group must sustain progress in short term
  - Strengthen IAEA

Summary

- Third edition of Index was released in January 2016
- Index is a valuable resource for countries as they strengthen nuclear security
- NTI Index will continue to be used to promote dialogue and actions

NTI on the web:
www.nti.org

NTI on Twitter:
@NTI_WMD

Back-up slides

Existing Mechanisms: Benefits and Limitations

BENEFITS

- Binding treaties provide the foundation for nuclear security
- Guidelines and recommendations help states to implement security measures
- Informal engagement mechanisms provide ways for states to cooperate
- Informal engagement mechanisms help states match resources to need
- The IAEA has technical knowledge/ expertise relevant to security
- Organizations like WINS help promote sharing and development of best practices

LIMITATIONS

- Treaties are not universal; some important provisions are not in force
- Treaties do not provide guidance on implementation
- Treaties have no enforcement or verification mechanisms
- Guidelines and recommendations are non-binding
- Engagement mechanisms are voluntary
- Variable implementation across states may compromise achievement of objectives
- Best practices are non-binding
- No standardized system to provide international assurance or domestic accountability

Convention for the Physical Protection of Nuclear Material (CPPNM)

Binding treaty requiring states to apply **physical protection measures** to nuclear material, primarily during **international transportation.**

2005 Amendment expanded the CPPNM's scope to require protection of nuclear materials in **use, storage, and domestic transit, and protection of nuclear facilities from sabotage.**

- Not universal
- 2005 Amendment not in force
- No mechanism to enforce/ monitor implementation
- No consequences for non-compliance
- No mechanism for verification/ assurances
- No guidance on implementation
- Variable implementation across states may compromise achievement of objectives

UNSCR 1540

Only **universal legally binding** instrument **requiring physical security measures** for nuclear material. Requires states to establish laws to prohibit non-state actors from acquiring, possessing, or using WMD, and implement appropriate controls over related materials, including security and accounting, to prevent WMD proliferation.

1540 Committee is responsible for managing implementation. Countries must report progress to the committee.

- No enforcement mechanism
- No consequences for non-compliance
- No guidance on implementation
- Reporting requirements are weak

- Lack of committee resources means no strong mechanism to monitor implementation or for verification/assurances
- Variable implementation across states may compromise achievement of objectives

International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT)

Requires states to **criminalize** and **prosecute** offenses related to the **use or possession of radioactive material and use or damage of a nuclear facility.** Establishes a legal framework for cooperation among states to detect, prevent, suppress, and investigate offenses and institute criminal proceedings.

- Not universal
- No mechanism to enforce/monitor implementation
- No consequences for non-compliance
- No mechanism for verification/ assurances
- Variable implementation across states may compromise achievement of objectives

INFCIRC/225/Rev. 5

This IAEA document provides **guidelines and recommendations** for the **physical protection** of nuclear material and facilities, **measures against unauthorized removal** of nuclear materials, and protection of nuclear material and facilities from **sabotage**. INFCIRC/225 provides **basic international guidance** for physical protection of nuclear material and facilities.

- Non-binding
- No clear performance objectives/ performance criteria
- No mechanism for verification/ assurances
- Variable implementation across states may compromise achievement of objectives

IAEA Fundamental Principles

A set of principles adopted by the IAEA Board of Governors and meant as a step toward **strengthening the physical security regime** and **promoting the effective implementation and improvement** of physical protection worldwide. They have been incorporated into the 2005 Amendment to the CPPNM.

- Non-binding until 2005 Amendment enters into force
- No mechanism for verification/assurances
- Variable implementation across states may compromise achievement of objectives

Safeguards and Nuclear Material Accounting

IAEA safeguards agreements require states to apply **standard nuclear material accounting systems.** All states with nuclear material (except NK) have safeguards agreements in place, though **coverage depends on whether a state is a NWS, a NNWS, or non-NPT state.**

- Safeguards are not universal
- No guidance on implementation
- Variable implementation across states may compromise achievement of objectives
- Inspections mandate limited to diversion of nuclear material from peaceful uses, not preventing acquisition of nuclear material by unauthorized persons

Nuclear Suppliers Group

The NSG was established to ensure that suppliers apply a **uniform approach to nuclear and nuclear-related exports and dual-use items.** NSG guidelines aim to ensure that peaceful nuclear trade does not contribute to proliferation of nuclear weapons. **Suppliers should authorize transfers of trigger list items only where those items will be subject to safeguards.** Guidelines also state that recipients should have physical security measures in place.

- Guidelines are non-binding
- Differences in national law and practice lead to inconsistent implementation

Nuclear Security Summits

Brings together government leaders from states around the world to **focus high-level attention on the threat of nuclear terrorism.** The summit produces a communiqué identifying priority areas. At the close of the 2010 Summit, more than 60 national commitments were made, over 80% of which were achieved by the 2012 Summit. At the 2012 Summit, over 100 commitments were made.

- Voluntary, non-binding, political commitments
- No mechanism for verification/ assurances
- Communiqué requires consensus, leading to lowest common denominator outcome
- Sustained high-level attention needed

G8 Global Partnership

A 2002 G8 initiative committed to **preventing terrorists from acquiring or developing WMD.** G8 countries pledged $20 billion over the first 10 years to fund projects to **secure and dismantle WMD stockpiles** in Russia. Since then the Global Partnership has successfully implemented numerous projects, including outside Russia. The G8 extended the GP for another ten years. Its informal nature allows countries to **match resources to specific projects.**

- Commitments are non-binding
- No mechanism to enforce commitments
- No mechanism for verification/ assurances
- Based on voluntary contributions

Global Initiative to Combat Nuclear Terrorism

The GICNT provides another **informal mechanism for state cooperation.** Its mission is to **strengthen global capacity** to prevent, detect, and respond to nuclear terrorism. Partner nations conduct **multilateral activities, workshops, table-top exercises, and field exercises.**

- Membership is voluntary
- Not universal
- No mechanism to enforce commitments/monitor implementation
- No mechanism for verification/ assurances
- Based on voluntary contributions

Proliferation SecurityInitiative (PSI)

An informal grouping of states that have joined together to **prevent trafficking by detecting and intercepting WMD and WMD-related materials.** Countries commit to strengthen national legal authorities to facilitate interdiction, develop procedures to facilitate exchange of information, and take specific actions in support of interdiction efforts. **Shipboarding agreements** give parties permission to board vessels sailing under the other parties' national flag. Several high-profile successes in interdicting or turning back WMD-related shipments have been attributed to PSI.

- Participation is voluntary
- Commitments are non-binding
- No organizing structure
- Not universal

IAEA Nuclear Security Advisory Services

Although the IAEA's mandate is limited to safeguards, recognizing that it has the **technical knowledge and experience** to provide advice and assistance in the security area, the **IAEA provides advisory services.** These services include missions, evaluations, and technical services to **help requesting states assess their nuclear security needs** and **improve their capabilities** for securing nuclear material.

- Services provided upon state's request
- Unless requested, missions do not assess actual quality of physical protection at facilities
- Outcomes confidential
- States not obligated to respond to conclusions or address deficiencies
- Services primarily supported through voluntary contributions to Nuclear Security Fund

World Institute for Nuclear Security (WINS)

An organization whose purpose is to provide a **forum for nuclear security professionals to share and promote best security practices.** Best practice exchanges can be a valuable tool to enable rapid and dynamic improvements for facilities' security implementation. WINS produces **best practices guides,** including **self-assessment tools,** and is **developing accreditation and training** for nuclear security professionals. WINS is also **developing peer review** offerings.

- Best practices are non-binding
- No mechanism for monitoring implementation
- No mechanism for verification/ assurances
- Funded through donations