Tilting At Windmills?
Research, Collaboration, Advocacy and Agenda Setting on Fissile Materials

Zia Mian and Alexander Glaser

UCS Summer Symposium on Science and World Affairs, Princeton, NJ, August 1, 2014
About the IPFM

MISSION

Providing the technical basis for policy initiatives to reduce global stocks of military and civilian fissile materials

• Established in 2006, IPFM has 31 members from 18 states

• Publications: annual Global Fissile Material Reports, research reports, and country studies

• www.fissilematerials.org and www.fissilematerials.org/blog
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- Pervez Hoodbhoy (Pakistan)
- Li Bin (China)
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- Gordon MacKerron (United Kingdom)
- Yves Marignac (France)
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- Fumihiko Yoshida (Japan)
Global Fissile Material Reports

2008: Scope and Verification of a Fissile Material (Cutoff) Treaty
    with country perspectives and draft FM(C)T

2009: A Path to Nuclear Disarmament
    with country perspectives

2010: Balancing the Books: [Weapon State] Production and Stocks

2011: Nuclear Weapon and Fissile Material Stockpiles and Production

2013: Increasing Transparency
    of Nuclear Warhead and Fissile Material Stocks as a Step toward Disarmament

NEXT: Unmaking the Bomb: A Fissile Material Approach
    A Fissile Material to Nuclear Disarmament and Nonproliferation, MIT Press, 2014
Among the toxic and threatening legacies of the nuclear arms race are tens of thousands of warheads, and distinguished authors have had a sustained involvement in the science and the politics of these issues. This cogent and stockpiles of plutonium and enriched uranium. How can these best be safeguarded and disposed of? The distinct.

Scott Sagan, Center for International Security and Cooperation, Stanford University

"Fissile materials pose a ‘perpetual menace to human security,’ Niels Bohr famously argued in nuclear engineering."

risks. It will be an invaluable guide to the subject for students of international relations, security studies, and both highlights the continuing truth of that observation and importantly outlines policies that can reduce the.

George Perkovich, Carnegie Endowment for International Peace,

"To address the challenges of nuclear disarmament and nonproliferation, the Princeton team persuasively details for, verifying, and ultimately eliminating stockpiles of fissile materials will be vital to international security and discussion in this regard."

Hu Side, former President of the China Academy of Engineering Physics

"Achieving a nuclear-free world is a common ideal of the international community. The authors of this book have materials, providing an opportunity for the international community to have a more extensive and in-depth

have made four specific suggestions for the gradual reduction and eventual elimination of worldwide fissile

been long involved in the study of nuclear materials. Based on their abundant research achievements, they

Alexey Arbatov, Director of the Center on International Security, Russian Academy of Sciences

"not only for professional nuclear physicists, military strategists, and arms controllers but also for the interested

and peaceful nuclear energy—their overlap and contradictions. The book is also valuable since it is designed

Unmaking the Bomb

MIT Press

www.unmakingthebomb.com

September 26, 2014
Fissile Materials and Nuclear Weapons

HEU in weapons usually more than 90% enriched in U-235 (0.7% in nature)

The Hiroshima bomb used 60 kg of 80%-enriched HEU

Plutonium (mostly Pu-239) separated from irradiated uranium

The Nagasaki bomb used 6 kg of Plutonium
Verifiably and irreversibly reducing and eliminating nuclear weapons will require openness about national stockpiles of nuclear weapons and fissile materials.

A modern thermonuclear warhead contains on average 3–4 kg of plutonium and 25 kg highly enriched uranium.

Highly Enriched Uranium, mid 2013

Global stockpile is about 1350 tons, almost 99% is in weapon states

- China: 16 MT*
- France: 26 MT*
- India: 4.6 MT
- Israel: 2.4 MT*
- Pakistan: 0.3 MT*
- Russia: 616 MT* (517 MT Eliminated, 141 MT Weapons Available, 63 MT Excess, 252 MT Naval, 260 MT Civilian)
- UK: 11.7 MT (20 MT* Civilian, 1.4 MT* Excess, 8.1 MT Naval)
- United States: 252 MT
- NNW States: 15 MT

(25 MT of HEU are equivalent to 1,000-2,000 nuclear weapons)

*Estimate
Separated Plutonium, mid 2013

Global stockpile is about 500 tons, more than half is civilian and this stock is growing

Metric tons

- Civilian stockpile, stored outside country (Dec. 2012)
- Civilian stockpile, stored in country (Dec. 2012)
- Excess military material
- Additional strategic stockpile
- Military stockpile
- Disposed

(5 MT of plutonium are equivalent to 1,000–1,500 nuclear weapons)
How IPFM Estimates Are Made
The Case of Israel’s Plutonium Stockpile
U. M. Staebler and J. W. Crouch, Jr., Notes on Visit to Israel, Draft, 23 May 1961
Available at www.gwu.edu/~nsarchiv/israel/documents/first, mirrored at www.ipfmlibrary.org/sta61.pdf
1985 Vanunu Pictures and Testimony
Technical Specifications of “EL-3”

Some data can be used to complement data otherwise unavailable for Dimona

Possible Operational Histories of Dimona
(1965–2015, Production Scenarios A–E)

- **Scenario A**: 40 MW → Cumulative plutonium production: 520 kg
- **Scenario B**: 40 MW → 70 MW → 40 MW → 720 kg
- **Scenario C**: 40 MW → 70 MW → 870 kg
- **Scenario D**: 40 MW → 70 MW → 140 MW → 70 MW → 40 MW → 870 kg
- **Scenario E**: 40 MW → 70 MW → 140 MW → 70 MW → 1010 kg

Starting in 1965:
- **1965**: Beginning of full-scale plutonium production at Dimona is uncertain; reactor went critical in 1962 and began operating in late 1963

*Possible circumstances or explanations

- **Power uprate prior to Vanunu’s arrival**
- **Tritium production becomes main mission of Dimona**
- **Decision not to qualitatively expand nuclear arsenal**
## 50 Years of Plutonium Production at Dimona

<table>
<thead>
<tr>
<th>Estimated plutonium inventory by 2015: 850 kg ± 130 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>(allowing for possible removals of about 20 kg in nuclear tests)</td>
</tr>
<tr>
<td>Current production rate: 10–18 kg/year, depending on Dimona’s power level: 40–70 MW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Israel’s nuclear arsenal is believed to include 100–150 warheads</th>
</tr>
</thead>
<tbody>
<tr>
<td>If these estimates are correct, Israel has more than enough plutonium to meet its current security needs and could cease fissile material production</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plutonium production possibly a “byproduct” today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main mission of Dimona now most likely tritium production</td>
</tr>
<tr>
<td>(Tritium could be produced with alternative non-reactor-based options)</td>
</tr>
</tbody>
</table>
How IPFM Estimates Are Used

The Case of South Asia
What Next?
Demonstrating Methods Required for Nuclear Archaeology

NRX, Canada

Ågesta Reactor (105 MWt), near Stockholm, Sweden
# Transparency Matrix, 2014

Information on nuclear warhead and fissile material inventories and status

<table>
<thead>
<tr>
<th></th>
<th>United States</th>
<th>Russia</th>
<th>Britain</th>
<th>France</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of total warheads</strong></td>
<td>Approximate</td>
<td>No</td>
<td>Yes (upper limit)</td>
<td>Yes (upper limit)</td>
<td>Relative (out of date)</td>
</tr>
<tr>
<td><strong>Number of deployed warheads</strong></td>
<td>Yes (strategic only)</td>
<td>Yes (strategic only)</td>
<td>Yes (planned)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Dismantlements</strong></td>
<td>Yes</td>
<td>No</td>
<td>Yes (no details)</td>
<td>Yes (no details)</td>
<td>No</td>
</tr>
<tr>
<td><strong>Verification</strong></td>
<td>Partial</td>
<td>Partial</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Fissile material stockpiles</strong></td>
<td>Yes</td>
<td>No</td>
<td>Yes (no details)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Production histories</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Excess/Disposal</strong></td>
<td>Yes (nothing new)</td>
<td>Yes (nothing new)</td>
<td>Yes (nothing new)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Verification</strong></td>
<td>Partial</td>
<td>Partial (but no longer)</td>
<td>Partial (some plutonium)</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>