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Lawrence Livermore National Laboratory

Monterey Institute of International Studies
A Graduate School of Middlebury College

DOE/NNSA Next-Generation Safeguards Initiative: Presentations by MIIS-LLNL Safeguards Policy Interns

August 2013

Work funded by the DOE/NNSA Office of Nuclear Safeguards and Security
Program Managers: Dunbar S. Lockwood and Melissa Scholz, NA-241

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DOE/NNSA Next-Generation Safeguards Initiative: Presentations by MIIS-LLNL Safeguards Policy Interns

Background

As part of its Next-Generation Safeguards Initiative (NGSI), DOE/NNSA's Office of Nuclear Safeguards and Security has funded each year since 2008 a summer internship program in International Safeguards Policy jointly organized by the James Martin Center for Nonproliferation Studies at the Monterey Institute of International Studies (MIIS) and the Lawrence Livermore National Laboratory (LLNL). Graduate students selected for the program first attend an intensive one-week course in Monterey on International Safeguards Policy and then, with NNSA-funded stipend support from MIIS, spend a 10-week internship at LLNL learning more about international nuclear safeguards and interacting with LLNL mentors and other Laboratory staff.

As one component of the internship experience, each intern undertakes a project designed to expand knowledge of international safeguards or other relevant nuclear nonproliferation topics, culminating in a final presentation and paper. Attached are slides from this year's intern project presentations, held August 16, 2013 at LLNL and attended by LLNL staff and by Bryan Lee from CNS.

In the course of their work at LLNL, students had access only to unclassified, open source information, and no classified or controlled information was used in their projects. The views and recommendations in the slides are strictly their own, and should not be construed to represent views or conclusions of Lawrence Livermore National Laboratory, the Department of Energy, the U.S. Government, or the MIIS James Martin Center for Nonproliferation Studies.

Annexes

1. Presentation by Jerry S. Davydov on "Facilitating Practical Implementation of National Nuclear Forensic Libraries"
2. Presentation by Yuma Kuwata on "Policy recommendations in response to Japan's long term nuclear fuel cycle policy after Fukushima"
3. Presentation by Katherine McCarthy on "IAEA Relations with India, Israel, and Pakistan: How do these non-NPT states impact the NPT safeguards system?"
4. Presentation by Kay Kahee Park on "Development of the South Korean Nuclear Energy Industry"
5. Annex 5. Presentation by Jessica Wilbourne on "Supporting Safeguards in Serbia: Designing an Open-Source Activity to Assist with Additional Protocol Implementation"

Annex 1. Presentation by Jerry Davydov on “Facilitating Practical Implementation of National Nuclear Forensic Libraries”

FACILITATING PRACTICAL IMPLEMENTATION OF NATIONAL NUCLEAR FORENSICS LIBRARIES

JERRY DAVYDOV

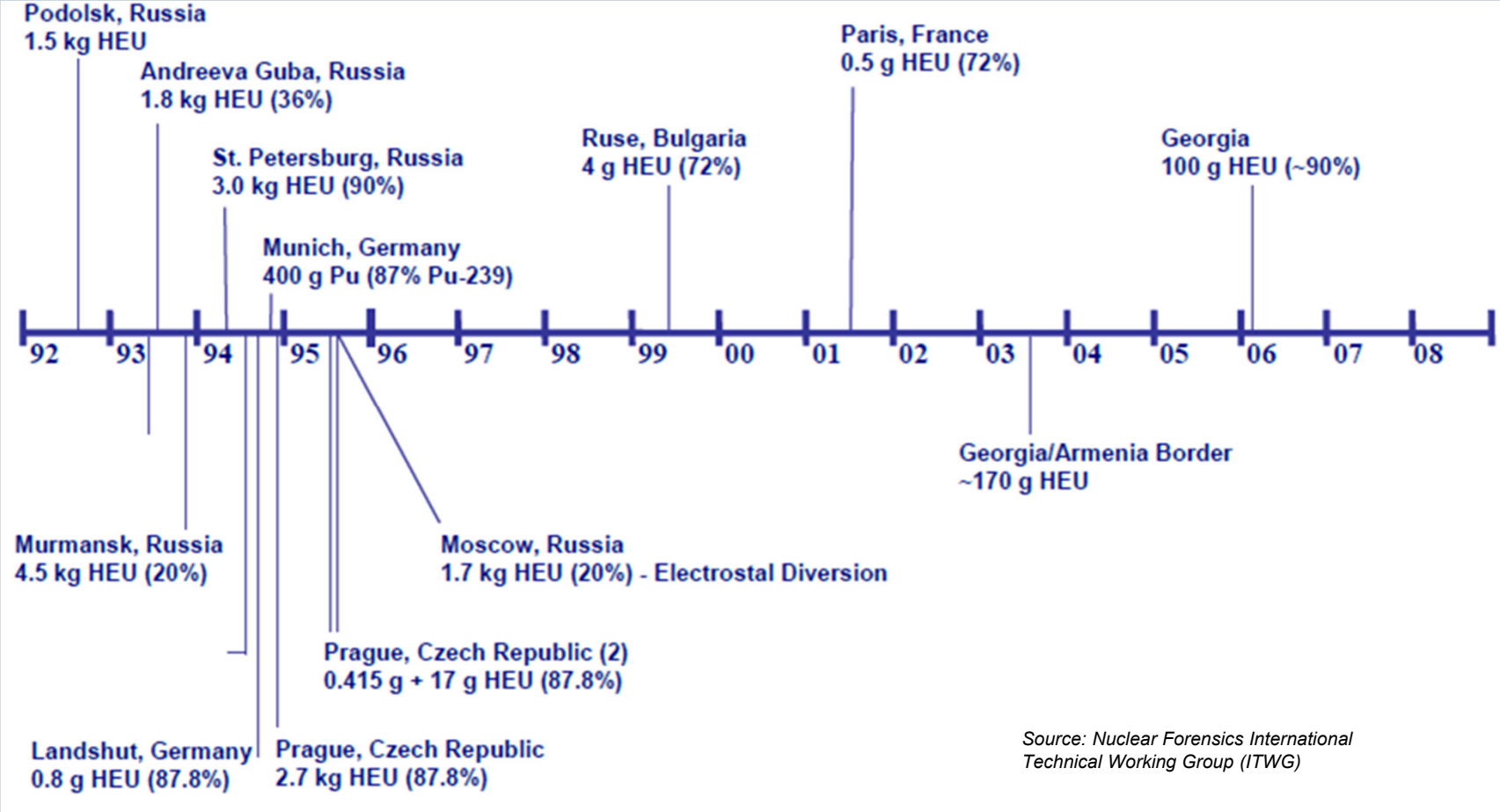
AUGUST 16, 2013

NEXT GENERATION SAFEGUARDS INITIATIVE
LAWRENCE LIVERMORE NATIONAL LABORATORY

CONTENTS

- Introduction and Background
- Purpose and Scope
- Development of NNFL
- Methodology and Design of a NNFL
  - Proposed Structure of NNFL
- NNFL Cost/Effort Breakdown
  - Factors
- Case Studies
  - Namibia
  - Ukraine

INTRODUCTION



Source: Nuclear Forensics International Technical Working Group (ITWG)

INFL v. NNFL

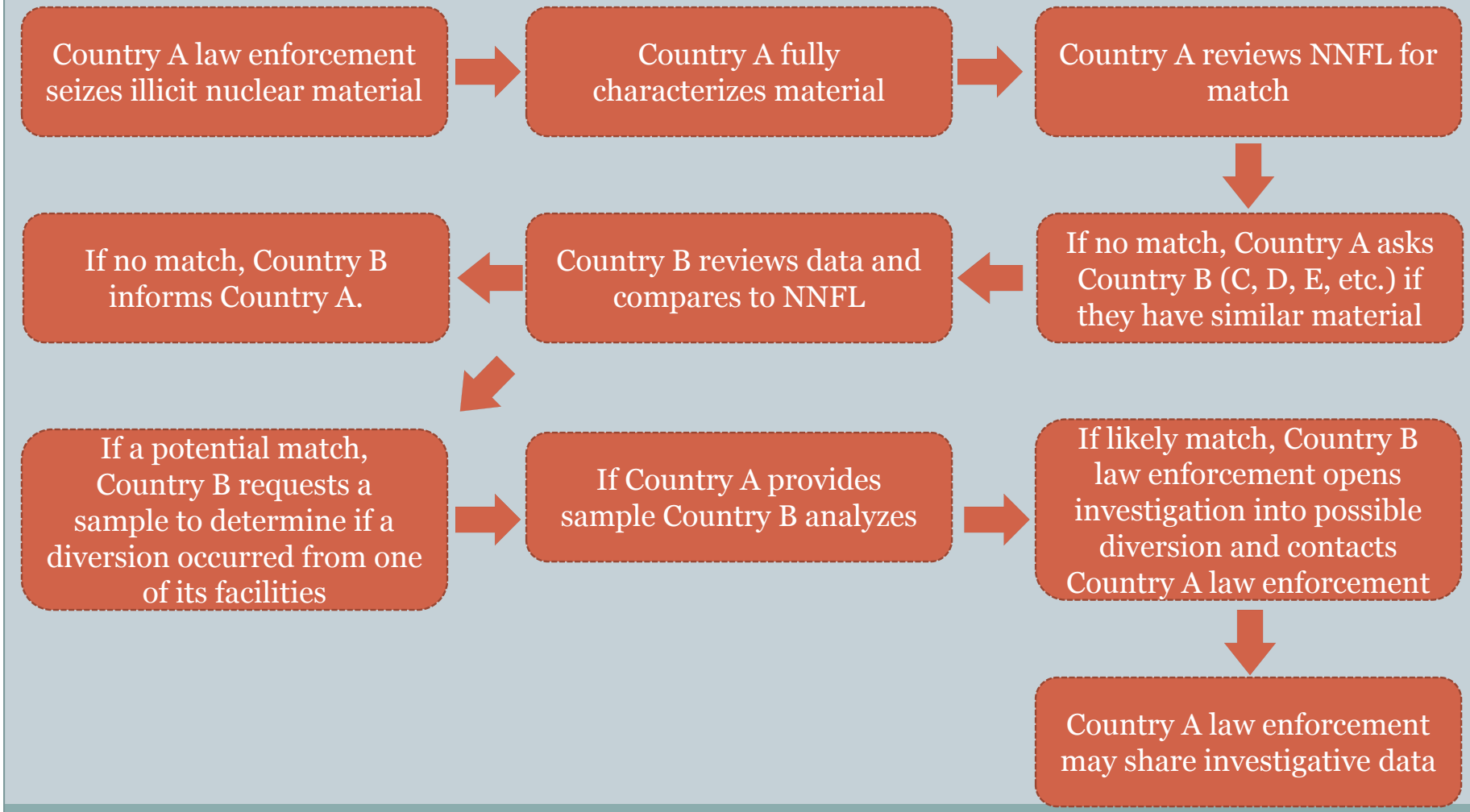
INFL

- Pros:
  - Centralized and tailored international database of material characteristics
  - Strong system of MPC&A
  - Mutually agreed upon material characteristics
  - Standardization of data
  - Framework for a wide range of nuclear forensic activities and cooperation
- Cons:
  - Proprietary and national security sensitivities make this unacceptable to most States

NNFL

- Pros:
  - Non-requirement of transferring of sensitive or proprietary nuclear material characteristics
  - Systematic way to process and update domestic nuclear material inventories and characteristics
  - International confidence that a State would be able to *properly* identify interdicted nuclear material as domestic material
  - Incentive for material produces and users to implement MPC&A procedures
  - Framework for a wide range of nuclear forensic activities and cooperation
- Cons:
  - Lacking validation of data
  - No mutually agreed characteristics
  - No standardization of data

PROCESS


Country A law enforcement seizes illicit nuclear material
Country A fully characterizes material
Country A reviews NNFL for match
If no match, Country A asks Country B (C, D, E, etc.) if they have similar material
Country B reviews data and compares to NNFL
If no match, Country B informs Country A.
If a potential match, Country B requests a sample to determine if a diversion occurred from one of its facilities
If Country A provides sample Country B analyzes
If likely match, Country B law enforcement opens investigation into possible diversion and contacts Country A law enforcement
Country A law enforcement may share investigative data

A GRADED APPROACH TO NNFLs

Group1	Group 2	Group 3	Group 4	Group 5	Group 6
Countries with radiological source holdings; little to no nuclear fuel cycle or forensics capabilities	Countries with Group 1 capabilities + geological disposition, mining, milling	Countries with Group 1 capabilities + at least one research reactor and/or nuclear power plant and associated nuclear waste and SNF	Countries with Group 3 capabilities + fuel fabrication, (and/or) conversion, and R&D activities	Countries with Group 4 capabilities + enrichment, (and/or) reprocessing, (and/or) MOX capabilities	Countries with Group 5 capabilities + current or previous weapons programs
New Zealand	Namibia ~10 Countries	Ukraine ~40 Countries	Romania ~10 Countries	Japan ~8 Countries	India ~9 Countries

DEVELOPMENT OF NNFL

- Organization
- Library Scale
- NNFL Associated Staff
  - National Point of Contact (POC)
  - Library Administrator
  - NNFL Scientific/Technical Staff
  - NNFL IT Staff
- NNFL Policies
- NNFL Database
  - Database Creation
  - NNFL Database Organization
  - Database Software

DATA TO BE INCLUDED WITHIN NNFL

IAEA NUCLEAR SECURITY SERIES NO. XX

NST018
DRAFT, February 2013

STEP 8: 120-day Member State comment: deadline 28 June 2013

DEVELOPMENT OF A NATIONAL NUCLEAR FORENSICS LIBRARY

DRAFT IMPLEMENTING GUIDE

DRAFT FOR MS COMMENT

INTERNATIONAL ATOMIC ENERGY AGENCY

VIENNA, 20XX

1

U.S. DEPARTMENT OF ENERGY

Nuclear Material Characteristics

Data Dictionary

DATA TO BE INCLUDED WITHIN NNFL cont.

- Sample identification for material
  - Location of manufacture or mine
  - Processing history, and associated dates
  - Location and use history, and associated dates
  - Storage history and associated dates
  - Sample splitting information and associated dates
- Nuclear Material Samples and Associated Signatures
  - Uranium assay
  - Major element composition
  - Minor trace element composition
  - Uranium and plutonium isotopics

DATA TO BE INCLUDED WITHIN NNFL cont.

Laboratory Information Managements System (LIMS)

- Reception and log in of a sample and its associated customer data
- Assignment, scheduling, and tracking of the sample and the associated analytical workload
- Processing and quality control associated with the sample and the utilized equipment and inventory
- Storage of data associated with the sample analysis
- Inspection, approval, and compilation of the sample data for reporting and/or further analysis.

Material Sample Archive

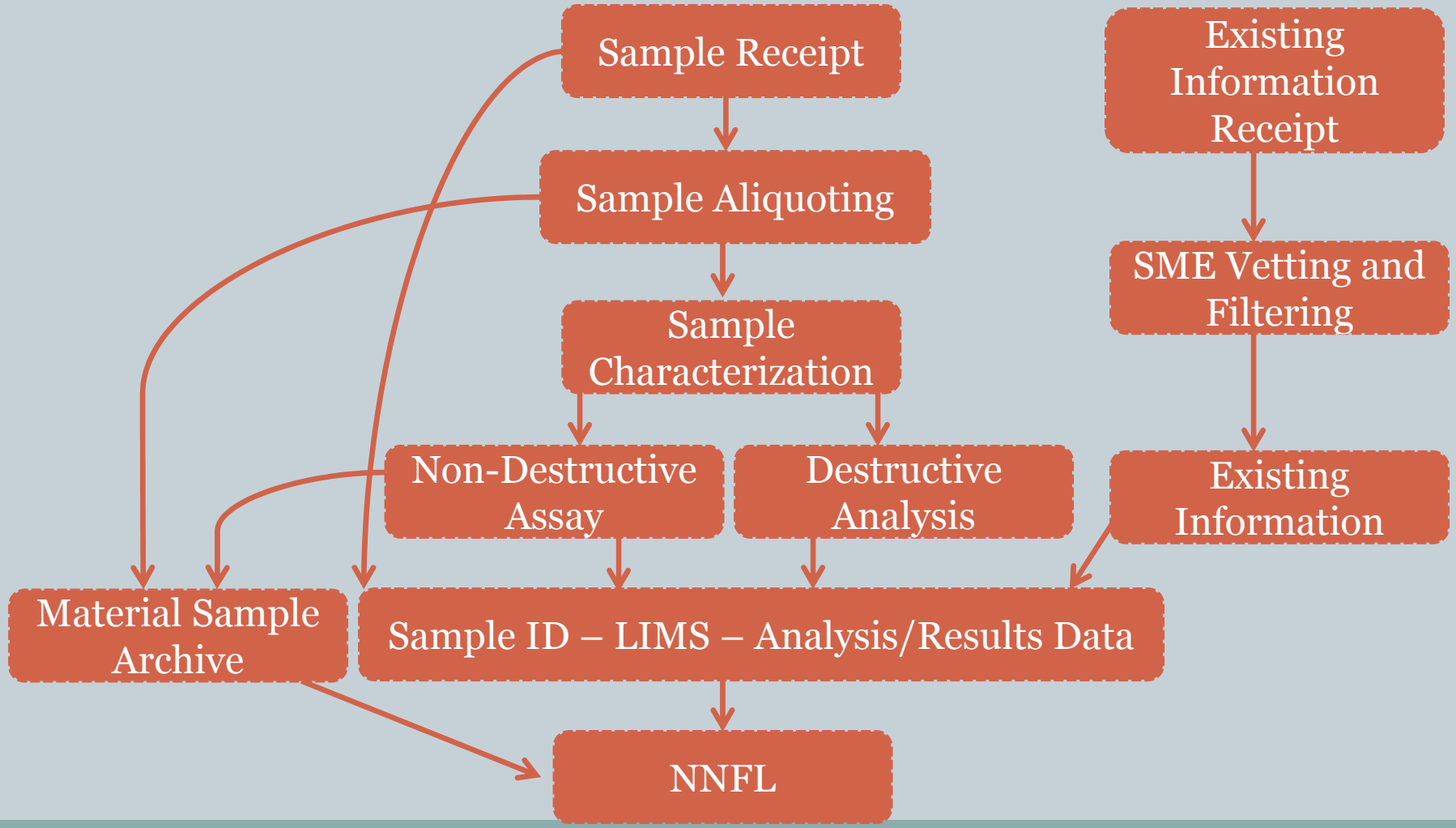
Pros:

- Validation its analytical procedures
- Future training of personnel on analytic techniques required for a robust NNFL
- Analyze all samples under the same protocol, simplifying comparative nuclear forensics
- Re-analysis of samples as new techniques and equipment become available
- Conduct new types of analyses to identify new signatures of the nuclear material

Cons:

- Cost of NNFL
- Large space
- Security could be extremely expensive depending on the types of nuclear materials included

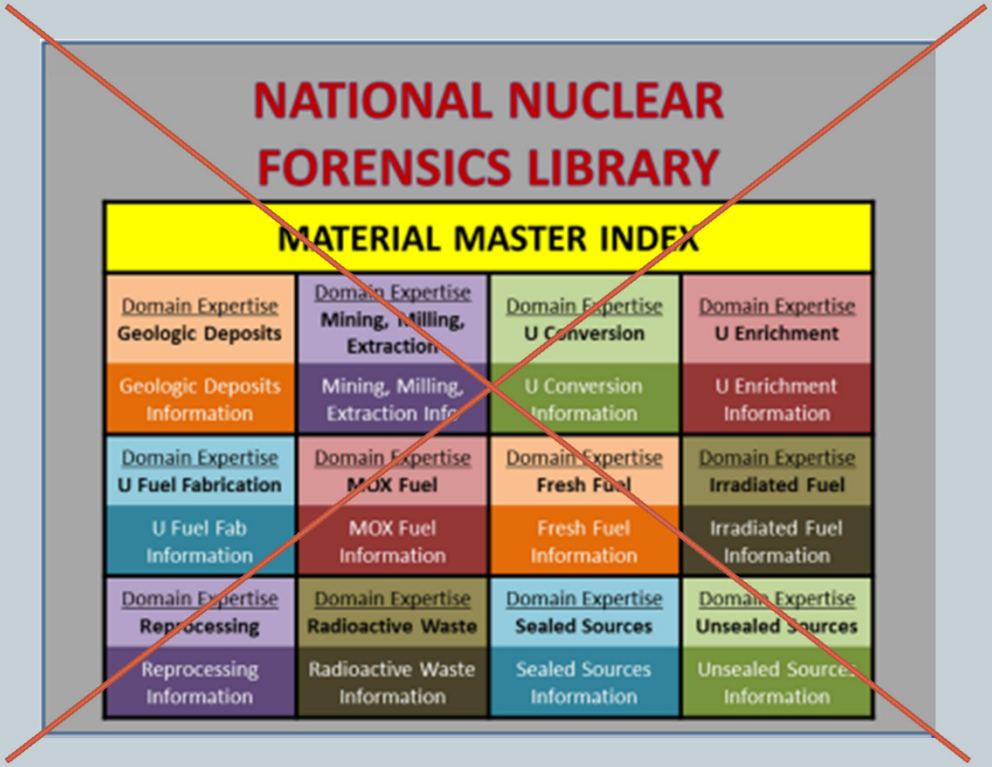
SAMPLE PROCESSING



*Throughout this entire process meta-data is collected

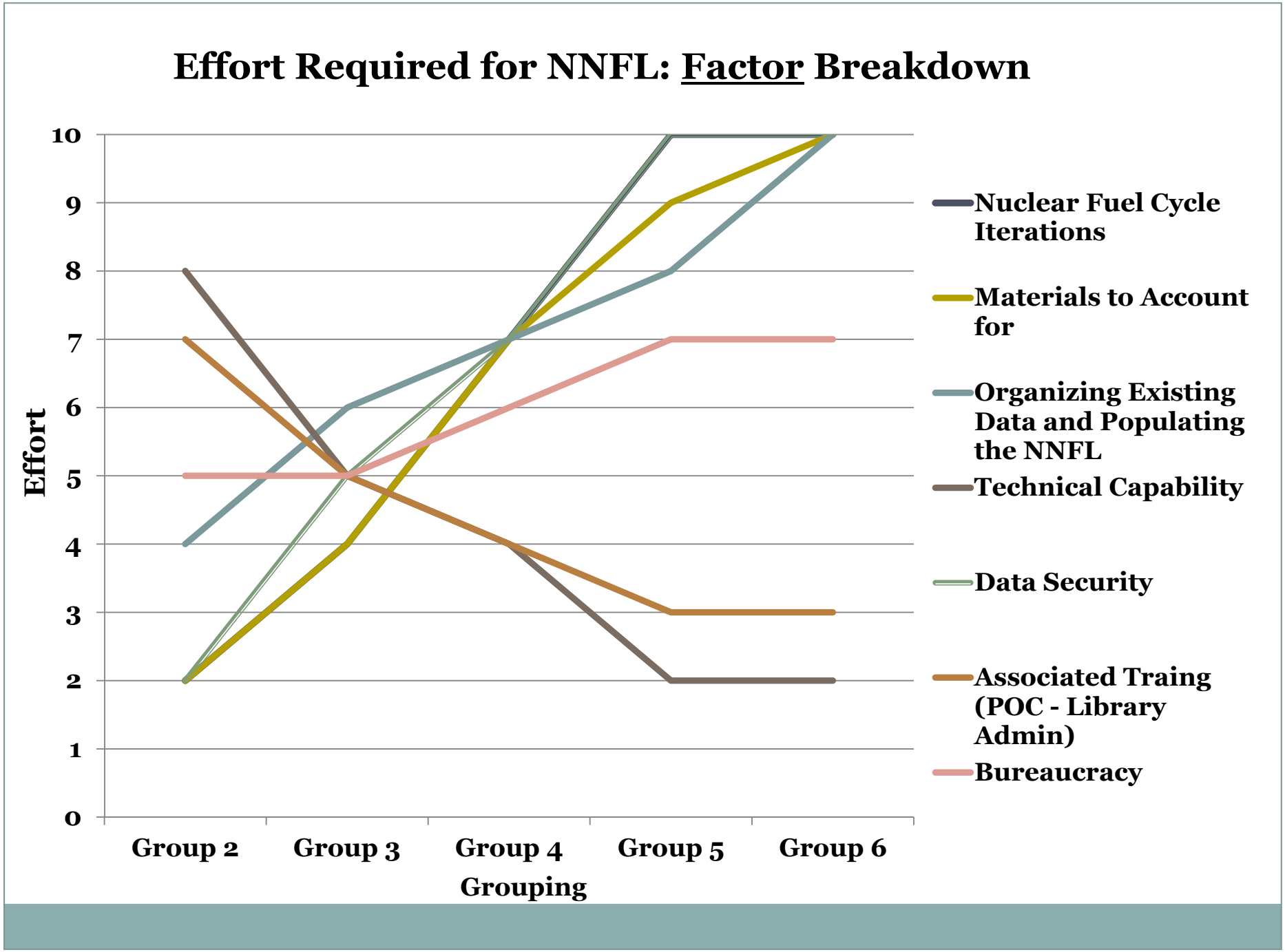
NNFL STRUCTURE

IAEA Structure



Material-Centered Structure

NUCLEAR FUEL CYCLE STAGES	EXAMPLE MATERIALS
1. Geologic Deposition	Ore, ore body
2. Uranium Mining, Milling, and Extraction	Ore concentrate, yellow cake
3. Uranium Conversion	UF6, UF4, UO2, U3O8, uranium metal and alloys
4. Uranium enrichment	UF6, UF4, UCl4, uranium metal
5. Uranium Fuel Fabrication	UO2, U3O8, pellets, rods/plates, elements, scrap
6. Mixed Oxide (MOX) Fuel Fabrication	MOX powder, pellets, rods, scrap
7. Fresh Nuclear Fuel	Fuel assemblies
8. Irradiated (Spent) Nuclear Fuel	Spent fuel
9. Reprocessing	Plutonium nitrate, uranyl nitrate, plutonium oxide, uranium oxide, mixed oxide, other actinides
10. Radioactive Waste Processing, Handling and Storage	Radioactive waste forms


Effort Required for NNFL: Factor Breakdown
Effort
10
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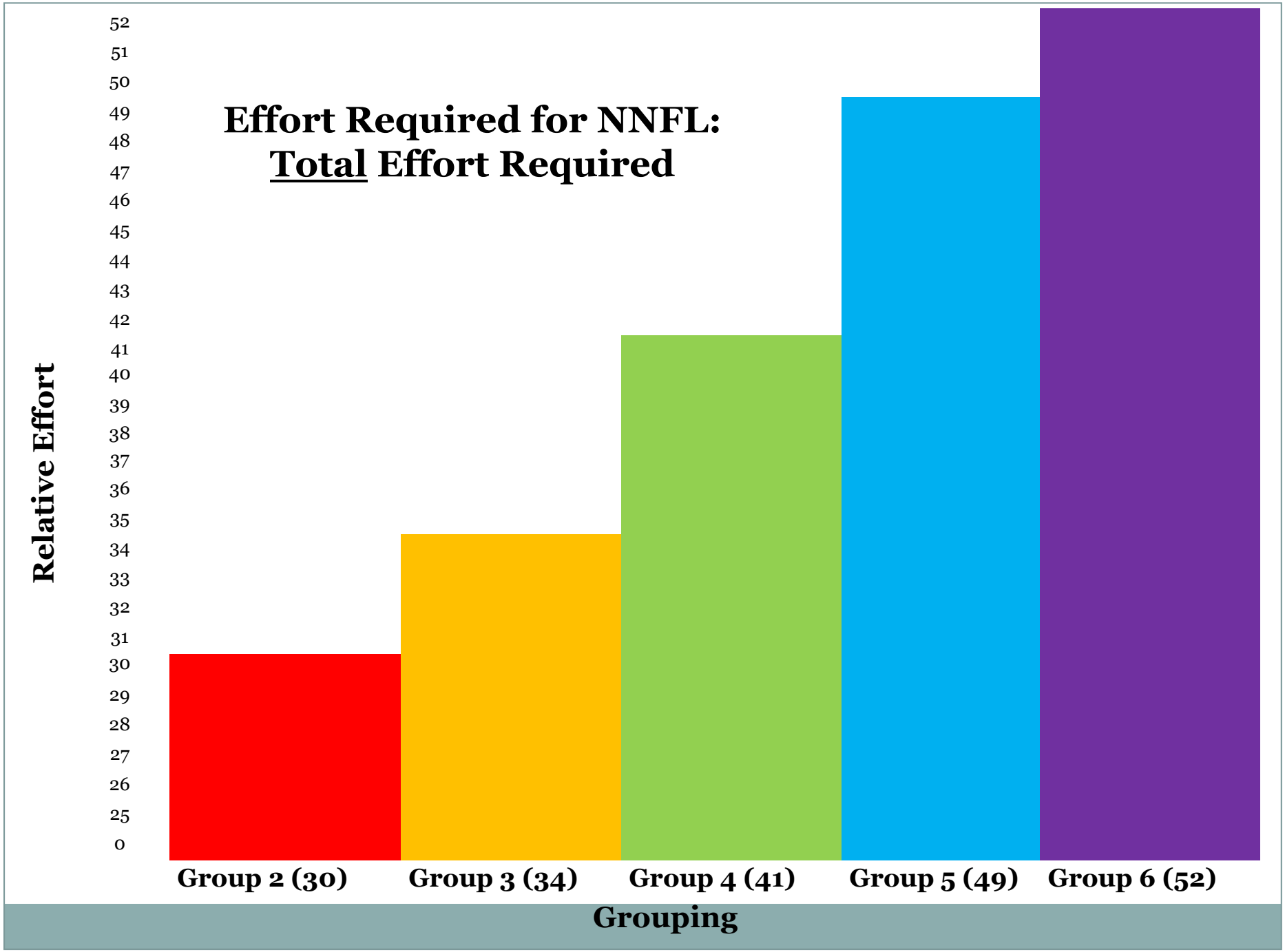
Group 2
Group 3
Group 4
Group 5
Group 6
Grouping
Nuclear Fuel Cycle Iterations
Materials to Account for
Organizing Existing Data and Populating the NNFL
Technical Capability
Data Security
Associated Traing (POC - Library Admin)
Bureaucracy


Effort Required for NNFL:
Total Effort Required
Relative Effort
52
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31
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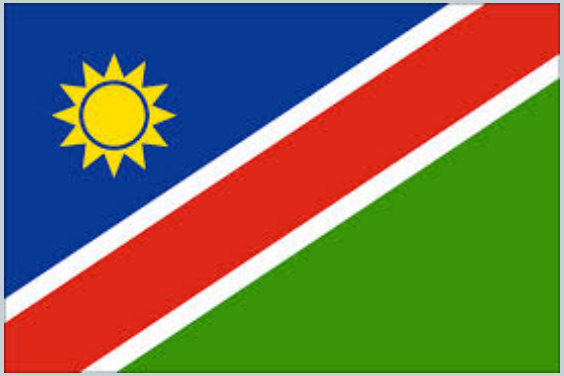
27
26
25
0
Group 2 (30)
Group 3 (34)
Group 4 (41)
Group 5 (49)
Group 6 (52)
Grouping

VALUES NOT INCLUDED

- Complexity of analysis vs. Discriminatory value
- Existing information
  - Miner/Manufacturer/Vendor/Operator supplied information
  - Information from safeguards related activities
  - Nuclear regulatory bodies
  - Radiation protection agencies
  - Nuclear research centers
- Quality of existing information
- Time

CASE STUDIES

- Nuclear Profile
- Legislation and Regulations
- Nuclear Material Holdings
- Government Agencies
- Indigenous Analytical Abilities
- NNFL Cost/Effort Breakdown



NAMIBIA

- 26 August 2011 – 324kg Natural Uranium Ore Concentrate (UOC) stolen from Trekkopje Mine (Areva) in Swakopmund
  - Incident reported on 29 August 2011
  - 3 Namibian – 1 Zimbabwe citizen arrested
    - 2 never arrested

NAMIBIA

- Several companies operate uranium mines and mills
  - Paladin Energy Ltd.*
  - Roessing Uranium Corporation Ltd.*
  - Areva*
  - Taurus Minerals*
  - Forsys Metals Corp.*
  - Bannerman Resources Ltd. *
  - Marenica Energy *
  - Zhonghe Resouces*
  - Xemplar Energy Corp.*
  - Deep Yellow Ltd.
  - Kalahari Minerals PLC*
- April 2011 - Namibia announced that its State-owned mineral exploration company, Epangelo Mining Ltd*
  - Any new tender wishing to mine uranium would have to do so as a joint venture with Epangelo
- Namibia is not operating any further nuclear fuel cycle elements within its borders
  - interest in establishing a nuclear power plant

* Source of Existing Information

NAMIBIA

Legislation -Regulation

- Atomic Energy & Radiation Protection Act
- Radiation Protection and Waste Disposal Regulations

Nuclear Material Holdings

- uranium ore
- uranium ore concentrate

NAMIBIA

Government Agencies

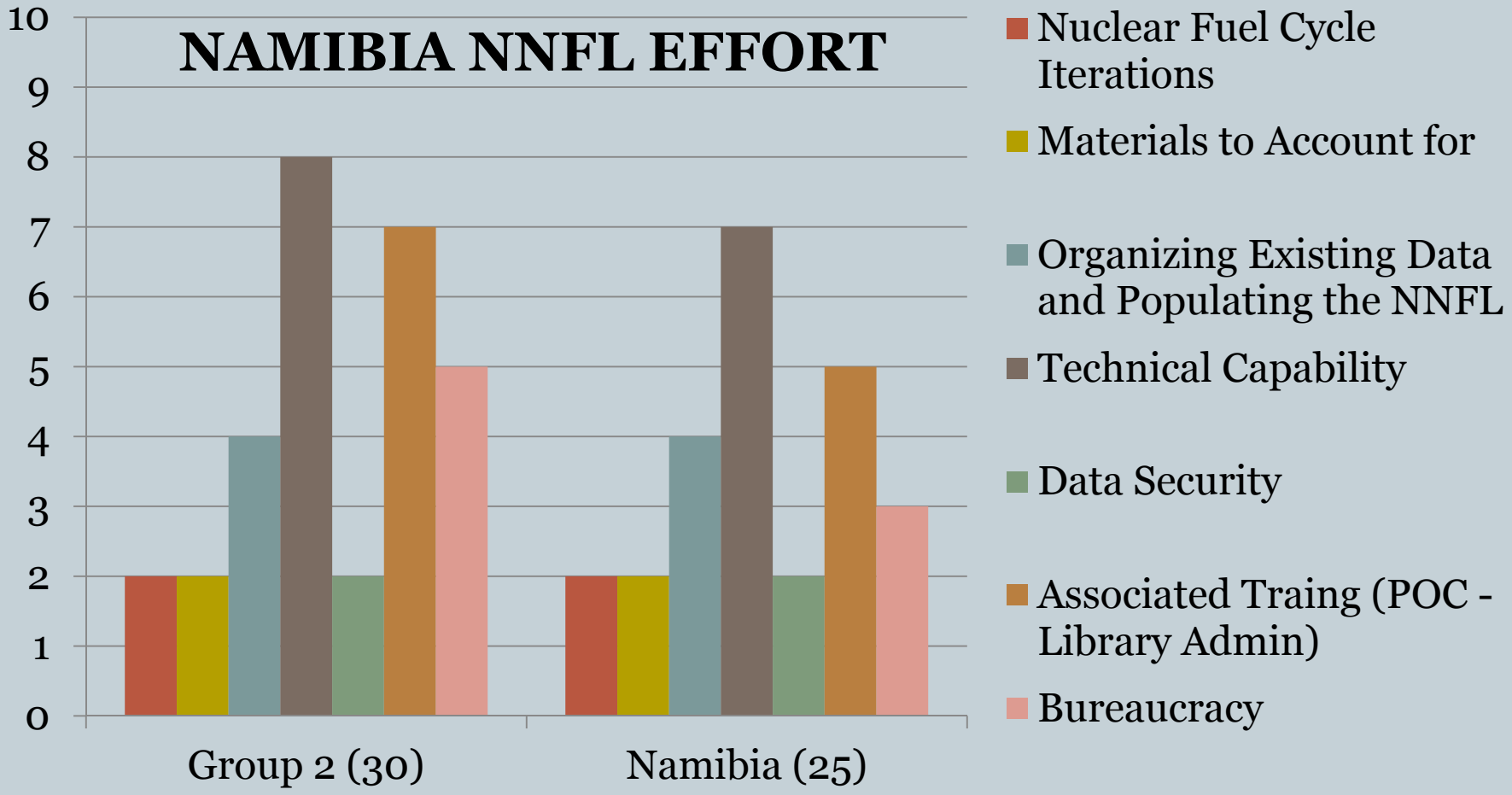
- Atomic Energy Board of Namibia
- Ministry of Mines and Energy*
- Ministry of Education
- Ministry of Foreign Affairs
- Ministry of Safety and Security

Technical Capability

- Actlabs Namibia (PTY) Ltd. (Windhoek)
- Bureau Veritas (BC) (Swakopmund)
- Univ. of Namibia (Windhoek)
- Namibian National Forensic Science Institute (Windhoek)

* Source of Existing Information

NAMIBIA


NAMIBIA NNFL EFFORT
10
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Group 2 (30)
Namibia (25)
Nuclear Fuel Cycle Iterations
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UKRAINE

(A few of many alleged incidents as reported in open sources)

- May – October 1992 - 100 kg of Uranium (unknown enrichment) was stolen; 80 kg could be recovered later – origin Chepetsk Mechanical Factory
  - Suspects say the material was apparently destined for the Middle East
- April 1993 - 80 tons of nuclear fuel were seized by the Ukrainian customs service on its way to Libya via Bulgaria – origin most likely Russian Federation
- 1995 – 10 pipes and 10cm bar - nuclear fuel rod fragments stolen – origin Chernobyl NPP
  - Incident reported on 28 September 2005
  - 4 suspects arrested (1995)
    - Material had been missing since 1995
- March 1996 - 6 kg of Uranium (~20% enriched U-235) were seized in Kiev, Ukraine, in March, 1996 – origin most likely Russian naval fuel storage facility
- 1 March 2005 – 582g of U238 interdicted at the Boryspil International Airport in Ukraine – origin unknown
  - Incident reported on 2 March 2005
  - 1 suspect arrested
- 17 March 2010 – 2.5kg Depleted uranium (3 pieces) OR 2.5kg U235 were interdicted in the Donetsk Oblast – origin unknown
  - Incident reported 12 May 2010
  - 6 Ukrainian citizens arrested

UKRAINE

Mining

- Ukraine has two mining sites in country, one operational and one decommissioned

Nuclear Energy

- Energoatom currently operates 15 nuclear reactors at 4 nuclear power stations

Research Reactors

- Ukraine has four research reactors (LEU)
  - Institute for Nuclear Research (2)
  - Sevastopol University of Nuclear Energy and Industry (2)

Fuel Cycle Development

- Current, conversion, enrichment and fuel fabrication takes place in Russia
- Several attempts in the past to set up a complete suite of fuel cycle facilities other than enrichment
- Current plans include developing uranium mining and fuel fabrication, but not conversion, enrichment or reprocessing
  - 2015 - fabrication of fuel rods and assemblies
  - 2020 - production of fuel pellets.

Spent Nuclear Fuel

- National Target Environmental Program of Radioactive Waste Management (2008)
  - Storage of used fuel for at least 50 years before disposal remains the policy
  - IAEA and Euratom recommendations
- Used fuel is mostly stored on site
  - Some VVER-440 fuel - Russia for reprocessing
- Used fuel from Chernobyl is stored
  - New dry storage facility is under construction there

Nuclear Waste Management

- New facility for treatment solid radioactive waste is under construction at the site of Zaporozhe NPP to be commissioned in 2015.
- From 2011, high-level wastes from reprocessing returned from Russia to Ukraine
  - Central dry storage facility.
- Deep geological repository for high- and intermediate-level wastes

Decommissioning

- 4 Chernobyl RBMK-1000 reactors
  - Unit 4 - enclosed in a large shelter new

UKRAINE

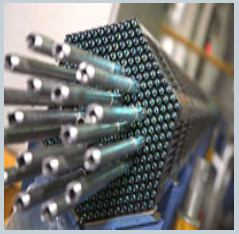
Legislation -Regulation

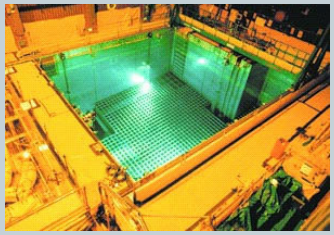
- Law on Physical Protection of Nuclear Facilities, Nuclear Material, Radioactive Waste, and Other Sources of Ionizing Radiation
- Law on Authorization Activity in Nuclear Energy Use
- Law on Human Protection against Impact of Ionizing Radiation
- Law on Radioactive Waste Management
- Law on Decision Making Procedure on Siting, Design, Construction of Nuclear and RAW Facilities of National Importance
- Law on Uranium Mining and Milling
- Law on State Supervision
- Law on Environmental Protection
- Law on the use of Nuclear Energy and Radiation Safety
- Law on Arrangement of Issues on Nuclear Safety Assurance
- **Decree of President of Ukraine, N73/2013, February 11, 2013 (study the issue of the creation of a National Forensic Laboratory and Regional Forensic Laboratory)**
- Decree of the Cabinet of Ministers of Ukraine No. 813, June 2, 2003 (illicit trafficking of nuclear materials)

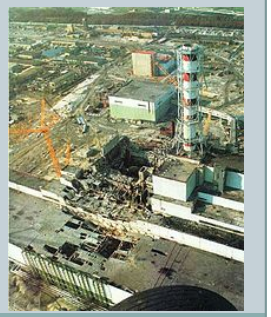
Nuclear Material Holdings

- uranium ore
- uranium ore concentrate
- Fresh nuclear fuel (LEU) – in the form of fuel assemblies

- Spent nuclear fuel
- Nuclear waste forms
- Legacy materials







UKRAINE

Government Agencies

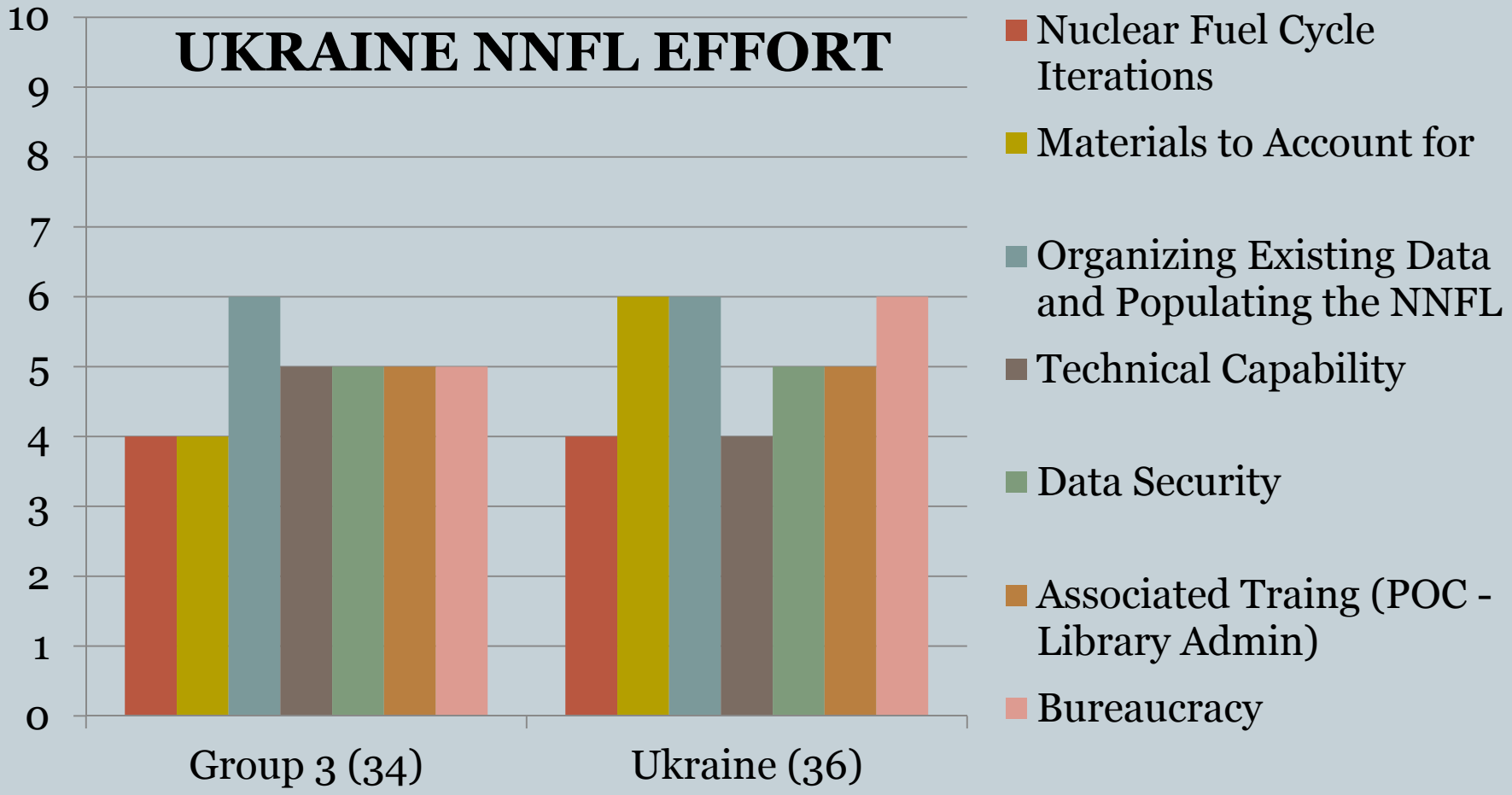
- State Nuclear Regulatory Inspectorate (SNRI)
- National Commission for Radiation Protection of Ukraine (NCRPU)
- Ministry of Fuels and Energy
  - National Nuclear Energy Generating Company of Ukraine (Energoatom) (+6 Subdivisions)*
- Ministry of the Internal Affairs
- State Emergency Service (formerly Ministry of Emergencies)*
- Ministry of Foreign Affairs
- Ministry of Science, Youth and Sport
- Ministry of Economic Development and Trade

Technical Capability

- Vostochny Integrated Mining and Concentrating Plant (VostGOK)*
- Dnieper Basin Chemical Works
- Science and Technology Center of Ukraine (STCU)
- Kiev Institute for Nuclear Research (Kiev)*
- Institute of Physics (Kiev)
- Sevastopol National University of Nuclear Energy and Industry (Sevastopol)*
- Kharkov Institute of Physics and Technology (Kharkov)

* Source of Existing Information

UKRAINE


UKRAINE NNFL EFFORT
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Group 3 (34)
Ukraine (36)
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Annex 2. Presentation by Yuma Kuwata on “Policy recommendations in response to Japan’s long term nuclear fuel cycle policy after Fukushima”

Policy recommendations in response to Japan's long term nuclear fuel cycle policy

Yuma Kuwata
2nd year Masters
The University of California, Berkeley

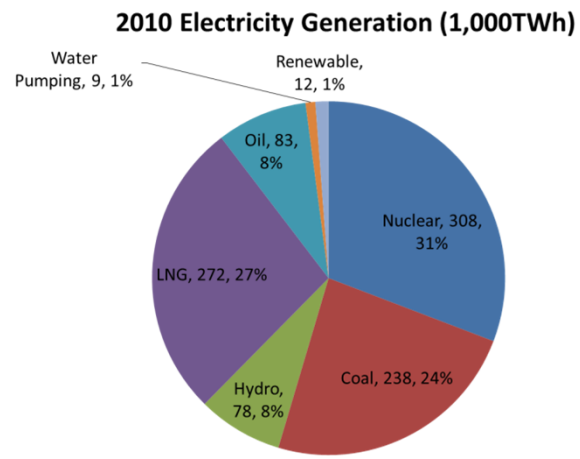
Overview

- This research aims to organize the current chaotic situation

- Analyze possible long term nuclear energy policy that Japan might pursue
  - ***0% Scenario*** (0 nuclear energy by 2030)
  - ***15%A Scenario*** (15% by 2030 and 0% by 2050)
  - ***15%B Scenario*** (15% by 2030 and 15% onward)
  - ***25% Scenario*** (maintain 25%)

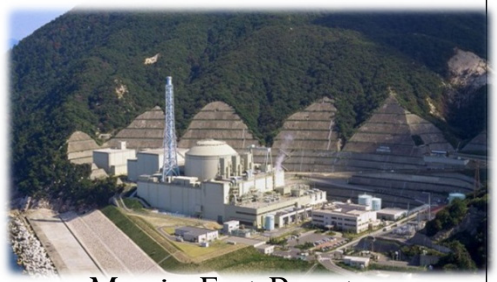
- Present policy recommendation for each scenario

Pre-Fukushima Nuclear Energy Plan



子力立国計画 Atomic Energy Nation Project

- Total Capacity
  - 48GW(30%)→68GW(50%) by 2030
- Full Reprocess
  - Rokkasho Plant operational in 2013
  - Reprocess spent fuel at La Hague and Sellafield
  - 800mTHM →1200mTHM by 2050



Monju Fast Reactor

- Commercial FBR by 2050, promote Plu-Thermal Project until then
  - Plu-Thermal Project- burn MOX fuel in licensed LWR
  - Full transition to FBR by 2150
  - Promises to not hold surplus Plutonium (2003)

Post Fukushima Chaos

Photo from TEPCO

- **52 out of 54** reactors shut down
- **Nuclear Regulatory Authority** (NRA) impose stricter regulation
  - 40 operation year regulation, earthquake & tsunami proof, etc.

原子力規制委員会
Nuclear Regulation Authority

- Accumulating MOX fuel stock
- 3 years of political chaos, unclear long term policy
  - Pro-nuclear Liberal Democratic Party gained control of Parliament on July
  - 61% of public is against Nuclear

Pro-Nuclear!!
↓
Anti-Nuclear!!

Kan
2010-2011

Zero Nuclear!
↓
Maintain Fuel Cycle

Noda
2011-2012

Maintain Nuclear
↓
?

Abe
2012-20??

US-Japan Nuclear Relations

1988 US-Japan Nuclear Cooperation Agreement

- **30 year Advance Consent** for reprocessing US origin fuel
  - At Rokkasho Reprocessing Plant, Sellafield UK, and La Hague France

- Significance?
  - 73% of imported uranium of Japan is US origin
  - Avoided need to obtain subsequent agreement from US each time they reprocess.
  - Only **few countries** have received advance programmatic consent to reprocess US-origin fuel

- Why did the US allow this?
  - Nuclear energy essential for energy security of Japan
  - Stockpiling spent fuel → Decrease with Reprocessing
  - They had plan to burn separated Plutonium

US Concern

Several US High Officials (Secretary of Energy, NRC, State Department) have directly told Japanese officials their concerns regarding:

- Unclear long term nuclear policy
  - Reformulating fuel cycle policy from scratch
  - Rokkasho operable next year
- Accumulating separated plutonium
  - Reprocessed fuel sent from Europe
  - But all MOX reactors are shut down

What does this mean for US?

Inconsistency in US nuclear energy policy

- Other states want similar rights as Japan

Our questions:

- Would Japan really need reprocessing for its energy security?
  - Will Japan be dependent on nuclear energy?
  - Will Reprocessing be necessary for the energy policy?
- Can Japan keep its "no surplus plutonium" policy under post-Fukushima nuclear energy futures?

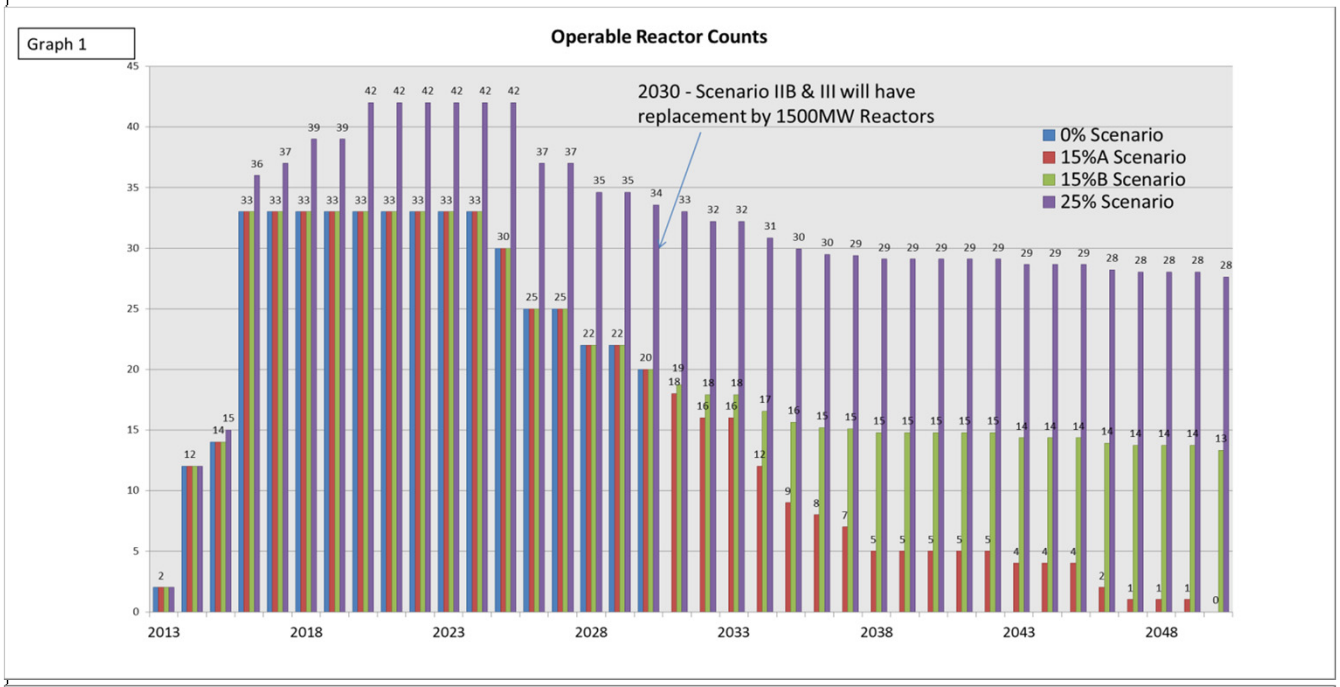
Explanation of scenarios

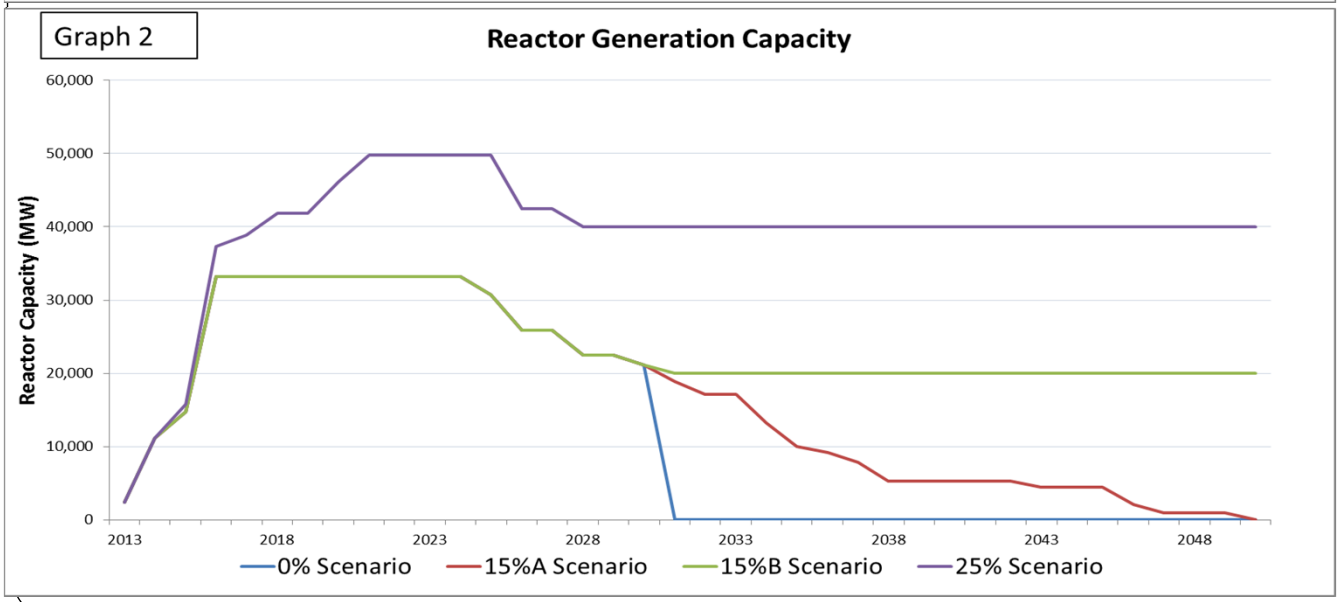
- **0% Scenario** Shut down all operable reactors at 2030
- **15%A Scenario** Bring the total capacity to 20GW by 2030 and decrease to 0 by 2050
- **15%B Scenario** Bring the total capacity to 20GW by 2030 and maintain 20GW
- **25% Scenario** Maintain 40GW, continue construction of all planned reactors

Assumptions:

- Every reactor will be decommissioned after 40 years of operation
- Reactors with operation year of 30 at 2013 will not come back online. (Utilities are hesitant on reinvesting.)
- Reactors will operate at 75% capacity; each 1GWe reactor will produces 16.67 t/y of spent fuel
- Plu-Thermal Program will continue as planned
- Rokkasho will operate from next year until 2050
- No unexpected accident will occur from 2013 to 2050
- Electricity demand stays constant (JAEC and MEXT assumed constant demand in their scenario)

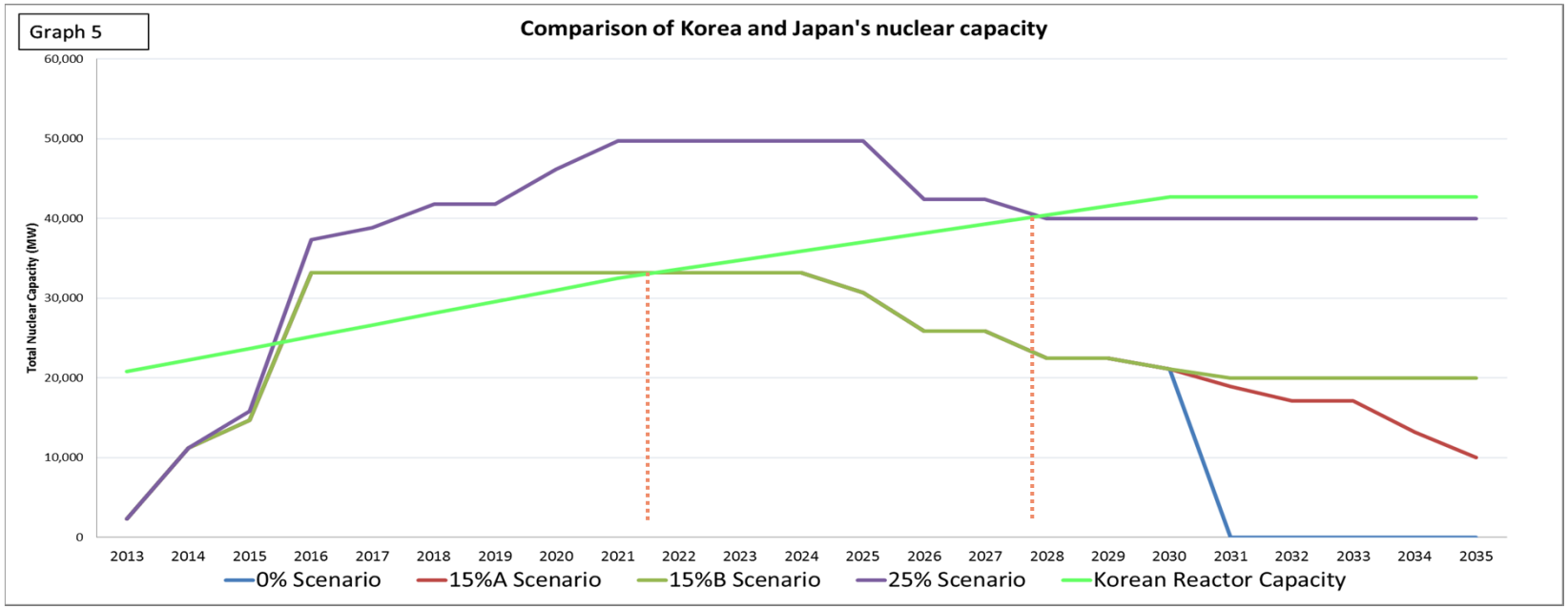
Dependence on nuclear energy





- 0% – Nuclear energy will not be significant
- 15%A – Nuclear can be considered significant until 2035
- 15%B – Nuclear can be considered significant all throughout
- 25%- Nuclear can be considered significant all through out

Dependence on nuclear energy



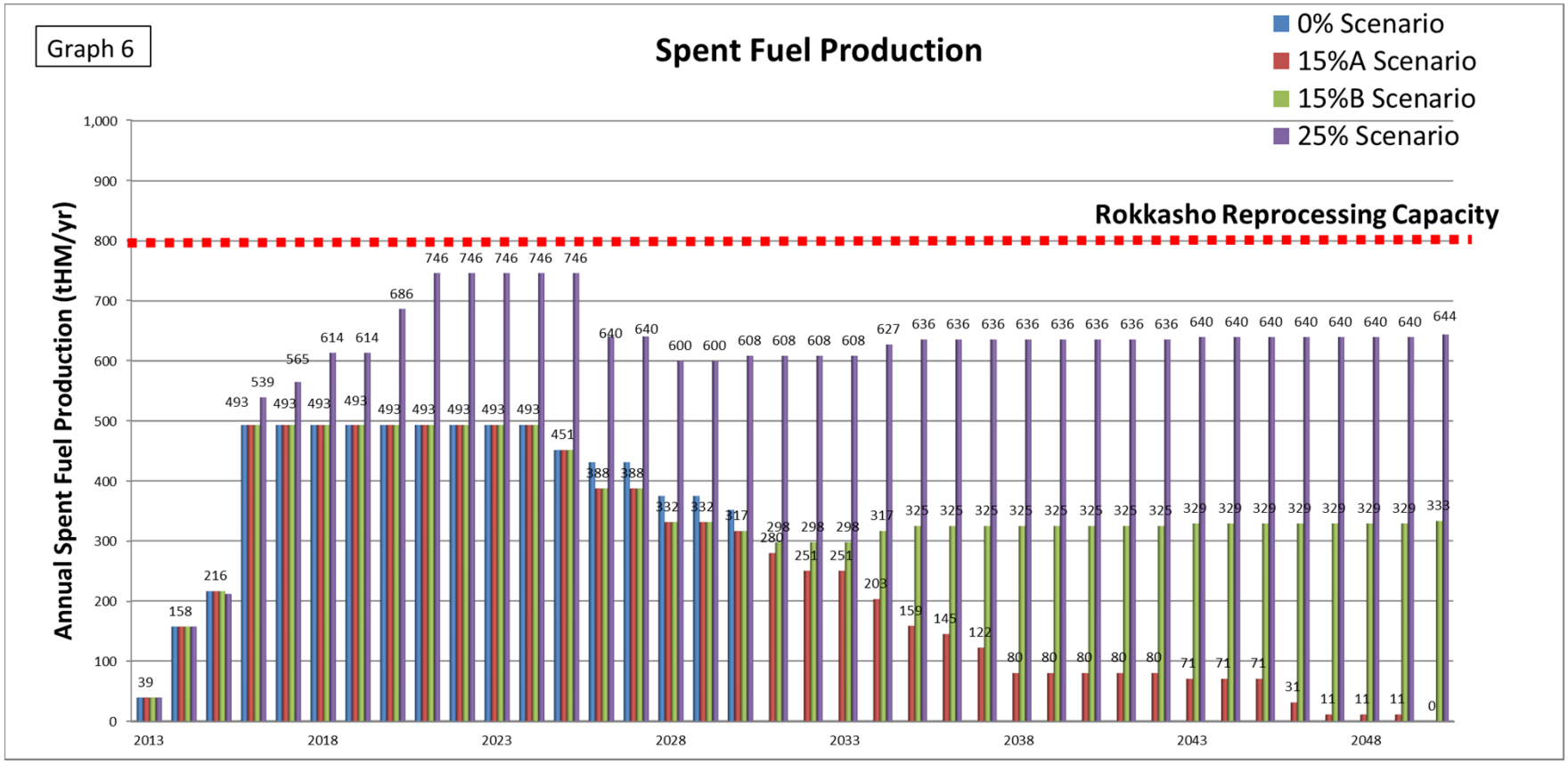
- South Korea's nuclear electric capacity will surpass Japan's under every scenarios by 2030.
  -Double the capacity of **0%** and **15%**

15%B and **25%** scenarios can consider nuclear energy as an essential energy source

<u>However</u>, we can expect stronger demand from other countries for reprocessing rights if Japan maintain advance consent

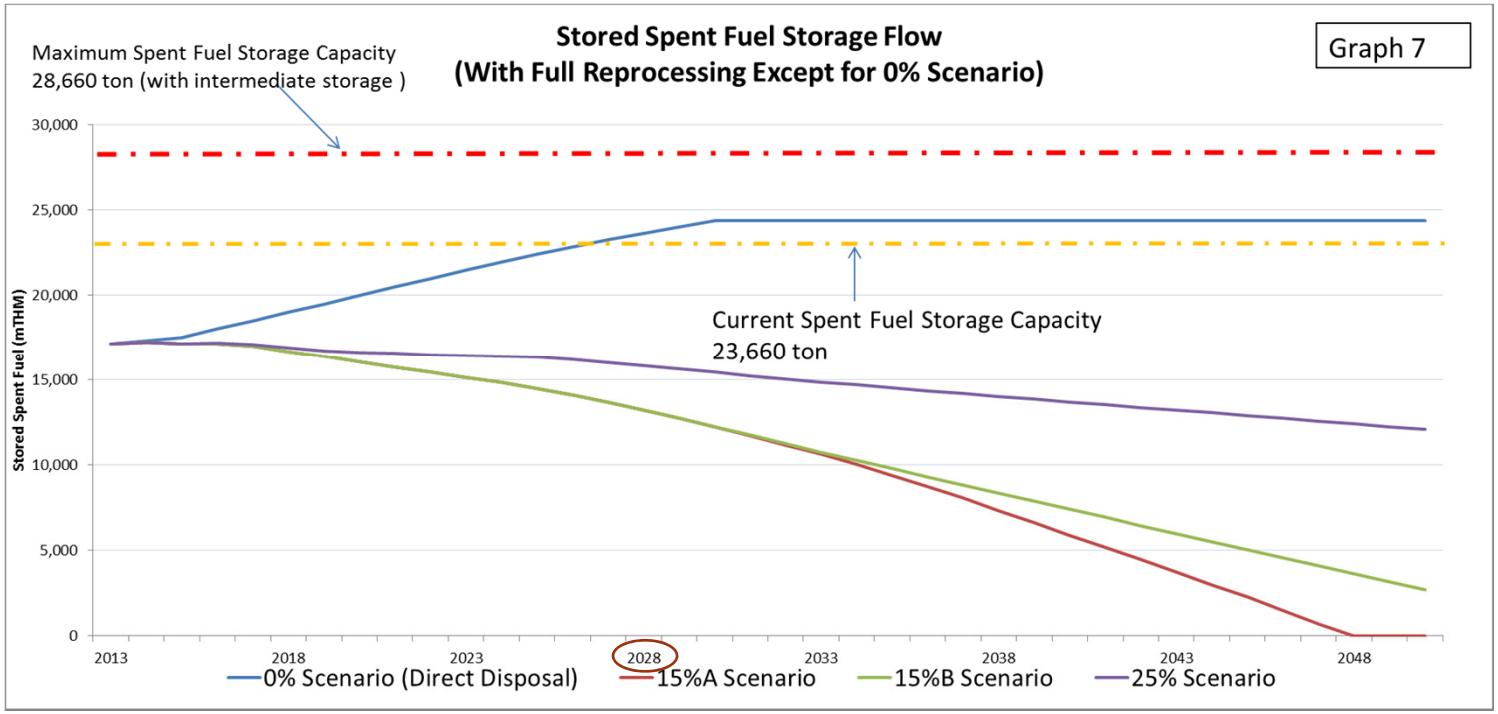
This could be seen as discriminatory and affect the perceived integrity of US policy

Spent Fuel disposition



Proportional to reactor capacity

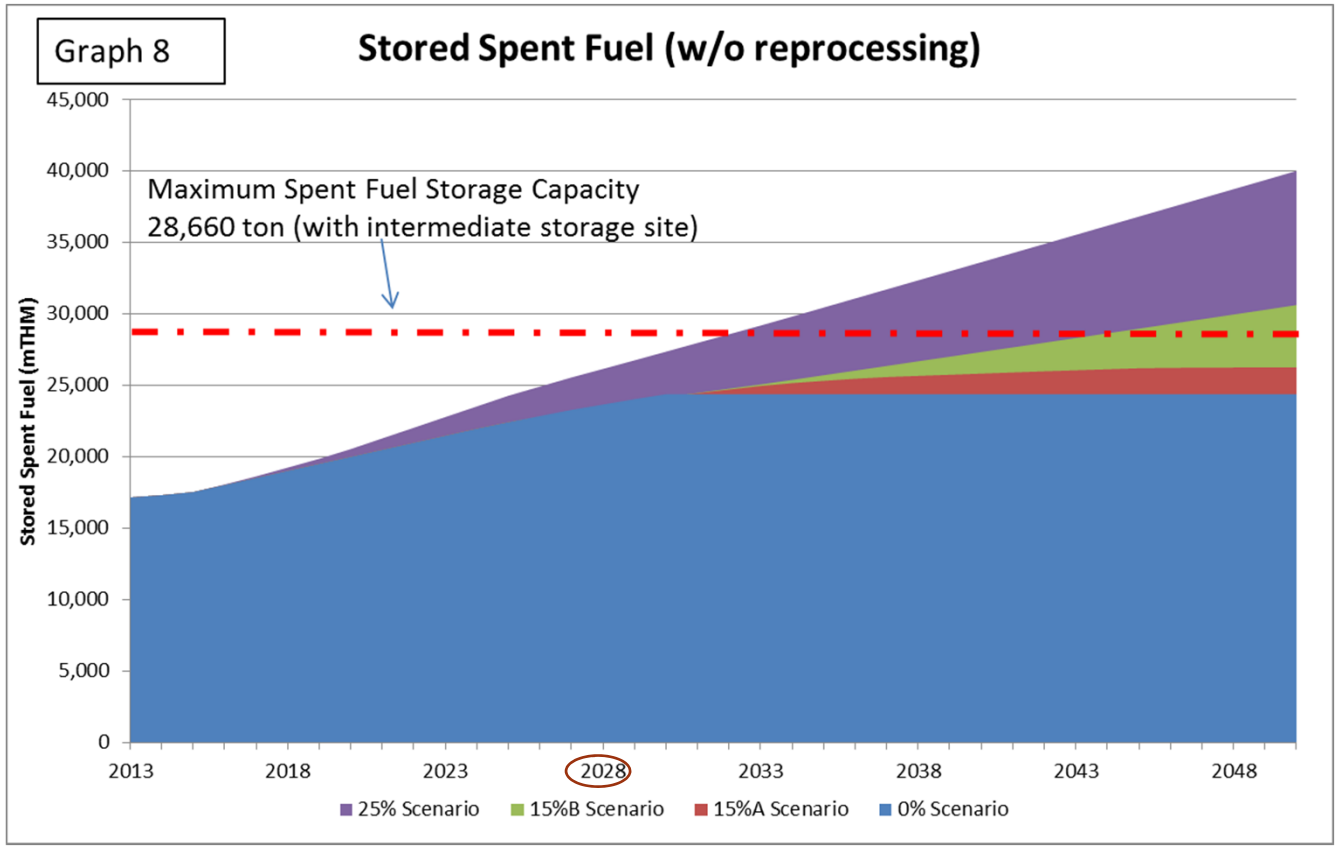
Spent Fuel disposition



- **0%** - Spent fuel stock will reach capacity by 2024, but intermediate storage facility can store them all.
  - **Does not need Reprocessing** under this scenario to handle spent fuel arisings
  - Plans to find final repository by 2028 will add further flexibility

- **15%** and **25%:** will be able to gradually decrease spent fuel stock w/reprocessing

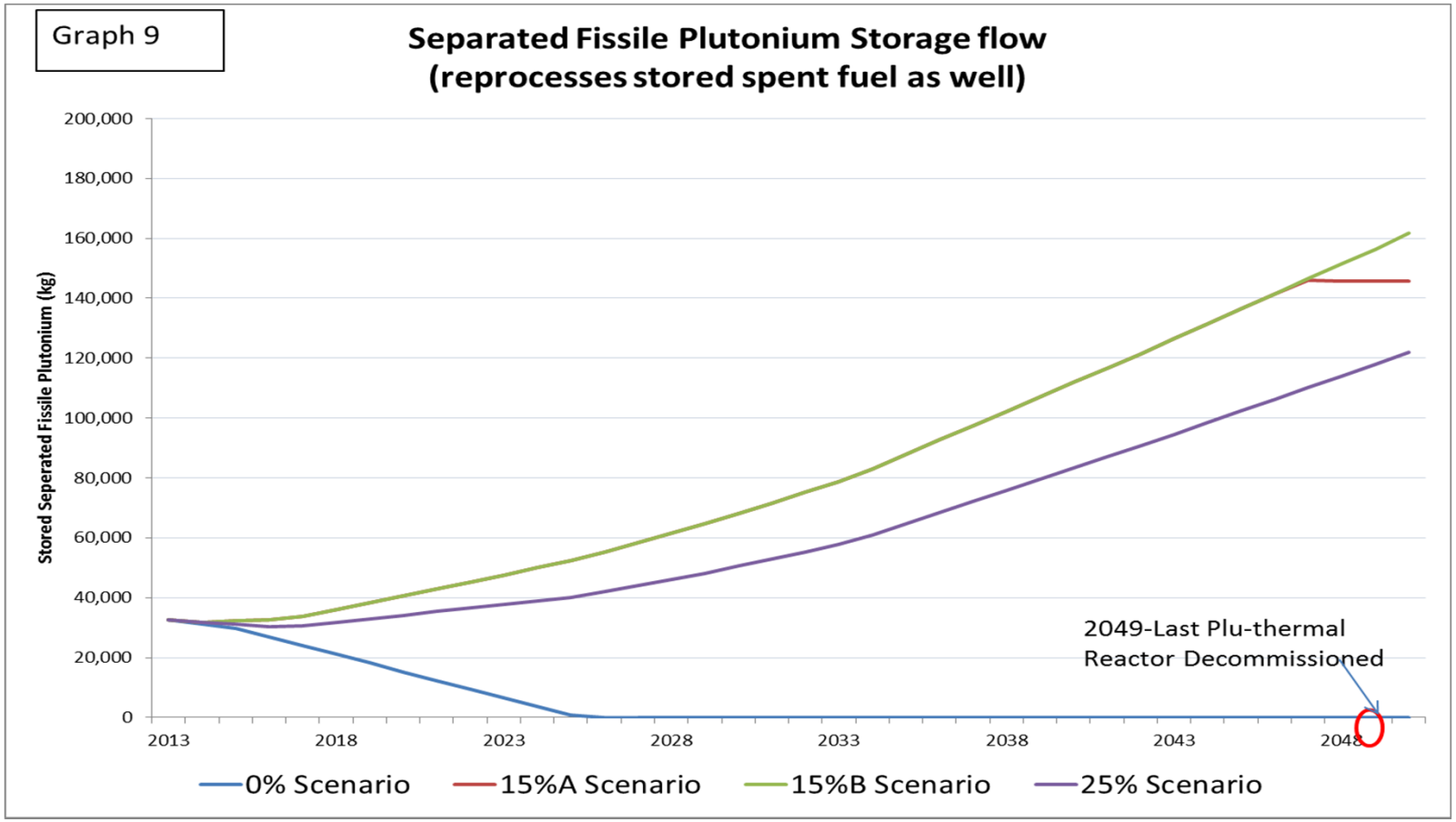
Spent Fuel disposition



- **15%A**- Total storage capacity including intermediate storage facility can store them all. **Does not need Reprocessing**

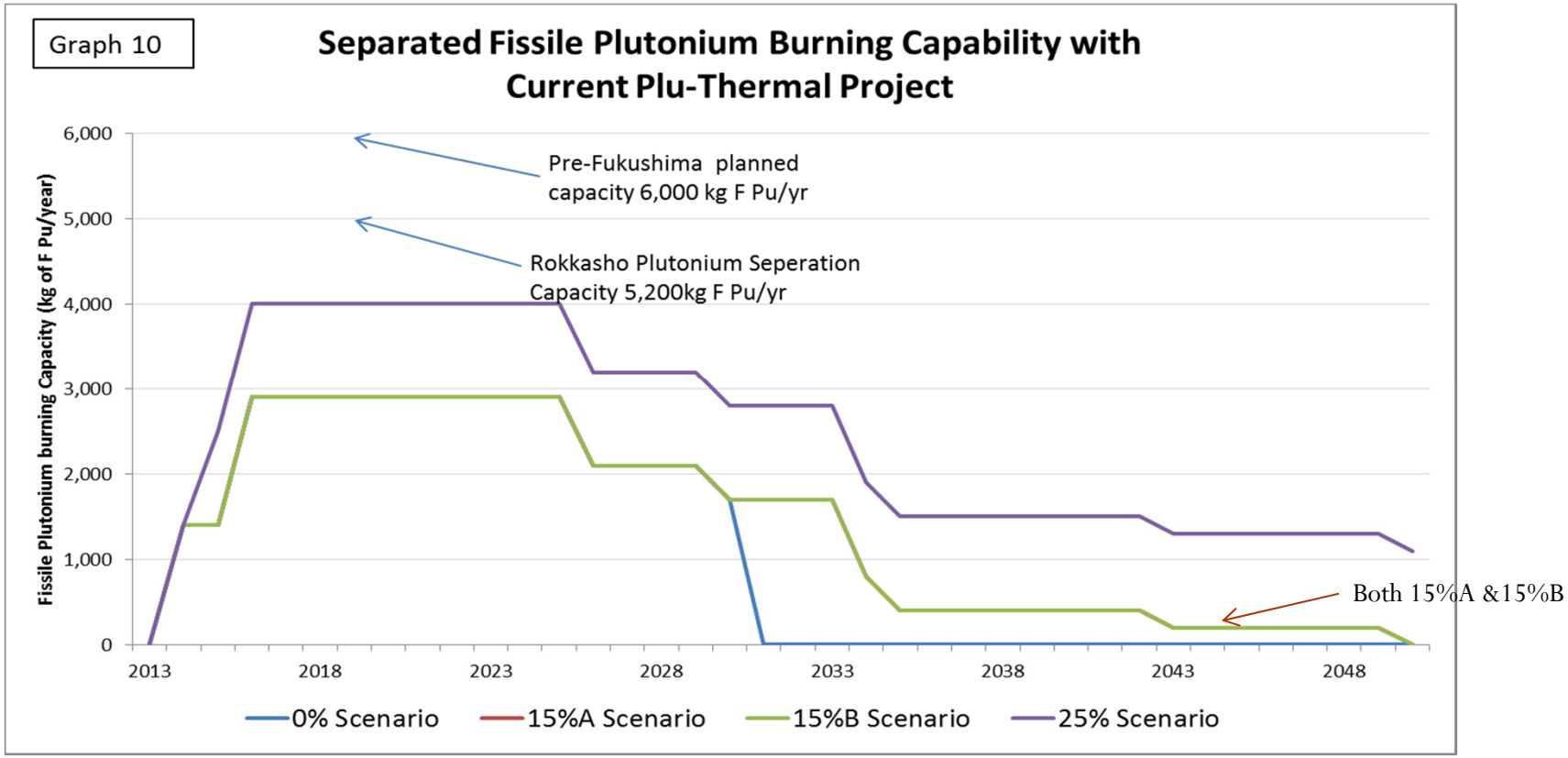
- **15%B** and **25%** will require reprocessing as it will reach maximum capacity
- But **15%B** has enough flexibility to choose direct disposal

Surplus Plutonium



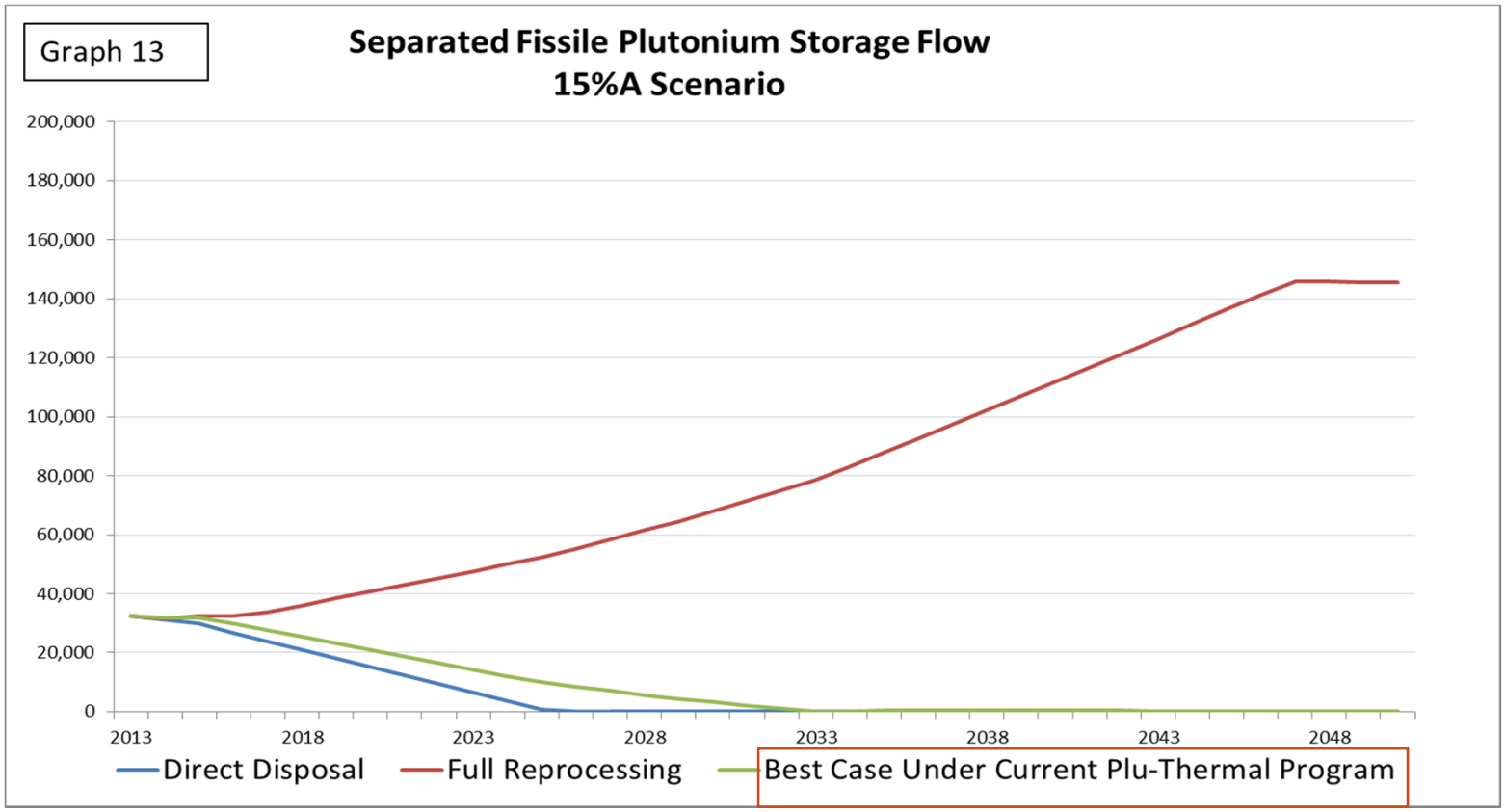
- **0%** - No problem burning all of the separated plutonium under current Plu-Thermal Program
- **Other**- great increase in separated plutonium stock under current Plu-Thermal Program

Surplus Plutonium



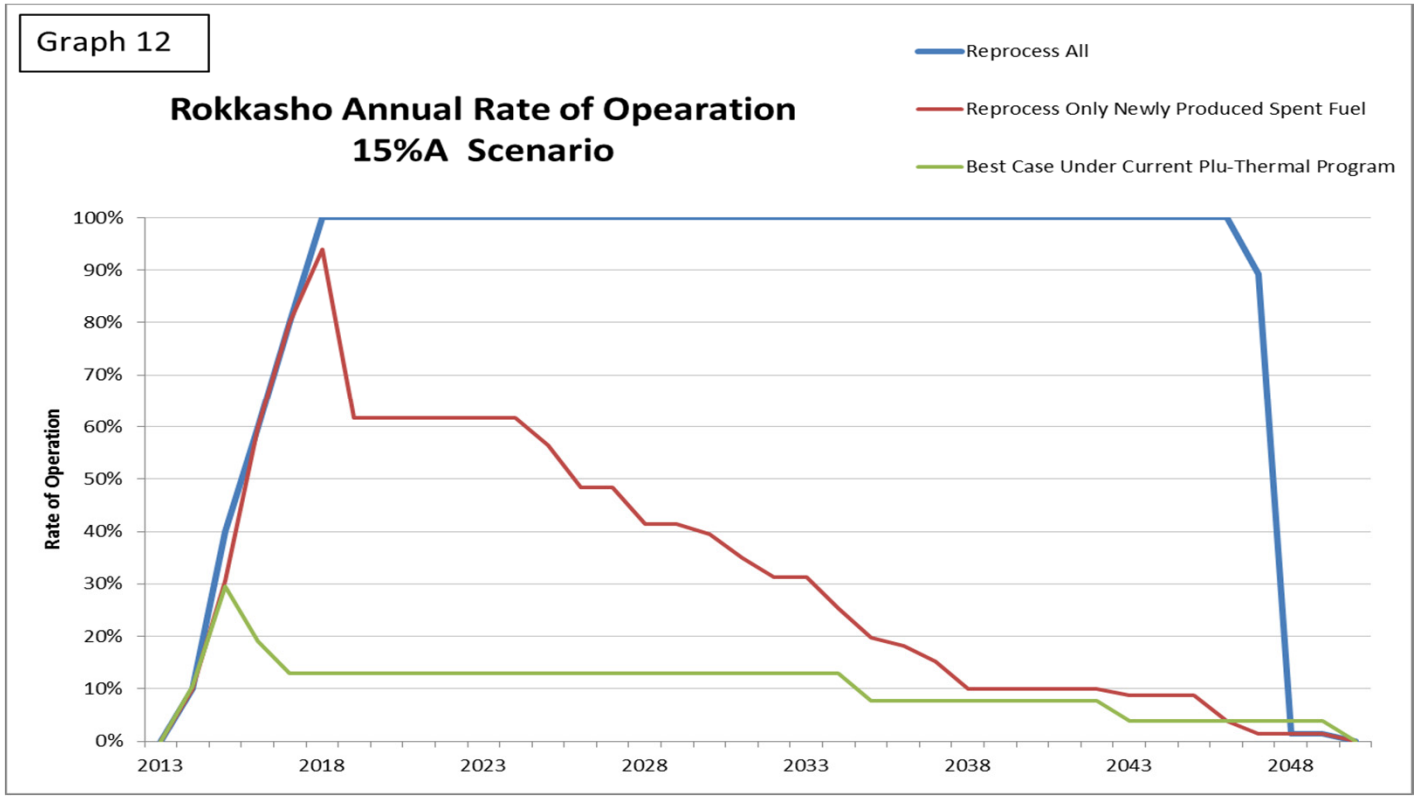
- **15%** and **25%** will not be able to burn plutonium as fast as the production of MOX fuel under current Plu-Thermal Program
- **15%B** and **25%** <u>will be able to expand Plu-Thermal Program</u> since they will sustain sufficient number of reactors

Surplus Plutonium (15%A Scenario)



- **15%A** will not sustain sufficient number of reactors to expand Plu-Thermal Program
- Under current Plu-Thermal Program, maximum amount of fissile plutonium that can be burned is **52,400kg**
  - Already separated 32,557kg,
  - Amount that can be separated at Rokkasho=**19,843kg**

Surplus Plutonium (15%A Scenario)



- **15%A** must burn most of the Separated plutonium by 2035 or else there will be no reactor that can be licensed to burn MOX

  -Should not reprocess

- **15%B & 25%** should expand their Plu-Thermal Program or use Fast Reactors to decrease their plutonium stock

Policy Recommendations

If Japan declares within the next 3 years any of the following scenarios, I recommend the US:

- **0% Scenario** Do not grant programmatic consent to reprocess US-origin fuel at 2018 Nuclear Cooperation Agreement negotiation
  - Japan will not need reprocessing
  - They will be able to burn all of the separated plutonium
- **15%A Scenario** Do not grant programmatic consent
  - Reprocessing is not necessary
  - They will not be able to burn the separated plutonium if they reprocess; excess separated Pu will be generated
- **15%B Scenario** Demand the readjustment of their Plu-Thermal Program

  Persuade them to take Direct Disposal option
- **25% Scenario** Demand the readjustment of their Plu-Thermal Program

Policy Recommendations

If Japan does not clarify their long term nuclear policy:

- For example, if they declare intent to decrease their dependence on nuclear to **15%** by 2030 but di not clarify long-term policy

  -Difficult to distinguish between **15%A** and 15%B

Shorten the advance consent to <u>15 years.</u>

Renewal negotiation at 2033 (start to see divergence between 15%A and 15%B)

Demand the readjustment of Plu-Thermal Program

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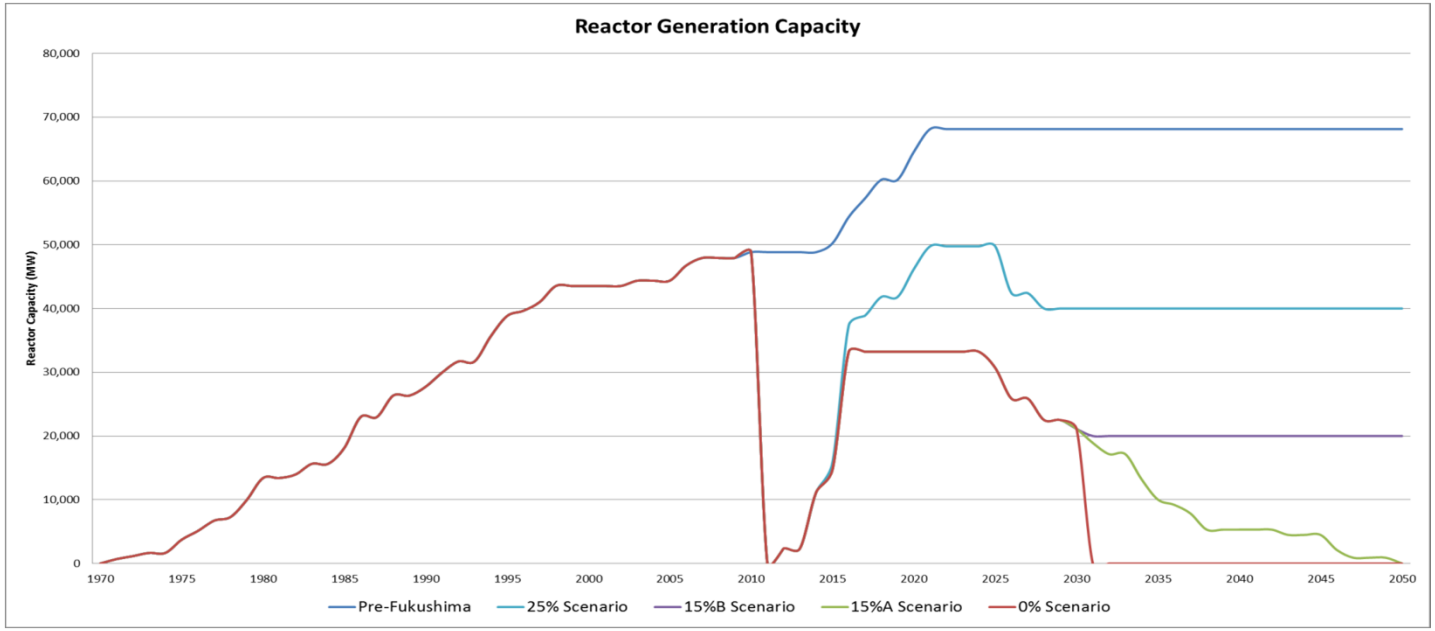
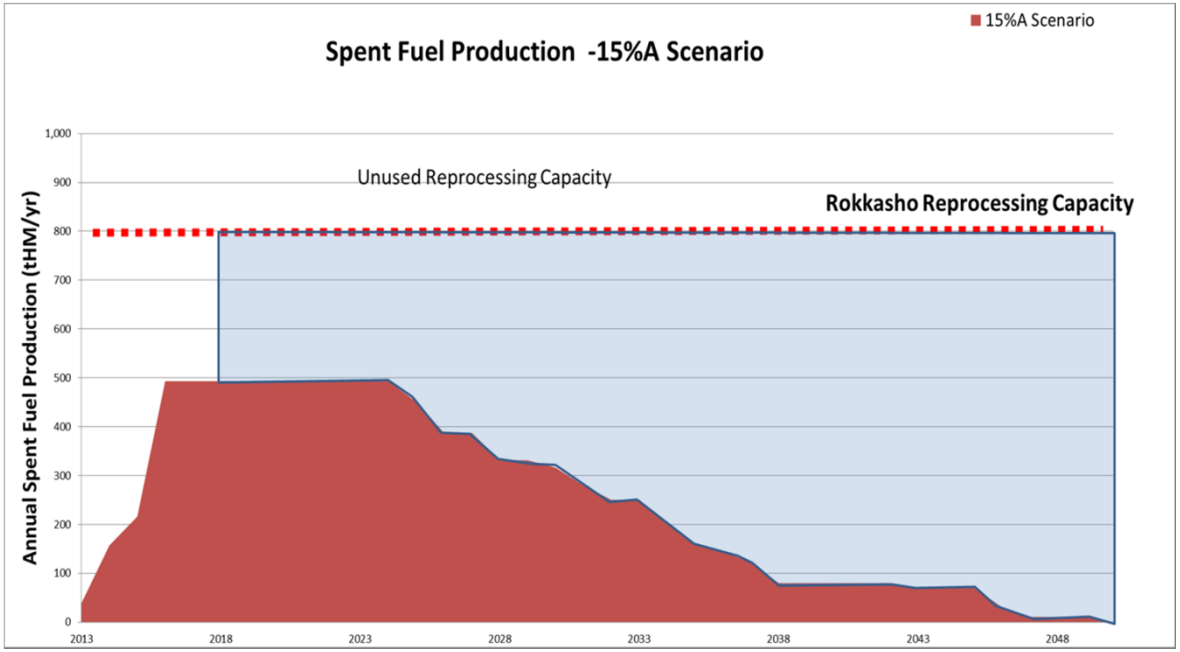

Reactor Generation Capacity
Reactor Capacity (MW)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Pre-Fukushima
25% Scenario
15%B Scenario
15%A Scenario
0% Scenario


15%A Scenario
Spent Fuel Production -15%A Scenario
Unused Reprocessing Capacity
Rokkasho Reprocessing Capacity
Annual Spent Fuel Production (tHM/yr)
1,000
900
800
700
600
500
400
300
200
100
0
2013
2018
2023
2028
2033
2038
2043
2048

Limits to this research

- New decision are made every day
- More reactors can be shut down due to strict regulation
- Operation of Rokkasho, and MOX fuel fabrication facility can be extended
- Electricity demand can change in a decade
  - AEC and MEXT claim that energy efficient technology will develop

Questions?

Annex 3. Presentation by Katherine McCarthy on “IAEA Relations with India, Israel, and Pakistan: How do these non-NPT states impact the NPT safeguards system?”

"IAEA Relations with India, Israel, and Pakistan: How do these non-NPT states impact the NPT safeguards system?"

KATHERINE MCCARTHY

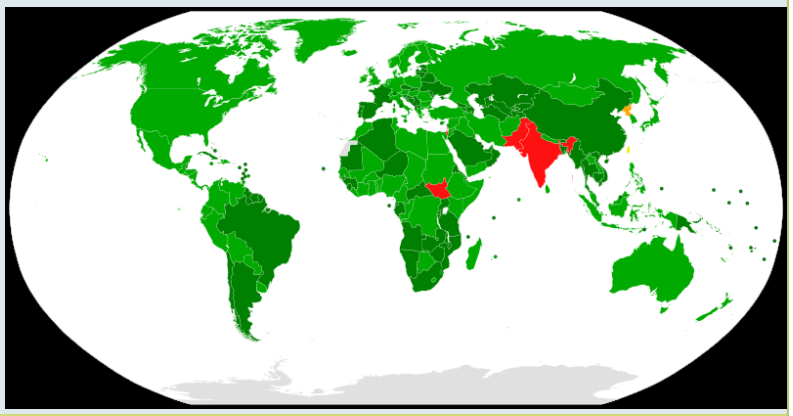
15 AUGUST, 2013

Outline

- Background
- Country Information
- Committee 24
- General Conferences
- Conclusions
- For Further Research

Background

- August 15th, 2013 is the culmination of one busy and learning-filled summer
- Putting it all together… with the mind of a visual learner.
- Why is this topic important/ what was the goal?



Method

- Read the interventions by India and Pakistan at Committee 24 (committee to negotiate the Model Additional Protocol)
- Read all the General Conference statements from all three countries from 1996 - 2012.
- Get a brief understanding of each countries histories
- Analyze above information to see how they have influenced the IAEA safeguards system

Relevant Country Information

India

- Began 1950s
- Three Stage Process
- Closed Fuel Cycle
- Thorium
- Nine Safeguards Agreements
- U.S./India Deal
- Nuclear Suppliers Group Waiver

Israel

- Has Never Acknowledged Having a Nuclear Weapons Program
- One Safeguards Agreement
- Security Concerns High Priority
- Long History of U.S. Relations

Pakistan

- Controversial Non-Pro History
- Program as Related to India's
- Top Beneficiary of TC Programs
- Six Safeguards Agreements
- Assistance From China

Committee 24

AP Negotiation Interventions: India and Pakistan

** UNDER "TITLE" SECTION**				
India	GOV/COM.24/OR.21/P31	3	USA, France	the Committee had been entrusted by the Board with the task of developing a model protocol for comprehensive safeguards agreements, in which case the title should perhaps refer to such agreements.
India	GOV/COM.24/OR.39/P51	4	Pakistan, China	prefer the first option, as the Protocol was intended to apply to States with comprehensive safeguards agreements.
Pakistan	GOV/COM.24/OR.39/P51	4	India, China	prefer the first option, as the Protocol was intended to apply to States with comprehensive safeguards agreements.
India	GOV/COM.24/OR.40/p2-3	4	Pakistan	retain all three options in square brackets until the foreword and the preamble are discussed.
Pakistan	GOV/COM.24/OR.40/p2-3	4	India	retain all three options in square brackets until the foreword and the preamble are discussed.
Country	Call #	Page #	Other Countries?	Summary
India	GOV/COM.24/OR.49/P35-38	4	Cuba, Pakistan	had reservations about the proposed wording of the title and the first paragraph of the preamble because any effort to apply the Protocol in States with INFCIRC/66-type agreements went beyond the limits of the current exercise.
Pakistan	GOV/COM.24/OR.49/P35-38	4	India, Cuba	had reservations about the proposed wording of the title and the first paragraph of the preamble because any effort to apply the Protocol in States with INFCIRC/66-type agreements went beyond the limits of the current exercise.
India	GOV/COM.24/OR.50/P12	4	N/A	prefer the title of the Protocol to read "Protocol Additional to Comprehensive Safeguards Agreements"; that had been one of the options given in the Chairman's working paper W.P.2 of 18 October 1996.
UNDER "FOREWORD" SECTION				
Pakistan	GOV/COM.24/OR.22/P34	6	N/A	Opposed Swedish Proposal
India	GOV/COM.24/OR.22/P105	7	N/A	oppose language that does not make it explicit that implementation of the protocol and of the strengthened safeguards system could only apply to countries having comprehensive safeguards agreements.
Country	Call #	Page #	Other Countries?	Summary
India	GOV/COM.24/OR.40/P35	9	N/A	could not go along with any proposal aimed, however indirectly and in however neutral a manner, at bringing about the application of provisions of the Protocol in countries with INFCIRC/66/Rev.2-type safeguards agreements.

- Why Look at This?
- Persian Gulf War 1991
- India and Pakistan Only
- INFCIRC/153 vs. INFCIRC/540
- Focus of Interventions

Observations and Conclusions

- Main focus for both countries: Support INFCIRC/540, but to ensure that it did not apply to INFCIRC/66/rev.2 States.
- Secondary focus (especially for India): Should not affect IAEA TC efforts
- "… any effort to apply the Protocol in States with INFCIRC/66-type agreements went beyond the limits of the current exercise." – India
- Eliminating language suggesting the Model AP included INFCIRC/66 States, did not "deprive [these] states of the opportunity to conclude additional protocols if they so desired." – Pakistan

i. India and Pakistan do not want increased safeguards mandated upon them

ii. India and Pakistan do support increased safeguards for NPT member states (both hope, however, they do not hinder TC mission of IAEA)

iii. India and Pakistan are engaged in high-level safeguards and non-proliferation discussions.

General Conference Statements

All Things Considered

Background/Potential Influences

- Director General
- Lead Delegate at Specific Conference
- Chair of Specific Conference

Direct Influences

- Statement-Emphasis
- Progression of Statement Over time
- Significant Changes from Year to Year
- Potential Outside Influences for Emphasis Change
- Similarities and Differences Between the Three States

General Conference Statement Emphases and Observations

Director General - HANS BLIX – SWEDEN

1996 - 40

India – Mr. R. Chidabaram : (from summary) Sustainability/environment, Food, health, reservations about imbalance of 93+2, concerned about promotion of wrong part of IAEA, interested in CSRWM but "spent fuel" inclusion not an option

Israel – Mr. Gideon Frank: Committed to peace process and NonPro, approved CTBT and encourages others to, commends principle of 93+2 but it cannot offer any lasting guarantees w/o political will and checks and balances.

Pakistan – Mr. Haji Muhammad Nawarz Khokhar: Supports CTBT but says can only be realized if it wins adherence of all nuclear capable countries. Praised safeguards but room for improvement such as 93+2. Does not want it to extend to 66 States though – this is contrary to the spirit of the program, safety is important and welcomes CNS, TCF important and they will fulfill next years contribution, pak's safe history, importance of cancer treatment.

Director General - MOHAMED ELBARADEI - EGYPT

1997 – 41

India - Mr. R. Chidabaram: Sustainability, commitment to safety, oppose inclusion of "spent fuel", in favor of increased export controls, supports TCPs, IAEA must be balanced btw promotional and safeguards activities, current TCP donor

Israel – Mr. Gideon Frank: Need ^ SGS capabilities, two resolutions: IAEA SGS in ME and Amendment to Article VI of Statute, supports TCPs, Supports AP but not currently in a position to sign, historically cooperative with Agency

Pakistan - Mr. Ishfaq Ahmad: salutes establishment of NWFZs, wishes to see one in South Asia, need for energy, Agency must be nondiscriminatory, pak has excellent safety record, supports TCPs and has benefitted from them, supports IAEA, hopes article VI issues will be resolved.

1998 – 42

India - Mr. R. Chidabaram: Future energy needs ^, environment and sustainability, India's closed fuel cycle, Thorium program, need balance btw promotional and sfg activities

General Conferences in Detail

Country #	Conference #	Delegate in Attendance	Title of Participan	#alternates	#advisors	Lead Delegate Same as year before?	# Other Member	Emphasis of Statement	Focus of Interventions at GC	Notes/Observations	Israel As Agenda Item?	Israel as Resoultion?	Israel Called "Threat" or just mentioned as "nuclear capability"
		Director General - HANS BLIX - SWEDEN											
India - 1996	40	Mr. R. Chidabaram	Chairman, AEC	5	0	n/a	0	(from summary) Sustainability/environment, Food, health, reservations about imbalance of 93+2, concerned about promotion of wrong part of IAEA, interested in CSRWM but "spent fuel" inclusion not an option			1996 - No	No	N/A
Israel - 1996		Mr. Gideon Frank	DG, IAEC	2	2	n/a	0	Committed to peace process and NonPro, approved CTBT and encourages others to, commends principle of 93+2 but it cannot offer any lasting guarantees w/o political will and checks and balances.					
Pakistan - 1996		Mr. Haji Muhammad Nawarz Khokhar	Minister for Science and Tech	7 (1 chairman of PAEC)	0	n/a	0	Supports CTBT, praised sfgs but room for imporovement such as 93+2 , does not want it to extend to INFCIRC66 states, safety is important, TCF important, safe history, successful cancer treatment activities					
		Director General - MOHAMED ELBARADEI - EGYPT											
India - 1997	41	Mr. R. Chidabaram	Chariman, AEC	4	2	Yes	0	Sustainability, commitment to safety, oppose inclusion of "spent fuel", in favor of increased export controls, supports TCPs, IAEA must be balanced btw promotional and safeguards activities, current TCP donor			1997 - No	No	N/A
Israel - 1997	41	Mr. Gideon Frank	DG, IAEC	3	2	Yes	0	Need ^ SGS capabilities, two resolutions: IAEA SGS in ME and Amendment to Article VI of Statute, supports TCPs, Supports AP but not currently in a position to sign, historically cooperative					
Pakistan - 1997	41	Mr. Ishfaq Ahmad	Chairman, PAEC	8	0	No	0	salutes establishment of NWFZs, wishes to see one in South Asia, need for energy, Agency must be non desciminatory, pak has excellent safety record,supports TCPs and has benefitted from them, supports IAEA, hopes article VI issues will be resolved.					

Timeline

India
Israel
Pakistan

Important Dates

Israel as nuclear threat Agenda Item

Pak nuclear tests "Chagai-II"

9/11

Iraq War: Operation Iraqi Freedom Begins

An inconvenient truth

Israel as nuclear threat Agenda Item - CAPABILITY

U.S./India Deal

Fukushima Accident

1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012

Committee 24

India Nuclear Test "Operation Shakti").

Bush State of the Union Address

Obama Prague Speech

Hans Blix

Mohammed ElBaradei

Yukiya Amano

IND																			07-^ in accomps			08-moves to calling 4 IAEA change (after deal?)		
ISR										01 -Agenda Items Mentioned?												08-1st mention of Iran/Syria by name		11-^intensity re: Iran
PAK					99-Rationalizing Tests														07-less critical of Agency		09-^export control talk		10-less on IAEA Balance	12-critical again

Continuing Postures

INDIA

- **Self-sufficiency and Autonomy**
- Achieving a Closed Fuel Cycle
- **Importance of Nuclear Energy as a Sustainable Energy Option**
- Reducing Devastation of Fossil Fuels on the Environment
- **India's Three Stage Process**
- U.S. Relations
- Moral Duty of all Member States to Contribute to the **TCF**
- Success of India's Expansive Nuclear Energy Network

ISRAEL

- Increase in Nuclear-Power-Needs must be Handled Properly to **Mitigate Proliferation Risks**
- Support for Strengthened Safeguards and IAEA
- **Verification and Timely Response are the Most Important Agency Role**
- Participant of the Proliferation Security Initiative
- **Non-Compliance of Iran and Syria must be Properly Dealt with**
- **Cannot Support Two Agenda Items: (1) Israel Nuclear Capabilities and Threat and 2) Creation of a Nuclear Weapons Free Zone in the Middle East (NWFZME) – Israel supports the latter in principle but asserts security and political conditions must change first and this process must come from within.**

PAKISTAN

- **Universal, Equitable Access to Nuclear Technology for all States, Especially if Safety-Related**
- One of the **Top Beneficiaries of Technical Cooperation Programs**
- Chinese Nuclear Facility Supply Relations
- Agency Must be **Non-Discriminatory**
- Pakistan's Excellent Safety Record
- Desalination, Need for Clean Water Access
- Growing Global Energy Needs Merit Universal Nuclear Tech Access
- **IAEA Activities Should Focus Mostly on Promotion of Nuclear Tech, not Safeguards**

Statement Changes

INDIA

- 2007: Huge influx of statements regarding India's accomplishments that they have achieved autonomously, including a "immaculate" safety and security records.
- 2008: (after U.S. and NSG deals) Focus changed drastically to calling for many IAEA changes and more international nuclear technology cooperation

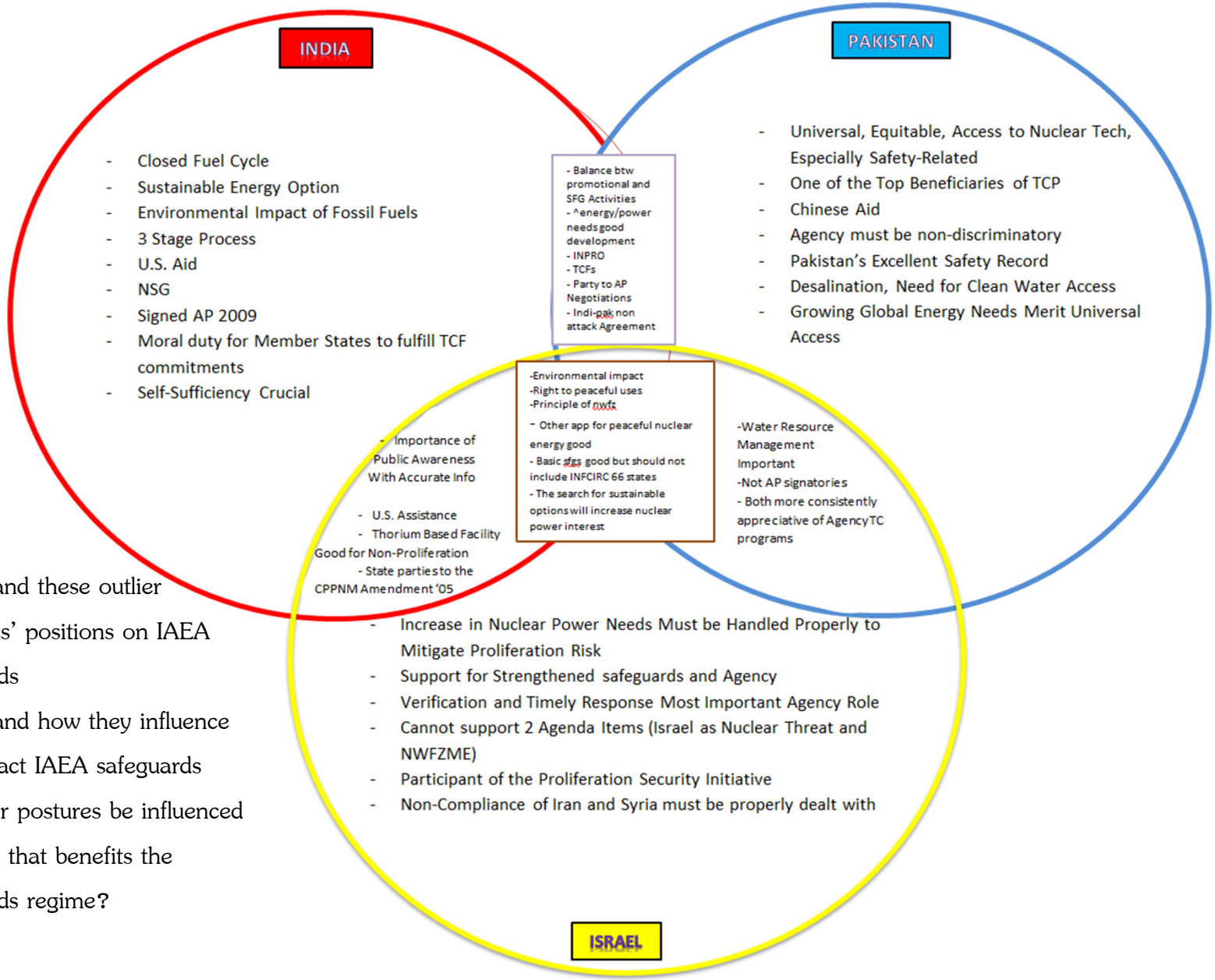
ISRAEL

- 2001: Only Statement (in those reviewed) that did not specifically refer to the "Two Irrelevant Agenda Items". (Either an interesting decision by Israel, or an interesting decision by the person in charge of writing the summaries that year)
- 2008: First time Israel mentions Iran and Syria by name in their Statement, instead of alluding to them generally as States in non-compliance.
- 2011: Greatly increased intensity in Statement regarding Iran and much less mention of other subjects.

PAKISTAN

- 1999: Heavy emphasis on rationalizing recent nuclear tests
- 2007: (during potential India deal) Much less critical than usual of IAEA and increased mention of safety record
- 2009: Increased focus on potential for export of nuclear medical technology and how Pakistan has greatly improved their export controls
- 2010: Did not include much detail regarding IAEA needing to rebalance activities and focus from safeguards to promotional.
- 2012: Extremely critical of IAEA – perhaps using Fukushima incidents as reason to call for increase technical help for all States

Similarities and Differences



Goals:

- Understand these outlier Countries' positions on IAEA safeguards
- Understand how they influence and impact IAEA safeguards
- Can their postures be influenced in a way that benefits the safeguards regime?

Conclusions

- The nonproliferation regime is facing challenging times
- Achieving understanding is the first step in cooperation
- Strong relations with the IAEA especially for States with, or with possible nuclear weapons programs, are very important
- There are similarities between these three non-NPT States that help explain their positions and positive and negative impacts on the IAEA Safeguards system
- May be possible to discourage negative influences and encourage positive influences that these States have on the IAEA
- Overall, all three countries support safeguards in NPT States (with many caveats but still a positive general stance)
- Overall, seem to be less of a negative influence than I have thought

Areas I wish I had more time for…

- How the Non-pro regime might incentivize these States to take on more safety and security measures
- Amendment to Article VI of IAEA Statute
- These States' influence on Nuclear Weapon Free Zones in more detail
- Who wrote the GC summaries?!

Thank you!

Email: ktmccarthy.73@gmail.com

Annex 4. Presentation by Kay Kahee Park on “Development of the South Korean Nuclear Energy Industry”

The Development of the **South Korean Nuclear Industry**

Kay Kahee Park
Next Generation Safeguards Initiative

8/16/2013

Contents

1. South Korean nuclear ambitions

2. Looking back at Park Chung Hee's export-driven economic development

3. KEPCO and Chaebols

4. Using social network analysis for visualization

5. SNU Power Mafia

Nuclear Outlook

- South Korea is aiming to become a nuclear exporter in the international market.
- Atoms for Peace.
- UAE 2009 Contract's Significance
- 123 Agreement Negotiations difficult due to South Korea wanting ENR capacity.

Value of South Korean Reactors

- South Korea was able to put together a competitive contract package compared to the other more established exporters.
- It absorbed the cost hoping for future profits from sales following the UAE contract.
- The UAE contract gave South Korea the prestige necessary to enter the market.

Park Chung Hee

- Viewed with ambivalence.
- South Korean economic development… **chaebols**.
- Conservative political leanings.

Park Chung Hee's Five Year Plans

- Yushin regime was justified on preserving the accomplishments of economic development.
- The masses were kept happy because they finally had jobs.
- **Bureaucratic Authoritarianism**
- Labor-intensive, export-oriented industrialization

The Importance of KEPCO

- Electricity and energy sector provided the foundation for South Korea's industrial growth strategy.

- Korea Electric Power Corporation started in 1961 as a state-owned and operated monopoly.

KEPCO

KOREA HYDRO & NUCLEAR POWER CO., LTD
KHNP
한국수력원자력(주)

KEPCO E&C

KEPCO KPS

KEPCO NF

KEPCO's Contributions

- Prioritized supplying power to large industrial facilities which provided export growth.

- **South Korea's economic growth attributed to formula of doubling electricity capacity every ten years.**

- **Earliest and largest modernization projects in post war period were power plants.**

Chaebols' connection to Nuclear Industry Begins

- Chaebols were charged with achieving technology indigenization in electricity sector.
- Hyundai and Daewoo were given governmental support to acquire knowledge about power plant engineering techniques.
- These arrangements allowed the chaebols to expand the scale and interests of their businesses.

“Close state-*chaebol* collaboration in the electricity sector was a feature subsequently replicated throughout the national economy, becoming a key factor in the country’s rapid industrialization”

EXPANSION OF THE ELECTRICITY SECTOR WAS GREATLY FACILITATED BY THE ADOPTION OF NUCLEAR POWER.

CHAEBOLS

DOOSAN

HYUNDAI
ENGINEERING & CONSTRUCTION

DAEWOO E&C

SAMSUNG

SAMSUNG C&T
Engineering & Construction Group

GS E&C

Export-driven Success

- Chaebols were formed through acquisition of former Japanese properties…
- Had privileged access to foreign aid, bank loans, public contracts.
- Received favorable treatment from the state through **political connections** through the state elites.

Timeline for change…

- KEPCO had great operational discretion when Park Chung Hee crushed dissidence against nuclear industry.
- Chaebols were given free rein following Park Chung Hee's assassination.
- IMF Financial Crisis due to indiscretion and extended capital.

Post- IMF: A CHANGED KEPCO

- Reduced government involvement in the economy.
- KEPCO was the single largest state-owned source of international debt.
- No more preferential treatment for chaebols and decentralized KEPCO to separate subsidiary companies.

Chaebols' Nuclear Connection continues…

UAE CONTRACT KEPCO CONSORTIUM

- KEPCO
- Korea Hydro and Nuclear Power
- KOPEC
- Korea Nuclear Fuel Company
- Korea Plant and Engineering Company
- Doosan Heavy Industries & Construction
- Samsung C&T
- Hyundai Engineering and Construction
- Westinghouse Electric Company
- Toshiba Corporation

Relationships with the State

Chaebol were able to gain economic favors in exchange for political contributions.

Nuclear Exports for Future Growth..

"Nuclear power-related business will be the most profitable market after automobiles, semiconductors, and shipbuilding"

- Ministry of Knowledge Economy Report

To President Lee Myung-bak

Common Points with PAST

- South Korea's drive to push **nuclear reactor exports for economic development.**

- New Ministry of Future Creation and Science – Similar to how President Park Chung Hee created new ministries to realize his policy goals.

- Close relationship between government and chaebol entities.

Relationships' Attributes

- "SNU Power Mafia" – Alumni connections
- KAIST
- Korean Nuclear Society
- These SOCIAL attributes make a personal relationships between the actors more likely.

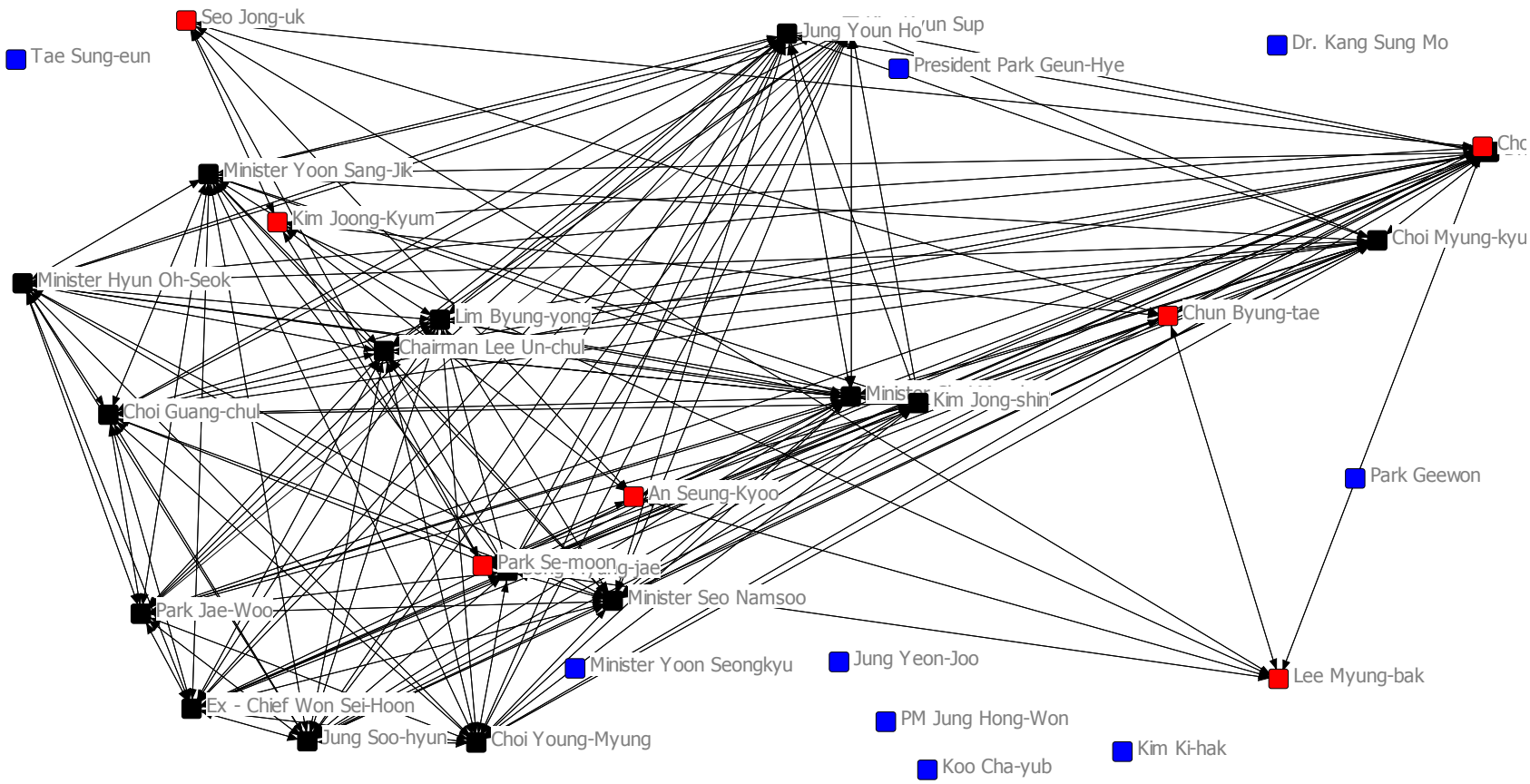
Social Network Analysis

- How do these actors relate to each other?
- Are there certain attributes that individuals share which makes certain outcomes more likely?

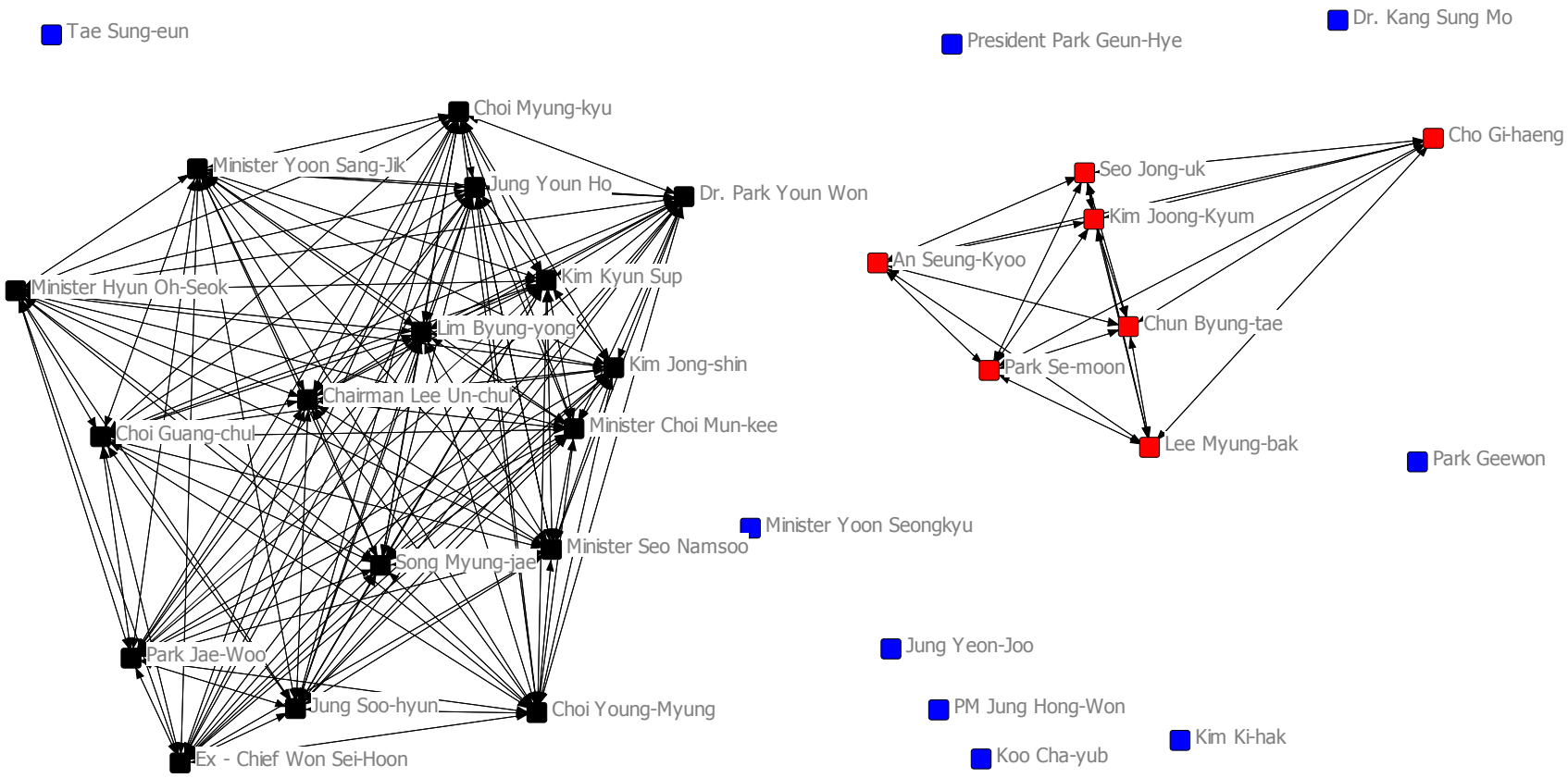
Nuts and Bolts

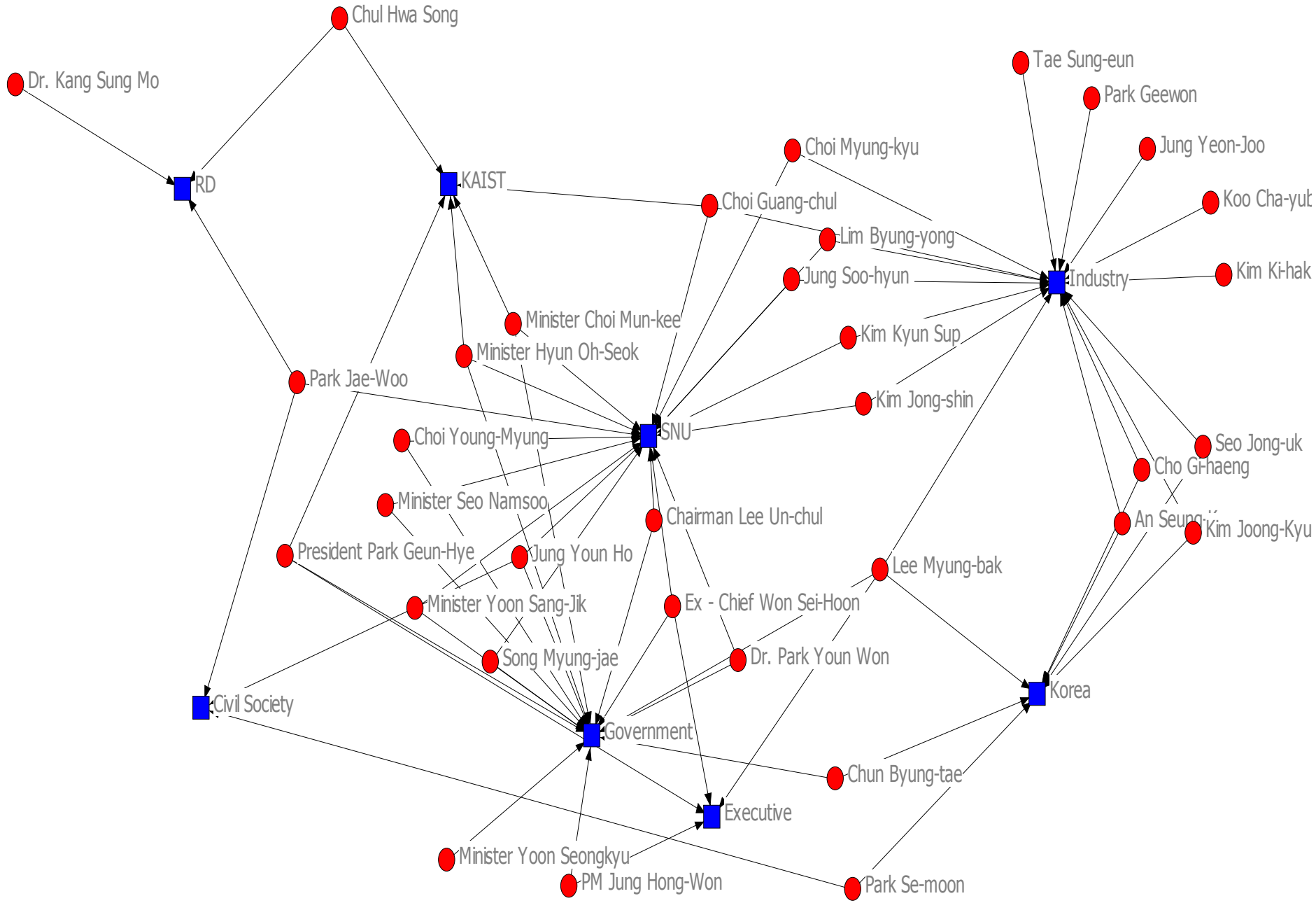
- Nodes: 34 Individuals in government, nuclear industry, R&D organizations, and civil society.
- Ties: School affiliations. Affiliations to organizations.
- All open source data from South Korean outlets.

Let’s see it!!!


Seo Jong-uk
Tae Sung-eun
Jung Youn Ho
President Park Geun-Hye
Dr. Kang Sung Mo
Minister Yoon Sang-Jik
Kim Joong-Kyum
Choi Myung-kyu
Minister Hyun Oh-Seok
Lim Byung-yong
Chun Byung-tae
Chairman Lee Un-chul
Kim Jong-shin
Choi Guang-chul
Park Geewon
An Seung-Kyoo
Park Se-moon
Minister Seo Namsoo
Park Jae-Woo
Minister Yoon Seongkyu
Jung Yeon-Joo
Lee Myung-bak
Ex - Chief Won Sei-Hoon
PM Jung Hong-Won
Jung Soo-hyun
Choi Young-Myung
Kim Ki-hak
Koo Cha-yub

SNU Power Mafia?

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Park Geewon
Jung Yeon-Joo
Choi Myung-kyu
Choi Guang-chul
Koo Cha-yul
Lim Byung-yong
Jung Soo-hyun
Industry
Kim Ki-hak
Minister Choi Mun-kee
Minister Hyun Oh-Seok
Kim Kyun Sup
Park Jae-Woo
Kim Jong-shin
SNU
Choi Young-Myung
Seo Jong-uk
Cho Gi-haeng
Minister Seo Namsoo
Chairman Lee Un-chul
An Seung-
Kim Joong-Kyu
President Park Geun-Hye
Jung Youn Ho
Lee Myung-bak
Minister Yoon Sang-Jik
Ex - Chief Won Sei-Hoon
Song Myung-jae
Dr. Park Youn Won
Korea
Civil Society
Government
Chun Byung-tae
Executive
Minister Yoon Seongkyu
PM Jung Hong-Won
Park Se-moon

CORRUPTION SCANDALS IN THE NUCLEAR INDUSTRY

- JS Cables – forged safety certificates.
- Ex-NIS Chief Won Sei-Hoon scandal leak.
- Bribery linked to construction contracts.
- Government officials who share a linkage to the industry… (formerly worked at Hyundai, etc.)

Is there a lack of oversight?

- Personal relationships may be driving continued emphasis on the growth of the South Korean nuclear industry.
- These relationships also have a negative impact because regulation does not occur the way it should.
- Disregard for the importance of regulations and safety standards.

Park Geun-Hye

- Primarily elected due to the older generation who yearn for the economic rise during her father’s administration.

- Although she campaigned on the promise of curbing the power of the Chaebols, she is still invested in realizing the nuclear reactor exports.

January 2013 Announcement

- **Ministry of Future Creation and Science** – charged with **REGULATION** of Nuclear Industry

- **Ministry of Trade, Industry, and Energy (Former MKE)** – charged with **PROMOTION** of Nuclear Industry

The population

- Unfavorable responses to the current safety incidents in nuclear industry.

- Pushback against chaebols which run everything in the country.

CONCLUSION

- Nuclear power mafia does exist.
- Personal relationships make for lax standards in nuclear industry.
- Is Nuclear Safety and Security Commission impartial enough?
- Recent corrupt scandals may highlight to the South Korean public what could occur if this culture continues to pervade in the industry.

Annex 5. Presentation by Jessica Wilbourne on “Supporting Safeguards in Serbia: Designing an Open-Source Activity to Assist with Additional Protocol Implementation”

Supporting Safeguards in Serbia: Designing an Open-Source Activity to Assist with Additional Protocol Implementation

Jessica Wilbourne
Next Generation Safeguards Initiative Intern
at Lawrence Livermore National Laboratory
Summer 2013

Outline

1. Overview of INSEP Program
2. Purpose of an Open-Source Activity
3. Activity Development Process: 4 Phases
4. Examples of Open-Source Exercises
5. Challenges and Lessons Learned

Overview of INSEP Program

INSEP

- International Nuclear Safeguards and Engagement Program
- DOE - NNSA Office of Defense Nuclear Nonproliferation
- Part of NGSI
- Regional and bilateral engagements: training, equipment, and expertise for partners
- Supports all aspects of safeguards, in particular:
  - Safeguards infrastructure development
  - Safeguards implementation cooperation
  - Advanced safeguards testing

INSEP in Serbia

- Serbia has signed, but not ratified AP
- Serbia wants to join EU
- Fourth engagement with Serbia this November
- Relationship of mutual trust: ready for open-source activity

Purpose of an Open-Source Activity

Brief Introduction to Open-Source Information for Safeguards

- Open-source information = publicly available (not classified or proprietary)
- IAEA uses open-source info as part of strengthened safeguards
  - Program 93+2
  - Important tool for State Evaluation Report
  - Has been used in IAEA safeguards activities before

Open-Source Activity in Serbia

- Useful tool to help a state learn how to collect and analyze open-source information
  - Developing an important skill-set
  - Hands-on, practical experience using mock exercises
  - Relevant, customized, state-specific exercises
- Open-source activity can help a state:
  - Know what information relevant to their nuclear activities is publicly available
  - Learn about and monitor nuclear-related activities within their territory including R&D in the private sector (industry, private universities, etc.)
  - See what kind of open-source information the IAEA can review
  - Prepare for declaration submissions

Activity Development Process: 4 Phases

1. Initial Familiarization/Planning Phase
2. Open-Source Research Phase
3. Analysis and Organization Phase
4. Activity Design Phase

Phase 1: Initial Familiarization/Planning

- Learning about the former Yugoslavia's past nuclear experiences
- Attempting to understand Serbia's current nuclear policies, projects, and ambitions
- Learning about Serbia's remaining nuclear-related facilities
- Taking a much closer look at the AP
- Deciding how best to approach the research phase: where to find information that might require an initial declaration when AP enters into force?

Open-source chronology of important events

- Late 1940's: **Tito regime initiates nuclear programs** - energy and weapons (security concerns over USSR, desire for status)
- 1948: Institute for Research on Structure of Matter (now **Vinča Institute**) is founded
- 1952: nuclear **collaboration begins with Norway** with visit from Gunnar Randers (head of Norwegian nuclear research program)
- 1950's-1960's: research into reprocessing Pu from spent fuel, uranium exploration and mining on Mt. Stara Planina
- 1956-59: **RA Reactor** - 6.5MW heavy water moderated and cooled research reactor built… uses 2% LEU until switching to 80% HEU in late 1970's
- 1957: **RB Reactor** built as zero-power natural uranium critical assembly, later upgraded to 50W flexible heavy water experimental reactor
- 1960: **weapons program deactivated** - reasons unclear
- 1970: Yugoslavia ratifies NPT
- 1974: India's 1st nuclear test - **weapons program restarted** (competition for leadership of NAM)
- 1981: TC project with IAEA studying recovery of uranium from phosphoric acid
- 1986: Chernobyl incident
- 1987: **ban on construction of nuclear power plants**, later strengthened with criminal penalties
- 1987: **end of weapons program** (cost, inter-republic disputes, indifferent scientists)
- 1995-2002: Vinča officials express concern over safety of HEU during political unrest
- 2002: **RA reactor shut down**, decommissioning begins
- 2002-2010: **removal of all HEU** at Vinča
- Late 2000's-present: high-level **discussions of nuclear power with Russia**, though Serbian government maintains that this is purely hypothetical due to the ban on power plants

The Additional Protocol

- **Article 2** - information to be declared:
  - Nuclear fuel cycle-related R&D not involving nuclear material
  - Gains in effectiveness or efficiency on "operational activities of safeguards relevance" at locations where nuclear material is customarily used
  - Site map with description of each building on each site
  - Annex I and II activities
  - Source material (U and Th) in large quantities (domestic, import/export for non-nuclear purposes)
  - Quantities, uses, and locations of nuclear materials exempted from safeguards under paragraphs 36(b) or 37 of INFCIRC/153
  - Information on the location or further processing of waste on which safeguards have been terminated
  - General plans for the next 10 yrs relevant to the development of the nuclear fuel cycle (including planned fuel cycle-related R&D)
  - 2.b. good faith effort to declare fuel cycle-related R&D carried out by private entities

- Article 3: timing/frequency of declarations required under Art. 2
- Article 4: Complementary Access - gives IAEA authority
  - Places the IAEA can visit to verify correctness and completeness of declarations, including certain places in conjunction with DIV visits, ad hoc, and/or routine inspections
  - Conditions that must be followed during CA ("bill of rights" for the state under CA), including advanced notice in writing specifying the reasons, opportunity to clarify, must be during regular working hours, right to have inspectors accompanied by representatives
- Article 5: states must provide access to IAEA
- Article 6: specific activities that IAEA can conduct to verify correctness and completeness
- Article 12: visas
- Article 18: definitions

Phase 2: Open-Source Research

- Looking for activities that might require a declaration
- Sources: primarily scientific journal publications, some media sources
- Keyword searches in multiple databases in English and Serbian
- Search terms derived from AP and its Annexes, as well as information gathered during familiarization phase (programs, facilities, research institutes, scientists, and activities of potential relevance)
- Lengthy process of sifting through and collecting information

Ab-initio calculation of electronic structure and electric field gradients in $HfAl_2$ and $ZrAl_2$ Laves phases

J. Belošević-Čavor *, V. Koteski, B. Cekić, A. Umićević

Institute of Nuclear Sciences Vinca, P.O. Box 522, 11001 Belgrade, Serbia

Received 4 December 2006; received in revised form 16 March 2007; accepted 25 March 2007
Available online 17 May 2007

Abstract

A detailed theoretical study of the structure, electronic properties and electric field gradients (EFG) of the $HfAl_2$ and $ZrAl_2$ Laves phases is presented. Using all-electron augmented plane waves plus local orbitals (APW + lo) formalism, the equilibrium volumes, bulk moduli and EFGs for the two compounds are calculated. The obtained results are compared with the available experimental and theoretical data. Better agreement with the experimental data is found by employing supercell calculations with Ta and Cd impurities.
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PACS: 71.15.Ap; 71.20.Lp; 71.70.Jp

Keywords: $HfAl_2$; $ZrAl_2$; Electric field gradient; Augmented plane wave

1. Introduction

Zirconium–aluminium and hafnium–aluminium alloys are potential structure materials in thermal nuclear reactors due to good mechanical properties at high temperature combined with low absorption cross-sections for thermal neutrons [1–3]. Extensive work has been reported on the Zr–Al alloys regarding amorphisation [4], nano-phase formation [5], formation of several metastable phases [6] and making zirconium based pressure tubes with aluminium linings [7]. Also, stability [8], getter potentialities [9], elastic moduli [10] and combustion synthesis [11] of Zr–Al intermetallic compounds have been investigated. However, there is a lack of electronic structure calculations for these alloys. The same is true for the Hf–Al alloys.

Our purpose in this work is to investigate the structural, electronic and hyperfine interaction properties of $ZrAl_2$ and $HfAl_2$, which are Laves phases with $MgZn_2$-type structure (C14). Studying hyperfine structure of nuclei is a powerful tool for investigation of interactions of atomic nucleus with local electric and magnetic fields. These interactions cause shifts and splitting of nuclear energy levels and enable us to obtain information about the symmetry of the charge distribution around the nucleus, about the electronic configurations of atoms and ions as well as about the peculiarity of the atomic structure of solids.

2. Computational details

The calculations have been performed using the augmented plane waves plus local orbitals (APW + lo) method as implemented in the WIEN 2k code [12], within the framework of the density functional theory (DFT) [13]. In this method, the space is divided into two regions. Near the atoms all quantities of interest are expanded in spherical harmonics and in the interstitial region they are expanded in plane waves. The first type of expansion is defined within a so-called muffin-tin sphere of radius R_{mt} around each nucleus. In our calculations the muffin-tin radii for Hf, Zr and Al were 2.3, 2.2 and 2.15 a.u., respectively. The Hf 5s, 5p, 6s, 5d, 4f, the Zr 4s, 4p, 5s, 4d and the

* Corresponding author. Tel.: +381 11 2453 681; fax: +381 11 3440 100.
E-mail address: cieca@vin.bg.ac.yu (J. Belošević-Čavor).

Phase 3: Analysis and Organization

- Determining which publications/activities could be declarable under specific articles of the AP: not always clear
- Table with over 60 entries
- Declarability rating: high, medium, low
- Justification/explanation for rating
- Some publications might be of interest to the IAEA and prompt some questions for clarification, even if they would probably not require a declaration

Article/Document Title	Declaration Significance Category(ies)	Original Search Terms	Search Engine	Rating (H, M	Declarability Reasoning	Author(s)	Da	Institution(s	URL
Kinetics of Hydrogen Absorption in Zr-based alloys	2(a)(i) - Fuel cycle R&D not involving nuclear material 2(a)(x) - General plans for future fuel cycle development	Nuclear Zirconium Serbia	Google Scholar	High	Mentions that the effects of H on Zr are important to nuclear industry (Zr structural components for nuclear reactors), and that hydrogen embrittlement is studied as a way of improving Zr recycling from spent fuel. Nuclear fuel cycle-related R&D, possible indication of plans for future activities. Very recent date.	Bozidar Cekic, Katarina Ciric, Mihail Iordoc, Smilja Markovic, Miodrag Mitric, Dragica Stojic	2013	Vinca Institute of Nuclear Sciences; Centre for Fine Particle Processing and Nanotechnologies at the Institute of Technical Sciences of SASA (Belgrade);	http://www.sciencedirect.com/science/article/pii/S0925838813001539
Ab-initio calculation of electronic structure and electric field gradients in HfAl2 and ZrAl2 Laves	2(a)(i) - Fuel cycle R&D not involving nuclear material 2(a)(x) - General plans for future fuel cycle development	Nuclear Zirconium Serbia	Google Scholar	High	Mentions Zirconium-Aluminum and Hafnium-Aluminum alloys as potential structure materials in thermal nuclear reactors. Nuclear fuel cycle-related R&D. Recent date.	J. Belosevic-Cavor, V. Koteski, B. Cekic, A.	2007	Vinca Institute of Nuclear Sciences	http://www.sciencedirect.com/science/article/pii/S0927025607000083
ADS Project in the Vinca Institute	2(a)(x) - General plans for future fuel cycle development	Nuclear reactor Serbia	Google Scholar	High	Discusses the project for designing a small modern subcritical research reactor driven by an accelerator beam (TESLA Accelerator Installation). Mentions possibility of using nuclear energy in the future. Plans relevant to development of the nuclear fuel cycle.	Milan Pesic, Nebojsa Neskovic, Ilija Plecas	1999	Vinca Institute of Nuclear Sciences	http://rt270.vin.bg.ac.rs/150/150Documents/1999_ITEP_Russia_VincaADS.pdf
Neutronic Design of an Accelerator Driven Sub-Critical Research Reactor	2(a)(x) - General plans for future fuel cycle development	Accelerator driven system Serbia	Google Scholar	High	Discusses the conceptual design of an ADS sub-critical research reactor using HEU. Mentions that nuclear power plants may become a "real option." Plans for development of the nuclear fuel cycle.	Milan P. Pesic	2002	Vinca Institute of Nuclear Sciences	http://rt270.vin.bg.ac.rs/150/150Documents/2002_PHYSOR_Korea_VincaADS.pdf
SCG Program on ADS Study with HEU and LEU TVR-S Type Fuel	2(a)(x) - General plans for future fuel cycle development	Accelerator driven system Serbia	Google Scholar	High	Discusses a new conceptual design of an ADS research reactor using LEU. Mentions that the ADS may be useful for an "eventual nuclear power option." Plans for development of the nuclear fuel cycle.	Milan Pesic	2005	Vinca Institute of Nuclear Sciences	https://www.iaea.org/OurWork/ST/NE/NEFW/documents/TMonUseofLEUonADS/P
Concept of an accelerator-driven subcritical research reactor within the TESLA	2(a)(x) - General plans for future fuel cycle development	Accelerator driven system Serbia	Google Scholar	High	Uses computer simulation models to compare ADS using HEU vs LEU so as to "study the physics and technologies necessary to design and construct ADSRR-	Milan Pesic, Nebojsa Neskovic	2006	Vinca Institute of Nuclear Sciences	http://www.sciencedirect.com/science/article/pii/S0168900206003203

Phase 4: Activity Design

- 7 exercises with 2 “bonus” exercises
- Using the open-source information that was collected and analyzed to build an activity for educational/training purposes
- Considerations:
  - Limited time for activity
  - Access to information may be limited (databases, subscriptions to journals, etc.)
  - Finding a balance between giving too much information and not giving enough
- Activity will not give all of the answers - simply a basis for learning and understanding the techniques involved
  - *Should generate additional questions that could be directed to IAEA country officer, government officials, or scientists involved*

Examples of Open-Source Exercises

1. Safeguards Inspections and Reactor RA

Reactor RA at Vinča was permanently shut down and slated for decommissioning in 2002. Significant progress towards decommissioning was made in late 2010, when Serbia and numerous international partners successfully transferred all remaining spent and fresh nuclear fuel intended for use in the reactor.

You work for Serbia's State System of Accounting for and Control of Nuclear Material (SSAC), and you have a new manager who is the head of the SSAC. She understands Serbia's safeguards relationship with the IAEA and is familiar with Serbia's Comprehensive Safeguards Agreement (CSA). However, she is not clear on how the decommissioned status of Reactor RA will change safeguards implementation in Serbia once the decommissioning project is complete. She asks you to prepare some comments to the following questions:

- What will the status of Reactor RA as a decommissioned facility mean with respect to implementing safeguards at the facility under Serbia's current CSA, and particularly with respect to IAEA inspection rights?
- If and when the Additional Protocol (AP) in Serbia enters into force, will safeguards implementation – again particularly with respect to inspection rights – at the fully decommissioned Reactor RA change?
- What specific safeguards activities could the IAEA conduct at the decommissioned Reactor RA under the AP?

2. Understanding Serbia's Potential Future Plans

It is early 2015, and the government of Serbia is preparing to ratify the Additional Protocol. Your supervisor has asked you to review Internet-based sources for information that might require a declaration under Article 2.a.(x) of the Additional Protocol.

> *2.a.(x) General plans for the succeeding ten year period relevant to the development of the nuclear fuel cycle (including planned nuclear fuel cycle-related research and development activities) when approved by the appropriate authorities in Serbia.*

You are aware that there is currently a law in Serbia banning the construction of nuclear power plants, but you also know that many countries including Serbia are looking to diversify their energy sector. You decide to research whether or not Serbia has considered developing nuclear power plants in the future, and whether or not Serbia has planned to conduct any nuclear fuel cycle-related research and development activities.

<u>Exercise:</u>

A. Conduct an Internet search to assess whether or not Serbian authorities have considered developing nuclear power plants over the next 10 years. Find at least three sources indicating Serbia's intentions.
B. Prepare at least two questions to ask Serbian authorities regarding future plans for nuclear fuel cycle-related research or development that could help Serbia prepare its AP declaration.

3. Future Plans for the TESLA Accelerator at the Vinča Institute

You work at the IAEA as an open-source information analyst and are responsible for Serbia. Serbia's country officer at the IAEA has informed you that the Serbian government will soon ratify the Additional Protocol, and has asked you to review Serbia's file in preparation for when Serbia submits its initial declaration. In particular, the country officer is interested in future plans for the TESLA Accelerator that is being built at the Vinča Institute. This is because there has been an increase in scientific literature investigating the possibility of using particle accelerators, such as the TESLA Accelerator, in reactor designs. The country officer asks you to research whether there are any discussions or plans regarding the use of the TESLA Accelerator at the Vinča Institute in a reactor design and how these might affect safeguards implementation in Serbia once the AP enters into force.

Exercise:

A. Find at least four non-media sources that describe whether or not there have been plans or discussions at the Vinča Institute to design a new type of reactor using the TESLA Accelerator.
B. Provide a brief assessment on whether you believe any of the information that you discover could be important for Serbia's initial AP declaration.

Challenges and Lessons Learned

Some Challenges Faced

- Language wasn't as much of a problem as originally thought
- Scientific/technical knowledge and terminology
- Definitions - "decommissioned", "process or systems development aspect", etc.
- Declarability unclear
- Designing activities: how much info to give participants? How to get them to find it?
- Sensitivity of nuclear issues: don't want to be too much of a detective during the activity

Some Lessons Learned

- Importance of engagement programs: building relationships is key to policy implementation
- Technical knowledge is extremely important for understanding nuclear policy
- Have a scientist friend (or many)!

Thank you!

Questions? Comments?

Jessica Wilbourne
jess0390@uga.edu