Current Status and Future Trends of Japan's Spent Fuel Management

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Institute of Nuclear Energy Research (INER)
Longtan, Taiwan

Outline

- Current status and future trends of spent fuel management in Japan
- A multilateral concept of managing nuclear fuel cycle

Current status and future trends of spent fuel management in Japan

Courtesy of Prof. S. Kondo, Chairman of Japan Atomic Energy Commission

Utilization of Nuclear Energy in Japan

- Promote safe and secure utilization of nuclear energy since 1956, strictly limiting it to peaceful purposes only, as provided by the Atomic Energy Basic Law.
- 10 electric power companies are operating 53 LWRs (48 GWe) that supply about 30% of electricity. They contribute to the increase in Japan's energy self-supply ratio from 4 % to 16 %.
- 3 units are under construction, 3 applications to construction permit are in the final stage of regulatory review and 3 units are in the decommissioning phase.
- Electric power companies have announced that they will start construction of 7 more units in ten years or so: the share of nuclear power in electricity generation in 2030 will be about 50% if aggressive measures for improving energy efficiency in consumer sector are taken to combat global warming also.

Nuclear Energy Policy Objectives

- Continue to construct and operate nuclear power plants effectively and efficiently;
- Reprocess used-fuel from LWRs and utilizing fissile materials thus recovered in LWRs for the time-being;
- Develop geologic repositories for disposing the vitrified high-level radioactive waste from reprocessing;
- Promote R&D of fast breeder reactor (FBR) and its fuel cycle technology that will contribute to better utilization of resources and possible reduction of the heat generation rate of the high-level radioactive waste, and other innovative nuclear energy technologies.

Short-Term Actions

- Continue the safe and reliable operation of existing plants, incessantly cultivating the public confidence in operators and regulators;
- Promote the MOX fuel utilization in LWRs by utilizing plutonium recovered and stored in Europe and that to be recovered at Rokkasho Reprocessing Plant;
- Steadily promote the process to determine the site for a high-level radioactive waste disposal facility.

Management of Used-Fuel

- Tokai reprocessing plant:
  - It has been operated for more than 20 years and the recovered Pu has been used for R&D purposes, including MOX fuel loading to FUGEN, prototype heavy-water moderated light-water cooled reactor.
- Rokkasho reprocessing plant:
  - JNFL has almost completed its construction and started reprocessing activities as a part of commissioning activities.
  - It is currently working hard for establishing the operation procedure of the ceramic-melter for vitrification that is an essential equipment to produce the vitrified waste as a part of the commissioning test of the plant.
- Interim storage facility of used-fuel:
  - An application of construction permit of 5000 ton AFR ISF is under licensing review.
- MOX fuel loading to commercial LWRs has been started.

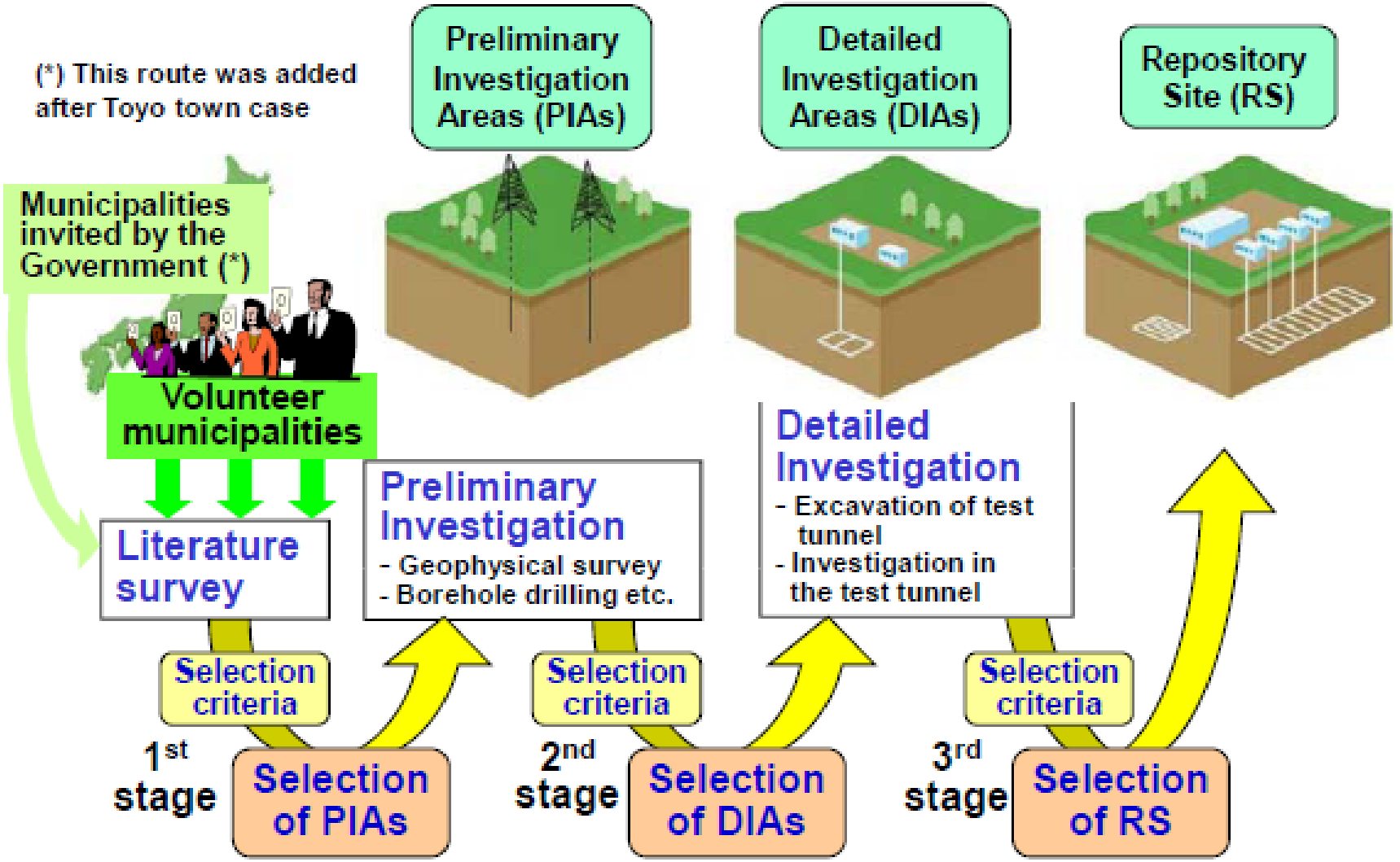
Site selection program of HLW disposal in Japan

- HLW disposal is one of intractable issues for nuclear power,
- In Japan, site selection started by NUMO (Nuclear Waste Management Organization of Japan) since 2002,
- The site selection process is based on “open solicitation”.

List of local communities which have considered the subscription

Open by medias	Local community	Motivation	Period	IFP
2003.4	Izumi, FUKUI	Finan. recons./Local dev.	6d	0.22
2003.12	Saga, KOCHI	——	9m	0.2
2004.4	Goshoura, KUMAMOTO	Demand by local Assem.	1d	0.11
2005.1	Kasasa, KAGOSHIMA	Finan. recons./Local dev.	2d	0.12
2005.7	Shinkamigoto, NAGASAKI	——	——	0.22
2005.10	Yogo, SHIGA	——	4m	0.18
2006.8	Uken, KAGOSHIMA	Finan. recons./Local dev.	4d	0.11
2006.8	Yogo, SHIGA	Finan. recons./Local dev.	3m	0.19
2006.9	Tshuno, KOCHI	Finan. recons./Local dev.	2m	0.15
2006.9	Toyo, KOCHI	Finan. recons./Local dev.	9m	0.14
2006.12	Tsushima, NAGASAKI	——	1m	0.21
2007.2	Futamana, FUKUSHIMA	——	——	0.42
2007.3	Mimamiosumi, KAGOSHIMA	Finan. recons./Local dev.	——	0.16
2007.7	Koani, AKITA	Finan. recons./Local con.	5d	0.14
2009.3	Naraha, FUKUSHIMA	——	——	——

The revised site selection program from 2009



Why is the “invitation method” added?

- The schedule of HLW disposal was determined by the Government,
- NUMO should have finished site selection by 2007,
- However, no site was selected so far,
- The “invitation method” is added by the Government to promote the site selection process.

Comparison of the two methods

“open solicitation”

- Preliminary Investigation starts after municipalities application
- Local government plays a main role on public acceptance
- Respecting public trust

invitation

- Preliminary Investigation is finished before government application
- Both national and local government play main roles
- Respecting validity

Renewal of the site selection process

- As preliminary site investigation can not be implemented due to the ineffectiveness of the “open solicitation”,
- The invitation method is added as supplementary,
- The renewed process would consider social context, transparency and fairness, it is a better approach.

A multilateral concept of managing nuclear fuel cycle

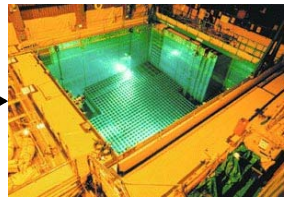
Opinion expressed here is strictly that of the author, it may or may not agree with his previous and present affiliations

Current business practice for fuel-cycle services

Front-End

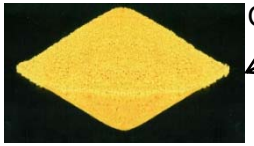
Utility/Reactor Operator

Spent Nuclear Fuel (SNF)



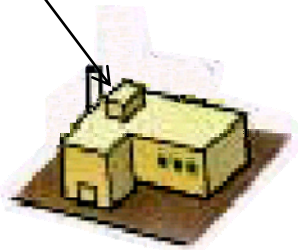
SNF On-site Wet Storage

Contract



Yellowcake

Contract



Fuel 燃料 Suppliers

Contract

ConverDyn

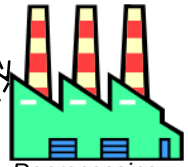
Contract

A BANK OF CENTRIFUGES AT A URENCO PLANT

Back-End

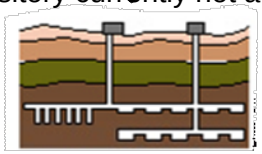
Contract/Nuclear Agreement

On- or Off-site Dry Storage



Reprocessing

Repository currently not available



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Separate contracts for fuel services,
Enrichment service could be
political and restrictive

Reprocessing service restrictive,
No repository available,
Utilities constipated with spent fuel

Front-End Fuel Cycle Services

World Uranium Production and Conversion Capacity

U Production from mines (tonnes U)

Country	2007	2008
Canada	9476	9000
Kazakhstan	6637	8521
Australia	8611	8430
Namibia	2879	4366
Russia (est)	3413	3521
Niger	3153	3032
Uzbekistan	2320	2338
USA	1654	1430
Ukraine (est)	846	800
China (est)	712	769
South Africa	539	566
Brazil	299	330
India (est)	270	271
Czech Repub.	306	263
total world	**41 282**	**43 764**
tonnes U_3O_8	**48 683**	**51 611**

Canada (20.5%), Kazakhstan (19.4%) and Australia(19.2%).

Forecast production for 2009 is 49,375 tU

World Primary Conversion capacity

Company	Capacity (tonnes U as UF_6)
Cameco, Port Hope, Ont	12,500
Cameco, Springfields, UK	6000
JSC Enrichment & Conversion Co (Atomenergoprom), Irkutsk & Seversk, Ru	25,000*
Comurhex (Areva), Pierrelatte, Fr	14,500
Converdyn, Metropolis, USA	15,000
CNNC, Lanzhou	3000
IPEN, Brazil	90
Total	**76,090 nameplate**

WNA Market Report 2009

•operating capacity estimated at 12,000 to 18,000 tU/yr

Front-End Fuel Cycle Services

World Enrichment capacity (thousand SWU/yr)

	2008	2015**
France - Areva	10,800*	7000
Germany-Netherlands-UK - Urenco	11,000	12,100
Japan - JNFL	150	750
USA - USEC	11,3000*	3800
USA - Urenco	0	5900
USA - Areva	0	1000
Russia - Tenex	25,000	33,000
China - CNNC	1300	3000
Other	100	300
total SWU	**59,650**	**68,850**
Requirements (WNA)	**48,000**	**47,000 - 61,000**

source: OECD NEA (2006) Nuclear Energy Data, WNA Market Report 2009.
* diffusion ** Including its US plant, Urenco expects to reach 15,000 in 2012,
** The US-Russia HEU Blend-down Agreement will end in 2013.

The front end nuclear fuel cycle is established,
reliable fuel supply can usually be obtained by market mechanism

Multilateral Approaches on Nuclear Fuel Cycle

12 Proposals for the Front-End Fuel Cycle: Reliable fuel supply

- U.S. Proposal on a Reserve of Nuclear Fuel (2005)
- Nuclear Threat Initiative (NTI) Fuel Bank (2006)*
- Global Nuclear Energy Partnership (2006)
- Global Nuclear Power Infrastructure (2006)
- World Nuclear Association (WNA) Proposal (2006)
- Six-Country Proposal (2006) – “Reliable Access to Nuclear Fuel”
- IAEA Standby Arrangement System – Japan (2006)
- UK Nuclear Fuel Assurance Proposal(2007)
- International Uranium Enrichment Centre (2007)
- Multilateral Enrichment Sanctuary Project (2007)
- Multilateralisation of the Nuclear Fuel Cycle (2007)
- Russian LEU Reserve Proposal (2009)

1 Back-end Fuel Cycle Proposal – Fuel Leasing Arrangement:
Russia agrees to take back spent fuel from Iran

* The NTI fuel bank proposal was opposed in recent IAEA Board meeting by NAM countries

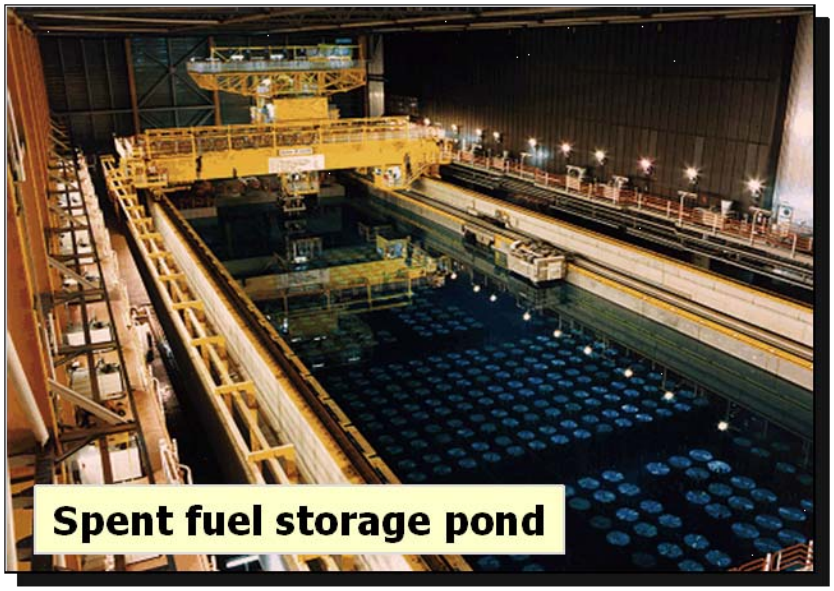
Back-End Fuel Cycle Services

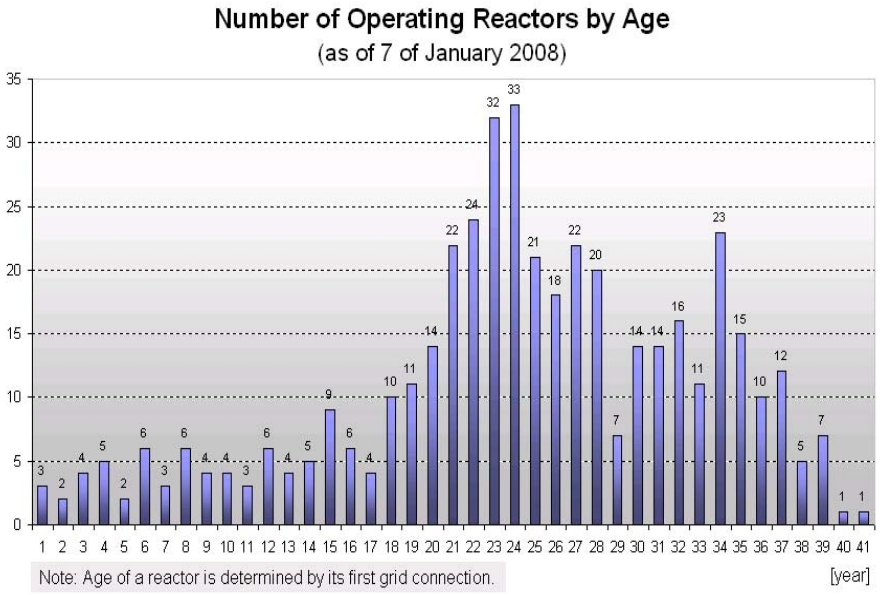
- Limited, and subject to the countries' nuclear fuel cycle policies:
  - Open Fuel Cycle (direct-disposal of spent fuel)
  - Wait-and-See (interim/indefinite spent fuel storage, wet or dry)
  - Closed Fuel Cycle (reprocessing/recycling, & waste disposal)
- Back-end fuel cycle has become a source of uncertainty for nuclear investment due to:
  - Growing inventory of spent fuel in existing programs
  - Indefinite spent fuel storage
  - Non-proliferation implications: spent fuel in newcomer countries
  - Availability of waste repository

Could multi-site/multilateral control of the nuclear fuel cycle help?

Growing Spent Nuclear Fuel Inventories

- Worldwide: >250,000 MT, grows by ~10,000 MT/yr
- US: >60,000 MT, grows by ~2,000 MT/yr
- Currently stored on-site or away-from-reactor, mostly in wet storage facilities

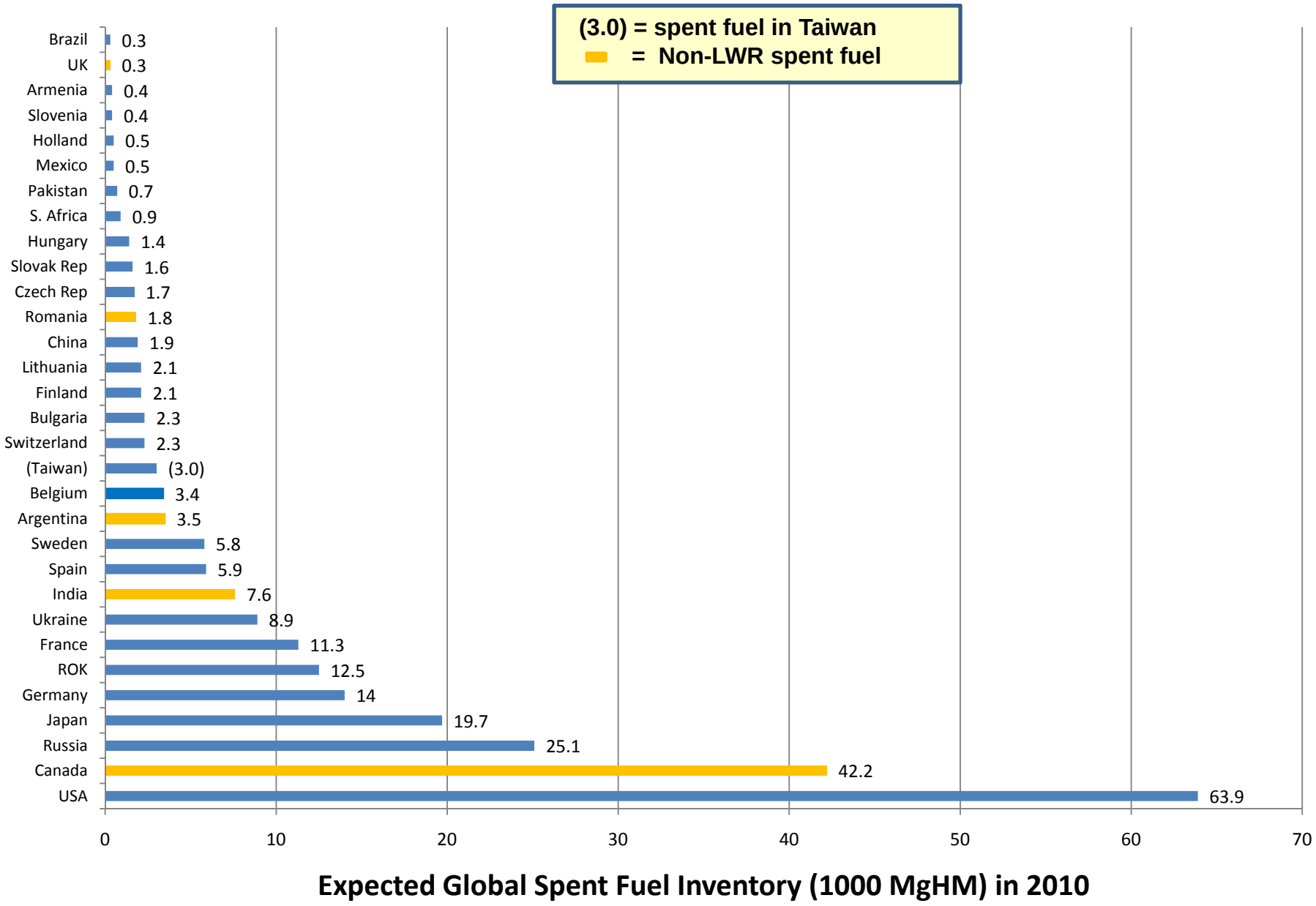




Countries with small spent fuel inventory may need help in managing their spent fuel – Can multilateral/regional storage be a viable option?

Ref.: Power Reactor Information system, IAEA

Spent Fuel Arising, Globally and in Asia Pacific



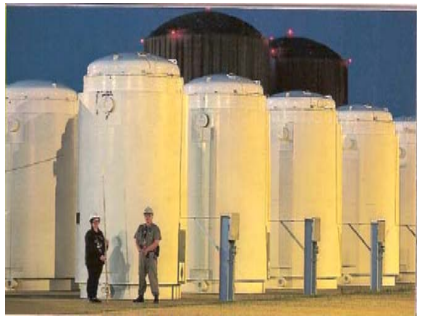
Indefinite Spent Fuel Storage

Key Decisions on Spent Fuel Management:

Before:	What can be done
Loss of full core reserve	Re-rack Transfer to pools of co-located reactor(s) On-site dry storage Transfer to away-from-reactor storage (AFR, wet or dry)
End of plant operation	On-site dry storage Transfer to AFR storage
Plant decommissioned & returned to green site	Transfer to AFR storage Transfer to disposal repository

The US experience on Spent Fuel Storage (years)

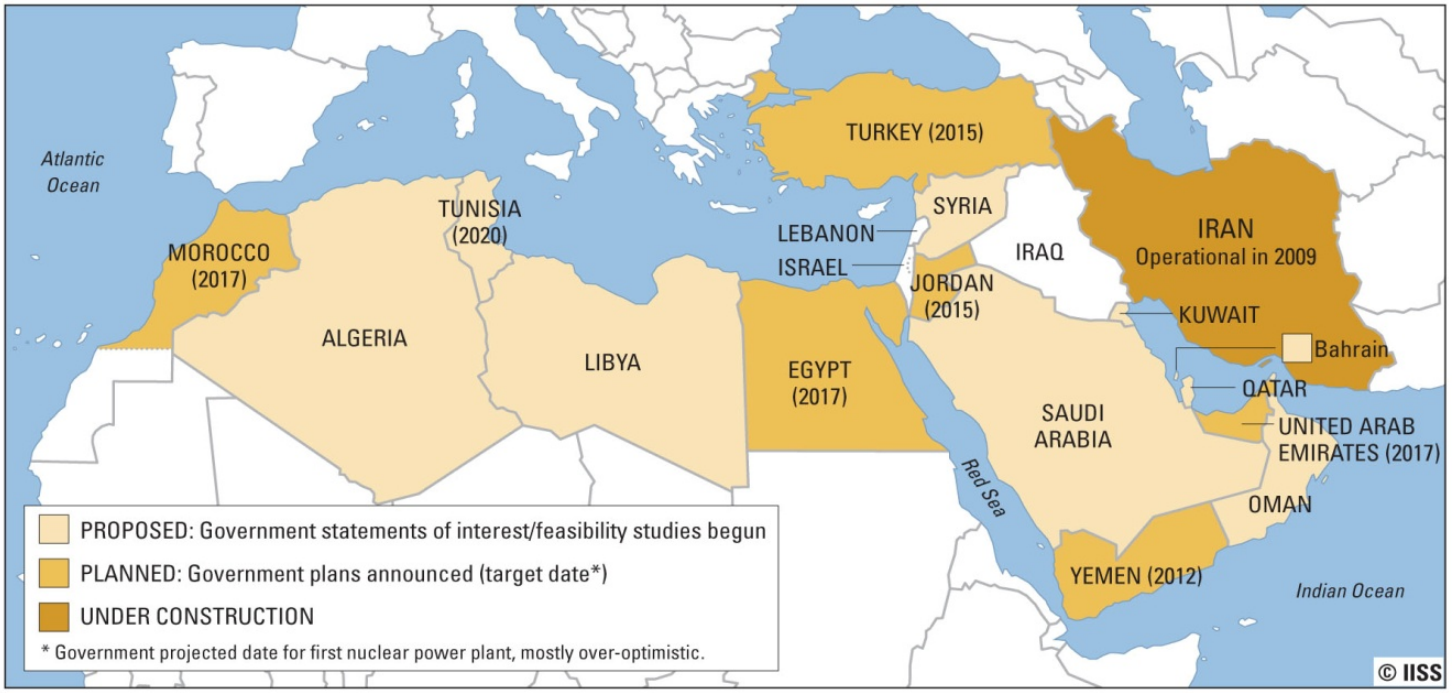
- Wet: Longest >40
  Average: 16-25
- Dry: Longest >20
  Average: 12-16
- The USDOE has opened and inspected dry storage casks at INL



Indefinite spent fuel storage will eventually lead to the need for centralized AFR storage. Could regional storage be possible? How to start?

Non-proliferation Implications: Spent fuel in newcomer countries

- Countries in less-stable region of the world are interested in building nuclear reactors,
- Leverages on spent fuel produced in these reactors are limited*.



* The 123-agreement between UAE and the US stipulated that spent fuel could be shipped to Europe for storage, reprocessing and returning of HLW (but not plutonium)

Non-proliferation Implications: Separation Process

- Chemical separation process (reprocessing) is not as technically restrictive as isotopic separation (enrichment),
- The process time required to acquire plutonium from spent fuel is estimated by IAEA to be ~3 months (and could be shorter under some conditions),
- Process equipment and materials used can be common and readily available, making export control difficult,
- The process could be performed covertly without detection.

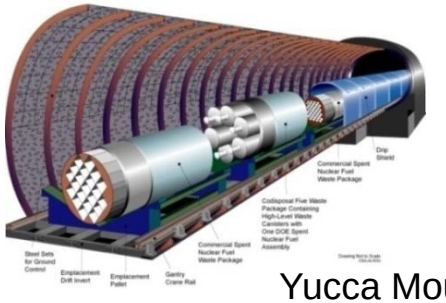
What can be done –
Multilateral Approaches?

The Crucial Role of Geologic Repository

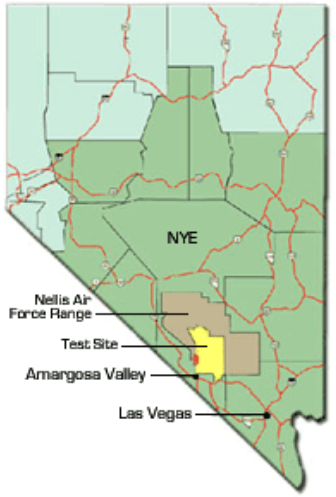
- Geologic repository is needed for ultimate waste disposal, regardless of open or close fuel cycle,
- Repository can provide a safe and secure disposition for spent nuclear fuel (SNF) and radioactive wastes (HLW),

USDOE operated a WIPP for TRU waste in New Mexico, and submitted a license application to USNRC in June 2008 for Yucca Mountain (YM) as the US SNF and HLW repository

Waste Isolation Pilot Plant



Yucca Mountain



- The US decision that YM is no longer an option would have significant ramification for other HLW repository efforts around the world,
- Sweden and Finland are moving forward on their repository programs.

Could regional/multilateral approaches driven by non-proliferation, security, and environmental considerations help?

A packaged deal for front-end fuel-cycle services

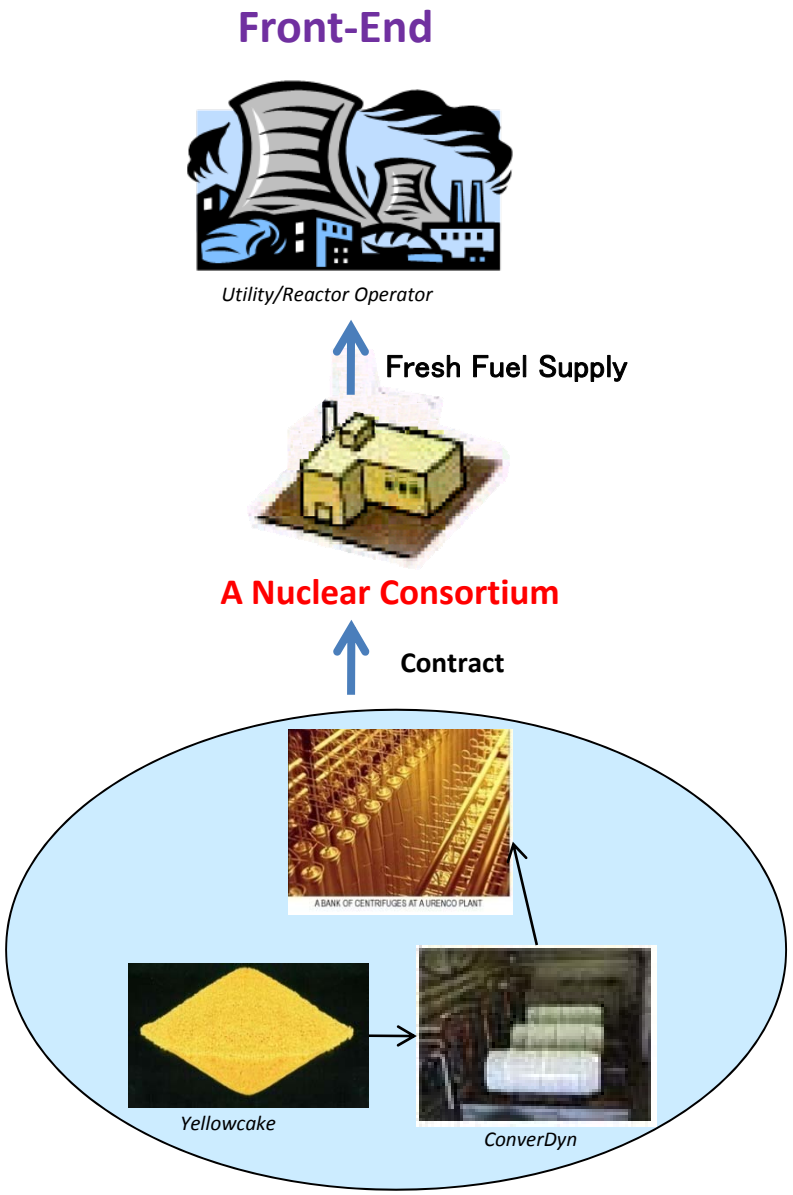
- Becoming a norm :

  The customers (utility companies) now prefer to deal with the fuel suppliers for providing front-end fuel services.

- Driven by market demand:

  A joint venture to manufacture nuclear fuel from Kazakh uranium using Areva technology and sell it to the Asian market as an integrated product.*

- Urenco is a multilateral control company operates enrichment facilities in a multi-site arrangement,
- Urenco is regulated by the Treaty of Almelo in 1971. The governments of Germany, Netherlands and UK control the company through shareholding executives (UK, RWE/Eon, Dutch government, Philips, Shell and Stork).



Ref.: "One-stop fuel shop coming for Asia", World Nuclear News, 10/6/09.

Is a packaged deal for spent fuel possible?

- In need of regional spent fuel storage:

  Without it, the fuel suppliers would not be able to offer spent fuel take-back or take-away services.

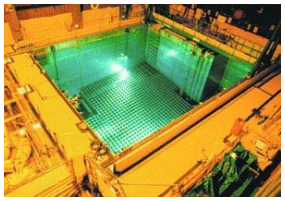
- Can nuclear weapons states help?

  Currently, Russia has offered take-back of spent fuel[1]. Can NWSs operate multi-site storage facilities for storing others NNWSs' spent fuel – on a contractual and time basis?

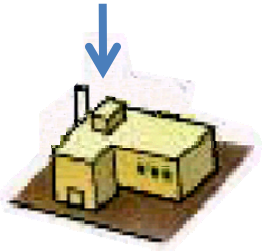
- Can uranium producing countries help?

  Former Australian Foreign Minister Gareth Evan is advocating storing nuclear waste generated by Australian uranium exports.[2]

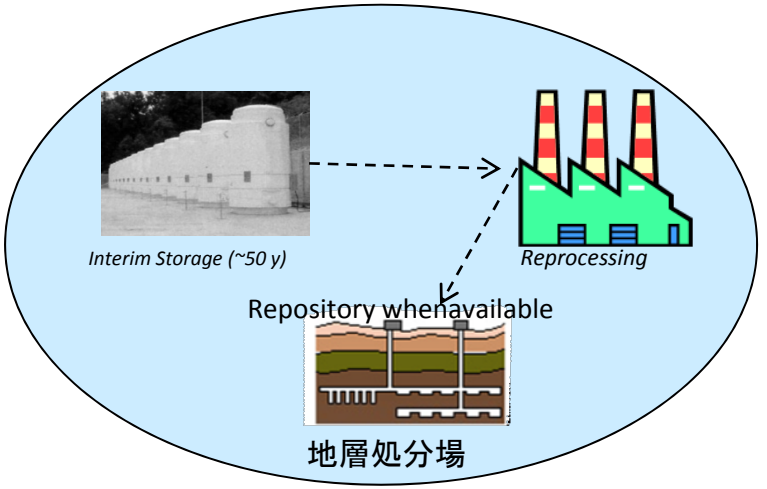
Back-End



SNF On-site Wet Storage

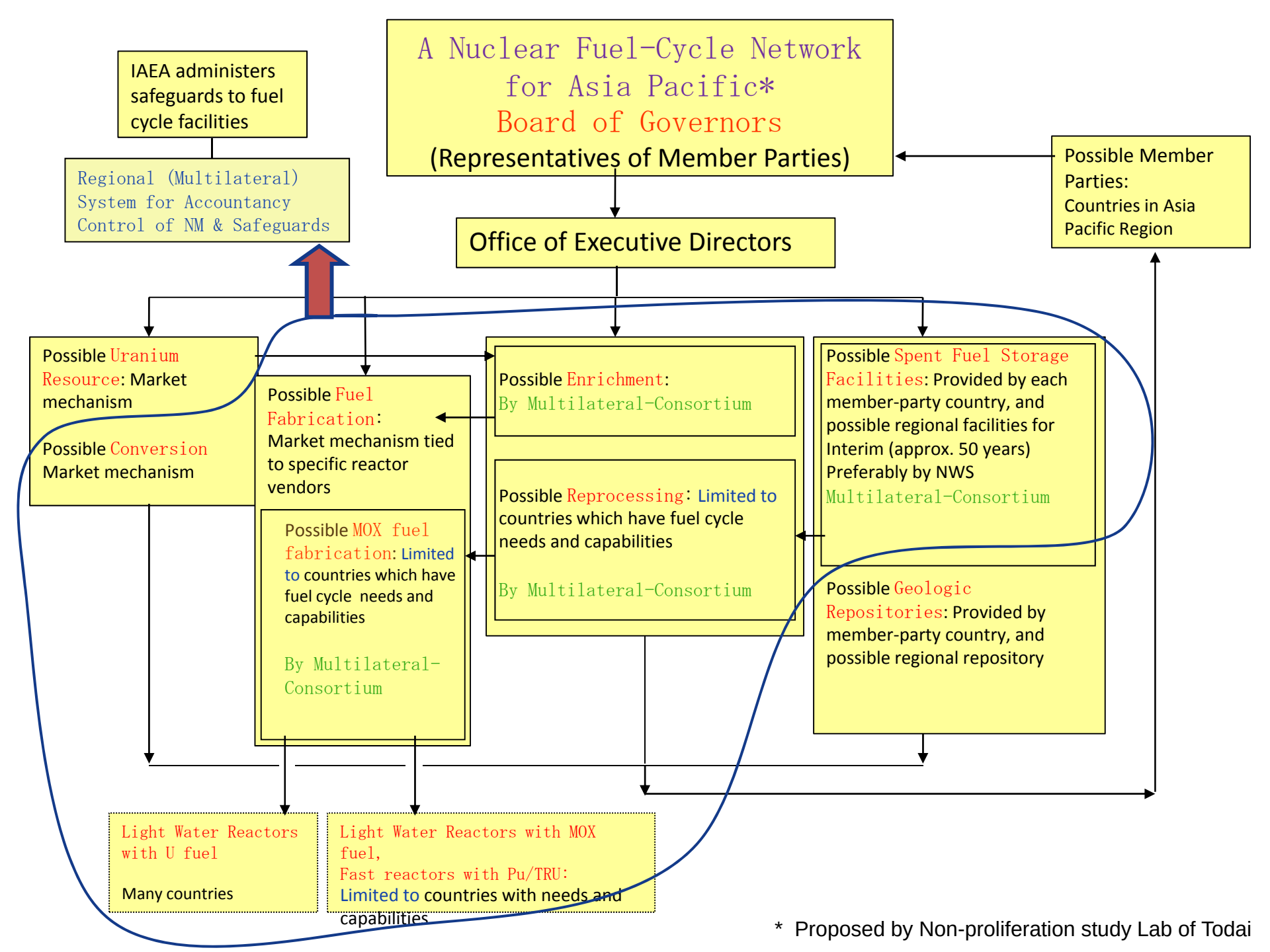


A Nuclear Consortium



It is important to provide a level-playing field for providing back-end services

1. Perhaps with conditions, such as buying Russian supplied reactors (e.g., Iran)
2. United Press International, Inc., 10/6/09.



* Proposed by Non-proliferation study Lab of Todai

Benefits

- Newcomer countries have access to nuclear power at market prices.
- Fresh fuel supplies are assured at competitive prices.
- Spent fuel from less-stable region of the world could be taken-back/ taken-away on a contractual and time basis.
- Spent fuel in existing nuclear programs can be managed in a cooperative manner.
- Spread of sensitive fuel cycle technologies (enrichment/ reprocessing) reduced or eliminated.
- Allow the expanded use of nuclear energy with reduced proliferation risks and environmental/waste burden.

- This is not a restriction to a country's own fuel cycle development.
- It is an option aiming at improving nonproliferation and waste management.
- If a country decides to develop its own enrichment and reprocessing, it will have to deal with the nonproliferation and wastes issues and conform to international safeguards, safety, and security standards.

Thank You Very Much for Your Attention

Questions?