Being both Similar and Different: the Case of Nuclear in Sweden and Japan

Imre Pázsit

Chalmers University of Technology

Division of Subatomic and Plasma Physics

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Some clarifications about the title

- "Nuclear" as opposed to "nuclear power":
  - because I will also talk about other applications of nuclear science and technology;
- Similarities and differences:
  - in Japan and Sweden we have the same goals and results, but arrive to the same solution sometimes with very different methods.

  This is true not the least in my own area, nuclear engineering.

Introductory thoughts

- Nuclear energy has been important in both Japan and Sweden, as part of the energy independence and clean energy effort.
- But during the years, both countries have made a remarkable journey "**From euphoria to phobia**".
- Sweden had a moratorium on nuclear power in 1980, allowing no further developments and demanding phase-out on the long term.
- Japan had the Great East Japan Earthquake and the accident of the reactors at Fukushima Dai-ichi 1-4 in 2011.
- I came to Sweden in 1983 and made my first visit to Japan in 1990. I will report on my part of this journey.

- Came to Sweden in 1983 as a guest researcher in Studsvik.

1991 – professor in Chalmers, Department of Reactor Physics.
Also the start of my contacts with Japan.

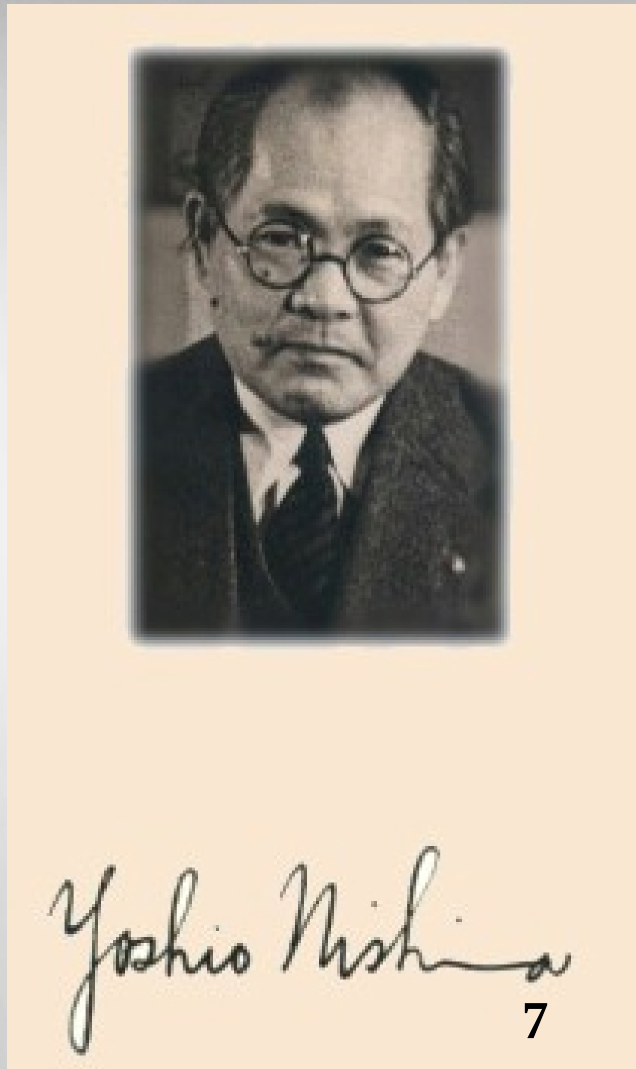
Contacts with Japan and co-operation in nuclear energy

- Nagoya University (Profs. Kojiro Nishina, Yoshihiro Yamane and Akio Yamamoto)
- Kyoto University Research Reactor Institute (KURRI) (many persons)
- University of Tsukuba (Prof. H. Konno)
- University of Tokyo (Prof. T. Nakanishi)
- Tohoku University, Sendai (Profs. Makoto Takahashi and Masaharu Kitamura)

The beginnings: 3 months JSPS stay in Nagoya in 1990. My host: Prof. Kojiro Nishina – son of Yoshio Nishina

Yoshio Nishina 1890-1951
Founder of modern phyisics in Japan

- Known for the famous Klein-Nishina formula for the scattering of light on electrons, derived together with the **Swedish physicist Oskar Klein** in 1928 in Niels Bohr's institute in Copenhagen



Birthplace of Y. Nishina, Satoh-show

Birthplace of Y. Nishina


仁科芳雄博士生誕百年記念之碑
久保亮五書

An article about Y. Nishina in KOSMOS 2004

(the annual booklet of the Swedish Physical Society)

Imre Pázsit
i samarbete med
Kojiro Nishina

Yoshio Nishina och skapandet av den moderna fysiken i Japan

Det finns knappast någon fysiker som inte känner till formeln Klein-Nishina och en av dess upphovsmän, den sedan länge bortgångne japanske fysikern Yoshio Nishina. Som bekant härledde Oskar Klein och Yoshio Nishina gemensamt denna berömda formel 1928, medan de båda arbetade vid Niels Bohrs institut i Köpenhamn. Å andra sidan är det förmodligen avsevärt färre som vet något om Nishinas livsgärning och verksamhet hemma i Japan, eller är medvetna om hans roll och betydelse för den moderna fysikens utveckling i sitt hemland. Nishinas vetenskapliga verksamhet var mycket bred; förutom den berömda formeln införde han acceleratorbaserad forskning och modern kärnfysik i Japan. Utan tvekan kan han uppfattas som den som har etablerat den moderna fysiken i sitt hemland, och hans roll i utformandet av den japanska naturvetenskapen kan aldrig överskattas. Hans livsöde är dessutom händelserikt och fascinerande, och innehåller för oss västerlänningar vissa ovanliga episoder som präglas av kulturen i Fjärran Östern. Denna artikel ger en beskrivning av Yoshio Nishinas liv och vetenskapliga verksamhet, blandat med en del unika personliga minnen genom Kojiro Nishina, Yoshio Nishinas andra och yngste son.

Yoshio Nishina (1890-1951).
Bilden är från 1948

Visits to nuclear power plants in 1990

During my visits and contacts, I noted interesting similarities and differences.

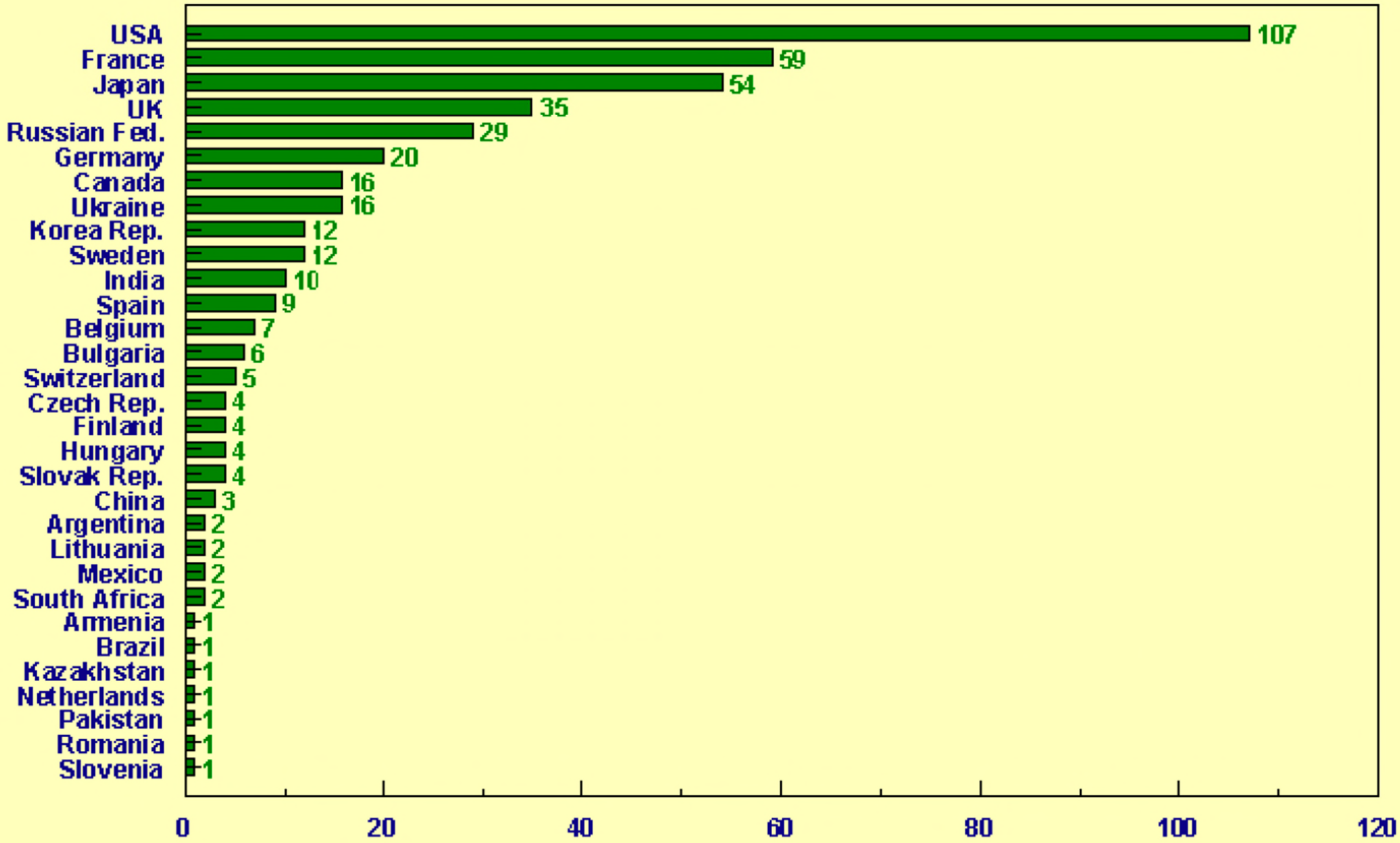
- **Similarities**: significance of nuclear energy
- **In Sweden**: ~50% of electricity from nuclear power; all electricity without imports;
  - most kWhrs per capita from nuclear power in the world
- **In Japan**: ~25% of electricity from nuclear power;
  - dependence on imported energy is among the highest in the world – need to eliminate it.

Similarities 2

- Both Japan and Sweden were world leaders in certain aspects of nuclear energy:

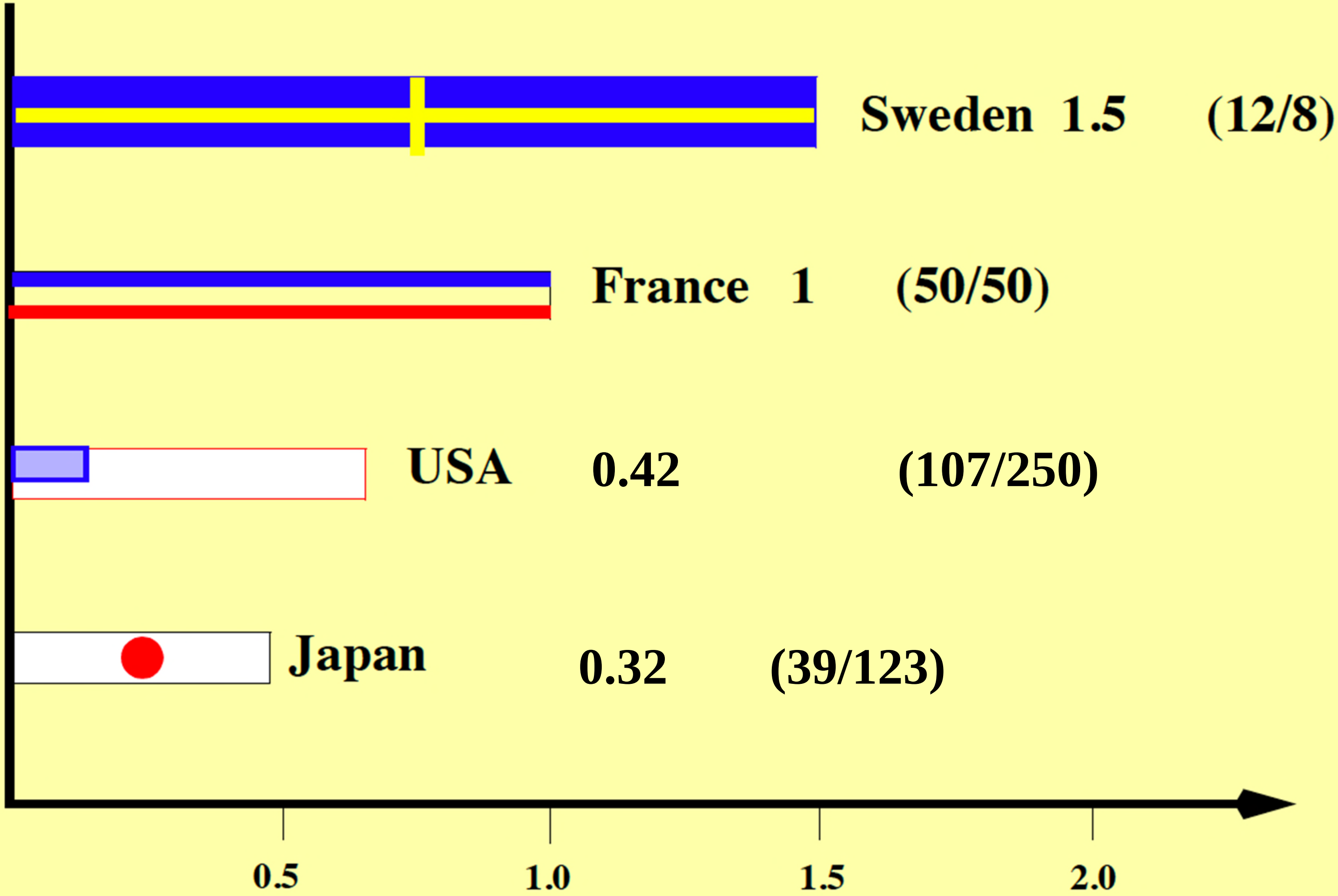
- **Sweden** produced most electricity per capita in the world in nuclear reactors.
- **Japan** had the largest/broadest nuclear energy program in the world.

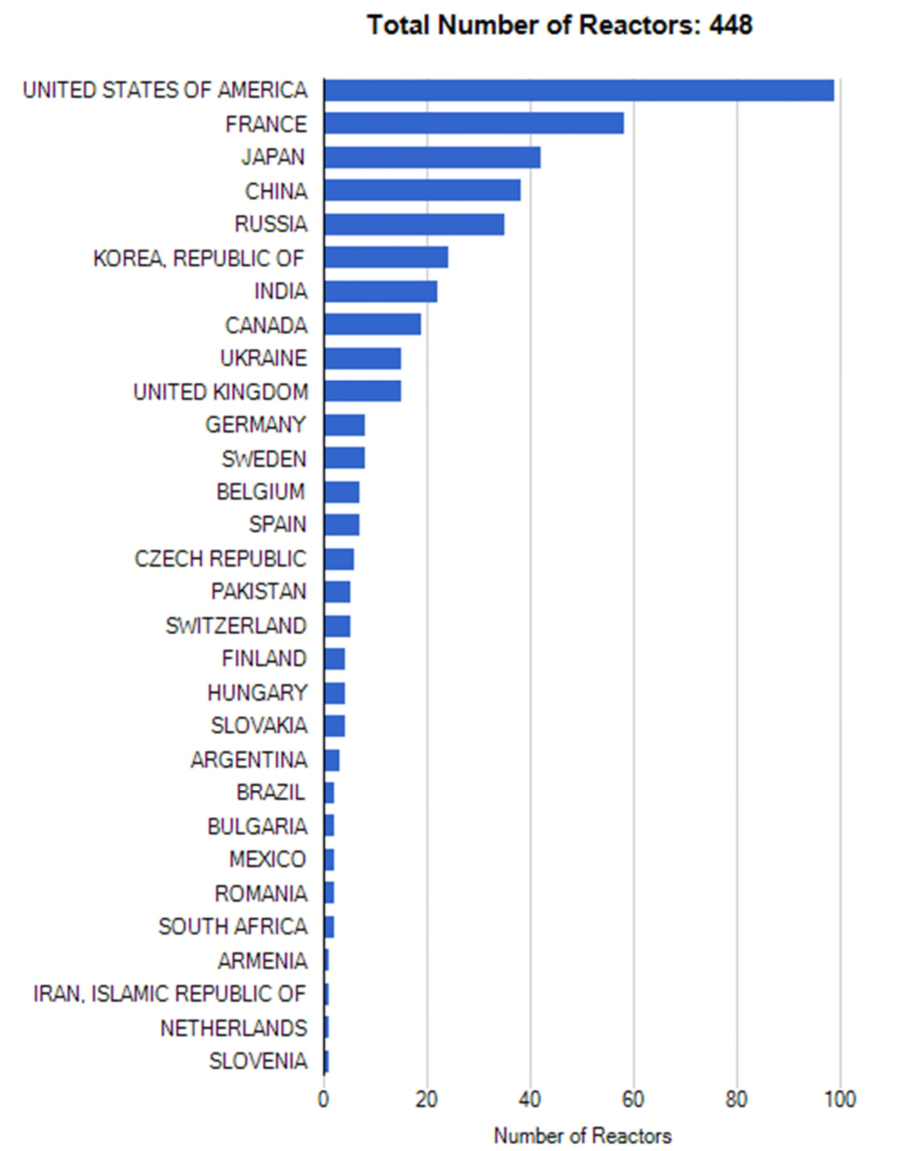
Number of Reactors in Operation in 1997

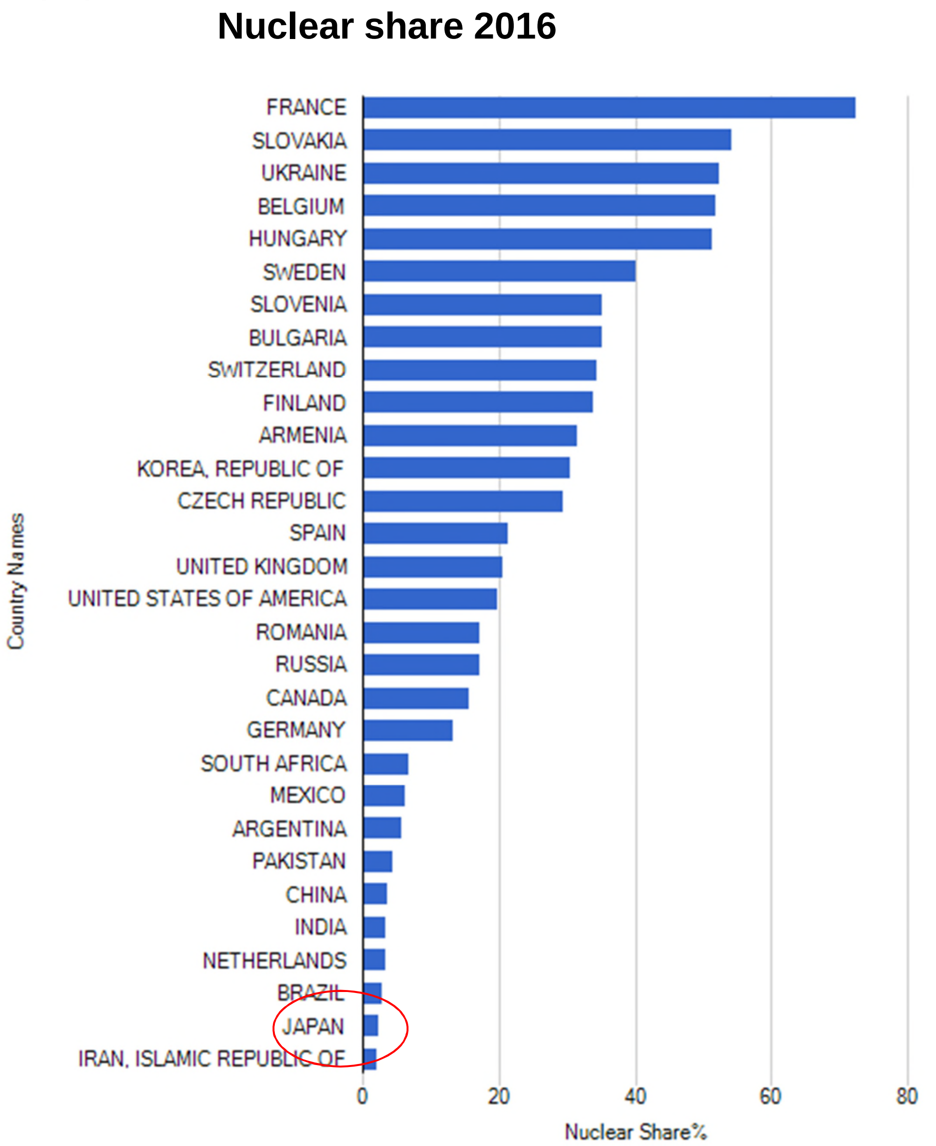


Source: IAEA PRIS Database

Nuclear Power Units per million inhabitants




Total Number of Reactors: 448
UNITED STATES OF AMERICA
FRANCE
JAPAN
CHINA
RUSSIA
KOREA, REPUBLIC OF
INDIA
CANADA
UKRAINE
UNITED KINGDOM
GERMANY
SWEDEN
BELGIUM
SPAIN
CZECH REPUBLIC
PAKISTAN
SWITZERLAND
FINLAND
HUNGARY
SLOVAKIA
ARGENTINA
BRAZIL
BULGARIA
MEXICO
ROMANIA
SOUTH AFRICA
ARMENIA
IRAN, ISLAMIC REPUBLIC OF
NETHERLANDS
SLOVENIA
0
20
40
60
80
100
Number of Reactors

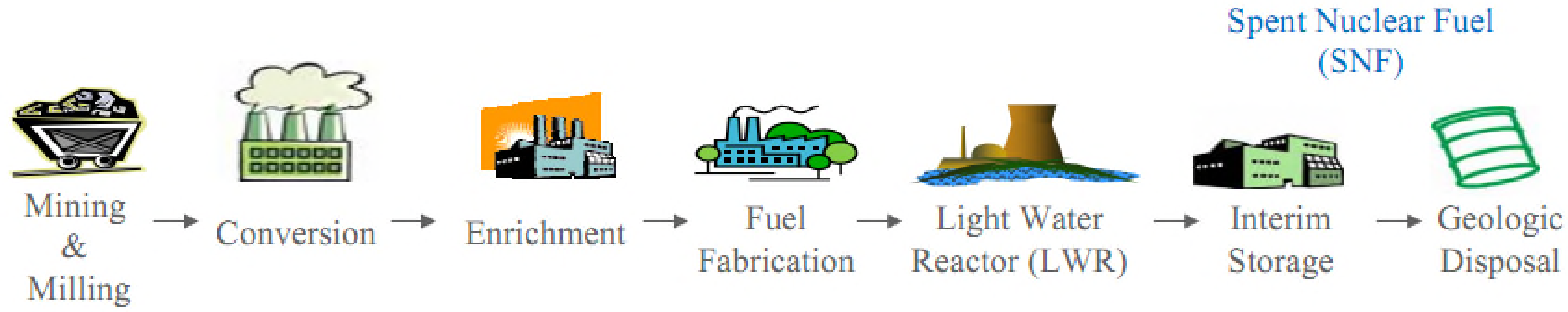

Nuclear share 2016
Country Names
FRANCE
SLOVAKIA
UKRAINE
BELGIUM
HUNGARY
SWEDEN
SLOVENIA
BULGARIA
SWITZERLAND
FINLAND
ARMENIA
KOREA, REPUBLIC OF
CZECH REPUBLIC
SPAIN
UNITED KINGDOM
UNITED STATES OF AMERICA
ROMANIA
RUSSIA
CANADA
GERMANY
SOUTH AFRICA
MEXICO
ARGENTINA
PAKISTAN
CHINA
INDIA
NETHERLANDS
BRAZIL
JAPAN
IRAN, ISLAMIC REPUBLIC OF
0
20
40
60
80
Nuclear Share%

However, there are also differences

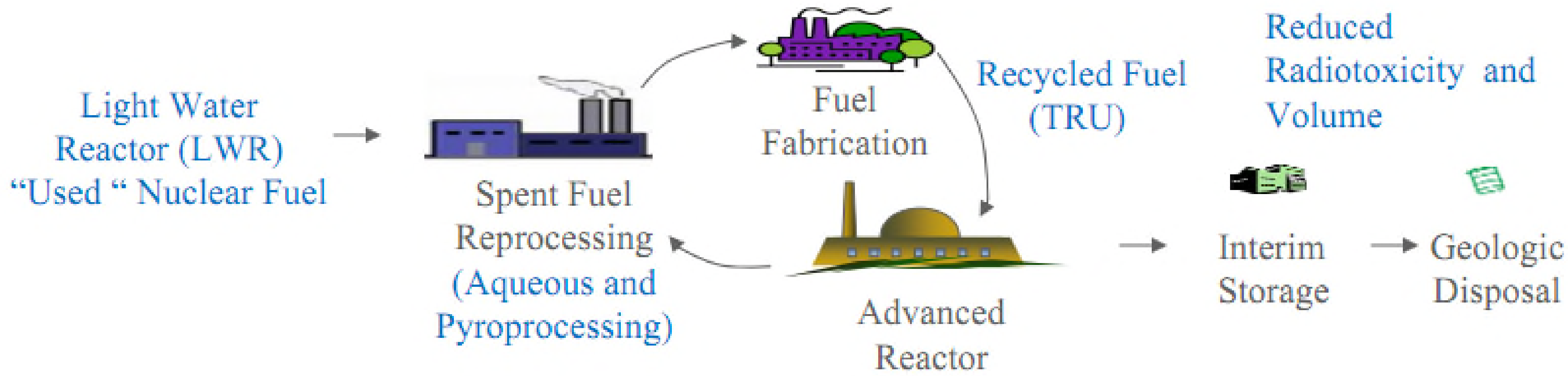
- **Sweden**: open debate, but no future planned (national vote in 1980 about phase-out);
  - "open" (once-through) fuel cycle
- **Japan**: no open debate, but the world's largest/broadest nuclear energy program existed until the Fukushima accident;
  - "closed" fuel cycle (recycling of spent fuel, reprocessing).

  A closed fuel cycle requires many different reactor types running in parallel (thermal, fast, breeder etc.) and a reprocessing plant.

Open (or Once-Through) Nuclear Fuel Cycle



Closed Nuclear Fuel Cycle (or Reprocessing/Recycling)



Some comparative data (1990)

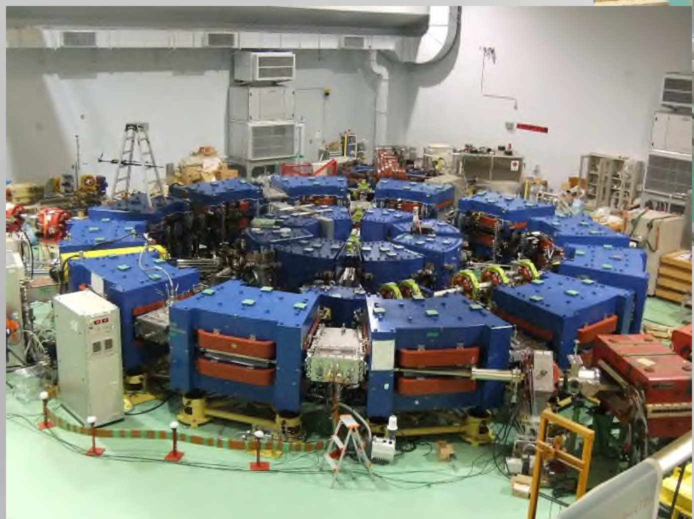
Sweden	Japan
Number of reactors: 12 - " - per million people: **1.5**	Number of reactors: 39 - " - per million people: **0.32**
Units under construction: 0 under preparation: 0	Units under construction: 11 under preparation: 3
# of universities with nuclear engng: (undergr + gr): 0 + 2	# of universities with nuclear engng: (undergr + gr): 10 + 9
# of research institutes: 1(0) Research reactors: 2	# of research institutes: 9 Research reactors: >20

KURRI (Kyoto Univ. Research Reactor Institute)

KURRI, aerial view

The best Sakura in Kumatori is in KURRI – open to the public

Facilites in KURRI



Lab exercises of Swedish students in KURRI from 2006 - 2012

- After my 3-months long stay in KURRI, 1999 (host Prof. Seichi Shiroya), we signed a letter of intent on scientific exchange between Chalmers and KURRI
- The last two Swedish research reactors in Studsvik were closed down in 2005 for good.
  KTH students ➢ Belgium (SCK.CEN)
  Uppsala students ➢ Finland
  Chalmers students ➢ KUCA cricital assembly in KURRI
- Due to the above agreement, the Chalmers students got not only the most extensive lab exercises, but they were also the cheapest!

Lab exercises in KURRI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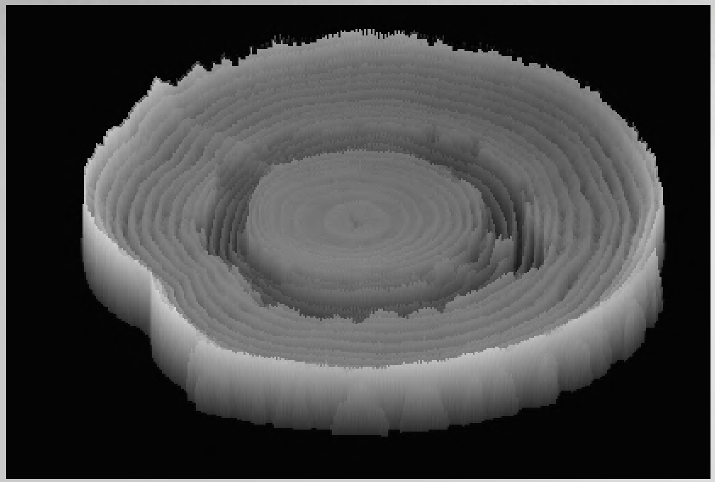
Non-energy applications: “indirect benefits of nuclear energy”

- Ionising radiation has a number of benefits and use in life sciences:
- Plant physiology (nuclear analysis methods)
- Medicine (both diagnostics and medical treatment)

Neutron radiography for plant physiology

(courtesy of Prof. Tomoko M. Nakanishi, Univ. of Tokyo)

Water distribution in plants (slice of cedar tree and carnation)



Uptake and transport of phosphorus and caesium in Arabidopsis

by R. Sugita

Boron Neutron Capture Therapy (BNCT) – a non-intrusive method to cure brain tumours (KURRI)

Radiological consequences of the Fukushima accident

- After the Fukushima accident, due to their supreme expertise in tracing the original distribution of fallout radioactivity, as well as their uptake and transport in living organisms, Prof. Nakanishi’s group got the task of measuring up the agricultural consequences of the Fukushima accident, and to work out methods of remedy.
- This research is quite unique in the world, and made a large international response. Prof. Nakanishi’s group published three books in English and one in Japanese.

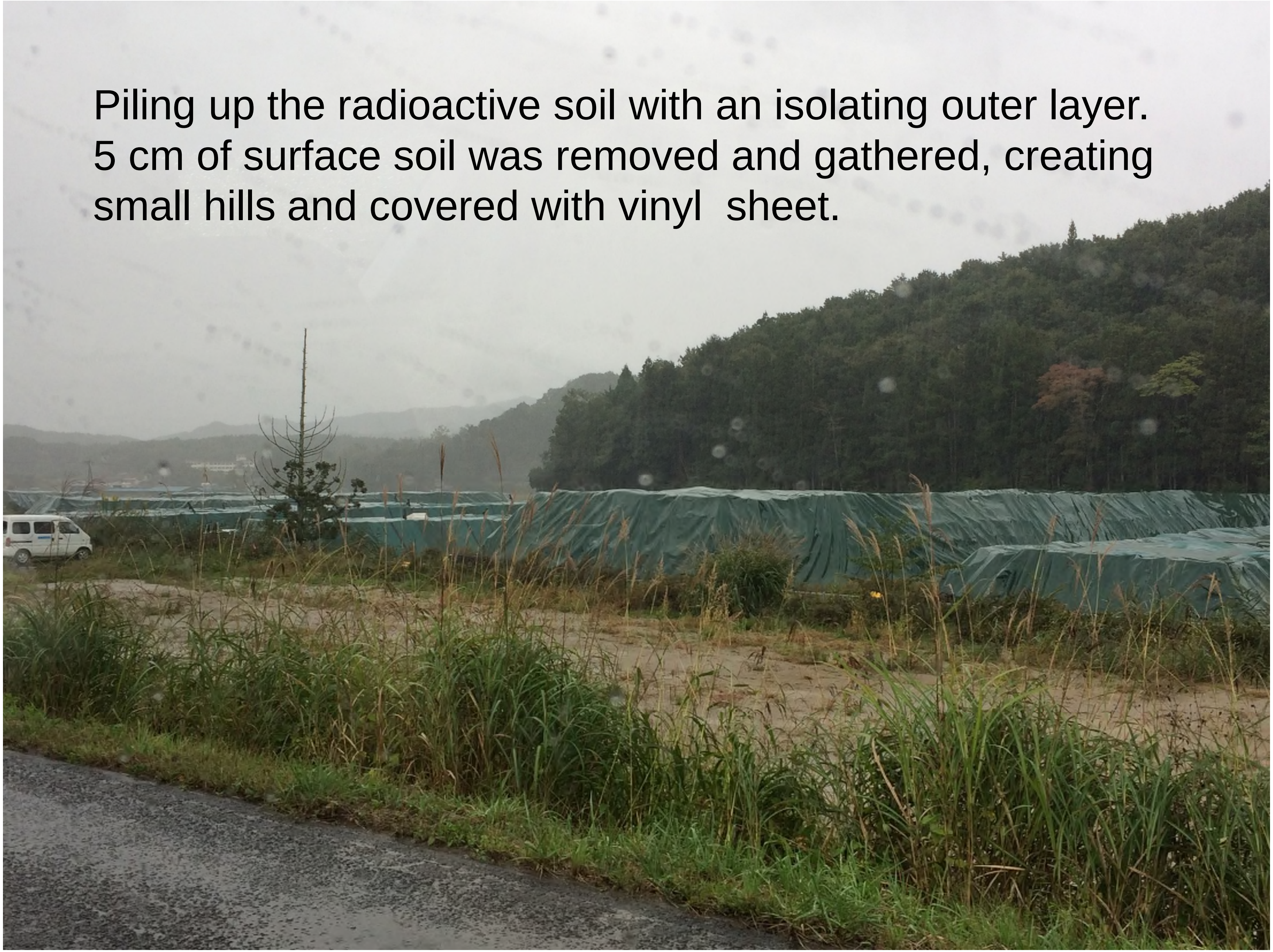
Radiological consequences of the Fukushima accident

- Through our contacts we got first hand information on this work, which included not only new research results but new ways of communicating radiation hazards to the public.
- Together with Prof. Eva Forssell-Aronsson, Radiation Physics, GU and Sahlgrenska University Hospital, we were involved in an assessment of this latter project. This included even a field trip to Fukushima Prefecture in October 2016.

General information about Fukushima situation at Decontamination Information Plaza in Fukushima Office

Every day all rice harvested in the area has been inspected before going to the market.
Each bag contains 30kg of rice grain. As from 2015, no contaminated rice (more than 100 Bq/kg) is detected.

Radiation control of the rice produced in Fukushima


Piling up the radioactive soil with an isolating outer layer.
5 cm of surface soil was removed and gathered, creating small hills and covered with vinyl sheet.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Field experiment to prevent uptake of radioactivity by plants (K in soil blocks uptake of Cs137)

Some final words

- The scientific collaboration and exchange with Japan is of course much wider than I could indicate here.
- It has also been appreciated with various distinctions at both sides:
  - Prof. K. Nishina became a Honorary Doctor of Chalmers in 2010;
  - Prof. T. Nakanishi became a foreign member of IVA in 2015;
  - undersigned received "Order of the Rising Sun, Golden Rays with Neck Ribbon" in 2016;
  - Prof. T. Nakanishi became a foreign member of KVVS (The Royal Society of Arts and Sciences in Gothenburg) in 2017.

Conclusions and outlook

- Although the circumstances and conditions of nuclear energy change all the time –
- the similarities and differences, as well as the joint interest in each other's situation and in the way how we tackle the problems remain.
- I look forward to many years more pleasant and successful contacts and co-operation.