

- THE «MEGATONS TO MEGAWATTS»
PROGRAMME:
- A CONTRIBUTION TO
- A PEACEFUL WORLD

▫ Comitato Civiltà dell'Amore – March
28, 2020

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Genova

14 - 01 -

2014

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I.1 - The "fundamentals" of nuclear energy

Only 0.7% of natural uranium is **Uranium-235** (92 protons + 143 neutrons); a nucleus of U-235, when colliding with a free neutron, breaks up in smaller nuclei, releasing energy and other neutrons which in turn can break other U-235 nuclei, generating a "chain reaction"

The remainder is **Uranium-238** (92 protons + 146 neutrons) which, if colliding with a neutron, will transmute into a nucleus of Plutonium-239, in turn a "fissile" nucleus as U-235

I.2 - Military and peaceful uses of nuclear energy

The raw material for nuclear weapons is fissile material: HEU (Highly Enriched Uranium) or Plutonium.

Pure U-235 or Pu-239 (> 90%) is used, in order to maximize the chain reaction using all neutrons to generate new fissions.

Nuclear plants use low percentages of fissile materials (<5%) in order to control the chain reaction, making available, after each fission, only one single neutron for further fission ("critical" reaction)

I.3 - The process of "isotopic enrichment"

- It allows to modify the composition of natural Uranium, increasing the percentage of U-235 from 0.7% up to:
 - <5% (LEU) for fuel for nuclear installations,
 - > 90% (HEU) in the case of nuclear weapons.
- It requires significant energy consumption, which grows exponentially as the final enrichment increases
- In the past large and complex gas diffusion plants were used; recently ultracentrifuges are used

I.4 - Nuclear fuel

The main items contributing to the cost of nuclear fuel are:

- The extraction cost of natural uranium at the ore (U_3O_8)
- The chemical treatment of the ore to produce Uranium Oxide
- The isotopic enrichment ($\sim 45\%$ of the total)
- The cost of building fuel rods

An alternative is *to produce fuel by reusing the enormous economic investment spent for the atomic weapons:*

- mixing HEU with natural uranium (avoiding enrichment costs)
- mixing HEU with "depleted" uranium (DU), a resulting product of isotopic enrichment plants, which is stocked in large, unused quantities (avoiding extraction and chemical treatment costs)

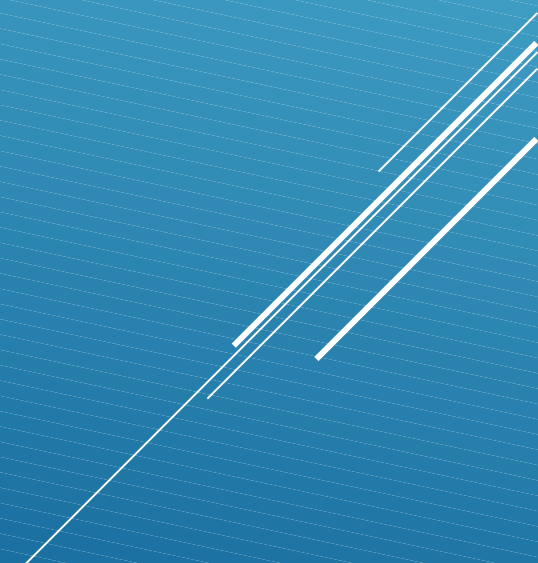
I.5 – Nuclear proliferation

- Civil nuclear power plants do not use HEU and do not produce "weapon grade" plutonium
- Atomic arsenals have been accumulated by producing HEU in isotope separation plants or by building dedicated nuclear reactors, which produce "weapon grade" plutonium.

**Nuclear power plants are the only tool
to destroy atomic arsenals
(and to recover value out of them)**

Index II.

The “Megatons to Megawatts” (M2M) Programme



II.1- M2M: Elimination of nuclear bombs

The twenty-year program Megatons to Megawatts, signed on 18 February 1993 following an agreement between the American and Russian presidents, ensured the conversion of **500 t of HEU** to 90% from **20,000 Russian nuclear bombs**, diluted with Natural Uranium to obtain 4.4% LEU, with the production of over **15,000 tons of fuel** suitable for nuclear power plants (1993-2013).

II.2- M2M: Main objectives

- definitively eliminate a huge amount of HEU, thus nullifying the risk of its re-use for nuclear weapons in the future,
- accelerating the dismantling of soviet weapons in excess of the START agreements,
- avoiding the accumulation of huge amounts of HEU with control and physical protection not always adequate,
- facilitate the conversion of Russian laboratories / scientists from the military to the civil sector
- provide Russia with economic resources in the difficult economic situation at the end of the Soviet Union,
- reduce US production of LEU (energy saving),
- protect the environment from the possible dispersion of HEU without the necessary precautions.

II.3- M2M: contracts and results

- Framework agreement reached in 1993.
- Various contracts have updated the economic aspects.
- USA paid the cost equivalent to enrichment from natural uranium to LEU (~ 12 billion US \$) and made available to Russia a quantity of natural uranium corresponding to what would have been required for the production of the LEU (~ 5 billion US \$) .
- Mutual control for the respect of the treaty (systematic inspector visits).
- Starting from 1 t of HEU (**40 bombs**) and 86.2 kg of natural uranium, 30.5 kg of LEU are obtained at 4.4% for the operation of a **1GWe plant for a year and a half**.
- With the HEU coming from **20,000 bombs (M2M)**, **500 plants of 1GWe were operated for 1.5 years, generating**
6500 billion kWh

II.4- Perspectives post-M2M

There is still the problem of eliminating:

- about 1,300 t of HEU (sufficient for over 50,000 bombs) *,
- about 500 t of Pu (harder to eliminate) *.

* 2015 data from the International Panel on Fissile Material (based on declarations to the IAEA of 31/12/2014)

- ✓ M2M was a tool for disarmament, fight against proliferation and nuclear terrorism
- ✓ M2M was the main economic case of reconversion of weapons and military installations for civil purposes
- ✓ M2M was an important piece in the relations of

II.5- Implications in the nuclear debate

1. To reflect on the essential contribution that nuclear power plants provide for an effective solution to the problem of atomic arsenals
2. To highlight that nuclear power plants do not feed proliferation but reduce it
3. To overturn the ever-existing link in public opinion between atomic armaments and nuclear power plants
4. To highlight the need for safe, sustainable nuclear power plants for the future world economy