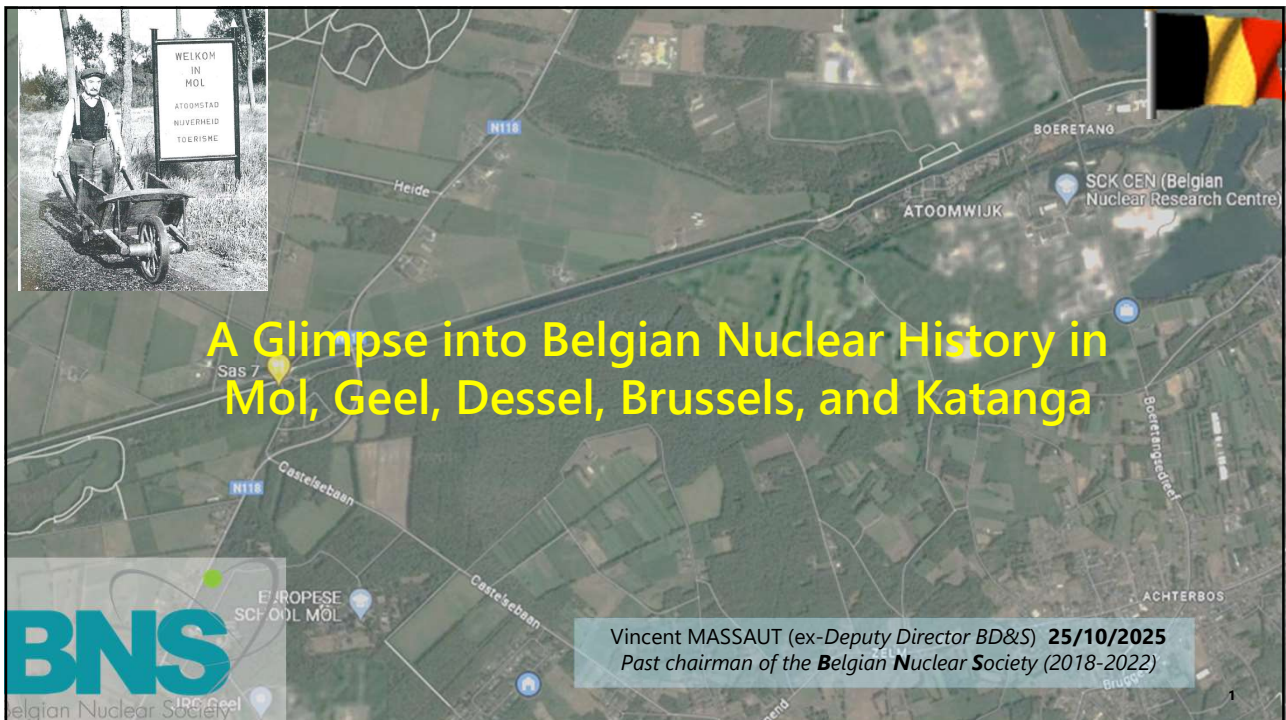




1

Disclaimer....

- I'm not a historian!
So « do not shoot on the pianist » if there are some small mistakes or not complete historical analysis...
- I had also to dig into several types of archives, books and remembrance of various people and authors (this is indeed the role of an historian !!)
- But I had a great pleasure to search for all the data...
- And, unfortunately, I had to shorten a lot of inputs to keep the presentation concise enough...

Note; it was originally requested by the JRC-Geel... therefore some special focus on this institute !

2

Belgium has been involved in the science of the atom since a long time

- Belgium was at the top level of nuclear physics, with the Solvay conferences



Already
in 1911

3

3

... The Solvay conference in Brussels...

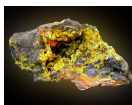
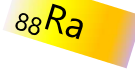
- And up to 1927...



4

4

Belgium was already in the 1920's one of the main producers of Radium



- **Shinkolobwe**, was a **radium** and **uranium** mine in the Haut-Katanga Province of the now "Democratic Republic of the Congo"
- The first mine was opened in the Belgian Congo in **1921**. Uranium-bearing ore was initially exported to **Olen**, Belgium for the extraction of **radium** (and uranium). Only the richest ore was sent to Olen, with the remainder held in reserve.

In no other mine could you see a purer concentration of uranium. Nothing like it has ever been found – Tom Zoellner (up to 65% U_3O_8 in the ore)

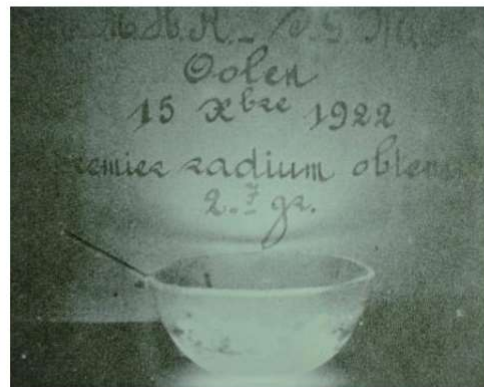
Wikipedia

Olen factory ...

The O(o)len radium factory 1922 - 1979



Courtesy from Stephan Heintz



First Belgian radium – 15th of December, 1922

Marie Curie visits the Olen Radium facility



Highly recommended literature:

- Anne Adams: *The origin and early development of the Belgian radium industry*; Environment International, Vol. 19, pp. 491-501, 1993:

Both Belgian companies involved in the production of radium up until the 1960's have officially declared that they have not preserved any of the company archives dealing with their radium production. Their silence is the result of a gentlemen's agreement, concluded between all the governmental and nongovernmental parties involved in the former industry, not to release any information concerning a (by now) noncontroversial period like the 1920's and 1930's.

Olen facility described by a chemist of the US Bureau of Mines as "more like a fine kitchen than an actual metallurgical plant"

Courtesy from Stephan Heintz

Radium was used everywhere and regarded as a miraculous product !



Olen facility described by a chemist of the US Bureau of Mines "more like a fine kitchen than an actual metallurgical plant"



But it is mostly during WWII that the Uranium from Congo (Katanga) will play an important role...



- Edgar Sengier (1879 – 1963) was manager of the UMHK, and based in New York, USA.
- At the beginning of the war, he transferred secretly more than 1200 T of Uranium ore to Staten Island (NYC),...
- ... and informed in 1942 the General L. Grooves, head of the *Manhattan project* that Belgium can deliver directly this Uranium and can proceed with almost unlimited quantities of Uranium in the following years ! Famous reply of E. Sengier to K. Nichols in 1942:

"You can have the ore now. It is in New York, a thousand tons of it. I was waiting for your visit."

- In exchange of this, Belgium requested to have privileged access to the peaceful use of nuclear energy after the war.

9

9

For this war effort, there was a secret agreement signed between Belgium, USA and UK



- The agreement was signed (secretly) between the Belgian Government, US and UK Governments, in 1944, with as art.9 contained only **vague** wording on information sharing:
- (a) In the event of the Governments of the United States of America and of the United Kingdom deciding to utilize as a source of energy for commercial purpose ores obtained under this agreement the said Governments will admit the Belgian Government to participation in such utilization on equitable terms.
- (b) The Belgian Government undertake that, in the event their contemplating the use of such ores as a source of energy, they will so use them only after consultation and in agreement with the Governments of the United States of America and of the United King
- In total, around 30.000 T of Uranium ore were sold to the US.

10

10



The story became then complicated... But lead to the creation of the **STK-CEAN**

- Complicated, because of the cold war and the « Atomic Energy Act » of 1946 (Mac Mahon act), which made any exchange of technical information on nuclear almost impossible...
- Several negotiations lead to a tax (of 12 million U\$ reduced to 9.5 MU\$) on the Uranium import to the US, from which 234 MBEF were given to the IIPN/IISN and 350 MBEF finally came to the set up of the **STK-CEAN** (future SCK CEN)
- And finally also an agreement was set to send a group of scientists and engineers to the US (Argonne national lab) to be **trained** on the basis of nuclear science and nuclear energy...

11

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The men who went to the US in 1952 (at Argonne national lab, USA)

- From these gentlemen, I have personally known at least two of them:
 - **Emile-Herman Hubert**, who gave me lessons at the University of Liège;
 - **Georges Stiennon**, who was Deputy Director General of SCK CEN when I started my career



1^{er} rang : Groven - Symon - Goens - Hubert
2^{me} rang : Tavernier - Hoyaux - Erkes - Dhont - Nève de Mevergnies-
Stiennon - Dopchie

12

12

First, the STK-CEAN was implanted close to Brussels

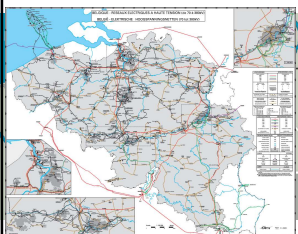


- The STK-CEAN was first implanted in Rhode-Ste-Genese (currently Von Karman Institute), but too close to very populated areas (Brussels and surrounding).
- From the beginning, it was intended to build a first nuclear reactor (BR1) at the site of the STK-CEAN
- First idea was in a unused area behind the Aeronautical research center (now VKI), but was considered unrealistic.
- Then between 1950 and 1952 several sites were considered (first close to Brussels, Leuven and Ghent), from which 4 remained: Lembeek, Beauvechain, Marche and Mol
- Minimum area ~100ha; proximity of a waterway; possibility to link to the high voltage network; not too populated but with potential local employment; stable underground; etc.

13

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Selection of the site of Mol...



- The Belgian Royal family held a large area (Royal domain) in the region of Mol, Geel, Dessel, Retie, Postel. This was sold, from the 1910's, in parcels (see the wonderful book « Koning in de Kempen »).
- The STK CEAN looked for an area close to waterways, not too heavily populated, with a stable seismic underground, connected to the grid, etc...
- In December 1953, the STK-CEAN bought 190 ha to the Royal family (via *Compagnie immobilière de Belgique*) for about 14 MBEF (~350 k€)
- And in 1958, the SCK CEN bought another 400 ha of Royal domain on which the JRC (CBNM at that time) was implanted
- In 1957, the OECD created the Eurochemic for the reprocessing of nuclear fuel, and Belgium proposed the site of Dessel as his participation to the project (moreover the labs of SCK CEN were not too far)

14

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The city of Mol issued several requests (conditions) to host a nuclear center...



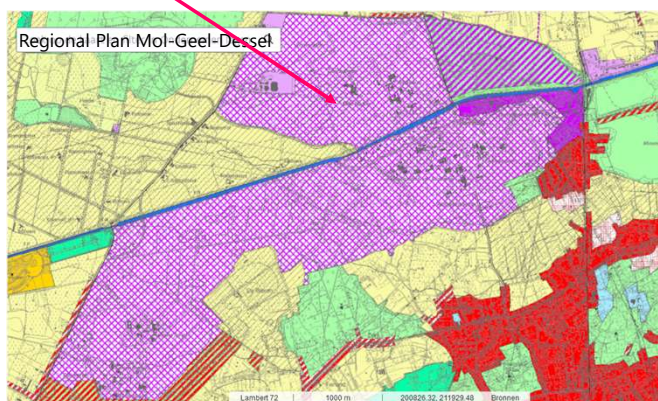
- The municipality issued 4 conditions to accept hosting this new atomic centre:
 - Measures to protect the population in case of an accident;
 - Absence of water or air contamination
 - Creation of a « fund » to protect the environment
 - The nuclear centre had to generate jobs for the local population
- The study centre could then convince the municipality administration on these 4 conditions...
(Nevertheless, some anxiety remained, e.g. in the Netherlands situated less than 15 km from the future reactor !)

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The area was then (much later) dedicated for nuclear installations (in the RUP)

Domain for nuclear installations



- Part of the Regional Plan (Plan de secteur, RUP) in Mol, Dessel and Geel is coloured in as « *areas for the establishment of nuclear facilities* »

This area (nuclear zone) covers approximately 1000 ha !

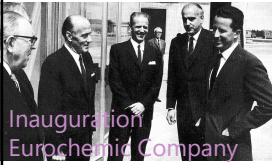
- This allowed the installation of other nuclear institutions and companies...

RUP = Ruimtelijk UitvoeringsPlan

16

16

The site attracted thus different nuclear compagnies and institutions



1966



- Starting with the Eurochemic pilot reprocessing plant (an OECD project) in the follow up of the works done on radiochemistry and fuel analysis at SCK CEN...
The Eurochemic association was created in 1957, and the building was built between 1960 and 1966 (start of operation)
- Next came the JRC (Joint Research Center) as one of the intentions of the Euratom treaty, signed in 1957 :

ARTICLE 8

1. After consulting the Scientific and Technical Committee, the Commission shall establish a Joint Nuclear Research Centre.

This Centre shall ensure that the research programmes and other tasks assigned to it by the Commission are carried out.

It shall also ensure that a uniform nuclear terminology and a standard system of measurements are established.

It shall set up a central bureau for nuclear measurements.

= CBNM

2. The activities of the Centre may, for geographical or functional reasons, be carried out in separate establishments.

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Remember: the signature of the Treaties of Rome in 1957...

Euratom Treaty – the start of JRC

Signing of the **Treaties of Rome, 25 March 1957**. Treaty of the European Economic Community (EEC) and Treaty of the European Atomic Energy Community (EURATOM).



Paul-Henri Spaak and Jean-Charles Snoy et d'Oppuers at the signature of the Treaty establishing European Atomic Energy Community (EURATOM) 25.03.1957

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The CBNM (future IRMM, then JRC-Geel) was open in 1960...



- In Geel different installations were built, starting with high voltage accelerators (KN 3.7 MV followed in 1976 by CN 7 MV van de Graaf; and Gelina **Geel Linear Accelerator**, started in 1965) for the studies of interaction of neutron with matter.
- Up to 1978, the work of CBNM was mainly focused in 3 main areas*:
 - Neutron metrology for the measurement of neutron cross sections and standards ;
 - Nuclear metrology associated with the decay of radionuclides and measurement of isotopic composition;
 - Preparation and characterisation of reference materials and surfaces required for nuclear and to some extent non-nuclear measurements.

* Source = *Europhysics News*, Vol.9, Nr. 5, May 1978

19

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The SCK CEN had also built three reactors and the needed auxiliary labs



1955 - 1956

Bouw van reactor BRL

Construction du réacteur BRL - Construction of reactor BRL



d, air cooled, U_{nat}) was ordered and
The reactor started operation in

20

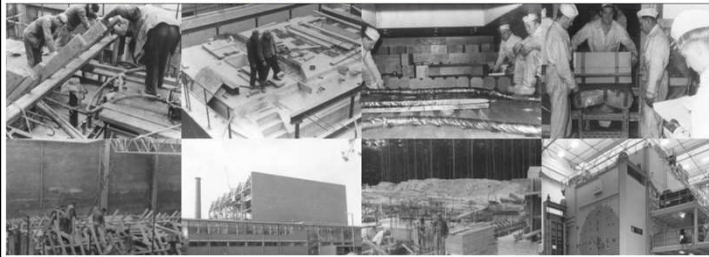
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The SCK CEN had also built three reactors and the needed auxilaire labs



1955 - 1956

Bouw van reactor BR1
Construction du réacteur BR1 - Construction of reactor BR1

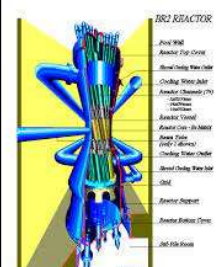
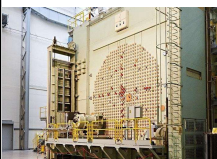


d, air cooled, U_{nat}) was ordered and
The reactor started operation in

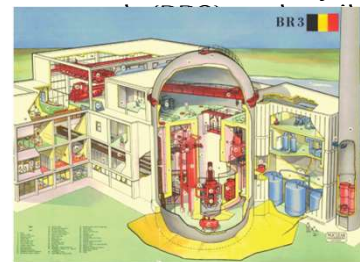
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21

The SCK CEN had also built three reactors and the needed auxilaire labs



- The BR1 (graphite moderated, air cooled, U_{nat}) was ordered and started construction in 1955. The reactor started operation in 1956!
- Two main labs (Physica+Electronica and Chemistry) were also constructed from 1955. Several other buildings were added later.
- Even before the start of the BR1 reactor, there were already plans for two other reactors: one electricity generating plant (BR3)
- In 1961 started the BR2 (high flu first PWR outside the USA.



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Originally, the BR3 NPP was intended to power the International Exhibition 1958!



- It was the follow up of « Atoms for Peace » from Eisenhower (1953)
- The nuclear power should solve all humanity energetic problems !
- But finally, the city of Brussels and the Royal Palace did not allow to have such a dangerous installation close to their premises...
The final selected site was then Mol at the recently created SCK-CEN (...problem of ownership!)

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23

Thus in a few years, from the mid-50's to beginning of the 60's, several important nuclear installations were built in the regio Mol-Dessel-Geel



- **Three** reactors (+ 1) installed at the SCK CEN;
- High energy **accelerators** at the CBNM (now JRC-Geel)
- A pilot **reprocessing plant**, for the fuel cycle industry (Eurochemic)
- ... they attracted also a **fuel assemblies fabrication** plant (MMN, later FBFC)... and a few years later (1970's) a **MOX fabrication plant** (Belgonucléaire)
- All of them using the Regional plan allowing for the installation of nuclear facilities on the sites of Mol, Dessel and Geel.

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A short time table: an impressive period !

1956	1958	1960	1962	1964	1966	
Start BR1	Design BR2	Start BR2	Start BR3	Start Venus		
Foundation Eurochemic		Start bldg Eurochemic			Operation Eurochemic	
Euratom treaty (57)		Birth of CBNM	3.7 MV Van de Graaff	Gelina (65)		
Creation Belgonucleaire SA	FBFC(MMN) selected the site	Start FBFC (then MMN)				BN plant (1973)

In about 10 years : 4 reactors, 1 reprocessing plant, 2 accelerators and a fuel fabrication plant !

25

25

Let us come back rapidly to the main facts of the various institutes & companies

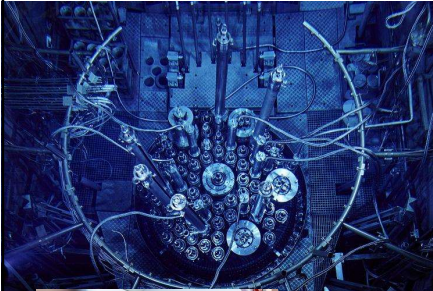


- We will rapidly have a deeper look at the various institutions:
 - **SCK CEN**, the Belgian Nuclear Research Center
 - **JRC-Geel**, the European Joint research Center
 - **Eurochemic**, the pilot reprocessing plant
 - **Belgonucleaire**, the FBR and MOX fuel fabrication plant
 - And do not forget some others, like:
 - **FBFC**, fuel assemblies fabrication (ex-MMN)
 - **Belgoprocess**, working daughter of ONDRAF/NIRAS
 - **TECNUBEL/TRANSNUBEL**, services to NPP and radioactive transport

26

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SCK CEN is producing up to 60% of the medical radioisotope for the World !

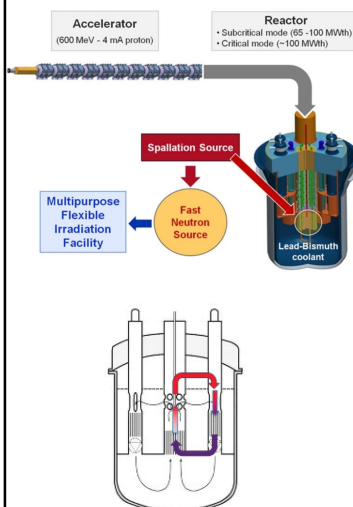


- Thanks to the BR2 reactor (very high neutron flux) the production of Mo-99 (precursor of Tc-99) can be very high...
- Developments are carried out TODAY for the production of radioisotopes for radioTHERAPY (e.g. TAT Targeted Alpha Therapy)
- BR2 also allows to dope semiconductors for high power electronics !

27

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SCK CEN also studies new types of reactors: MYRRHA (ADS) and SMRs



- MYRRHA should allow to reduce dramatically the lifetime of long lived radioactive wastes
- The Belgian Government agreed on funding the first phase of MYRRHA
- The Government also asked SCK CEN to have a preliminary study on potential SMR developments
- A new contract has been signed for the design of a lead cooled SMR plant

28

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The Joint Research Center (JRC): changed name ...

1960

Central Bureau for Nuclear
Measurements



1993

Joint Research Centre
Institute for Reference
Materials and Measurements



2016

Joint Research Centre
(Geel)

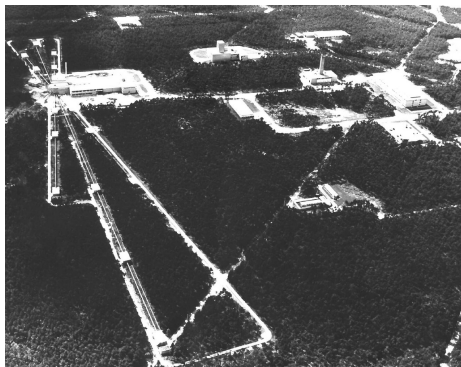


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Some important milestones...

1965

Inauguration of the linear accelerator



1970

Flight path at the linear accelerator



30

Some important milestones...

1960-2000 | 3,7 MV machines
1976-2016 | 7 MV machine

Van de Graaff accelerators



2016

MONNET, Tandem accelerator



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Nuclear laboratories at JRC Geel



GELINA
neutron time-of-flight facility for high-resolution
neutron measurements



MONNET
tandem accelerator based fast neutron source



TARGET
nuclear target preparation laboratories



METRO
nuclear reference material and measurement facility



HADES
low-level gamma-spectrometry laboratory



RADMET
laboratories for standardisation of radionuclide
activity



32

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JRC, yesterday and today...

Nuclear research at JRC Geel

- Nuclear data for nuclear safety
- Reference materials for nuclear safeguards and non-proliferation
- Harmonisation of measurements of radioactivity in the environment



010: Main building
010: Main building & Hades
Reference measurements of
radioactivity, metrology



020: MONNET building
Fast neutron reactions
Neutron metrology



040: Mass spectrometry &
sample preparation
Ref. materials & measurements



050: GELINA – time-of-flight facility
Electron accelerator for neutron
interaction measurements

33

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Some interesting facts from the CBNM/IRMM/JRC...



- Annex V of the Euratom Treaty described this entity as a 'bureau of standards specializing in nuclear measurements for isotope analysis and absolute measurement of radiation and neutron absorption ... in support of nuclear industry'.
- Installation of a « **cold** moderator » (liquid methane at 77 °K, almost -196°C) in a high radiation area... to study neutron spectrum of very low energy.
It seems to be the **only** place (GELINA) in the World where it has been realized.
- The JRC-Geel has got a **worldwide reputation** for the preparation of "high quality samples for nuclear measurements" (radioactive or stable samples). No good measurements can be done without good samples !

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The Eurochemic reprocessing plant (now Belgoproces) 1966 - 1974



35

Eurochemic in figures

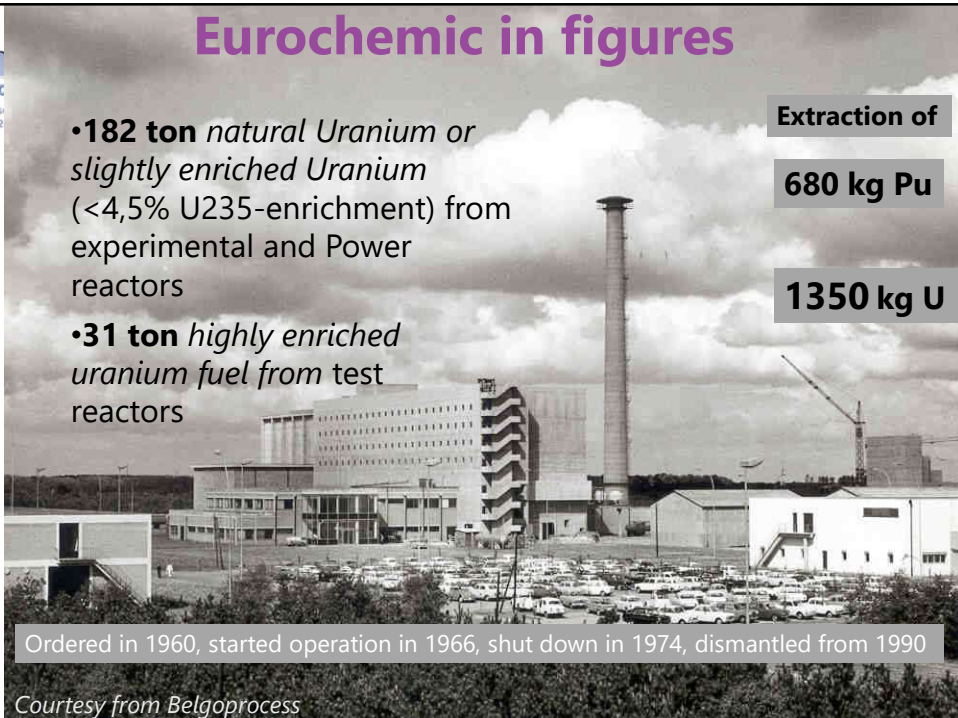
• **182 ton** *natural Uranium or slightly enriched Uranium* (<4,5% U235-enrichment) from experimental and Power reactors

• **31 ton** *highly enriched uranium fuel* from test reactors

Extraction of

680 kg Pu

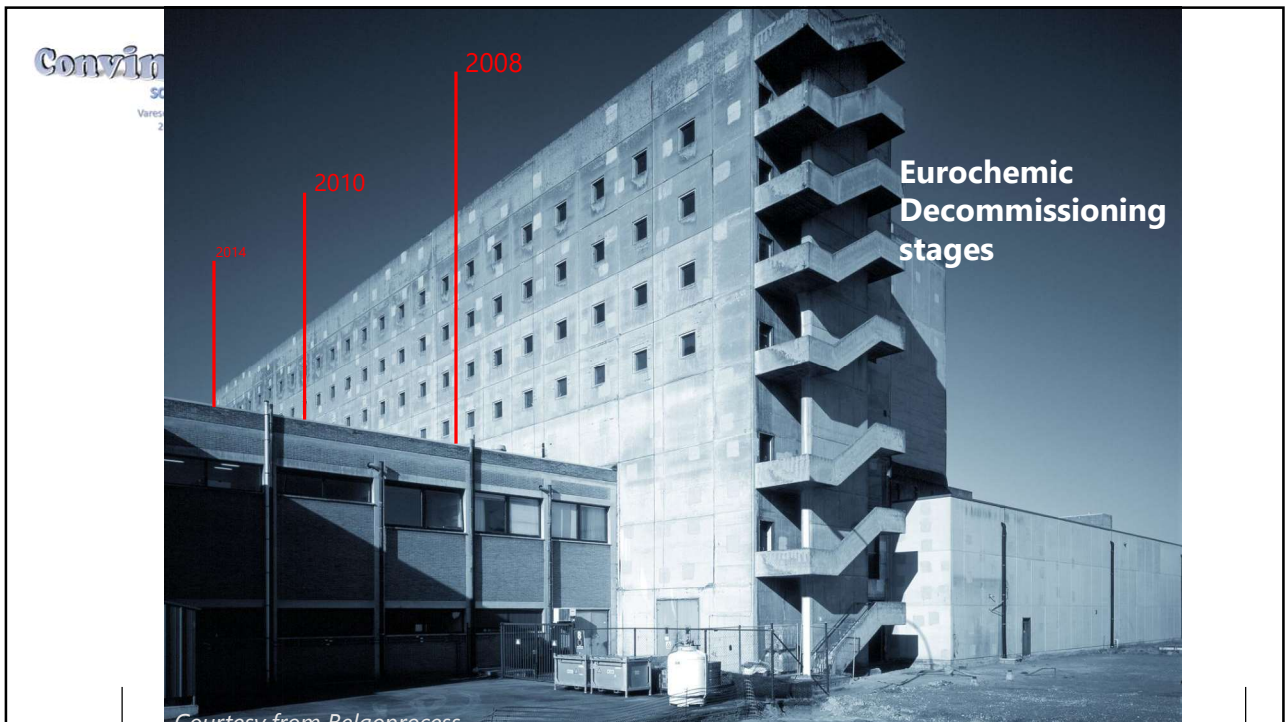
1350 kg U



Ordered in 1960, started operation in 1966, shut down in 1974, dismantled from 1990

Courtesy from Belgoproces

36



37

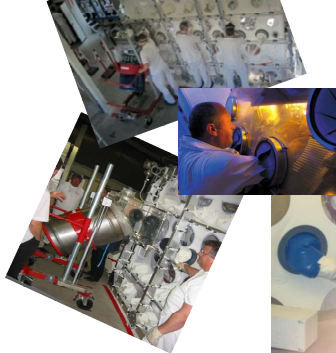


38



The Belgonucleaire plant, production of MOX fuel

- BN was created in 1957 at the initiative of UMHK (first President was the deputy of Edgar Sengier)
- License submission for the plant in 1969, after the DeBeNe agreement on SNR-300 (FBR in Kalkar)
- Started operation in 1973
- Shareholders: 50% Belgian Government through SCK CEN



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The main figures of Belgonucleaire

- The **original capacity was 40 tons LWR MOX fuel and 10 tons FBR fuel...**
- In 1976, the LWR contracts with the US were cancelled due to the non-reprocessing policy of President Jimmy Carter
- The plant fabricated 30% of the fuel for the 1st core of SNR-300 and a lot of MOX reload for European NPPs
- In 1984, France asked BN to help produce MOX for EDF (first delivery in 1987)
- End of operation in 2006 (mostly due to political decisions)
- In total it has produced **600 tons of MOX** with the **recycling of 40 tons of Pu**



40

40

With all these installations, Belgium had to develop all the needed services around



- For controlling the installations and industries, the Belgian Government had to set up the necessary **regulations** (laws and decrees) but also to install the regulatory **bodies** (first separated under two Ministries, then in one body FANC) and **inspectorate...** (TSO)
- The radioactive **waste management** is also an important aspect which had to be developed: first within SCK CEN, then afterwards through an agency (NIRAS/ONDRAF) and an operating installation (Belgoprocess) + final disposal (catA)
- The **industry** started to build up at the same time to face the needs of this new activity developments...
- And last but not least, the nuclear **medical** applications grew very fast, thanks to Universities and the SCK CEN (later on through IBA and IRE and other players)

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Several important facts, originating in the regio Mol – Dessel - Geel



- BR1 reactor built **in 2 years**;
- BR3, **First PWR** outside the USA, first to be dismantled
- BR2, reactor with one of the **highest neutron flux** in the world, producing between 30% and 60% of the worldwide medical radioisotope.
- HADES, **first underground** laboratory in clay (1980), for the study on the disposal of HLW
- GELINA Linac, ordered in 1960, in operation in 1965, is still in operation today, i.e. **after almost 60 Years** for neutron studies !
- **First MOX** fuel rod irradiated in the world ! (1963)
- **Dismantling** of a MOX fuel facility up to the free release of the site; and **first** dismantling of a PWR in Europe...

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To finish: not to forget, some anecdotes !



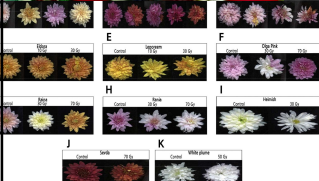
- In JRC, holding a weapon (and in particular bladed weapon), is strictly forbidden ! Nevertheless, in 2007 came a Dutch Professor in the control room of Gelina with a Sword ! ☹☹
- ...It was a sword from the bronze age, that he wanted to analyse via the "neutron resonance analysis"
- Until a few years ago, the BR2 irradiated gems (diamonds) to change their colours (from white to blue, rose or yellow);
- ...often to hide some internal flaws and give them a higher value than original
- This activity has been discontinued for ALARA reasons...



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Some anecdotes (continued)



- Flowers seeds are still irradiated at the BR2 reactor (mostly only by gamma rays) to change the colour of the flowers themselves (e.g. for Chrysanthem)
- Here also to increase the value or to offer different types (colours) of flowers to the customers
- The name of the exhibition centre (on radioactivity and radioactive waste management) is TABLOO; where does it come from ?
- It seems to have been derived from the Esperanto « Tablo » which means 'table', as the building has a form of a table...
- It is also a nice mean to avoid the **typical** Belgian **linguistic** problem !

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44

A few general references which helped me

- Un demi-siècle de nucléaire en Belgique, P. Govaerts et al, BNS (1994)
- Vers un avenir durable; le CEN à Mol (1952-2022), Geert Vanpaemel, (2022)
- Koning in de Kempen (De ontginning van het koninklijk domein 1850-1950), D. van der Veken et al (2023)
- « Charles Pecher et Edgar Sengier », by Amand Lucas, Bulletin de la Société Royale des Sciences de Liège (Volume 87 - Année 2018 — Actes de colloques — La radioactivité - Novembre 2018 - Liège) (<https://popups.uliege.be/0037-9565/index.php?id=8342>)
- SCK CEN 1952-2002, Folder issued at the occasion of the 50th anniversary of the SCK CEN (2002)
- Treaty Establishing the European Atomic Energy Community (EURATOM), April 1957
- BELGIUM, BRITAIN, THE UNITED STATES AND URANIUM, 1952-1959, Jonathan E. Helmreich, Allegheny College, Meadville, Pennsylvania

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And mostly thanks to some colleagues for their very valuable inputs



- Jean Vanvliet, from Belgonucleaire
- Sophie Roulette, Wim Mondelaers, Jean-Marie Salomé and Peter Schillebeeckx from the JRC-Geel
- Prof. Cyriel Wagemans, from Ugent
- Sabine Claessens, from SCK CEN
- Wim Van Laer, from Belgoproces (presentation at Tabloo)
- The Tabloo counter (for the book on the Royal domain)
- Stephan Heinitz, from SCK CEN
- My wife, for the various documents found back



- ... and indeed my friend Google !

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**And thank you to have listened to me ...
without too much difficulties (I hope)**

