

La Fission Liquide



Présentation au groupe des bénévoles, The Shift Project



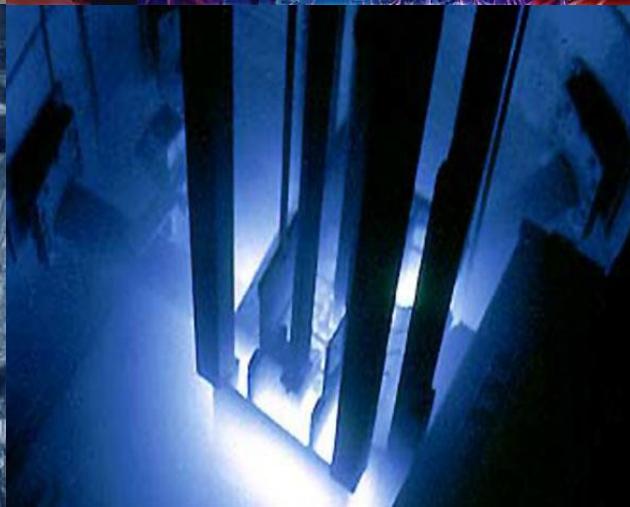
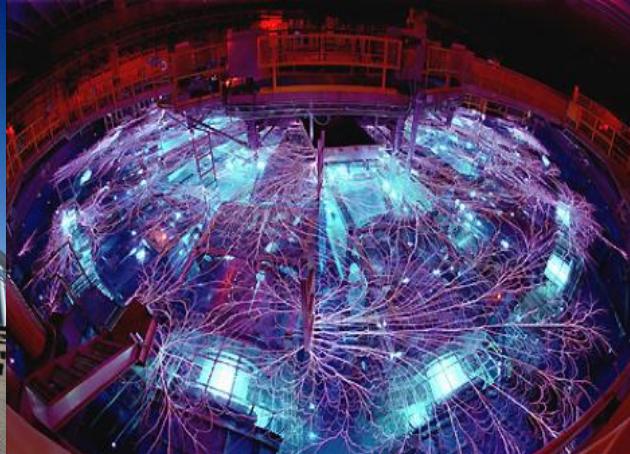
Redesigning the Economy to Achieve Carbon Transition



John Laurie

<http://energieduthorium.fr>

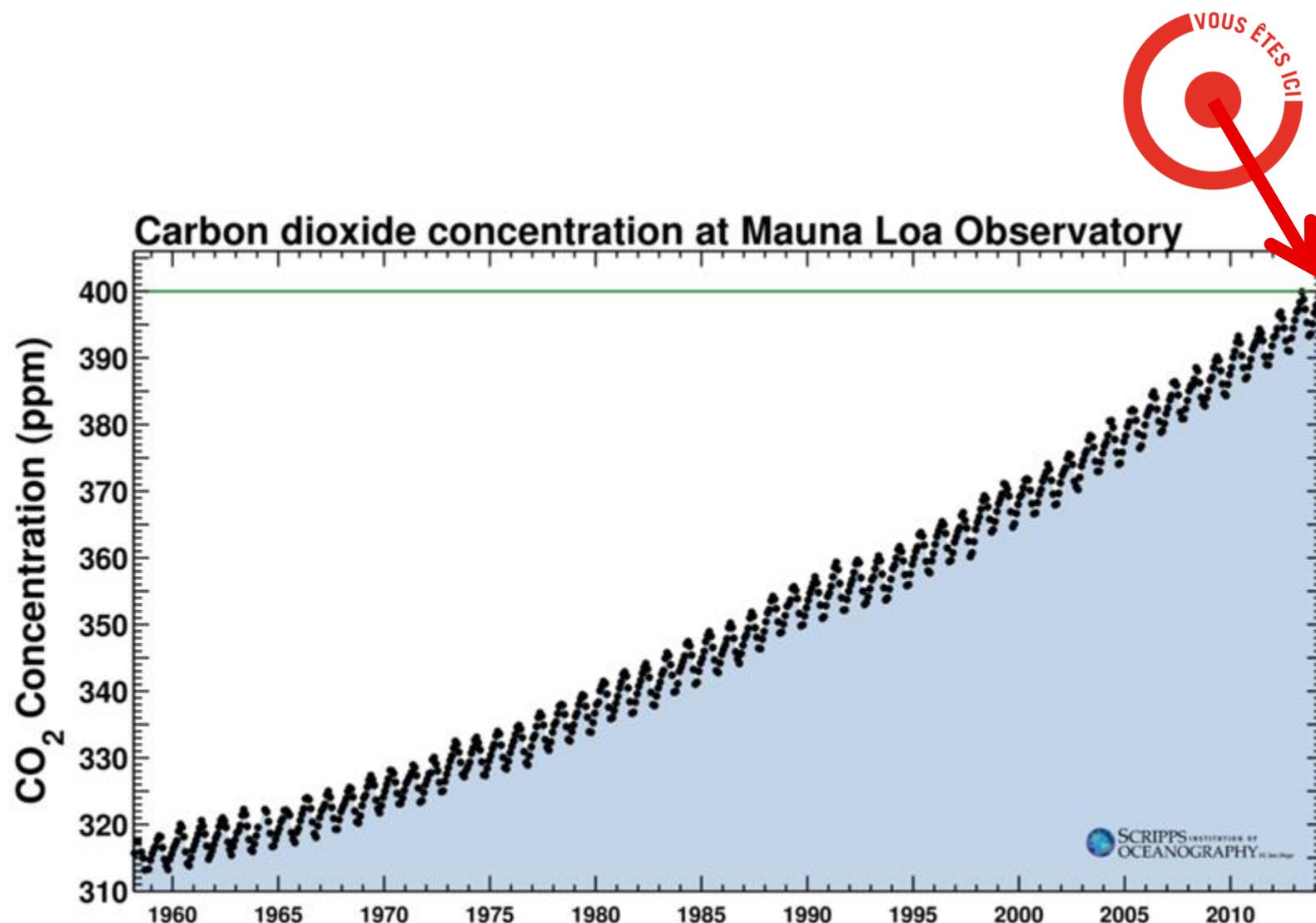
Mardi 20 mai 2014



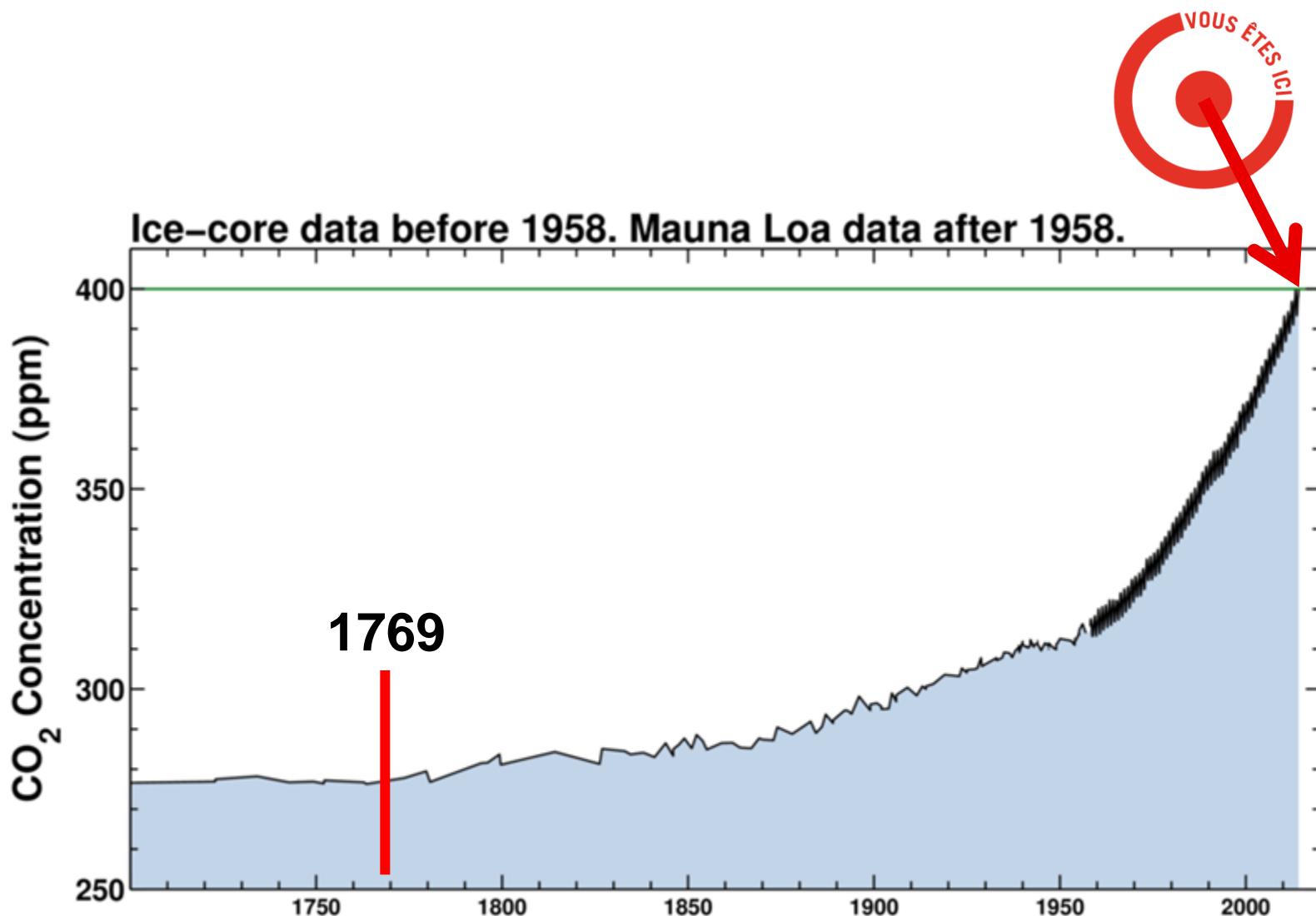
**FIABLE
BON MARCHÉ
SÛRE
DURABLE
PROPRE**

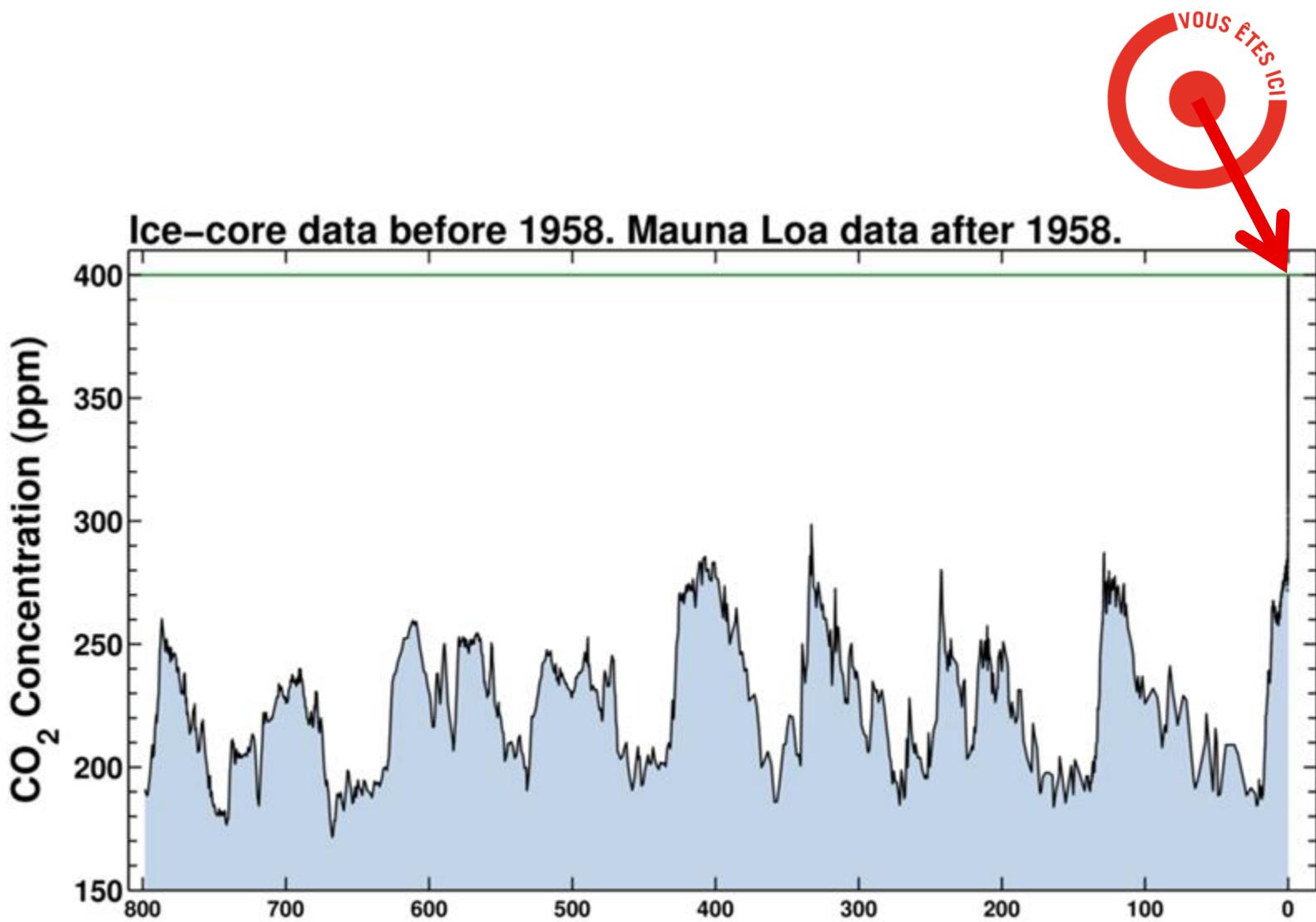


FIABLE 😊
BON MARCHÉ 😊
SÛRE 😕
DURABLE 😕
PROPRE 😕



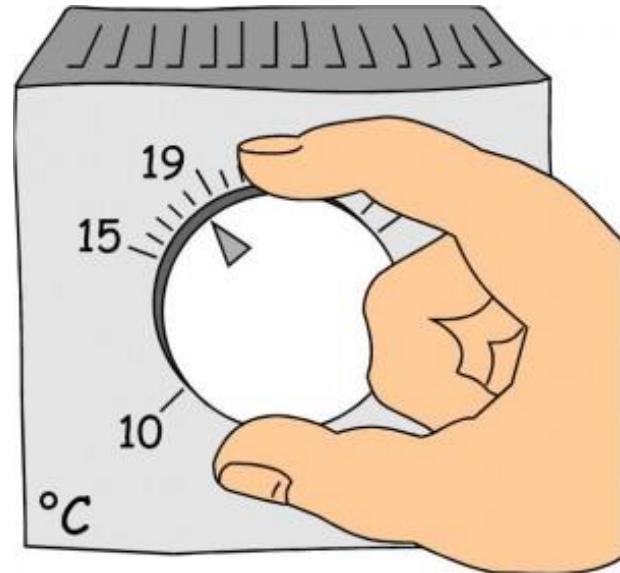
VOUS
ETES
ICI







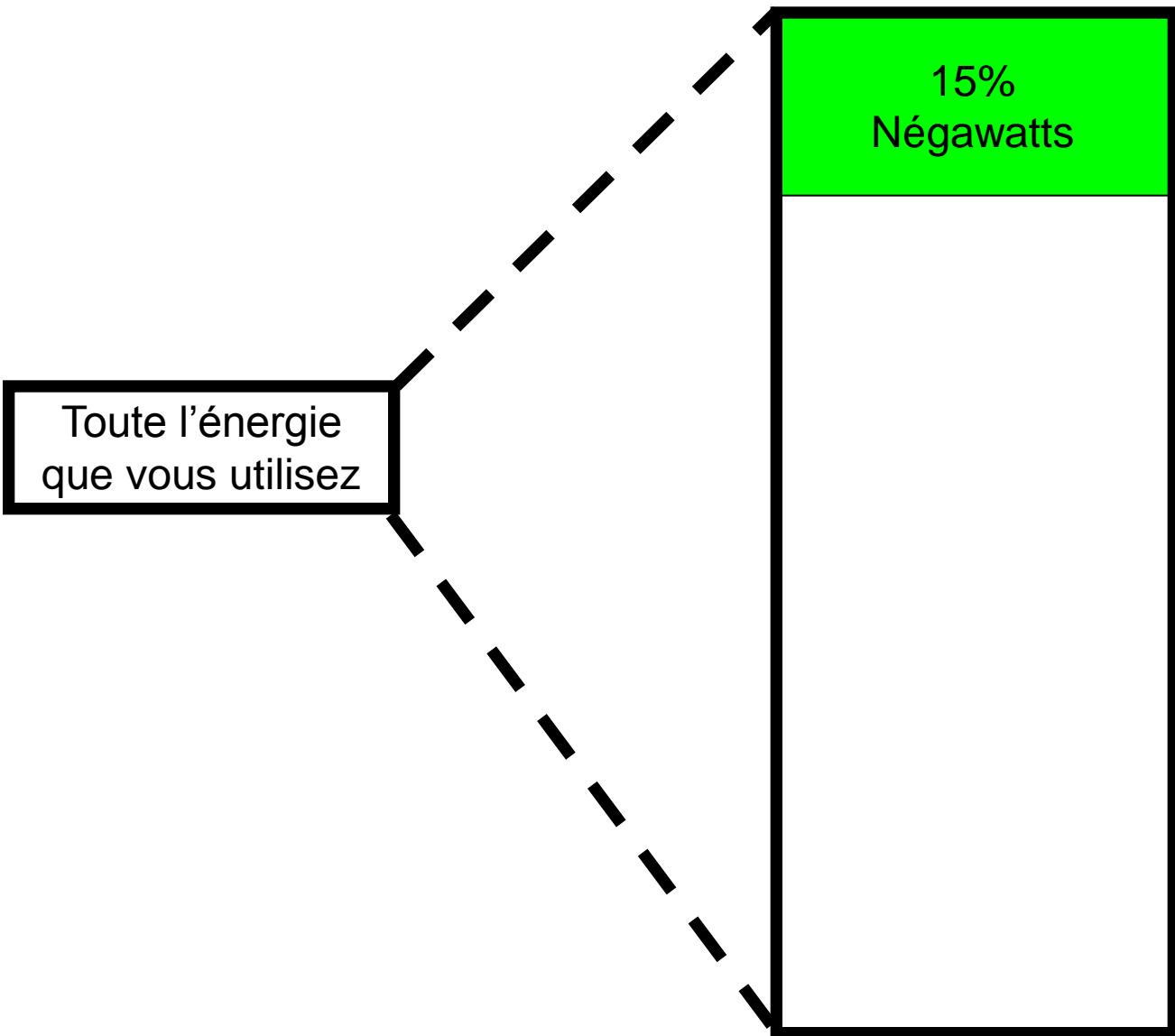
NÉGA-WATTS





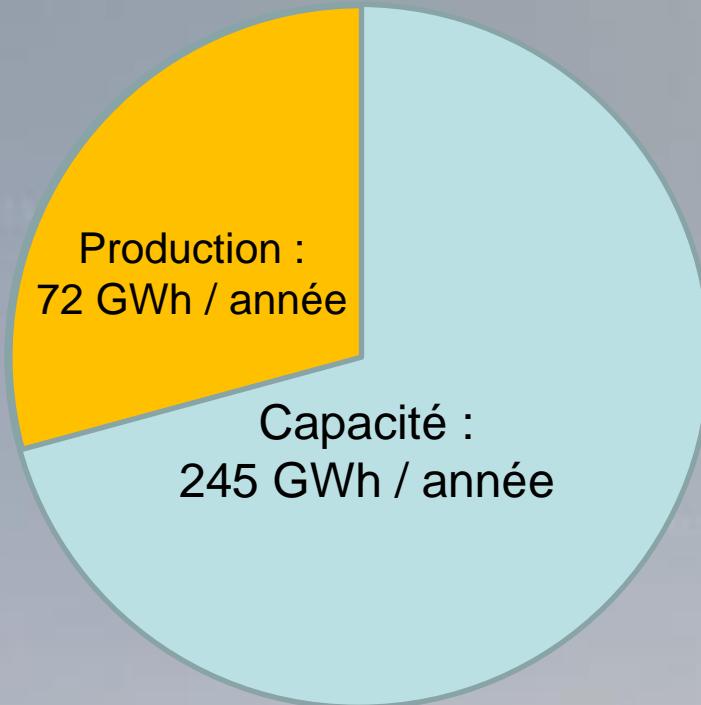




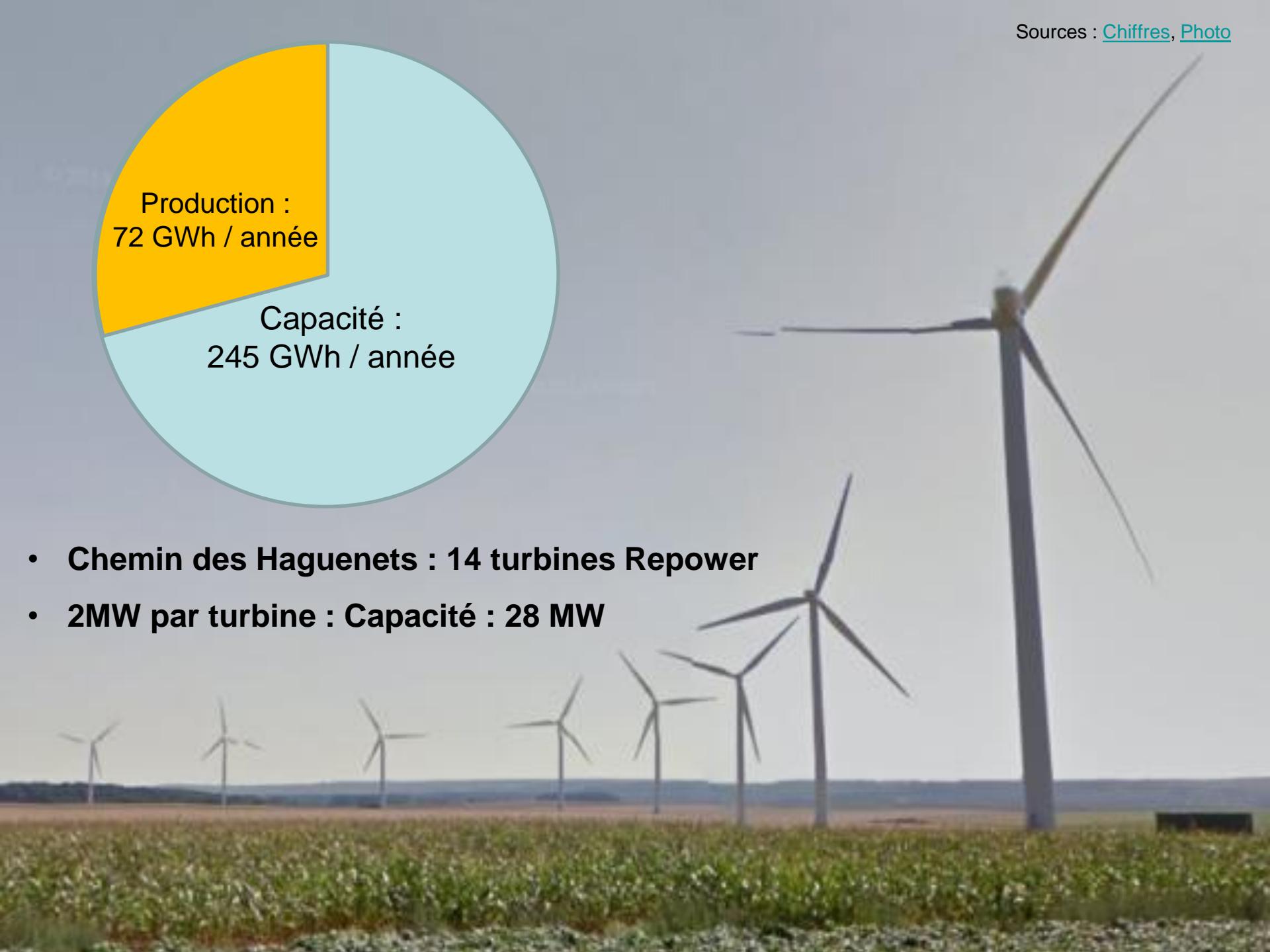




FIABLE 😕
BON MARCHÉ 😕
SÛRE 😊
DURABLE 😊
PROPRE 😊



- **Chemin des Haguenets : 14 turbines Repower**
- **2MW par turbine : Capacité : 28 MW**

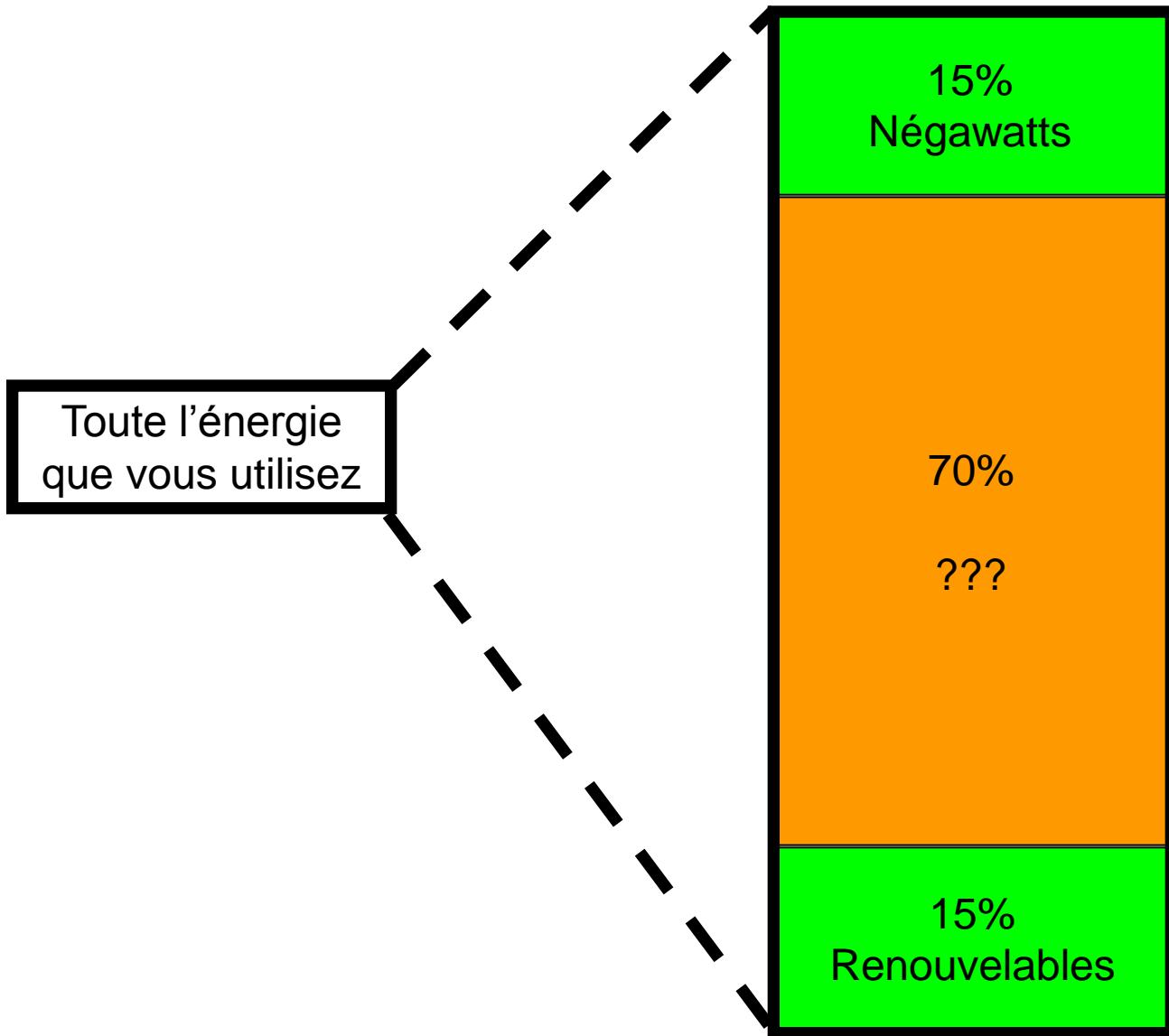


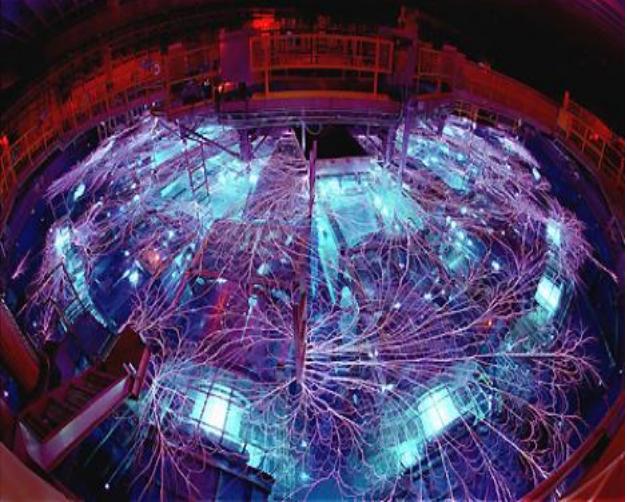
INTERMITTENTE

DIFFUSE

CHÈRE

Le sandwich de l'énergie



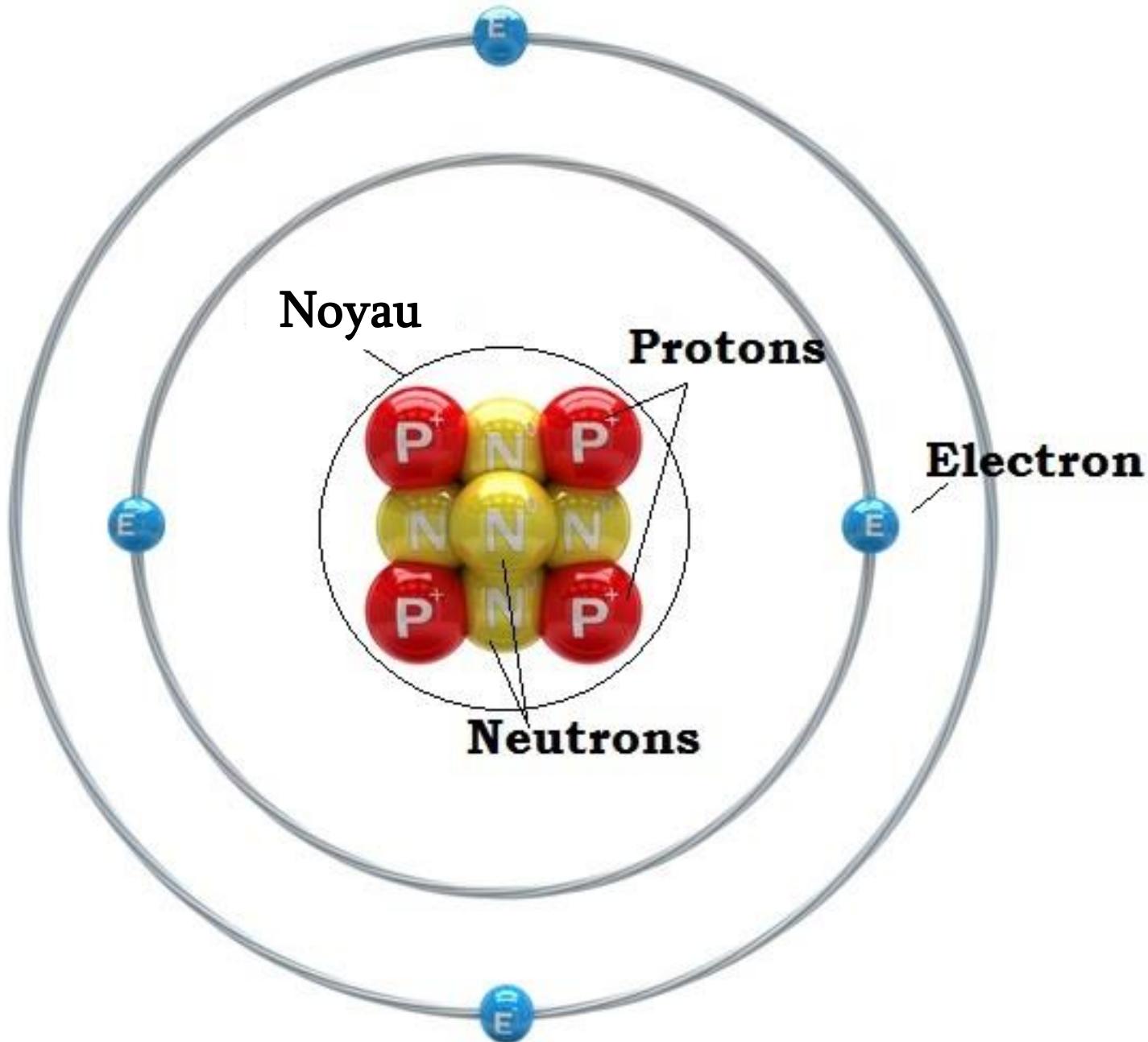




Ceci n'est
pas une
bombe



Ceci n'est
pas une
centrale



4 protons : Beryllium

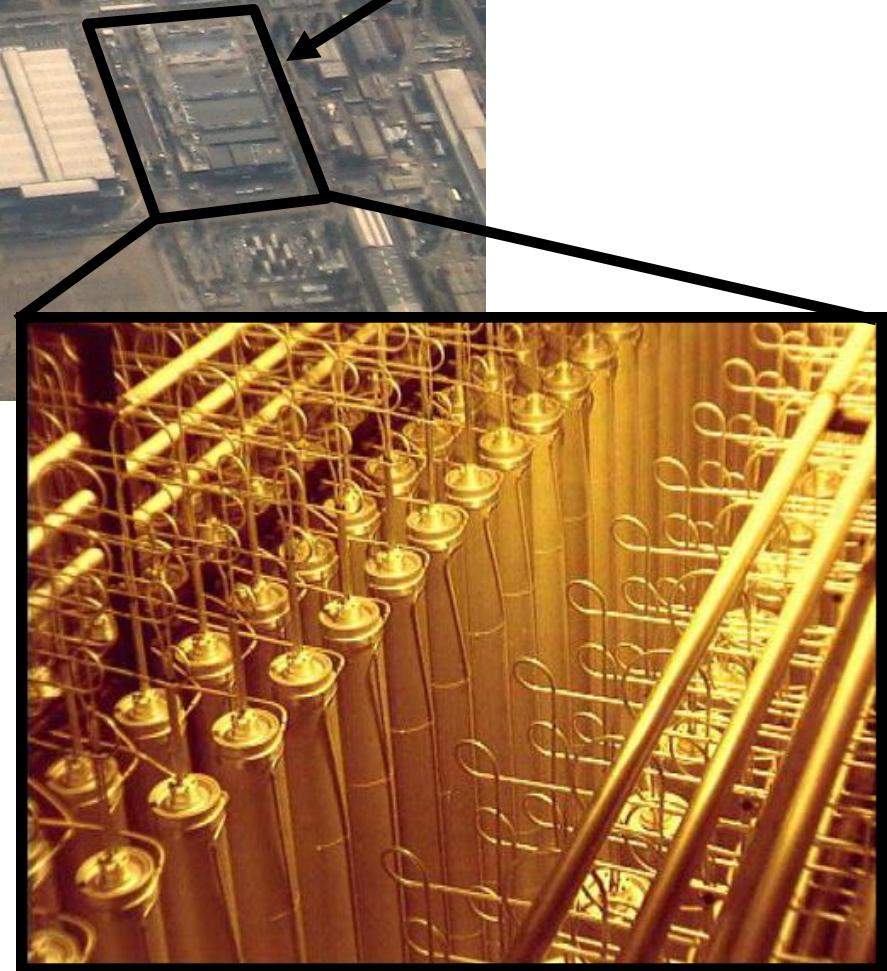
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↓ Period	1 H	2 Li	3 Mg	5 B	6 C	7 N	8 O	9 F	10 Ne	11	12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
1	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30	31	32	33	34 Se	35 Br	36 Kr
2	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Tl	51 Sb	52 Te	53 Xe	54 Rn
3	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Po	83 At	84 Rn	85 Po	86 Rn
4	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ts	111 Og	112 Nh	113 Nh	114 Nh	115 Nh	116 Nh	117 Nh	118 Nh
Lanthanides			57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm										
Actinides			89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu										

Uranium naturel
99.3% uranium-238
0.7% uranium-235

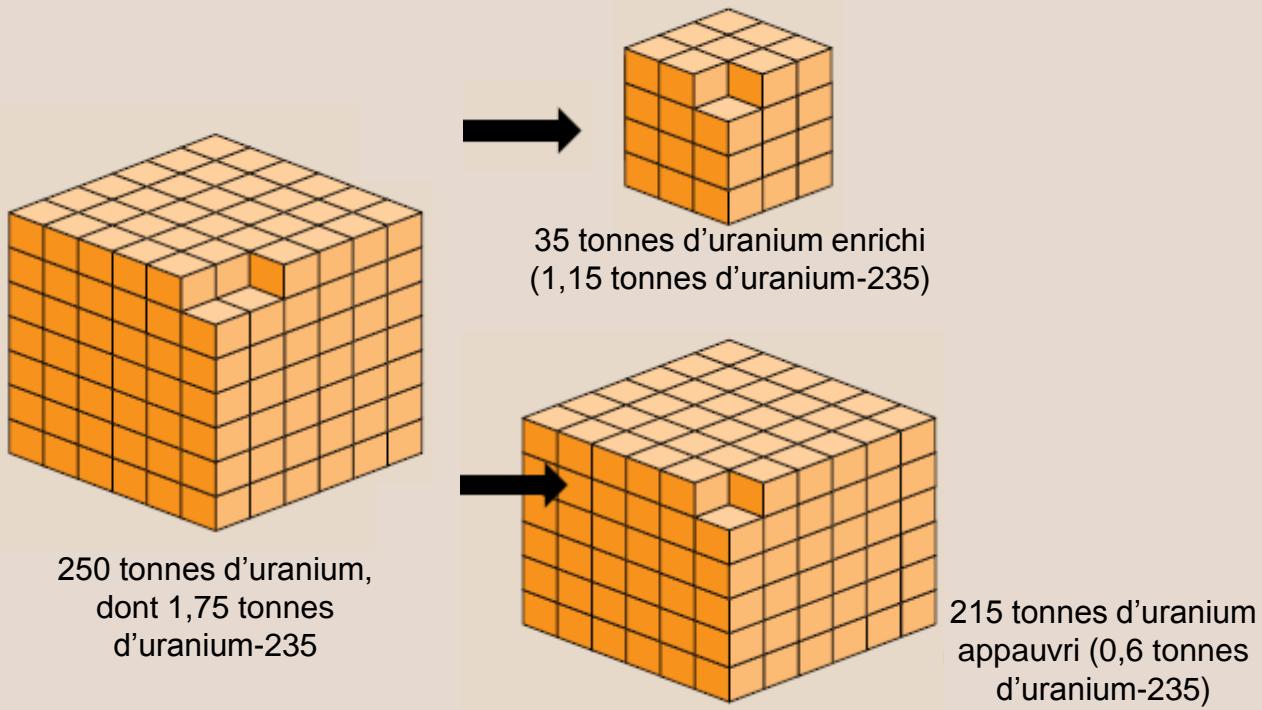




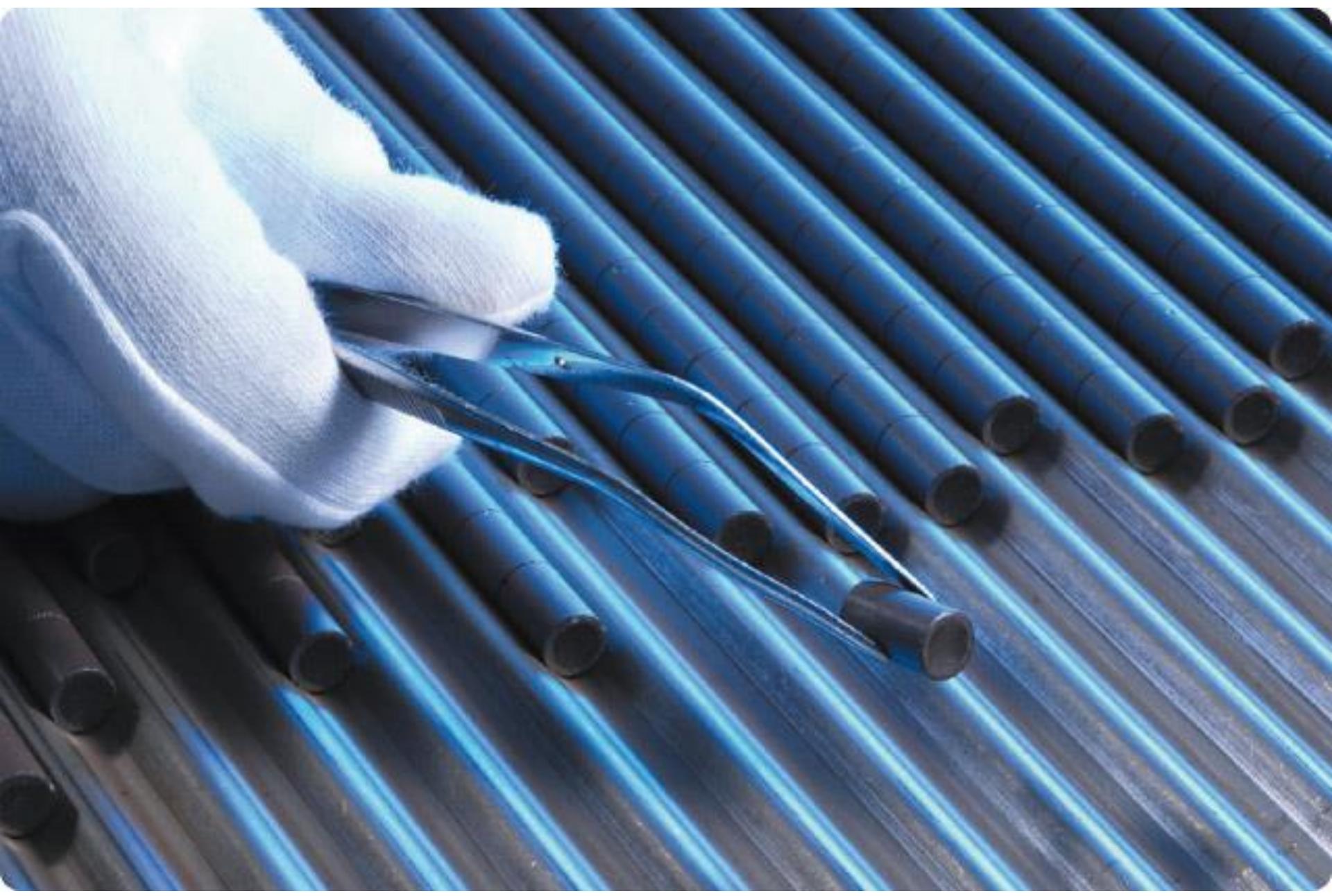
Usine
d'enrichissement



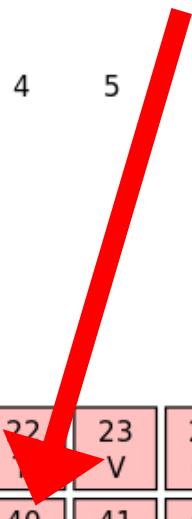
Pour produire 1 GigaWatt-Année d'électricité :





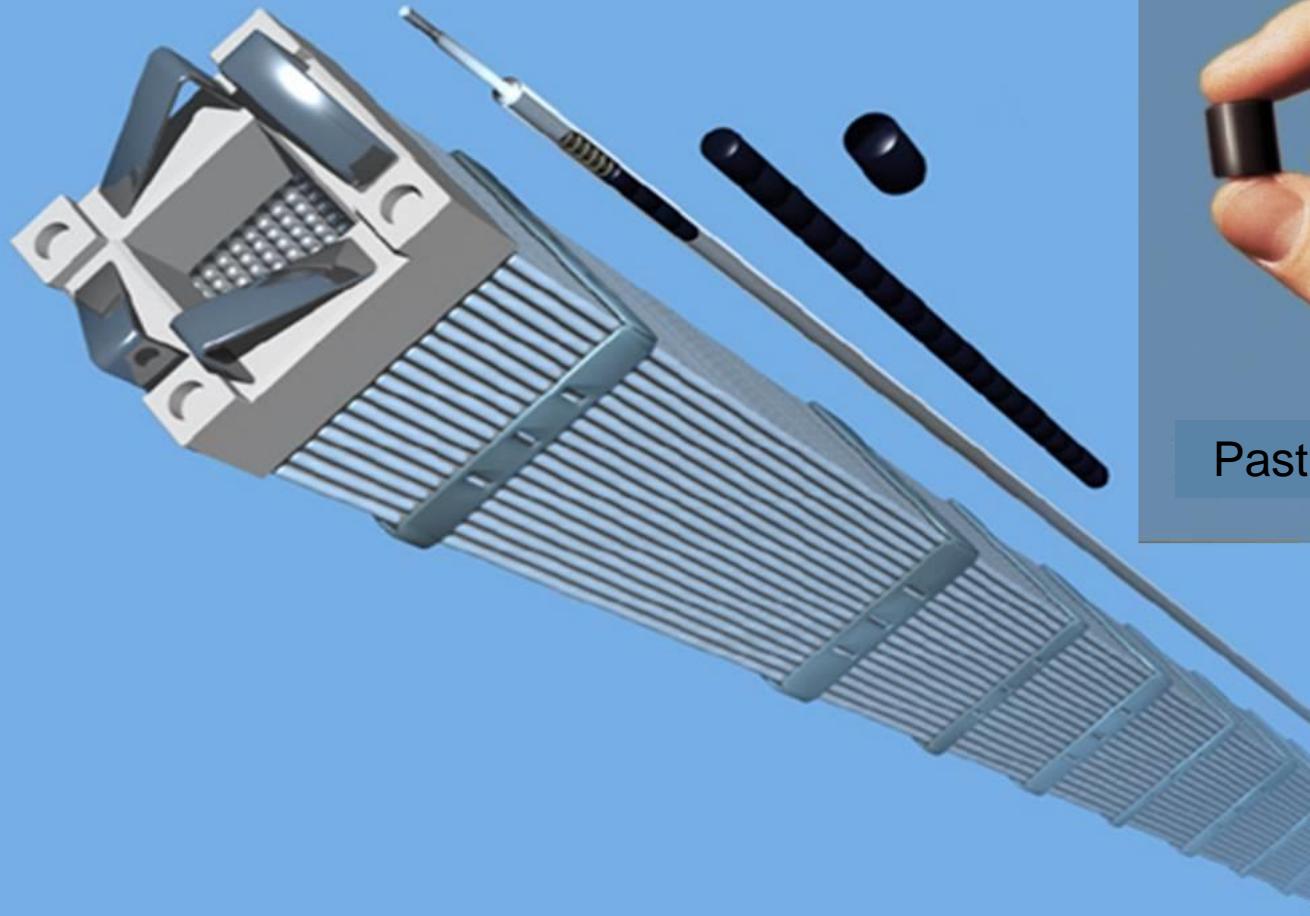


Zirconium

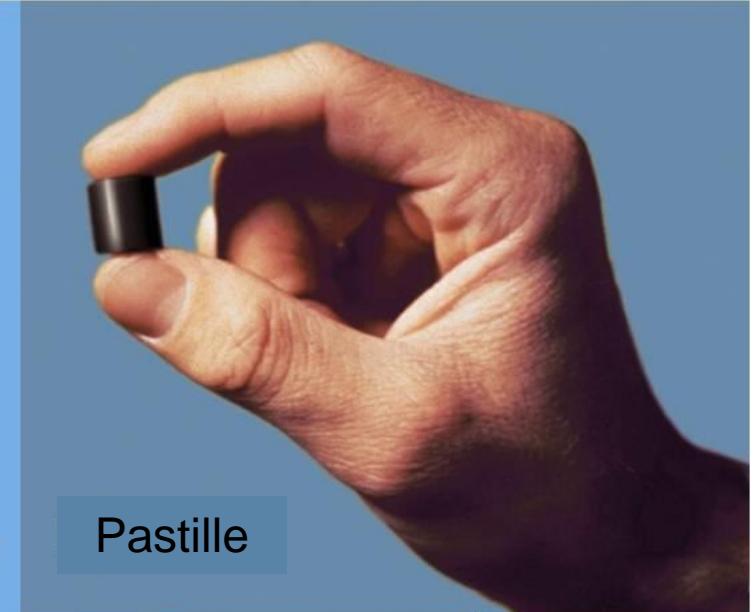


Group → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
 ↓ Period

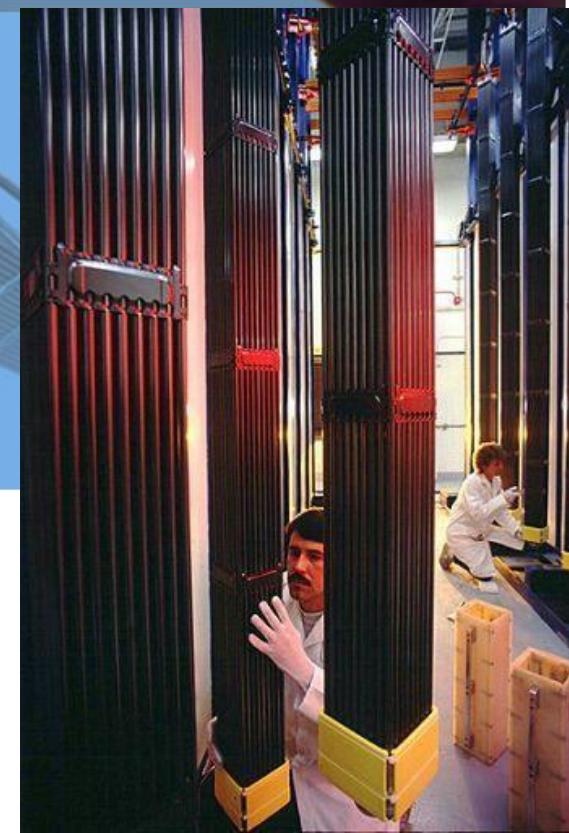
1 H																	2 He
3 Li	4 Be																10 Ne
11 Na	12 Mg																18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo
Lanthanides		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
Actinides		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	



Assemblage de combustible

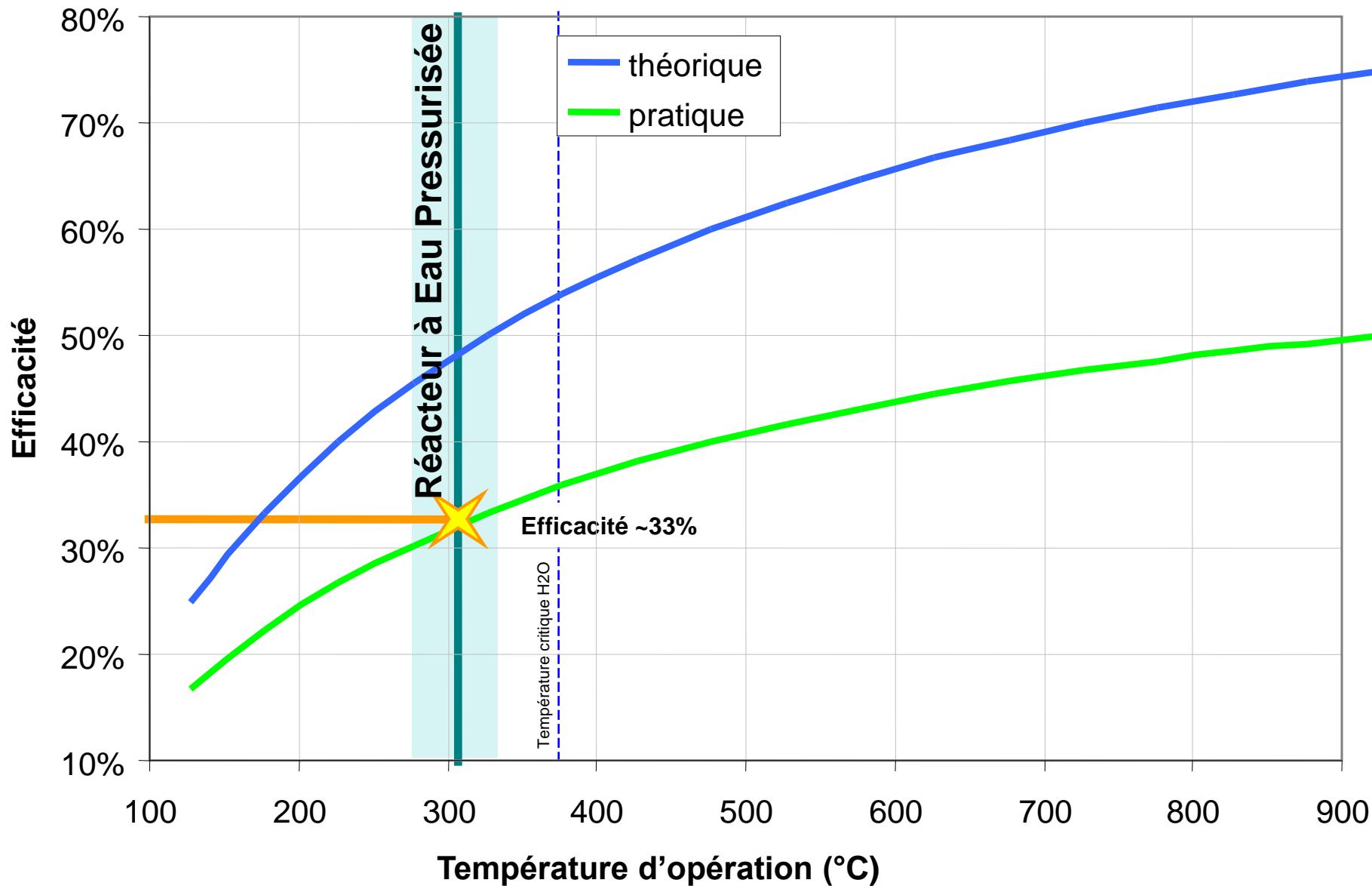


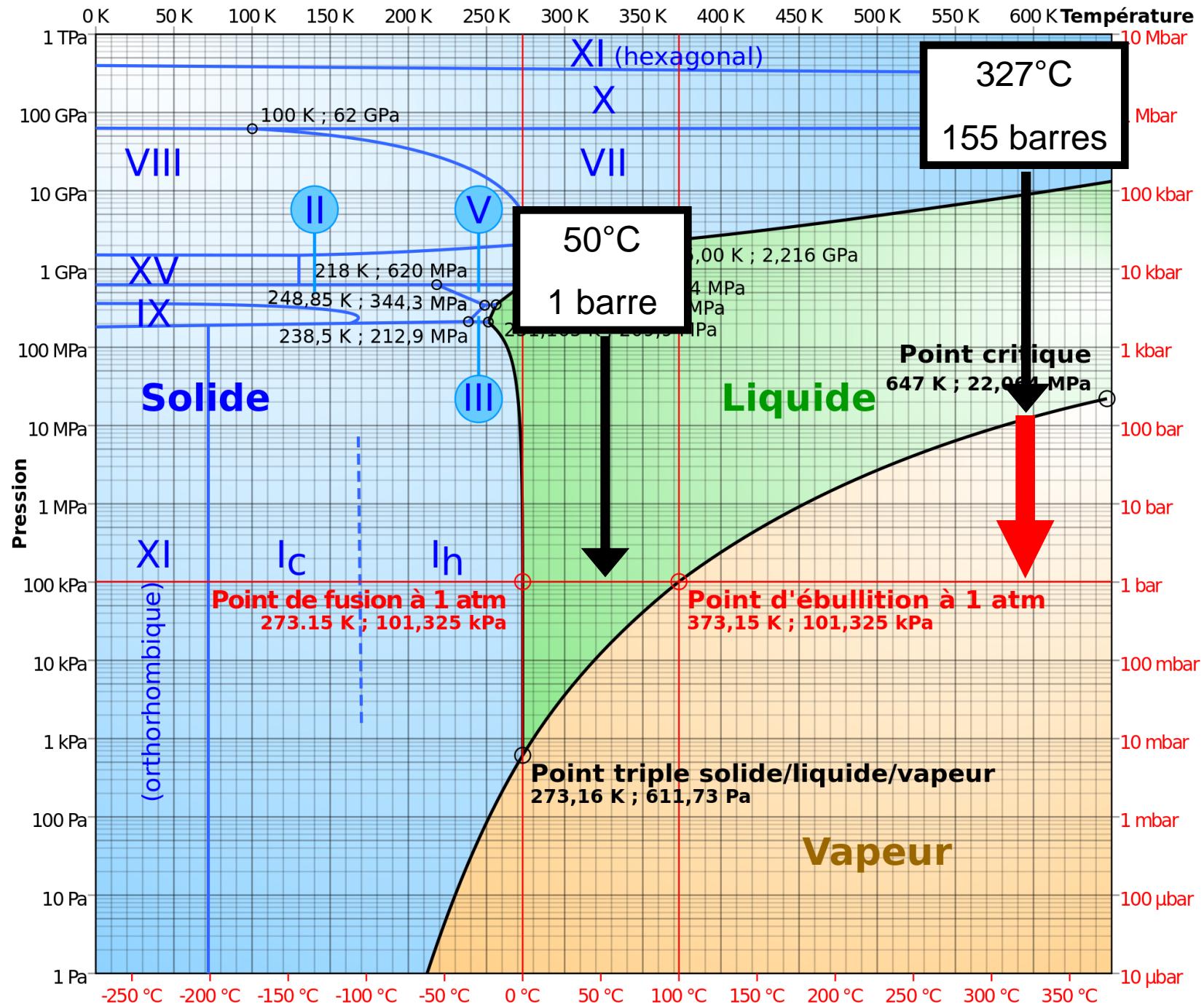
Pastille



(video)

Conversion de puissance Chaleur → Électricité







SPL

2 Enceintes de confinement : épaisseur 130cm



Cuve du réacteur





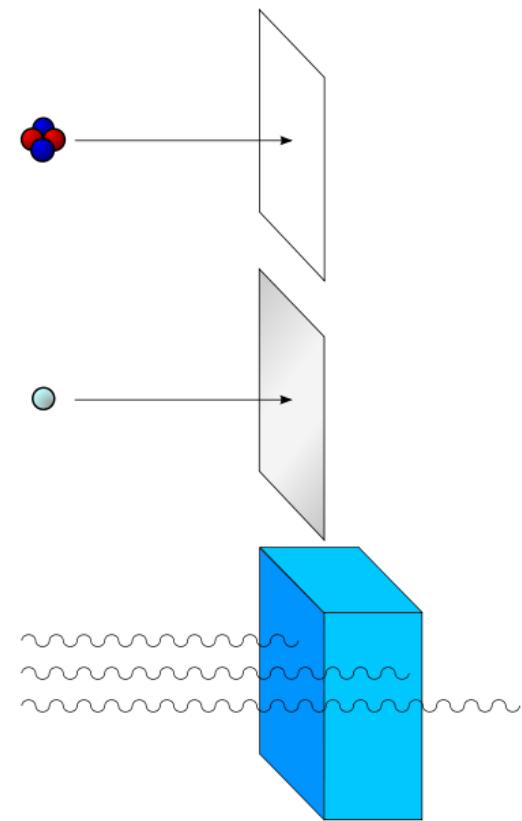
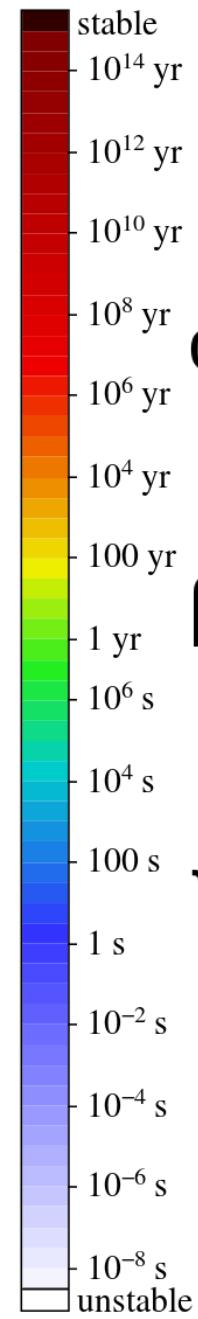
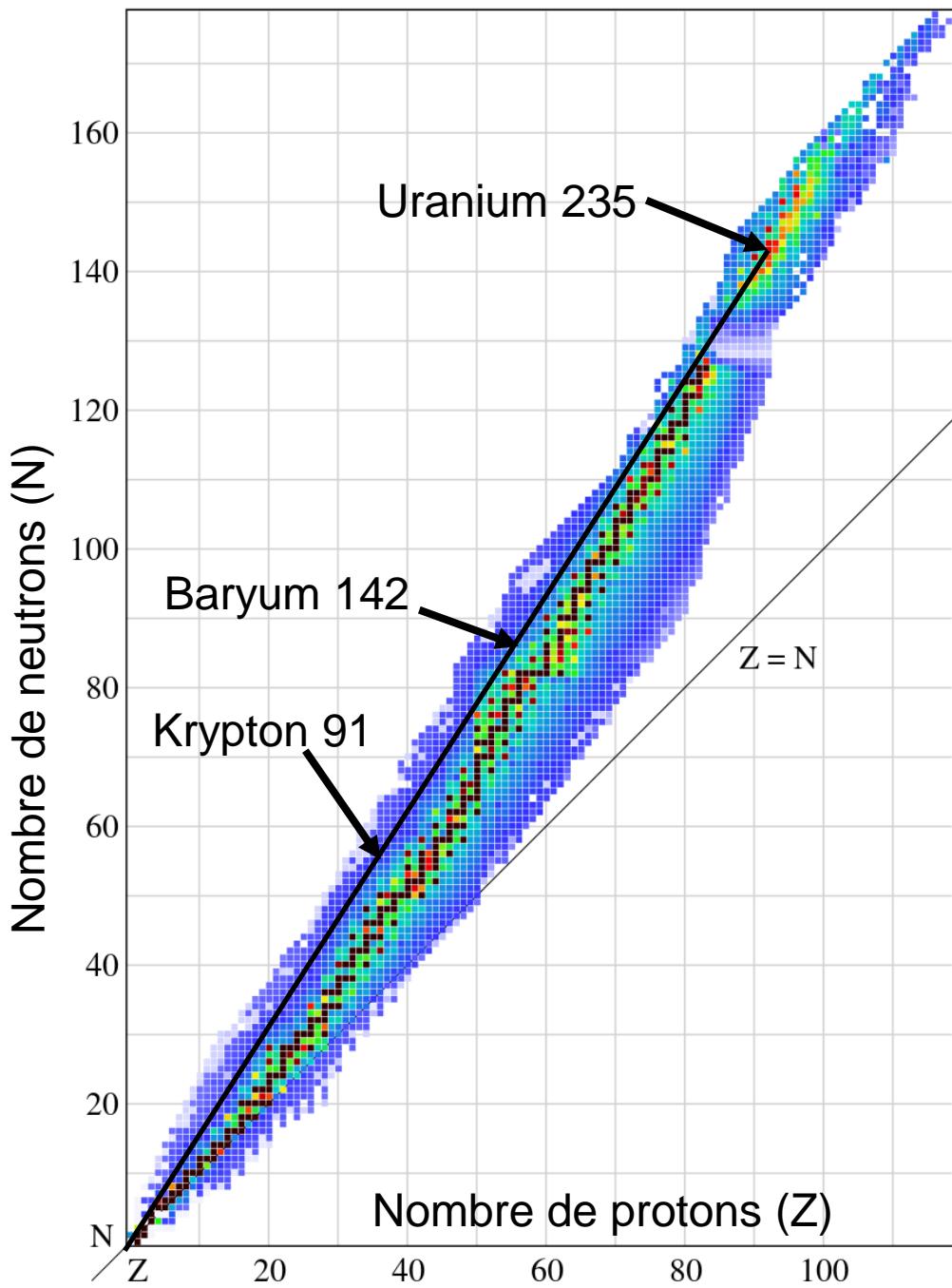
>20cm



accelerated
neutron

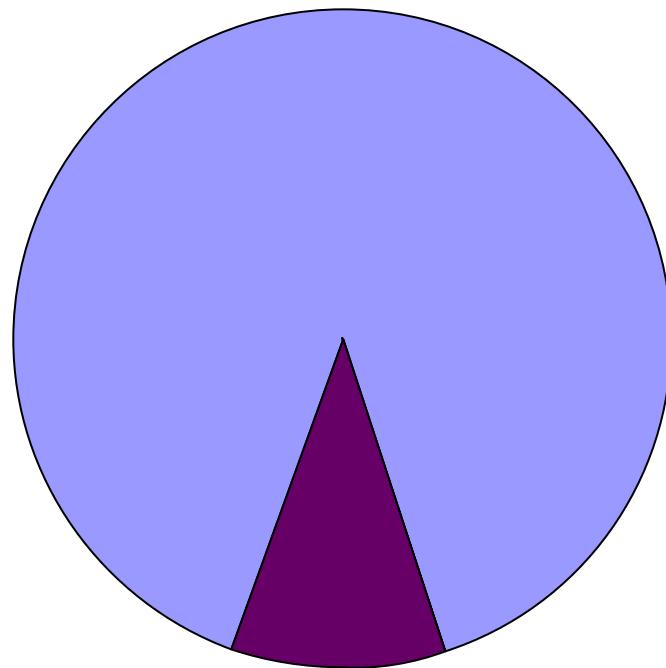


uranium

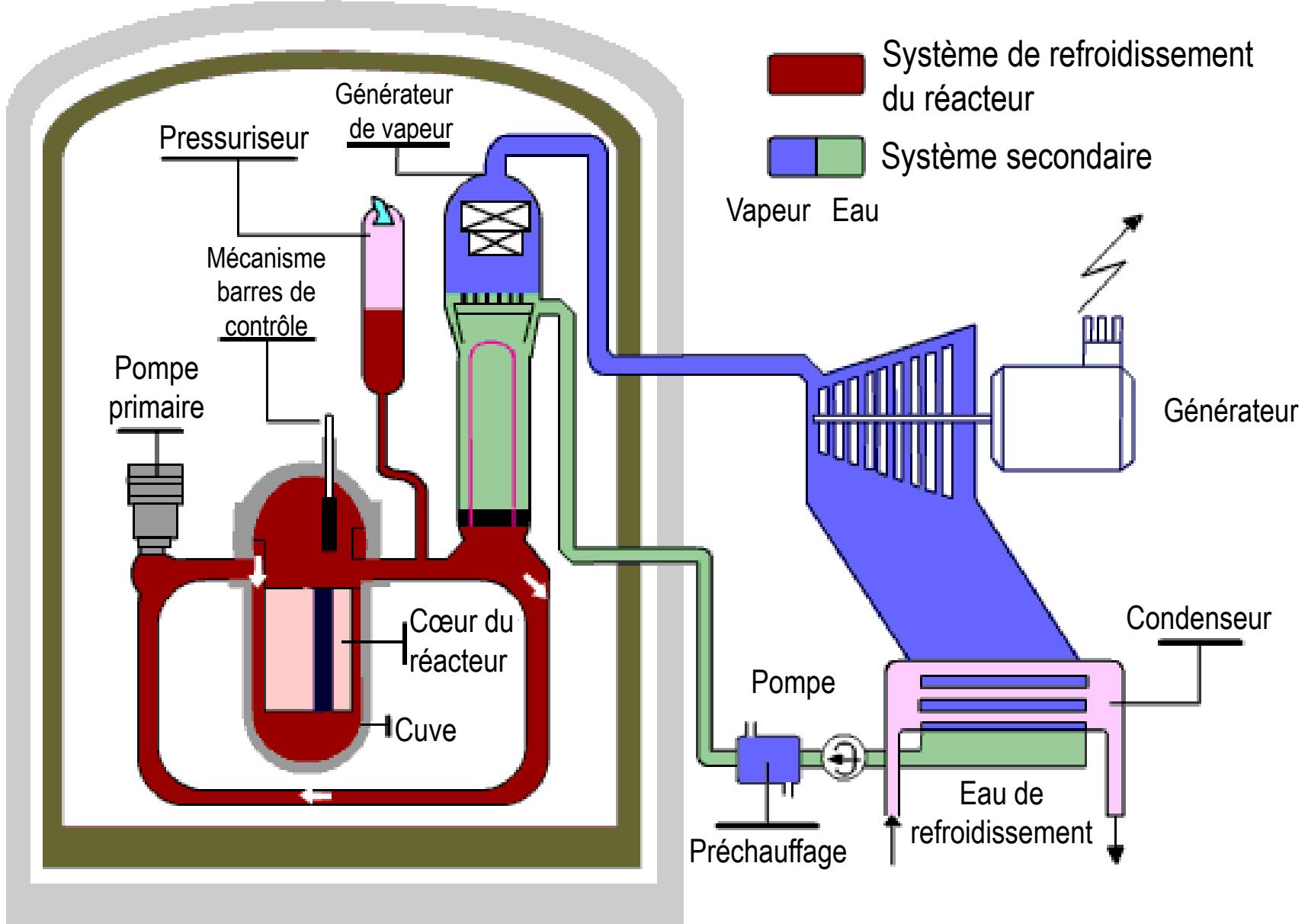


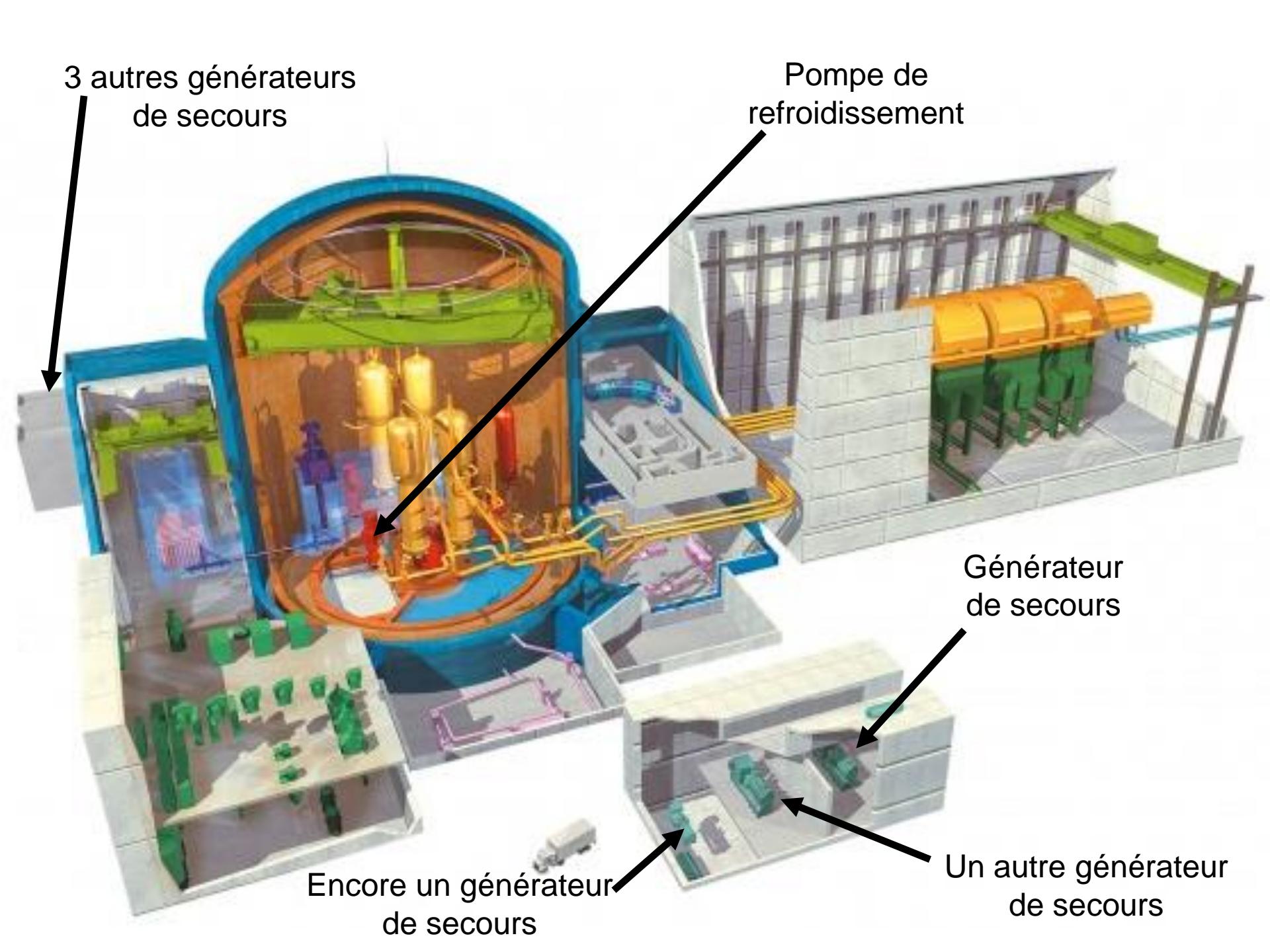
Energie de la fission d'un atome d'Uranium 235 :
202 Million électron-volts

181 Million électron-volts
de la fission
89%



21 Million électron-volts
de la désintégration des produits de fission





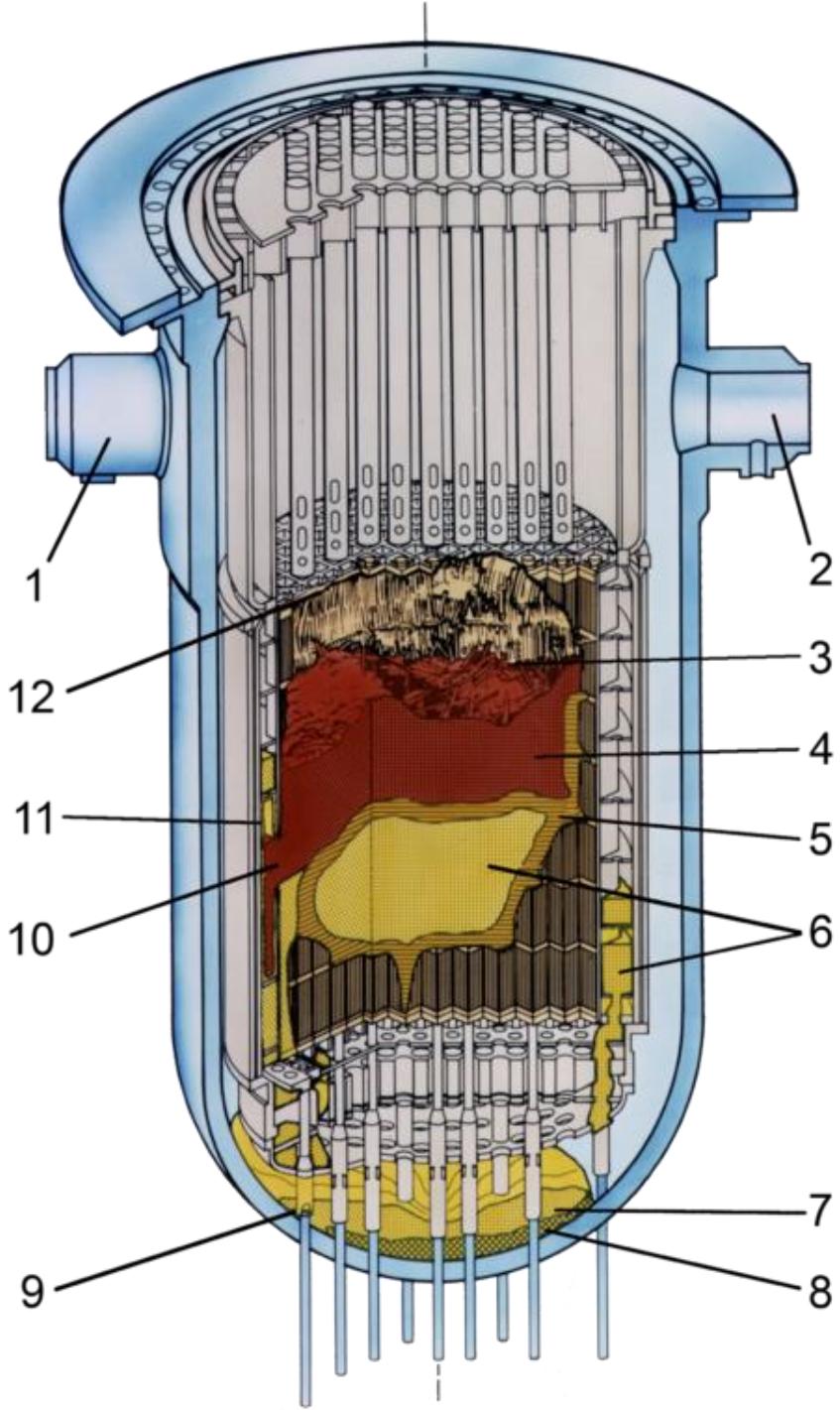
3 autres générateurs de secours

Pompe de refroidissement

Encore un générateur de secours

Générateur de secours

Un autre générateur de secours



Three Mile Island



Fukushima

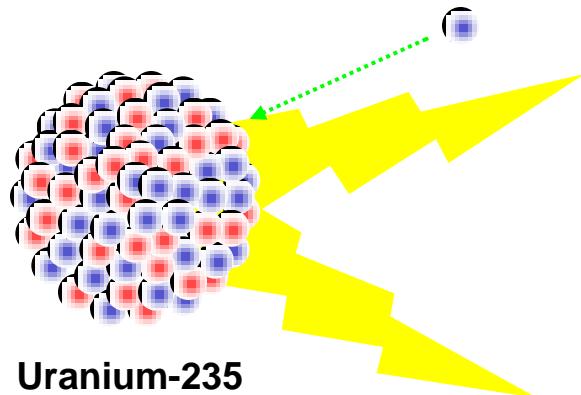


Tchernobyl

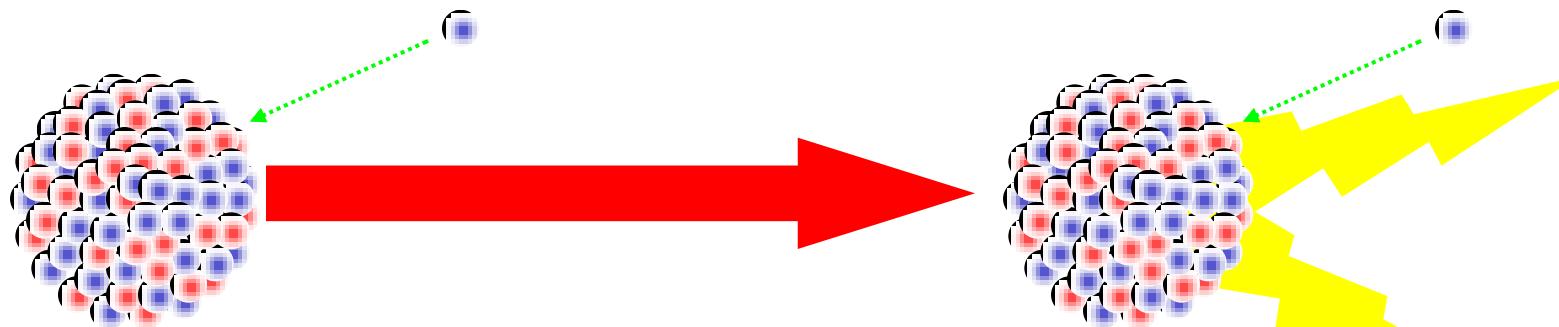


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↓ Period	H																He	
1	1 H																	
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Lanthanides																		
Actinides																		

Transuraniens



Fissile

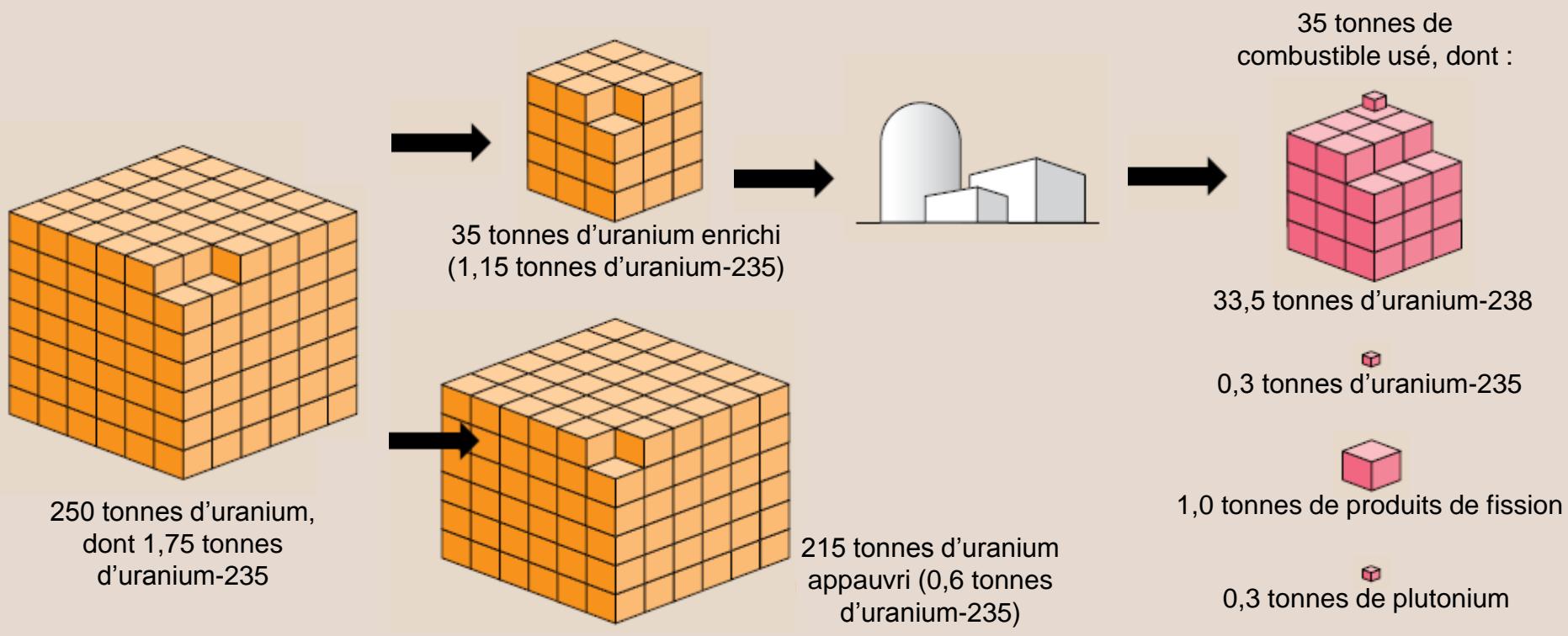


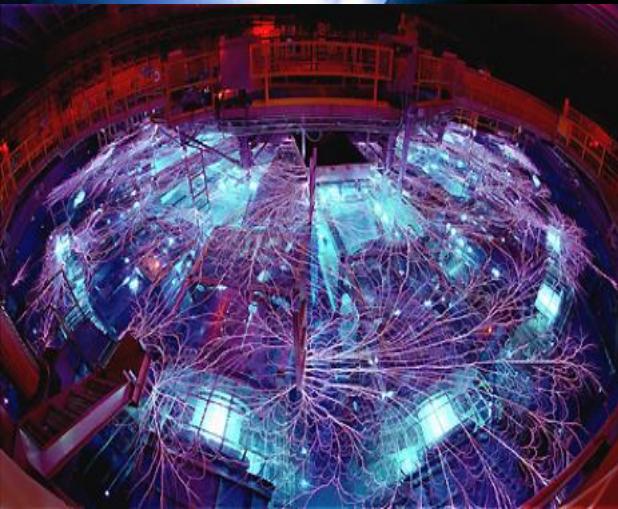
Uranium-238
(99.3% de tout U)

Fertile

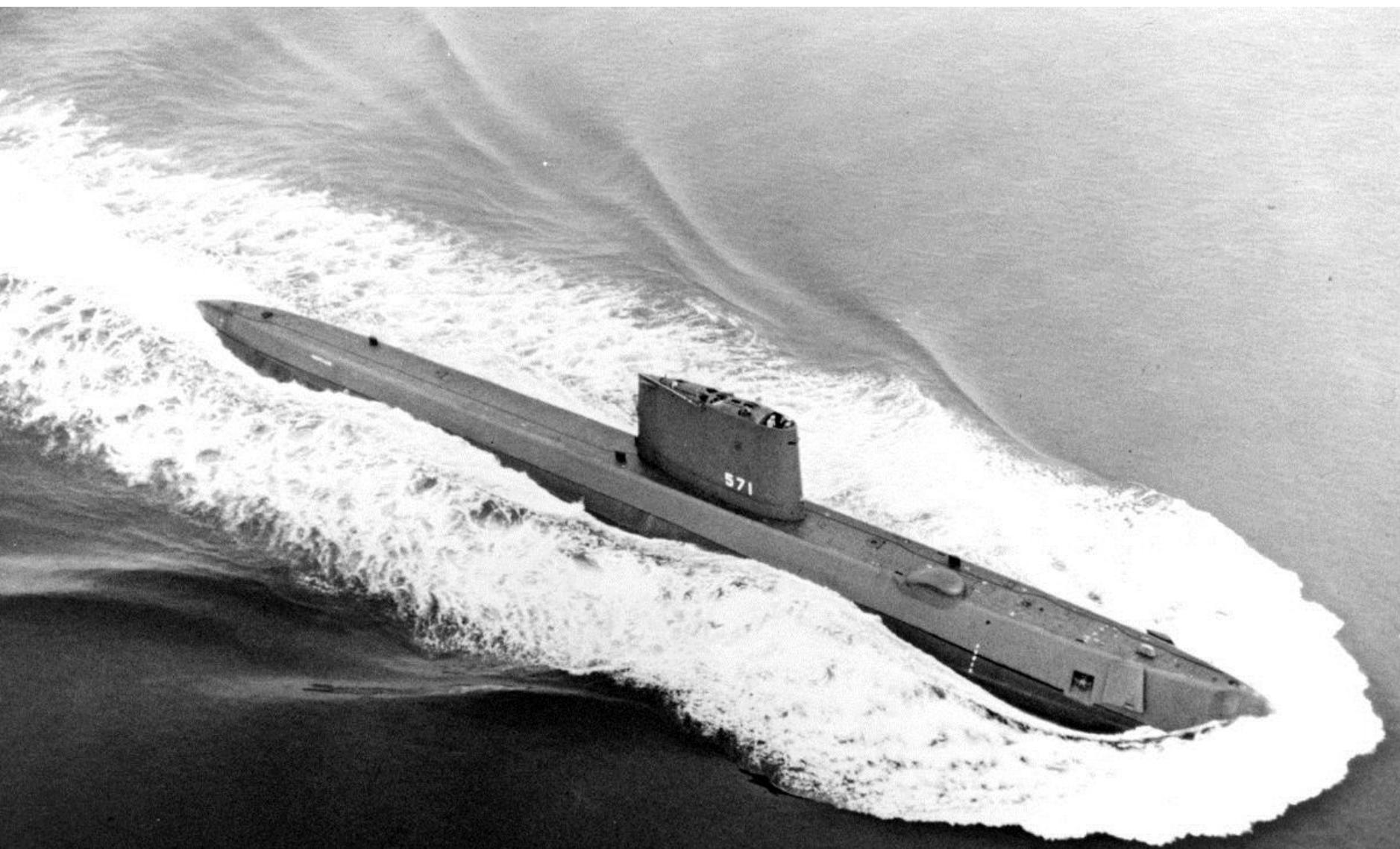


Pour produire 1 GigaWatt-Année d'électricité :



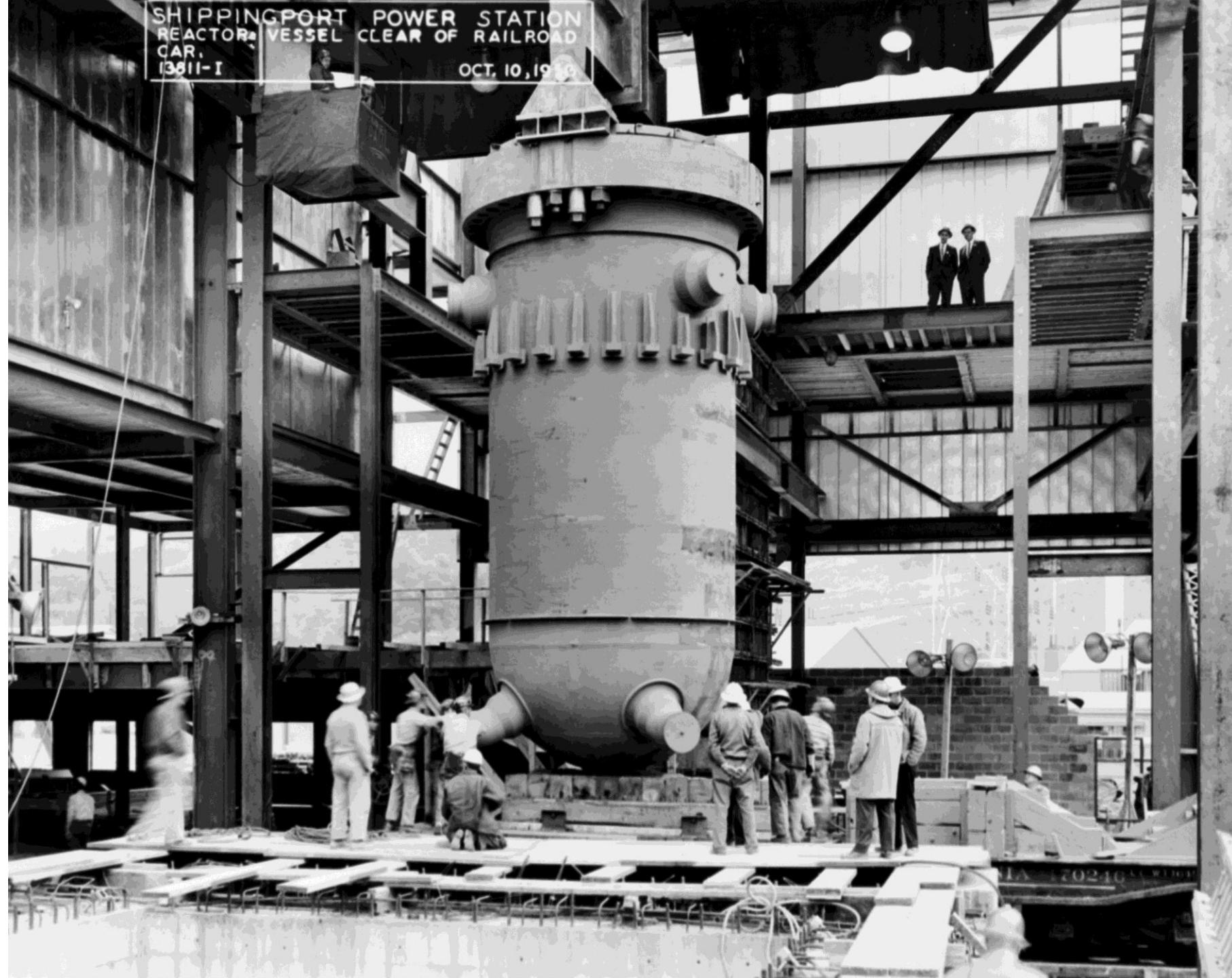


FIABLE 😊
BON MARCHÉ 😊
SÛRE 😕
DURABLE 😕
PROPRE 😕



SHIPPINGPORT POWER STATION
REACTOR VESSEL CLEAR OF RAILROAD
CAR.
13811-I

OCT. 10, 1959





**FISSION
LIQUIDE**

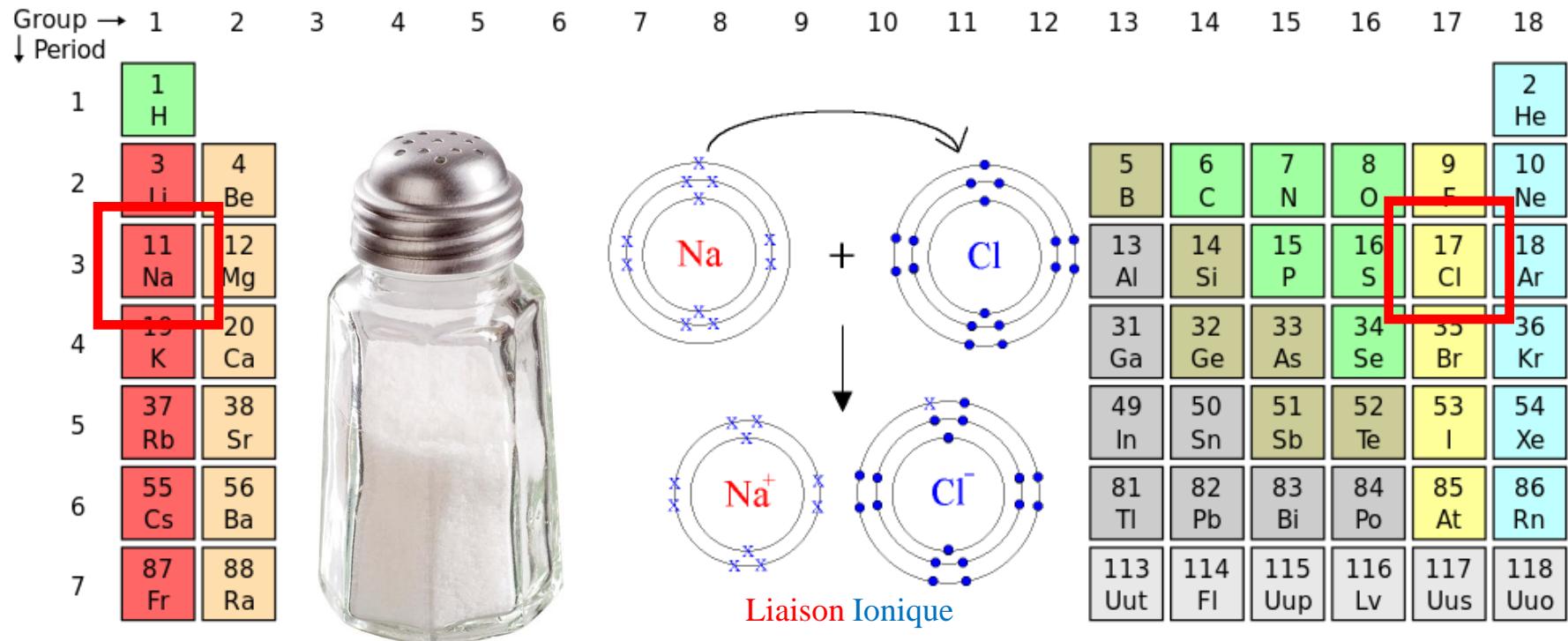
Quel Liquide ?



- Température de fusion basse
- Température d'ébullition élevée
- Bonnes propriétés thermiques
- Bonnes propriétés hydrauliques
- Bonne stabilité sous rayonnement
- Bonne solubilité des matériaux fissiles et fertiles
- Eviter la production d'isotopes radioactifs
- Permettre le retraitement du combustible



Sels Fondus



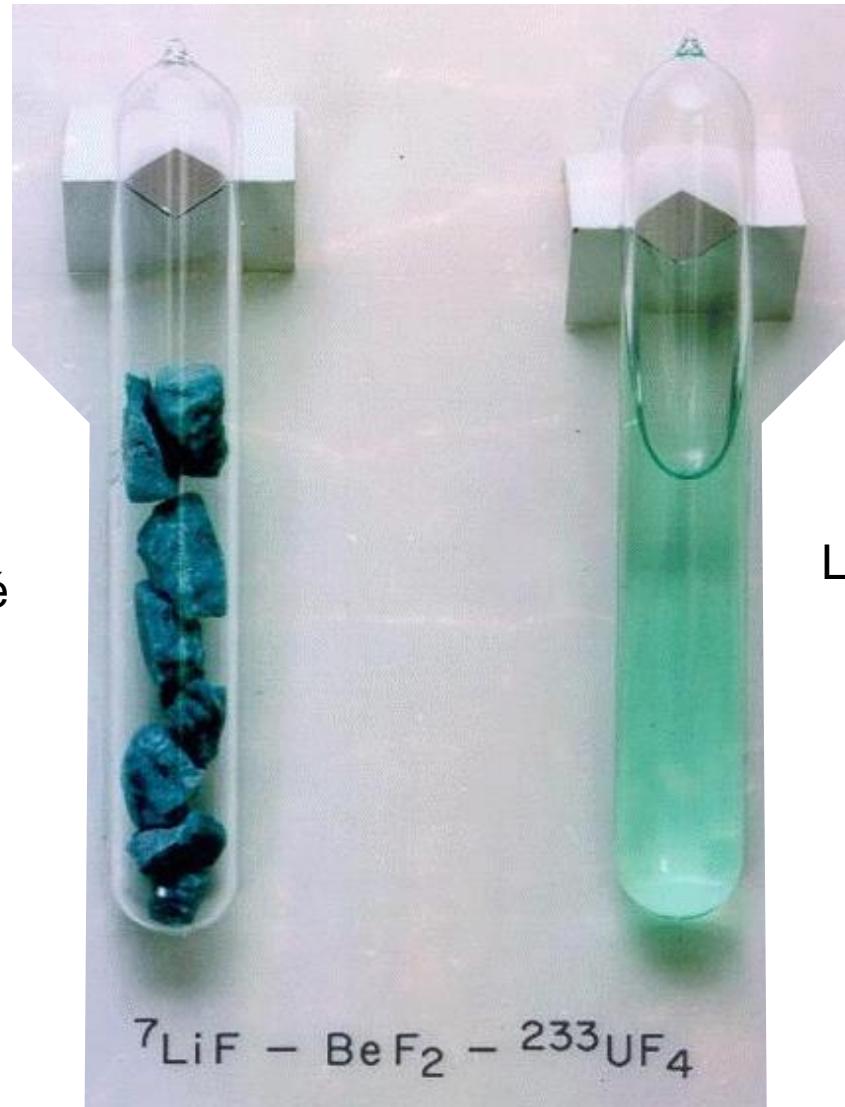
Lanthanides

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Actinides

LiF : Fluorure de Lithium
BeF : Fluorure de Béryllium
Mélange de Fluorures de Lithium & Béryllium : FLiBe

Combustibles nucléaires liquides

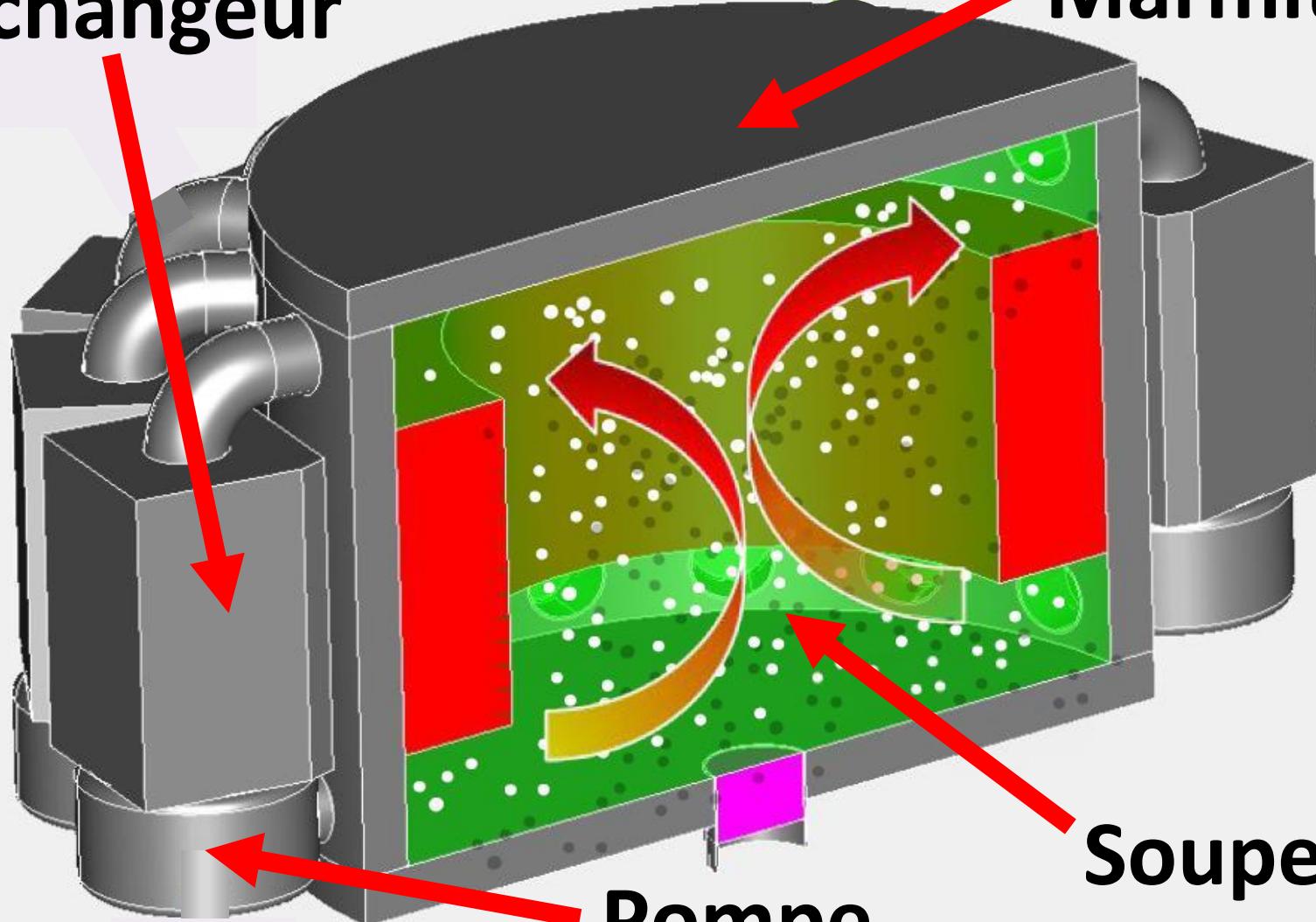


Echangeur

Marmite

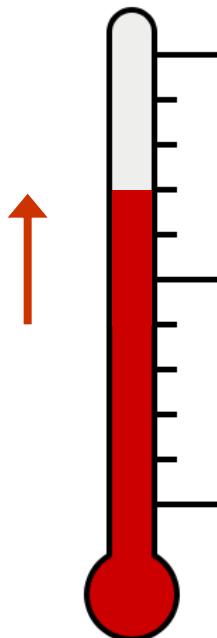
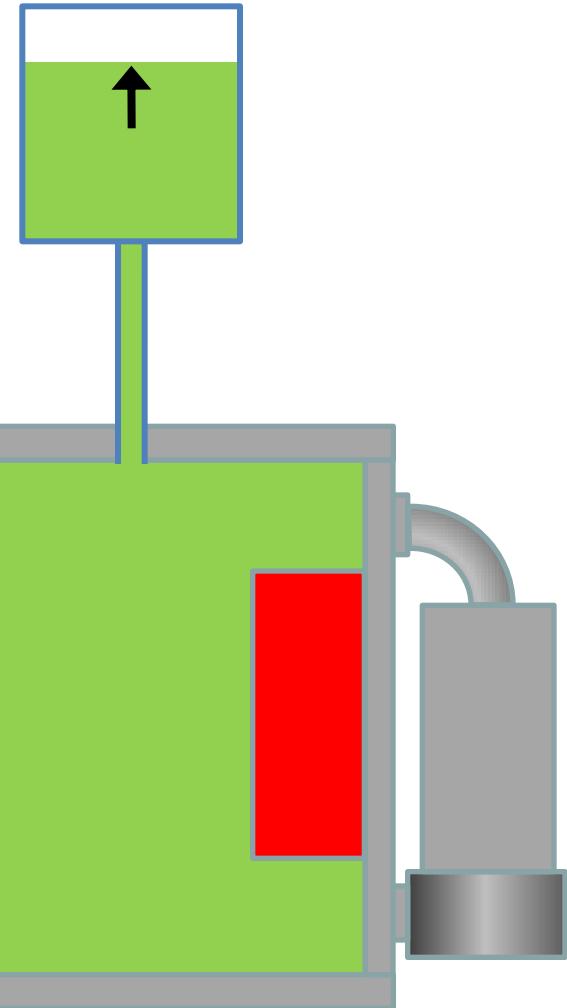
Pompe

Soupe



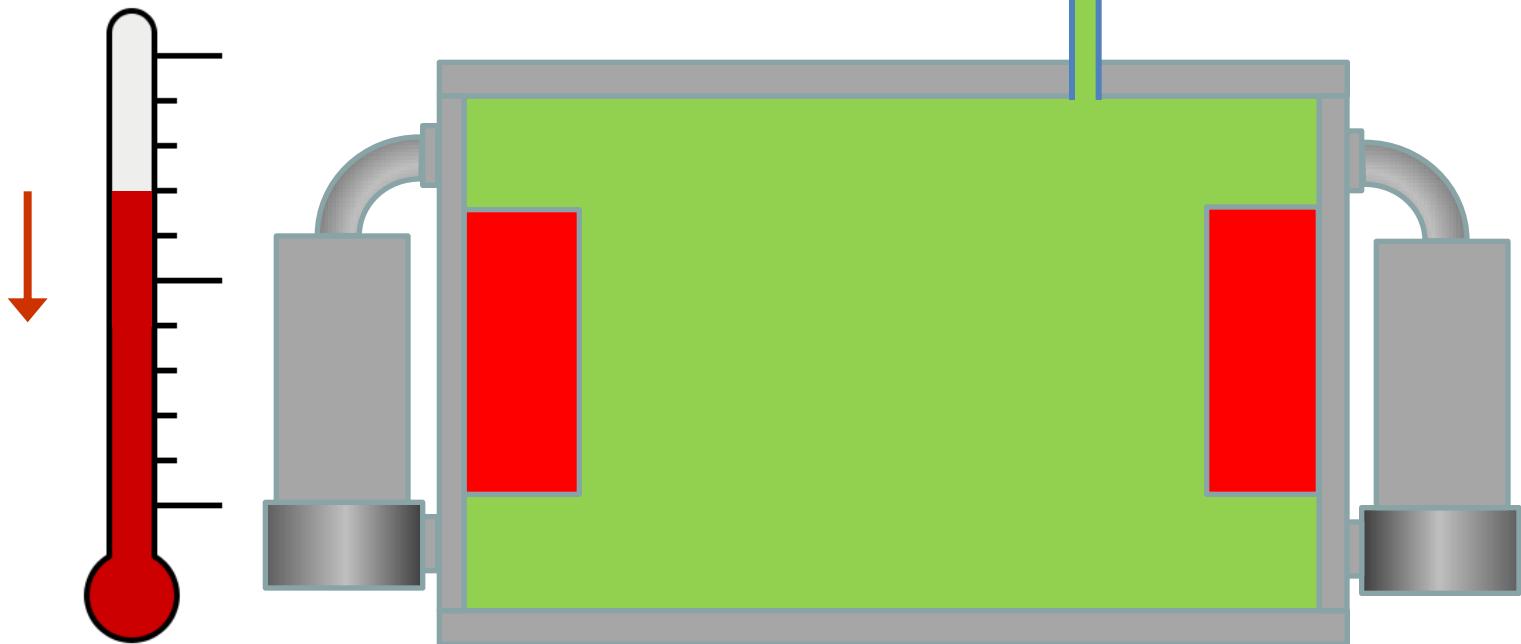
La température augmente

- Dilatation du liquide
- Moins de sel dans le cœur
- Ralentissement de la réaction

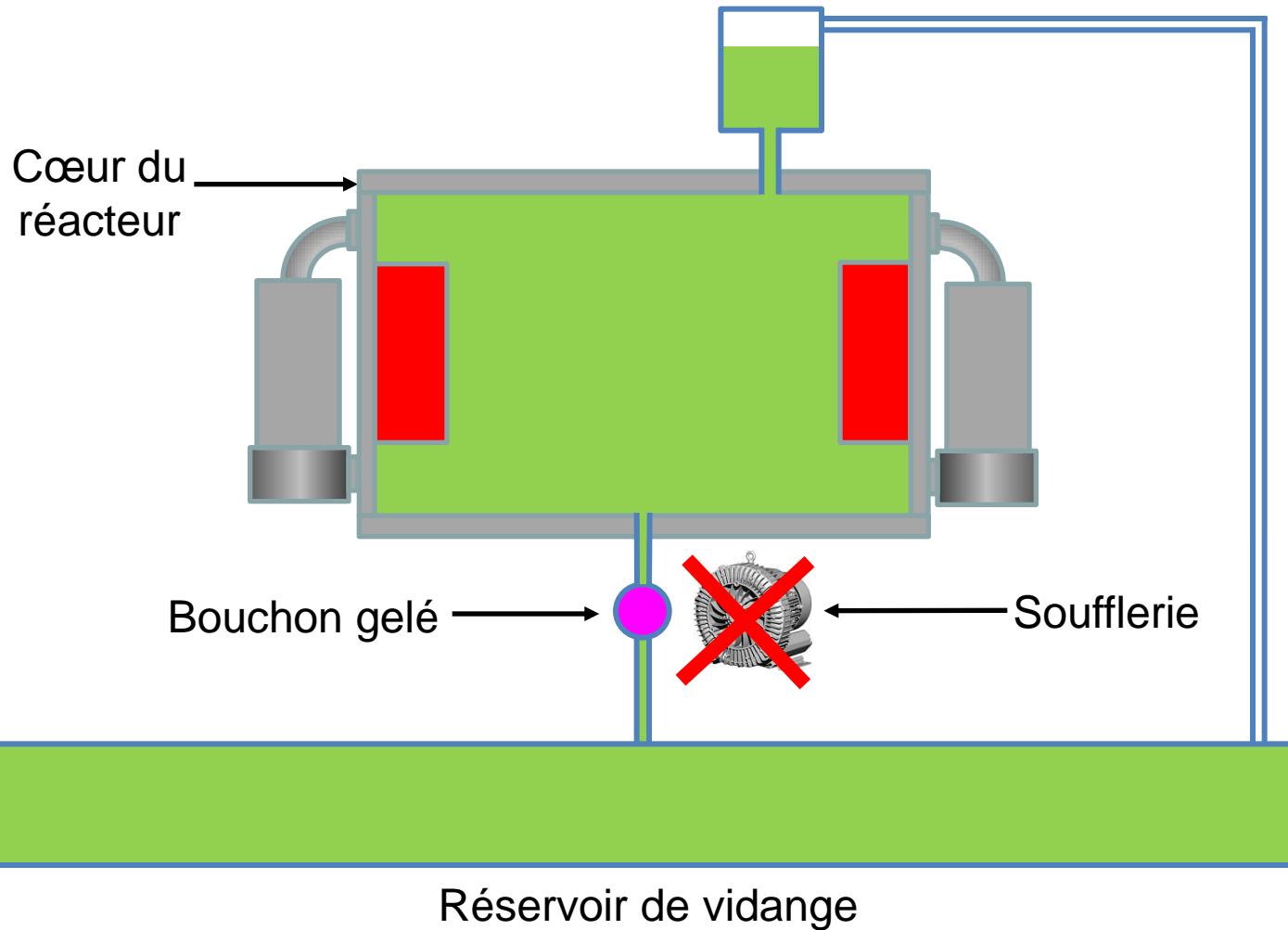


La température diminue

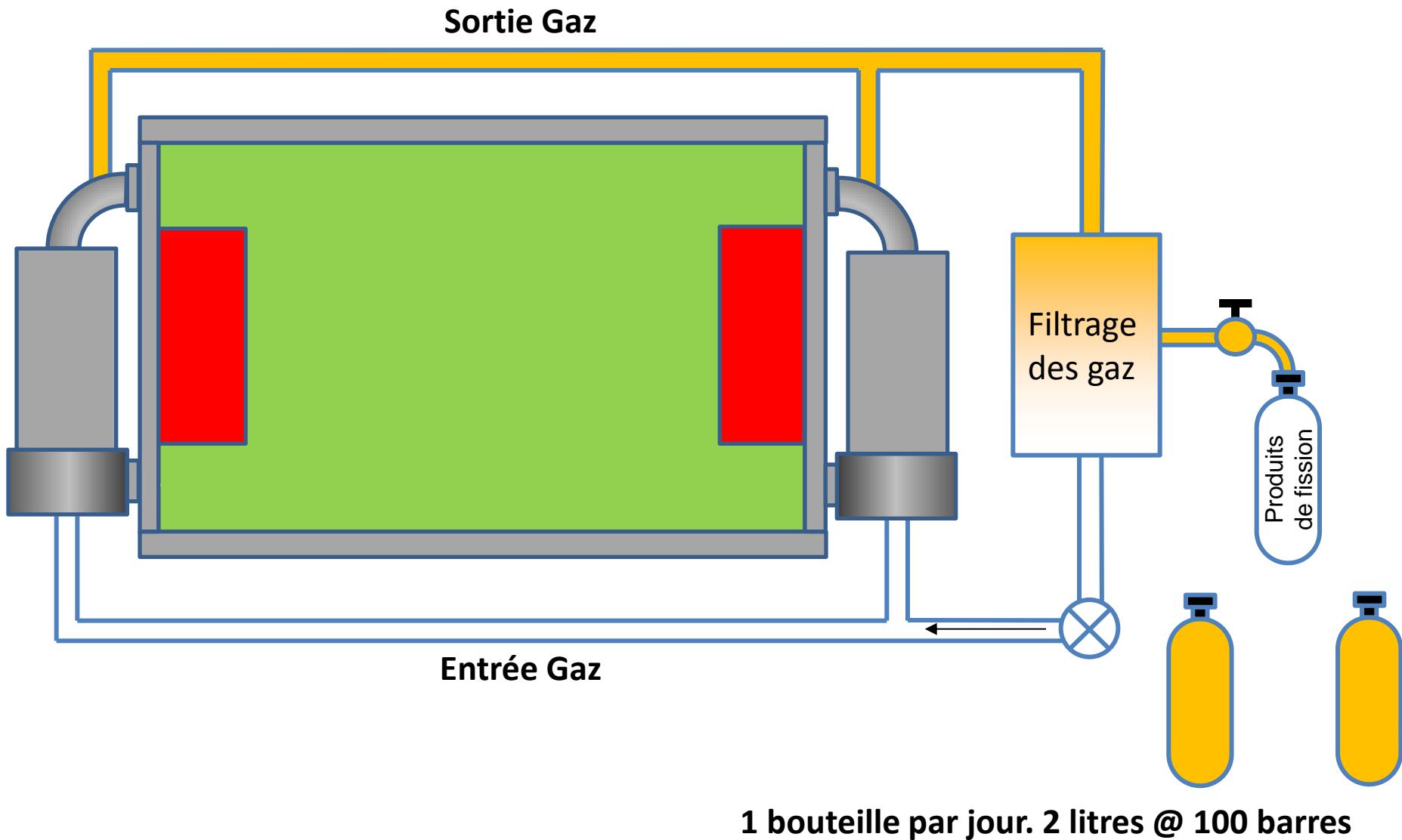
- Contraction du liquide
- Plus de sel dans le cœur
- Accélération de la réaction



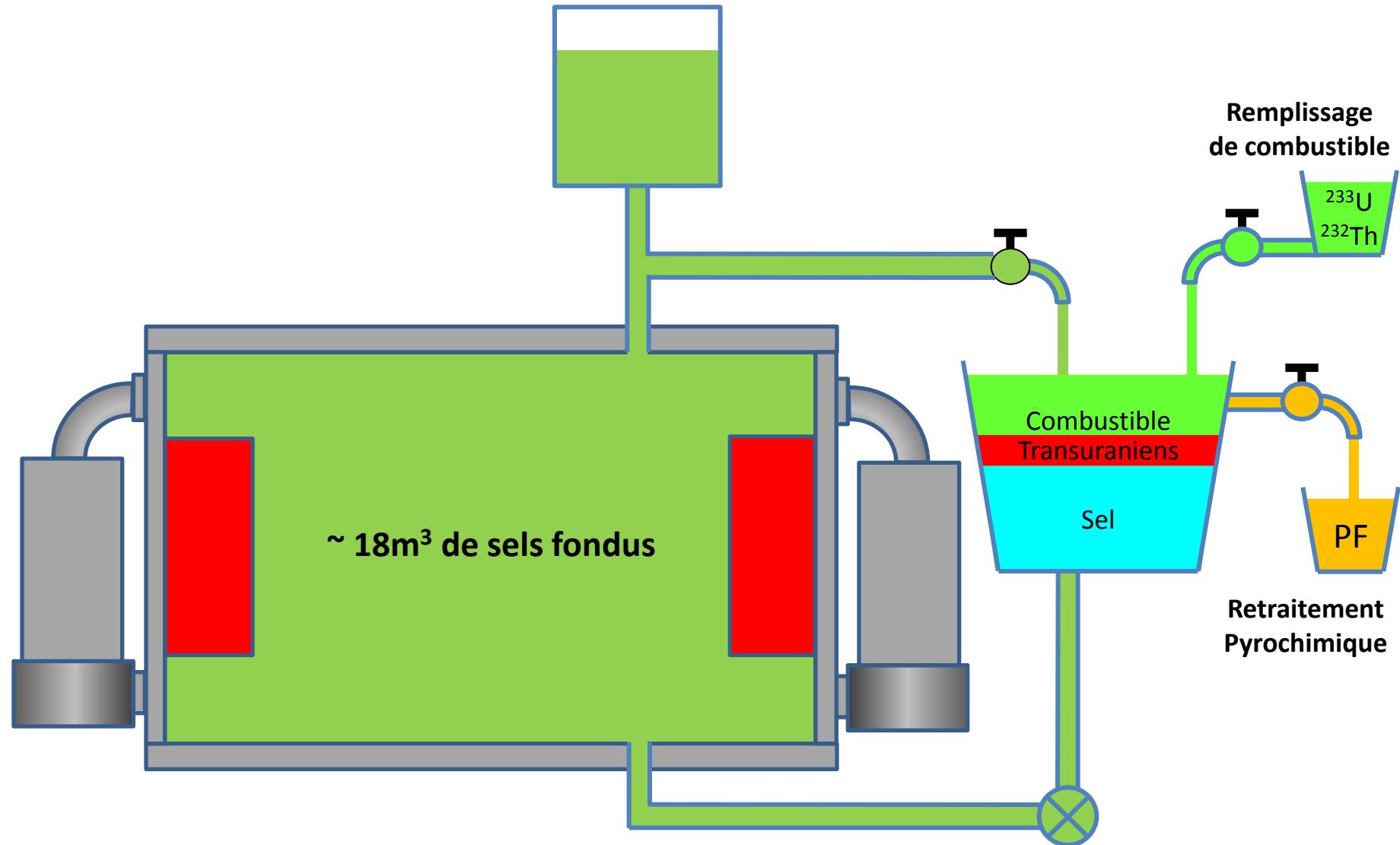
Enceinte de Confinement

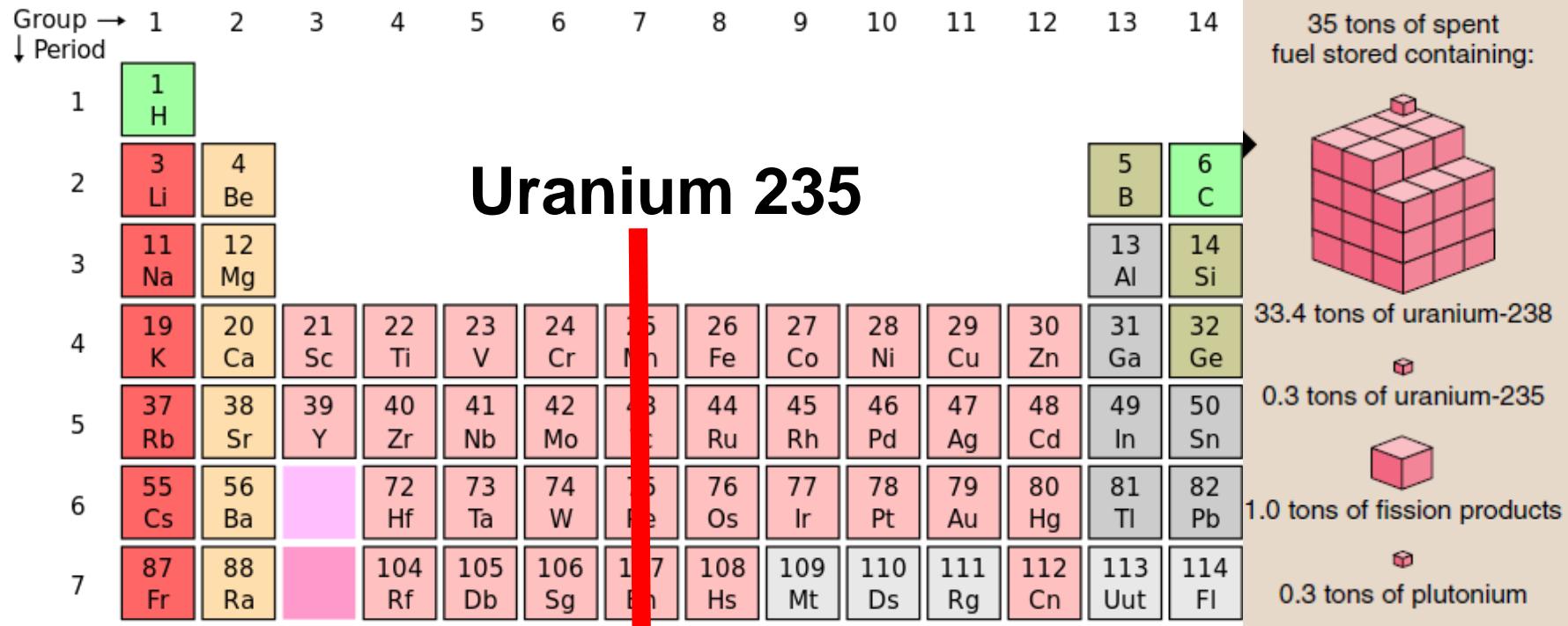


Nettoyage des produits de fission gazeux dans un réacteur MSFR par bullage de gaz



Traitement du sel combustible d'un réacteur à sels fondus MSFR





Lanthanides

57 La	58 Ce	59 Pr	60 Pm	61 Sm	62 Eu	63 Gd	64 Tb	65 Dy	66 Ho	67 Er	68 Tm	69 Yb	70 Lu	
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

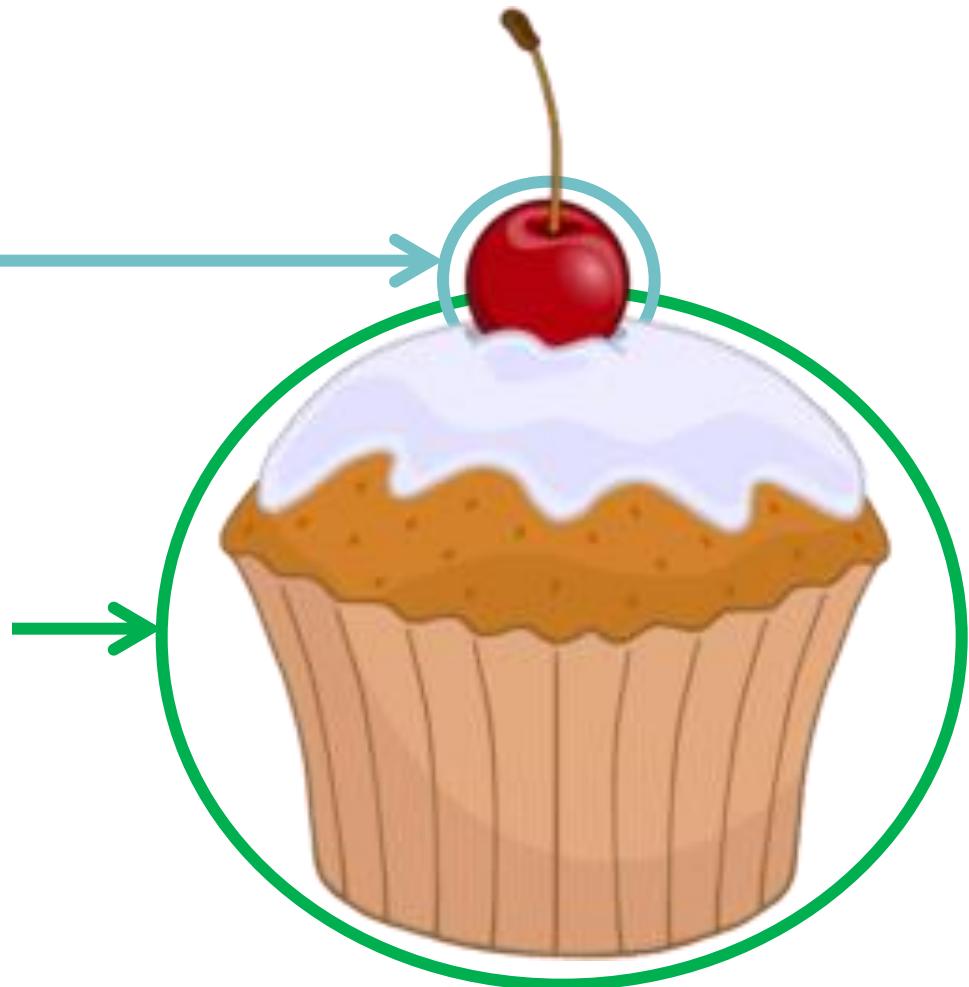
Thorium

Plutonium

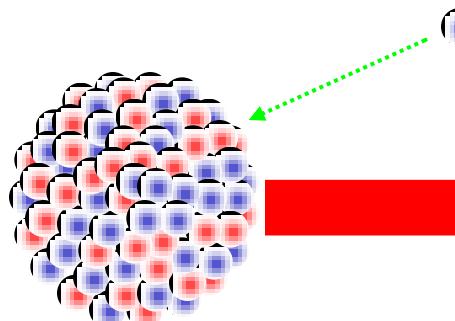
Le Thorium est la cerise sur le gâteau

Thorium

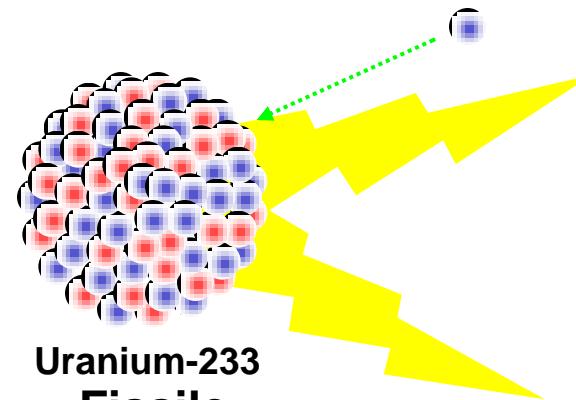
Combustible
Solide → Liquide



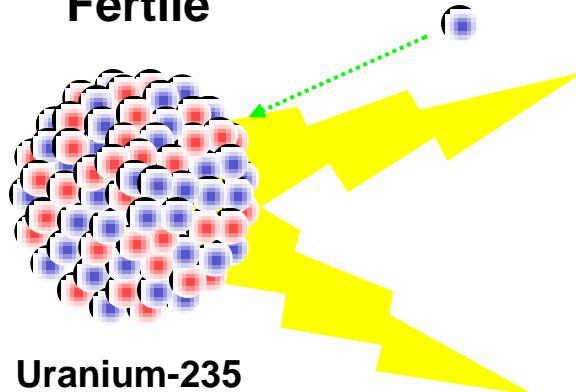
Trois options de combustible nucléaire



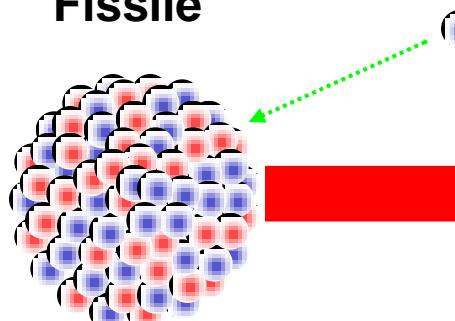
Thorium-232
Fertile



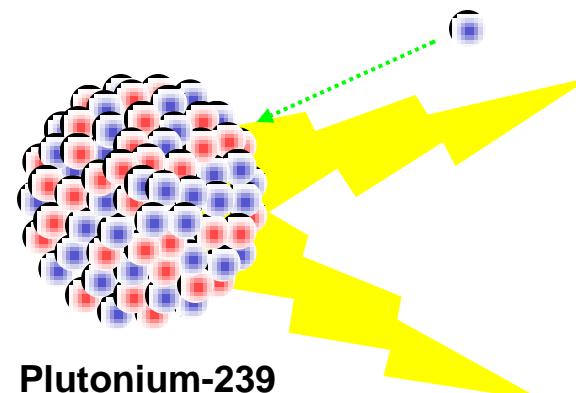
Uranium-233
Fissile



Uranium-235
Fissile

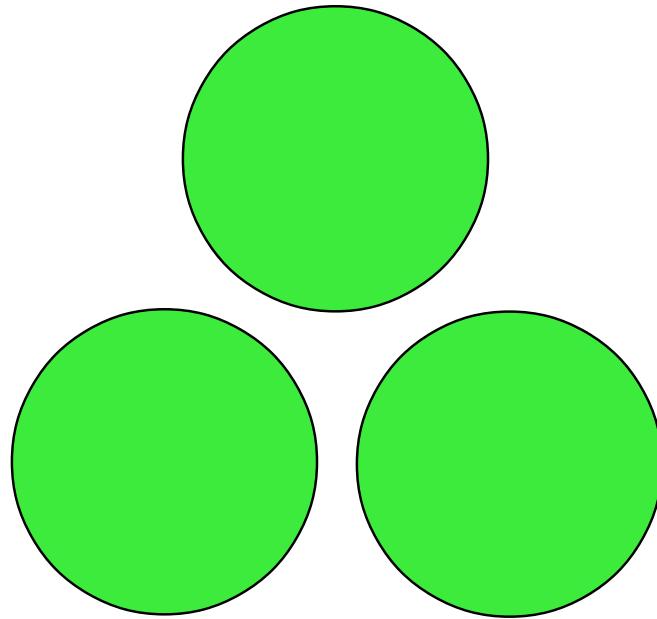
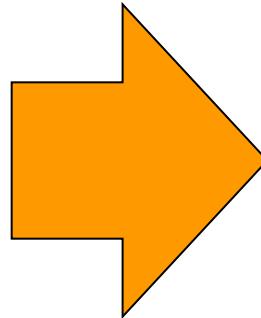
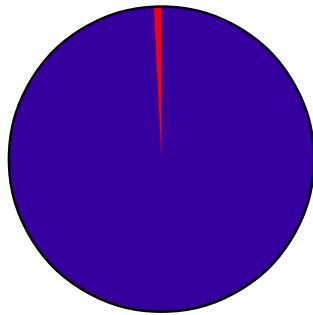


Uranium-238
Fertile



Plutonium-239
Fissile

Le Thorium est plus abondant



Uranium naturel
99.3% uranium-238
0.7% uranium-235

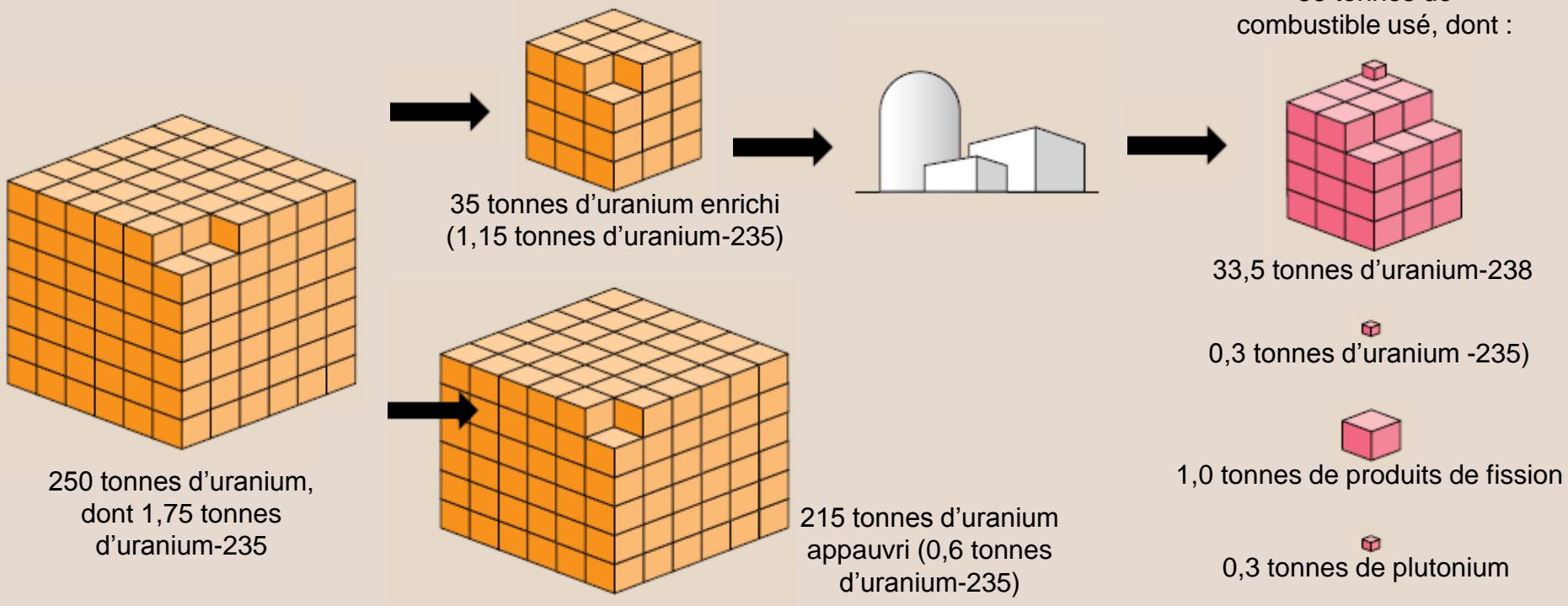
Thorium naturel
100% thorium-232

Réacteur à eau pressurisé :
Typiquement 0,5% de la teneur
en énergie de l'uranium

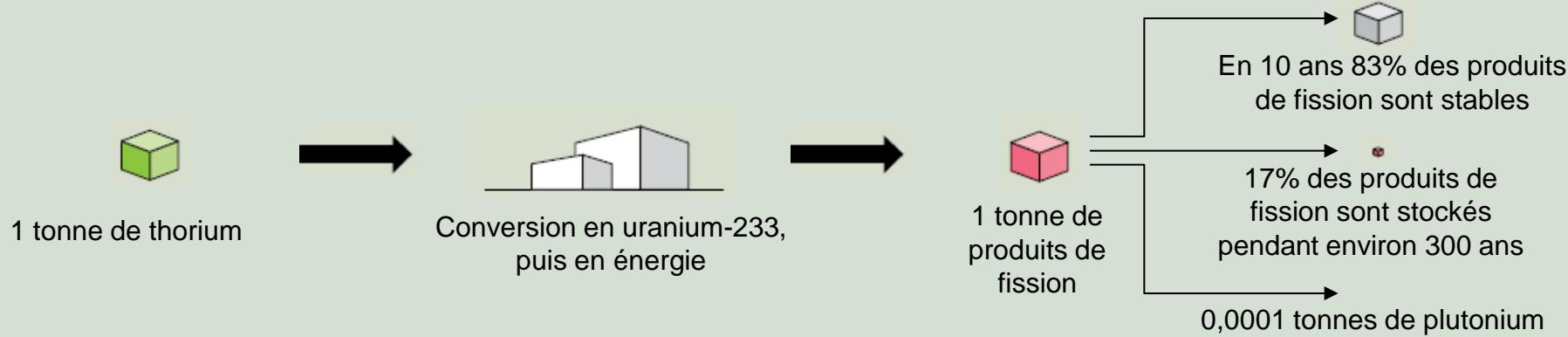
Combustible liquide :
100% de la teneur en
énergie du thorium

Pour produire 1 GigaWatt-Année d'électricité :

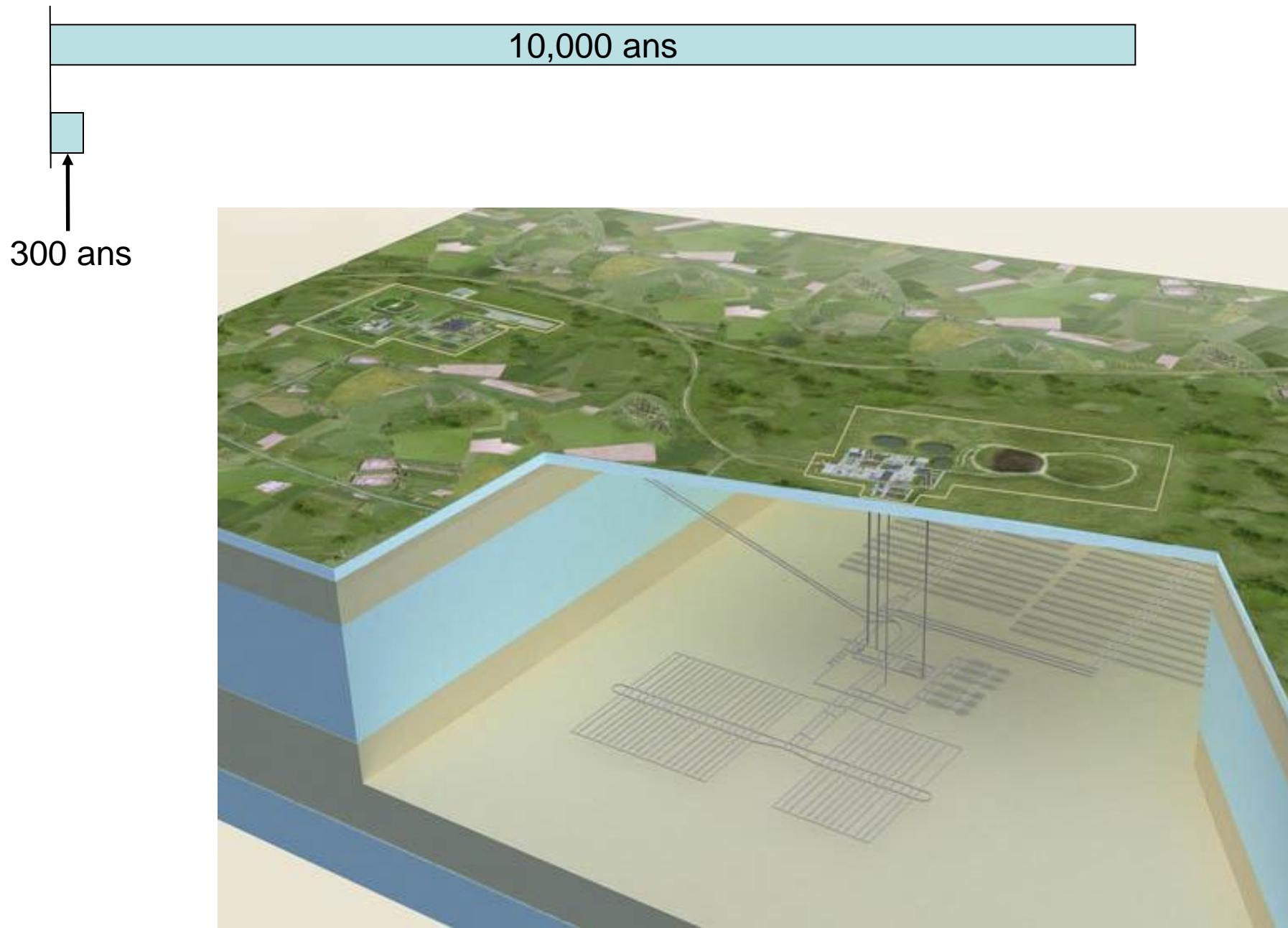
Réacteur à Eau Pressurisée



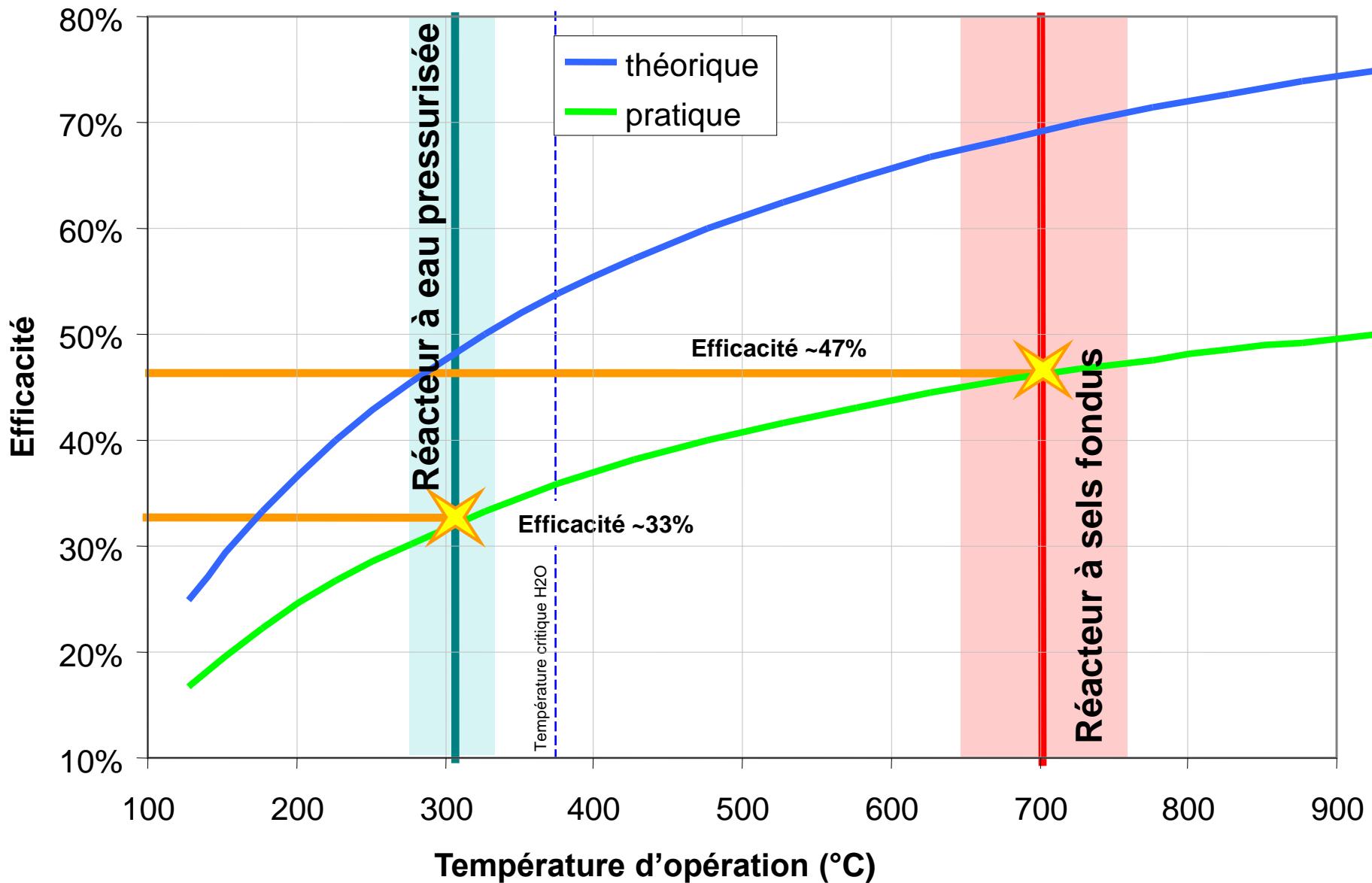
Réacteur à Sels Fondus

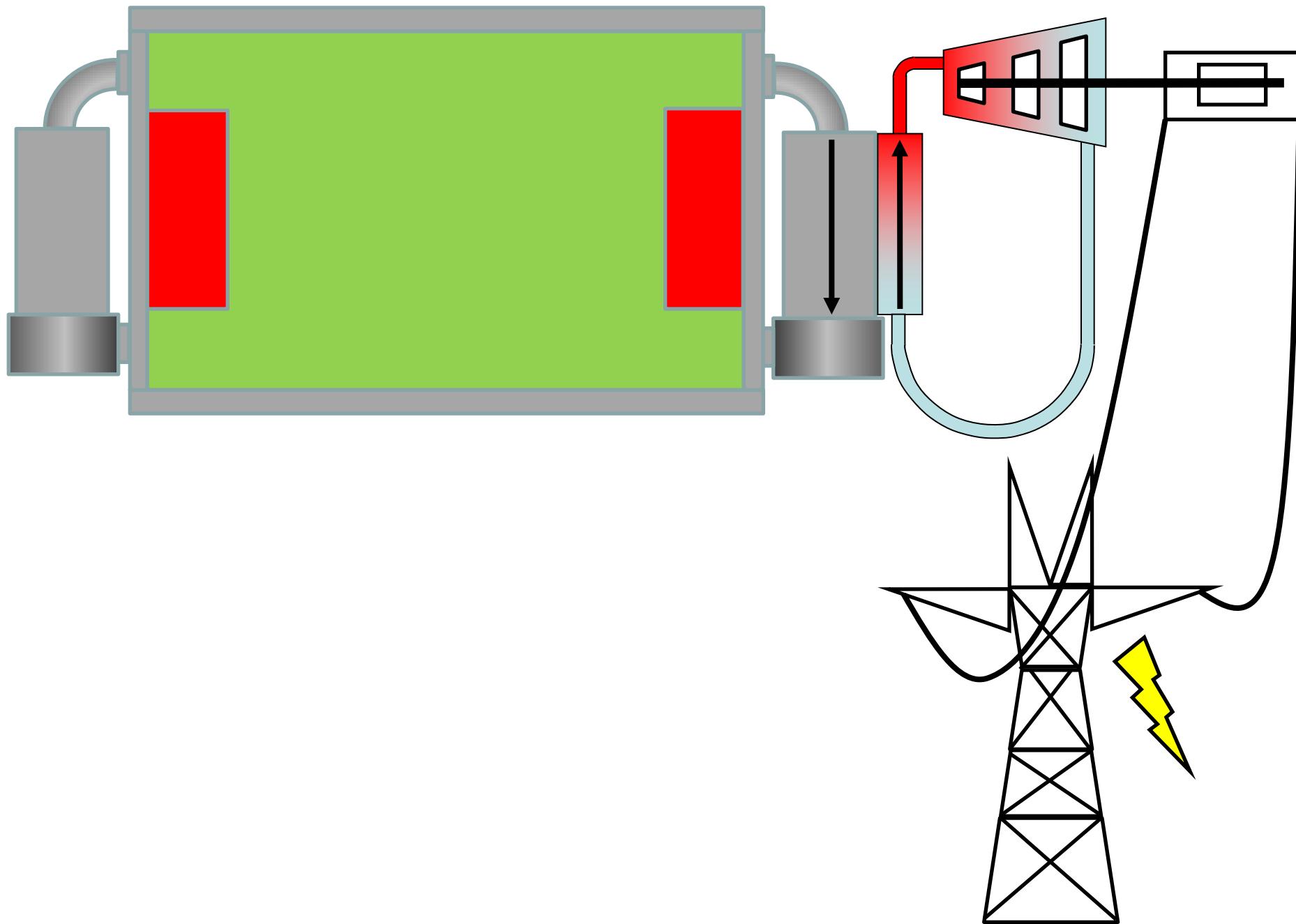


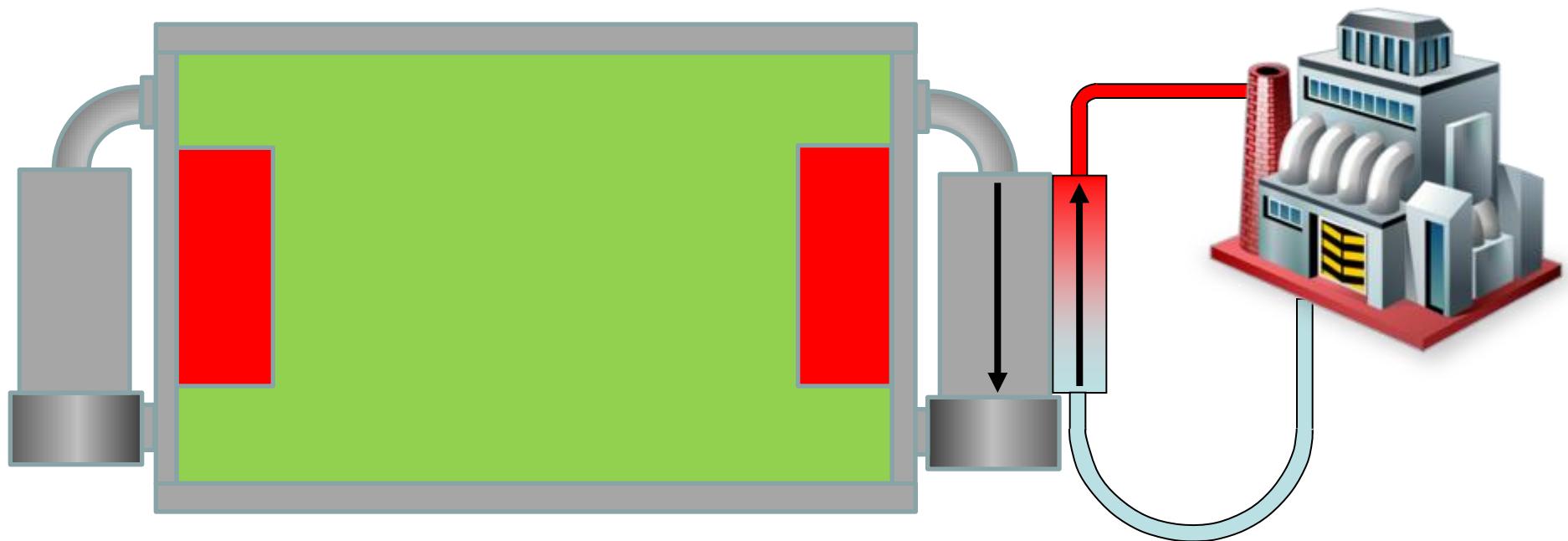
Aujourd'hui



Conversion de puissance Chaleur → Électricité





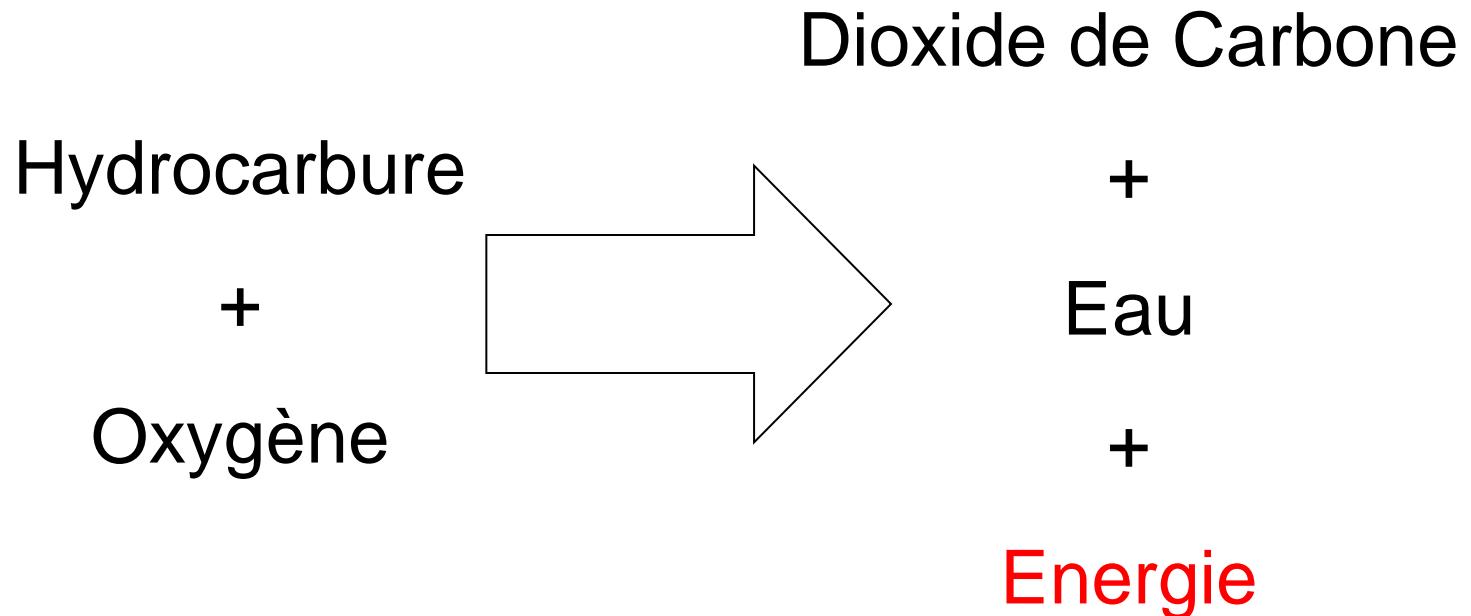


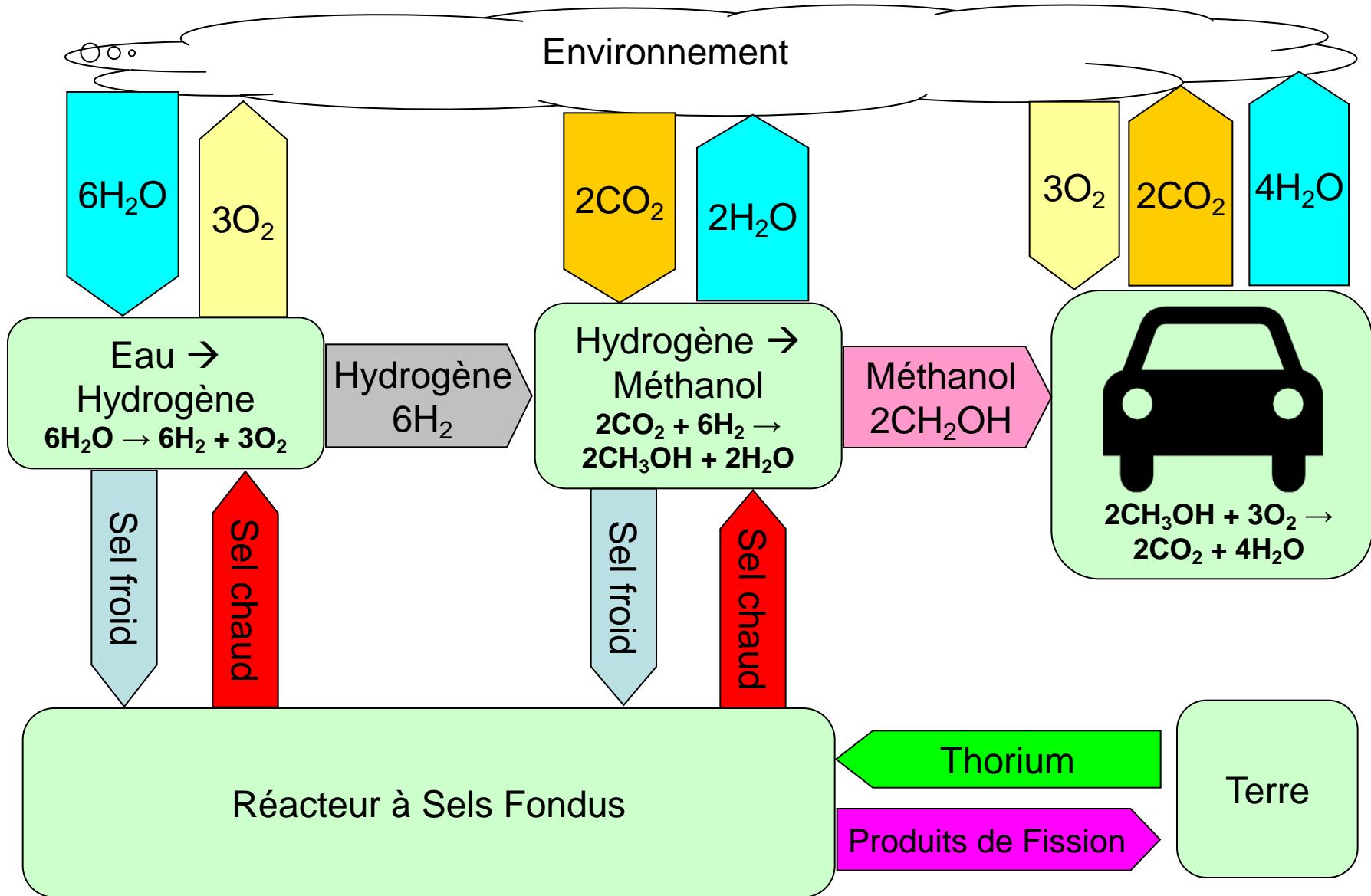






Carburants de synthèse à partir de la chaleur nucléaire

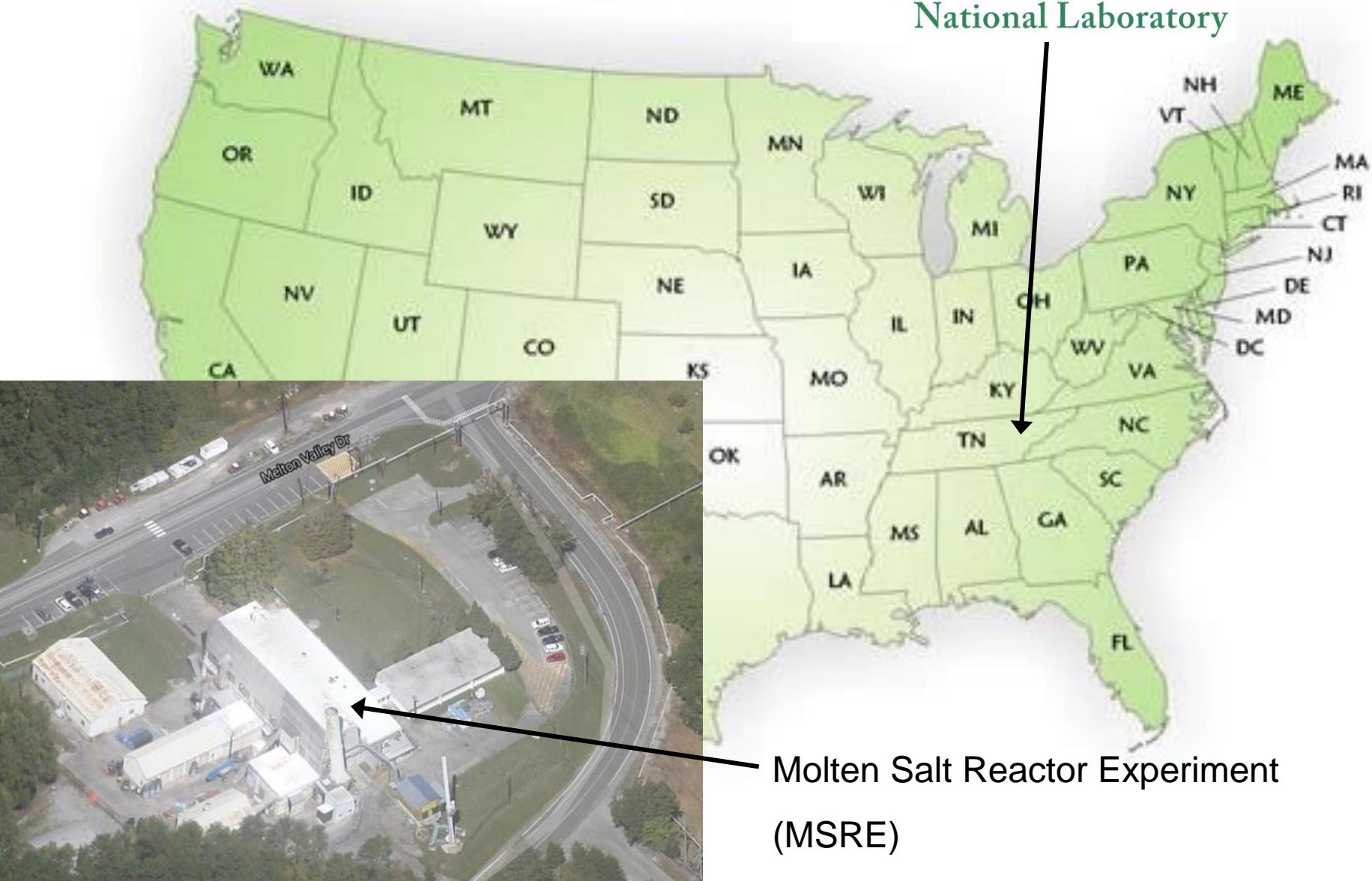




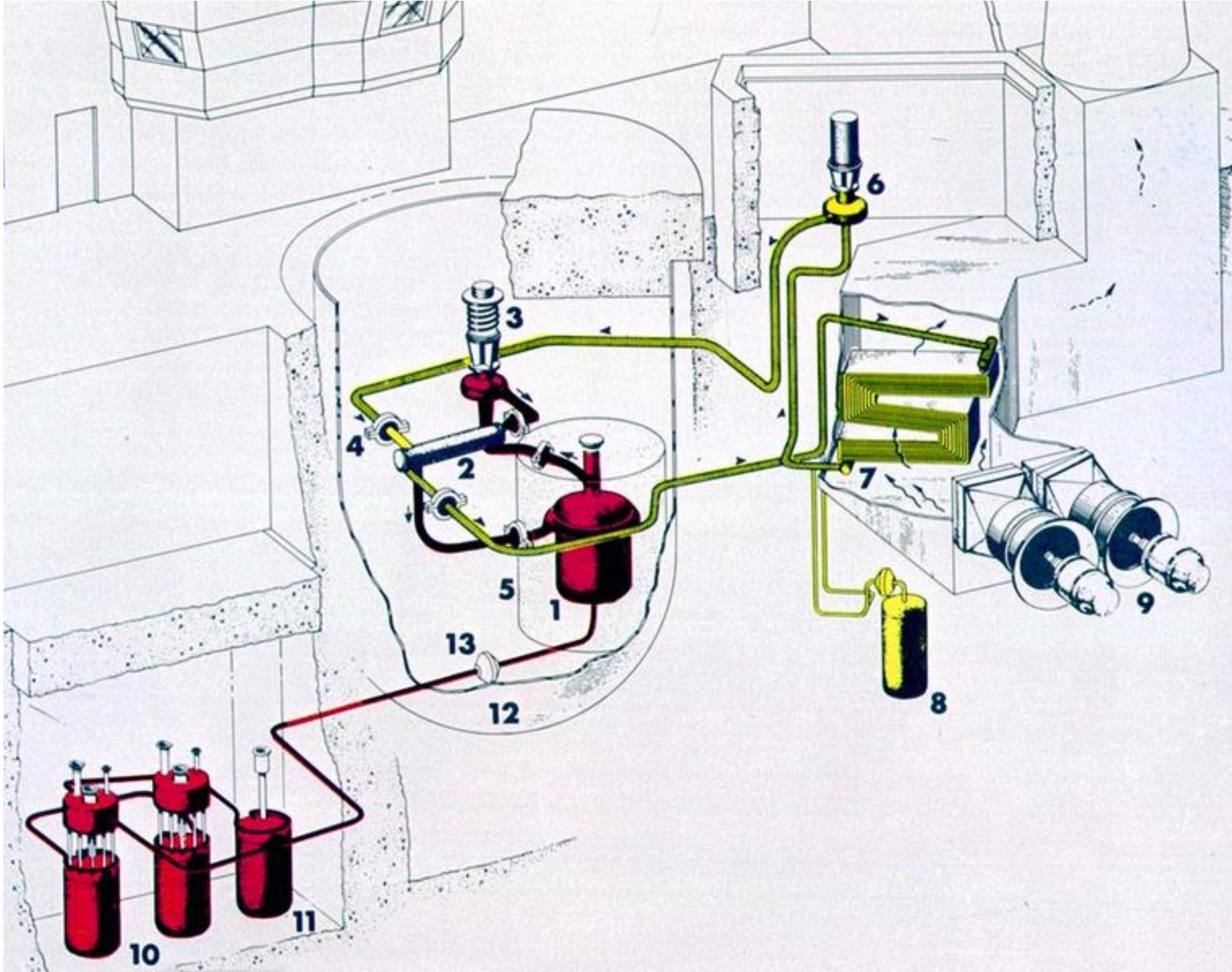


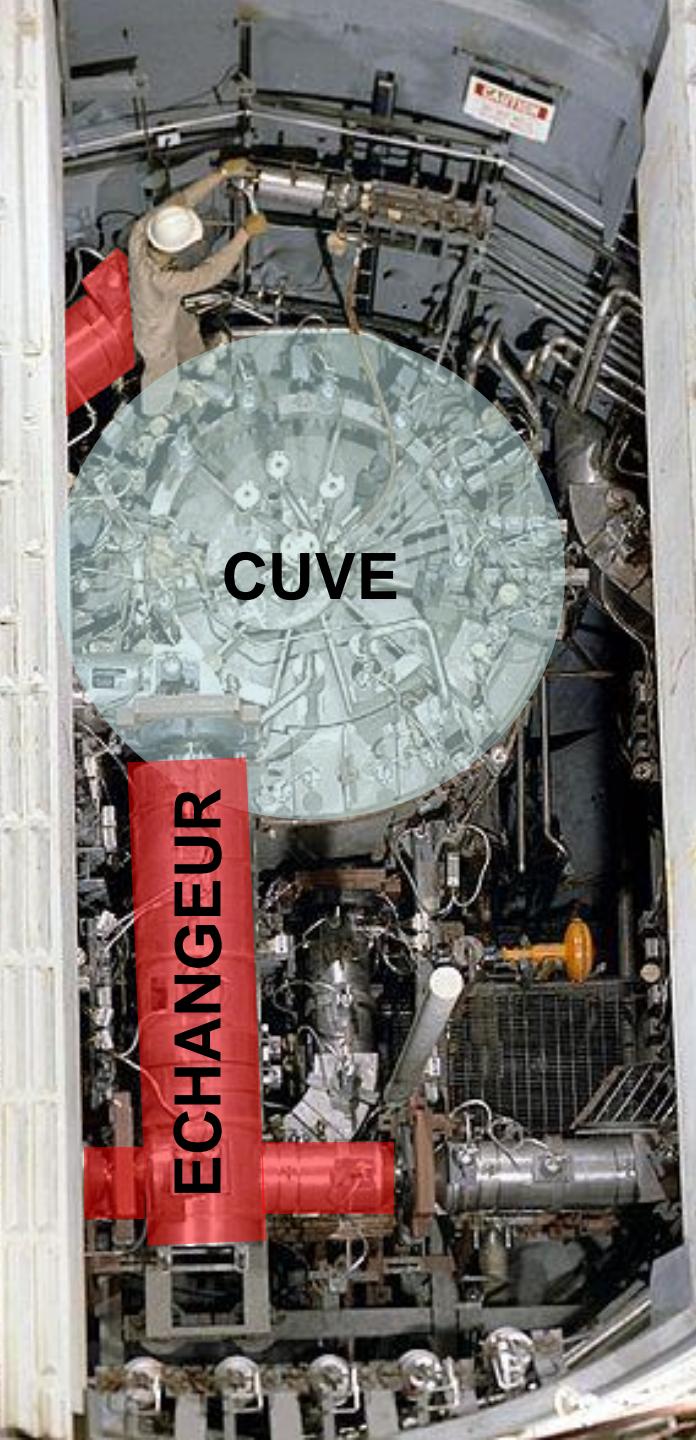
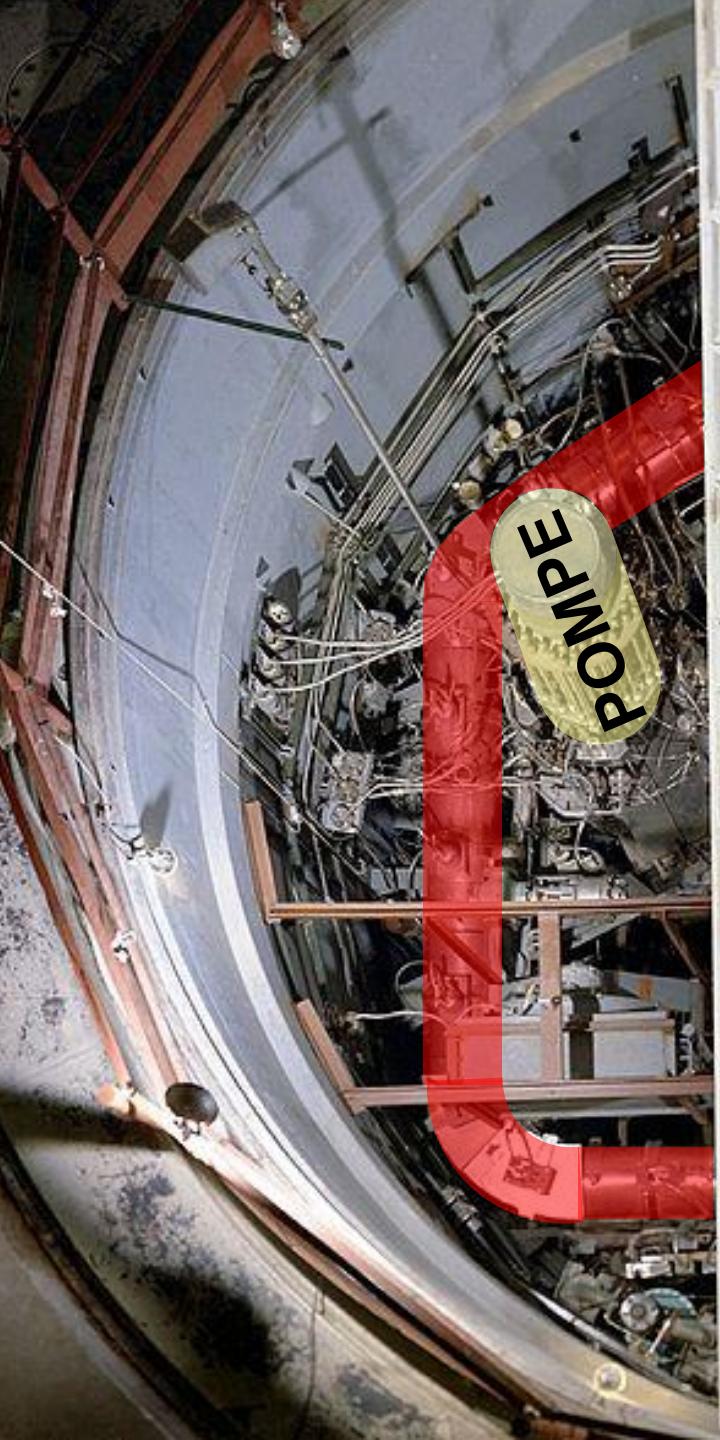


Alvin Weinberg

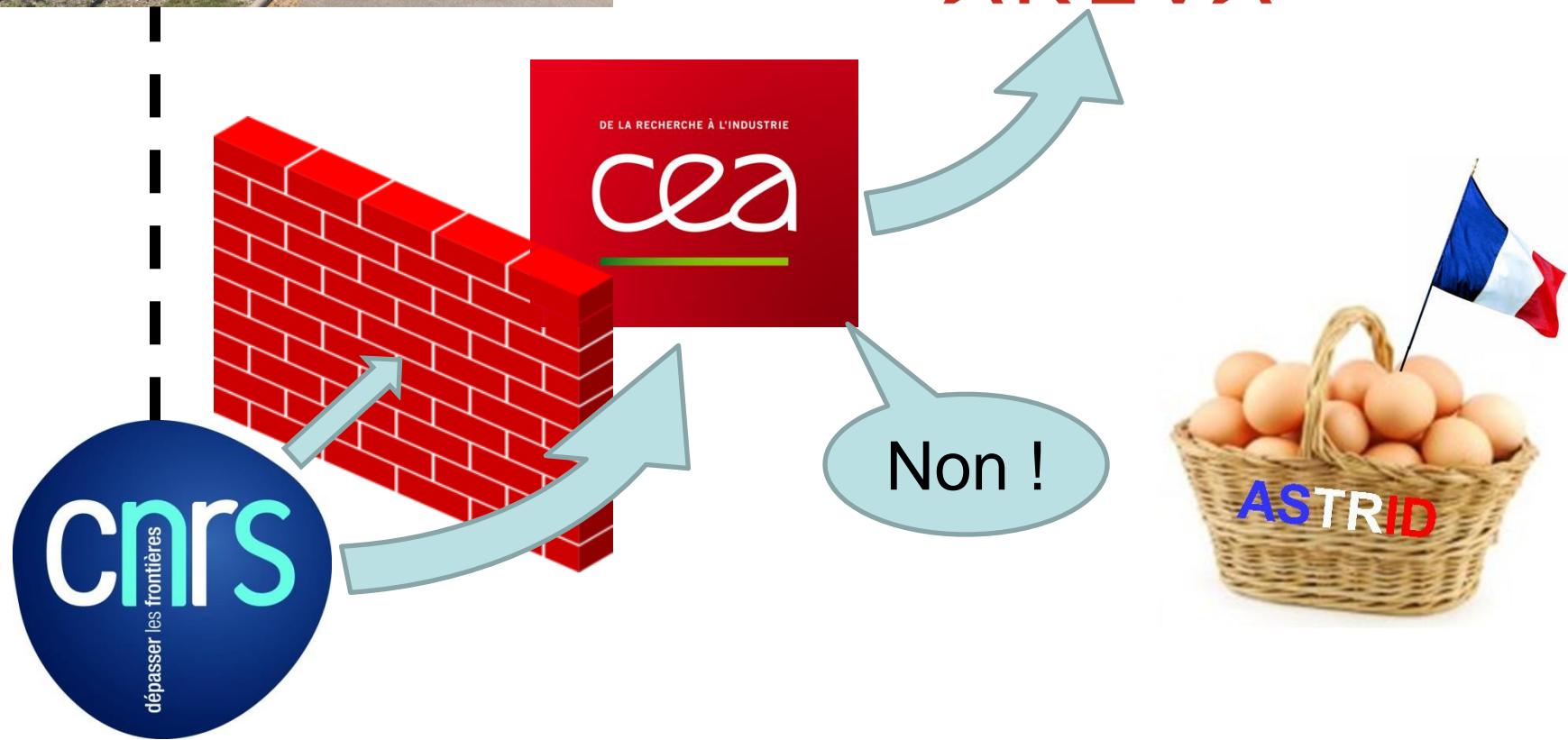


Molten Salt Reactor Experiment
(MSRE)











Jiang Mianheng

Hongjie Xu

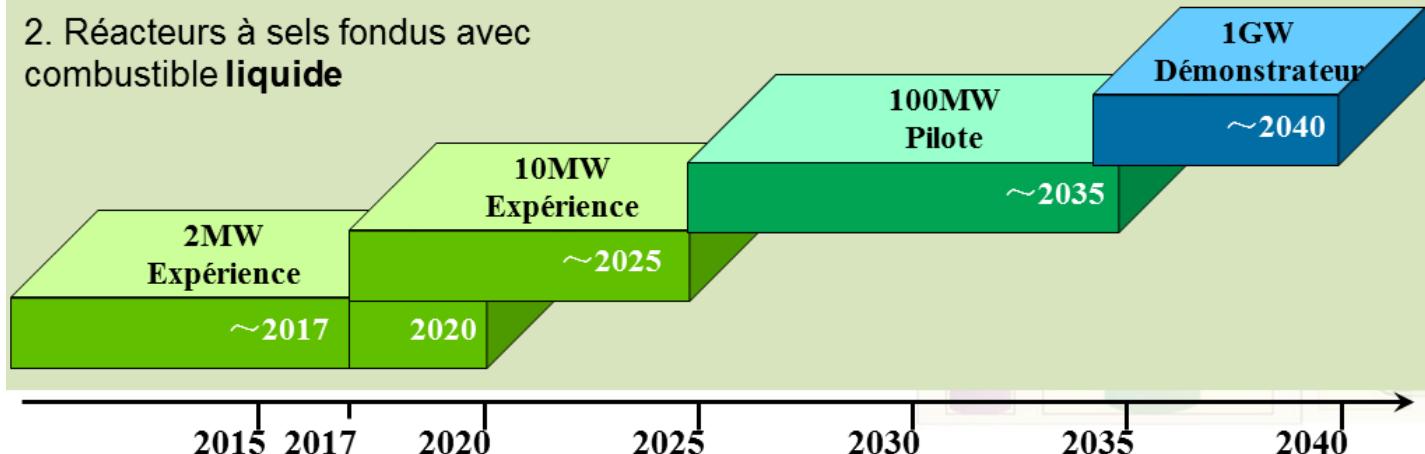


1. Réacteurs à combustible solide, refroidis aux sels fondus



Ce programme permettra également de prototyper, démontrer, puis commercialiser la production de méthanol et hydrogène nucléaire

2. Réacteurs à sels fondus avec combustible liquide





TERRESTRIAL ENERGY

Ex-PDG, Energie Atomique du Canada limité

Avocat



Ingénieur, industrie des sables bitumineux



Scientifique, exploration pétrolière



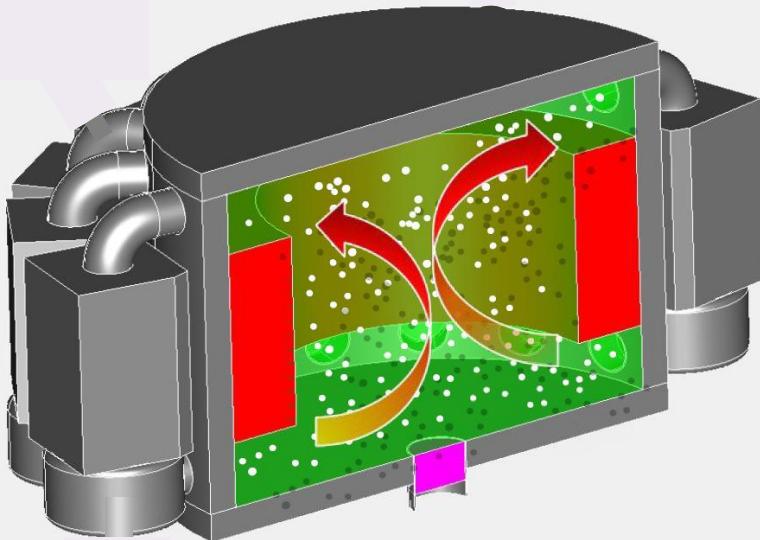
Directeur, alliance pour l'énergie du thorium (association)

Banquier

David Leblanc
Physicien, expert en réacteurs à sels fondus

Financier

Cadre, industrie pétrolière



FISSION LIQUIDE

FIABLE 😊

BON MARCHÉ 😊

SÛR 😊

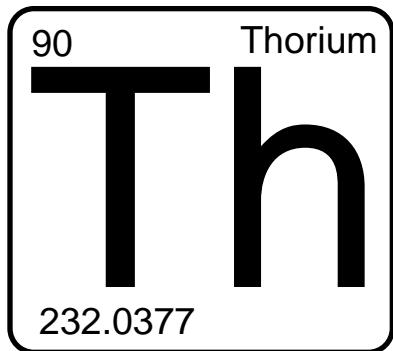
DURABLE 😊

PROPRE 😊



Request to the audience :

Please :



Think about
Liquid Fission

Pour en savoir plus :

The screenshot shows the homepage of the Energie du Thorium website. At the top, there's a navigation bar with links for Accueil, Communication, Education, Promotion, R&D, and A propos. Below the navigation is a large grid of images related to thorium energy, including diagrams of reactors, portraits of people, and various scientific and industrial scenes. The overall theme is the promotion of thorium as a future energy source.

<http://energieduthorium.fr>

The screenshot shows the Facebook page for Energie du Thorium. It features a large profile picture with the letters 'Ed Th'. The page has 90 likes and 4 people talking about it. A prominent 'Like' button is displayed with a hand cursor pointing at it, and an arrow points upwards towards it. Below the button, there are links for Follow, Message, and a dropdown menu. The page description includes the text 'Le thorium comme source d'énergie du futur www.energieduthorium.fr'. There are also links for Photos and Likes.

<https://www.facebook.com/energieduthorium>

The screenshot shows the Twitter profile for @EnergieduTh. It features a large header with the letters 'Ed Th' and the text 'Energie du Thorium'. Below the header is a 'Suivre' (Follow) button with a hand cursor pointing at it. The profile also includes the Twitter handle '@EnergieduTh'.

<https://twitter.com/EnergieduTh>

The screenshot displays logos of several partner institutions: LPSC Grenoble, Laboratoire de Physique Subatomique et de Cosmologie; CNRS IN2P3 Les deux Infinis; and Université Joseph Fourier GRENoble. The LPSC logo is on the left, featuring the letters 'LPSC' with 'Grenoble' underneath. The CNRS IN2P3 logo is in the center, with 'IN2P3' in red and 'Les deux Infinis' in blue. The Université Joseph Fourier GRENoble logo is on the right, with 'Université Joseph Fourier' in red and 'GRENoble' in blue.

LPSC Grenoble