The Plutonium Economy in France
Under Increasing Pressure

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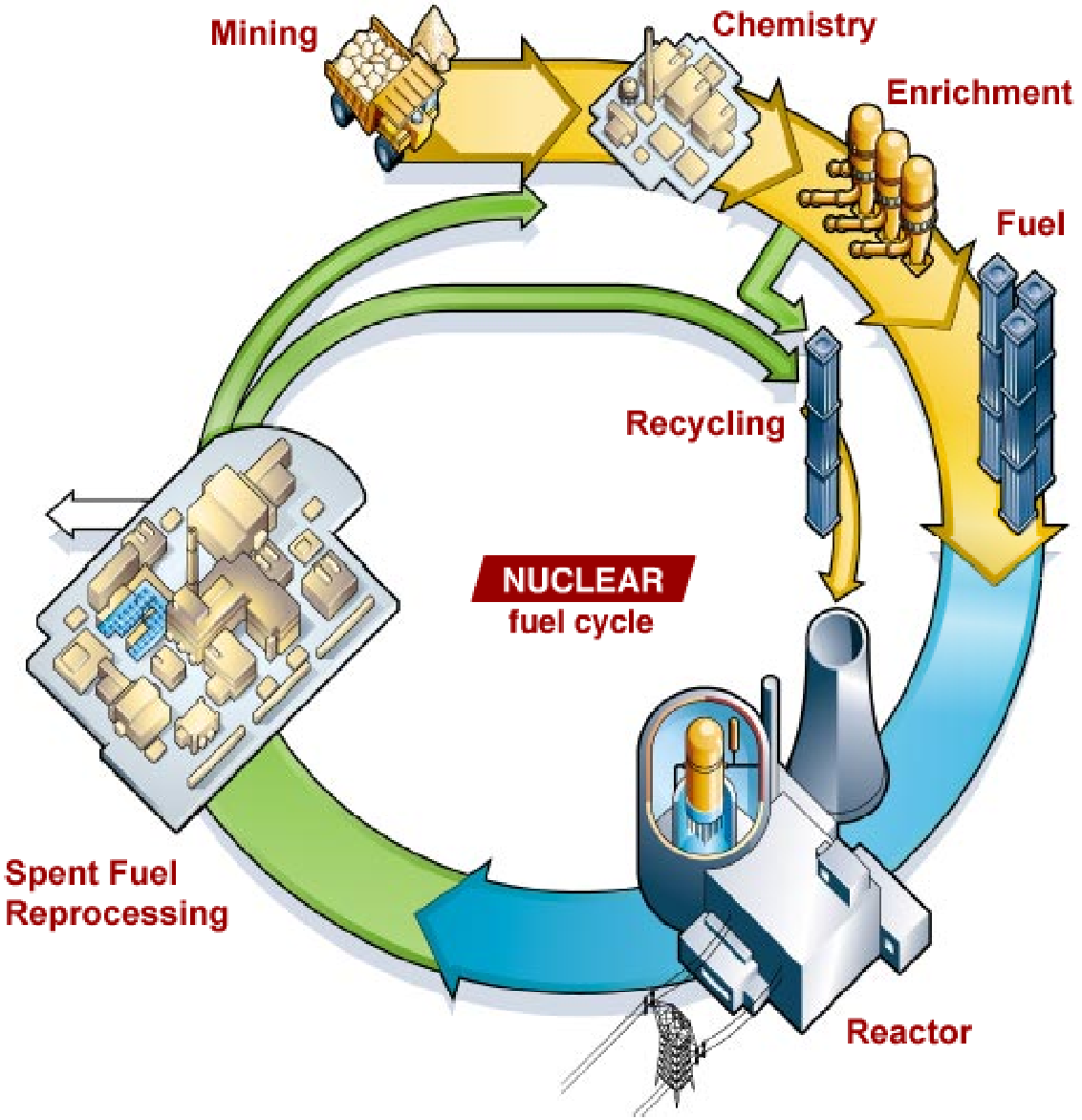
Pressure Points – What Are the Limits?

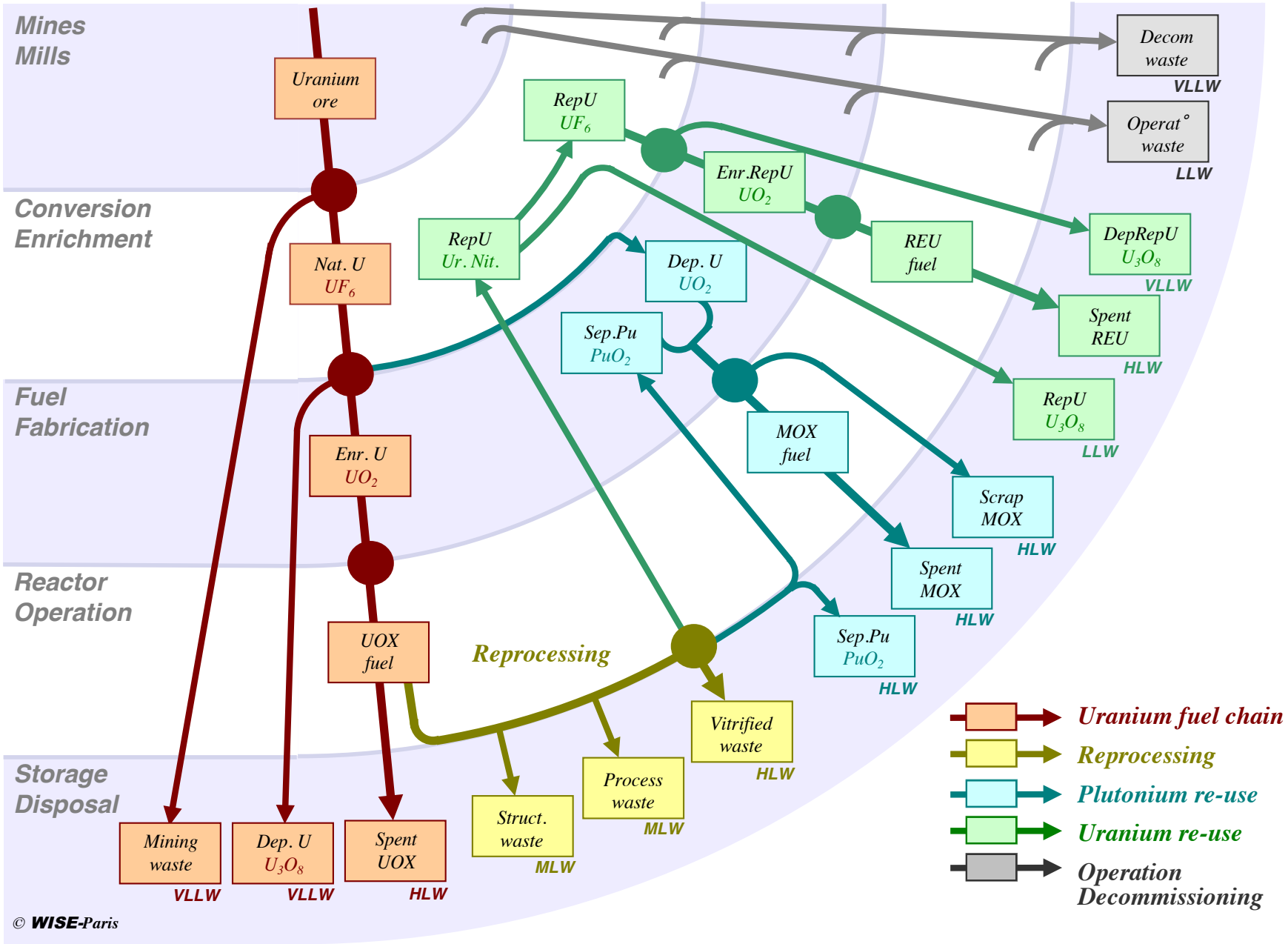
1. The French Nuclear System
2. Commercial Aspects
3. Plutonium and Reprocessed Uranium Stocks
4. Spent Fuel Storage
5. Aging Issues
6. Energy Policy Implications
7. Economic Troubles
8. Industrial Restructuring
9. Impact on Working Conditions Safety and Security
10. …and ASTRID?

AREVA Representation of the « Fuel Cycle »



Source: www.areva.com

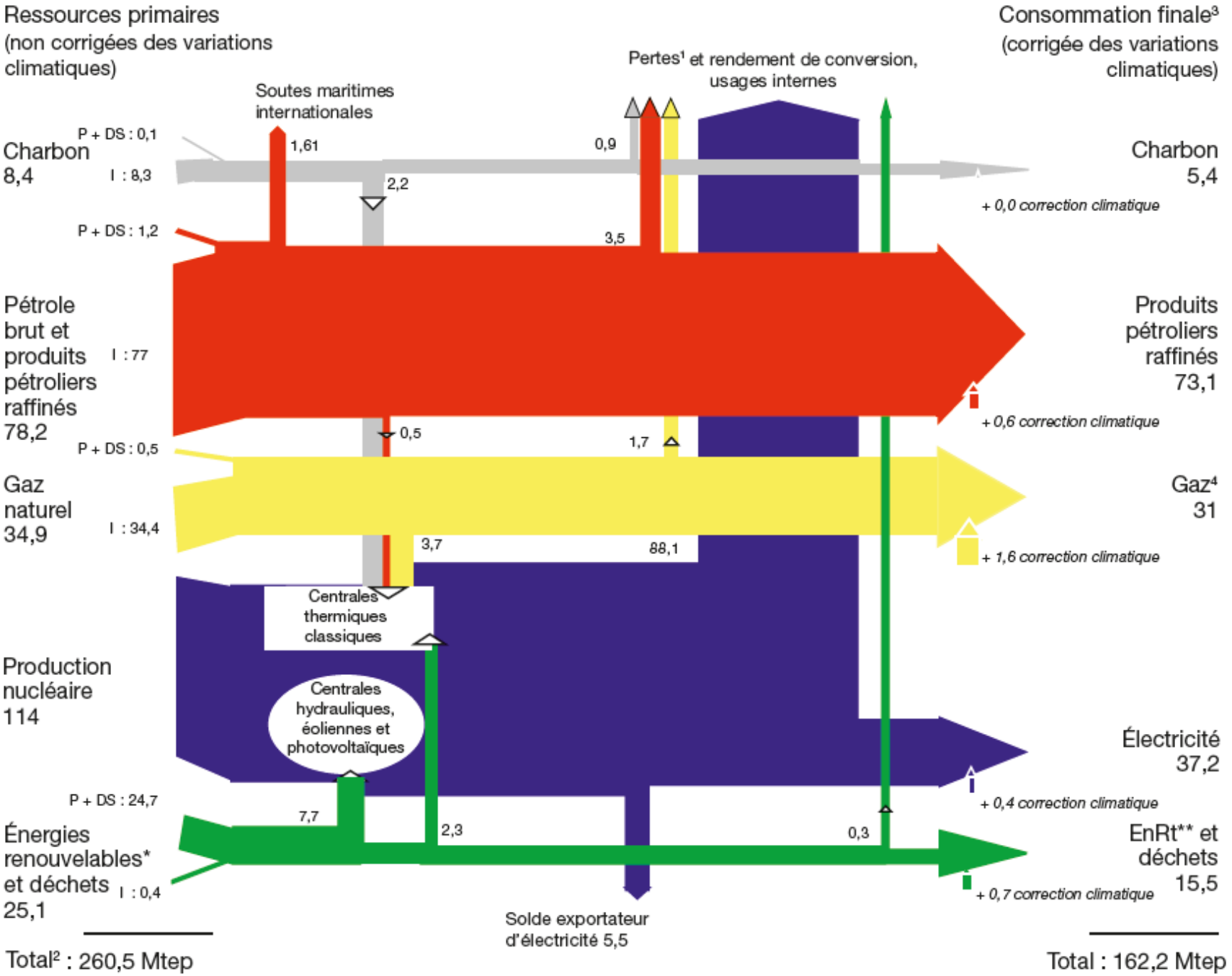
The Nuclear Fuel System in France



Plutonium and Energy Independence

- Nuclear power in France ≈ 75% of electricity
  ≈ 50% of primary energy
  ≈ 15% of final energy

French Energy Balance 2015



Plutonium and Energy Independence

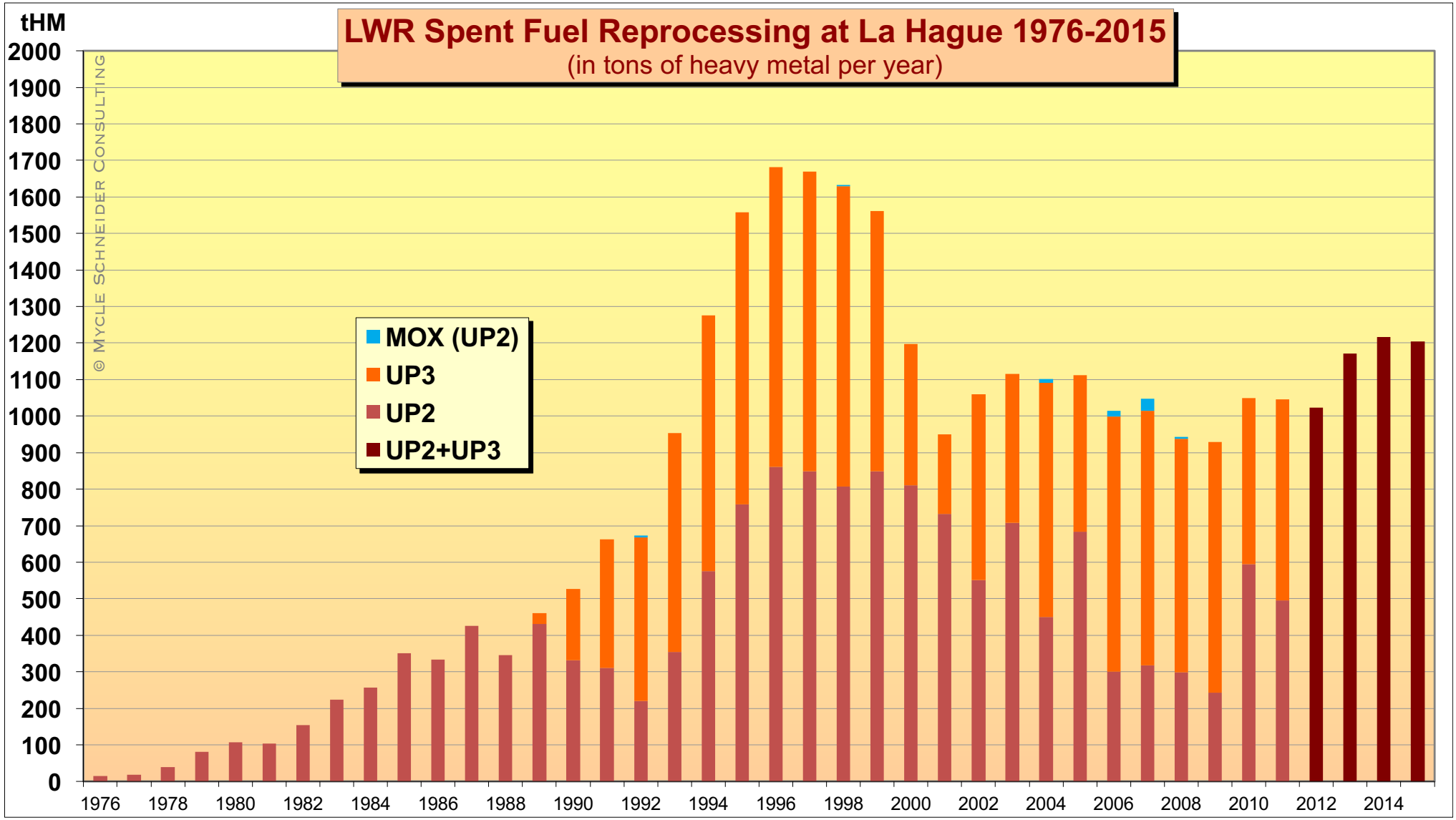
- Nuclear power in France ≈ 75% of electricity
  ≈ 50% of primary energy
  ≈ 15% of final energy
  (2/3 fossil fuels)

- MOX = max. 30% in max. 24 reactors (of 58)

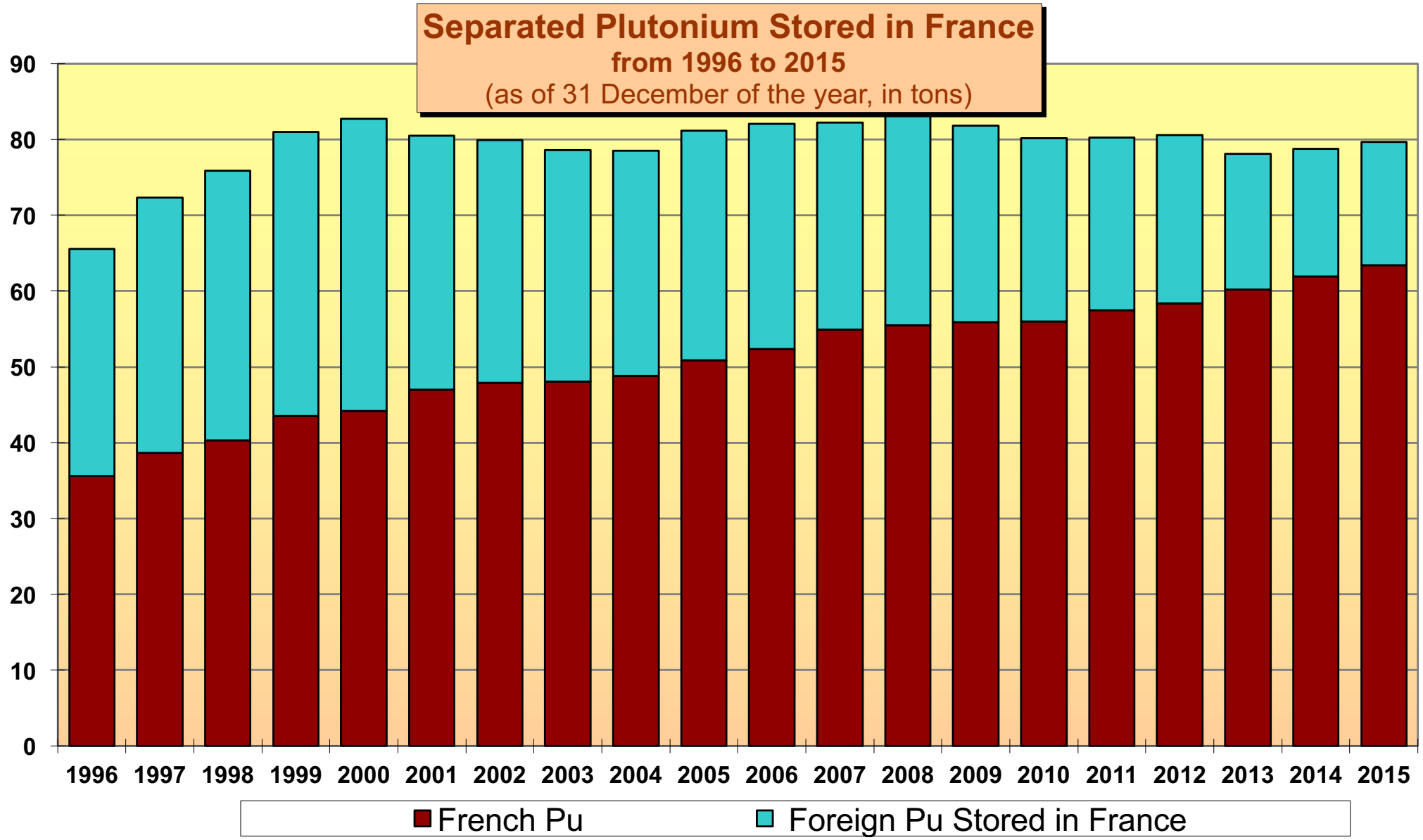
- Plutonium ≈ 10% of electricity
  < 2% of final energy

Plutonium contributes < 2% to energy independence in France

PS: No reprocessed uranium is currently re-enriched in France



Note: Quantities include minor quantities (<1 t) of spent research reactor fuels. *Sources: COGEMA/AREVA/ASN*



Source: IAEA 1997-2016

Plutonium Stocks in France (as of end of 2015)

- 79.7 tons: 63.4 tons French + 16.3 t foreign (16.25 Japanese!)
- Locations La Hague: 58 tons of which 14.8 Japanese (PuO2, other?)
  Marcoule, Melox 20 tons?
  Creys-Malville, Superphénix, APEC: 6 tons?
  Other sites: ?
- Forms Oxide
  MOX pellets, assemblies
  MOX fabrication waste (powder, pellets, assemblies)
  Breeder reactor fuel (Superphénix, SNR-300)

Reprocessed Uranium Stocks in France (as of end of 2016)

- approximately 30,000 tons
- no industrial scheme for reuse since 2013

Plutonium & Uranium Stored at La Hague (31 December 2015)

Matières radioactives entreposées sur le site AREVA NC LA HAGUE au 31 décembre 2015			
		Part par Pays en %	
		Uranium	Plutonium
France		100	74,5
Allemagne		0	0
Australie		0	0
Belgique		< 0,1	< 0,1
Italie		0	< 0,1
Japon		0	25,5
Pays-Bas		0	< 0,1
Total		100	100

Source: AREVA NC, June 2016

Total quantities:
- **58 tons of plutonium (oxide),**
- **348 tons of reprocessed uranium; none is currently re-used.**

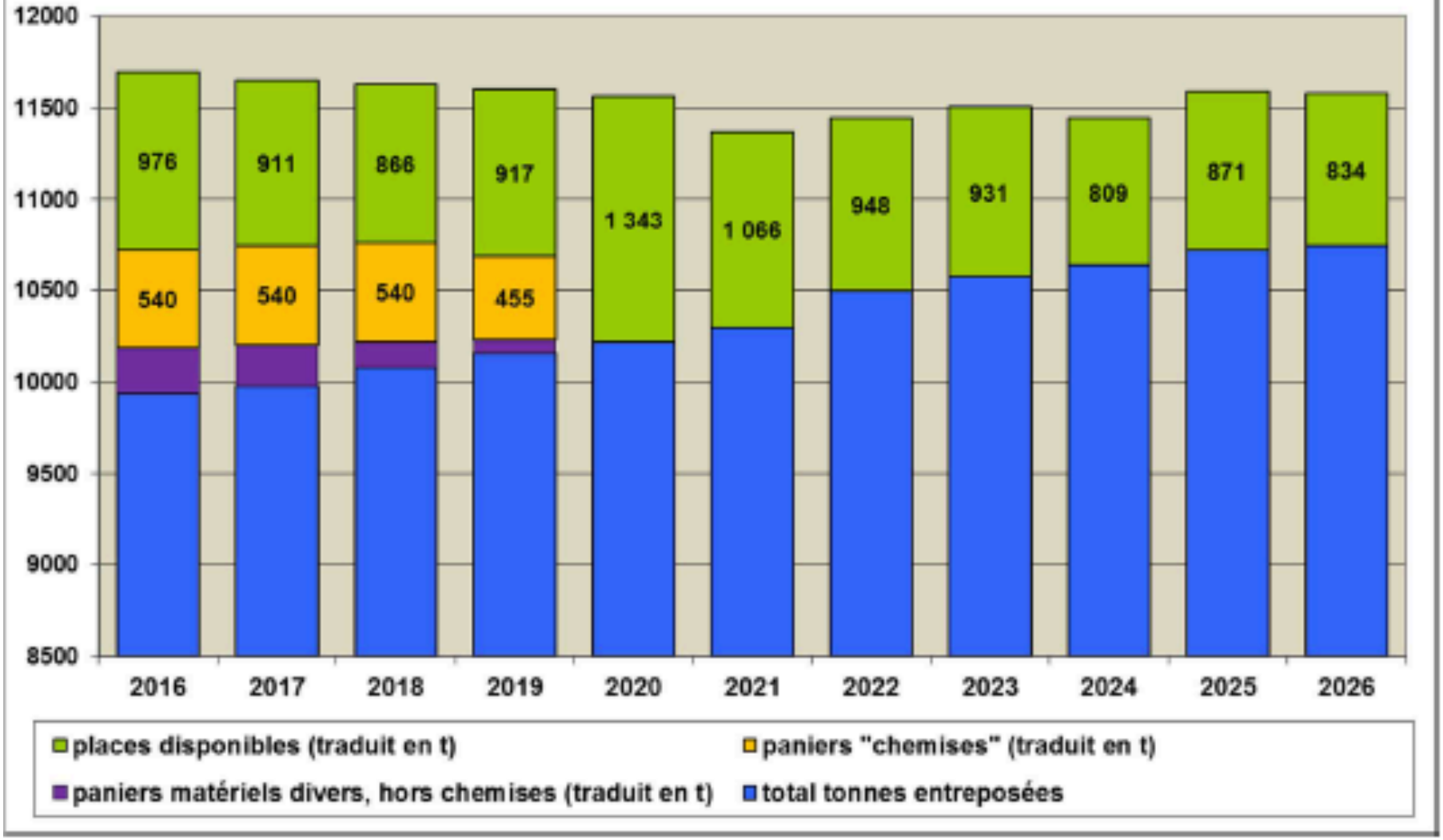
Spent Fuel Stored at La Hague (31 December 2015)

Combustibles usés présents sur le site AREVA NC LA HAGUE au 31 décembre 2015		
		Part par pays en %
France		99,7
Australie		0
Belgique		< 0,1
Italie		0,3
Pays-Bas		0
Suisse		< 0,1
Total		100

Note: Total quantity stored at La Hague : 9,759 tons.

Source: AREVA NC, 2016

La Hague Spent Fuel Storage Capacity Filling Up



CLI AREVA NC la Hague - Situation des piscines - 25/02/2016 – p. 4

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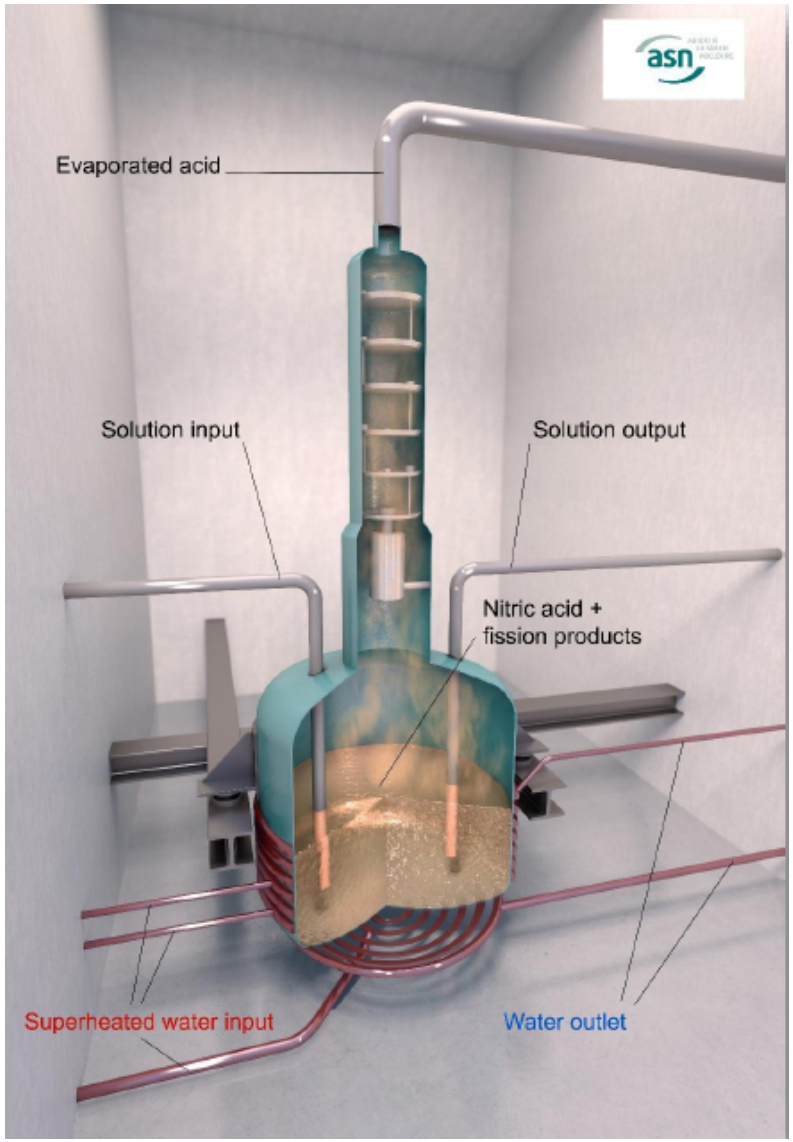
Saturation of French Spent Fuel Storage Capacities

- **58 spent fuel pools at EDF reactors sites**
  - Total nominal capacity 8,100 tHM, operational capacity unclear
  - ca. 4,500 tHM stored as of end of 2016 (< 4 x annual reactor discharge)
  - In 2009, ASN calls for EDF action on capacity management
  - In 2012, EDF re-racking plans rejected by ASN decision
  - Post-3/11: safety concerns and need to reduce inventory
  - By end of 2016, EDF requested to submit storage strategy to ASN (not public)
  - By mid-2017: EDF requested to provide technical proposal for new storage capacity
- **La Hague spent fuel storage capacities**
  - Nominal capacity 17,600 tHM but operational capacity ≈12,700 tHM (Feb. 2016)
  - Current available capacity estimated <1,000 tHM (less than annual reactor discharge)
  - Potential to gain capacity in existing pools limited
- Complete saturation of all storage capacities projected within 10 years
- EDF plan to build centralized storage capacity will take 10 years
- Maintaining La Hague reprocessing throughput will be challenging (aging)

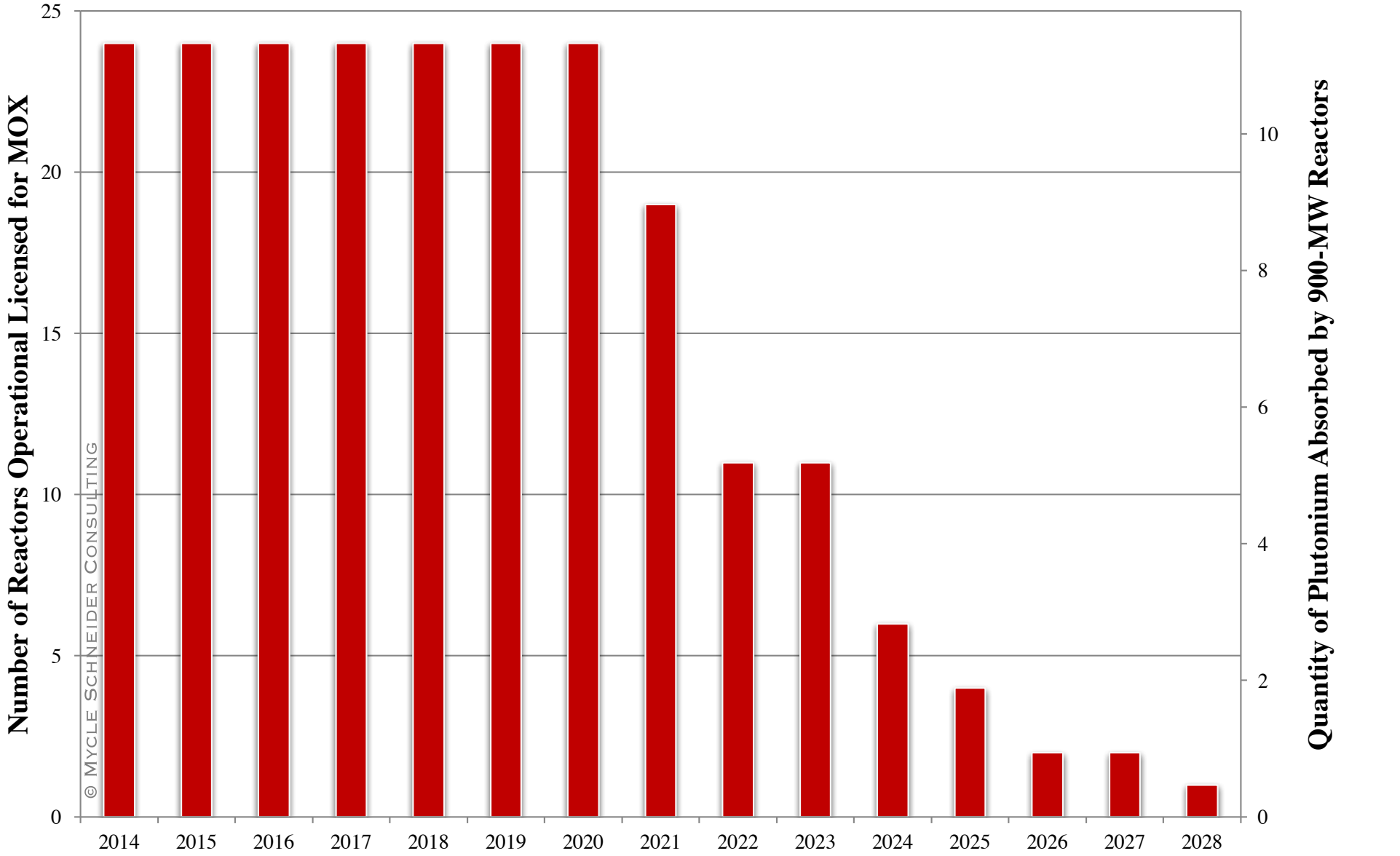
La Hague Evaporator Corrosion Faster Than Anticipated



Source: ASN, 2016

- **UP3/UP2-800 designed for 30 years**
  (reached in 2019/2024)
- **Evaporator Corrosion**
  - Minimal required thickness could be lost by 2018 on most corroded evaporator
  - AREVA plans replacement by 2021
  - ASN says replacement takes at least 6 years
- **Reprocessing reduced or interrupted for several years**
- **Other ageing / safety issues**

Plutonium Absorption Capacity by 900 MW Reactors (40 y. lifetime)

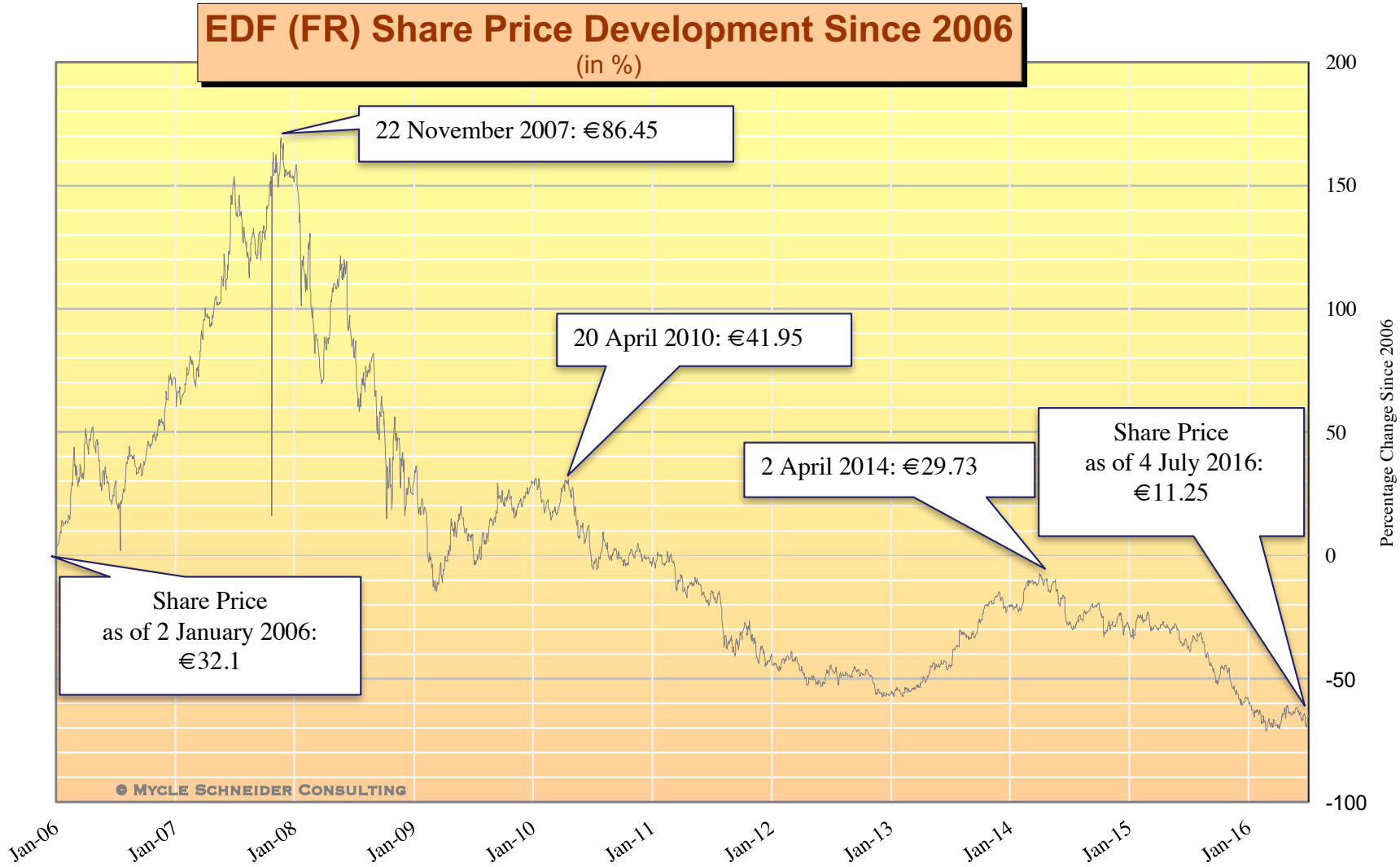


Nuclear Companies in Trouble: EDF

- Investment wall
  - Backfitting/Post-Fukushima
  - Hinkley Point C
  - Decommissioning
  - Diversification of generation capacity (renewables)
- Serious quality-control issues/increasing production costs
- Shrinking client base/declining consumption
- Stock value plunged >85% since 2007
- High debt €37.4bn for turnover of €71bn

- *EDF's forecast cash flows cover neither its capex requirements nor its actuarial nuclear dismantling costs.*
- *The acquisition of Areva's nuclear engineering division may just turn out to be the proverbial last straw.*
- *We believe that EDF is solvent for now but won't be in future, implying that its equity has no value.*

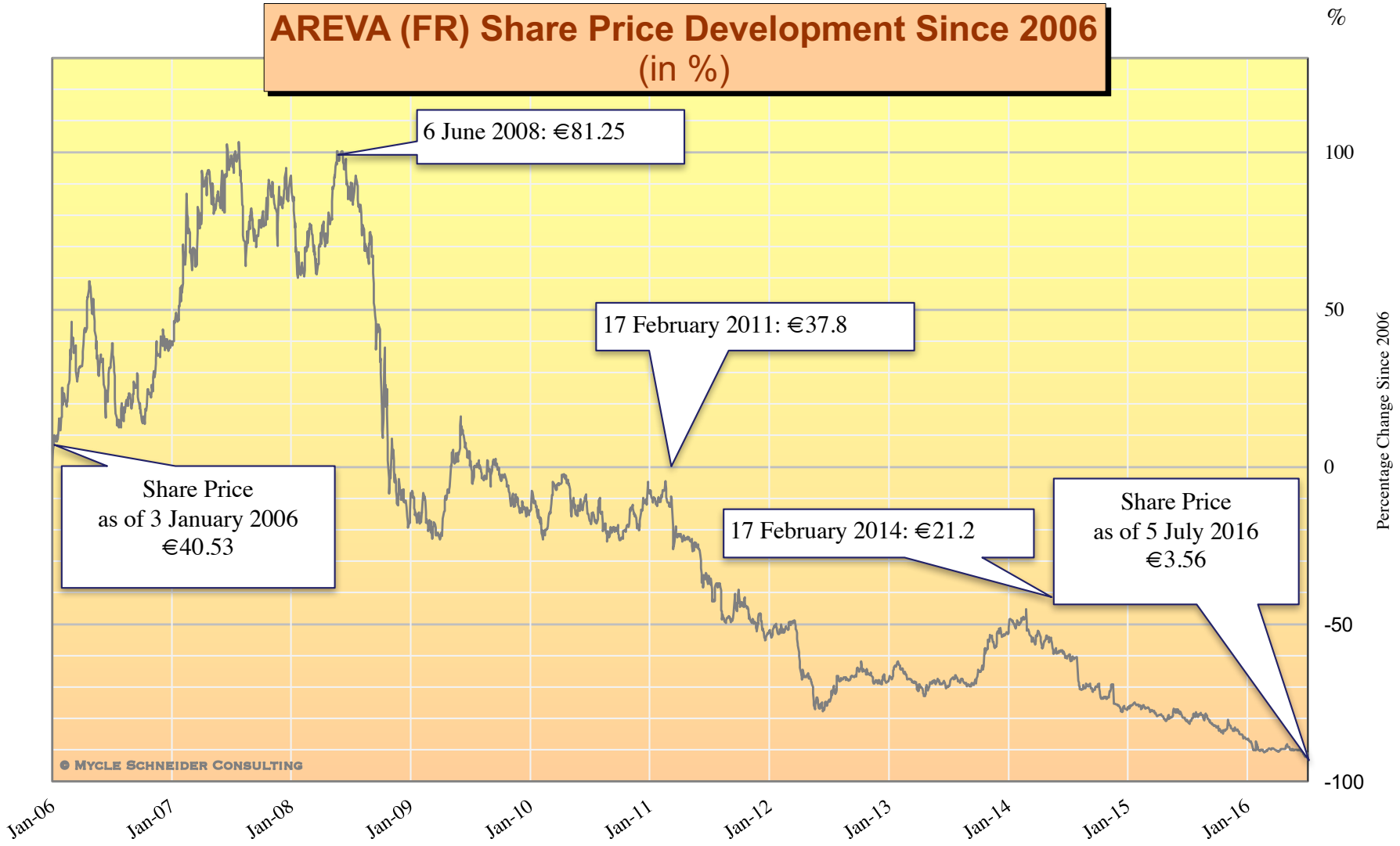
Alpha Value, "EDF – What a mess!", December 2015



Source: Investing, 2016

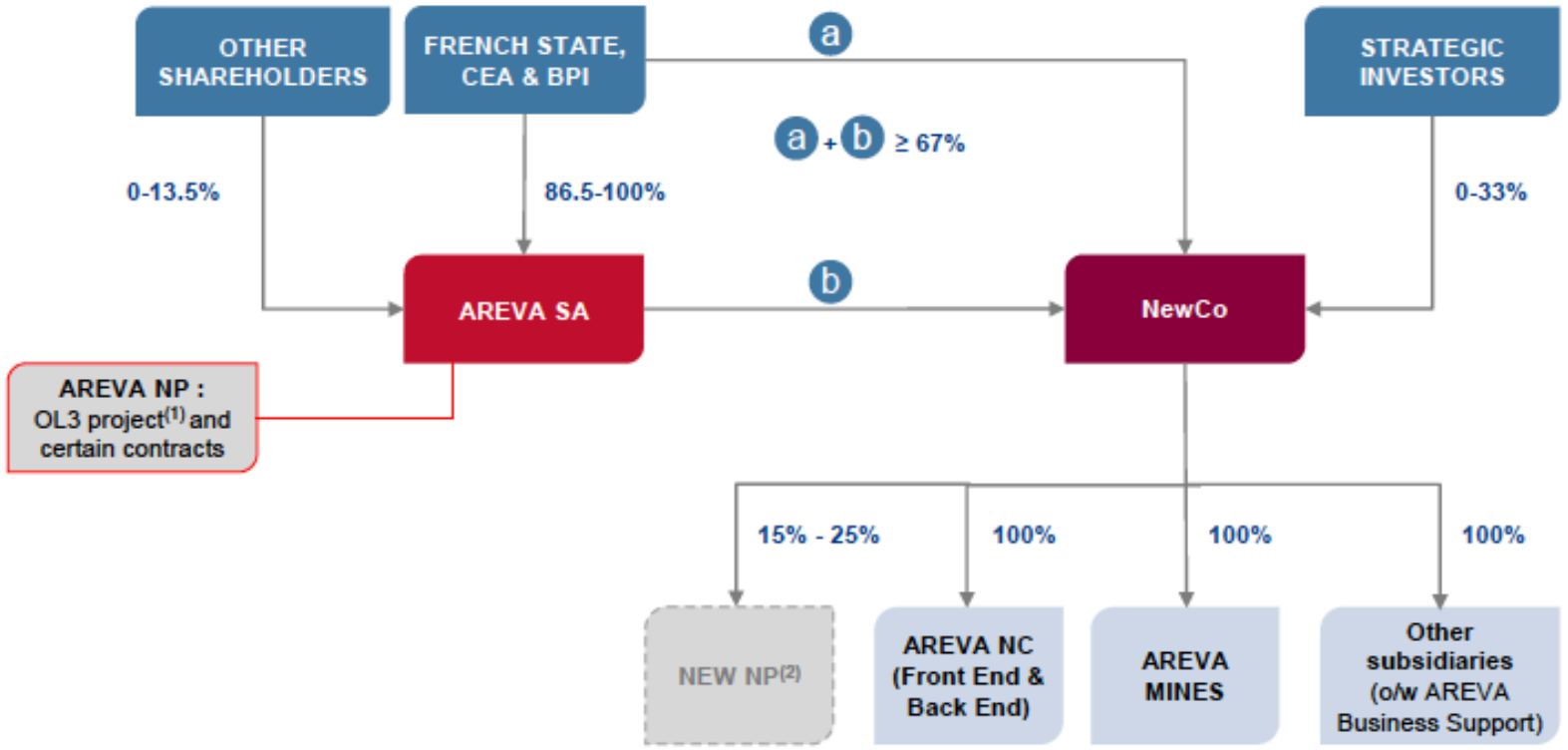
Nuclear Companies in Trouble: AREVA

- Technically bankrupt
- Serious quality-control issues in Creusot Forge
- Loss of €10bn in 5 years
- High debt €6.3bn for revenues of €4.2bn
- Stock value plunged by up to 96% since 2007
- Standard & Poor's downgraded AREVA shares to BB- ("junk")
- Dismantling AREVA:
  - AREVA NP → EDF
  - AREVA TA → French state (via CEA, DCNS)
  - Creation of NewCo with fresh capital (public+private, incl. MHI and JNFL for €500m; CNNC is out)



Source: Investing, 2016

Reminder of proposed structure post-reorganization



(1) AREVA NP will ensure the completion of the OL3 project, with personnel continuing to be fully mobilized, in compliance with contractual obligations

(2) NEW NP : AREVA NP operations, excluding the OL3 projects and certain component contracts

Strategy update and bondholder solicitation | August 30, 2016 | p.5

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Serious Degradation of Working Conditions at the La Hague Reprocessing Plant Threatens Safety and Security (1)

Tales from a leaked internal trade union memo (December 2016)

- Since 2014, numerous reorganizations with "only one motivation: contribute to the decrease of costs".

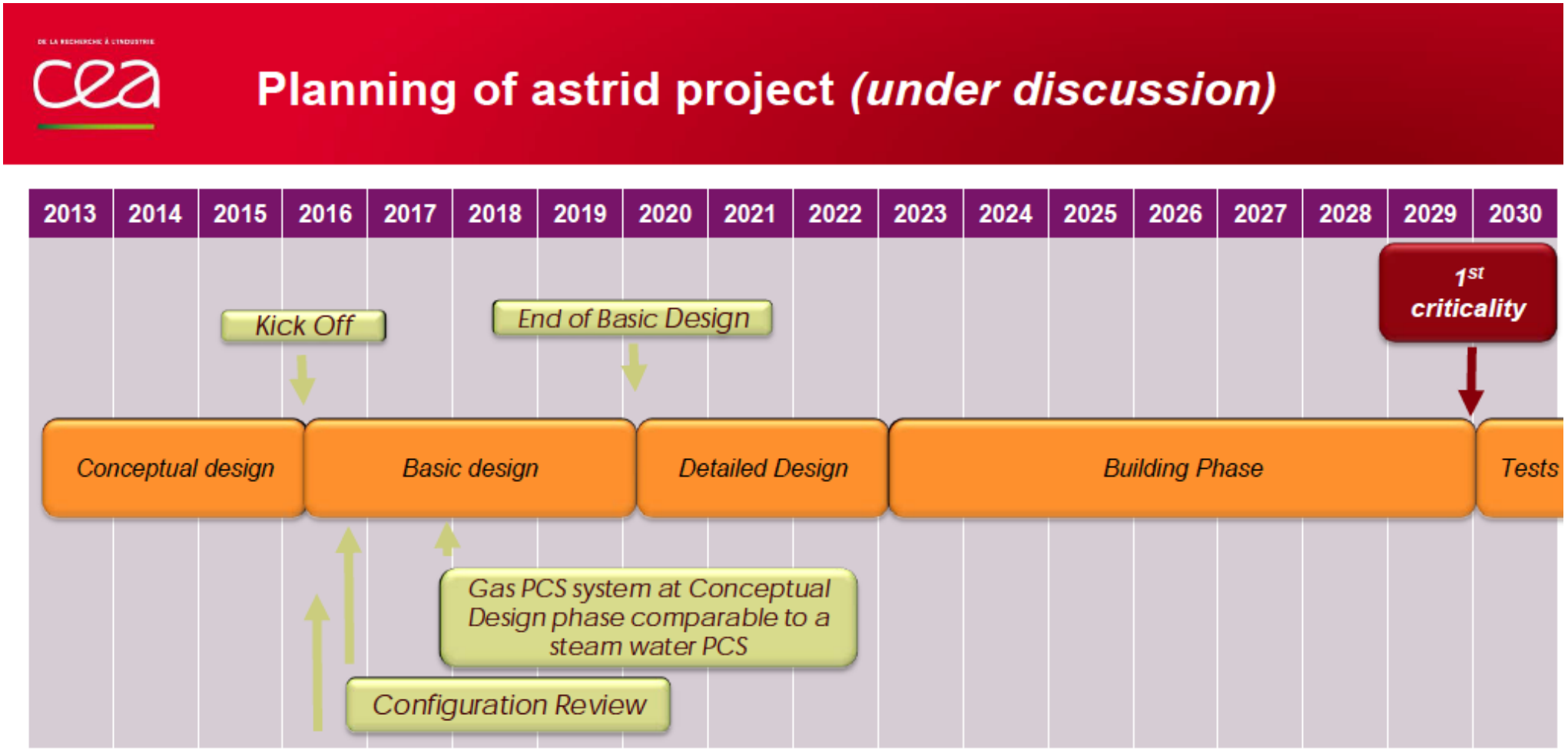
By these measures the management "only confirms a situation of already precarious, chronic under-staffing".

- This leads to "situations, where there is only one or two persons in the control room to manage 4, 5 or 6 centralized control-command positions".
- In order to reach minimum production, "management tolerates without any problem that the staffing is topped up by trainees".
- "For months, none of the five brigades working 24x72 hour shifts has been at nominal workforce".

Serious Degradation of Working Conditions at the La Hague Reprocessing Plant Threatens Safety and Security (2)

- In one department, after reorganization that cut 19 positions, 17 positions remain open. After an attempt of internal job offers failed, jobs were advertised externally via the public unemployment office, but not one single candidature was received.
- Several high-level vitrified waste canister have been produced that do not meet technical specifications, because a leak in the glass feed went undetected. Even after detection of a suspicious change in the exhaust gas composition, management refused to investigate as "production shall not be stopped".
- One example "we found shocking": outsourcing of a highly specific maintenance task in order to cut two jobs.
- Health department annual report shows: "the number of consultations of the work psychologist by employees has exploded".

ASTRID – Alternative Reality?



Source: JAEA International Symposium | 17 February 2016

- Project in very early stages
- €600 million for design studies over 10 years
- Implementation increasingly unlikely in view of economic crisis of the nuclear sector in France

Conclusions

- Reprocessing economically unattractive. Plutonium and reprocessed uranium = zero book-value, negative market-value.
- No more foreign reprocessing clients. La Hague facility operating at <2/3 capacity. EDF to cover all costs.
- Costs are increasing with serious ageing issues.
- Increasing plutonium stocks. Absorption capacity declining with phasing out of old reactors licensed for MOX use.
- AREVA technically bankrupt, share value plunged, downgraded by S&P deep into junk (BB-). EDF also in great difficulties.
- Dramatic impact on worker morale, operational safety and security.
- Decisive and short-term action is needed. Phasing-out plutonium separation would make great economic, security, environmental and geo-political sense.

Thank You! Contact: mycle@orange.fr **www.WorldNuclearReport.org**

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In 2010-2011, he acted as Lead Consultant for the Asia Clean Energy Policy Exchange, implemented by IRG, funded by USAID, with the focus of developing a policy framework to boost energy efficiency and renewable energies. Between 2004 and 2009 he has been in charge of the Environment and Energy Strategies Lecture of the International Master of Science for Project Management for Environmental and Energy Engineering at the *Ecole des Mines* in Nantes, France.
From 2000 to 2010 he was an occasional advisor to the German Environment Ministry. 1998-2003 he was an advisor to the French Environment Minister's Office and to the Belgian Minister for Energy and Sustainable Development.
Mycle Schneider has given evidence or held briefings at national Parliaments in 14 countries and at the European Parliament. He has advised Members of the European Parliament from four different groups over the past 26 years. He has given lectures or had teaching appointments at 20 universities and engineering schools in 10 countries.
Mycle Schneider has provided information and consulting services to a large variety of clients including international institutions and organizations, think tanks and NGOs.
In 1997 he was honoured with the *Right Livelihood Award* ("Alternative Nobel Prize").