Lessons to be learnt from the French nuclear program

From dreams to promises... of disillusions

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Main author of Global Chance's report **Nuclear power:** the great illusion*, Nov. 2008*

Context of a so-called "nuclear renaissance"

A "nuclear path" for countries' energy security and climate change policies

France's stance as world champion of nuclear power, promoting its "nuclear model" everywhere

Why a Global Chance report "Nuclear power: the great illusion"?

A group among few French independent experts on nuclear and energy issues

Gather its fact-based, point-by-point analysis of the French nuclear program

Publish as an alternative to the widespread official information

Contents:

Assessing the French nuclear program…

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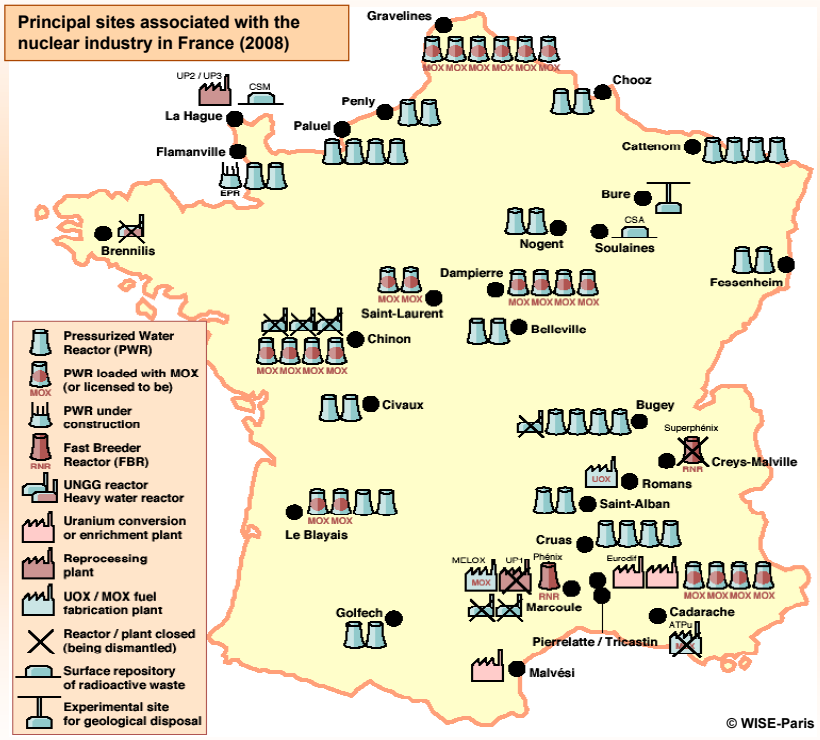
Assessing the French nuclear program…

Background
History, status and projects



A long history:

• From the beginning:
France part of the scientific adventure of nuclear energy

• After World War II:
political consensus on a nuclear program (weapons then energy) to restore international role and develop national independency

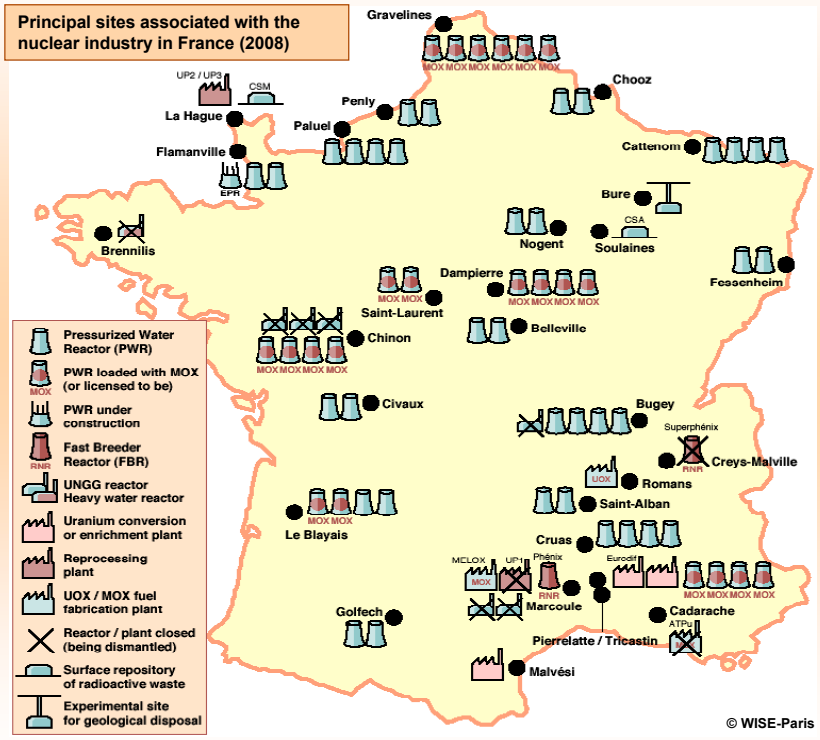
• After oil shocks:
nuclear energy to become the main driver of energy (and now climate) policy

Current status:

An industry covering all stages of the "fuel cycle"

58 PWRs in operation (63.2 GWe)

Close to 100 other nuclear facilities (incl. other reactors, research, and fuel cycle facilities)



Main players:

CEA (1946) - Public R&D up to industrial stage (military and civilian prog.)

COGEMA (1976) - Private status of CEA industrial activities

AREVA (2001) - Merging of COGEMA and reactors building/service FRAMATOME

EDF (1946) - Nationalization of electricity. Operator of reactors Now private status, partly own.

ANDRA (1991 from CEA) - Public agency in charge of final radwaste management

IRSN (1998-2002 from CEA) - Public expertise on nuclear risks

ASN (2006 from Gov. department) - Nuclear safety authority

Assessing the French nuclear program…

Background

Effectiveness
(1) Energy security

Government & Industry:

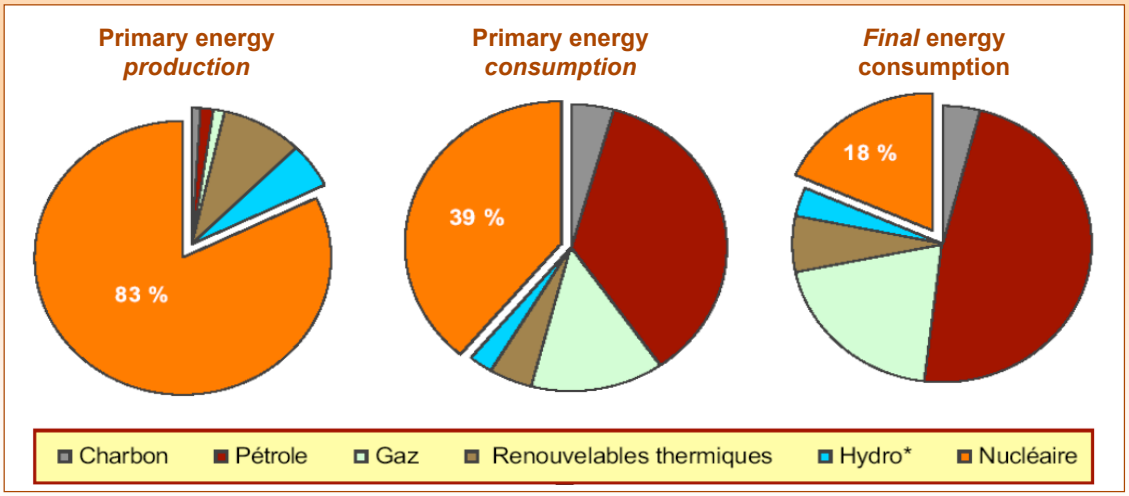
France's nuclear program is key to guarantee its energy security

The development of nuclear power raised France's energy independency up to a level of 50%

Nuclear energy in French energy consumption

Nuclear ~ 80% of France's electricity output, an unparalleled contribution…

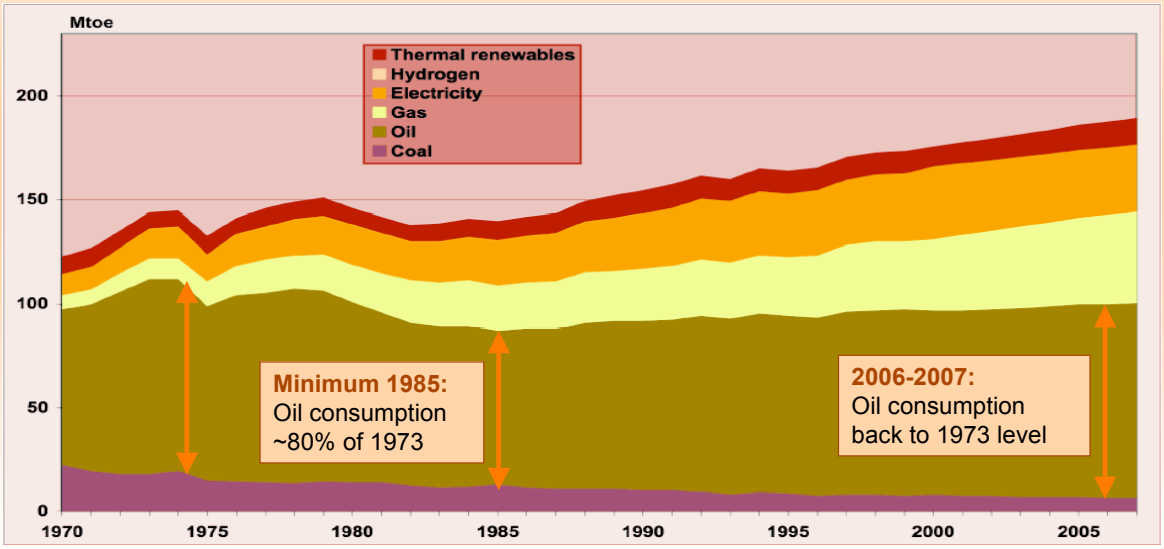
…but electricity ~ 20% of France's final energy consumption (versus oil ~ 50% and gas ~ 20%)



Limited impact of the substitution policy on the supply side (e.g. not on transports)

Lower efforts on more effective action on the demand side (e.g. oil in transports)

Final energy consumption in France, 1970-2007



Source: Observatoire de l'énergie, DGEMP, 2008

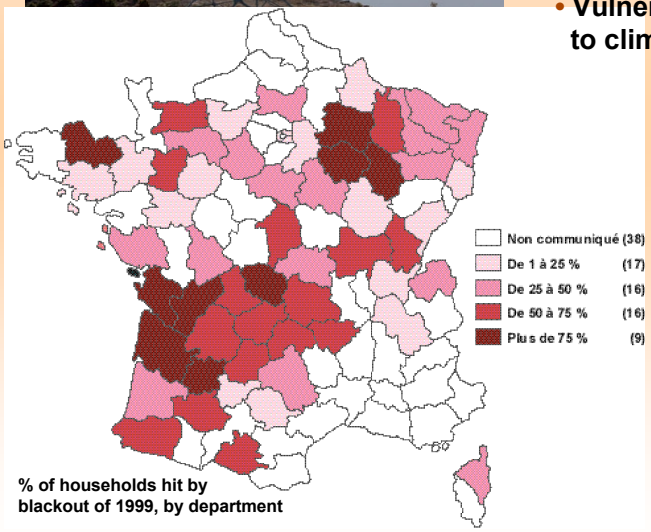
Official energy independency largely overestimated

$$\text{Energy independency} = \frac{\text{Domestic energy production}}{\text{Domestic energy consumption}} \approx 50\% \; ?$$

Calculation	1973	2008	
(A) Primary energy Including 2/3rd of energy wasted as heat by NPPs	**25%**	**51%**	x 2 official
(B) Final energy Discounting wasted heat	30%	38%	
(C) B minus losses Discounting own consumption (enrichment, grid)	30%	33%	
(D) C minus uranium imports Domestic mining of uranium ended in 2001	**30%**	**15%**	÷ 2 realistic

(In)security of domestic supply

- **High dependency to a sensitive technology**
- **Vulnerability of a highly centralized grid**
  (25% of population hit by blackout of 1999 tempest)
- **Vulnerability of nuclear power plants to climatic events** (tempest, flooding, heat)



% of households hit by blackout of 1999, by department

Flooding around a French NPP, 2004

Assessing the French nuclear program…

Background

Effectiveness

(1) Energy security

(2) Climate change policy

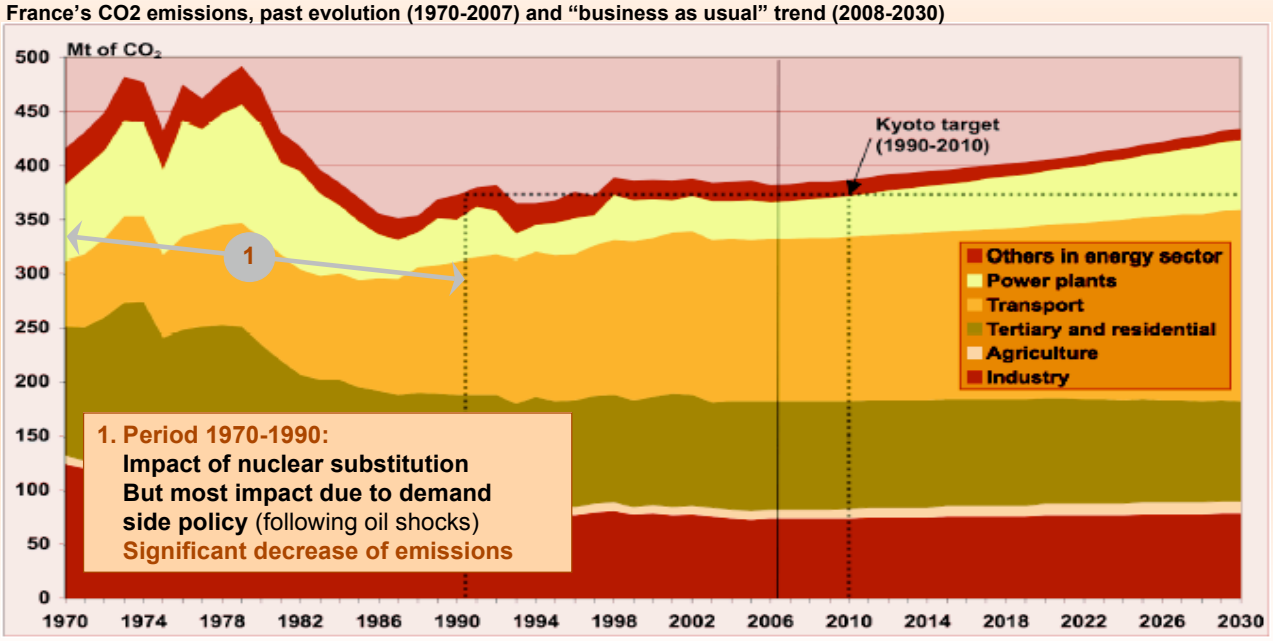
Government & Industry:

Nuclear energy is key to France's GHG emissions low record

Pursuing is core of France's climate change policy

The limits of the substitution logic

France's CO2 emissions, past evolution (1970-2007) and "business as usual" trend (2008-2030)



Source: Observatoire de l'énergie, DGEMP, 2008

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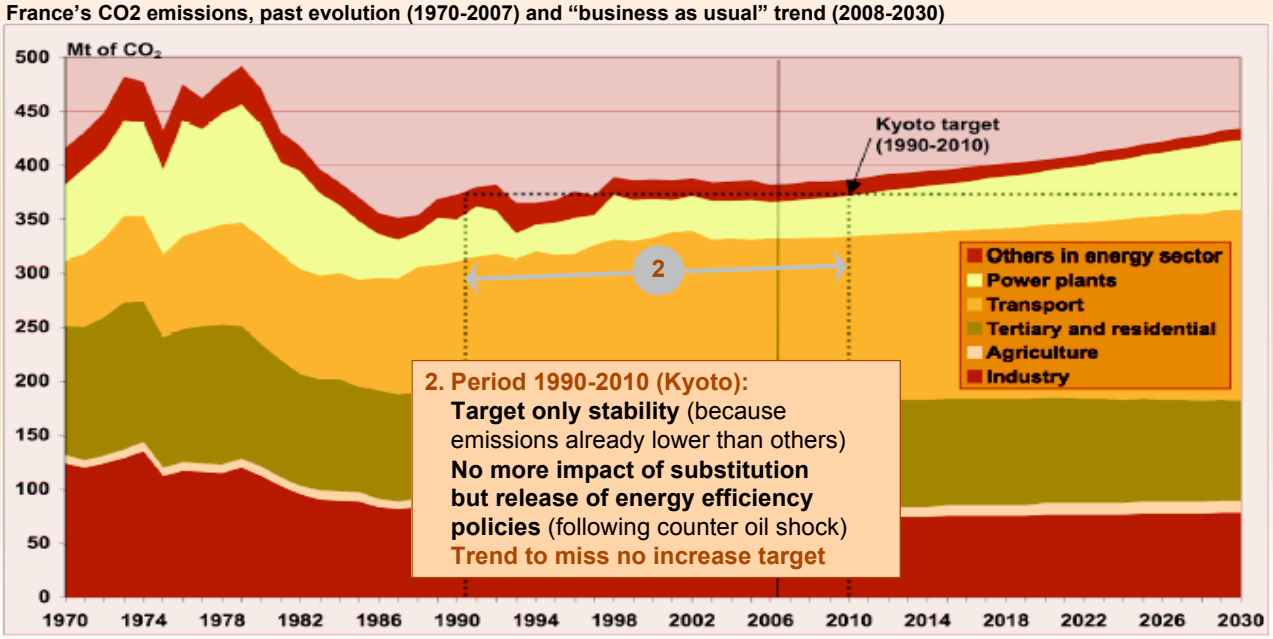

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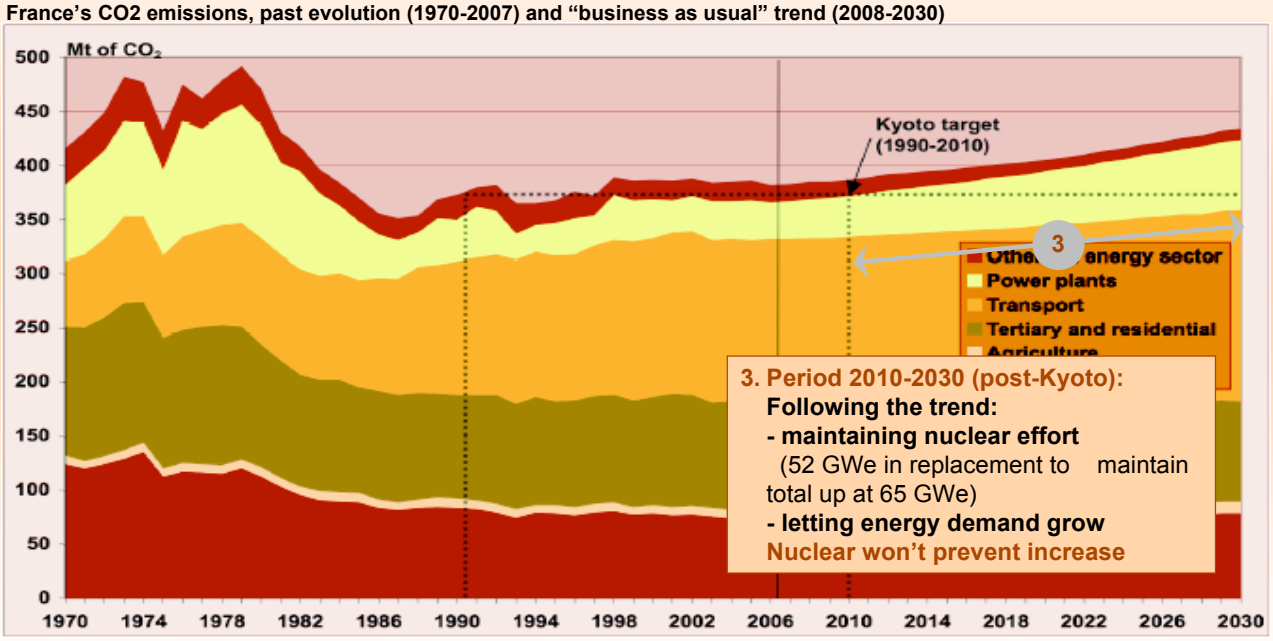

Source: Observatoire de l'énergie, DGEMP, 2008

Nuclear energy and long term CO2 emissions

France's medium and long term commitments:

- **EU Climate-Energy package (2008): -20% CO2 by 2020**
  (and 20% energy efficiency / trend, and 20% renewables in consumption)
- **French energy law (2005): 4-fold division by 2050** ("factor 4", or -75%)

Government scenarios:

- **acknowledge the prime role of energy demand decrease**
  (low carbon supply only secondary)
- **take pursuing or increasing the nuclear program as basic assumption**
- **consider the development of renewables as complimentary**

Alternative scenarios:

- **search for further energy efficiency and energy sufficiency potentials**
- **take the liberty to try not replacing ageing reactors by new ones**
- **embed further development of renewables as prioritary**

Nuclear energy and long term CO2 emissions

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Comparison of prospective scenarios 2020-2050 Scenarios[a]			CO_2 emissions (evolution /1990)	Energy efficiency (/2006[b])	Renewables (% of total primary energy)	Nuclear power (Twh and % of total electricity)
2006			+1%	0%	n.d.	428.7 (78.3%)
2020	CAS	Ref. Markal	-3%	+13%	n.d.	431.3 (70.6%)[d]
		Vol. Markal	-23%	+6.6%	10.4%	549 (82.1%)
		Ref. MedPro-Poles	+3.5%	+1%	8.1%	431.3 (70.6%)[d]
		Vol. MedPro-Poles	-21%	-16%	9.8%	439 (65.8%)
	négaWatt		-26%	-18%[e]	19%[e]	209 (53.7%)
2050	CAS	Ref. Markal	+2.5%	+35%	n.d.	n.d.
		Vol. Markal	-52%	0%	15.4%	731.6 (78.4%)
		Vol. MedPro-Poles	-58%[c]	-38%	16.2%	453 (59.8%)
	négaWatt		-75%	-41%	70%	0 (0%)

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Conclusions from prospective comparison:

- **No nuclear scenario meeting 4-fold division target:**
  High level of nuclear power won't bring French CO2 emissions down to sustainable levels
- **Demand side policy is more effective, supply side policy can't be enough:**
  Key to limit emissions is energy efficiency, renewables come second
- **Scenarios with nuclear power deliver less:**
  Comparison suggests an adverse effect of nuclear lock-in against appropriate shifts in the energy system

Assessing the French nuclear program…

Background

Effectiveness

(1) Energy security
(2) Climate change policy
(3) Industrial policy

Government & Industry:

Ranking top success of the French industry

France must take responsibility and spread its technologies and skills throughout the world

French nuclear industry's troubled history

- **picked wrong technologies, ended up buying foreign ones**
  US license for PWR reactors, Urenco's license for centrifugation enrichment…
- **maintained some options even when rationale lost, rather than confessing fault**
  pursuing reprocessing and pay overcost although the initial plan of a "plutonium industry" is dead
- **developed structural mishap based on wrong planning**
  e.g. in 1973, projected 750 TWh of electricity in France by 2000, turned 430 TWh
- **missed by far its exportation targets**
  aimed to build 1 reactor abroad for 1 constructed in France, only exported 9 reactors before EPR

- **systematically fell short of meeting its own performance objectives for new projects, e.g.**
  - 4 last reactors built took 10.5 to 14.5 years against initial plan for 5 years
  - average load factor reaches 75 to 80% against initial plan for 85 to 90%
  - EPR construction work far beyond schedule
    In Finland, 2 years late after 2.5 years work
    In France, estimated over 1 year after 1.5 year

Assessing the French nuclear program…

Background

Effectiveness

Safety
(1) Risk of accident

Government & Industry:

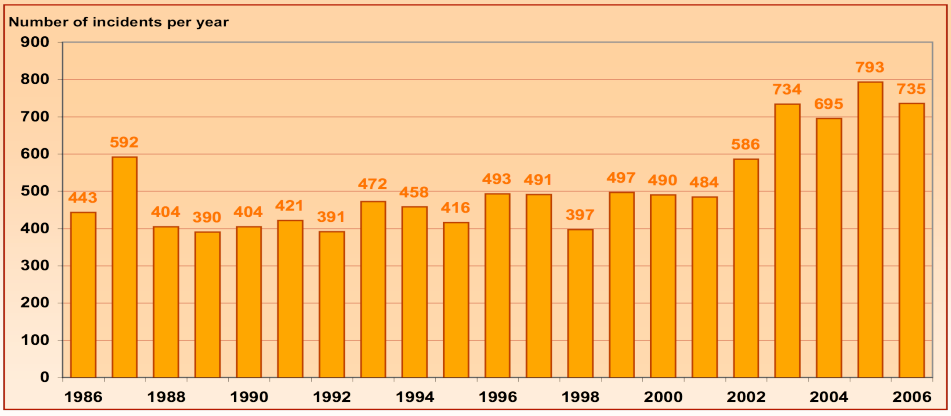
France's nuclear industry much more controlled than other dangerous activity

French nuclear facilities amongst the safest in the world

A Chernobyl-type accident is below probability

Increasing safety concerns with French nuclear facilities

- **46 of 58 reactors** ordered before TMI (1979)**, only 2** after Chernobyl (1986)
  French safety authority, 1995: 58 reactors would not be licensed under new criteria
- **a series of "near miss" or warning signals through the years**
  covering a whole range of root causes (e.g. Bugey 1984, Le Blayais 1999)
- **new concern:** growing economic pressure, ageing reactors, loss of competencies
- **shows in a global increase of "significant events" in the past decade**



Source: *Residual Risk* report, 2007, based on IRSN

Assessing the French nuclear program…

Background

Effectiveness

Safety

(1) Risk of accident

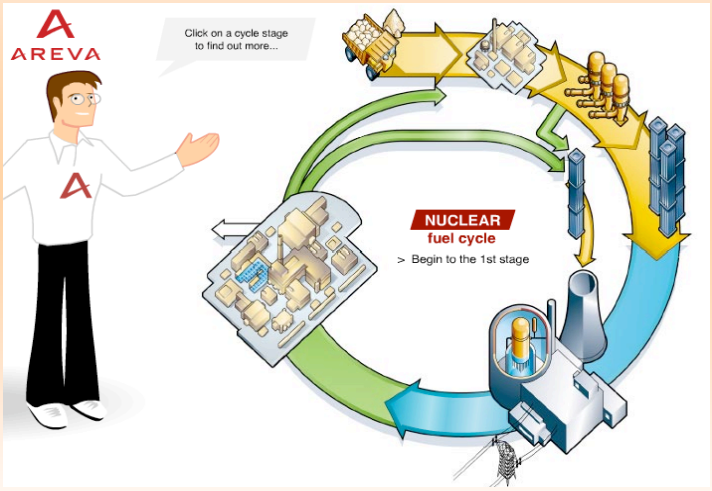
(2) Waste management

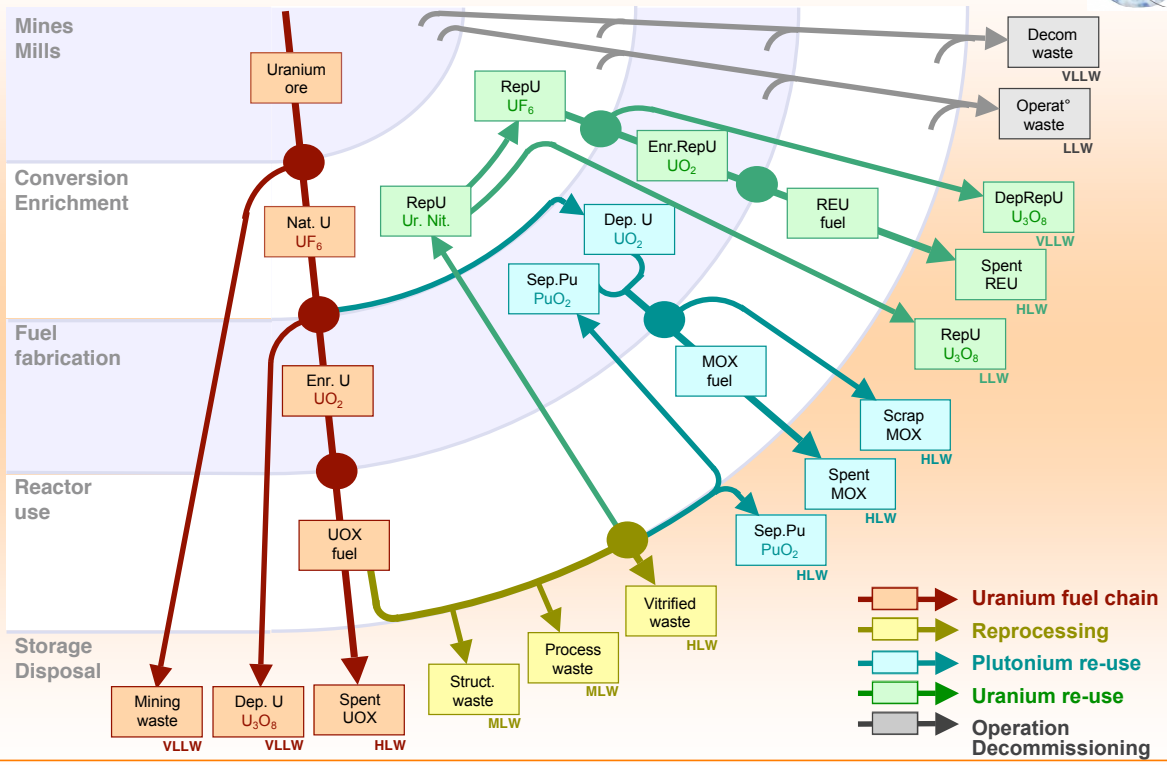
Government & Industry:

Reprocessing developed as most sustainable policy for radioactive waste management

Projects well on track for long-lived waste disposal in geological site

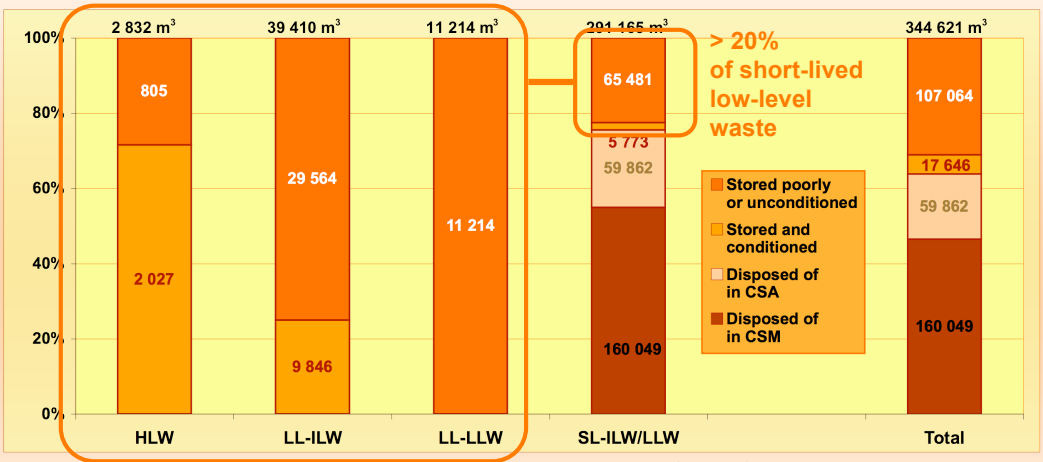
The real complexity behind "recycling"





Piling up of radioactive waste and nuclear materials

Inventory of waste arising from the French fuel cycle, by status of storage or disposal (in %)



Source: WISE-Paris, based on ANDRA's national inventory, 2006

- **Accumulation of "reusable" nuclear materials with only partial or no use**
  Including spent fuel (> 8,000 tons), separated plutonium, depleted uranium, mining residues
- **First decommissioning projects facing unplanned difficulties**

- **Existing disposal face technical problems** (leakage at CSM, near La Hague, 1966-2003)
- **Solutions remain to be found / demonstrated / implemented for most categories**
- **First law on radioactive waste management passed in 2006, deadlines already beaten** (LL-LLW already 6 years beyond schedule, 2019 instead of 2013)

		LL – Long-lived	*SL - Short-lived*	*VSL – Very short-lived*
	Period Activity	> 30 years	≤ 30 years > 100 days	≤ 100 days
HL *High Level*	> 10^8 Bq/g	Under study Art. 3 of the law of 28 June 2006 1 laboratory for geological disposal: **Bures**		Management by radioactive decay
IL *Intermediate Level*	≤ 10^8 Bq/g > 10^5 Bq/g	Under study Art. 3 of the law of 28 June 2006	Surface disposal[a] 1 closed facility: **Centre de Stockage de la Manche (CSM)**	
LL *Low Level*	≤ 10^5 Bq/g > 10^2 Bq/g	Study of dedicated subsurface disposal	1 facility in operation: **Centre de Stockage de l'Aube (CSA)**	
VLL *Very Low Level*	≤ 10^2 Bq/g	Dedicated surface disposal 1 site in operation: **Morvilliers** Limited recycling for some categories		

a. With the exception of specific waste, eg contaminated with tritium, for which dedicated management is still being studied.

Source: based on PNGMDR, 2007-8

Assessing the French nuclear program…

Background

Effectiveness

Safety

(1) Risk of accident
(2) Waste management
(3) Security / proliferation

Government & Industry:

French nuclear reactors technologies (PWRs) are non-proliferating

France's duty to help countries access nuclear energy for collective security and shared prosperity

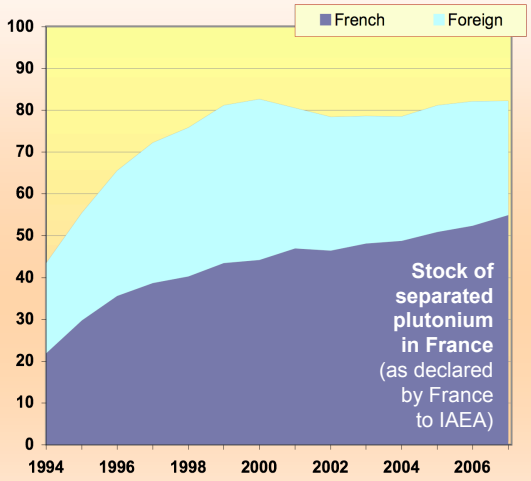
France, pyromaniac fireman of proliferation

- **Piling-up of plutonium:**

  >300 tons accumulated by the end of 2008
  of which (declared as of the end of 2007):
  - 52.4 tons of French separated plutonium
  (makes EDF n°1 producer in the world)
  - 29.7 tons of foreign origin

  Usable for bombs - denied until 2006 by AREVA
  Stock in La Hague more than 5,000 times IAEA's called "significant quantity" (8 kg)

  Bad signal on the international scene



- **Selling nuclear technology:**

  France helped military program of several countries (Israel, Irak, South Africa…)

  Now prepared to sell its civilian technology to any country (Algeria, Lybia...)

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Assessing the French nuclear program…

Background

Effectiveness

Safety

Economics
(1) Direct / indirect costs

Government & Industry:

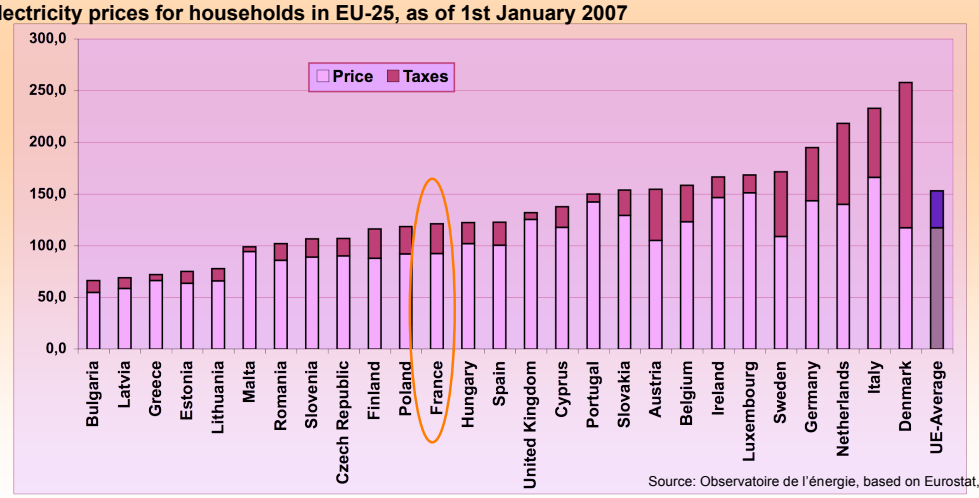
Nuclear electricity is cheaper than any other technology

French electricity prices are lowest in Europe thanks to nuclear reactors

French electricity prices show no clear advantage

- French prices within medium range in EU
- Predominant regulated market prevents real costs to reflect in tarifs
- Promotion of electric consumption (e.g. for heating) leads to average household consumption twice the EU "standard"

Electricity prices for households in EU-25, as of 1st January 2007



Source: Observatoire de l'énergie, based on Eurostat, 2007

Real costs of nuclear power: unclear and escalating

- **No learning curve**
  Historical record of projected costs escalating, still more slowly than real costs
- **No transparency**
  French Government not publishing data anymore ("commercial sensitivity")
- **EPR costs climbing**
  Latest official estimates:
  - **Finland** (Olkiluoto)**: from €3 bn up to €5.3 bn**
  - **France** (Flamanville)**: from 28.4 to 54 c€/kWh**

French EPR cost estimates	Construction Cost (€/kW)	Production Cost (€/MWh)
DGEMP 2003*	1043	28,4
EDF 2005		43
EDF 2006	2060	46
EDF 2008 - 1st EPR	2500	54
EDF 2008 - 2nd EPR		60

+ 92%

*The Goverment estimate of DGEMP 2003 served as a basis for the political decision in 2005

Indirect costs or hidden subsidies:

- R&D program
- Structural costs (grid…)
- Liabilities / major accident
- Economic burden of reprocessing
- Future long term costs (waste, decommissioning)
- Security costs (guards, etc.)

Assessing the French nuclear program…

Background

Effectiveness

Safety

Economics

(1) Direct / indirect costs

(2) Global economics

Government & Industry:

Nuclear energy key in France's competitiveness

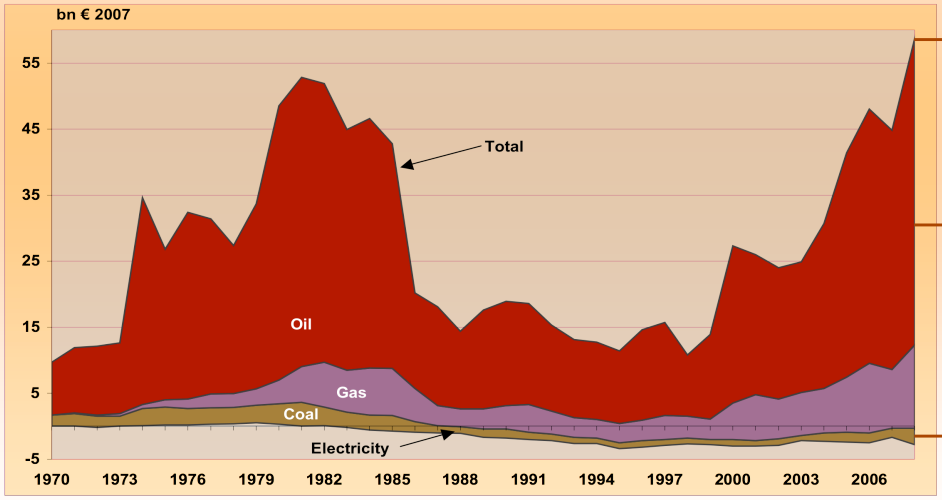
It benefits France's commercial balance through electricity exports and reduction of oil imports

No evidence of any impact on French global economics

- **Comparison** with other countries: **no breakthrough on global indicators (GDP…)**
- **Commercial balance still heavily dependent on oil**
  2008: positive at €3.3 billion without energy, record at -€58.7 billion with energy

France energy bill 1970-2008

By energy source, in 2007 €



€58.7 bn all time peak (+29% / 2007)

including €46,4 bn for oil

€2.8 bn from electricity

Source: Observatoire de l'énergie, based on Eurostat, 2008

Assessing the French nuclear program…

Background

Effectiveness

Safety

Economics

Democracy

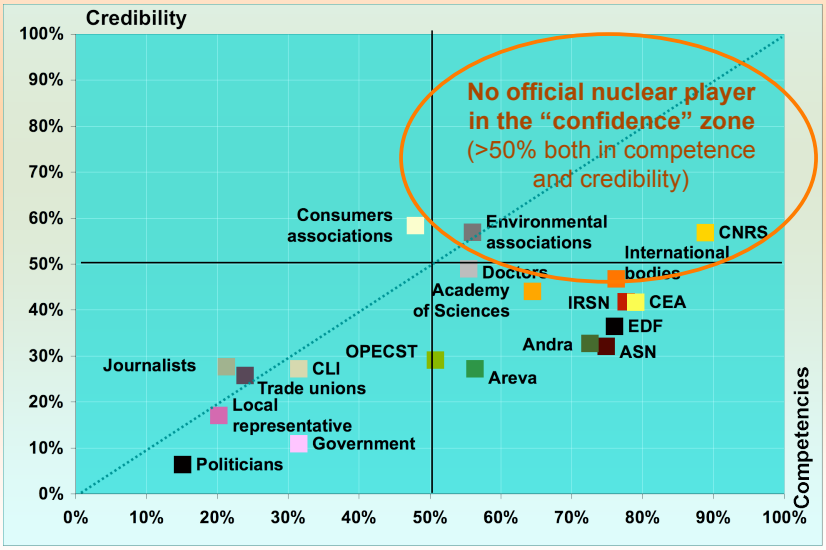
Government & Industry:

Large support in French society to the continuation of the nuclear program

The French nuclear industry builds confidence through full transparency

Confiscated decisions and public mistrust

- **Decisions made by a small elite in Government and industry** (Corps des mines)
  Lack of real external assessment / public review processes (*ex-ante* or *ex-post*)
- **No public confidence in official statements about nuclear risks**



Source:based on 2007 IRSN Barometer (survey of November 2006)

- **No strong public support:**
  European Commission poll in 2007 on the role of nuclear power in climate change policy:
  • **28%** French to increase
  • **59%** to decrease
  (closed to EU average, resp. 30% and 61%)

Assessing the French nuclear program…

Background

Effectiveness

Safety

Economics

Democracy

Lessons to be learnt

Main conclusions from the French nuclear experience

- **Systematic difficulties:**
  The French nuclear program has constantly failed to meet its own set targets
- **Structural problems:**
  The French nuclear program creates a lock-in of the energy system while creating new risks and not showing positive impact on global economics
- **Deficient assessment:**
  Pursuing of the program is based on an image disconnected from reality

Main lessons for the United States

Developing a nuclear program based on the "French model" would:

- **Introduce practices to the US energy system that conflict with its fundamentals**
- **Not ease significantly the energy/climate problems**
- **Increase *specific* problems arising from *specific* nuclear risks**
- **Make it more difficult to develop much more effective solutions**

Thanks for your attention!

Further contact:

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