France, showcase for the limitations of nuclear power

"The production of energy with low CO_2 emissions requires to mobilize renewable energy sources (…) and nuclear generation. Any decrease of the share of nuclear energy in electricity production (75% today) would make it impossible to reach greenhouse gas emissions reduction targets."

Report from the Energy Commission, chaired by J. Syrota, on 2020-2050 energy perspectives for France, Conseil d'Analyse Stratégique (CAS), February 2008

"Nuclear energy accounts for 6% of final energy in Europe, 2% worldwide and 17% in France. Given these percentages, focusing the debate on nuclear energy in order to build up a climate strategy does not seem justified. In France, the areas that need urgent attention are existing buildings, transport and the development of combined heat and power technology (CHP) in industry."

Report from the Working Group on "Achieving a fourfold reduction in greenhouse gas emissions in France by 2050", chaired by Ch. de Boissieu, August 2006

While the contribution of nuclear power to the energy consumption is undoubtedly marginal at a worldwide scale – hence its potential role in solving energy and climate crisis at that level –, its distribution is also very uneven. Only 31 countries run nuclear power plants, and the 6 biggest producers (United States, France, Japan, Germany, Russia and South Korea) generate almost 75% of the world's nuclear electricity production.

Confronted to the issue of scale limitation for nuclear energy, the advocates of nuclear renaissance take argument of this situation and claim that at least, nuclear power has a major role to play in countries or regions where it is already developed and that are ready for more – altogether in the technical, economic and political sense. Although there is no evidence from the past of a clear advantage in terms of energy security and mitigation of greenhouse gas emissions for countries operating large nuclear fleet,[26] the idea is worth consideration for the future.

Then comes the case of France. With 78% of its electricity production provided by nuclear power plants, the country has pushed the use of nuclear energy as far as it could be using current technologies. Its "all electric, all nuclear" plan, which remained the pillar of its energy policy since the programme started in the mid 1970s, has no equivalent in the world. The analysis of the real contribution of this development to France's energy security, and now climate policy, therefore provides a unique benchmark for similar plans currently discussed in other countries.

The original myth of energy independence

The idea that developing a domestic fleet of nuclear power plants would provide "energy independence" to the country by cutting down its dependency on oil became a decisive argument to launch a large programme of PWR reactors just after the first oil shock in 1973. The argument is still, 35 years later, the cornerstone for most decisionmakers' support for nuclear energy in France.

Yet the reasoning was biased from the beginning. In 1973, electricity production was only the fourth sector for French oil consumption, with 11.7% of the total (including non energetic uses), well behind transports (24.4%), residential and tertiary use (25.7%), and industry and agriculture (21.3%). This was actually the reason for promoting, as a complement to the construction of reactors, the extension

[26] The archetypal example being, of course, the United States that are the world leaders of both greenhouse gas emissions and nuclear electricity generation, with respectively more than 20% and around 30% of the world total in 2007.

of the use of electricity in sectors where this would be achievable, first the industry then the residential and tertiary sectors (through electric heating).

The substitution of nuclear power plants to fossil fuel-fired ones successfully brought down the share of electricity production in the French oil consumption down to 1.5% by 1985. By that time, about 30 reactors out of the 58 PWRs currently operating had been started-up. It is also the time when the counter oil shock, in 1986, put an end to ambitious energy efficiency policies that had been developed for the previous years following the oil shocks of 1973 and 1979. Altogether, the intensity of efforts on the demand side in the industry, residential and tertiary and transport sectors, related to the evolution of oil price, had much more influence on the level of French oil consumption than the nuclear programme alone.

This is true in both ways. Between 1973 and 1985, the reduction achieved in the power sector was only half of that obtained from the combined efforts on demand in the industry and residential and tertiary sectors. But the laxity of these policies from 1986, and the global lack of demand side policy in the transports sector reverted the decreasing trend to a growth of oil consumption up to now. According to the Ministry of Industry, the contribution of oil in terms of French final consumption reached a peak of 94 Mtoe in 1973 and went down to 74 Mtoe in 1985. The constant increase trend ever since has just brought the contribution of oil back to the record level of 1973, with 93 Mtoe in 2007 (see the part on evolution from the past years in Figure 9, below.) The actual dependency on imported fossil fuel is even higher if one considers that over the same period, the contribution of gas to French final consumption went up from 10 Mtoe in 1973 to more than 40 Mtoe in 2007.

Nuclear programme is nevertheless still considered a major contributor to French energy security in official reports. According to Government accountancy, it has brought French energy independence up from less than 25% to more than 50% – 50.4% exactly for the year 2007. This figure is based on a controversial choice to calculate the energy independence (the ratio between the energy domestically produced and consumed by the country) in primary rather than final energy: this allows for the two-thirds of primary energy used in nuclear power plants that are actually lost as heat in the atmosphere to be accounted for as produced… and consumed.

It is of course paradoxical that this large amount of wasted energy (roughly of the same order as the total oil use in the French transport sector) plays a positive role in the calculation. The absurdity shows when one considers that replacing French nuclear power plants, which reach a 33% efficiency, with less efficient plants would actually increase the official energy independence, while replacing them with hydropower and windmills, both assumed to have 100% efficiency, would bring it down to a mere 30%.[27]

Therefore it appears much more realistic to use a calculation based on final energy produced and consumed in the country. This implies, however, to make some choices in the calculation on how to account for energy losses, electricity exports, etc. Depending on those, published estimates range from less than 10% to 18% independence.[28] This is more consistant with the fact that nuclear power, after all, only accounts for 75% or more of the electricity produced in France, and electricity in turn only accounts for around 20% of French final energy consumption.

The difference between the two calculations is central to understand the huge gap that could develop between the importance given to nuclear power when discussing energy and climate options, and its real impact.

It should be noted that the authorities introduce other bias to enhance the role of nuclear power when they reduce energy security to the simple measurement of an ‘energy independence’ ratio. The first one is to discard any similarity when reasoning on security of supply of oil and uranium. On one hand, 99% of the oil used in France is imported and most of it (around 90%) is refined in France. On the

[27] It is interesting to note that even the planned improvement of new reactors performances, should these reactors replace the current ones with all things even, would have a negative impact on the calculated energy independence: this would drop from 50% to 48% if using the European Pressurized water Reactor (EPR, aimed to reach 36% efficiency) for replacement, and 42% if using hight temperature reactors reaching 50% efficiency or so.

[28] See in the first part of this chapter Global Chance’s calculation of a 14% energy independence ratio for France in 2007.

other hand, 100% of the uranium used in France is imported since the last French mine closed in 2001, and most if not all of it is enriched and fabricated into nuclear fuel in France. Yet nuclear electricity is accounted for as domestic production, while oil use is accounted for as imported energy, one reason given being the difference in the number and nature of supplying countries.

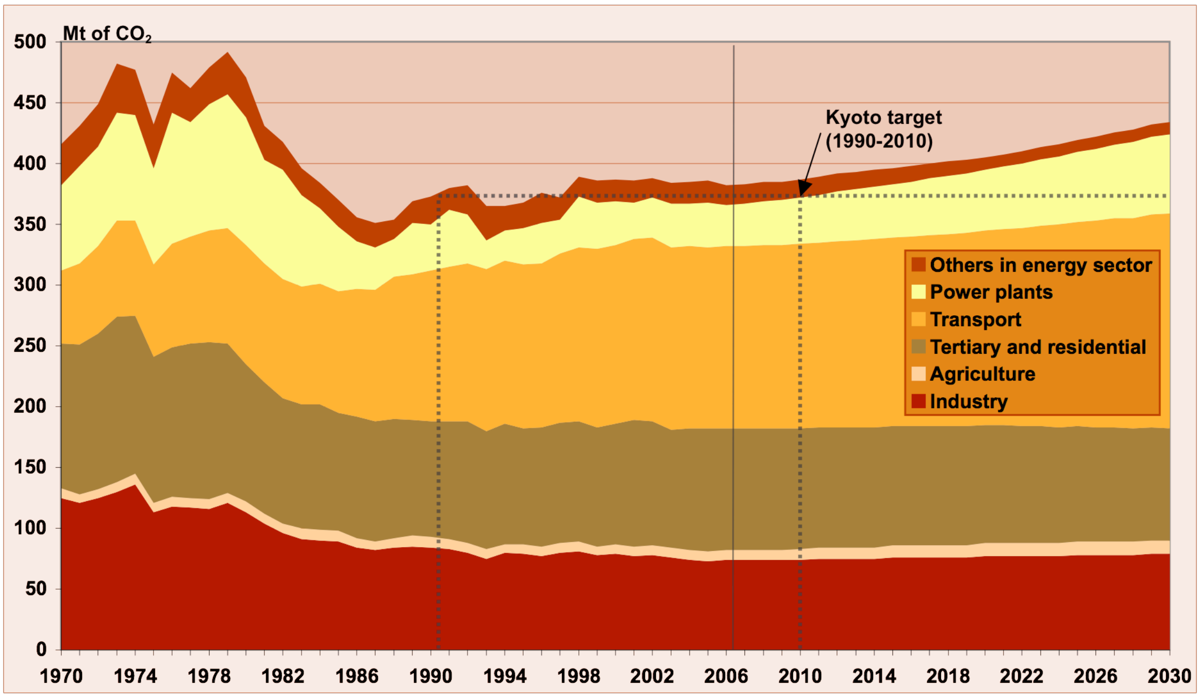
The second bias is to ignore any energy security issue besides the security of supply at the boarders, as if the domestic energy system were not impacting on the risk of energy shortage for end-users, which is what energy security is really about. The highly concentrated organisation of the electric grid that goes with nuclear power is not neutral regarding the potential for grid failures and their consequences. This systemic effect was involved in the very large extent, compared to the neighbouring countries, of the electric blackout following a record-breaking tempest in December 1999.[29] Moreover, the high dependency on nuclear power plants to 'fuel' the French economy and society with indispensable electricity creates, in addition to the remaining vulnerability to oil imports at least for transports, another serious vulnerability.

The inherent limits to the substitution logic

The failure of nuclear power to provide France with real energy security stresses the limits of an approach to energy policy that is based on technological substitution. Although this was obviously not intended at the time when the programme was decided, this rationale of substituting nuclear power to fossil fuels has been later extended to the growing issue of mitigating greenhouse gas emissions.

Figure 8 shows how the substitution mechanism applies to the evolution of greenhouse gas emissions – and more specifically to the CO_2 emissions from energy production and use, which are those concerned with nuclear development and account for roughly three quarters of France's total GHG emissions.[30]

Figure 8 **Past evolution of CO_2 emissions from energy production and use in France by sector and projection in a "business as usual" scenario (1970-2030)**



Source: Observatoire de l'énergie, DGEMP, 2008

[29] More than 3.4 million households were left without electricity at the peak, of which more than 500,000 for at least 5 days. In 25 departments (or about one fourth of the total territory) it was more than 50% of the population that was affected.

[30] The CO_2 emissions shown in the figure are those calculated by the Energy Observatory, with a slightly different method than the official United Nations Framework Convention on Climate Change (UNFCCC) method.

The figure clearly shows the impact of the development of the nuclear programme from the start-up of the first French PWR in 1977. But the decrease is also due, for a great part, to the efforts during that period on the demand side. These efforts drop dramatically in 1986 and from then, the growth of energy demand as a whole results in more increase of new fossil fuel consumption than is substituted by new nuclear reactors. Once all nuclear power plants are in service and an upper limit of substitution is reached, there is no more counterbalance to the overall growing trend.

The relatively low level of French GHG emissions, compared to similar countries, was taken into account to attribute its share of burden to France as part of emissions reduction for the European Union in the framework of the Kyoto Protocol. As a result, the French objective under the Protocol is only to maintain its level of emissions in 2008-2012 compared to their 1990 level (one should note that the choice of this year of reference, when emissions were peaking after the steady decrease of the 1980s, was already quite favourable for France).

But the trend, according to the 'business as usual' scenario published in 2008 by the Directorate general for energy and primary materials (DGEMP), is a constant growth of emissions for the next years and up to 2030 (Figure 8.) Consequently, France with all its nuclear power plants is not on the right tracks to respect its Kyoto assignment regarding CO_2 emissions.

This situation has nothing to do with some kind of nuclear phase-out. On the contrary, the DGEMP scenario assumes that, beyond the start-up in 2012 of the EPR under construction in Flamanville, more EPRs will be constructed to compensate for the shutdown of ageing reactors, so as to maintain all the way until 2030 a total installed nuclear capacity of 65.4 GWe, compared to 63.3 GWe in 2008. This is hardly 'business as usual': it represents about 52 GWe of nuclear reactors to be replaced between 2015 and 2030, roughly an average of 2 EPR reactors per year. The problem is that maintaining the nuclear capacity brings no more substitution but drains resources away from other energy options, while the rest of the energy system just grows.

Nuclear in France and the 'Factor 4'

Obviously something different will be needed if France is to aim not only for maintaining, but furthermore reducing its GHG emissions. It has actually set for itself a very ambitious goal for the long term with the 'Factor 4' concept.[31] This objective is based on the assessment by IPCC on projected temperature rise depending on global GHG concentrations. As it was put by the French Prime minister Jean-Pierre Raffarin at the opening of the 20th plenary session of the IPCC in Paris in 2003, "global GHG emissions must be halved by the year 2050"; for France, "this is equivalent to a fourfold or fivefold cut in emissions."[32]

The objective has been incorporated in French law through the Energy Policy Act n° 2005-781 of 13 July 2005 and its Article 2, which states that "tackling climate change is a priority of the energy policy, which aims to reduce by 3% per year on average French GHG emissions." Moreover, "France supports the establishment of a twofold cut objective for world GHG emissions by the year 2050, which implies, given the different level of consumptions between the countries, a fourfold to fivefold division of emissions for the industrialised countries."

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[31] This application to greenhouse gas emissions is derived from the much broader 'Factor 4' concept introduced by E. U. von Weizsäcker and A. Lovins in a 1997 report to the Club of Rome, *Doubling wealth – halving resource use* (Earthscan Publications Ltd).

[32] The reasoning behind is as follows. The equilibrium of temperatures on the low side of projected warming by the year 2100 (i.e. a temperature rise of 2°C or less) implies, according to the models, that GHG concentrations are stabilised at 550 ppm by the year 2050, which roughly correspond to a stabilisation at 450 ppm of CO_2 alone.
This, in turn, implies that annual emissions in 2050 would have to amount to no more than 14.7 Gt of CO_2, roughly half of the current level of emissions. This corresponds to 2.3 t of CO_2 per person per year based on the current word population of 6.5 billion people. If this burden had to be shared on the basis of an equitability principle, France and its current 61 million inhibitants would be entitled to 138 Mt of CO_2 emissions, compared to French emissions of 382 Mt of CO_2 for the year 2006.
Finally, this target of 138 Mt of CO_2 emissions in 2050 is assumed to be about one quarter of a projected growth of French emissions up to 550 Mt of CO_2 in 2050 if prolonging the current trend up to then. The factor four has later been further interpreted as a need to reduce emissions in 2050 to a quarter of their reference level in 1990.

It should be underlined that this self-compulsory objective was set prior to any elaboration of a French official energy and climate scenario matching this factor 4 goal. In fact, the first prospective scenario demonstrating a path to reach a 4-fold reduction of French CO_2 emissions by 2050 was published by an independent group of energy experts, négaWatt, in 2003. This scenario, updated in 2006, is based on a comprehensive implementation of energy sufficiency and efficiency on the demand side and of renewable energies on the supply side.[33] It therefore considers no need to build new nuclear reactors, even for replacing the existing ones when they shut down: it stresses that achieving the potential efforts to curb down energy demand is necessary *and* sufficient for keeping it to an absolute level of primary energy which the potential of renewables can reach on the long term.

On the contrary, official scenarios that have been developed since are bound to some continuity with the nuclear power precept. In that sense, they fully illustrate the potential contribution of this energy to meet long term energy and climate objectives.

The first 'factor 4' study commissioned by the Ministry of economy in 2004 was published in 2005.[34] The authors are themselves very cautious with the results, as the long-term part of the scenario (up to 2050) is based on a model of equilibrium between energy supply and demand that is built on the rules of the past while the need for real rupture is recognised by all experts. The model favours the share of electricity in final energy and that of nuclear power in primary energy, but that is a "possible factor 4 scenario" which "might not be the most desirable, the most economic or the most likely".

This scenario, which actually achieves a 3-fold reduction of emissions between 2000 and 2050 – considered as a sufficient burden for France inside a 4-fold reduction of emissions of the developed countries – envisions an increase of French nuclear electricity, up to 420 TWh in 2050. Yet this compares to some 480 TWh of nuclear electricity by 2050 in the 'trend' scenario. Why it takes less nuclear power to reach important reduction goals? Because the main difference lies in the overall electricity production, respectively foreseen at 690 TWh in the 'factor 4' scenario against 890 TWh in the business as usual case.

The most important lesson is there: curbing energy demand is the main key to curbing CO_2 emissions. The scenario adapted from this first study and presented as 'factor 4' scenario by the Ministry of industry in 2005 therefore envisions an average decrease of 0.6% per year through 2050, bringing the final energy consumption down to 116 Mtoe from 159 Mtoe in 2000 (figure 9.) This decrease is remarkably comparable to that envisioned in the négaWatt scenario, demonstrating that the development of a low carbon energy supply based on renewables or nuclear energies is a secondary choice which is meaningless if not preceeded by a primary priority on reducing energy demand.

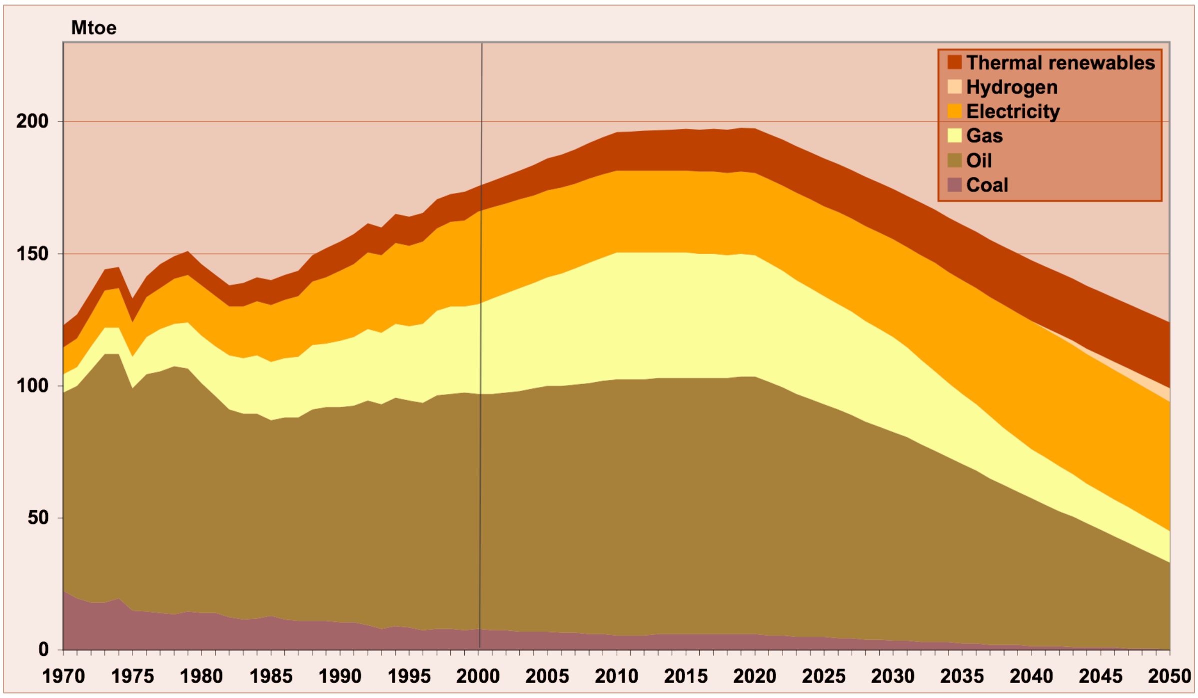
Unlike the négaWatt scenario which sees an immediate and progressive decrease of final energy consumption, the official scenario, however, concludes that curbing the demand is not realistic in the short term. It therefore postpones any inflexion to 2020 or even 2030. With less time remaining towards 2050 but the same level to reach, this obviously requires a much steady decrease, in the order of 1.7% per year between 2030 and 2050. The scenario has been deemed an unrealistic vision, for it fails to justify why it considers a slight inflexion impossible today but sees a steeper one possible 15 years later.[35]

[33] négaWatt, *Scénario négaWatt 2006 - Pour un avenir énergétique sobre, efficace et renouvelable*, Document de synthèse, December 2005.

[34] Enerdata / LEPII, *Etude pour une prospective énergétique concernant la France*, commissioned by the Observatoire de l'énergie, Direction générale de l'énergie et des matières premières, Final report, February 2005.

[35] Commission Particulière du Débat Public on the project of a first EPR at Flamanville, *Rapport de restitution du groupe de travail dit "Bilan prévisionnel RTE"*, February 2006.

Figure 9 **Past evolution of final energy consumption in France by energy and projection in a "Factor 4" scenario (1970-2050)**



Source: Observatoire de l'énergie, DGEMP, 2006

Late developments of official consultancies to the Government on French energy and climate 'factor 4' strategy have notably insisted on the marginal role of nuclear power as compared to energy demand policies[36] and the need to curve the trends as soon as possible.[37] The most recent advice, provided by a commission chaired by a former director of the energy department in the Ministry of industry and former CEO of Cogema, Jean Syrota, states that "reaching a division by 2 or 4 of GHG emissions by 2050 would hardly be compatible with leaving them unchanges between now and 2020."

These findings are reflected in the basis of the 'energy/climate package' passed by the European Council in March 2007, which sets goals for 2020 as a key condition to reach long term objectives, and establishes a link between the reduction of emissions (20% cut by 2020 compared to 1990), the development of renewable energy (20% of energy supply by 2020) and the effort on the demand side (20% reduction of energy consumption by 2020 compared to the projected trend).

Nuclear power: an obstacle to change?

The first French official 'factor 4' scenario matches none of these objectives. The meaning of these intermediate targets, in the case of France, is that relying on nuclear power to maintain the relatively low level of French CO_2 emissions in the short term does not dispense with the rapid implementation of strong policies on the other parts of the energy system as key for reducing the emissions on the longer term. But the basic philosophy of the French 'factor 4' scenario is that such policies aiming at reducing energy consumption or developing decentralized renewable energies could not deliver in the short term. This actually suggests that the whole technical, economical and political organisation of the French energy system around the "nuclear pillar" is an obstacle to the deep changes needed to face energy security and climate change challenges.

[36] Ch. de Boissieu (Dir.), *The Factor 4 Objective: addressing the Climate Challenge in France*, Report from the Working Group on "Achieving a fourfold reduction in greenhouse gas emissions in France by 2050", Ministère de l'économie et des finances and Ministère de l'écologie et du développement durable, August 2006 (free English translation of the authentic version of the report.)

[37] J. Syrota (Dir.), *Perspectives énergétiques de la France à l'horizon 2020-2050*, Rapport de la commission Énergie, Centre d'analyse stratégique, February 2008.

The Syrota commission of the Centre d'analyse stratégique (CAS), which pointed that need for rapid changes apart from pursuing the development of nuclear power, developed a series of energy scenarios combining these policies to reduce CO_2 emissions. The scenarios, which use two different sets of well established models (Markal and MedPro/Poles), compare reference or trend situations with voluntarist policies that are seen as the most efficient ones in realistic limits. The performances of these scenarios regarding the 2020 European targets and the national 2050 target are summarized in Table 7, which also includes the scenario developed by négaWatt.

Table 7 **Comparison of CO_2 emissions, energy efficiency, share of renewable energies and use of nuclear energy in 2020-2050 scenarios for France**

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%)

a. Scenarios include reference (or trend) versus voluntarist scenarios ('Ref.' and 'Vol.') based on two different sets of models: the Markal model used by a team of the Ecole nationale supérieure des mines de Paris (ENSMP) and the MedPro and Poles models used by Enerdata.

b. The European objective of 20% of reduction of final energy consumption by 2020 compared to a projected growth is assumed to be equivalent to 14% of reduction compared to the demand in 2006.

c. Excluding carbon capture and sequestration (CCS).

d. The reference for 2020 is the projection of electricity supply published in 2007 by RTE.

e. The authors of the négaWatt scenario rather refer to primary energy consumption and to the share of renewables in final energy. Regarding energy efficiency, the decrease from 2006 reaches 24.3% in primary energy; the difference in 2020 négaWatt's own reference (or trend) scenario is -31.9% in primary energy and -26.6% in final energy. Regarding renewable energies, they represent 22.4% of final energy consumption in 2020.

Source: CAS, 2008, based on ENSMP, Enerdata; négaWatt, 2007

The quantitative output of such prospective analysis should be cautiously considered due to the high level of uncertainty of the models and arbitrariness of some hypothesis. However, this summary of scenarios' results sheds an interesting light on the overall performance of energy and climate strategies embedding the nuclear option:

- the fact that CO_2 emissions rise in both models' reference scenarios, although they maintain a stable level of nuclear generation, recalls that a strong share of nuclear power is no guarantee against a negative trend;
- the comparison suggests an adverse effect of a high level of nuclear generation on the development of energy efficiency and renewables. In particular, the scenario with the highest development of nuclear power (Vol. Markal, +71% in 2050 compared to 2006) is also that with the least effort on final energy consumption (only coming back down in 2050 to its 2006 level)

and renewables (remaining with 15.6% far off the 2020 target even in 2050)[38]… and the least efficient of the voluntarist scenarios for cutting CO_2 emissions;

- conversely, it can also be noted that none of the scenarios published by the CAS reaches the same level of energy conservation and the same share of renewables than the négaWatt scenario, which excludes new nuclear reactors… and reaches more reduction of CO_2 emissions;
- finally, the performance of CAS scenarios, which all include an increase of nuclear power production, remains short of a 4-fold reduction of CO_2 emissions by 2050. The 2.1 to 2.4 reduction reached is deemed by the Syrota commission as a realistic maximum. The report therefore calls, instead of a further domestic effort, for diminishing France's commitment in the framework of a burden sharing within European Union of a European factor 4 objective (which is of course misleading, since France's factor 4 objective is already based on the application to the French population of a worldwide per capita target).

In addition, the CAS report acknowledges for significant biases in the models that clearly both increase the weight of nuclear energy in the calculated energy mix and its role in reducing emissions. Firstly, the models mostly calculate average energy supply and demand without including potentially significant variations through time. This is especially important for the macroeconomic modelling of the electric system in France, marked by a massive use of this form of energy – which can't be stocked on such a scale – for heating in buildings.[39] The huge variability of heating needs influences the needs for electricity generation through days and seasons.

The variation between the yearly peak and low of French electricity demand increased from 27 GWe in 1978 (between a minimum of 12 GWe and a maximum of 39 GWe) to 57 GWe in 2007 (between 32 GWe and 89 GWe), mostly as a result of the development of electric space heating that was decided together with the nuclear programme. By ignoring this structuring factor, the models used by the CAS do not account for its important economic and environmental impacts. Covering a large part of varying electric needs with nuclear power plants over the year actually combines periods when their capacity is higher than demand so they lose profitability, and periods when it is far from sufficient and a massive support of fossil fuel thermal plants is needed.

Also, the models do not provide an acurate representation of decentralized energy sources, especially those with the highest efficiency. The scenarios, according to the CAS report itself, give excessive importance to centralized sources like nuclear energy because they underestimate the potential for developing renewables and combined production of heat and power (CHP) – exactly those the most needed according to bottom-up scenarios like négaWatt.

The nuclear lock-in of the energy system

In summary, these models that have been developed in a context of supply oriented energy policies based on centralized technologies fail to give a fair representation of energy alternatives. The irony of the CAS report conclusion that without a high share of nuclear power France could not meet its long term energy and climate goals, while the scenarios actually show that this would not succeed, is typical of how the importance given to nuclear power locks in French long term energy policy.

The idea of a competition between the current energy system and a new policy based on energy efficiency and renewables is denied any relevance. Instead, the French authorities advocate the complementary nature of renewables and nuclear power to form a mix of carbon free energy supply. They claim that their support for nuclear electricity does not prevent other developments. Recent evolutions of the French energy debate on some key issues reveal on the contrary that clear choices against renewables or energy efficiency come with nuclear projects.

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[38] Although, due to the high level of energy demand compared to other voluntarist scenarios, this relatively low share of renewables in primary energy corresponds in absolute terms to a higher level of production than in the voluntarist scenario produced with the other model (Vol. MedPro-Poles).

[39] Electric heating represents around 10% of the total electricity consumption in France, and 30% of the consumption of households. About 7 million of flats and houses, or more than 29% of all lodgings, use electricity for heating. In 2007, 70% of new lodgings were equipped with electric heating.

This shows for instance in the very low development, if compared to the potential, of CHP or proven renewable energies like wind power.[40] The development of CHP practically came to an end in 2002 due to the end of public support, and there is no plan to back this technology. A report commissioned by the Ministry of industry in 2007 concluded that any development of CHP should be cautiously limited to the most efficient plants and underlined a potential waste of public money, judging that it would be more economic to invest in new nuclear reactors.[41] The decentralized development of windmills is limited by the instability that it can induce on the highly centralized French electric network. Also, any increase of wind power, which must be used when the wind blows, would reduce the share of baseload electric demand covered by nuclear power plants and therefore erode their economics. The government's clear intention is to constrain the development of wind power to a limited, controllable number of large plants instead of using the whole potential of the French territory (estimated to be the second highest in Europe).

There are even stronger hidden effects of competition between nuclear power and energy efficiency. This is particularly true with choices to be made regarding heating in the residential and tertiary sectors. Heating needs in buildings represent more than 20% of French CO_2 emissions and a clear consensus has emerged in recent years that the factor 4 objective implies strong changes in the consumption of this very slow evolving sector. This includes both a large programme of rehabilitation of the thermal performance of existing ones and the introduction of strong new constraints of thermal performance for new buildings. In October 2008, the introduction in a project of law of a plan to impose a level of 50 kWh/m^2/year of primary energy for space heating in new buildings forced political reactions in defense of the nuclear industry: this level could not be reached in new buildings using electric heating from thermal (nuclear and fossil) plants, which has the lowest overall efficiency of heating systems. The debate underlined the contradiction between the urgent need for a policy to reduce the huge wasting of energy in that sector and the will to maintain a supply-side policy favouring nuclear power.

Historical and prospective analyses of France's energy and climate policies clearly show that other priorities than the sempiternal stance on nuclear power must be developed in order to meet the country's medium and long term goals. However, the analysis also shows that the disproportional importance given to nuclear power makes it hard to grasp those real priorities. Moreover, it suggests that under the influence of nuclear power, the whole energy policy is trapped in some mechanisms and constraints that hinder appropriate shifts in the energy system, irremediably leading the country to failing to its own commitments. Although current level of CO_2 emissions create the illusion of a successful policy, the lack of further decrease comes as a warning. France appears well on track to show that long term negative impacts of this nuclear lock-in outweight positive impacts of nuclear substitution.

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[40] According to RTE, the French production of electricity from renewable energies other than hydroelectricity reached 7.8 TWh in 2007 (or 1.4% of a total of 544.8 TWh), of which 3.8 TWh from 960 MWe of thermal plants using renewable fuel and of photovoltaic, and 4.0 TWh from 2,250 MWe of wind power.
The capacity of electricity generation from CHP is around 4.7 GWe in the end of 2007, of which only 0.7 GWe have been installed between 2002 and 2007.

[41] Inspection générale des finances and Conseil général des mines, *Rapport sur les installations de cogénération sous obligation d'achat*, Report to the Ministry of economy, finance and industry, January 2007.