The past futures of techno-scientific promises

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Abstract

Previous studies have shown that techno-scientific promises play key roles in the process of emergence of new technologies. The role of promises in the emergence of old technologies when they were young has, however, been overlooked. The main objective of this paper is to fill this gap. We draw on the concept of 'regime of historicity', defined as an organizational structure given societies impose on the experience of time and articulate the present, the past, and the future. Using four case studies, we argue that the way techno-scientific promises align with regimes of historicity is crucial. This paper shows that promising in the presentist regime using the modernist frame of innovation (creative destruction) raises many problems Instead, the building of horizons of hope may rest on promises based on processes of collective experimentation.

Key words: technoscientific promises; sociotechnical imaginaries; horizons of hope; regime of historicity; genetics; nuclear energy

1. Introduction

Techno-scientific promises have been identified as devices that play key roles in the process of the emergence of new sciences and technologies (Van Lente 1993; Joly 2010; Audétat et al. 2015). They are instrumental for creating a horizon of expectation where the new technology appears as a necessity—or something highly desirable; for stabilising the future through the coordination of expectations of many actors who get enrolled; and for performing a technological path creation. To perform these functions, promises are crafted by technology promoters—'promises entrepreneurs'—in order to convince various audiences and successfully pass different trials of strength.

Summarizing previous analyses by Joly (2010), we suggest that promises are shaped to fulfil two main conditions: legitimacy and credibility. The condition of legitimacy may be equated to an operation of translation in which promoters strive to demonstrate that the new technology is the solution of important societal problems, thus translating it into an obligatory passage point (Callon 1986). But the requirement of novelty associated with legitimacy contradicts the condition of credibility in its very foundations. Credibility builds on experience, while legitimacy rests on the claim of radical novelty—the idea that the solution proposed is very different from what is already available. Claiming that the technology is radically new and powerful may raise concerns for actors that may be threatened by possible deliberate substitutions of economic activities and/or by unintended effects that may affect the social field, the health or the environment.

Scholars have explored the main characteristics of the regimes of techno-scientific promises (see Audétat et al. 2015 for an overview). Techno-scientific promises are relational. They draw on the distinction between those who formulate them (the future makers) and those who are supposed to believe (the future takers). This relational characteristic distinguishes promises from other future-oriented concepts such as socio-technical imaginaries (Jasanoff and Kim 2015).

However, whereas a promise is relational, the economy of techno-scientific promises (Joly 2010) does not only consist of communication. It also involves the production of knowledge and material investments. Accordingly, we define techno-scientific promises as the apparatus by which actors (promise entrepreneurs) interest and enrol different audiences in order to mobilize resources to achieve techno-scientific transformations. The economy of techno-scientific promises is a set of practices (discursive, R&D experiments, infrastructure and material investments, strategic alliances, etc.) that allow the mobilization of necessary resources all along the transformation pathway.

Temporality is an important dimension of the regimes of techno-scientific promises, which has been understudied in the existing literature dealing with current promises. As suggested in the

survey dedicated to future studies in the Handbook of STS, 'the studies of dynamics of expectations […] tend to focus on specific contemporary developments and patterns, often not taking explicit account of how these are embedded in broader, long-term cultural patterns' (Konrad et al. 2017). This paper aims at filling this gap in two ways. First, we aim at better understanding the historicity of techno-scientific promises. This involves analysing the way promises determine the relationship to the future, and are designed by it. Some historians have focused on the analysis of the differences in the relationship to the future in different periods of history (e.g. Hartog 2003; Koselleck 2004). The latter proposed the concept of 'regime of historicity', defined as an organizational structure that Western culture imposes on experiences of time. Changes in 'regimes of historicity' entail changes in the relationship between past, present, and future. Therefore, the research question behind this paper may be formulated as follows: how do specific techno-scientific promises fit with the regimes of historicity they are embedded in?

Moreover, considering promises in different periods allows us to investigate possible changes in the internal temporality of techno-scientific promises. Long duration is one of the main characteristics of techno-scientific promises: it may take dozens of years for a techno-scientific promise to concretize. This characteristic leads us to consider two key issues. First, how does a promise stabilize a project and its environment? The gathering of irreversibility in the process of techno-scientific investment can be analysed in the terms of momentum (Hughes 1987) or path creation (Garud and Karnoe 2001). Second, the lag between investment and impact may generate instability. Promises require convincing various audiences in order to create strong expectations, which can lead to overselling the new technology. As the process for performing transformation is generally longer than expected, the lag may generate cycles of hypes and disappointment as famously suggested by the Gartner group (Borup et al. 2006; Konrad et al. 2017). This leads to formulating a second question. In a regime of historicity characterized by acceleration and futures that are contested and fragile (a 'presentist regime' to refer to Hartog), is it still possible to perform path creation? And, if so, what are the specificities of the internal process?

We propose to explore these questions through the analysis of cases of promises at different periods in time. As the socio-technical imaginaries have been shown to be dependent on national contexts and slightly different according to broad fields of activity (Jasanoff and Kim 2015), we study four French cases, respectively, in energy and agriculture, before and after 1980: Fast breeder reactors (FBRs), Smart Grids; Hybrid corn, and GM corn. Our analysis partly draws on secondary sources but we apply systematically a common analytical grid and produce stylized cases accordingly. This analytic approach aims at supporting a set of hypotheses on changes in the regimes of socio-technical promises in France over the past 60 years, which is outlined in the first section of this paper.

2. Two temporal dimensions of techno-scientific promises: historicity and duration

Regimes of historicity and the paradox of techno-scientific promises inflation

In this section, we consider the way techno-scientific promises are embedded in historical contexts. Drawing on historians of the future, we summarize how the relation with the future has been historically shaped; then, we suggest that this entails crucial implications for techno-scientific promises.

In *Futures Past*, the German historian Koselleck (2004 [1979]) argued that the way societies articulate spaces of experience and horizons of expectation have been displaced and changed during the course of history. Whereas *experience* is *present past*, whose events have been incorporated and can be remembered, e*xpectation* is *the future made present.* Expectation directs itself to the not-yet, to the non- experienced, and to that which is to be revealed. Hope and fear, wishes and desires, cares and rational analysis, receptive display, and curiosity: all enter into expectation and constitute it (Koselleck 2004: 273).[1] Modernity (*Neuzeit*) as it appeared in the eighteenth century is characterized by the separation between expectations and all previous experience (p. 276). Of course, this shift did not appear as a universal and homogeneous change in all societies, neither in all areas of life. For instance, scientific discoveries such as the Copernician revolution in the fifteenth century seriously challenged previous deeply rooted representations of the place of mankind in the universe and created a breakthrough between experience and expectation. However, in the traditional societies that prevailed then, 'the expectations cultivated in this peasant-artisan world (and no other expectations could be cultivated) subsisted entirely on the experiences of their predecessors, experiences which in tum became those of their successors' (Koselleck 2004: 273). In Weberian terms, tradition was the main source of legitimacy. Expectations were controlled not to disrupt experience.

The French *revolution* is regarded a key exemplar of the change of the relationship to the future. Condorcet, Comte, and others are considered to have endorsed the role of 'moral agents for change' (Adam 2010). In those times, the past was devaluated and it could not serve anymore as a guide for imagining the possible otherness of the future: 'The future would be different from the past, and better, to boot' (Koselleck 2004: 279). Expectations became free from the past; time was no more cyclical but linear and it followed the arrow of progress. The future was no more God's creation or fate; it was the result of the action of human beings.

This separation between expectation and experience is both a condition and a consequence of techno-industrial progress. Because of its grounding on scientific rationality, the ideology of progress replaced tradition as the main source of legitimacy for public decision-making.

Basing on Koselleck, the French historian François Hartog coined the concept of regime of historicity (Hartog 2003). Dealing with recent changes, he interestingly identifies two regimes of historicity:

- A modernist regime (1789–1989), well described by Koselleck and characterized by a sharp separation between past and future. Because of the collective belief in a better future, the past was depreciated, since time was oriented to the future. Modernism is thus associated with the idea of progress.

- A presentist regime since 1989: in this regime, the present has become its own horizon of expectation. Consumption is the moral of the world, imposing a cult of fashion and ephemeral; aiming at novelty just for the sake of novelty, one lives in constant acceleration and planned obsolescence of products and technologies. In the presentist regime, the future is thus embedded in the present. The expression 'there is no alternative' is emblematic of the closure of the future.

The philosopher Daniel Innerarity further suggests that the current political crisis corresponds to a crisis of the future (Innerarity 2012). Dynamics of acceleration and the hegemony of short term imposed in many sectors (media and social networks, financial market strategies, fashion and marketing, etc.) translate into a tyranny of the present.

We suggest that science and technology play an important role in the shift towards the presentist regime. First, following Helga Nowotny, the category of the future is shrinking towards becoming a mere extension of the present because science and technology have successfully reduced the distance needed to accommodate their own products. Moreover, an incessant need for innovation creates obsolescence at an ever-increasing rate, posing problems for future absorption, difficult issues that have to be dealt with in the present, again with the effect that the future is incorporated into the present (Nowotny 1994). This acceleration comes along with nostalgia for something that is about to disappear (Nowotny 1994; Baschet 2018).

Second, presentism is also linked to the questioning of the modernist ideology in the light of growing controversies about risks entailed by sciences and technologies, a shift that Beck (1992) summarized as the rise of the 'risk society'. The horizon has been obscured by the issue of climate change, the irreversible environmental footprint of mankind captured as 'the Anthropocene', and the ensuing catastrophism. The future is still very present, but it is not a horizon of hope anymore. It is mainly considered as a threat for humanity and planet earth. In this context, it takes a good deal of rhetoric and communication skills to convince that, whereas techno-modernization is the source of our current problems, the solution will still come from technological innovation (Baschet 2018: 73). Promising is thus part of this huge effort. As observed by sociologists of techno-scientific expectations, the recent period is

characterized by 'hyperbolic expectations of future promise' (Borup et al. 2006; Audétat et al. 2015). At first sight, this may be surprising since, whereas promises are an integral part of the modernist regime, the crisis of the future characterizing the presentist regime does not leave space for an open future, thus rendering promising problematic. This issue was pointed out by the French historian of technology and philosopher Bernadette Bensaude-Vincent (2015). Considering that any regime is plural, especially the presentist one, she argued that techno-scientific promises constitute a reminiscence of the modernist regime. This argument, however, cannot explain the shift in intensity of promises observed by Borup et al. and to which we concur. Our hypothesis is that the inflation of promises is (at least partly) due to the attempt of promoters to renew their key role as future entrepreneurs, whereas techno-sciences are contested. These efforts for maintaining an expectation horizon for new sciences and technologies may in some cases amplify contestation.

Constructing the new cathedrals: the role of promises for path creation

The second key temporal dimension of techno-scientific promises is the long duration. Shaping important technological changes is like constructing cathedrals in the twelfth century. Promises are related to processes that may last dozens of years. Important technological changes require continuity in action and in the mobilization of resources towards the objective, despite changes in the environment, high uncertainty, unexpected difficulties, etc. *Ex post*, one may observe that these changes result from path-dependent processes characterized by a strong irreversibility, which some have interpreted as lock-in effects (David 1985; Arthur 1989). Adopting a real-time perspective, Garud and Karnoe (2001) rightly suggested that these processes, although emergent, may be related to the agency of actors who engage in a variety of purposive actions to initiate and sustain a bandwagon. Hence, without ignoring the properties of such emergent projects, such processes can be analysed as path creation. This involves translation in the sense of Michel Callon, that is, a process that allows to create new associations, spur alignment of human and non-human actors, and construct new socio-technical entanglements that possibly become irreversible (Callon 1986; Akrich et al. 2002). Translation is therefore the elementary process through which path creation gains momentum.

In a pioneering contribution, Harro van Lente identified the different roles of promises in the build-up of development agendas and in the interlocking of activities shaping technology (Van Lente 1993: 34). He made several key observations and proposed an original analytical framework. First, at the micro-level, promises play three main complementary roles: (1) legitimize the new technology, thus considered as essential (a form of generalized problematization); (2) mobilize resources through the 'interessement' and enrolment of actors; (3) reduce strategic uncertainty by the sharing of visions and by construction of a scenario—and even a script— that provides a shared understanding of the role of different actors. Second, promises may contribute to align visions at different levels from micro to meso and then

macro. Van Lente uses the expression 'nested spaces' and distinguishes the micro/protected space (the space of the project), the meso/rhetorical space (the space of policy of the field), and the macro/cultural space (general political landscape). Third, he considers that the dynamics of promises may create momentum when it fosters positive feedbacks between promises and requirement, which may play at the three mentioned levels.

The dynamics of promises raises different key open questions; among them, the issue of the protected space that isolates technological exploration from environment instability and contestation, the issue of generalization, through which the new socio-technical agencements may be upscaled and be a subject of wider social uptake, but also the issue of the asymmetric influences between the micro- and the macro-agenda.

These different elements on historicity and duration lead to formulate an additional hypothesis. Techno-scientific promises in the presentist regime are framed by the future being absorbed into the present by urgency, fascination for novelty, a cult of fashion, acceleration, and by the related need to renew the promises, with the need to convince wider audiences. This renders the process of path creation much more problematic.

Our methodology requires some clarifications. First, in order to identify and characterize the temporal patterns of techno-scientific promises in different historical periods, our research questions lead to perform a qualitative process- oriented analysis. Second, such an analysis has to draw on several case studies (four in our cases); the added value of this paper does not rest in each individual case study (about some of which we have already published) but on their combined analysis. Lastly, we do not pretend to perform a comparative analysis but to identify patterns allowing us to grasp some of the diversity of the phenomenon and deduce new insights on both sides of the temporality of the promises.

Hence, we designed an analytical grid that was applied to the four cases while paying attention to their own singularities. This grid involves the following themes: (1) the type of promise; (2) the actor's constellation (promise entrepreneurs); (3) the sources of legitimacy; (4) the sources of credibility; (5) contestations and control of the agenda; and (6) dynamics of expectations.

We now present the four cases, beginning with promises in the modernist regime.

3. Promises in the modernist regime

We chose to illustrate the modernist regime by two cases that are emblematic of the post WWII period in France. In many ways, this is the key period of modernization governed by the National State with the aim to reconstruct the post-war economy, to increase welfare, and to recover 'French grandeur' in the 'Concert of nations'. The adoption of hybrid corn (1949–1970) is our first case, and the project of Fast Breeder Nuclear Reactor (1954–1980) our second case.

Hybrid corn, France (1949–1970)2

> *'Hybrids are the best way to improve a crop that is essential to our small farms and useful to the French economy.' Louis Bidau, Président Association Générale des Producteurs de Maïs (AGPM), Congrès du Maïs, Pau, décembre 1949.*
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> *'The future of maize in France is linked to the use of hybrid seeds. We need to organize the production of hybrid seeds.' Luc Alabouvette, Professeur de génétique végétale, Ecole d'Agronomie de Montpellier, Journées du Maïs, Pau, décembre 1952.*

In the aftermath of WWII, French agriculture was considered as dramatically lagging behind (Dumont 1946) and it was identified as one of the economic sectors in need of urgent modernization. Several visits of French experts in the USA were organized to detect the best technologies to transfer for speeding up technological progress. Hybrid corn was identified as a key potential innovation. With the support of FAO, field trials of 'American hybrids' were organized. In the Plan Monnet, the French government foresaw a sharp increase in corn acreage and corn yield (respectively, from 300,000 to 372,000 hectares and from 15 to 20 quintals/hectares between 1948 and 1952). To achieve this goal, the Marshall Plan funded the import of hybrid seeds from the USA. With the support of the Ministry of Agriculture, the newly created French association of corn producers (AGPM) organized a national system of production of hybrid corn seeds. Meanwhile, the National Institute for Agronomic Research (INRA) undertook research based on French genetic resources and created new high-yielding varieties, well adapted to the French pedoclimatic conditions in the late 1950. These varieties would progressively substitute 'American hybrids'.

Promise entrepreneurs constituted a coalition of progress that gathered farmers' leaders (like Louis Bidau and Hubert Buchou), agronomists and plant breeders (like Luc Alabouvette and André Cauderon), and high civil servants at the Ministry of Agriculture (like Louis de Saint Martin). With the diffusion of hybrid corn, their project was to transform a traditional activity, related to a subsistence economy, into an industrial one fully integrated in a market economy. This was a lever for freeing expectations from the secular experience of small

farmers and to spur the 'end of peasants' (Mendras 1967). The cult of modernization favoured this innovation. The future was considered as necessarily different from the past. Pioneers of hybrid corns constituted the perfect example of 'anti-malthusianists' (to use the words of Pierre Mendès- France in 1952, then President du Conseil), that is, actors considering that our world is not limited and that the future is open.[3]

Some contestation rose among potential adopters because of the uncertainties related to the new varieties, adding to the concerns over the quality of the grain as compared to traditional varieties. As shown by sociologist Henri Mendras, many farmers did not see any interest in increasing production because this would require changing their production and exchange system. However, contestation remained limited and quickly diminished. This was probably related to several factors. First, AGPM and local services of the Ministry of Agriculture organized an intense activity of demonstration. Any local agricultural contest organized at the village level was used to compare hybrids to the traditional varieties. Although the scientific quality of these contests could be discussed, they were highly efficient in terms of communication and persuasion. On the other hand, some complementary innovations (fertilizers, herbicides, mechanization, etc.) increased the technical efficiency of hybrids; the bank credit policy helped farmers to adopt the new production system; and the agricultural policy supported high prices. First adopters made money and were progressively imitated by their neighbours, even the more reluctant. The coordination of these interlocking activities was spurred by the agenda related to the visions and expectations of the coalition of progress. This alignment reinforced the momentum of the new production system going along with hybrid corn seed.

After a few years, the techno-scientific promise was fulfilled. Hybrid corn was successfully adopted and contributed to a rapid increase of productivity and of production, far beyond what was expected.

The promise of fuel abundance: the fast breeder nuclear reactor, France (1954–1980)

> *'The country which first develops a breeder reactor will have a great competitive advantage in atomic energy' Statement by Enrico Fermi at Los Alamos in 1945 (Cochran et al. 2009).*

The development of the FBR in France started within the Atomic Energy Committee (CEA) in the early 1950s. Upon their return from a study tour to the USA in 1954, scientists had been convinced by their American counterparts that the FBR was the most promising nuclear technology (Vendryès 1997). They dedicated themselves to 'the art of interessement' (Akrich et al. 2002) and obtained budgets for exploratory research, soon followed by the setting up of

specialized teams. The plea for the FBR was based on a technological promise that of almost inexhaustible energy—a concern at this time when the perspectives of soaring economic growth contradicted scarce fuel resources, thus leading to an 'energy gap' (Aykut 2019). The reasoning was as follows: economic growth requires abundant and cheap electricity; current nuclear power plants (water reactors or graphite-gas reactors, developed in France and the UK) use a marginal isotope in uranium and, as a result, quickly exhaust the natural uranium stock while converting only a small percentage of its energy potential. On the contrary, the FBR uses the main isotope of uranium and can even regenerate its fuel; its development should be fostered in order to establish its technical feasibility and to move towards industrial maturity in the longer term. Thus, technological development was constructed as the 'obligatory passage point' to make this technological promise come true.

Starting after the USA and the UK in what seemed an international race, the French CEA attempted to make up for lost time. Moreover, such technological development had been entrusted with the mission of restoring 'French grandeur'

lost during the war (Hecht 2009). After 1957, three research reactors were designed and built with the support of Euratom (Vendryès 1997), adding to the techno-scientific promise the promise of European unity (Le Renard 2018). In 1967, on the CEA's site in Cadarache, Southern France, the completed experimental reactor (24 MW) Rapsodie, a name standing for RAPide SODIum, was inaugurated by the Général de Gaulle and two ministers. Scaling-up went on at a rapid pace: the size retained for the following FBR demonstration reactor, 250 MW, was the size of a standard coal-fired power plant at the time. This reactor called Phénix reached its nominal power in March 1974, before its British counterpart PFR, leading the *Financial Times* to entitle an article « French world lead in fast reactor technology » on 15 March. The fulfilment of the techno-scientific promise seemed within reach. The availability of the fast breeder paved the way for a nuclear future, freed from fuel supply concerns, rendered even more acute by the oil crisis.

Nevertheless, at the very moment when the Général inaugurated the Rapsodie reactor, the relationship to the future in the planning of technological modernization began to change. From 1967 on, 'technology enthusiasts' began to lose ground to the advantage of 'cost-benefiters' to use the categories proposed by Jasper (1990). 'Cost-benefiters' were civil servants and company executives concerned with return on investments. Rigorous cost-benefit appraisals progressively gained more weight in the decision-making concerning new technological projects. This occurred both at the General Commission for Planning (Fourquet 1980) and in the nuclear establishment (Simonnot 1978; Hecht 2009). In 1969, the development of an industrial-scale FBR prototype was already perceived as costly; therefore, three European utilities (French, Italian, and West-German) joined to share costs and experience. Step by step, the project that would later be called 'Superphénix' gathered momentum. In 1972, at the French Parliament, the

technological choice of FBR development rallied a broad consensus among elected representatives. Being a 'national' technology development, contrary to light- water nuclear reactors (LWR) chosen for the industrial fleet, Superphénix was to embody French *grandeur*.

But from 1974 on, the project triggered a controversy initiated by scientists and experts about both its effects on health and the environment and the risk of being locked in nuclear technology. The future became a potential threat. Scientific journalists from major daily newspapers expressed criticism towards the 'major technology projects in which the 4th and 5th Republic put their faith, so to say our new cathedrals',[4] and later compared the features of the Superphénix project to the Concorde supersonic flyer, questioning its social uptake.[5] Nevertheless, in 1976, the government gave its green-light decision and the construction started, soon followed by massive demonstrations against the industrial- size FBR and the subsequent nuclear future. The expert critique intensified. Yet, throughout the 1970s, as an answer to these concerns, official discourses hailed the FBR for the promise of future energy abundance. In 1980, a series of radio and television broadcasts attempted to conduct 'Public hearings on the FBR', giving voice to citizens, representatives of the major political parties, and experts—or counter-experts (Jobert and Le Renard 2016). Shortly after the 1979 second oil crisis, memorable statements insisted upon the promise of the FBR:

> *'If uranium from French soil were finally to be used in breeder-type power plants, we would have an energy potential in France, a reserve comparable to that of Saudi Arabia'*[6]

> *'I'll give my conclusion, because I have three children, and I have planted trees with my own hands, and planting trees is not for one's sake but for one's children and grandchildren.. so for me the breeder is the Liberty Tree for my children and my grandchildren ! Believe me, Madam, I tell you this with great sincerity'*[7]

This image of the Liberty Tree refers to a symbol of the French Revolution, the first being planted in 1790 (inspired by the American example). The statement renders explicit the reference to modernity and an open future entrusted to the promise of the FBR, as well as the moral obligation enclosed in the promise by technology enthusiasts. Meanwhile, in closed arenas, 'cost-benefiters' had expressed their doubts from 1976 on regarding FBR's industrialization. In their eyes, Superphénix was too costly, it did not fulfill the credibility condition. Moreover, a successful industrialization of the more economical LWR was the major stake in the nuclear sector at the time. So, they proposed an ambitious cost target for future FBR plants, and 'technology enthusiasts' discussed its (non-)feasibility but tended to be marginalized. While Superphenix' construction went on, their negotiation resulted in postponing FBR industrialization and reformulating the promise (Le Renard 2018). The new promise concerned a more economical FBR design for a postponed fleet. Thus, even before

Superphénix' completion, they requalified it as an early prototype of a technology that would required another step before reaching 'industrial' stage. In 1994, after 7 years of operation marked by several shutdowns of the plant, the government requalified it as a research reactor while stating that FBRs might still be necessary in the very long term. Therefore, regarding 'hype-disappointment cycles', this case suggests that the moment when the promise becomes solid by the realization of a prototype is not a moment of disappointment in a cycle about an unchanged promise but a moment of distortion and requalification of the initial promise in the light of new knowledge on the technology's feasibility, costs, and industrial perspectives (Le Renard 2015a; Ruef and Markard 2010).

4. Promises in the presentist regime

GM corn— 'feeding 10 billion people in 2050'

> *'Biotechnology represents a potentially sustainable solution to the issue, not only of feeding people, but of providing the economic growth that people are going to need to escape poverty. Biotechnology poses the possibility of leapfrogging the industrial revolution and moving to a post-industrial society that is not only economically attractive, but also environmentally sustainable.'*
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> *Robert Shapiro, CEO, Monsanto Company, Speech before the Biotechnology Industry Organization (BIO'98), New York, 17 June 1998.*
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> *'The freight train bearing down on us is the crisis of sustainability and sustainable development. The precautionary principle tells us that even without full certainty about the paths ahead, we should act to avert the serious and irreversible harm that is occurring even as we speak. Failure to move forward with new technology .. global trade and business development .. is probably the biggest risk we face. Our inertia on our historical track will kill us for sure if we act too slowly.'*
>
> *Rob Horsch, Senior Monsanto Executive, 1997.*

The promise of GM corn is encapsulated in the escalating promises of biotechnology: feeding the world in 2050, fighting against deadly human diseases, offering solutions for sustainable agriculture, for poverty alleviation, for climate change, etc. Development of these technologies is presented by its promoters as a moral obligation since delaying its use would have harmful consequences for the poor and for the environment. For this claim to be credible, the coalition of promoters (agribiotech companies, venture capital firms, policy makers, and molecular

biologists) were eager to present plant breeding as an obsolete technology whose potential had vanished (Joly and Ducos 1993). Genetic engineering was thus presented as a breakthrough, something radically new and powerful. At the same time, it was said that this same technology falled within the continuity of our relationship with nature and that it was part of a millenary process of transformation of living organisms, thus not triggering new specific dangers.

The promise of biotechnology was much challenged and, eventually, the diffusion of GM corn, the first GM plant candidate for cultivation in France was blocked. Although they were backed by the European regulation that framed the adoption of GM crops as a stepwise process based on field experiments (Directive 90.220), the promise entrepreneurs did not succeed in imposing their own agenda and failed in the legitimacy and credibility tests. The failure of the promise was less due to expectations overselling (Cf. the famous hype- hope-disappointment cycle suggested by Gardner) than to an adverse environment. In the aftermath of the 1996 'mad cow disease' crisis, many actors became concerned for potential hazards related to new technologies in the food chain. These concerns were voiced by consumers' organizations as well as supermarkets, and even the powerful farmers' union FNSEA. In this context, a strong adversary coalition lead by alter globalist farmers' union *Confédération Paysanne* successfully bridged frames (Snow et al. 1986); GM crops soon became the symbol of 'mal bouffe' (junk food), social and environmental issues related to agriculture and food being controlled by global companies (primarily Monsanto), and marginalization of small peasants. The social benefits of GM crops were deeply contested: the need for increasing productivity was challenged (because of concerns related to structural agricultural production surplus); GM crops were associated with the increased use of pesticides; and dependency of farmers and of the food chain on a handful of big companies was a major matter of concern. Because of this strong controversy, promise entrepreneurs lost control of the valuation of the technology; they failed in enrolling allies and did not succeed in imposing their agenda. Their claim of inevitability of GM crops ('there is no alternative', 'we have no choice') fed the contestation; the will to open the future operated as a powerful engine of the anti-GM coalition. The public agenda of GM crops soon focused on difficult issues such as labelling and coexistence. This strongly contributed to postpone the cultivation of GM crops, henceforth subjected to increasingly stringent conditions. In terms of dynamics of expectations (Van Lente 1993), this change of use scenario created unanticipated functional requirements (no pollen transfer between GM and non-GM crops) and new specifications (distance between parcels, ways of managing the co-existence). In this context, the promise of GM corn failed in aligning interlocking activities and building an agenda that would favour the use of GM crop.

Smart Grid technologies for energy transition

Since the mid-2000s, Smart Grid technologies have been presented as an 'obligatory passage point' for the integration of massive quantities of electricity from renewable energy sources (RES) into the electricity system, thus achieving sustainability transition in the energy sector. The European Commission has developed a Smart Grid policy, at the crossroads of energy efficiency plans and the post-Lisbon RTD policy, which took the shape of roadmaps and demonstration projects (Nadaï et al. 2018). In France, such a culture gave birth to a specific innovation policy model: pre-industrial 'large-scale demonstrator projects', responding to a roadmap, in which the ADEME—Agency for Waste, Environment and Energy Management—played a key coordination role. This policy has pursued the perspective of a broader generalization of such technologies, but the new developments funded by this policy were situated in a relatively short project time span, as well as in precise places, with specific actors, and specific focuses—none of them was a complete 'Smart Grid'. These 20 'niche' projects were funded through a top-down policy as part of the State Investments for the Future Program (PIA) initiated in 2009. According to the ADEME, the objectives of these demonstrators were fourfold: promote demand-side management and load shedding; favour the insertion of renewable energy; anticipate the evolution of existing grids; prefigure business models of Smart Grid solutions. Such publicly funded projects were carried out by consortia including both the actors of the existing electricity system and newcomers, together with researchers, both in technology development and in the social sciences. While communicating publicly about the projects, the actors' discourses about the development of Smart Grids were typical of a techno-scientific promise: evoking Smart Grids at a global scale, in a long-term horizon, reflecting the broader 'Digital Utopianism' (Slayton 2013). But the consensus on the legitimacy of the long-term promise contrasted with a dissensus about the means to achieve it, which reflected the diversity of their visions of energy transition and hence their expectations regarding the demonstrator projects.

In one of these projects (Le Renard 2015b), some actors imagined the diffusion of a 'grid of the future', or even micro- grids providing local energy autonomy, while considering innovation as a bottom-up process. As an answer, power transmission and distribution system operators rejected this perspective and insisted on their roles and responsibilities to prevent the current system from failures and adapt it to a growing share of renewable energy sources. They aimed at integrating local innovative systems into the national grid in an incremental way, following past improvements. But, interestingly, on a small scale, this demonstrator project enabled actors to collaborate despite their incompatible strategic visions. The digital and innovative technologies developed in the demonstrator project served multiple goals of different actors: suppliers gained public funding, support, and visibility for their innovative developments, system operators tested the integration of digital technologies, and locally elected representatives stated publicly their

support towards technological innovation in the field of energy transition, together with the other stakeholders.

Endowed with the legitimacy of the Smart Grid's promise, the demonstrator program benefited social uptake and credibility: projects were condemned to be successful, performing part of the promise on a small scale—the 'showroom' meaning of the term *demonstrator* (Rosental 2013)—by means of high engagement by all actors in the experiments, including final consumers eager to participate in the stakes of Smart Grids and Energy transition (Escoffier et al. 2015; Caron 2016). Social uptake is one of the aims of Smart Grid and, in these demonstrator cases, it was attained. By demonstrating their own success (and not that of the broader Smart Grids), they made the future present.

The demonstrators programme raised awareness towards the broader promise of Smart Grids and contributed to its visibility and social uptake. Some elements constitutive of a Smart Grid are already available on the market (devices, offers)— on a somewhat discreet mode. Nevertheless, the short time scale of these demonstrator projects contrasts with the longer duration enabling a 'path creation'.

5. Promises, figures of the future, and regimes of historicity

Main lessons from the cases

Table 1 summarizes the results of the four cases studies. As hypothesized, the main difference between the cases is related to the figures of the future. However, interestingly, we also observe important differences between cases in the same historic periods. These differences provide key insights to elaborate on the temporality of techno-scientific promises.

Table 1. Summary of the case studies

Hybrid Corn • Modest promise • Strong national coalition controlling the agenda • Legitimacy related to the need for modernizing agriculture • Credibility cycle related to demonstration • Low level of contestation, Negotiations in discreet arenas[1]	**Fast Breeder Reactor** • Ambitious promise • Fragilised national coalition (opposition between 'tech enthusiasts' and 'cost-benefiters') • Legitimacy related to the need for economic growth, address resources scarcity, "French Grandeur" in a global race, European project • Credibility cycle facing strong contestations by 'cost-benefiters' • Negotiations in discreet arenas followed by public mobilisation
GM Corn • Escalation of promise to impose GM as an obligatory passage point • Strong adversary coalition • Contestation of legitimacy grounded on *alter-globalisation* • Agenda going out of control • Credibility cycle broken by an inflation of technical requirements • Strong public contestation	**Smart Grid** • Promise to address a need (whichever the means) • Enrolment process creating strong coalitions around experiments • Legitimacy of the goal is not contested • Shared agendas at local level • Low public contestation for demonstrator projects

In the modernist regime, progress is the master frame shaping the relationship to the future. There is a widespread belief that tomorrow will be better than today and that science and technology will bring social prosperity. The hazards related to new technologies—when known—are considered to be necessary for moving forward and accessing to a better global situation. They are, so to say, the price to pay. This does not mean that there is no contestation as rightly reminded by historians of modernity and the contemporary period (Fressoz 2012; Pessis et al. 2013). However, actors focussing on risks and dangers are in a weak position because they have to fight against widely shared beliefs. The future is open and a source of hope yet not deprived of concerns of techno-nationalism, with the fear of France losing its rank in a global race. Innovation as 'creative destruction', the expression coined by Joseph Schumpeter, is a good summary of the mood of the modernist regime. Overall, the shared belief is that society will benefit from the innovation and, although some may lose in the process, there is a confidence in the capacity of the Welfare State to take care of potential problems. The legitimacy test is made easier by the belief in progress and the confidence in the technological fix, as well as international comparisons with countries embracing similar paths. Thus, social goals that the new technology is due to achieve may remain modest; the audience to convince remains specialized (essentially the potential—often professional—users). The process of translation constituting the new technology as an obligatory passage point is mostly entrenched.

[1] « Discreet spaces » are opposed to « public arenas » by Gilbert and Henry (2012) in their analysis of the formation of public problems.

The credibility test, however, may be more difficult to pass as experts have to be convinced that the new technology will work. The success rests on the ability of the progress coalition to create a shared vision and to build a project agenda enabling the promise to successfully pass trials of strength for engendering a positive cycle of credit (Latour 1987). This ability makes the difference between our two modernist cases; in the case of hybrid corn, the credibility of the promise entrepreneurs built on the US experience. Local adaptation of the technology was performed by a progress coalition controlling the agenda and contributing to the alignment of interlocking activities (INRA labs, agro-equipment, seed industry, farmers, agro-industry, and Ministry of Agriculture). Activities of demonstration were key for initiating the adoption of the new technology. The project of developing a French industrial FBR successfully passed the first credibility trials. But from 1974 onwards, it was subject to increased scrutiny, both inside institutions with the 'cost- benefiters' and the safety control service gaining weight over 'technology-enthusiasts' and in public arenas with expert critique. The project's agenda was slowed down. Due to a halt in the global sales of LWR, the pressure on resources lowered and the promise of fuel abundance became secondary. 'Cost-benefiters' became more and more powerful with the growing financialization of the economy and European integration. Moreover, the anti-nuclear protest brought forward the stakes of both the environment and of the critique of progress (Ollitrault 2008; Tompkins 2016), opening the way for their political transcription (Hatch 1991). The time horizon for an industrial FBR fleet was postponed in such a way that it rendered new technology developments irrelevant. Hence, a shift towards the presentist regime obviously began long before 1989. As widely acknowledged by historians, transition between regimes is far to be an overnight process.

In the presentist regime, the future is absorbed by the present: it is a source of threat rather than a source of hope. This macro-cultural frame of reference (to put it like Van Lente) renders legitimacy claims much more problematic. As observed in the GM case, promises are overstated. The quest of new technology is shaped as a moral obligation or a matter of survival (either actual or symbolic because of the economic struggle/competition in a neoliberal mode—such discourses can already be found in the 1970s regarding FBRs in a techno- nationalist mode). According to promise entrepreneurs, there is no alternative but investing in the new technology. Overstatement and closure of the future trigger strong contestation and intense debates in public arenas. The contestation is not limited to matters of efficiency but is also directed towards the set of values embedded in the promise. This legitimacy fight is a major impediment for promoters to impose their visions and to build their agenda. The path creation becomes a much more complex and uncertain process. The circulation of the problem in different arenas (scientific, technical, political, judicial, economic, etc.) confronts promoters to different audiences. Different issues are raised, which leads to an inflation of *ex ante* evaluations (Bonneuil et al. 2008). In the modernist regime, innovations can stay for long in protected niches, but this does not apply in the presentist regime. There is also an issue

of responsibility for the future (Adam 2010; Innerarity 2012). In the modernist regime, a widespread belief in progress leads to consider innovation as creative destruction, and the collective wisdom is that the change is worth the price to pay—although some contestation may occur. In the presentist regime, the future is regarded as fragile. The awareness that history is path dependent raises concerns about the necessary caution regarding the engagement into irreversible trajectories that may prove unsustainable.

Our two presentist cases exemplify different patterns of promises. The GM case appears as a way to still govern innovation in the creative destruction frame. Although the technology was very new, the promise took a traditional form. And as the contestation strengthened, so did the promise, which both created an escalation process escaping the control of promise entrepreneurs, eventually exposing the new technology to many demanding tests. With this escalation, the issue of governance of the technology became crucial, whereas the choice of GM was framed as engaging in an uncertain and irreversible journey (Grove-White et al. 1997). In the presentist regime where the responsibility for the future is so important ('what are we doing to the future?'), this is a major matter of concern. The promise of Smart Grids is quite different. It has been problematized as a key obligatory passage point for changing the energy mix by removing barriers to the integration of renewable energies into the grid and for adjusting and lowering electricity consumption. As a major device facilitating energy transition, the objective of designing and implementing Smart Grid technologies is widely shared. Yet, definitions of energy transitions are situated and the original aim of the *Energiewende* (reducing the dependency upon concentrated sources of energy, be it nuclear or fossil resources-based electric power plants) has been adjusted to national contexts. Indeed, French public policies have reframed it as a transition towards a low-carbon electric supply (Stefan C. Aykut and Evrard 2017). Definitions of Smart Grids are even more flexible. Whereas the objectives are fixed, the means to achieve them remain to be invented. The experimental mode promoted through public funding of demonstrators allowed to open up the process and to explore different solutions, as well as enrol actors and foster public uptake. Contrasting with the GM corn case, technology was not presented as omnipotent but something that had to be collectively cared for in order to solve important issues. Of course, this policy of bottom-up innovation in a top-down State programme was not exempt from ambiguities regarding the role of local authorities (Nadaï et al. 2015). To use the distinction suggested by Joly et al. (2010), the promise of Smart Grid technologies—as it was framed in this demonstrator programme—was embedded in a collective experiment, whereas the GM corn case is illustrative of the traditional regime of techno-scientific promises.

Techno-scientific promises in a post-modernist society

This leads to formulate a first result and a first proposition. Techno-scientific promises have existed for decades at least, and they are generally considered by STS scholars as a way to coordinate expectations and align actions. However, they may take very different forms, and a change in regimes of historicity modifies the conditions of success of promises. In the modernist regime, the progress master frame is strongly related to the nature of the future, which remains open and a source of hope. The general praise of novelty and the credit granted to science and technology result in promises not having to be over-stated in the first place. New technologies are presented as necessary for the general march for progress. In this context, a strong promoters' coalition can both control the agenda and fix a scenario that is difficult to challenge. The promise of modernization is strongly linked to a representation of innovation as creative destruction.

Yet, in the presentist regime, as the future is problematic, and the myth of progress is challenged, the legitimacy of techno-scientific promises is more difficult to establish. This may lead to the type of dynamics just discussed with the GM case: due to a contested legitimacy, and a transformed use scenario, the cycle of credibility hardly works. As a side comment, one may find many examples of such dynamic in recent new emerging techno-sciences, such as nanotechnology or synthetic biology (see, for instance, Bensaude-Vincent 2015). Such promises are mainly based on the modernist regime, which is in crisis. The same pattern can be observed for macro- promises such as the Lisbon Agenda (invest 3 per cent of GDP in research for warranting future prosperity of Europe) or the need of Research and Innovation (R&I) for addressing big societal challenges as promised in Horizon 2020.

Interestingly, we observe a change in techno-scientific promises, illustrated by the Smart Grid case where the promise of the experiment was negotiated along the process. We suggest that these promising activities—distinct from the traditional regime—may be considered as ways to adapt to the presentist regime. This change comes along with new representations of innovation. As mentioned in Table 2, innovation as a source of sustainability transitions constitutes an alternative frame. Directionality of innovation is the key notion, a key change as compared to the creative destruction frame. The set of values underlying this frame are widely shared, which is an important source of legitimacy. The alignment of macro-meso-micro activities is facilitated by the experimental mode that favours opening up, ongoing negotiation, and exploration. But ways to shift from a phase of plurality of experimentations to a stage of generalization and closing down still require to be explored. Such promises are criticized for postponing action, whereas an efficient implementation would be needed to fix urgent problems such as climate change.

Table 2. Regimes of historicity and techno-scientific promises.

Regime	Figure of the future	Frame of innovation	Values	Legitimacy test	Credibility test
Modernist	Open future, Future as source of hope	Creative destruction / Innovation is always good	Progress Productivism Entrepreneurial freedom	Easy to pass because of progress master frame Need to manage acceptability	Credibility cycle is manageable Economic trial, cost-benefit appraisal
Presentist	Future pre-empted, Future as a threat	Sustainable transition / The need to direct innovation	Sustainability, Safety, Care, Repair	Consensus on stakes and objectives But dissensus on the means and the obligatory passage points	Capacity to articulate top-down steering and bottom up experimentation Trust the public

6. Conclusion

This paper itself rests on a promise, or at least an assumption, stating that much can be learnt from the study of techno-scientific promises from the past. To this end, we have articulated two dimensions of time: historicity and duration. As previous research has shown, promises play key roles for legitimizing new technologies, mobilizing resources, coordinating actors, and fostering interlocking activities. The way they play these roles depends on the alignment of agendas at different levels from the microlevel of the construction of new socio-technical agencements, to the meso-level of the socio-technological regime of the field, and to the macro-level (politics, values, culture, macro-economy, etc. and regime of historicity). Using four case studies, we argue that although techno-scientific promises have existed for decades at least, examining the way they align with regimes of historicity provides a possibility to refine the typology. Regimes of historicity as established by Hartog may be coexisting (Andersson 2012; Bensaude-Vincent 2015; Pels 2015), and shifts may not occur at a single moment in time. Nevertheless, using them as ideotypes for organizing our case studies proved heuristic. In the modernist regime, the master frame of progress is a strong baseline for promises. This is key for promoters to build and control the agenda, legitimize novelty, and benefit from the positive feedbacks of a credibility cycle. Drawing on our cases, the shift between regimes started in the mid-1970s rather than in the late 1980s, when the economic crisis following the oil shock changed the relationship to the future. But it took another 15 years for public authorities to implement new discussion forums and policy instruments regarding technological development, which provided more space for pluralist expertise (Joly 2009)—and less space for promise entrepreneurs to control the agenda and the use scenarios.

This paper shows that promising in the presentist regime using the modernist frame of innovation (creative destruction) raises many problems When the future is fragile and a source of threat, while confidence in technological progress has faded away on the grounds of many controversies about their social and environmental consequences, the foundations of promises can no longer be the same. This echoes the call to identify 'the future's enemies' by Innerarity.

'The future's enemies must first be uncovered among those who seem to be its most fervent supporters. They are found anywhere the future is trivialized and amid those who promote unproductive accelerations with no concern for the costs of modernization.[…] A good deal of the rhetoric of innovation […] constitutes a trivialization of the future when it is not inserted into a meaningful social context' (Innerarity 2012: 4). On the contrary, Stengers (2017) drawing on Tsing (2015) underlines the necessity to build a positive imaginary for a future 'life in ruins' of landscapes shaped by past industrial activity derived from progress and techno-scientific promises.

Even with a fragile future, a horizon of hope has to be built but in a different way. A new kind of promises may be built on collective experiments following new ways that have to be considered, whereas, reciprocally, collective experiments could fuel new promises. Sustainability transitions may offer a new frame for a different type of techno-scientific promise resting on the need to direct innovation. These research topics have to be further explored as it would be interesting to identify the features of these innovation modes, to contrast them with the regime of the economy of techno-scientific promises, and to compare their capacity to sustain and expand themselves, whereas the kinds of 'collective experiments' studied here are often funded in the form of projects with a fixed time frame.

To conclude, this development leads us to point out a key challenge that has to be addressed collectively. The issue does not lie in the restauration of conditions that would favour technological change according to the patterns of past promises. The key issue is to rebuild horizons of hope in a post-progress society and to transcribe them in renewed innovation modes.

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Notes

1. The sociology of expectations would add a key property of expectations: 'Expectations are foundational in the coordination of different actor communities and groups (horizontal co-ordination) and also mediate between different scales or levels of organization (micro, meso, and macro—vertical co-ordination)' (Borup et al. 2006: 286).

2. Sources: Papoz (1960); Mendras (1967); Joly and Ducos (1993); Myotte (1999); Bonneuil and Thomas (2009); Théau (2015).

3. Even though the open future meant in this case following the path opened years ago in the USA.

4. « Les nouvelles cathédrales I.—LA FOI. » Le Monde, 05.11.1974, Nicolas Vichney.

5. « UNE AVENTURE » Le Monde, 17.04.1976, D. Verguèse.

6. « M. Giscard d'Estaing réaffirme l'intérêt que porte la France aux surrégénérateurs », Le Monde, 19.01.1980. Quoted by Jobert and Le Renard (2016), our translation.

7. Michel Hug, Head of EDF's Equipement division, on Antenne 2 TV channel, 29.09.1980. Quoted by Jobert and Le Renard (2016), our translation.

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