Expectations in nanotechnology and in energy - Foresight in the sea of expectations. Background paper

Borup, M.; Konrad, K.

Publication date:
2004

Document Version
Publisher's PDF, also known as Version of record

Background Paper - Research Workshop on Expectations in Science & Technology
April 29 – 30, 2004, Risø, Denmark

Expectations in Nanotechnology and in Energy – Foresight in the Sea of Expectations

Mads Borup and Kornelia Konrad

Introduction

Expectations and visions about the future are increasingly acknowledged as central aspect of science and technology development processes and as key elements in analysing and understanding scientific and technological change.

The roles and dynamics of expectations in science and technological innovation are the focus of increasing attention from a wide range of scholars within areas as economics, history, and social studies of science, technology, and society (STS). The scholars seek typically to provide insights in the relationships between expectations and longer-term transitions as well as in the rise and/or fall of various science and technology fields. Further studies delve into the status and role of future visions and expectations in the practices of and interactions between different actors involved in science and technology processes not only scientists and engineers, but also e.g. policy makers, industry actors, media, citizens, and public authorities. Moreover, they seek to develop a conceptual vocabulary with which to better understand the expectations dynamics.

The focus on expectations and visions developing in these years corresponds to the general tendencies that technology development as well as science and research to an increasing degree are seen as strategic activities. In the last decades of the 20th century, what has been termed a *strategic turn* of research and technology has taken place. This has been demonstrated in the development of explicit research and innovation policies in many countries and in changes in the research & education systems and their funding structures. Technology development and scientific knowledge are considered of central importance for societal development as such, not least through economic growth.

In the knowledge society knowledge production has moreover obtained the status as the central driving element of societal economy and thus a strategic focus. Knowledge development - including scientific knowledge and learning processes - has to a larger extent become a subject of management and planning. This is to say that the constitution and dynamics of different knowledge cultures is now not only of philosophical and academic relevance but also a practical and strategic issue.

Hand in hand with the strategic turn of research and technology development goes the tendency to an increased change-orientation in our culture. Many activities are to a larger degree than earlier focusing more or less explicit on the future rather than on the present or the past. The ability to discuss aspects of the future and to define the understanding of the future at present is central and of strategic importance. Futures, not least in connection with technoscientific developments, are highly debated and contested. Expectation interactions are part of agenda setting.

Dynamics of expectations and visions have probably always been important in processes of science and technology, but it seems that they to some degree are more pronounced now than they were earlier. At the same time, the processes of science and technology innovation have also become more complex and confusing, with significant increase in the amount of communication

and interactions across institutional and epistemic borders. For example scientists and researchers are no longer communicating primarily within the borders of their specific field of expertise, but are typically in contact with many different kinds of actors with a heterogeneity of backgrounds. Firms and policy makers are confronted by large amounts of technology promises (and often also concerns) and have to decide what to do about them.

The role of expectations in science and technology is not only a question of policy or a matter of a specific strategic layer in science and technology processes. Studies of expectations and visions show that they play a role in connection with all aspects of science and technology, not only at macro levels of national policy and at meso levels of sectors and institution networks, but also at micro levels e.g. within research groups and in the laboratory work of the single scientist. Expectations and visions are thus also a cognitive matter. *Generative visions* are guiding and focusing measurements, calculations, and models. At the same time, visions and expectations are often developed and reconstructed in scientific activities. In a sense, they can be seen as one of the important products of scientific activities.

Expectations may have different characters and different kinds of contents. Typical types are scenarios of use, broader comprehensive visions or socio-technical scenarios, metaphorical-symbolic expectations, and expectations of techno-economical potentials. Overlapping with the concept of expectations are other concepts such as scripts, *Leitbilders*, guiding or generative visions. Also studies of metaphors in science and technology, of *anticipatory knowledge* and perspectives of time, etc. are often close to expectations studies. Forceful *ideographs*, or widely shared metadiscourses, about science and technology, for example the ideograph 'technological progress', are embedded in our vocabularies and cultures. They enable and structure the dynamics of science and technology expectations.

One of the important dynamics often observed in connection with science and technology expectations is *promises - requirements cycles* in which promises with in the beginning diffuse pictures about possible worlds lead to requirements and identification of more specific functions which can define a protected space and a set of activities (funding and a research project) to follow the promises. Through a number of repeated iterations of such cycles the gab between promises and the technology activities might become smaller (but it is not always the case). The promises-requirement cycles are different to e.g. the requirement – promises relationship in connection with purchasing and use of consumer products. In the latter the gab (in time as well as in contents) between on the one hand promises and indication of potentials and on the other hand the deliverable and use of the product is usually not so big.

Another, to some extent related, dynamics of science and technology expectations is *hype - disappointment cycles*. This designates the observation in some areas, that expectations, after a period of development and gaining of strength, can break down and more or less suddenly loose the power to drive and coordinate actors. The metaphor of bubbles that get inflated and at some moment burst has been used to describe this. Hype – disappointment cycles have e.g. been of importance in the domain of information and communication technology and in the biotechnology domain. After a period of disappointment the expectations may start to grow again, either with an almost identical contents or in a changed and reconstructed form. Successive collapses of expectations can occur within the same area.

The description above is only a very brief summary of some of the important findings from the studies of expectations in science and technology. For more thorough and general descriptions of expectations in science and technology, please see the background paper from the earlier expectations workshop in Utrecht 2003 and the annotated biography developed in this connection, or (van Lente 1993; van Lente & Rip 1998; Brown et.al. 2000; Konrad 2004).

The workshop focus

With the objective of furthering the general understanding of expectations dynamics, the focus on the workshop is on two specific topics: Firstly, to examine **specific science & technology domains** and the expectation dynamics within these in order to come closer to an understanding of how expectations and domains mutually characterize and shape each other. Two S&T domains are selected for the workshop: the **energy** area and the **nanotechnology** area. The domain theme will address questions like: What are the expectations and the expectations dynamics in the domains? How are the expectations characterised by the domain? Can a general picture of expectations in the domain be drawn? Are there similarities and differences between domains? How can these be conceptualised? And what can practitioners learn from these findings of expectation studies?

The second topic of the workshop is **foresight exercises** and similar attempts to systematically deal with S&T expectations and future visions. Which roles do foresight activities play in the larger 'sea of expectations' and how can they be characterized? This issue stems from the conclusion on earlier discussions in the research network that: *"Expectations (and the competencies to articulate and voice expectations) are the basic stuff of foresight exercises, but have not been studied at all (just assumed to work out alright)."* More specifically, the focus on foresight will address questions like: How are foresight activities influenced by expectations and future visions and the dynamics of these? How do foresight activities influence the expectations? How to navigate foresight projects in the larger sea of expectations? What do the increasing emphasis on foresight and the professionalization of the activities mean with respect to expectation dynamics?

At the earlier workshop in Utrecht basic studies of expectations in science and technology were presented and recapitulated. Compared to this, the themes of the present workshop are of more explorative character. We do not have a many ready-made studies exactly on the themes to build on. We have some that come close, but to a large extent we have to rely on the workshop interactions and their capabilities of giving new analytical insight and structure to the themes and thereby to the general understanding of expectation dynamics.

Expectations in different S&T domains

In discussions of expectations studies, it has been a recognition that the dynamics of expectations vary between different science and technology domains. Yet, what the similarities and differences of the dynamics exactly consist in is not well understood. How to capture and understand the variation across domains is not straightforward. It is the intention that the two workshop sessions on the specific domains of nanotechnology and of energy should each ensure enough space to go in depth with the expectations and dynamics of the single domain and get an, at least to some extent, elaborated picture of this. In addition to this, there is time in the workshop programme to make comparisons between the domains and to discuss and reflect upon the differences and similarities.

From the discussions thus far of expectation dynamics in different domains, an initial suggestion of how to address the issue can be described as centred around two main dimensions: an actor dimension and a dimension of the character of the visions and expectations.

The actor dimension concerns the basic question of which actors that are involved in the expectation interactions of the domain. Visions and expectations of any influence and power are always shared between actors, however there are differences with respect to how many different actor groups and types of actors that are involved. In some cases we see a relatively homogenous

set of actors involved in the visions and expectations and their dynamics. This can for example be researchers and scientists within specific fields. In other areas however, the composition of the set of actors involved is much more heterogeneous and the visions are shared by many types of actors with different backgrounds.

This is parallel to a question of how broadly shared the visions are in a domain. Are all actors inscribed in and guided by the same visions or do there exist different visions within the domain followed by different groups (or sub groups) of actors? A situation with different, competing expectations is not unusual, but this need not always be the case when talking about different visions within a domain.

In some domains, e.g. within information and communication technology, it might be fair to talk about a hierarchy of visions and expectations. In these cases some expectations and visions are very general and encompassing a large share of the actors using, producing or developing the technology, while other expectations and visions are more local and connected to specific actor groups and specific ICT uses and functions still following the broad and general visions. Aspects like these are central in connections with attempts to describe a complete picture of the expectations and visions dynamics in a domain.

When saying 'actors' we also include institutional actors. Institutions and how expectation processes are institutionalised might be a very central aspect for the understanding of similarities and differences of expectations dynamics in different domains. A further point in connection with the actor dimension of expectations in domains is the experience that there in some domains are patterns of typical producers and typical (intended) users of the expectations. Not all actors are involved in the same way. Some actors might be actively engaging in the construction and development and in the dissemination and protection of the expectations, while others to a larger degree are following the expectations (passively).

For example, in some domains governmental actors and policy makers might be considered the prim active producers and drivers of the expectations, while engineers and researchers are those that are intended to use and be enrolled in the expectations. This may e.g. be the case in some cleaner technology areas. In other domains it is the other way around: that the producers and disseminators of the visions are primarily technologists and engineers trying to enrol more government and policy actors. These examples might be extreme cases; usually the picture is more complex and the actor groups involved are more specifically defined. In connection with the different actors roles and who is intended to 'buy' the expectations, a distinction between different arenas for the interactions, e.g. whether it is primarily public or private spaces, might be useful.

The second suggested main dimension in the investigation of expectations in specific domains and their similarities and differences, is the character and contents of the expectations. A classification could here be made according to differences in the picture of the promising applications of the technology and the technoscientific knowledge. Some expectations can be said to be about embedded solutions (systems) while other expectations consist in pictures of specific devices and are primarily about *parts of* solutions. The former will typically be broad and elaborated pictures of future sociotechnical systems while the latter are more simple and focused on a specific technical function.

Parallel to this studies of expectation dynamics have shown that there are differences with respect to how technologically the expectations are defined, i.e. to what extent the influential expectations in a domain are defined primarily (maybe exclusively) in technological terms or whether other aspects are included as well. By talking about the energy domain (and not about the energy *technology* domain) we have indicated that this domain is not to the same degree as many other domains defined by technology aspects primarily.

Some domains are characterised by primarily positive expectations and promising technologies. Threats and risks from new scientific and technological developments and other 'negative' expectations are not a significant part of the future visions in these domains. In other domains however both positive and negative aspects are part of the expectations. There might also be domains in which negative or pessimistic expectations are dominating for a longer or shorter period. However, there seems to be a tendency to more positive than negative expectations in most S&T fields cf. the ideograph of technological progress.

Risks are closely connected to the fact that there is much uncertainty in connection with new technology. Uncertainty is however not only connected to negative expectations and fears. Probably it might be useful in many ways to be able to characterise expectations and dynamics within domains according to how much room they leave for uncertainties and whether they are capable of ensuring a proper treatment and integration of new important uncertainties coming up. These aspects, as well as many of the above-mentioned aspects, can of course vary over time and across countries and cultures.

Inscribed in expectations and visions are often explicit or implicit actor roles. There is a *script* included which prescribes how e.g. technology users, technology developers etc. shall be and how they shall act in the future. In some cases the visions describe larger sociotechnical systems with a number of different roles to be played in the future. The script is one of the ways expectations and visions guide and coordinate actors. Whether it is possible to distinguish different patterns of scripts in different domains, e.g. due to different knowledge cultures of different domains, is a very interesting question.

As an initial brief description of the domains of energy and of nanotechnology it is suggested that the domains in many ways are very dissimilar areas, with nanotechnology as a primarily science and research defined domain with 'golden' and revolutionary promises and visions able to encompass and enrol a large number of research activities, funding, investment programmes and industrial innovation interests. Compared to this, the energy domain is a well-established and well-institutionalised domain, however with a range of new technologies, systems and knowledge fields developing in interaction with positive as well as negative expectations (threats and risks) often directly connected to societal policy at regional, international or national level.

The institutionalisations of the energy domain include a long range of organisational units and institutions working precisely with what to expect of the future. These are e.g. strategy departments, scenario units, and networks and centres of calculation and forecast. These are located e.g. at national and international level in public or semi-public institutions or in larger companies like electricity system operators, oil & gas companies etc. Parts of the expectations interactions in the energy domain are thus professionalized and standardised.

Though future technology developments to some extent are included in these forecasts, scenarios, econometric models etc., the emphasis is in many cases on other aspects. It seems likely that important parts of the expectation developments concerning science and technology in the energy domain also happen in less standardised and institutionalised ways. Some of these developments are probably relatively closely connected to individual technologies of energy production, of energy consumption, or of energy storage, e.g. fuel cells, solar cells, CO2-sequestration technology, biomass combustion, combined heat and power plants, wind turbines etc. Others are more of sociotechnical character, focusing on systems of production and consumptions of energy and on broader social, environmental and political aspect. These can e.g. be the vision of renewable energy systems, hydrogen economy, third world development, efficient energy markets, security of supply, climate change issues, decentralised energy infrastructures, etc. A variety of actors are often involved in connection with these expectation dimensions. The question is whether it, despite

these very complex aspects, is possible to say something general about the S&T expectation dynamics in the energy domain.

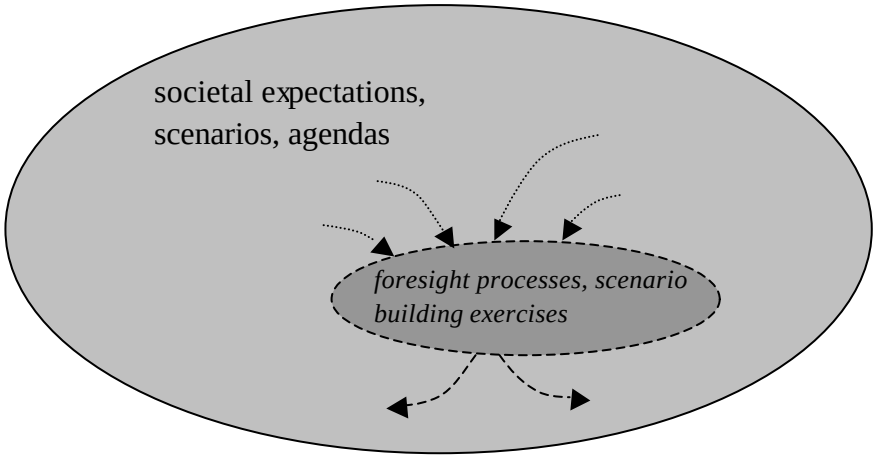
An interesting aspect of the expectations dynamics in the nanotechnology domain is the fact that nanotechnology to a large extent has acted as an umbrella term which has gathered and to some extent aligned activities from already existing research areas e.g. material physics, chemistry, biochemistry etc. This on the other hand also means that there are internal tensions in the domain and a critique of nanotechnology as the unifying metaphor and headline. It is not unusual that scientists as well as other actors see the nanotechnology headline as not only enabling but also limiting for their activities. Nanotechnology has to a considerable extent been a domain lead by or centred round activities in the United States. In some respects this is probably still the case, however many networks, institutionalisations and policy and planning discussions are now also embedded in many other countries in Europe, Asia and elsewhere. It is an open question whether there can be made a distinction between the expectation dynamics in the different cultures. Until now, threats and risks have played a minor role in the expectations dynamics in the nanotechnology domain. However, it seems that such aspects to some extent currently are becoming a more important part of the picture.

Foresight in the Sea of Expectations

Hand in hand with the increasingly strategic focus in connection with technology and science and with the general increase in future- and change-orientation, technology foresight has appeared over the last decades of the 20th century. There has been increasing focus on foresight exercises and similar attempts to systematically deal with and communicate expectations and future visions. Many industrialised countries have established foresight projects, often as part of the national research and technology governance. In the EU system is foresight currently a supported and favoured kind of activity. Foresight is in some areas about to become a standard and part of the normal practices in national and EU policy and governance activities e.g. in connection with research programmes. Also in larger companies and in industrial sectors and regions technology foresight processes are not unusual.

Different descriptions of what technology foresight exercises are exist. A broad and relatively general definition is that technology foresight activities are systematic attempts to analyse and discuss technological futures.

It is not seldom that technology foresight activities are presented as the only kind of processes that deal with the future in connection to science and technology. Expectation studies show something else: to describe and discuss futures is a very usual and widespread type of activity among actors connected to science and technology developments. Explicit foresight activities are only a small, maybe infinitesimal part of the total amount of future-oriented interactions in connection with science and technology innovation. Foresight projects are not isolated future vision activities, but embedded in a much larger and broader sea of expectations.



Foresight activities are influenced by and dependent on the expectation dynamics in the broader sea of expectations. The activities will necessarily be in a relationship to external expectation aspects and they must react to the currents and flows and the waves in sea of expectations. To navigate foresight activities, the broader expectations aspects must be taken into consideration.

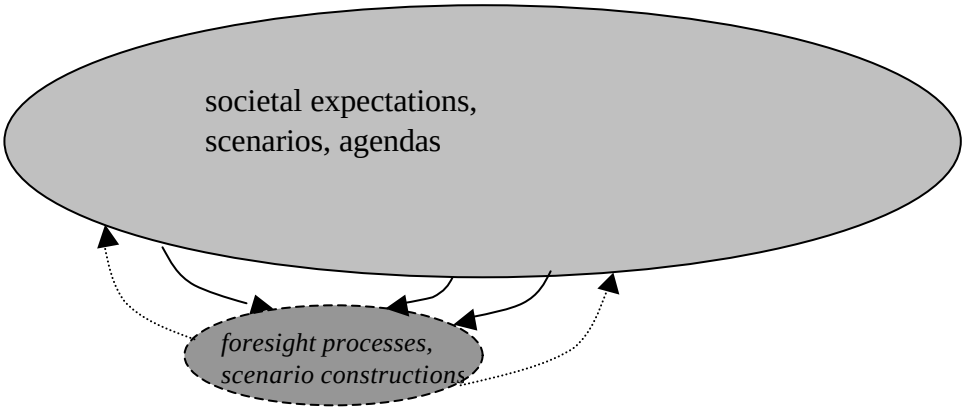
This basic insight from expectation studies might put foresight in another light than is usually most normal. It gives rise to other kinds of questions and perspectives on the character and role of foresight. Studies of expectations and visions have however only to a limited extent dealt with technology foresight. In general there is a lack of systematic and independent analyses of interaction processes in connection with technology foresight projects as well as of their impact. The few existing studies typically show that the role and impact of foresight are clearly smaller than promoters of foresight will say, when talking about the single technology foresight project. While the impact is seldom significant concerning the single foresight processes, technology foresight might gain importance if it becomes a widespread activity and a normal practice and tool in policy, planning and strategy processes in connection with technology. On four contemporary and partly overlapping foresight processes on environmental science and technology policy in the Netherlands van der Meulen concludes that:

"The interesting point however is that at the system level a new balance has been constructed. The four foresight processes together create a new balance of future oriented strategy development which includes different perspectives and interests." (van der Meulen 1999, p. 20)

In the perspective of expectation studies, foresight activities may be conceptualised as "local sites of communication and production of expectations". It is likely that main elements in the broader societal expectation landscape (agendas) strongly influence the topics and perspectives chosen for foresight processes. Foresight processes combine, reproduce, rearrange, modify, examine (e.g. check the plausibility of certain expectations, consider contradictions) and extend (explore possible consequences and interactions of specific scenario elements and assess them) expectations. Expectations shared by different groups of actors provide largely the visionary elements which are taken up in the processes. In technology foresight activities the actor groups represented are often not least technologists, researchers and engineers within different technology and research areas, however, there are exceptions from this picture. In general, the scope, potentials and limitations of the activities are defined by which actor groups that are represented. Foresight processes may

partly 'just' reproduce existing expectations and scenarios. The results, e.g. the contents of scenarios developed in scenario processes, are in this way often no real news or surprises to actors already involved in the areas.

To see foresight as embedded in and a part of the general expectation picture, as indicated on the first figure, is one way of approaching the foresight issue. Another way is to more specifically look into the interactions and the inputs/outputs between foresight exercises and the general expectation picture.



The locally constructed or modified expectations and scenarios may feed back into the larger landscape of expectations. However, if, and how, this happens remains to be answered. Impacts may concern the content of expectations and scenarios as well as the dynamics, e.g. foresight processes may be an element of self-reinforcing dynamics: ongoing foresight processes, which are – at least partly – motivated by expectation may reinforce the assumption that a specific field is promising.

The increased amount of foresight activities has itself resulted in the emergence of a new body of knowledge about visions and expectations of technological futures in a wide range of technology and research areas. The character of a body of knowledge stems from the fact that it is normal in foresight exercises to make references to and draw on the results and expectations in other foresight projects. Thereby the knowledge body gets an at least to some extent self-dependent nature and one might talk about the specific knowledge culture and epistemic culture of technology foresight. It is however also clear that foresight knowledge to a large degree draws on knowledge from a lot of other areas, not least from different domains of technology and research.

The body of foresight knowledge also includes knowledge on the methods and tools employed in foresight. The specific understandings of expectation dynamics (and of science and technology dynamics in general) embedded in the methods and tools of foresight are also an interesting point in connection with the issue of foresight and expectations.

The increasing focus on foresight means that a new institutionalisation of expectation processes is happening. Institutional actors and organisational units explicitly on foresight are established e.g. in ministries, industrial companies, research institutions etc. There are international networks of people and institutions involved in foresight.

The institutionalisation also includes a professionalisation of expectation interactions and of communication and descriptions of visions. There are now people whose main expertise and prim field of work is expectations management and navigation of expectation processes. However, the field is to a considerable degree also characterised by cross-disciplinarily. With reference to hype-disappointment circles and bubbles of expectations that might burst, the question has been raised whether these kinds of professional activities might also be designated bubble management. Or to put it another way, is it possible as institutional and professional actor to control the stability of an expectations bubble and prevent it from bursting? Is it possible, despite basic uncertainty, to ensure robust expectations? If so, which methods and tools are employed in that.

The way foresight activities are institutionalised and the degree of institutionalisation in connection with different technology domains might, if the tendency to increasing emphasis on foresight continues, become crucial to character of the expectations dynamics in the domain as well as to the developments of the domain in general.

It is obvious that the knowledge from expectation studies might be useful to people and institutions working with foresight and expectations management. On some points it can contribute to an improved and more reflexive handling of expectations. Thus it might be fruitful to look more into the more constructive and normative sides of expectation studies; how the findings about expectations dynamics can be used in educational activities and as practical advises for expectation management.

References

Brown, Nik, Brian Rappert & Andrew Webster (eds.) 2000: Contested Futures. A sociology of prospective techno-science, Asgate

Konrad, Kornelia 2004: Prägende Erwartungen – Scenarien als Schrittmacher der Technikentwicklung, Berlin: Edition Sigma

van der Meulen, Barend (1999): The impact of foresight on environmental science and technology policy in the Netherlands, Futures, 31, p. 7-23

van Lente, Harro 1993: Promising Technology. The Dynamics of Expectations in Technological Developments, thesis, Enschede: University of Twente

van Lente, Harro & Arie Rip 1998: Expectations in Technological Developments: An Example of Prospective Structures to be Filled by Agency, in Cornelis Disco & Barend van der Meulen (eds.) (1998): Getting New Technologies Together. Studies in Making Sociotechnical Order, Berlin: de Gruyter