

How understandings colour the means and ends in the case of environmental innovations

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Abstract

Different understandings of the concept of innovation have resulted in different means and ends in the innovation activities within Danish industry. The different emphasis on economic, technical, organisational, inter-organisational and institutional issues in product and process-innovation has influenced the initiatives made by state, market and civil society. Focusing on environmental innovations, this is revealed in the initiatives and outcome of the previous environmental policy in Denmark. In this paper, I will make an analytical distinction between different understandings of innovation, exemplified with cases from the environmental practise in Danish firms. Finally, this leads to a discussion of, how a comprehensive understanding of innovation can form a co-ordinated and giving environmental practise.

Motivation

Simply, innovation can be defined as:

Innovation = Conception + Invention + Exploitation.

The word conception refers to the creation of a new idea. Invention applies to the transformation of ideas to reality, and exploitation refers to getting the most out of an invention (Rosenfeld and Servo, 1991). However, this overall definition tells us nothing about, who is getting the ideas and on what basis, how the ideas is transferred to reality, and values used to define, what it means to “get the most out of an invention”. Innovations are human creations made under different conditions and in different contexts, and the creators’ understandings are embedded in the innovations – in processes as well as in products.

In my thesis, I analyse the relation between environmental communication in the product-chain and environmental innovations. In the communication process we carry on understandings of the reference, which we discuss – in this case what we consider as innovation, and how we link this concept to environmental issues. Furthermore, our understanding of innovation colours the means and ends of innovative practise – including the practise of environmental innovation.

In this paper, I will exemplify this by describing three main paradigms for understanding innovation, which can be recognised in the previous innovation theory and practise in Denmark. The three paradigms have an overtone of economic, organisational and inter-organisational issues, respectively, where the last mentioned has lead to a more comprehensive system approach to innovation. On this basis, I will argue that a comprehensive understanding of innovations is needed, in order to promote environmental innovations.

Analytic parameters

In describing the three paradigms, I have chosen the following analytic parameters as my main focus. The choice of these parameters has been made for two reasons. First of all, I use Kipling's saying, that all he has learned is a result of asking why, how, what, who, where and when.

First of all, by asking why we innovate, I will focus on, how the innovators *balance their resources* by questioning, whether the human, natural, economic and technical resources are seen as means, ends or both. A perfect balance of these resources would lead to sustainability, or even accumulation of the resources. For every type of resources the innovators can see a purpose in ignoring, exploiting, accumulating or sustaining the resource, respectively. Among other things, this depends on, whether the companies consider the ends in a long or in a short perspective.

Secondly, by asking how we innovate, I will look at the strategies used by the companies to handle the innovation process. In every case, an innovation project is an investment, and how this investment turns out depends on the process management and the reaction from actors in state, market and also civil society. Therefore, innovation projects contain a high degree of unpredictability. The companies can strategically try to avoid the uncertainty by investing in innovation projects with a relatively high number of known parameters – an example is a strategy based on imitations of techniques or products. However, they can also try to cope better with the uncertainty – an example is intensive focus on product innovations based on technology push or pull, or focus on organisational issues.

Thirdly, by asking what is being innovated, I will try to describe the *types of innovations* that have been in focus in the different paradigms. The kinds of innovation can be distinguished as shown in the following list derived from Christensen (1992):

- Market innovation, as for example the digital watch (universal innovation), the electric car (niche-innovation) or fashion clothes (creative innovation).

- Basal innovation, as for example a sewing machine that introduced a new technique to sew clothes based on the scientific break-through of electricity, a whole new material to produce clothes (all technological basal innovations) or the form of a bulb (dominating design).
- Incremental innovations, as for example the stand-by function on electric equipment (technical orientated) or round corners on televisions (design orientated).
- Technological substitution, as for example the assembly line (internal development) or the plastic frames around windows (transferred technology).

To the list, I have added organisational changes, as for example changing the organisational structure to a more flat structure, or changing the understandings underlying the “way we just happen to do things”.

Fourthly, by asking who is innovating where, I will look at the *contextual boundaries* considered in the conception, invention and exploitation parts of innovations. The contextual boundaries defined by innovators in charge are reflected in, who they will turn to for ideas, who they will accept to influence the realisation, and which target groups they consider will gain from the innovation. In other words, innovation can be seen as a more or less distributed process between several actors.

And last by asking when innovation takes place, I use the three paradigms to characterise the conceptualisation in three different time periods within the last 40 years. The name of the paradigm characterises the break in “solution-strategy” from the previous dominating paradigm. Here, the break is caused by technical, organisational and inter-organisational focus. For every solution-strategy, there is an understanding of the main success-criteria – in this case economical growth, flexibility, and sustainability, respectively. Thereby, the following three paradigms will be described:

- The technical paradigm with focus on rapid economic growth
- The organisational paradigm with focus on flexibility
- The inter-organisational paradigm with focus on sustainability

When using the concept of paradigms, it is important to keep in mind that these paradigms are never totally dominant. There will be other conceptualisations present at the same time, and therefore it will always be possible to find projects, companies or even whole sectors that differ from the characterisation of the dominating paradigm of a given period. It is also important to note that the action in practise is always behind time of the conceptualisation. Therefore, there is a high degree of generalisation in the following text. However, this coarse-grained picture can be used to exem-

plify the connection between the conceptualisation of innovation and environmental issues, respectively.

The technical paradigm

Balance of resources

In many cases Schumpeter has been seen as the father of innovation theories, and he stresses the connection between innovation and economic growth. For Schumpeter, innovation is defined as the economic exploitation of invention, where invention is purely seen as a technical scientific output. (Christensen, 1992). In this perspective, innovation was accumulation of money in return of human labour, natural resources and technical competence.

Strategy

Schumpeter recognised that radical innovation had a discontinuous nature, as these extensive innovations were breaking with previous procedures for production. The Albernally/Utterback model based on an analysis of the automobile-sector can illustrate this, see figure 1.

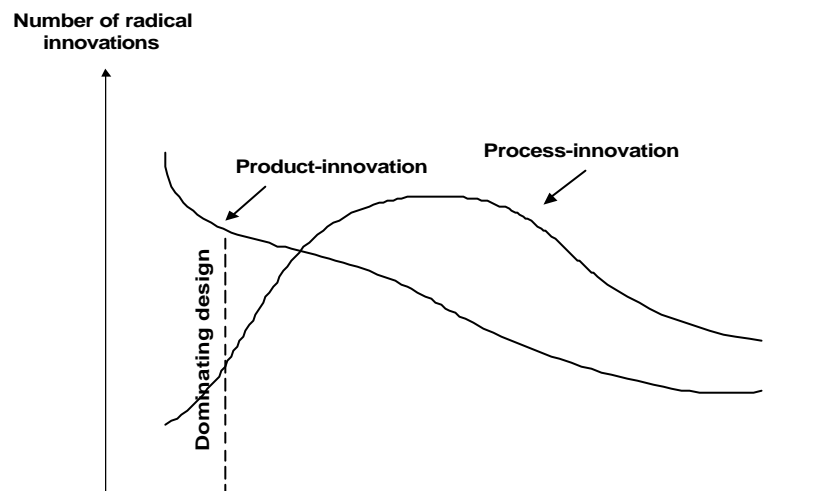


Figure 1: The Albernally/Utterback model (Christensen, 1992).

The curve for product innovation shows that the process will develop from a fluent phase with radical innovations and rivalry between different product concepts, but at some point it will result in a dominating design, and afterwards there will be incremental innovations based on this design. When the product concept has been chosen, it is possible to adjust the production system to the new product-design, and the curve representing the process-innovation will rise, but as the production-system is getting optimised, there will be less need for radical innovations in the production.

This picture shows the strategy in the 1960s and 1970s, where the market of products was not very differentiated, wherefore the companies often turned to mass-productions strategies.

Types of innovations

The companies mainly focused on incremental innovations, in order to optimise the production focusing on the amount, price and standardisation of products. This mass-production philosophy led to very specialised production-systems.

In this period, while the technical and scientific issues were highlighted, organisational issues were mainly regarded as necessary procedures for mass-production, where the main purpose was seen as division of labour and the impact on the innovation activity was regarded as minor.

Contextual boundaries

In the period of the 1960s and 1970s, the technical competence seemed to have almost unlimited potentials for a better standard of living, and it was regarded as the main key to solve existing and future problems. Therefore, technical experts in scientific and business communities were seen as the main carriers of innovation.

The case of environmental innovation

The focus on technical competence and short-term economic growth resulted in lack of environmental innovations in the 1960s. Nature was regarded as an object meant for human exploitation, to satisfy human needs concerning economic growth (Colby, 1991). Companies and regulatory authorities saw environmental problems as local and there was emphasis on higher smokestacks and longer discharge pipes, in order to dilute the pollution. There was a great faith in the capability of the oceans and the atmosphere, in order to absorb the pollution (Remmen, 1999).

However, the increasing environmental problems as a consequence of this strategy were starting to show. This gave rise to a Ministry of Environment in 1972 and the first Danish law on environmental protection in 1974, demanding companies to be in compliance with certain emissions limits. However, it was made clear by law that environmental protection should happen with considerations to the economy of state and industry (Christensen, 1994).

The industry made an effort to treat wastewater and atmospheric emissions, so the concentration of pollutants was reduced before discharge to the recipients. All though this meant that environmental issues were included on the companies' agenda, it only resulted in technical fixes, the so-called end of pipe technologies, where environmental problems were moved and not prevented. For example, the air emissions moved to other waste materials, which had to be deposited (Remmen, 1999).

To sum up

The technical paradigm dominated the view on innovation in the 1960s and 1970s. The characteristics of this paradigm can be seen in table 1.

	Characteristics
Balance of resources	Profit in return of human labour, natural resources and technical competence
Strategy	Mass-production creating very specialised production system
Type of innovation	Incremental process innovations in the production with focus on optimising the amount, expenses and standardisation of products
Contextual boundaries	Technical experts in scientific and business communities as carriers of innovation
Environmental issues	Environmental problems as local, which could be diluted or treated by end of pipe technologies, and thereby moved from the local areas

Table 1: The characteristics of the technical paradigm.

The organisational paradigm

Balance of resources

In the 1980s it was the sellers market in Denmark, but at the same time the productivity was stagnating, and in certain sectors it was decreasing. An analysis of this paradox indicated that the expected increase in productivity failed to appear, because the companies did not carry out the necessary organisational changes and was denied to develop employee qualifications (Gjerding et al, 1998).

This became more and more clear, as the Danish firms was forced from the market of mass-production towards niche-production designed for quick delivery to limited target-groups. Here, the flexibility of products and production was in focus, and the innovation in the company was, to a high degree, discontinuous and distributed. The philosophy in the production was thereby moved from a technical focus to an organisational and more actor based approach (Johansen, 1999). In line with this, the link between innovation and organisational theory was studied intensively through the 1980s and 1990s, with organisational learning as the key to higher productivity.

In recognition of the need for a flexible production-system, in the 1980s, the strategy changed to flexible specialisation of the technical resources. However, it became clear that also the human resources had an important role to play creating a flexible organisation that could manage a quick changeover of the daily procedures. Even though accumulation of money in return of human labour and natural resources and technical competence was still in focus, there was new focus on developing the human and organisational resources by organisational learning.

Strategy

In the organisational learning-process the individuals co-operate and co-ordinate their understandings, so they are working along the same trajectory. Dixon (1994) describe this process in the following way (se also illustration on figure 2):

- *Generation of knowledge:* Knowledge can be generated among the organisations own members and from other organisations. This knowledge shall be distributed in the organisation and form the basis for experiments. Knowledge is seen as accumulation of human experience.
- *Integration:* In the integration-process, knowledge is tested by experiments to analyse different approaches to the given problem. The involved has the possibility of adapting to the specific experiences through an individual learning-process.
- *Collective interpretation:* The strategy concerning goals and means is formed in the collective interpretation of individual experiences from the integration-process.
- *Action:* The result of the collective interpretation is action, and thereby new experiences are developed and the organisational learning-process is starting over.

In the collective interpretation of individual experiences it is important that the people act in relation to this interpretation. This means that an non-learning process might follow the organisational learning process, and this can result in discharging old understandings and adapting new ones. The non-learning process is as important as the learning process (Winston, 1999).

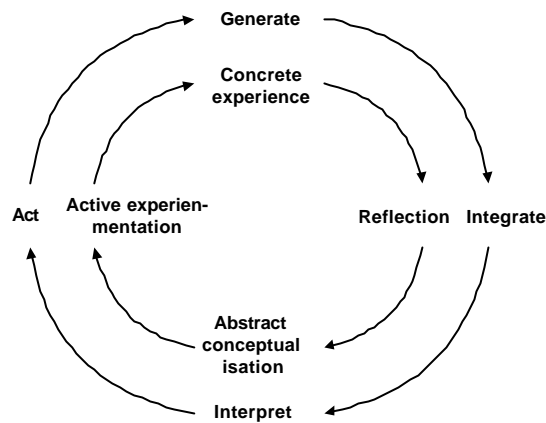


Figure 2: The individual- and organisational learning-process, after (Dixon, 1994)

Types of innovations

In this period, focus was on making more creative product innovations for a niche market. As the technical substitutions had shown not to be sufficient, the focus was mainly on organisational changes of both the organisational structure and culture.

The structure can be defined as the stable pattern in a company's activities, and the concept can be described by the following three dimensions (Jespersen, 1996):

- Degree of complexity, concerning how many levels the organisation is divided into.
- Degree of formalisation, concerning whether the jobs are standardised or adjusted to the individuals.
- Degree of centralisation, concerning whether the decisions and control are attended by few or many persons.

To which extent the complexity, formalisation and centralisation affects the innovative activity in a company is hard to say without analysing each case. However, a more flat structure, varied jobs and decentralisation are often seen as good conditions for creating new ideas (Gjerding et. al, 1998).

The organisational culture is often called the unofficial structure or the organisational glue. The organisational culture can be defined as the pattern of myths, norms and routines survived from generations, causing certain types of explanations and actions to seem natural and obvious (Christensen & Molin, 1983). As we see those explanations as obvious the organisational culture is often hard to change.

Contextual boundaries

The contextual boundaries in this period were broadened from the technical experts to all employees in the company. A keyword in this period was employee participation. Management on all levels played a key-role in gathering and developing the human resources, and co-ordinating the effort in a way that could promote organisational flexibility.

The case of environmental innovation

The focus on organisational issues was also reflected in the case of environmental innovations from the 1990s. The focus was no longer limited to the input of resources and output of emissions from the company's production. Now, the focus was on the activities inside the company, trying to prevent the environmental problems by cleaner technology, good environmental housekeeping and also by changing work procedures and the planning of the production. The keyword in connection with this is environmental management.

Environmental management is an on-going process, where the environmental impact from the company's production is reviewed, and by setting this review in relation to an environmental policy, it is possible to define some concrete goals. From this perspective, the companies seek possible solutions and make an action-plan to reach these goals for reducing the environmental impact. The effort is evaluated by setting the goals in relation to a new review, and the process can continue. (DEPA, 1992)

The advantages of environmental management are that the environmental efforts become systematic and dynamic activities in the companies with focus on continuous improvements and the organisational conditions (Remmen, 1999). Especially, focus has been on the commitment from the top-management and employee participation.

Another advantage of environmental management is the possibility of marketing the company as environmental responsible by getting the environmental management system certified by ISO 14001 or registered by the European order EMAS (Environmental Management and Audit Scheme).

To sum up

The organisational paradigm was dominating the view on innovation in the 1980s and in the first part of the 1990s. The characteristics of this paradigm is seen in table 2.

	Characteristics
Balance of resources	Focus on developing the human and social resources
Strategy	Flexible specialisation of the technical re-

	sources in the 1980s and the learning organisation in the 1990s.
Type of innovation	Focus on making creative product innovations – not as much by technical substitutions in the production system as by organisational changes, changing both the organisational structure and culture
Contextual boundaries	All employees in the company are involved in the innovation process. The management plays a key-role in gathering, co-ordinating and developing the human resources to promote organisational flexibility.
Environmental issues	Cleaner technology, good environmental house-keeping and changing work procedures. Environmental management, with focus on systematic and continuous improvements, commitment from the top-management and employee participation.

Table 2: The characteristics of the organisational paradigm.

The inter-organisational paradigm

Balance of resources

When the results of the organisational paradigm showed considerable signs of higher productivity, the companies developed a more comprehensive understanding of the balance of resources. Accumulation of money was seen as a synergetic interaction together with human, technical and organisational competence. Furthermore, many companies recognised the importance of sustaining and not only exploiting the natural resources.

However, the main shift from the last paradigm is the changed focus regarding the human resources. Competence to co-operate and co-ordinate the innovation process is not seen as limited to the companies internal sphere anymore, as the inter-organisational competence showed to be increasingly important. This is underlined in the system of innovation approach.

Strategy

The concept “Systems of innovations” was introduced in 1988 by Lundwall, but Freeman was the first to use it in a publication (Edquist, 1996). For definition of a system Lundwall uses Boulding’s work from 1985, where a system is defined as anything that is not chaos (Lundwall, 1993). The system of innovation approach can be further described in the following way (Edquist, 1996):

“The innovation process is characterised by complicated feedback-mechanisms and interactive relations involving science, technology, learning, policy and demand. Innovation processes

occur over time and are influenced by many factors. Because of this complexity, firms almost never innovate isolated. In the pursuit of innovation they interact with other organisations to gain, develop and exchange various kind of knowledge, information and resources.”

The concept “Systems of innovations” is used in many different ways. Sectoral Innovation Systems (SIS) can be defined as a system (group) of firms active in developing a sector’s products and in generating and utilising technologies. Such a system of firms is related in two different ways: through processes of competition and innovative market activities. On the contrary, Technological Systems (TS) can be defined as networks of agents interacting in a specific economic/industrial area under a particular institutional infrastructure. While the concept TS looks at networks of vertical as well as horizontally connected agents and organisations engaged in development of specific technologies, the concept of SIS focuses on competitive relationships among firms (Breschi & Malerba, 1996).

Innovation at macro level is often mention as National Innovation Systems (NIS), and by choosing the geographic boundaries, NIS is related to regional- and local innovation systems. The idea is to identify actors that to a certain extend share the common culture, history, language, social and political institutions (Lundwall, 1993). National innovation systems have been defined in a narrow and broad way by (Lundwall, 1993):

“The narrow definition would include organisations and institutions involved in searching and exploring – such as R&D-departments, technological institutes and universities. The broad definition which follows from the theoretical perspective includes all parts and aspect of the economic structure and the institutional set-up affecting learning as well as searching and exploring – the production system, the marketing system and the system of finance present themselves as sub-systems in which learning takes place.”

From this follows, that the innovation strategy does not take organisational flexibility into account, but also a question of creating a knowledge network outside the company and making strong business relationships within the product-chain. This to secure a possibility for specialisation in balance with stability with flexibility.

Types of innovations

It should be clear by now, that the system approach puts great emphasis on the inter-organisational interaction. There will still be focussed on making more niche and creative product innovations by technical substitutions and organisational changes – however, the purpose is to make them together with other firms in more

close relations, to get a balance between flexibility and specialisation.

Contextual boundaries

In the system approach the contextual boundaries are broadened to the inter-organisational sphere, mainly by setting the external networks in focus. Lindegaard (1997) presents an example of interaction network domains of innovation systems, see figure 3. The figure shows that the company have to co-ordinate their innovations within the following five domains: suppliers and related industries; the education and R&D system; market, customers and competitors; regulatory authorities; public sphere movements. In other words: Innovation is an interactive process, and interaction promotes innovation (Remmen, 1999).

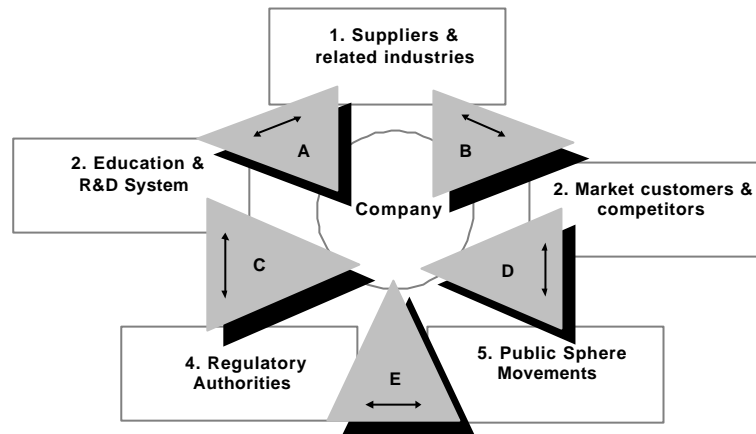


Figure 3: Propeller model of the interactive innovation network domains of the innovation system (Lindegaard, 1997).

The case of environmental innovation

From the mid 1990s it was recognised that the internal environmental effort within the companies was not sufficient, as the main problems in the future was regarded to be the general resource consumption in society and the impacts from the use of products (Remmen, 1999). Beside the production, the other phases in the lifecycle of products were highlighted, such as the extraction of materials, transportation, use and recycling of products.

This confronted the companies with new challenges, as the environmental effort in this perspective should be co-ordinated in the entire product-chain. It caused the environmental innovations in the companies to move in a more inter-organisational arena, at least on the conceptual level – which was in line with the general changes in the innovative activities in companies. Now the discourse changed from environmental management to lifecycle management (LCM), as a more sustainable management concept – balancing environmental, economic and social concerns.

Cleaner production, environmental management and assessment of the environmental impact from products in a lifecycle perspective are like co-operation in the product-chain and in the knowledge

network all parts of LCM (Remmen, 2001). The Danish company Brd. Hartman has suggested the following definition: LCM is company management based on environmental considerations in a lifecycle perspective (Pedersen, 2001).

	Characteristics
Balance of resources	Accumulation of profit together with human, technical and organisational competence was seen as a synergetic interaction. Human competence to co-operate and co-ordinate the innovation process inter-organisationally in focus
Strategy	By creating a knowledge network outside of the company and making strong business relationships in the product-chain
Type of innovation	Making more niche and creative product innovations by supplementing technical and organisational changes by inter-organisational activities.
Contextual boundaries	The contextual boundaries are broadened to the inter-organisational sphere, mainly by setting the external networks in focus.
Environmental issues	Focus on the environmental impacts from the complete lifecycle of products, moving the environmental effort to a more inter-organisational arena. Among other things by introducing lifecycle management.

Table 3: The characteristics of the system paradigm.

To sum up

The inter-organisational understanding of innovation described by the system paradigm has been dominating the view on innovation from the mid 1990s. The characteristics of this paradigm are summed up in table 3.

Conclusion

In this paper, I have described three paradigms for understanding innovation, which have an overtone of economic, organisational and inter-organisational, respectively, in their conceptualisation of innovation, where the last mentioned has led to a more comprehensive and sustainable system approach. This trajectory is illustrated in table 4.

On that background I will argue, that a more sustainable and comprehensive understanding of innovations is needed to promote the necessary environmental innovations. The internal environmental effort within the companies is not sufficient, as the main environmental problems in the future is connected with the impacts from use and disposal of products.

However, it is not sufficient to stay on the conceptual level – we need to go into action to see actual reductions in the environmental impact. Examples of that can be drawn in a Danish context, especially looking at the large companies, but is not yet sufficiently diffused to the overall company-practise in Denmark.

The missing diffusion is problematic for reaching the inter-organisation paradigm on a more practical level, as the companies in the product-chain may act in relation to different paradigms, and this makes co-operation and co-ordination of environmental innovations difficult. The next task, is therefore to gather much more experience from the first-runners in the area of environmental innovations in the product chain – and view this in relation to their overall understanding of the means and ends to innovation.

	Trajectory
Balance of resources	From a main focus on accumulating money by technical support, to seeing this in a synergetic interaction with sustaining natural resources and developing the human resources in the areas of organisational flexibility and inter-organisational co-operation.
Strategy	From coping with mass-production on a not very differentiated market, to organisational and inter-organisational learning in a differentiated market, creating knowledge networks inside and outside of the company and making strong business relationships in the product-chain
Type of innovation	From a focusing on imitation of radical innovations and optimising the production by technical substitution, the companies shifted to more creative product and process innovations by flexible specialisation over organisational to inter-organisational changes.
Contextual boundaries	From letting the technical experts in scientific

	and business community be the carriers of the innovations, the contextual boundaries were broadened to the organisational and inter-organisational sphere, mainly by setting the internal and external networks in focus.
Environmental issues	From seeing the environmental problems as local, and trying to solve them by dilution and end of pipe technologies, the environmental problems was recognised as global. This called for prevention – in the first case in the companies’ production by environmental management, but later on with focus on the environmental impact from the whole lifecycle of products – in a life cycle management perspective.

Table 4: The development in the understandings of innovation from the 1960s up till now.

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