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INFORMING EARLY-PHASE TECHNOLOGY DECISIONS IN PARADIGMATIC INNOVATION

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1. Introduction

The innovation activities of a company facing paradigmatic change with regard to both technology and business model includes taking many decisions, where the information available, as well as the decision makers' ability to understand this information, is limited.

Technology decisions in the very early phases of innovation have been explored in a Scandinavian energy-utilities company facing exactly these paradigmatic changes. In the company there are 5500 employees, with the major footprint in Denmark. The company has activities in the full energy value-chain including: production & trade of oil & gas, production & trade of electricity and sales & distribution to end-costumers. Their agenda is to shift from 15% sustainable energy and 85% fossil energy to 85% sustainable within 25 years. At the same time, their business model has changed from *energy planning* to *business development,* thus increasing the focus on innovation drastically.

Literature on decision making e.g. [Rasmussen, et al. 1991], often describes decisions in the very early innovation phases as "intuitive" and to be governed by "gut feeling". However, when an entire industry, in this case the energy sector, is forced to change their knowledge-world in such a radical manner, they start facing problems with making efficient decisions as knowledge generated through experience is mainly useful when the future mimics the past, which is not the case for such radical changes.

Therefore, a 3 year long research project within this industry has been initiated, with the purpose of generating an extensive understanding of the decision-making process related to assessing new technologies when designing radically new products and services for the market. It is expected that this understanding will enable further development of methods to improve the provision of knowledge and information required in the early phases of technology decisions.

This article reports on the first part of this project, and provides a descriptive model for understanding the complexity in the early phase intuitive decision-making process, answering the specific research question:

How are decisions regarding technologies informed in the early phases of innovation, when dealing with paradigmatic "new to the company" knowledge fields?

To explore the question, a case study; investigating the decisions made for radical new innovations, and the knowledge needed for supporting these decisions, was carried out. The investigation is based primarily on document analysis, interviews and observations which were carried out at the collaborating company, and the results are presented in this article.

2. Background – Informing early decisions in paradigmatic innovation

Motivation

Many companies in the energy sector are facing a paradigmatic shift of innovation path within the coming decades as the shift from a fossil (storable) to a renewable (fluctuating) mindset becomes more and more influential. As a consequence of this, absorption of new knowledge, the continued relevancy of existing knowledge and systematic unlearning of outdated knowledge become key industrial issues.

Knowledge and Innovation

Today, a clear link between knowledge and innovation is established, where [Tidd, et al. 2009] proposes a knowledge based definition of innovation as "*Innovation is about knowledge – Creating new possibilities through combining different knowledge sets*". Furthermore, [Adams, et al. 2006] defines knowledge management as one of the key performance metrics for measuring innovation management performance. From a process perspective, innovation can thus be modelled as a series of decisions and actions, gradually creating new business from the synthesis of knowledge.
With this perspective, knowledge management becomes a central part of innovation process quality, as [Davenport, et al. 1998] argues that "*What makes knowledge valuable to organisations is ultimately the ability to make better* decisions *and* actions *taken on the basis of the knowledge*". As this analysis is about paradigmatic innovation, the consequence becomes that innovation here is a issue of deciding, acting on and synthesising new and changing knowledge.

Technology Assessment and Decision Making

The terms *intuition* and *gut feeling* [Rasmussen, et al. 1991] described in the intro often shows up when dealing with high uncertainty and early phases of innovation. These descriptions are of little assistance when trying to understand what actually goes on in these phases, but they do, describe the central place of knowledge in this process. Grants expanded OODA model, consisting of the steps: Plan, Decide, Act, Observe, Orient, Sensemaking and Repeat [Philp and Martin] adds another useful element, besides knowledge, which is the introduction of sensemaking, and hereby difference in situational images between actors. This helps to understand different interpretations of the same knowledge. Turning to *technology assessment* [Doering et al. 2000] propose a model for the technology assessment process (TAP), see Figure 1, that describes on a overall level the phases a company goes through when assessing new technology. However, going to the more operational level, it provides very little help, as descriptions such as "scoping relevant knowledge" emerges.

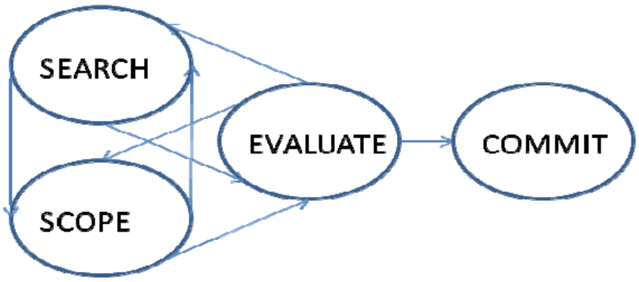

Figure 1. The technology assessment process (TAP)

The explanation for the missing operational theory, comes when looking deeper into the theory on knowledge management e.g. [Blackler. 1995], where a myriad of classifications exist, all dependant on the context in which the analysis is to be performed, meaning it is the same case here: no meaningful hypotheses is possible to create taking origin in the context for analysis.

Research Purpose

Based on this background, the purpose of the research is to perform a case study investigation of the early-phase decisions made in paradigmatic innovation processes, with the specific research-questions to be empirically answered: *How are decisions regarding technologies informed in the early phases of innovation, when dealing with paradigmatic "new to the company" knowledge fields?*

3. Methodology

In this project, an inductive approach has been applied, where the research is driven by the case study. An approach like this is especially well suited for research in relatively unexplored areas where prior theoretical constructs are not sufficiently exhausting to get an overview of factors influencing the observed phenomenon. [Eisenhardt 2007]

Case study Specifics

In order to investigate how decisions about new technology are informed a case study was set up with the energy utilities company described in the introduction. Data was collected from 2 different projects: Cleantech (CT) and Local Energy Production (LEP) Besides the two projects, data was collected from the corporate level Innovation-Centre (IC), due to its influence on the projects and formal responsibility for the innovation process. Most of the data collected pertain to the early phases of the company's innovation model; before the projects enter the formal corporate decision gates, see Figure 2, and form the focus of this article. In the next phase of the project, data will be collected by observing the formal decision meetings and interviewing the key stakeholders. This way the interactions between the formal and the informal decision making system will become clearer.

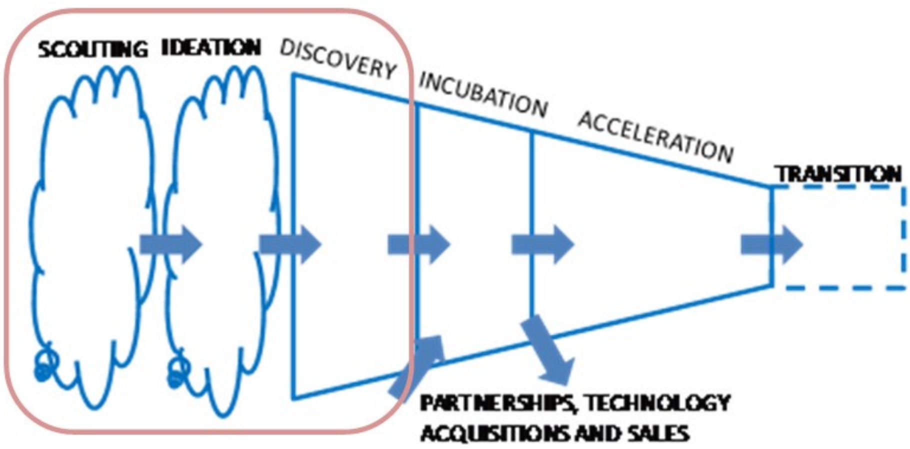

Figure 2. Data collection focus in relation to the case-company's overall innovation model

Data Collection methods

Four different methods were applies to collect the data for the further analysis, being:

Document analysis was based on procedures, handbooks and project documentation and the major outcomes are: Understanding of project history and a description of the formal decision making system used within the company – the latter is a formal description of the right side of Figure 2

Interviews were undertaken in a semi-structured manner, with questions in the following categories: 1) Personal Networks and their function 2) The interviewees understanding of innovation, knowledge and DM 3) Personal narratives on knowledge flow and DM 4) Experience with Methods & Tools for DM and KM. All interviews were between 1 and 1½ hour in duration, and situated in the company.

Observations were done without any predefined frame of interest, other than opportunity of observing actual technological decisions. The 4 project observations were of 1½ hour duration in average, where the 12 IC-meeting observations each took 3 hours. The latter was only recorded in field notes, as no sound recording was allowed by the company during the meetings.

Workshop was carried out with 20 people being: IC - members, project members and stakeholders with central position in the technology decision process. The workshop was a full 7 hour day, where the participants were actively engaged in creating the descriptive models from data and analysis results obtained from the interviews, observations and document analysis.

Table 1. Overview of data collection methods.
CT = Cleantech, LEP = Local energy production and IC = Innovation Centre.

Method	Amou	Source	Data collection
Document Analysis	-	Intranet, Project Documentation	Summary notes
Interviews	5	CT and LEP Project members	Sound Recording
Observations	4+12	CT and LEP Projects, IC meetings	Sound Recording / Field Notes
Workshop	1	20 participants doing technology decisions	Produced Material

Analysis Methods

A method capable of integrating the different types of data collected with the four methods mentioned in Table 1 was needed, hence *KJ analysis* was selected due to its ability to handle different forms of qualitative data into one integrating picture, consisting of bottom-up structured elements and their relations. The KJ analysis [Buur 1989] is essentially a very simple model of gaining an overview of large amounts of rich data. It was originally developed for structuring data from anthropological fieldwork, and provides a systematic bottom-up approach for post-structuring of qualitative data.
In the analysis, four predefined relationships were used to structure the data i.e. *Connection, Cause and effect* and *interdependence.* Besides these relationships, no other predefined structures from literature were added. After the construction of the models mentioned below, they were analysed through comparison with theory dealing with portfolio decisions – however, the objective of this article is not to prescriptive any method for portfolio management, but merely to provide a descriptive model with reflections on theory.

4. Empirical Findings

First, the formal decision making system is examined with emphasis on the early phases and radical technology decisions. Second, the case of technology decisions examined in the study is described and finally, the actual process of informing early phase decision making is described.

Formal Decision System

As in many other companies, the formal decision making model is build up around a stage-gate model, with clearly defined gates and templates for what to prepare before entering the gate. Besides the model, two committees are also part of the DM system, being the R&D committee and the investment committee. These act as high level gates, where the project needs to apply for funding as it matures.
Project idea is the first decision in the DM model and an overview of the required information is seen in Table 2 underneath here.

Table 2. Information requirements in the formal DM model

Evaluation Factors	Explanation
Project Categorisation	Projects are categorised according to complexity and required investment. The higher the sum of the two factors, the more formal the project will be managed, more procedures applied and more control functions in the structure.
Budget	The requirements for amount and timing of resources
NPV	Net Present Value indicates financial value of the project
PVI	Present Value Index indicates the utilisation of the investment
Documentation Level	This measure indicates how well the project is thought through, with respect to business case, competitor analysis, risk etc.

The table describes a very traditional way of evaluating projects, mainly based on financial measures. However, it became clear through both observations and interviews, that the technology decisions carried out in the observed projects did not adhere to this formal model; however, they did also get their funding through the committees. It was explained by the project managers, that the reason for not following the above model, is that it is unable to handle decisions regarding radically new technology and also is incapable of handing small start-up projects, as the supporting tools were made for calculating business cases for project on the scale of erecting a power plant.

Therefore, the next natural step in the analysis is to find out how the decisions are informed and made, when dealing with radical new technology; if, in fact, they are not following the above requirements for information as it is argued by the interviewees that they do not.

Case: Local Energy Production

To find out how the decisions were made, a case of technology decision making was studied through interviews with participants in the related projects, as well as observations of project meetings and meetings in the innovation centre where these projects were discussed. In the description, there is differentiated between *general technologies* and *specific technologies*. The difference is that the first relates to a general range of technologies with similar function, such as "producing energy locally", whereas the latter relates to a technology for a specific product fulfilling the function e.g. heat pumps.

Local Energy Production covers basically the entire portfolio of energy-producing products and related services, which can be installed in a private household. Examples of such products are geothermal heat-pumps, Small wind turbines and photo-voltaic cells. LEP is synonymous with the term *distributed generation* which is widely applied in especially American contexts.

The trend of having small scale production units in the grid has been normal on a medium scale for several years in Denmark, with the utilisation of de-central combined heat and power plants (CHP). Together with the integration of wind energy, the control and management of production from these sources has provided the company with both experience and supportive technologies to control small fluctuating units, which can be developed further to support LEP.

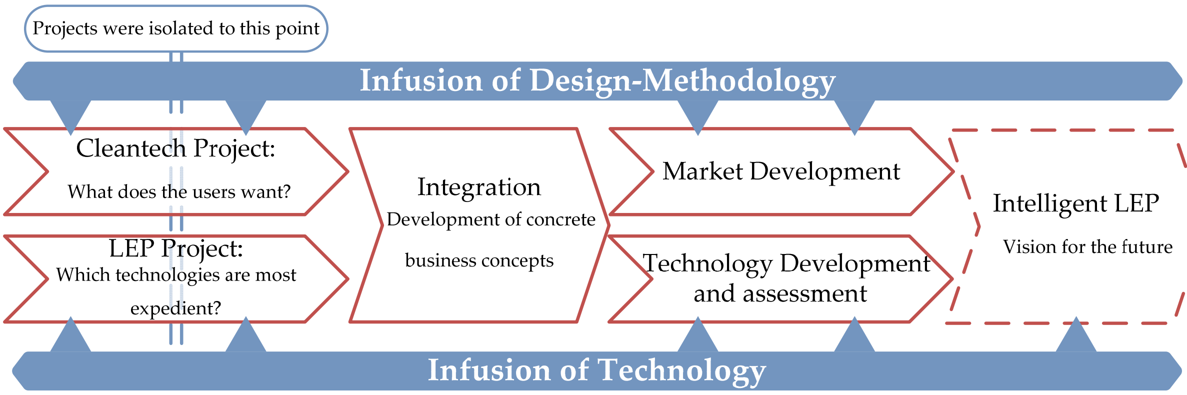

Figure 3. Time-wise overview of central events and knowledge flows in Local Energy Production

The purpose of starting the development of LEP offerings is divided in two, as it started as two different projects in separate departments. The CT project was started after an in-depth anthropological analysis of energy customers carried out by the sales and distribution department, indicating an opportunity in the market for offering these solutions to customers.

The LEP project was the technical angle, where the purpose was to turn the potential threat posed by customers starting to produce their own electricity, into an opportunity for new business creation, by supplying a portfolio of these *specific technologies* and developing them to into supporting the needs from the grid.

The decision relating the *general technology* was made before actual projects were defined and the interviewees themselves had a hard time explaining exactly when the decision was made. From the interviews it is apparent that this decision was largely done through informal discussions internally in the company. As there seemed to be support for investigating the opportunities further, the actual projects were defined and then the further course of events is described in Figure 1. – It is interesting to note that the decision on the general LEP technology was never formalised.

As it is seen from the blue arrows of technology infusion there has basically been two rounds of decisions regarding specific technologies. In no. 1, the focus was on selecting a set of appropriate technologies to start up with. In no. 2 the focus is on assessing technologies for expanding the portfolio of products. The vision for the future of the general LEP technology is one of developing the products to enable an intelligent grid to control them, often referred to as Smart-Grid, where they will be run as small production assets on the grid.
This project was the first in the company to adopt a user driven innovation (UDI) methodology, which was a necessity due to the active role the energy user plays in a future where they own energy-production assets.
During the interviews and observations in the project teams, it was discovered that the largest portion of decisions in relation to new specific technologies, were made from intuition and that very few technologies actually made it into the team discussions. I.e. a key stakeholder in evaluating new technologies came back from a 2 day technical conference, proposing one new technology, which was discussed in the project team, before it was rejected with reference to the low maturity of the technology. However, from the conference program it was apparent that quite many technologies had been presented and yet only one had proved interesting enough to be considered further.

The Actual Decision Process

The observed decision process can roughly be divided into two separate phases separated in time. The first one is the intuitive and informal part. Here, the technologies show up in chaotic timing where decisions need to be made very fast. You very rarely have a well defined set of equally developed technologies to rate against each other, making attempts of selection by comparison challenging: If e.g. the technology T1 in Figure 4 is to be decided upon, DA have virtually no knowledge about how the rest of the future portfolio will look like and the existing technology portfolio is deemed as outdated due to the change in technology paradigm faced. What was seen to happen be once again the intuitive evaluation, based mainly on vision about the future, and in practice the decisions are made as quick negotiations between decision advocate and his peers. In the last part of the figure, the technologies have entered the formal DM system in the form of projects, and as it can be seen, some technologies have already been killed by the DA and his peers. In the formal system, downstream from the intuitive phase, there exist a neatly ordered process, where the technologies are evaluated based the criteria listed in back in Table 2. The reason is, that no matter how visionary the project may be, it still needs to get funding, and the way to get it is through the aforementioned committees.

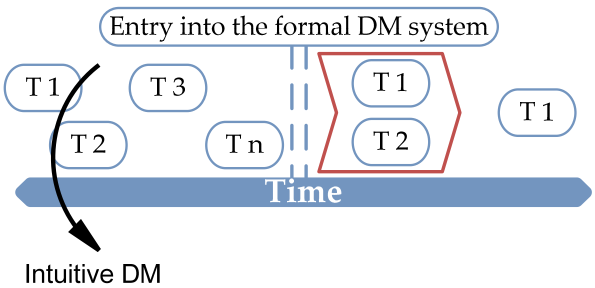

Figure 4. The two phases observed in technological decision making

Distributed decision making describe very well the intuitive phase, where all the DA's is expected to posses the corporate DNA and hereby be equipped to make decisions about technologies, and take interesting opportunities further throughout the innovation process. When moving down stream, the decision making turns more and more central; ending with a gate where the CEO and VP's of the company is involved in all projects above a specified size. In this way, the vast majority of decisions are made distributed, but the final one is made centrally.
On the basis of a *KJ analysis* of observations and interviews; a preliminary model describing what this intuitive DM actually consists of, in terms of knowledge, was constructed. The preliminary model was then distributed at the workshop, where the 20 people were divided into 4 groups and each group was

given the task of redoing the model to their liking. This process spawned 4 new models, with both extensions and reductions to the preliminary one. From these 4 models, and the extensive amount of comments posed by the workshop participants, the researchers synthesised the final model in Figure 4.

Figure 5. Central knowledge domains for the decision advocate, and their connections

Interviewees were on average capable of supplying two or three of the domains during the interviews, however, when observing the actual decisions and having the 20 decision advocates comment on the elicited knowledge domains, the model became the detailed view seen in Figure 4. When confronted with the model, the reaction from the DA's was that they had never been readily aware that of drawing on all these domains, and therefore have not proactively tried to update knowledge in all domains.

Knowledge domains and relations

Here, the domains are explained in detail, based on a summary of the discussion from the workshop, thus definitions are strictly empirical, and can be seen as general evaluation criteria for technologies. Starting at the top *Business model and Processes* entails knowledge about *how* to develop the technology into a successful business concept. In the case described, the issue of how to do user driven innovation came in and during the workshop other procedural knowledge elements mentioned included: formation of subsidiary companies, design across large geographical distances and iterative design processes. The domain leads on to *Development Funding*, of the aforementioned business concept. Obviously, this refers to development of the technology seems likely be financed. Three main areas, shown by the *interdependence* arrows in the figure are seen to be the main sources: *Internal Alliances, External Alliances* and *Regulatory Environment*. Financing can come from one or all of the above sources and the ability to create stable supportive networks in these three spheres were described in the interviews as the primary competency of any business developer / DA. In the observed case, the decision in favour of the technology was perceived as being made, when a *signal of willingness to buy* was obtained from either an internal or external stakeholder. However, the regulatory part plays a crucial role in these decisions, by subsidising and regulating technologies. The magnitude of this effect is underlined by the presence of a *regulatory affairs* group supporting IC. A domain closely interrelated to *Regulatory Environment* is *Dynamics of the Market* which is often considered the object to be controlled by regulatory initiatives e.g. the Kyoto Protocol. Regulations are not everything though; knowledge about liberal market forces becomes increasingly important as the DA's have to argue for business cases in a market becoming increasingly liberalised. A connection on to *insights into users world* is seen, which represents another change to the sales-thinking in the company: from being mere subscribers to electricity, the electricity are increasingly gaining agency in the socio-technical system surrounding energy production, distribution and use, as was exemplified in the case description earlier. Detached from the other domains, lies the three domains making up the intrinsic technical properties of the technology: *Technical Characteristics, Synergies with the Energy*

System and *Energy Resource Reliance*. The first covers the technology itself in terms such as reliance, efficiency, availability and production cost. The second covers the benefits offered when the technology is connected to others in the grid e.g. the electric cars with wind-turbines, where the storage capacity in the first can even out production fluctuation in the latter. The final domain covers knowledge about the company's dependence on resources such as coal, gas biomass and wind will be changed if developing the technology considered into a product on the market.
Early phase decision making is seen to be a highly iterative process, visiting all of the above domains, with increasingly higher quality of data as time progress. In the first iteration, where the DA is initially presented for the new technology, he will tend to use his existing knowledge in the domains. In the next iteration, the process becomes highly social and he discusses the technology in relation to these domains with his peers. It was furthermore observed that later iterations are aimed at supporting the initial decision in the form of a stable support alliance and readiness for committee funding.

Issues in Accessing Knowledge

In the following, the issues related to the DA's access to knowledge elicited through interviews and observations are presented in schematic form. However, a central notion for understanding the table is the finding that the access to the abovementioned knowledge domains relies heavily on personal interaction, as opposed to access through a system of codification.

Table 3. Issues in accessing domain knowledge

Issue	**Example from data**
Issue 1: Organisational Design 1) Organised in four business units (BU), the company follows a classical concern structure, where each BU has its own responsibility in the value chain. However, this was reported in the interviews to create challenges regarding utilisation of knowledge across BU's who tend to focus on their own activities.	1) Project funding was described as an example of this issue, as projects with similar knowledge base were seen to be running in different BU's. This situation was caused by projects following money instead of knowledge. An extreme example is the LEP case described above, where no one knew that similar projects were running at the same time in two different BU's
Issue 2: Business Processes 1) When accessing knowledge domains in relation to a specific technology, the difference between perceived core competencies and actual/future core competencies was seen as a central issue. 2) The first iteration in the decision process is done almost without interaction thus, quality of knowledge possessed by individuals become an issue. Especially, because experience is seen to be the most dominant way of getting knowledge making unlearning a central theme. 3) Frequency of interaction with knowledgeable people previously unknown by the decision maker.	1) A project where the technical domain related to the project was perceived to be outside the core competencies came close to a kill, when based on a core competency developed bottom, driven by necessity in other projects. 2) In one observed case, 20 years old knowledge about user behaviour was used to make a decision about a technology's future, but this was not realised until the authors asked elaborating questions about the rationale behind the DA's negative position towards the technology. 3) It was seen that introducing a new person in a key position with entirely different competencies opened a new opportunity for the company and made the CT project possible, underlining the importance of rethinking instead maintaining the knowledge domains.
Issue 3: Corporate Culture 1) Personal trust is the dominant way to determine quality of information. In the first iteration through the knowledge domains, the personal trust is directed at the technology-inventor, and perception of trustworthiness decides whether to believe claims on quality of the technology. 2) Differing perceptions on how to inform a decision, caused be a merger of two opposite models, were seen to hinder the free flow of knowledge.	1) In the second iteration, where the process turns highly social, the personal trust is directed towards representatives of the knowledge domains, where information almost exclusively is gathered from people already known and trusted by the DA. 2) A competition between two fundamentally different models of informing a decision was seen, caused by a merger less than 5 years ago. One model is described as the gunslinger model where decisions are taken as a shot from the hip, and the other one is a highly analytical

3) People were in general good at sharing know what, being knowledge pertaining to the content of a specific domain, however they are facing a challenges when it comes to sharing know how, being knowledge procedural knowledge.	scenario-model. 3) The recent shift in business model from energy planning to business creation was seen to make focus on efficient business processes very new, hence only partially adopted and any process change have to come through a concrete technological project.

5. Discussion

First, key-findings are summarised, second, these are compared to theories of technology assessment and portfolio management, and finally, the practical implications of the research is discussed together with the limitations of the study.

Summary of key findings

From the case study, three levels of descriptions is supplied: An overview of the information requirements in the formal decision making system, a description of a specific case study where technology decisions were made and finally the results from unwrapping the decision process together with participants from the company. The key findings from these activities are:

- Intuitive decisions related to the early phases in radical innovation are largely affected by downstream formal decision system, though they were intended not to be.
- Visions are made and remade all the time through discussions of new technologies, making it a whirlwind process, where new the discussions of technologies at the same time shape the vision and are evaluated according to it in the early phases of innovation – The visions were seen to consist of anticipated future development within the 10 identified knowledge domains.
- New technologies were seen to bring with them requirements for new design methodologies, which the company needs to learn in order to benefit fully from engaging into the technology.
- Learning and unlearning knowledge within the domains were seen to happen primarily through socialisation and persistence of old knowledge a challenge.
- Examining the sources of the knowledge, it is seen to come from both external and internal sources and even though there is a shift towards more and more open innovation, the visions of the future energy system relates first and foremost to exploitation of internal knowledge.
- Definitions of core competencies was observed to be in a fluent phase, where some traditional core competencies were perceived outdated by the DA's while new competencies moved closer to the core, from mere problem solving in the past.
- Main parts of the shared vision is introduced by the wind technology, which has created a shared vision of future based on fluctuating sources, where business models can be created on the basis of supplying ancillary services to the market, through e.g. LEP.

The findings together reveal a complex socio-technical decision making system, where decisions and further development of the technology alternates; while moving in the direction of a technology vision. This vision, however, is not a solid bearing mark itself, as it undergoes changes whenever a new technology is considered. The process observed is very much in accordance with the findings from *Actor Network Theory* scholars as Madeleine Akrich, whom refers to it as a whirlwind process, where technology evolves through construction and deconstruction of stable socio-technical networks. The findings from this study add the role of socially constructed visions as bearing marks for technology development to this description.

Technology Assessment Process

In the following, the findings are considered in the view of the TAP described earlier.

The logic of the model is that there is a general body of knowledge available to the company, made up from a total sum of knowledge from internal and external sources. From this body of knowledge, the company scopes a certain part which is where they direct their attention. In the scoped part of knowledge they search and select some specific technologies represented by the geometric shapes. The scouting process will select a set of technologies, which it feeds into ideation that starts to turn the immature technologies into specific innovation ideas through a process of knowledge combination.

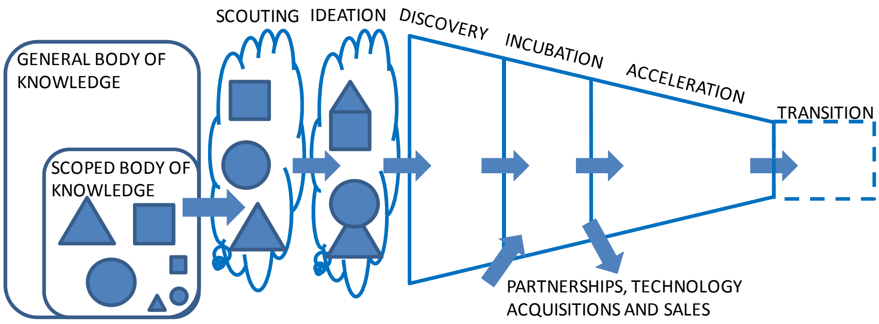

Figure 6. Assessment of technological knowledge in the case-company's innovation model

From the first stage, where a part of the *general body of knowledge* is scoped, it is hard to be proactive in the scoping of which knowledge to actively search through, when the updating of domains mainly happens through experience. However, standing before a paradigmatic technology change force the company to look into new technology related areas, like the UDI view inherent in the LEP case. Using these new methodologies to push the boundaries of the knowledge scope could prove beneficial.

Looking at how to search through the knowledge within the scope, it seems apparent that, because the search was found to be limited by trust and personal networks and fit with the vision about the future energy system, that many potentially groundbreaking technologies will be overlooked because of their signals being too weak in this context.

Portfolio Management

Considering the function of the above assessment process, it can, in essence, be seen as portfolio management (PM) issue, where the main interest is one of the portfolios fit with a future business and technology paradigm. In the tradition of methods for this kind of fore-sighting, there is two fundamental viewpoints; a positivistic one and constructivist one. The first viewpoint is e.g. manifesting through the mathematical models for forecasting, with basis in historical data, which is much researched in fields such as Operations Management. However, the problem with applying this type of PM method in the present case is twofold: First of all, the assumption that the future will mimic the past is unlike to be true in the case of paradigmatic change. Second, even though these models are capable of handling large uncertainties in the data, they still depend on the uncertainties to actually be possible to assess, which is not the case when the technologies at hand relies on the complex socio-technical configuration described earlier.

A common way of handling this problem, is the utilisation of the constructivist scenario-technique, which was developed in the 60’s by the shell corporation and since then has been refined into a quite strong strategic planning tool, e.g. for making portfolio decisions. This approach is build around mapping out a set of equally plausible futures, and then decisions are measured against their robustness across the different scenarios. A method like this would seem to be a strong way of getting the aforementioned visions about the future energy system synchronised across DA’s, however, the method offers no directly operational solution to deciding in a future where value-chains are not even chains yet, but still only value-elements, tied into other networks. In conclusion, portfolio management offers no directly applicable solution to the problem; however challenges in the constructivist approach is of a nature where they perhaps could be overcome through further development of tools.

6. Conclusion, Implications and Limitations

The study is mainly based on empirical evidence, where emphasis has been putted on describing the decision making process in the early phases of innovation as it actually plays out in a real life industrial context. As such, an inherent limitation of the study is that it consists of an in-depth description in one company, hence, it is only limited possible to generalise the results to other companies. However, the study has contributes to further industrial work with developing prescriptive tools, where these results is useful along dimensions such as: 1) Organising knowledge for decision support in both IT systems and networks aimed at knowledge transfer through socialisation. 2) Further work on the elements and effect of technology-visions, on the development of new technologies within a field. 3) A starting point for a process where new constructivist foresight methods, including socio-technical co-configuration, can be developed in an industrial applicable manner. 4) Realisation of the intimate connection between new technologies and new development methodologies in the given context is expected ground the development of methods for continuous process learning.

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