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New Innovative Ways for Multidisciplinary University Research Based Open Innovation
- *Comprehensive case study within in-door climate remediation*

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Abstract. *This paper describes and put into an international perspective an untraditional innovation and development project that was initiated by the Capital Region of Denmark in August 2011. The on-going project aims at finding new and innovative ways of solving in-door climate problems in houses situated on contaminated soil and/or groundwater, where volatiles from the said pollutions seeps into the facilities and creates in-door climate problems. The project was instigated based on the fact that traditional innovation processes involving universities and research institutions did not provide satisfactory innovative results. Incremental improvements to already known methods were the result. Consequently the project named NYMIND was launched by the Capital Region of Denmark addressing three key points: Firstly, the project should be based on multidisciplinary university research. Secondly, scientists with a known capacity to innovate and an expertise outside the field of in-door climate and contamination should be connected to the process in order to enhance innovation. Thirdly, different process tools should be applied and tested during the innovation process including the use of art and other creative tools to visualise possible ideas and solutions. The project has now reached a decisive stage where three pre-project tracks has been formulated and are now being implemented as cross-university and cross-disciplinary projects. These tracks represent possible solutions that did not come out of the earlier mentioned traditional innovation process. In conclusion, the project NYMIND has so far been successful and resulted in a number of important lessons learned. These are discussed and put into an international and general perspective in this paper.*

The following scientists are participating in the project in this final pre-project stage: Associate Professor Birgitte Andersen, Technical University of Denmark; Professor Emeritus Erik Arvin, Technical University of Denmark; Professor Allan Gross, University of Aarhus; Senior Scientist Rasmus Jakobsen; GEUS (Geological Survey of Denmark and Greenland); Project Manager Carsten Johansen, Technological Institute of Denmark; Associate Professor Tjalfe Poulsen, University of Aalborg; and Professor Anders Priemé, University of Copenhagen. Meetings have been facilitated by Innovation Consultant Bettina Pedersen and Visualisation Consultant Claus Rye Schierbeck.

Key Words: Contaminated Soil and Groundwater, In-door Climate, University Research Based Open Innovation, Multidisciplinary Team Innovation, Creative Tools for Innovation, Visualisation in Innovation.

1. Background and Introduction

Denmark underwent a substantial industrialisation following the 2nd World Word. The country now suffers from the effects in terms of environmental degradation. A large number of contaminated sites are left behind in the wake of this industrialisation and many contaminate or are in the process of contaminating the groundwater – the primary source for drinking water in Denmark. Based on this, cleaning up the thousands of contaminated sites has been a top priority in Danish environmental legislation and management over the last 30 years. The Danish Regional Authorities have been the leading authorities within this area since 2007 (there are five regions in Denmark).

The Capital Region of Denmark covers the Greater Copenhagen Area in the Eastern Part of Zealand and contains the largest number of contaminated sites due to the heavy industrialisation around the capital, Copenhagen. Following this, the region has put a lot of importance on developing new, more cost effective and smart solutions for cleaning up these sites with an annual budget around 50 million €. This has resulted in substantial emphasis on innovation and development projects in cooperation with consulting engineers, entrepreneurs, and research and development institutions including universities since 2007. The overall and underlying strategy for this development process has been to develop solutions which represent a fully clean up, in the sense that the pollution at a site has been removed or neutralised. Based on this, a number of new and innovative remediating methods and processes have been developed for the so-called open sites – sites without constructions above the pollution.

At a fairly big amount of sites in the Greater Copenhagen Area houses are situated above the contaminated site and this makes it very difficult to apply the fully-clean-up concept. On these sites toxic volatile gasses from the contaminated soil and/or groundwater creates in-door climate problems by intrusion through various venues including construction and sewers. Based on this, a special innovation and development process for these sites were launched in 2009 covering the same resource base as for the open sites namely consulting engineers and entrepreneurs as well as universities and other research institutions.

However, the team responsible for developing the new methods and processes within the Capital Region of Denmark concluded that despite of this process being dynamic and innovative it only provided a variety of incremental innovations in terms of refining and further developing already known methods and processes. The result was fairly traditional abatement systems with no final solution to the problem and especially the need for the establishment of permanent monitoring systems. The solutions that were developed would be very costly and create daily nuisance for the people living in the houses. Furthermore, the building in question would be stigmatised in relation to daily use and functioning and in connection with possible future selling.

Based on this, the team decided to search for new innovative ways based on the fully-clean-up and no-monitoring basic concept. In consequence of this the *NYMIND Project – creating safe in-door environment* (NYMIND is a Danish abbreviation for *New Methods for In-door Climate, which plays with the English word MIND and NY, which is NEW in Danish*) was born in August 2011.

2. Conceptual Setting of the NYMIND Project

The objective of the NYMIND Project, which is still on-going, is to plan an intensive and cross-disciplinary innovation process with the aim of identifying once-for-all solutions (the full-clean-up concept) to in-door climate problems created by contaminated soil and/or contaminated groundwater. We define once-for-all solutions as solutions with a maximum impact horizon of 5 years that will ensure a permanent healthy in-door climate. There should be no need for further measures including monitoring. Consequently, a new approach was required in order to deepen and broaden the innovation perspective based on the earlier more traditional approach, which did not give satisfactory results. This new approach has two distinct but interlinked dimensions based on the experience derived from the first project:

1. To seek to widen the innovation perspective through a multidisciplinary approach involving disciplines that are not traditionally involved in solutions related to in-door climate problems or contaminated sites but instead have a broad and deep capacity for innovation.
2. To apply untraditional innovation approaches including art based creativity and visualisation.

The tangible output of this new innovation and development process is expected to be the establishment and functioning of a Danish as well as an international innovation platform related to the area. Furthermore, a number of innovation tracks should be identified and structured, which will be relevant to pursue in relation to research and development as well as field testing. Finally it is expected that the method behind the process can be generalised and used in other areas in need of untraditional and cross-disciplinary approaches. Due to the international perspective, the project and the preliminary results were presented at the INKT12 Conference in Bournemouth in April 2012 as one of several cases of innovation: Lønholdt, J.R. et al. *Next-Practise in University Research Based Open Innovation – from push to pull: case studies from Denmark.* In addition to the present paper, which focuses on the innovation process, an abstract that primarily focuses on the technical solutions coming out of the innovation process has been prepared for the AquaConsoil international conference in Barcelona in April 2013: Lone T. Karlby et al. *Innovating Solutions to Prevent In-door Air Quality Problems Caused by Soil Contamination.*

The overall NYMIND Concept is illustrated in Chart 1 overleaf. As can be seen, the project is organised within three groups. It consists of a primary *Core Group* with high capacity for innovation within their field of expertise and especially with capacity for applying this outside their own field. This group mainly consists of non-topic scientists and researchers in the sense that their daily field of work is mainly not within either soil or groundwater contamination or in-door climate. This group conducts the main innovation work. The group is supported by a *Wider Group* consisting of resource persons from their professional network that they can draw on when needed for support. A *Backing Group,* consisting of experts and practitioners within in-door climate and soil and groundwater contaminating, functions as a sounding and approval board for the ideas and solutions coming out of the Core Group and thus ensures the viability of the solutions. As mentioned earlier and as shown in the chart overleaf this process and organisation of the

process when set in motion should provide some innovation tracks for further research and development, and in the end, new practical solutions.

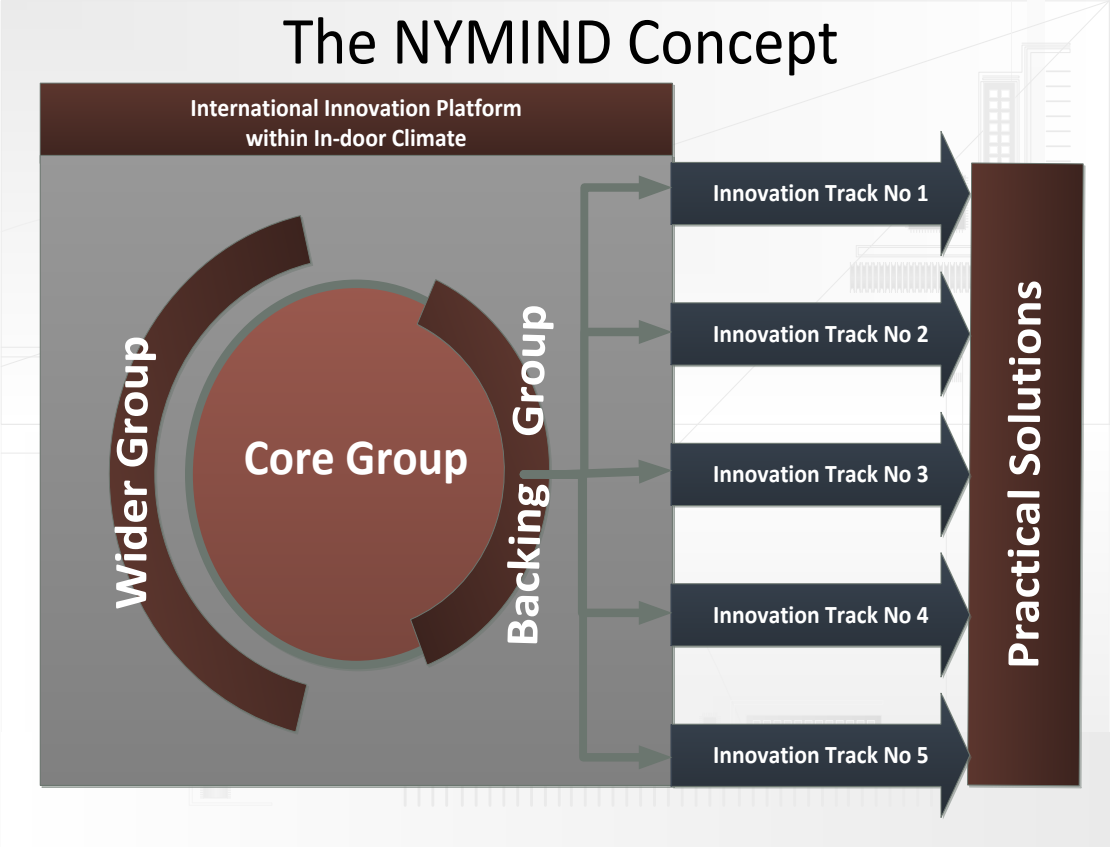

Chart 1: The NYMIND Concept

3. Implementation of the NYMIND Project

As given in the Chart 2 overleaf the NYMIND Project, which was started in august 2011, is presently in its Phase IV and still on-going. It is expected that three full research and development projects will be launched in autumn 2013 based on the pre-project work in the first half of 2013.

Phase I, the Inception Phase, was conducted from August 2011 to the end of January 2012. During this phase potential researchers and scientists were identified and contacted primarily based on personal network of the key persons of the project, and the innovation process was structured. The network includes scientists, professional knowledge exchange facilitators and match making personal at the universities. It was surprisingly easy to interest busy scientists and researchers in this untraditional endeavour outside their normal field of work. In order to ensure that the selected scientists had the dual capacity looked for in the Core Group, a kind of audition like meetings were conducted at the participating universities with participation of interested and prospective participants. Unexpectedly, nobody was offended by this kind of You-Got-Talent or X-Factor approach, which was quite successful. Contact also covered two international innovations networks: The KES/IKT network through Professor Robert J. Howlett

and the Swiss/German network Platinn/smE-MPOWER through Dr Christophe Meier and Dr Andreas Wolf.

The *1st Core Group Meeting* was scheduled in Denmark in November 2011 with participation of around 20 researchers and scientists including Professor Robert Howlett and Dr Andreas Wolf from the above-mentioned international networks. The participants' fields of expertise covered medicine, microbiology, environmental engineering, physics, chemistry, and social science. Trying out new art-based innovation processes was one of the aims of the NYMIND Project. A Danish company specialised in this was contracted to conduct the process together with a number of actresses that had been through an EU-based education in innovation, *Innovation Actresses*. This was structured around storytelling, the Planets and the Universe. In order to accommodate the mainly technical and natural science participants, they further tried to put the challenge at hand into a mathematical formula.

The meeting was conducted in English due to international participation and this turned out to somehow impede the process even though Danes normally master the English language. However, this was not the major lesson learned. The main lessons learned was that when dealing with technical and natural science researchers and scientist the creative show should not take the scene. They should be given interesting topics to tug into together as soon as possible since they apparently find common ground together across disciplines.

This is how we reached this conclusion: Besides trying out untraditional innovation tools, this first meeting was planned as an introductory and warming-up meeting where the participants should get to know each other. This was achieved successfully and completed before planned mainly due to the *Innovation Actresses*. Consequently, half through the meeting the researchers and scientist asked to be allowed to do real work and the organisers were not prepared for this situation. It lead to certain frustrations which however did not induce anyone to walk out because they liked their new colleagues and would like to start field and lab work concerning the issue as soon as possible. The meeting was not implemented as planned but the process itself was dynamic and motivating to a certain extent. It was completed with e-tales prepared by all the participants based on a macro provided by the Innovations Actresses. The tales covered soft as well as hard issues in relation to what had happened at the Meeting.

Based on the lessons learned from the 1st Core Group Meeting it was decided to revise the approach strategy for Phase II – February to June 2012. The project took one step back and began by conducting an in-depth discussion with all the participating scientists grouped according to universities. They were asked to discuss their specific expectations and visions concerning the project and their participation. In hindsight this should have been done before the 1st Core Group Meeting. The first clear common wish was to conduct the further process in Danish and consequently the international perspective of the NYMIND Project was toned down temporarily. Furthermore, a cursory screening of the international literature in relation to innovation processes and tools were conducted as part of this Phase II.

Full agreement was reached to structure Phase II in accordance with a sort of innovation cascade model and without using too many and too art based creative tools (a specific requirement from the participating scientists):

1. Separate innovation meetings with participating scientists from each of the participating universities.
2. The results were brought to twin university meetings.
3. The results from these meetings were sounded and tested at twin university meetings with regional consulting engineers and entrepreneurs.
4. The combined results of this were presented and discussed at the joint 2nd Core Group Meeting in April 2012 with participation of consulting engineers and entrepreneurs as well.
5. The results from this meeting were structured into 6 innovation tracks that were reduced into 3 pre-project innovation tracks at the joint 3rd Core Group Meeting in June 2012 as given in the Chart 3 overleaf.

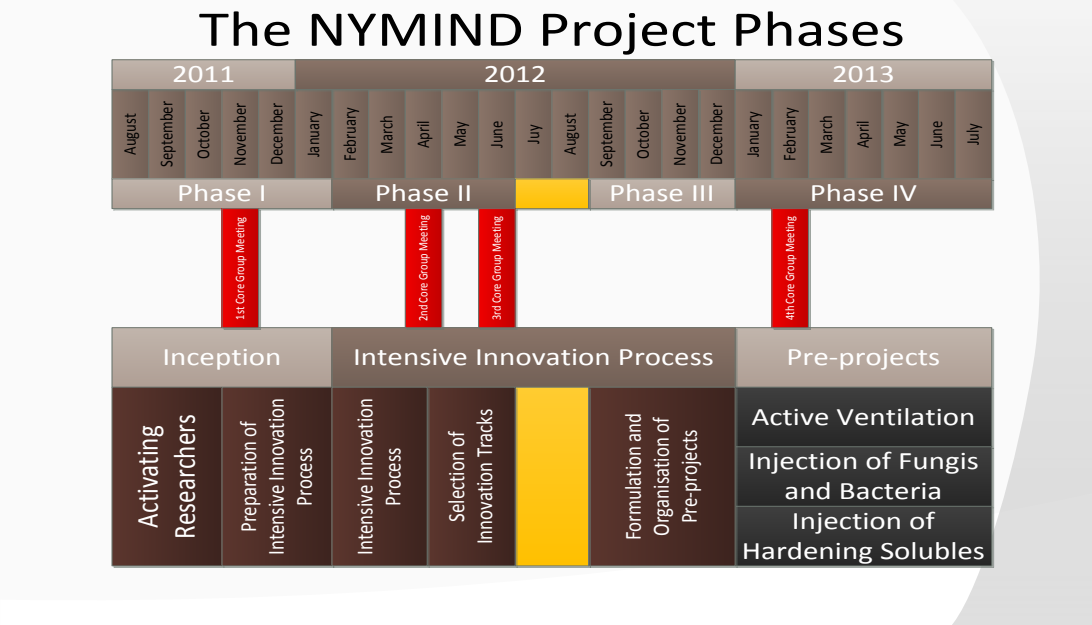

Chart 2: The NYMIND Project Phases

Based on the above, it was decided that the further process should be managed and conducted by a team consisting of two professional innovation and process consultants supported with an expert in visualisation because drawings are known to be a strong communication tool for technical and natural science scientists. In this way the Project took it to a higher level by contracting a visualisation expert with an engineering background. In the following process visualisation was successfully used as a strong innovation tool in meetings and as the reporting media. In order to ensure that the solution tracks reached by the non-topic scientists were thermodynamically viable and possible to implement in the real world, a scientist within this area was connected to the process in Phase II.

As can be seen from Chart 3 overleaf, the 1st Core Group Meeting in November 2011 provided four untraditional innovation venues and thus underlined the innovation capacity present with the non-topic scientists:

- *Personal and Build-in Sensors and Information Systems*, which would monitor the air quality in the building and on each person continuously,

process the information and inform individuals what to do if air quality deteriorated.

- *Absorbents including Intelligent Clothing, Intelligent Wall Paper and Carpets*, which in combination with the above solved the problem by absorbents inside the house and on individual persons.
- *Biological Barriers*, as plants, bacteria, fungi between the pollutant and the house and thus ensuring that volatiles did not pass this barrier and preferably degraded.
- *Air Purification* as in spraying the problem away just as it is done through traditional air improvement measures.

As can be seen from Chart 3 hart seven preliminary innovation tracks based on the four innovation venues were formulated during the *2nd Core Group Meeting in April 2012*. This was done through an intensive innovation process using visualisation as a strong tool and applying the laws of thermodynamics.

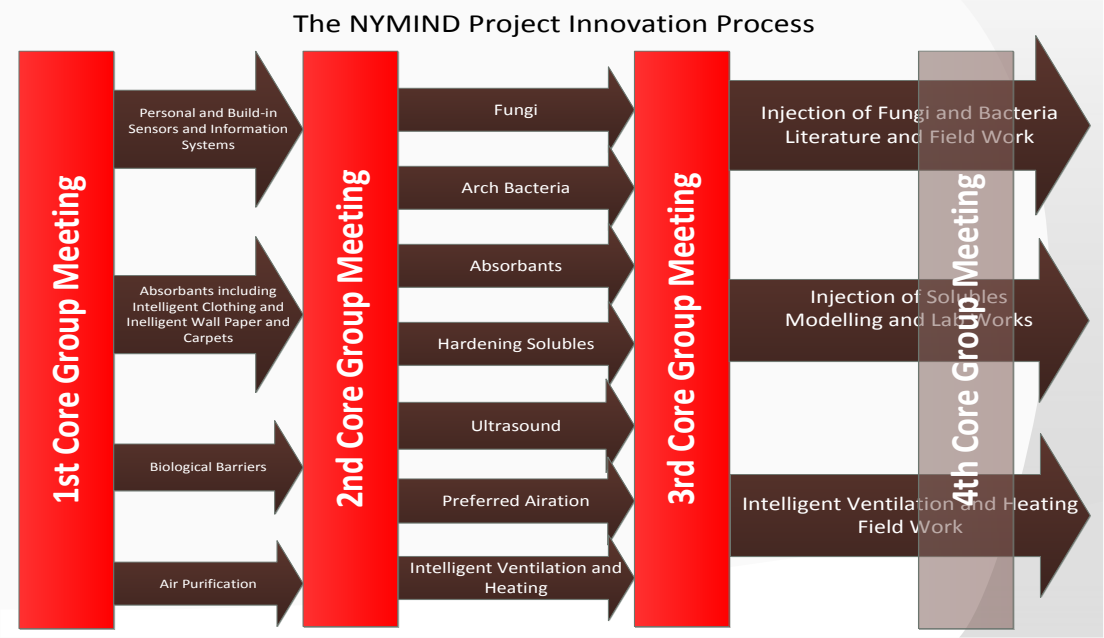

Chart 3: The NYMIND Project Innovation Phases

These comprised the following preliminary innovation tracks and were investigated further after the meeting in smaller task groups consisting of the non-topic scientists that were present at the 2nd Core Group Meeting:

1. Could *Fungi* be used to degrade or neutralise the pollutant and/or the volatiles from the pollutant?
2. Could bacteria especially the very persistent *Arch Bacteria*, be used for the same purpose?
3. What kind of *Absorbents* could be used and how could they achieve the same goal?
4. Could *Hardening Solubles* be injected in the pollutants and/or above the pollutants in the influence zone to neutralise or encapsulate?
5. Could *Ultrasound* be used to break down the pollutants?

6. Could planned and structured *Preferred Aeration* systems be used to clear away the in-door pollution
7. How could *Intelligent Ventilation and Heating* be used as a way of neutralising in-door volatiles?

The results of the work in the smaller task groups after the 2nd Core Group Meeting were presented and discussed at the *3rd Core Group Meeting* in June 2012, again by using visualisation as a strong innovation tool. The results of this meeting were the formulation of three pre-project innovation tracks that each had a dedicated group of scientists allocated. The track above – *Ultrasound* – was not found viable, and another – *Absorbents* – is now at a development stage where it could go directly to planning and implementation of real field testing through consulting engineers and entrepreneurs.

During the course of the process a lot of untraditional, wild and innovative ideas were floated by the scientists as well as the other participants including the innovation consultants, the consulting engineers and the entrepreneurs. The following is just a random selection demonstrating the broadness and depth of the innovation process: Releasing Mole Robots chewing the pollution and/or delivering absorbents or other solutions; releasing Gene Modified Earthworms doing the same; inserting a Dialyse Chamber function cleaning the subsurface fluid; a Large Diaper under the house in question with sort of reverse affect; larger The Bags doing the same; Carbon Nanotubes for injection and sort of a dialyse function; a special chamber under the house using Household Waste as cleaning agent; Fracking the soil underneath the house in order to facilitate injection. At the moment these ideas are reported and assessed for possible future use.

The three Innovation Tracks, which were described in detail – including planning and budgeting – during Phase III, comprised the following that were funded in this pre-project stage by the Capital Region of Denmark:

1. Use of *Fungi and Bacteria* should be further investigated through literature and field work.
2. Possible *Injection of Solubles* should be further investigated through modelling and lab work.
3. Establishment of *Intelligent Ventilation and Heating* should be further investigated through field work.

A *4th Core Group Meeting* has been scheduled for late February 2013. The meeting is part of Phase IV that covers the completion and reporting of the above three innovations tracks in the pre-project stage. The objective of the meeting is to make a mid-term joint status of the work accomplished and learn from each other in relation to the implementation of the pre-projects that are scheduled for completion in June 2013. By that time, fully fledged, planned, budgeted and funded innovation projects should be available for the said three tracks. In order to ensure the crucial funding, a Funding Specialist will partake in the 4th Core Group Meeting.

4. Discussion

The discussion will be structured around the following three main findings and main lessons learned during the first three phases of the NYMIND Project:

1. The establishment of a multidisciplinary team consisting of non-topic scientist as the Core Group providing the initial innovation boost.
2. The use of different tools and a team of facilitators for the innovation process.
3. The innovation cascade structural model with the said Core Group, a Wider Group and a Backing Group consisting of topic researches and developers.

4.1 Multidisciplinary Team of Non-topic Scientists

As described previously, the NYMIND Project has been successful in establishing and facilitating a multidisciplinary innovation process based mainly of the work of non-topic scientists who are top scientists in their own field. As can be seen from Chart 3 above the Core Group has provided a flow of innovation that has resulted in three innovation tracks. These tracks did not come out of the traditional innovation process prior to the NYMIND Project. The Project has in this connection been successful in relation to the fairly hard core selection and recruiting process based mainly on personal network and with an approach similar to “You-Got-Talent”.

The Project was not very successful in the activating phase after the selection phase as too little time and effort were allocated to align the aims and expectation of the NYMIND Project with the expectation and willingness of the scientists. As university researchers, they are independent and have to be severely motivated to partake with only an honorary fee. However, stepping back the Project solved this problem and ensured high motivation of the Core Group in the following work.

The beneficial use of multidisciplinary teams and interactive networks is in line with many studies (Camagni, 1991; Miles, Miles, & Snow, 2005; Nelson, 1993). Fay and his colleagues (Fay et al, 2006) support the basic idea of the Core Group and underlines that the quality of this multidisciplinary group is essential for having a good quality of outcomes – the quality of innovations. The Core Group supported by the Wider Group corresponds with Williams & O’Reilly’s argumentation that a group’s ability and cognitive resources increase with raising levels of multidisciplinarity (1998). Multidisciplinary teams create multidisciplinary perspectives and new and untraditional ideas long before homogeneously teams (Paulus, 2000). The broader the range of knowledge and experience that team members bring to the project tasks, the higher the potential for cross fertilisation (Jehn et al, 1999).

4.2. Innovation Tools and Facilitators

As given previously in the chapter about the Conceptual Setting of the NYMIND Project, two main issues were to be addressed in this untraditional innovation project. Firstly, the non-topic multidisciplinary approach and, secondly, the application and testing of untraditional innovation approaches including art based creativity and visualisation. The first topic is addressed above and in the last part of this discussion.

In order to test art-based creativity tools consultants from an art-based innovation company were commissioned to plan and run the 1st Core Group Meeting in November 2011. The company has developed an EU funded education in

innovation processes and the consultants were mainly professional actresses from Danish theatres and television who had undergone this education. The programme was mainly based on storytelling involving the participants and it was basically successful in creating motivation and team spirit and knitting the team together.

This goal was reached earlier than planned and the participants wanted to begin what they considered the real work. The concept was not prepared for this reaction and consequently a fair amount of frustration arouse amongst the participants. During the following review, the participants – technical and natural science scientists – expressed little interest in continuing with this kind of art-based innovation tools. Consequently, the concept was thoroughly revised; the tools part toned down and the facilitation turn up in terms of establishing a team of three facilitators all with technical and natural science background including the visualisation expert who became a key figure in this setting.

One process consultant was responsible for overseeing and supervising the overall innovation process as well as supporting the innovation process at individual meetings. One innovation consultant was responsible for the innovation process at meetings using fairly simple innovation tools acceptable for the natural science scientists. And last but not least an innovation visualisation consultant was responsible for continuously visualising the ideas, the discussion and the solution possibilities and in this way facilitating and supporting the innovation process including the reporting of each meeting which was done cartoon wise. This concept was appreciated by the participating scientists and as shown previously was successful in providing new and unexpected results.

Based on this, the lesson learned from this case is that technical and natural science scientists are not interested in too much art-based creativity in connection with the innovation process but are eager to take the innovation process into the field and the lab as soon as possible. Another lesson learned is that a team of facilitators with technical and natural science background is productive in a technical/natural science setting. It has not been possible to find references which support the findings in this Project about technical and natural science scientists being reluctant to partake in too much art based innovation processes. Consequently it has to be treated in this paper as a singularity.

Darsø (2004) mentions an international testing that shows that the general use of actors/actresses/artists and art-based innovation tools will give a more creative and innovative process. Art and creative based resource persons can help illustrate and conceptualise discussions and solutions in the team just as the visualisation consultant did in the NYMIND Project. They can provoke questions through the strong tool of ignorance which can challenge present knowledge and thus boost the innovation process (see also Okaley, 2007). Furthermore, the said resource persons can capacitate the participants with listening, presentation and communication skills as well as storytelling (Kerr & Lloyd, 2008). As mentioned before, the storytelling tool used at the 1st Core Group Meeting did knit the team together but was somehow counterproductive in relation to the further work. It could be that the basically mixed role of the facilitators at that event confused themselves as well as the team. See Nissley (2002) and Darsø (2007) for further examples of using art-based innovation tools as well as Lloyd (2007) and Kerr & Lloyd (2008).

The successful use of visualisation by a professional visualisation consultant in this Project is supported by a number of references. It improves group innovation. At present, a whole new field of Knowledge Visualisation is emerging (Faulhaber, 2012; Eppler & Burkhard, 2004; Eppler & Burkhard, 2005; Bresciani, 2010). Cartoons as a strong innovation tool are described by Albinsson (2006). The 1st Core Group Meeting was documented in two ways: As individual e-tales from the participants and in the form of a short video based on editing of the whole session video. Albinsson (2005) supports the use of dramatizing in the form of movies and interactive multimedia.

4.3. Organisational Structure with Core Group, Wider Group and Backing Group

The NYMIND Project was organised with the multidisciplinary non-topic Core Group, the connected personal network-based Wider Group, and the topic focused Backing Group. This organisational structure is supported by Engestrom and his colleagues (Engestrom, 2004; Engestrom & Karkkainen, 1995), who have called such activities poly-contextual work or knot-working. Multidisciplinary teams have a potential for creating innovation and this can be explained by the fact that in dialogical relationships people with different kinds of expertise get new ideas which they develop further from their own starting points, frameworks and context. The lessons learned were that the effort used to create motivation and good team spirit was insufficient at first. This is supported by Darsø (2007). Darsø claims that real innovative capacity is highly dependent on the establishment of a good team spirit in this kind of mixed teams based on the fact that innovation thrives in dynamic teams capable of combining topic and especially non-topic knowledge and experience in previously unknown ways and concepts. Theoretically this can be described conceptually as the zone of proximal development (Vygotsky, 1978; Lewicki, 1997). Birkinshaw and his colleagues (2008) also support the idea of the three tied structure of the NYMIND Project as they argue that successful innovation should be driven by two groups of individuals: external and internal change agents. In the case of the NYMIND Project the external change agents could be considered as the Core Group with its connected Wider Group, while the internal change agents could be considered as the topic focused Backing Group (DiMaggio, 1988; Howell & Higgins, 1990; Kaplan, 1998; Stjernberg & Philips, 1993).

5. Conclusion

The aim of the NYMIND Project is to provide new innovative ways of solving in-door climate problems caused by contaminated soil and/or groundwater based on the fact that traditionally innovation processes did not provide sufficient innovative solutions. The strategy to ensure this was dual as it comprised new ways of staffing the innovation team as well as new processes and tools for the innovation process. As described in this paper the NYMIND Project has been successful in its endeavour as it has provided three pre-projects within innovation tracks that are new in relation to present innovation efforts within this field.

In this aspect the organisation with a multidisciplinary Core Group with non-topic scientists, a connected Wider Group and a Backing Group with topic researchers and developers has proven viable. This is also supported internationally with academic as well as case study references as one of the best ways to create new innovations that are not incremental.

The NYMIND Project has been successful regarding the facilitation and tools for the innovation process using three facilitators one of which was a visualisation consultant. All of the facilitators had an engineering background including the visualisation consultant. This was recognised by the participating scientists as a strong point. In this connection, the most successful process tools have been the use of visualisation such as drawings and cartoons in connection with the meetings as well as the reporting. This was supplemented to a minor degree with soft process tools. The organisation of the facilitation and especially the tools part related to visualisation is also supported with international academic as well as case study references.

There were two findings of the NYMIND Project where international references could not be found in connection with preparation of this paper. The first one is the rejection of the technical and natural science scientist of the original art-based and creativity focused concept provided by professional actresses trained in innovation processes. The second was the recognised importance of the facilitators all having an engineering background. An abundance of literature can be found concerning the capacity of the facilitators as facilitators, but not about the sort of basic educational background. Consequently, it would be interesting if these two apparently interrelated findings are Danish, topic, or team composition singularities, or if other innovation researchers and/or consultants have experienced the same or have any research results related to this.

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