Work package 2- Historical and recent attitude of stakeholders

Case 27: Blue Energy (salinity power) in The Netherlands

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*C*ultural Influences on *R*enewable *E*nergy *A*cceptance and *T*ools for the development of communication strategies to promot*E* ACCEPTANCE among key actor groups

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1. Introduction

This case study addresses the Blue Energy socio-technical development in the Netherlands. Blue Energy is a sustainable energy source that is based on the difference in salinity between sweet (river) water and salt (sea) water. When sweet and salt water join, the concentration will diffuse until the salinity is equal in the total fluid (fundamental law). When a selective membrane is placed between sweet and salt water, the diffusion can be controlled and potential energy gained. There are two ways to get energy out of water via membranes: Pressure Retarded Osmosis (PRO) and Reversed Electro Dialysis (RED). It is the second principle, RED, that has gained renewed attention in The Netherlands for the last five years and has received the label Blue Energy. This development can be divided into two phases. Phase one started in the eighties with early attempts to conduct research on Blue Energy. This leaded to a consortium of several industrial companies that started a feasibility study and system research on Blue Energy in 2003. About a year later, a newly founded research institute developed a similar research program and attracted several participants to commercialise the principle. The consortium that first attempted to develop Blue Energy has lost their leading role to the research institute and at this moment only conducts a research as a subcontractor. This case study aims to understand how visions and expectations in the Dutch Blue Energy development have changed over the years. It covers the development from the mid eighties until contemporary developments in April 2007, which predominantly involves the research and development phase of this principle. A variety of stakeholders are involved in the Blue Energy development and Appendix A gives an overview of the complex network configuration. Also see Appendix B for a list of important events.

Data has been derived from various heterogeneous sources including; semi-structured interviews and conversations with involved actors, research reports, scientific journals, newspaper articles, in- and external communication. See detailed reference list at the end of this paper. Parts of the developments have been difficult to uncover because of classified information. Both phases concern strategic actions from stakeholders and not all information around rejections of subsidies and financial activities have been handed out to this research.

2. Country overview

The Blue Energy principle is already more than one hundred years old and has received some international attention during the oil crises of the seventies and research only continued at a few locations. Outside the Netherlands there are no current activities reported on the RED principle and the main barrier for the further technical development has been the price of membranes (Post et al., 2007). Furthermore, the raw materials necessary for Blue Energy are sweet and salt water, which makes membranes susceptible to fouling. An important factor for the revival of Blue Energy in the last couple of years is that the price of suitable membranes has decreased and an important aspect for the further development is that knowledge is already available in other sectors. Blue Energy and the osmosis variant are based on reversed desalination techniques (Post et al., 2007), which implies expertise on these problems in the water management and techniques industry. Membranes and water treatment are therefore important sectors for the further development of Blue Energy and the Dutch expertise on water management and technologies is globally acknowledged: The Netherlands belong to the fore-runners. The Netherlands also has a lot of expertise in membrane research. The Dutch University of Twente for example is the only European university with a separate membrane department (Nymeijer, 2007).

As this case study will make apparent, these expertise factors have given Blue Energy a boost of attention. Other country/region specific factors that played an important role in the further development and acceptation of Blue Energy were the national financial support programs and the establishment of Wetsus.

2.1 Financial programs

The Dutch government had committed itself to the realisation of a 10% share of sustainable energy in the total energy production by 2020. SenterNovem is the government agency, part of the ministry of economic affairs that carries out the policy and supports innovative initiatives. SenterNovem offers advice, networks, information and subsidies. Organisations, research institutes and local governments can apply for several programs to gain subsidy for energy efficient measures, environmental care and risky technologies. SenterNovem runs the program Energy Research Subsidy (EOS) that aims to support the energy-efficiency and sustainable energy developments. EOS consists of four programs covering all phases of development, from innovative idea to market introduction. EOS-LT (Long Term) is developed to support research for several years. EOS-ES (energy and cooperation) supports non-commercial research and development of innovative energy techniques and EOS-Demo is issued for the first serious pilot tests. EOS-NEO (New Energy Research) addresses to the first phase of development: work out new ideas. Under this subprogram unconventional research is stimulated with funding for feasibility, research and development projects: projects that could have potential to develop into a new energy research domain.

These government support programs often received critique. The unclear procedures with subsidies such as the MEP, have strengthened the sentiment that the government is an unreliable partner (Energy Magazine, 2006). This can be attributed to the fact that these programs have changed over the years. Most of the respondents mentioned this as a barrier for development. According to SenterNovem, The Ministry of Economic Affairs (EZ) who is responsible for these programs, is familiar with the critique and aims to resolve this matter (Sijens, 2007). Before 2004, two agencies operated under EZ to support the production and development of sustainable technologies: Novem and Senter. Novem was responsible for the realization of policy on energy and environment. Senter worked on the domains of innovation, environment, energy and sustainable development. In 2001 EZ published the diplomatic note EOS (energy research strategy) to revise the policy on energy research (EZ, 2001). After consulting the market, the outcome of this strategy resulted in a new program called EOS (energy research subsidy). This research support program was different in two expects: not everything will be supported but restricted theme's (spearheads) that are considered to contribute to the Dutch energy production were chosen and second, research should be supported in all of its phases: from research to market introduction. In 2004, SenterNovem originated from a merger between previous agencies Senter and Novem, to cancel the overlap and realize a more transparent, efficient and better accessible platform for its customers. The NEO arrangement was already operational since 2002 and became part of EOS in 2004.

Besides the EOS program also other governmental activities have attributed to the Blue Energy development. In 2003 the Dutch cabinet founded the 'Innovationplatform' to get The Netherlands to the European top in education, research and innovation. The platform consists of key players in the knowledge economy with experts from politics, business, science and education. The prime minister is the chairman of the platform and many Dutch companies such as Shell and Philips participate. In this platform transition routes towards a more sustainable future are negotiated which influences the subsidy programs such as EOS. One of the initiatives resulting from the Innovation platform was to found a Technological Top institute for Water technology (The TTIW-program). The government and water sector work together in the Innovationplatform Water technology because the Dutch water technology sector have a strong position in the Netherlands but economic export is lacking the world growth. The Innovationplatform has pointed out the water sector as one of the key sectors in the Dutch economy. The water sector has presented their vision arguing that the water sector should cooperate in a new manner and focus on promising clusters. Even though The Netherlands already contains unique technologies, they should keep their strong position and even strengthen it. For this purpose, more research and development is necessary, therefore they proposed the Technological Top Institute Water technology, in which public and private organizations participate. They also proposed to

install two other instruments: Innowator and a guarantee fund. Innowator is a subsidy instrument to support excellent knowledge development into market products, necessary because mainly middle-range organizations are involved in innovations and cannot cover the risky product developments without government support. The guarantee fund should cover the costs that are made when projects do not satisfy the expectations. Tenders for Innowator have started in 2006. The cooperation between industries, institutions and the national government has the ambition to bundle the technological expertise in the Dutch water sector and an important aspect of the technologies must be sustainability (Stuurgroep Watertechnologie, 2006). The development of the TTIW program also serves as a good example of how the national government wishes to stimulate the Dutch innovative development.

Research on Blue Energy has been initiated by industrial organizations and the national government embraced this project as an interesting Dutch innovation and assisted by means of financial support. In this case study it will become apparent however, how Blue Energy was initiated in the context of these changing programs and that this radical innovation project struggled to receive public financial support. Even though the innovation support programs increasingly recognized Blue Energy as a promising step in the transition towards sustainable electricity production, the project did not always fall under the restricted theme's that were chosen. Another important country/regional factor with a positive influence on the development was the establishment of Wetsus.

2.2 Wetsus

The economy of the Northern provinces Groningen, Friesland and Drenthe had fallen behind national economic development. These provinces had bundled their political forces since 1992 in the SNN. SNN jointly negotiates with the national cabinet to strengthen their economic structure. The Northern provinces cater a lot of water management and technology companies and one of the results of the SNN negotiations together with EZ, the Leeuwarden municipality, the Province of Friesland, local education institutes and water industries was the founding of Wetsus in 2003. This research institute joins the forces of universities and industrial partners on the development of treatment technologies for sustainable water. Wetsus conducts research on five themes involving water technologies (and in several cases also membranes); Blue Energy comes under 'energy out of water' (Wetsus, 2005). Financed by industrial participants and lump sump governmental support, Ph.D. students conduct the research in collaboration with three Dutch universities: Delft, Twente and Nijmegen. Water was and is seen as 'hot' and the amount and size of the organisations involved grew rapidly, leading to more publicity in (above all) the water sector. Little public participation has been involved so far, but, as will become apparent in this report, Wetsus attracted a lot of publicity and many famous or highly influential actors. Especially national governmental spokespersons and the Innovation platform have high hopes for Wetsus and Blue Energy. Blue Energy in particular is often present at meetings, congresses and other promotional activities as an example of an interesting Dutch innovation and recently the research institute made an important step towards becoming 'the' water treatment research institute of Europe. The Dutch water technology industries have brought up 17,5 million Euro and EZ has reserved 35 million for TTIW. TTIW will be accommodated at Wetsus and according to Wetsus they will eventually merge.

In the context of changing subsidy arrangements, the first phase of Blue Energy developed. The national attention for the project and the entrance of Wetsus initiated the second phase.

3. Summary

The first phase of the Blue Energy development in the Netherlands started during the eighties when Kema (Dutch research and Consultancy Company) had coincidentally discovered an alternative technique for the production of ion-permeable membranes during research on the deg-

radation of power cables (Ross, 2005). The research group had high expectations for this technique because it would reduce membrane production costs significantly. Further research did not belong to the core business of this consultancy company, also concerned with certification and testing, because Kema needed a commercial order or external financial support to proceed. Kema tried to get governmental support several times without success. In 1994 for example, an application was rejected because membrane research concerning hydrogen fuel cells was already conducted at another Dutch institute (ECN). In 2000, Kema found a partner who was interested in using membranes for an alternative water pumping method. As will be explained in the next chapter, a consortium was formed around Kema that applied for research concerned with Blue Energy. Applications were rejected because of the unfamiliarity with the principle (it just cannot work) and also due to incorrect or incomplete application requests. Eventually the consortium received NEO (new energy research) start-up support in 2003. Despite positive reactions from government and industry on this feasibility study and even-though they won the ID-NL price for best innovation, the project did not continue in the follow-up program of EOS. This program categorized energy research in wind, tidal, and solar energy and Blue Energy did not fit in any of these categories (Ross, 2005). In their attempt to attract other financial support Kema also experienced a new player in this field of research: Wetsus. The research institute for sustainable water technology started in 2004 and was interested in the Blue Energy development at Kema because this radical water technology fitted their strategy of starting projects on highly radical innovative water technologies. Both organisations applied for financial support and searched for influential participants from that moment on. Wetsus did not further cooperate with Kema and started PhD projects on this topic, to the dissatisfaction of Kema. Kema was supposed to follow the Wetsus formula. Kema however, could not contribute the 50.000 Euro yearly participant fees. In the following second phase of the Blue Energy development in the Netherlands, which is still ongoing, Wetsus comprises scientific and technological research on the Blue Energy system design, membrane design and fouling of membranes. Financed by industrial participants and lump sump governmental support, Ph.D. students conduct the research in collaboration with the Dutch universities. In 2006, three commercial participants in Wetsus founded a spin-off company, under the name of Redstack, to commercialise the results of the fundamental research and eventually deliver the necessary parts for the installation. After several rejections, which will be explained later, Redstack received NEO support for membrane research and production in 2006 and secured their research for at least one year. Three research institutes will conduct the research on alternative membrane technologies: Kema, EMI in Twente and the Ben Gurion University in Israel. Attempts to receive additional government funding for trial and pilot-plant activities have failed so far; however, industrial applications and accompanying finance are being negotiated. At the time of writing, there are no concrete plans for a commercial power plant (e.g. at river delta's) and also worldwide there are no (commercial) power plants reported based on the RED principle. This case is in such a preliminary phase that objections from civilians and environmental organisations have not been apparent. Contrarily, the environmental organisation for the protection of the Wadden (waddenvereniging) is indirectly involved in the proposition to invest money in the Blue Energy development. In some interviews sceptical reactions on the RED principle were mentioned. This opposition was directed towards the waste of money for this project (it cannot become economically viable). However, these actions are not organised.

4. STEP ONE: Vision

Kema was the first Dutch company to start on Blue Energy in the Netherlands and I have referred to this as the first phase. After the unsuccessful approach to get their research on membranes financed for the application of fuel cells they developed a new strategy together with a consortium of industrial partners to build a Blue Energy installation. Initial visions on Blue Energy therefore began with this consortium that wanted to apply the alternative membrane production technique for the production of cheaper membranes that could be used in a Blue Energy system. Blue Energy was seen as a completely sustainable power supply. There is no need for

any fossil fuels, it doesn't release any greenhouse gasses, all raw materials are available at river delta's and the installation is unaffected by weather. According to the pioneers: the only thing that needs to be done is bring down the membrane costs (Global Contact, 2006). Feasibility studies were conducted in order to receive financial aid and attract new partners. The availability of sweet and salt water made river delta's the most suitable locations for Blue Energy and calculations were made on the amount of water entering the Dutch sea. Based on the amount of water running to the sea and the efficiency of the available membranes, the Blue Energy technology could produce 3000 MW in The Netherlands, covering almost one third of the total Dutch annual energy consumption. The optimal location would be the 'Afsluitdijk', which the consortium entitled 'the inexhaustible battery', capable of producing 200 MW (Ross & Krijgsman, 2004).

For several years Kema had experienced much disbelief (form governmental organisations, industry but also science), due to the unfamiliarity of the Blue Energy principle and they needed this vision of an actual application in the Dutch waters to attract and convince stakeholders. Especially stakeholders present at the Innovationplatform meetings, such as energy producers and governmental spokespersons ran off with this principle as the perfect Dutch energy alternative for the future. Kema also catered the concerns of sea-level rise by the Dutch agency for water protection (Rijkswaterstaat). The Afsluitdijk will eventually need more spouting pumps and must be heightened in the future due to climate change (Kema et. al. 2005). Blue Energy could be integrated in this project, offering a spouting alternative with additional electricity production. Another expressive global vision was that "Blue Energy installations would be the derricks of the future" (Oudakker, 2005). The vision of a 200 MW power station at the Afsluitdijk has been present ever since the introduction of Blue Energy in the Dutch innovation domain. The consortium around Kema expected to start with a few hundred kW power station in 2005 and could be able to integrate a 200 MW installation in the expected renovation of the Afsluitdijk. When Wetsus entered the scene and phase two started, they took over most of the visions, predominantly because several stakeholders were already involved in the Kema project. As the development of Blue Energy matured, more realistic visions came to the fore.

Wetsus' early expectations were about also about the 200 MW power plant at the Afsluitdijk and eventually other salt streams at industrial sites are seen as more suitable locations for the first commercial applications. The use of natural water incorporates many disadvantages (e.g. fouling, algae's) and therefore initial applications are perceived to appear at salt producing industries and industrial locations where uncontaminated sweet and salt-water remnants are produced. Locations at river deltas (and especially the Afsluitdijk) are, at the time of writing, mainly used for promotional purposes and perceived as far future possibilities. Blue Energy is expected to be produced in modules (sea container shape) that can be coupled. Redstack focuses on the use of Blue Energy for energy production and expect the following stages for up scaling the project:

2005 - 2009	PhD projects Wetsus	mW - W
2006 - 2010	Pilot Harlingen (Frysia, red)	kW
> 2010	Full-scale applications	MW

The vision by Kema was that they could produce economically interesting plastic membranes that could be used for Blue Energy. Wetsus and later Redstack focus on the system design and expect to deliver an economically viable power plant for which Wetsus conducts the research and the companies participating in Redstack will deliver specialised parts.

5. STEP TWO: What were the various expectations of the case?

The development of the vision involved multiple actors with a variety of expectations at local, regional and national levels. Table 5.1 lists the main actors and their expectations.

Table 5.1 *Main actors (in) directly involved in the Blue Energy development*

Actor	Function in the network	Expectation	Speaking for publics
Kema	Research / PR	Develop a competitive, alternative membrane production method	Redstack (project leader) and Kema shareholders
VolkerWessels	Finance	Alternative (innovative) spouting technique and to be the installation company	Shareholders
Velsen Flexoplast	Finance	Produce the specialized membranes	Shareholders
NUON	Finance/expertise/ PR	Sustainable electricity alternative / sustainable reputation	Shareholders
Wetsus	Research / PR	Commercially relevant outcomes of scientific and technological research	Commercial parties
Landustrie,Hubert Stavoren B.V. and Magneto Special Anodes B.V.	Finance Redstack/ deliver expertise	Deliver the specialized materials and knowledge for the blue energy pilot	Shareholders
Redstack	PR / managing demonstration project	Commercialize RED principle. Install a 200MW Redstack power plant	Shareholders
Frysia	Deliver demonstration facility and expertise/finance	Reduce electricity costs / sustainable reputation / increase expertise	Shareholders
City council & state province	PR	Attention, promotion for the city/province	General public Leeuwarden/Friesland
Dutch national government	Finance and stimulate the innovation	Opportunity for the country	General public
Universities and research institutes	Scientific and technological development	Power generation by RED principal / low cost membrane	Knowledge creation

Kema expected to provide their specialised research for proving the principle and assist in developing the first power plant. Revenues would result from selling patents and taking care of future research, quality control, advice and the inspection of constructions. As mentioned earlier, no money was available within Kema to support this project. Several employees, however, put much of their spare time in the promotion and attraction of participants. They believed this project could be a breakthrough because contemporary membranes were very expensive and the raw material for their production technique was ordinary cheap plastic. Internal contacts brought these employees to VolkerWessels, a reasonable Dutch civil construction company. They had heard about an alternative way of spouting using membranes, called osmosis. In their search for more participants the ambitious group that had formed laid contacts with Statkraft. This Norwegian electricity producer developed the osmotic variant of salinity power. They had been working on the PRO principle since 1997 and claimed to be world leader in this area (Statkraft, 2003). Statkraft was not interested to join the Dutch companies because it believed in the osmotic variant and did not need/want to bet on two horses. The osmotic variant is also more suitable to integrate in hydro-power plants which Statkraft exploits (Oudakker, 2005). In order to finance the project and apply for government subsidy, Kema and VolkerWessels needed a third party: Velsen Flexoplast was attracted. This Foil Production Company produces plastic bags and the new production method (discovered by Kema) could be installed at their production facilities.

VolkerWessels joined the consortium because they could use this technique as an alternative spouting possibility and they expected to construct the installation. However, they were not interested in electricity, but in an alternative (cheaper and innovative) method for the displacement of water. For them, it does not matter if the installation is based on osmosis or reversed electrolysis. Kema on the other hand had acquired patents for the alternative ion-permeable membrane (suitable for RED) and foresaw possibilities to develop knowledge on an interesting new field of research. Knowledge and expertise is their main product for consultancy purposes and this project could extend their expertise and provide more work. The technique discovered by Kema to electrically modify plastics is also suitable for desalination purposes, fuel cells and super conductors (Kema Brochure, 2005). Velsen Flexoplast, producer of plastic bags, was only attracted for the mechanical facilities (instead of contemporary manual production) to produce large quantities of polyethylene (main ingredient for the alternative membrane) and eventually this would imply new business opportunities for them. The largest Dutch energy production company (Nuon) provided their expertise and was attracted to exploit the power plant in the future. They did not participate in the consortium but helped with calculations and were present at meetings and functioned as a benchmark to generate publicity. In 2005 Nuon introduced the Blue Energy power plant at the Afsluitdijk to its 'green' consumers in their newsletter (Nuon, 2005). Even though the expectations about the functionality of the Blue Energy system did not correspond, all companies expected the project to generate work: VolkerWessels as the construction company; Velsen Flexoplast for the production of the membranes; Kema for research and development; and Nuon to communicate its green profile and possibly to exploit the power plant in the future.

In the second phase of the project Wetsus took over the leading role of the Blue Energy development in the Netherlands. The radical, pioneering technique concerned with water and sustainability fitted their profile of excellent research. The founding of this research institute generated a lot of attention within the water sector. As mentioned above they had acquired direct EZ, European and provincial funding and in cooperation with three Dutch universities and industrial participants, Ph.D. students conduct the research. The participants (industrial companies) are financially involved and have the ability to buy patents and develop these into commercial applications. Companies are usually involved in more than one of the five themes within Wetsus and get in contact with the latest technologies and other companies from diverse industries. Several participants in Wetsus who expected to develop the technique into a business opportunity founded Redstack. The shareholders in Redstack, Harlingen Holding Industries B.V. (Landustrie en Hubert Stavoren BV) and Magneto Special Anodes B.V. expect to develop a commercially interesting sustainable energy alternative for which these engineering companies will deliver the materials and knowledge (Hack, 2007). These shareholders do not have the financial possibilities to commercialise the principle on their own and therefore their next step is to prove the principle by means of a pilot installation of several kW and attract investors. Nuon or any other electricity producer is attracted in the hope that they would finance and exploit the eventual power plant. Nuon again reported on Blue Energy to their customers in 2007 but is involved as a partner and not financially. Another partner is Frysia Zout B.V. who is also involved as a participant in Wetsus. At this salt production company located in Harlingen (province Friesland) all kinds of salt concentrates are available which makes it an interesting site for the Blue Energy trials. Pure salt and sweat water do not foul the membranes, and many mechanical facilities and technical expertise is present. Frysia can also use the positive publicity around the sustainable project. They have had much critique in the past by environmental organisations and farmers because of soil settlement due to salt mining. Furthermore, a substantial part of their production costs is energy; almost 50% of their production costs. Green and cheap energy that could be produced on site would therefore be an interesting technique (Mulder & Weewer, 2007).

Besides industrial participants, Wetsus also attracted a lot of governmental organisations. The province Friesland, where Wetsus, Redstack and Frysia are located and its capital Leeuwarden have high expectations of Wetsus, and the Blue Energy development in particular, for the atten-

tion it attracts and the jobs it offers. The region contains a lot of expertise in water technologies, but falls back in industrial activity. The province and its capital have a share in the founding of Wetsus.

As mentioned in the country overview, the Innovationplatform is also acquainted with the developments at Wetsus. Blue Energy in particular is often presented at meetings, congresses and other promotional activities as an example of an interesting Dutch innovation. Rijkswaterstaat, responsible for the Afsluitdijk, has high hopes for Blue Energy. Through various routes they came in contact with Wetsus and Redstack. They also conducted their own research on necessities and possibilities for the Afsluitdijk in which Blue Energy was discussed at great length. However, according to Rijkswaterstaat, they keep all options open: that is PRO or RED (Regeling, 2007).

Other actors worth mentioning are the universities. Salinity power and the RED method in particular are almost untraceable in literature. Membrane research on the other hand has enormous potential and is very popular. A new point of view could cater for new research and possibilities for membrane research (Nymeijer, 2007).

6. STEP THREE: Understanding 'participatory' decision-making: negotiation expectations

The various forms of participation and negotiation of expectations are summarised in Table 6.1.

Table 6.1 *Forms of participation in the Blue Energy development*

Type	Organizer	Involvement	Purpose
Informal meetings with interested industry and Rijkswaterstaat	Wetsus, Kema, Redstack	Possible stakeholders	Gain financial support and increase awareness
Newsletter	Wetsus	Participants and interested public	To inform about the project, interest people and gain support
Participant meetings (frequently held)	Wetsus	Directly involved participants	To negotiate results and discuss further steps
Inform the media	All	Interested public	PR
Open house Wetsus	Wetsus	Interested public	PR
Answering questions via mail, internet, media	Wetsus	Those who are interested in the project	To prevent the spread of negative and incorrect rumours
Attending Innovation Platform meetings	Wetsus, Kema, Redstack	Industry, policy makers, NGOs, scientists, interested public	Gain support and increase awareness of the project
Attending workshops, give presentations etc.	Wetsus, Kema, Redstack	Dignities (such as the Dutch Queen, prime minister, EU commissionaires), general public	Promotion for BE

One of the most important activities in the Blue Energy development has been and still is: convincing other actors. Employees at VolkerWessels, Kema and Nuon, who negotiated the initial ideas and expectations did already have internal contacts and got involved because they saw possibilities for their company. The resulting consortium has done most of the preliminary work in trying to convince more actors for the possibility to gain energy out of water. The unfamiliarity of RED led to rather critical reactions of scientific, governmental and industrial organisa-

tions. To convince and attract new stakeholders, the consortium had built a small-scale installation, based on commercially available membranes, which they carried to meetings, organisations and workshops. This did not always prove convincing. VolkerWessels for example, was interested in the usage of RED in sluices and dikes as an alternative for pumps. However, the management was not impressed by the first prototype that drove an electrical motor. With a background in mechanical constructions, electrons did not mean a lot to them. They got convinced after the second prototype pumped the water back into the reservoir; 'water could run up the mountain' (Oudakker, 2005).

As mentioned earlier, Wetsus had received a lot of attention when it was founded in 2004. Water was and is seen as 'hot' and the amount and size of the organisations involved grew rapidly, leading to more publicity. The location is situated in the same building as the engineering school of Leeuwarden and several research institutes. The founders of Wetsus also possessed a large network of industrial and scientific organisations and local, regional, national and European authorities were involved in the development. Furthermore, the management and many of the participants in Wetsus already knew each other from their previous collaboration in the water sector, and more specific, most of them had worked for the same company called Paques B.V. This water and gas purification company had changed its strategy, which didn't suit the innovative style of many involved and resulted in employees moving to (starting) Wetsus. Also previous employees of Paques and other 'friends in the business' now participate. Both scientific as well as industrial partners from a wide range of disciplines have been attracted because of personal relations. Besides this network advantage, the actors also occupy highly influential positions in their organisation. Participants in Wetsus have to come up with substantial financial means. Financing a highly radical innovation with unpredictable and risky outcomes usually need time and strenuous negotiation. Wetsus and Redstack did not need a lot of effort to convince parties to join. The advantage of personal relations with influential actors resulted in good cooperation and made decision-making fast and easy. Because these actors new each other for a long period they trusted and supported each other (Hack, 2007).

Wetsus frequently organises open access congresses and private participant meetings to discuss outcomes. "Wetsus' main characteristic is cooperation" and the "commercial parties involved in Wetsus define and guide the research program to ensure commercial relevance of the developments." (Wetsus, 2004). A monthly newsletter and frequent articles in newspapers, journals and more specialised papers also inform those who are interested. Furthermore, the management, PhD students and the involved stakeholders are frequently found at workshops, congresses and innovation platform meetings to increase publicity and get more parties involved. Publicity is often enlarged by attracting famous or highly influential actors at Wetsus in Leeuwarden, such as The Dutch Queen, Prince (also involved in water management), Prime-Minister, members of the National and European parliament, Commissioners of the Queen, the mayor, etc. Besides publicity, Wetsus and also Redstack approach those who might be involved in future implementations. They are aware of the necessity to attract actors and to evade negative rumours around the project, especially objections that might arise when a power station would be implemented on the Afsluitdijk (the Waddenzee is an ecological environment). They have approached several stakeholders for the development and also the implementation phase of the development. The anticipation of such a project has been discussed for example with a consultancy company called IMSA. IMSA has expertise in these kinds of projects and has contacts within NGOs involving the Waddenzee. However, these initiatives never resulted in a profound study (too expensive). Wetsus didn't take any effort to involve the public in these projects besides providing information to those who are interested. They did invite Rijkswaterstaat several times at demonstrations to become acquainted with the project and take the option into consideration when discussing the new sluices at the Afsluitdijk. However, Wetsus as well as Redstack believe that all these initiatives do not have priority at the moment. First they have to prove the principle, get reliable data and their strategy is to start at industrial locations for this purpose.

7. STEP FOUR: From visions to actualities

At the time of writing, no power plant, pilot installation or demonstration project has started. At this moment both developments at Kema and Wetsus only created 'tension' and no 'power'. The consortium around Kema that started the initial project is no longer active in the Blue Energy development and the consortium has ended. They could not finance the project anymore. There is also another reason why VolkerWessels is not involved anymore. In civil construction projects, companies that have done explorative research can be excluded for acquiring the project. Therefore, if Blue Energy would be integrated, VolkerWessels could not be the constructor (Oudakker, 2005). For several years the Kema research group worked in their own spare time and students upheld further research. At this moment, Kema is only involved as a subcontractor for research and development of membranes and lost control over the Blue Energy project. Moreover, the same research within Kema is also part of a larger European programme on membranes for CO_2 capture.

As mentioned earlier, Wetsus had started their own Blue Energy research program and Kema did not follow their approach. The early visions of a Blue Energy power plant, however, are still upheld by Redstack and Wetsus.

The availability of financial support has been an important factor in the development of visions to actualities. Wetsus had secured their research with the lump sump grants and industrial capital, whereas the consortium around Kema did not receive follow-up governmental finances for Blue Energy despite positive reactions and also Redstack has had their difficulties in acquiring research subsidies. Why all these rejections?

The Blue Energy simulator was present at many workshops and seminars of the Innovationplatform. Prime Minister Balkenende even mentioned this technique as promising and project folders of the innovation platform use Blue Energy as one of the examples of an interesting Long Term research program (SenterNovem, 2006). However, the EOS-NEO program had been adjusted. Specific themes were chosen and Blue Energy did not fit in any of the categories. This problem was also noted by the Innovationplatform and EZ, responsible for the content of these programs. Projects are rejected formally when not fitting the specific spear points. These themes are chosen on purpose to strengthen specific developments that were selected as promising for the Dutch innovative industry. This can lead to limitations and Blue Energy was one of those projects that was unpredictable. Evaluation rounds between SenterNovem and EZ take place yearly to overcome these problems. (Sijens, 2007). After several rounds of evaluation with SenterNovem, the category 'remaining' was taken up in which Blue Energy could be accommodated (Hack, 2007). However, the committees installed by SenterNovem to evaluate and grant the subsidies for innovative projects have been reluctant to the development. Several times the application was rejected because the idea of gaining energy out of water using membranes just could not work or become economically viable. Another comment for the rejection has been that research on one type of membrane was considered limiting and too vulnerable for the further progress of the Blue Energy development. Eventually Redstack applied for EOS-NEO and Kema together with two other research groups conduct the research on three different membrane production methods.

Redstack also applied for a new subsidy arrangement related to innovative water techniques. Innowator supports early pilot installations. Redstack applied for this grant to finance the pilot tests at Frysia (or any other location). Again, Blue Energy was mentioned in the programme brochure (Stuurgroep Watertechnologie, 2006a/b), however, the application was rejected because the assessment comity did not believe this RED principle might work. The same disbelief and unfamiliarity that had hindered subsidy applications for EOS support, slows down the further development of Blue Energy again. The tests at Frysia were expected to start in 2005 and have been delayed for more than a year already. There are proposals for trials at Frysia, however, an actual start-up date, at the time of writing, was yet to be announced (Mulder, 2007). No

further action has been made, because of this financial drawback. Another reason for the delay of the trials at Frysia is technical: the difficulty of building an operational installation has been underestimated. Redstack, however, is also working on other locations for preliminary tests. Industry with salt residues might benefit from extra energy income and positive 'green' publicity. These forms of implementation are also economically viable within several years (Hack, 2007).

The developments at Wetsus have been prosperous. The ambition to become the European Centre of Excellence for sustainable water treatment has become a step closer when the Technological Top Institute Water technology (TTIW) was accommodated at Wetsus in early 2007. The extra attention and financial means create more opportunities for research at the institute and in the field of research in general. At the time of writing, Wetsus is so popular that many organisations contact 'them', whereas the management actively approached stakeholders in the start-up phase of Wetsus three years earlier. Established (conservative in the eyes of Wetsus) companies in water technology and management, who have dominated the sector for more than 100years, were rather sceptical about Wetsus and Blue Energy will eventually join, they have to (Boonstra, 2007). The situation at Wetsus concerning the content of scientific research on Blue Energy is unclear. Recently the first scientific article was published in a specialised membrane journal, making a comparison between RED and PRO. This article was meant to justify the RED strategy and is positively accepted in the membrane society. Technical development, however, has not been reported so far. There have not been any tests that proved the principle significantly for the suitability of electricity production.

8. Lessons learned

What can be learned from these early experiences in the Dutch Blue Energy development is that there is a big difference between the initial phase started by the consortium around Kema and the latter development at Wetsus and Redstack; The alignment of visions and expectations and also network possibilities have been crucial in this development. Furthermore this case has given insight in the complexity of financial support programs and can serve as a good example of how expectations become requirements.

8.1 Alignment and network advantages

Visions and expectations played a crucial role in both developments. Decisions on PRO or RED, and power plant or spouting alternative have not been made during phase one. PRO is interesting as a spouting alternative for which electricity production is an additional benefit. RED on the other hand is meant as a power plant and because of the necessary water management also displaces water (Regeling, 2007). Osmosis and RED need different types of membranes and Kema worked on RED. VolkerWessels on the other hand has patents for spouting alternatives. Participants in Wetsus and Redstack on the other hand share similar and more clear visions and contribute to this vision by means of expertise and expect to deliver crucial parts for this installation. The personal network has also been crucial for attracting participants, funding and attention. To participate in Wetsus and Redstack means investing large amounts of money in a radical project for which pay back is very uncertain. Kema for example did not have the financial means to join the research institute. Due to the familiarity between most of the parties involved in Wetsus, the Blue Energy project developed relatively well. The stakeholders that participated already knew each other from previous jobs and projects. They now occupy highly influential positions at middle-range companies. Which provided them with a sort of 'carte blanche'. Either they are the general manager of the company involved, or are highly placed and have a long history in their company and good understanding with their management. This makes decision making fast, simple and less bureaucratic. The founding of and participation in Wetsus and Redstack therefore did not need a lot of bureaucratic and formal arrangements but could be initiated by actors that trusted each other and were enthusiastic to start a project together. What also became apparent during interviews is the enthusiasm of most of the actors

that came in contact with the project. Most of them spent their spare time in the project and functioned as a 'spokesperson or champion', fulfilling an important PR network function.

8.2 Financial support

The second lesson that can be learned from this case study is the complex and opaque public financial support system and the difficulty for a national government to install a satisfying system. After the struggle in phase one to familiarize the Dutch innovative system with Blue Energy, the project became popular and was frequently put forward as a promising development for The Netherlands. SenterNovem, the Innovationplatform, governmental spokespersons and many highly influential actors have supported the vision of a promising renewable energy alternative. However, both Kema as well as Redstack have struggled to get public financial support. In the beginning Blue Energy did not fall under the strategically chosen paths in subsidy programs to stimulate sustainable electricity projects. Later, when also water related subsidiary support programs were available, the project got rejected again. In both cases, the responsible organisations were in favour of the project and Blue Energy appeared in official governmental publications concerning strategically projects. Kema, Redstack and Wetsus have all been present at meetings and have been cited in publications. The comities that should approve the projects, however, rejected the project because the principle could never work, or could not become economically viable in the future. According to several actors involved in the development, these comities consist of established institutes and organisations. These actors are usually pensioners and respected actors from within the field and more conservative and related to established organisations. One of the committee members for example was also involved in an organisation that competed with Wetsus for the accommodation of TTIW. This also relates to the first point of personal relationships. Many respondents from within the Blue Energy development therefore mentioned these personal relations between actors and organisations both as hindering as well as stimulating.

8.3 Popularity

An important lesson can also be learned from a stimulating factor on the development. The attention Blue Energy received in the second phase of the development can be attributed to the 'hype' around Wetsus. Wetsus is hot and opens doors: funding, participants, etc. (van Riet, 2007) Factors, such as the national interest for innovation, the underdevelopment of Friesland, the attention for water and membranes have all attributed to the successful start-up of Wetsus. Wetsus attracted more stakeholders and increased the expectations about the research institute. However, if results fail and nothing is proven within several years, this dream might fall into peaces and might even be a serious threat to Wetsus as a whole. It is important to understand that the developments at Wetsus and the attention it attracts do not only involve the Blue Energy development. Many stakeholders and media attention is directed towards other themes at Wetsus. However, Blue Energy has been one of the main attractors for Wetsus, because Blue Energy is one of the first projects and Redstack the first spin-off.

8.4 Promises become requirements

Finally, the Blue Energy development is a good case to show how expectations turn into requirements (Van Lente, 1993: promise-requirement cycle). The initial expectation of the 200MW power plant at the Afsluitdijk has travelled from Kema, to Wetsus and eventually Redstack. It convinced and enrolled many (industrial as well as governmental) actors, and set requirements for the future installation. Wetsus attracted enormous amounts of funding for scientific research completely based on expectations (Wetsus as a whole, not only BE). Besides a scientific article, and three patents they haven't produced energy yet. Kema and Redstack have had more struggles to get public finance for actual specific installations, but eventually did. The prospect of an alternative energy technology, the reduction of CO_2 emissions, the availability of (weather independent) supply, low cost spouting possibilities and the symbolic meaning of gain-

ing energy out of water has led to the expectation of a power plant running on river and sea water. This requires cheaper membranes and the Afsluitdijk functioned as the flag on the horizon, to which every participant and researcher lives up to. The requirements therefore became: develop efficient cheap membranes (for less than one €/mm^2), a 200 MW power plant on the Afsluitdijk, and electricity production for 0.05 cents per kWh (to compete with fossil fuels). Wetsus is expected to conduct the research and develop the pilot installations together with Redstack who will lead the project and deliver the parts.

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Almost all stakeholders have been enthusiastic about this research and cooperated. Only SenterNovem and EZ were reluctant and did not fully cooperate. For this case study various stakeholders have been approached for the last three years through interviews, (telephone) conversations and by attending workshops and seminars.

The following actors cooperated:
Wetsus: Boonstra, J. (2007); Euverink, G. (2007); Post, J. (2005-2007); Veerman, J. (2005); Schrader, G. (2005)

Magneto/Redstack: Hack, P. (2005, 2007); (Post, J.)

Kema: Roest-Krijgsman, J. (2005); Ross, R. (2005, 2007); Ende, K. van der (2007)

VolkerWessels/Tetradon: Ouderakker, G. (2005)

Rijkswaterstaat: Regeling, E. (2007)

Frysia: Mulder (2007), Weewer (2007)

IMSA: Tameling, H (2005, 2007), Wiltink, H (2007)

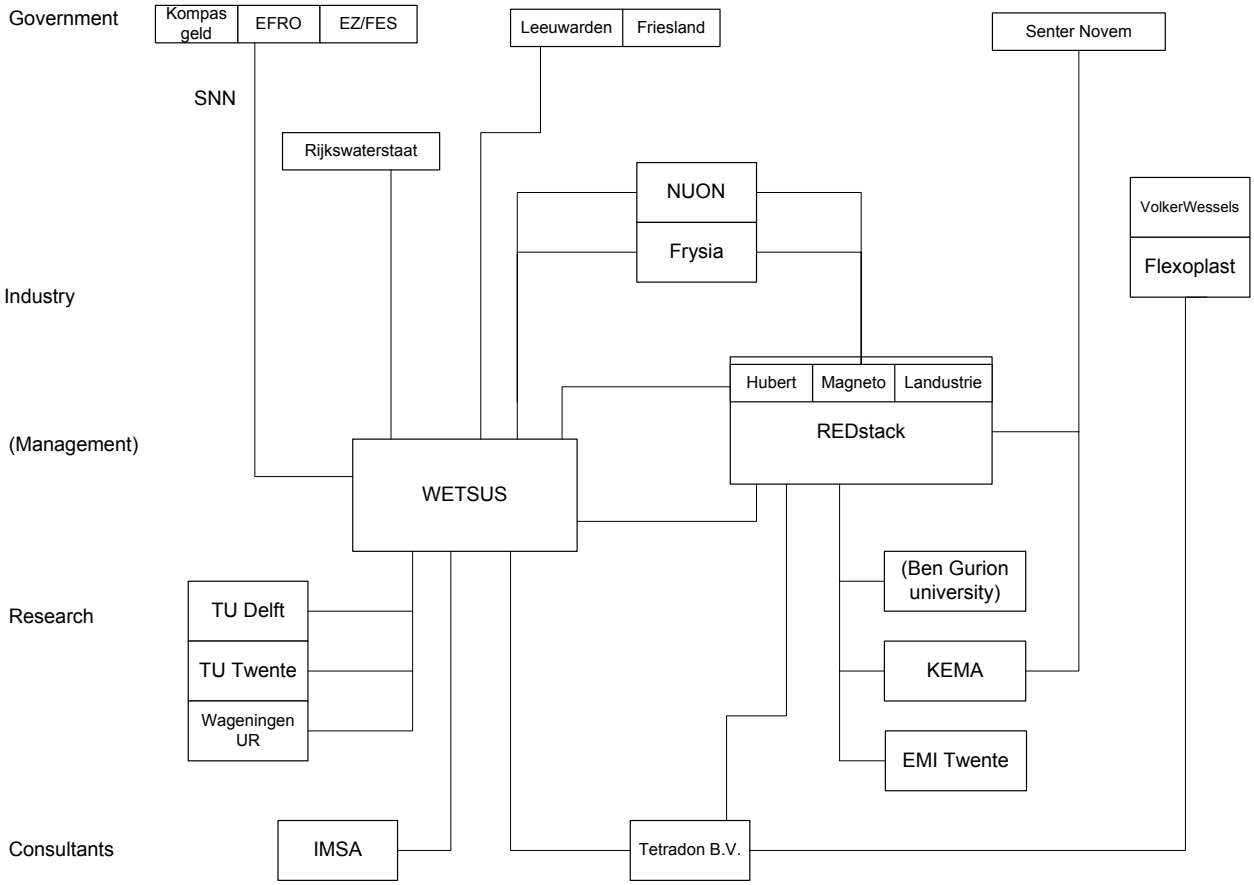
University Twente: Nymeijer, K. (2007); Wessling, M. (2005)

Nuon: Riet, M. van (2007)

SenterNovem: Sijens, L. (2007), Reijnders, J. (2007)

EZ: Damme, L. van (2007)

Appendix A Network configuration of stakeholders in the Blue Energy development



Appendix B Chronology of notable events in the Blue Energy development

1994	Senter Application Kema rejected (ECN already research on hydrogen membranes)
2000	Kema short feasibility study on Blue Energy, financed by VolkerWessels
2001	Senter application Kema rejected, incomplete research proposal
2003	NEO subsidy (EOS programme) granted to Kema, VolkerWessels and Velsen Flexoplast to conduct a one year study on the technical and economical feasibility of Blue Energy based on an alternative membrane production method.
2004	Startup Wetsus
2006	Redstack starts with NEO subsidy on three membranes research projects conducted at EMI, Kema and Ben Gurion
2006	EOS programme, NEO subsidy granted to REDstack for research on the feasibility of applying new types of ion-specific organic membranes.
2006	INNOWATOR application Redstack rejected, although mentioned in product folder innowator