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The Energy Factory

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1. Introduction

Since climate change and fossil resources depletion have become high priority issues, clean energy and sustainable resources represent a response to these future challenges. In doing so, the Dutch Water Board districts have developed a unique project called 'Energy Factory' (*Energiefabriek*), with the aim of achieving energy self – sufficiency production.

The *Unie van Waterschappen*[1] challenged all the 26 water boards in the Netherlands to think about new, out of the box, sustainable possibilities in the water circuit (Energiefabriek, 2009). Several water boards accepted this challenge by implementing the Energy Factory, which produce and recycle energy from waste water in order to create an energy cycle (Energiefabriek, 2009).

The Energy Factory contains a technical installation in which green energy is produced from waste water or other organic flows (De Energiefabriek, waterschappen binnenstebuiten, 2009).

The aim of the project is: a) to develop waste systems that treat sewage water in an energy-neutral way and b) supply green energy.

It is, in fact, well known among the scientific literature that effluent contains energy, so before being discharge into surface water, the effluents are subjected to a cleaning treatment process, which takes place in Sewage Treatment Plants (STPs). The purification plants represent the location where the conversion of waste water towards energy is best implemented, since they can be transformed into Energy Factories because of their commercial design (*De Energiefabriek, waterschappen binnenstebuiten*; 2009).

The aim of this paper is to a) further provide additional insight on the development of the Energy Factory plant(s) and b) fill the knowledge gaps for implementing policy and to conclude c) find out possible improvements that can be applied in order to improve the water management of the Energy Factories.

In doing so, the policy of the Dutch Energy Factory is assessed by using the *Ten Building Blocks as assessment method*.

In order to address these objectives, the following questions will be answer:

[1] Dutch Association of Regional Water Authorities (Energiefabriek, 2009)

a) The Dutch Energy Factory project is only theoretically feasible (in terms of energy production)?
b) The self-sufficiency energy production and potential supply of energy is achievable?

In order to approach these questions the concept of Energy Factory is outlined in the section 1. Subsequently, the paper takes a closer look at the assessment method (section 2), which is described in all its steps. Then, the results are evaluated by using the assessment methods (section 3). In the concluding part, the results are discussed and possible improvements of the Energy Factory policy are suggested (section 4).

1.1 Inside the waste water Energy Factory

Waste water contains a lot of energy. The energy is 'stored' in thermal- and chemical energy. The Energy Factory is focusing on the chemical energy that is present in the waste water.
As presented above, the *Unie van Waterschappen*, proposed a new technique to produce energy. Thus, several water boards designed and implemented a so-called waste Energy Factory.
Due to this challenge a lot of new information and techniques were produced and invented. *But why waste water energy?* A large amount of energy is contained into the waste water, and subsequently discharged via the sewer system to the waste water treatment plant (WWTP). So the question of the *Unie van Waterschappen* was: *"Why do not re-use the energy we put in the system for processes that demand energy?"* (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, p. 5). The abstraction of energy from the waste water technique is already implemented in several large WWTP's. However, there is still a high potential of energy that can be produced also from the smaller WWTP's. The Energy Factory is implemented in 350 WWTP's, in order to make the WWTP energy neutral (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, p. 5). Moreover, in case of energy left, it can be discharged into the system (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, p. 5).

The concept of energy neutral WWTP with a possibility of energy left which can be discharged back into the system, represents a new opportunity in order to achieve the energy self – sufficiency production. However, there are still some barriers in the implementation of the Energy Factory project. On the one hand, there is a consensus among the scientific literature that this

technique can supply a large amount of potential energy. On the other hand, the neutral energy concept is still theoretically feasible, and high financial investments are needed.

All the WWTP's, which controlled by the water boards, use 750 GWh for the treatment processes, but only150 GWh of them are produced independently from the water boards during the sludge fermentation. Which means that the water boards themselves produce about 25% of the total demanded energy, and consequently the Energy Factory responds to the remaining 75% (and maybe more) (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, p. 5).

To give an example of how large the energy demand is: an average household in the Netherlands uses 3.000 kWh on an annual basis; this means that the water boards use the same as 250.000 households (!) (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, p. 7).

Comparing the potential energy and the demand of energy, the possibilities are there. However, in order to produce the remaining 75% of energy demand, the abstraction of waste water process needs to be implemented.

The more waste water is discharged into the Energy Factory, the more biomass is converted toward energy. This process combined with new waste water treatment techniques – which requires less energy – leads to create energy neutral WWTPs. With further innovation of treatment and energy abstraction techniques, the water boards may become green energy long-term producer. (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, pp. 7-12)

The theoretical potential and the business case (compiled by various water boards) are there. Since new WWTPs are rare, further scientific knowledge has to be provided in order to understand how much energy can be produced from waste water. Each water board can design the Energy Factory depending on its final goals.

Three types of Energy Factories have been outlined by the *Unie van Waterschappen*, which are presented as followed:

- "*Basic: expansion of the energy abstraction installation with proven techniques. This is resulting in an energy neutral WWTP and can be implemented 'today'"* (Energiefabriek, 2009)
- *"Plus: the basic scenario with implementing an fuel cell and an additional digestion step for the sludge treatment. This scenario can be implemented 'today'"* (Energiefabriek, 2009)

- *"Super: the plus scenario, the fermentation has to be cut-out of the process, in order to implement the supercritical gasification of sludge. This scenario still needs several years for development reasons"*(Energiefabriek, 2009)

These scenarios are not all the possibilities, in the business case the *Unie van Waterschappen* has defined transparent, and easily to apply, techniques in order to make a '*quick-win'* strategies in the upcoming years. (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, pp. 11-21).

Therefore, in order to implement new suitable techniques, several developments and trends have to be taken into account in the next following years. In the business case autonomic developments and trends were taking into account in order to give an overview where the vulnerabilities and challenge lie in the future (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, p. 5). A brief overview of these, has presented below.

- ✓ Energy prices:

  It is hard to anticipate how energy prices will change; prices are, in fact, dependent on the stocks market. Therefore, the energy prices are projected on the future scarcity of it. The International Energy Agency (IEA) has predicted that the energy prices will double in the next 20 years. The prices are taken into account in order to calculate the pay-off time. The prediction was made by assuming that the energy prices will be doubled in the following 10 years (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, pp. 18-19).
- ✓ New sanitation:

  "New sanitation involves separation at source and treating certain types of effluent separately" STOWA, Energie fabriek, waterschappen binneste buiten, 2009, pp. 18-19. Urine separation can have a positive influence, because less nitrogen has to be treated in the WWTP (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, pp. 18-19).
- ✓ Separation of precipitation:

  The separation of precipitation can also have a positive influence on the Energy Factory. According to the Unie van Waterschappen (2009), this practice reduces the dilution of the effluent supplied, and consequently causes an increase of the chemical waste

concentrations (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, pp. 18-19).

- ✓ Carbon dioxide (CO_2) emission rights:

  CO_2-emission rights are tradable, this represent a possible benefit for some companies because CO_2 emission can be seen as commercial good (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, pp. 18-19). Even if, the WWTP's do not relied on this framework, the energy produced is CO_2 neutral. Therefore, a consumer of this energy can have emission surplus right, if it has CO_2 rights (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, pp. 18-19).

- ✓ Permits and procedures:

  The Energy Factory can abstract energy from waste water, and supply that energy without any permits (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, pp. 18-19). In the case of more biomass processing, the *Wet milieu- beheer* (Environmental Management Act) has to be amended (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009, pp. 18-19)

1.2 The Assessment method

The integrated and interdisciplinary method for sustainable water governance is used to assess and implement the Energy Factory water policy (van Rijswick et al., 2014). The goal of the assessment method is to integrate the water management as expected in the EU Water Directive. This method is based on water system analysis, economics, law and public administration and consist in three-step (content, organization and implementation) with multiple criteria (10 steps in total), and it is used to assess any water governance and policy topic (see Figure 1)

The content step gives the basic knowledge about water system in time, space and values, principles and policy discourses. The knowledge is necessary to have a general overview of the system organization (van Rijswick et al., 2014).

The organization process is evaluated with the organization part, which assesses stakeholder involvement, trade-off between social objectives, attribution of responsibilities, regulations and agreements and financial arrangement (van Rijswick et al., 2014).

Finally, the implementation step is used to develop the policy by using engineering and monitoring, enforcement and conflict prevention and resolution (van Rijswick et al., 2014).

To conclude, the three step and the related 10 building blocks in the water management and governance have to be dealt with and they must be evaluated by taking into account they strong relationship.

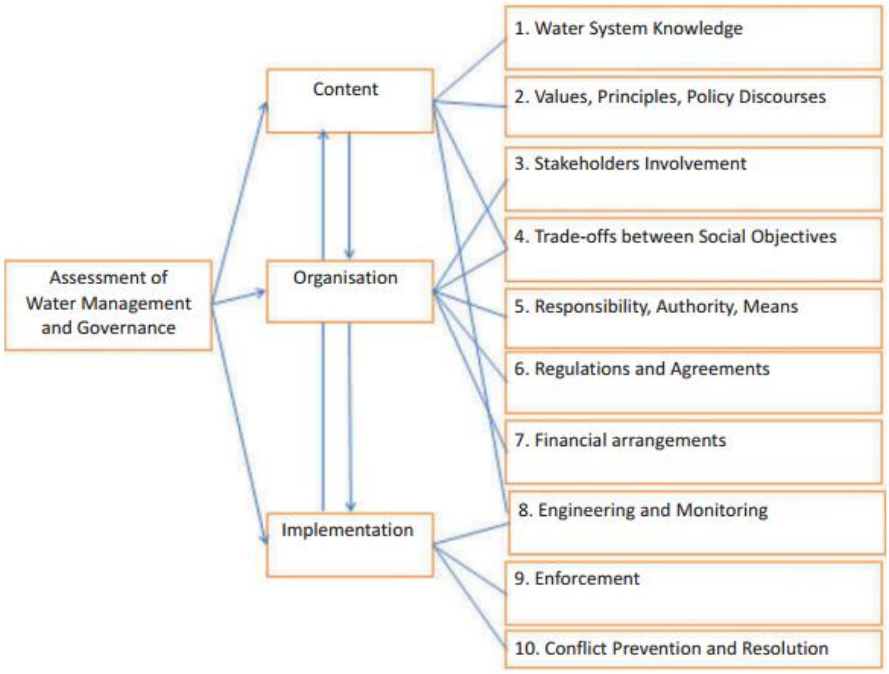

Figure 1 – *The ten building blocks of the Water Management Assessment Method (Van Rijswick et al., 2009)*

To assess the Energy Factory policy these ten steps have to be followed. Before assessing the Energy Factory policy, a brief explanation of the ten building blocks is given (section 1.3) Subsequently, the assessment criteria and their strength of each building block are outlined (section 3).

1.3 The ten building blocks: a brief overview.

Subsequently a brief explanation of each block follows.

1. Water system knowledge

The water system is a combination of physical-natural resources (rives, rainfall, lakes etc.) and man-made infrastructure (e.g. canals, pumping station, reservoirs etc.) (van Rijswick et al., 2014). According to Rijswick et al. (2014), water system knowledge depends on the "*societal functions*" (e.g. domestic and industrial water use, irrigation, shipping etc.), that can be changed according to spatial and temporal scales (van Rijswick et al., 2014). As a consequence, it is important to assess the impacts of these changes in order to understand the water system future performances. In

addition, water system is affected by uncertainty and ambiguities (e.g. natural variability and epistemic uncertainties) that have to be taken into account (van Rijswick et al., 2014). Thus, the risk (probability and damage) on the water system has to be assessed (van Rijswick et al., 2014).

2. Values, Principles and Policy Discourses

As stated by (van Rijswick et al., 2014) water issues are based on values, principles and policy discourses. A brief explanation of these terms followed below, by using the definition given by (van Rijswick et al., 2011)

- ✓ *"Values: change according to the history, culture and policy of a country. Notwithstanding the existing of different values, contributes to good water management and governance which are based on shared values. Values can be elaborated into principles.*
- ✓ *Principles: include institutional principles; principles of good governance, proportionality and public participation; specific environmental principles; technical principles. Together with values, principles play a central role in developing new policy strategies and alternatives decision-making.*
- ✓ *Policy Discourses: are important in order to share the water issues information. They defined values and principles".*

In order to understand the content of water issue is necessary to understand both facts and frames (van Rijswick et al., 2014).

3. Stakeholders involvement

Water issues imply various actors (e.g public, private and semi-private), who are characterized by several objectives (van Rijswick et al., 2014) . In order to achieve an effective water management, stakeholders involvement and collaboration have to be developed ((van Rijswick et al., 2014). Stakeholders are involved during decision-making and implementation processes ((van Rijswick et al., 2014). Participation is necessary in order to a) enhance the content of the policy proposals, b) increase the legitimacy of the water policy and c) improve the quality of the decision-making process ((van Rijswick et al., 2014). Moreover, participation and objectives sharing allow to an increase of public knowledge and understanding ((van Rijswick et al., 2014). According to (van Rijswick et al., 2014), there are two forms of participation:

- ✓ *Width of participation*
- ✓ *Depth of participation*

Those determine the strength of public participation ((van Rijswick et al., 2014).

4. Trade-offs between Social Objectives

According to (van Rijswick et al., 2014), trade-offs are divided into:

- ✓ Allocation: include water scarce resources and safety allocation process that is a political process in which pro's and con's are weighted. During the process *"insight is required into various social (potentially conflicting) objectives and into the trade-offs between the impacts on various objectives of alternative measures"* (van Rijswick et al., 2014).
- ✓ Reallocation: is necessary in order to reforming and implement the pre-existing water allocation. It has different implication and impacts, which increase the complexity of the process.
- ✓ Allocation mechanisms: is necessary to translate the service-level agreements into rules, regulation and procedures. *"The service-level agreements can be achieved by water allocation mechanisms, water quality and safety standards*" (van Rijswick et al., 2014)

5. Responsibility, Authority and Means

(van Rijswick et al., 2014) classified this step into: property rights, allocation authority and responsibilities and means. A brief summary of these objectives is presented below.

- ✓ Property rights: are the social relations between the titleholders. They define four ownership: private property, common property, state property, no property. Finally, the property rights create restriction of property such as communalization of rights (van Rijswick et al., 2014)
- ✓ Allocation authority and responsibilities: the restrict property rights require the assignment of responsibility to public and non-public actors, moreover they generate means to empower authority. The authority has the responsibility to guide the process

in order to achieve a more appropriate and collective based preference choice (van Rijswick et al., 2014)

- ✓ Means: can be divided in public mean (e.g. expropriation or redistribution of rights, compensation, cost recovery based on profit or solidarity) and financial means (e.g. How and by whom is water management financed?) (van Rijswick et al., 2014)

6. Regulation and Agreements

According to van Rijswick et al., (2014), regulation and agreements are defined as follow:

- ✓ Appropriateness: depends on the circumstances, the legal tradition, the governmental organization, the involved parties, the leading values and principles, the water system characteristics, the problem issues and the parties' intention.
- ✓ Legitimacy: is the assessment criterion of regulation and agreements. Includes different aspect depending on the discipline.
- ✓ Legal certainty and adaptiveness: on the one hand, regulations and agreements have to be flexible and adaptable, legal certainty on the other ((van Rijswick et al., 2014).

7. Financial arrangements

Financial means are necessary in order to achieve effective and efficient water governance, and as a consequence to avoid instability (van Rijswick et al., 2014)

There are different possibility to finance the water management ((van Rijswick et al., 2014)

- ✓ Cost recovery though a profit principle
- ✓ Cost recovery though solidary principle

Financial means have to be agreed with the international principles ((van Rijswick et al., 2014).

8. Engineering and Monitoring

(van Rijswick et al., 2014) claimed that engineering and monitoring have to be implemented by considering the following objectives:

- ✓ Improving water infrastructure: Service Level Agreements (SLAs) is used in order to determine if and which types of improvement in the infrastructures are needed. The SLAs are developed by the collaboration between the responsible authorities, agencies and stakeholders. Furthermore, the 'from global to detailed' principle is used with the aim of sharing the available resources (van Rijswick et al., 2014). Economic analysis are also needed in order to assess the returns on investments and the cost-effectiveness of alternative infrastructure (van Rijswick et al., 2014). Also the maintenance is taken in to account (van Rijswick et al., 2014).
- ✓ Monitoring: allows to apply the SLA's and achieve the water system requirement. It is not always essential (van Rijswick et al., 2014).

9. Enforcement

Enforcement plays a key role in order to develop an efficient, effective and legitimate water management and governance ((van Rijswick et al., 2014). It includes implementation in regulations and agreement. The lack of enforcement should bring respectively to a) a decrease of policy effectiveness and legitimacy, and b) to an increase of conflicts (van Rijswick et al., 2014). Enforcement can be develop by private or public parties depending on the regulation and agreement that have been taken in to account (van Rijswick et al., 2014).

10. Conflict Prevention and Resolution

Cooperation has to be considered in order to prevent conflicts. In doing so, clear norms, standards, responsibility, instrument and agreement have been developed ((van Rijswick et al., 2014). When conflicts occur, an external arbiter is nominated in order to solve them (van Rijswick et al., 2014).

In the following section, the results of the assessment method are outlined.

2. Result

In this section, the Energy Factory policy is assessed by using the Ten Building Blocks Assessment Method. The results of every block are presented as follow.

2.1 Water system knowledge

Assessment criteria: "Is there sufficient knowledge of the existing water system in order to deliver the required service level of societal functions? If not, what are the gaps?"

The available data derives from the scientific literature that us claim that there is sufficient knowledge about the existing water system. It is, in fact, mandatory for municipalities mapping and controlling their sewer system. The provided knowledge, allows them to calculate the potential amount of energy that can be abstracted by the Energy Factory. The outline of sewer system and the related parameters (e.g. discharge, mass of the waste water, temperature, etc.), represent the first step of the policy implementation.

Some Energy Factories are already implemented (only for the biggest WWTP's), which leads to: a) broaden the information available, and b) develop the Dutch Energy Factory project.

Key information regarding the real amount of energy produced has to be developed. In particular, it is important to understand the relationship between the available energy, the discharge and its fluctuation (time and precipitation dependent) and finally the connected households. Treating the water in a sufficient way is, in fact, the main goal of the WWTP's. Also because abstracting the energy from the waste water is not the main goal of the WWTP's, but to treat the water in a sufficient way. So the policy implemented had to state that the Energy Factory is secondary goal.

The Energy Factory produces green energy by re-using the energy generated from the sewer system. This approach represent indeed a sustainable way of generate energy. Therefore, it requires the level of societal functions. Fossil fuels are not used and there is not skyline destruction because of windmills for example. This means that the societal function is already there, but the Energy Factory needs marketing policy in order to transmit the potential societal function.

2.2 Values, principles and discourse

Assessment criteria: "Is there sufficient knowledge of shared or conflicting values, viewpoints and principles (represented by different policy discourse coalitions) for water issues and their consequences for facing water management issues"

There is sufficient knowledge regarding the Energy Factories already implemented. As stated above, the primary goal of the water board is to treat water in a sufficient way. Thus, the in the first step of the ten building blocks, they look into the consequences of water management issues. As far as concerns, the question: "*is there sufficient knowledge of shared viewpoints and principles?*, more knowledge is needed. It is, in fact, claimed that the re-use of the potential energy in the sewer system can cause water management and water treatment issues (Unie van de Waterschappen, 2009). This is because by producing energy a second goal is occurring for the WWTP's and maybe this will influence the process of the water treatment. However, the Energy Factory represents a sustainable improvement because green energy is produced in an alternative way. Therefore, in order to answer the question, the definitions of sustainable development – regarding the implementation of the Energy Factory – are stated below (Costanza et al., 2012). According to Costanza et al. (2012), the definitions of sustainable development are divided into six different categories, which are:

- ✓ Nature: the Energy Factory does not directly influence the components of the nature such as earth, biodiversity and ecosystems. However, producing sustainable energy means that there is no use of fossil energy. Reducing the use of fossil energy leads first to reduce CO2 emissions, and secondly to increase the protection of ecosystems and biodiversity.
- ✓ People: the Energy Factory has an important role in education. With implement the Energy Factory the water boards can show to the world about the potential energy of waste water. Therefore waste water can be an important component in the future, about using the waste water in order to produce energy. So the worlds statement to reduce the waste can be converted into re-use the waste in an different way.
- ✓ Life support: the Energy Factories produce energy, which can be used by the population. This means that the Energy Factories supplies life-support resource. In addition, by reducing the CO2-emission they create a positive effect on the environment, which also can be seen as a life-support.

- ✓ Economy: the development of the Energy Factory needs of course investment and maintenance costs. The energy supply does not mean an additional cost since waste water is produced continuously. Thus, this is an interesting improvement in the energy circuit. The potential energy that can be produced is interesting for the economy sector. Energy it is, in fact, present in a huge amount and it is also a sustainable resource. There will be always consumption of energy, but fossil energy is finite while waste water energy not.
- ✓ Community: the Energy Factory does not directly influence cultures or groups. But there are a lot of proponents in favour of sustainable energy, where the Energy Factory is a responds to it.
- ✓ Society: by producing green energy a so-called *social capital* emerge. The energy that has been spilled over the last decades can be used. That represents, indeed, a positive consequence on the environment, education and economy. In addition, it is worthy for the society to show that it is possible to produce (a lot) of green energy by using the pre-existing components, which has never been used before.

As far as concerns the definitions of sustainable development, the Energy Factory has consequences on that, but in a positive way. The information for the Energy Factory is not brought to the *bigger public* and therefore the sustainable definitions regarding the Energy Factory are potential. On the one hand, this can create potential issues because the WWTP's have a two-fold goals policy. On the other hand, the Energy Factory focuses on a sustainable way to produce energy. Thus, the water board generates income by producing green energy, which can be profitable for the tax-payer. Because there is also a potential economic profit, the Energy Factory can be popular implementation, which has a positive effect on the environment and the tax-payer.

2.3 Stakeholders involvement

Assessment criteria: "Are all relevant stakeholders involved? Are their interests, concerns and values sufficiently balanced considered in the problem analysis, solution search process and decision-making?"

Four different stakeholders are involved in the implementation of the Energy Factory project and policy: the water boards, municipalities, government and the energy companies (energy infrastructure). The collaboration between: a) the water boards themselves, and b) between the

water boards and the municipality, is well build up. The municipality is responsible for the sewer system, and consequently it has to share all the information and the parameters regarding the sewer with the water boards. The knowledge about that is important in order to design the Energy Factory and to predict the potential growth and/or decline of the energy production. The municipality has agreed with the government to first reduce CO_2-emissions, and secondly to produce 20% green energy of the total energy demand of The Netherlands in 2020. Hence, the Energy Factory preserves the interests of the municipality by producing green energy.

The government however states that 20% of the total energy demand has to be provided by gre energy. Therefore there are policies that support this policy (e.g. the energy of solar panels that is discharged to the energy system can be deducted of the energy use (of the supplier) and also the taxes. The energy from the Energy Factory can be deducted of the energy use, but not from the taxes, because the policy is only for solar panels. In order to implement an Energy Factory in favourable conditions, the policy has to be adjusted. In particular, the Energy Factory has to be the same *rights* as solar panels.

Finally, the users represent another important stakeholder. They do not directly influence the implementation of the Energy Factory, but they have their own interests. There is criticism on the water boards because they are (potentially) generating revenue with the Energy Factory, by producing energy. Because the water board is a semi-governmental institution, many people do not think that it is their responsibility to produce energy and subsequently profits. In order to make the policy, the potential revenue has to be stated in the policy. Questions like: "*what the water boards are doing with the revenue and if the tax-payers will profit from the revenues?*", are asked frequentl

2.4 Trade-offs between social objectives

Assessment criteria: Are agreed service-level decisions based on trade-offs of costs, benefits and distributional effects of various alternatives?

According to Van Rijswick et al. (2014), the economics of water management is about: "*the allocation of scarce resources, which can be water quantity, water quality as well as safety against flooding*" (Rijswick, Edelenbos, Hellegers, Kok, & Kuks, 2014). For what concerns the Energy Factory, the economics is about the (potential) energy produced from the waste water.

The social trade-offs are still there. The potential economic value is given by the following objectives:

1. Green energy production,
2. Development of energy-neutral WWTP's
3. New possible energy supplier.

By generating potential revenue a trade-off with the users is then possible. But with implementing the existing Energy Factories, there was not been a trade-off. In order to implement the Energy Factory on a larger scale, trade-off has to be implemented in order to earn confidence from a wider part of the public. Not only the users, but also other parties like energy (producing) companies. Energy Factory can represent a rival for the other energy companies because they are new potential energy supplier. However, if clear trade-offs are developed and promoted, they can cooperate together as a team.

2.5 Responsibility, authority and means

Assessment criteria: "Are authorities, responsibilities and means well-organized to deal with water issues at the appropriate administrative scale(s) in a participative and integrative way?"

- ✓ Property rights

As stated above, water boards are semi-governmental institutions. With this fact given, it is hard to defining the private property. The Energy Factory is property of the Water Board and, as a consequence it is partly possession of the government and public (tax-payers). *But who is the owner of the waste water?* That is not stated in any policy. The water boards are responsible for the treatment of the waste water, but does it mean that the water board owns the company? A more clear and transparent objectives about the waste water ownership have to be defined. Moreover, the policy has to state how the water board will use the potential revenue, and if the users can benefit from the revenue. So a top-down approach is not appropriate in this case. In order to involve all the stakeholders, including the users (that pay the water board via taxes), a bottom-up approach has to be implemented. By using this procedure all the stakeholder interests can be taken into account in the future Energy Factory policy.

- ✓ Allocating authority and responsibilities

A bottom-up approach increases the consensus among the community. It is, in fact, claimed that cooperation in the decision making play a central role in the realization of the plan. In doing so, users (tax-payer) have to be considered in order to update and adjust the Energy Factory policy.

Green energy production leads to widespread the community support, the Energy Factory in fact generates energy by using sustainable techniques, which can represent also potential economic benefits.

The Energy Factory can be a strong collective, because it is a sustainable measure which also have potential economic benefits.

With a strong collective the progress of the Energy Factory can only increase, because the stakeholders have the same vision regarding the production of green energy. Therefore, future improvements and implementations are easier to realize.

In order to create the same vision, marketing a bottom-up approach has to be followed seeking widespread stakeholders involvement allows further the knowledge about the Energy Factory capabilities and possibilities among the public.

- ✓ Means: participative capacity

According to van Rijswick et al. (2014), "*decentralization and strong local communities"* are key factors in order to increase the participative process. In the specific case of the Netherlands, a strong community – characterized by a sustainable view or opinion – is present. Thus, a positive future is ahead of the Energy Factory.

However, government decentralization is needed in order to increase the public consensus and participation. In doing so, the water boards do not represent the only voice that has to be taken into account, but also other stakeholders need to be involved in the project. Although, the stakeholders cannot decide about the Energy Factory as technical component, they have to be involved by sharing information and sharing potential benefits and revenues. Stakeholder's participation and their integration increase the success of the decision process.

2.6 Regulations and agreements

Assessment criteria: "Are regulations and agreements legitimate and adaptive, and if not, what are the main problems with regard to the above mentioned legitimacy aspects?"

- ✓ Appropriateness 

Regulations and agreements in a legitimate aspect are not there yet for the Energy Factory. However, it is already implemented on the eight largest WWTP's. The water boards can recognize potential future issues regarding first the waste water property, and secondly the responsibility of the produced energy. But with the implementation of the Energy Factory, the water boards responds to the agreement to reduce the greenhouse gasses and use more green energy. So there are different points of view to look at the Energy Factory. In order to combine these different objectives and stakeholders' participation, a clear policy has to be implemented.

In doing so, water boards have to collaborate together with the government and energy companies for developing agreements about the potential revenue and (green) energy surplus produced by the Energy Factory. Moreover, the water boards and the energy companies are in charge to define a common agreement about the energy prices. The prices are related to the energy supplier (energy companies to users) entitled to buy back from a secondary supplier (the Energy Factory in this case). A governmental institution, such as the water boards, can recognize as a possible source of profit the income derives from the energy sale. Therefore, they have to define clear statement in the policy about the potential benefit of the tax-payer regarding the profit (Overheid, 2015).

- ✓ Legitimacy

van Rijswick et al. (2014) claimed that in order to create legitimacy, different interest and objectives among several parties have to be involved. As described above, stakeholder's participation plays a key role on the implementation of a clear and reasonable policy. According to Rijswick et al. (2014), the policy has to be formulated in an enforceable and effective way with mentioning clear goals and future perspectives of the Energy Factory. Therefore, the policy has to be based on transparent rules and on sufficient and relevant information (e.g. information

regarding to the already implemented Energy Factories or other secondary earnings by the government by new implementations). The development of a transparent and clear policy, conflicts will be avoided. This, as a consequence, has a positive influence on the policy implementation and the implementation of the Energy Factory itself.

With a flexible attitude of the water board, the Energy Factory can adapt to future and present challenges concerning the sustainability achievement. All the components and opportunities are available; therefore legal certainty is necessary to realize the potential of the Energy Factory (van Rijswick et al., 2014).

2.7 Financing water management

Assessment criteria: "Is the financial arrangement sustainable and equitable?"

This is one of the leading points about the Energy Factory. The financial arrangement is sustainable (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009; Unie van de Waterschappen, 2009). Green-energy is produced from waste water, which creates sustainable energy cycle. The WWTPs generate energy from waste water, which means that WWTPs in theory can be a) energy neutral and b) potentially surplus energy supplier. The pay-back costs (break-even point) are not accessible for the public, but the scientific literature provides knowledge about the energy consumption of the WWTP's. All the WWTP's in the Netherlands, at the moment, use the equal energy amount of 250.000 households (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009). The data published by the Unie van Waterschappen (2009) shows that *"energy-neutral water boards are able to save the equivalent of the energy consumed by the population of Rotterdam or 60% of the energy consumed by NS (Dutch railways) through the treatment of waste water".*

By achieving the energy-neutral waste water treatment, the WWTPs can be self-provided in terms of costs (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009). Consequently, the use of national or regional budgets may not be needed, because the income generated by providing energy are enough to enable the water boards energy self-supplying (STOWA, Energie fabriek, waterschappen binnenste buiten, 2009).

The water boards are *paid* by the tax-holders via its own tax system .The main goal of the WWTP's is to treat the water (and tax is paid for the primary goal), there is a point of view that the water

boards should pay-back the tax payers. What pay-back means has to be stated in the Energy Factory's policy, which can differ from lower taxes to a more sustainable environment.

2.8 Engineering and monitoring

Assessment criteria: "Are SLA's (Service Level Agreement) sufficiently available (implicit or explicit) in order to redesign the existing infrastructure? Are the design and consequences of different alternatives sufficient available? Is there sufficient monitoring of the system and are the data analyzed?

The existing Energy Factories perfectly embody the societal functions, they, in fact, represent a great example for the Energy Factories that will be implemented in the next following years. At the present time, the municipality is in charge of managing the sewer and influent infrastructures. Therefore, the water boards do not have to consider this aspect in their policy. However, the potential energy surplus has to be discharged into the energy system, which means that extra infrastructures have to be realized in order to meet the new requirements. The Energy Factory is, in fact, a rather new technique; thus the SLA's (Service Level Agreement) needs to be refined in order to improve both techniques and infrastructures.

SLA's can be implemented in different ways, by using different components. In engineering text books the principle 'from global to detail' is used often. The global scenario has to be investigated first in order to derive sufficient knowledge about the system, and in second place techniques or objectives can be implemented. Consequently, the available resources are used in a more effective way. Finally, this approach allows the involvement of the relevant stakeholders (van Rijswick et al., 2014) .

- ✓ Economic analysis 

The economic analysis leads first to assess investment return and secondly to determine its implications on the infrastructure (van Rijswick et al., 2014).

With the economic analysis, assessing the return on investment in the infrastructure can be determined. The economic analysis plays a key role for the water boards, they, in fact, use the money that comes from the taxes to develop new Energy Factory plants. Therefore, a structural and transparent economic analysis has to be done in order to provide sufficient knowledge at the

relevant stakeholders. The costs of the infrastructure for waste water, energy and the Energy Factory itself has to be calculated. With different alternatives and techniques the most economic version can be determined.
Maintenance costs have to be implemented (or calculated?) in order to determine the pay-back time and the future potential income.

At the present time, eight Energy Factories are already in use REFERENCE. Thus, there is sufficient knowledge about the system, which can be also be extended. To conclude, collaboration and knowledge sharing between the water boards and stakeholders can result in a quick and transparent economic analysis REFERENCE.

- ✓ Monitoring

The monitoring phase allows to determine a) adequacy of the SLA's, and b) the level of goals achievement.
Does the Energy Factory have negative influence on the waste water treatment goal? Is the energy supplied that they calculated or agreed with other stakeholders?
These questions have to be answered during the monitoring phase. In doing so, both the system and the employed techniques can be assessed.

2.9 Enforcement

Assessment criteria: "Are regulations and agreements enforceable by public and/or private parties, and are there appropriate remedies available?"

The regulations and agreements are enforceable by the different stakeholders, also regarding to the already implemented Energy Factories. However, the Energy Factory's policy is characterized by the lack of clear goals and targets. In order to define clear goals and targets, objectives sharing and stakeholder's participation have to be promoted during the policy implementation. As a consequence of this, the Energy Factory can be enforced and improved in terms of efficiency.

The rules and agreements have to be defined together with all the relevant stakeholders. This allows to create more transparency and secondly to implement the Energy Factory in more WWTP's. Van Rijswick et al. (2014) argued in favour of rules and agreements based on shared

principles and value; it is, in fact, strongly believed that shared interests are easier to implement. (Rijswick, Edelenbos, Hellegers, Kok, & Kuks, 2014). As far as concerns the Energy Factory, all the stakeholders need to be involved in order to assess a win-win policy.

From the knowledge of the already implemented Energy Factories, more strict regulations can be made. Thus, the new policy has to be developed upon the knowledge derives from the existing Energy Factories, in order to assess a long-term policy. Future scenarios and developments have be taken into account, in order to improve and enforced the Energy Factory project in the following next years.

2.10 Conflict Prevention and Resolution

Assessment criteria: "Are there sufficient conflict prevention and resolution mechanisms in place?"

Waste is like water. It is shared and therefore it can be a source of conflict, especially because the waste water regarding to the Energy Factory has a value and can cause potential revenue. It is still vague who *owns* the waste water. To prevent possible conflicts, the stakeholders have to collaborate. One of the key components for collaboration is to share the benefit of the waste water. "*Sharing is caring"* is a statement, which is often used, and is an application regarding to the Energy Factory.

3. Discussion

In this section a discussion takes place in which difficulties and points for improvement are elaborated on. The ten building blocks are thus reviewed as followed.

3.1 Water System Knowledge

Knowledge concerning the water system is available but there are still some gaps. Although, scientific consensus on the energy produced from waste water exists; the amount of the potential energy that can be generated is still theoretic. Moreover, further insight regarding the relation between the produced energy, and the discharge fluctuations have to be provided. Additional acknowledge on waste water treatment process has to be developed, in order to achieve the self-sufficient energy production. The main goal of the Energy Factory, it is, in fact, treat waste water in a sufficient way. The Dutch Energy Factory represents, indeed, a sustainable technique; thus, the societal function has to transmit among the public.

3.2 Values, principles and discourse

More knowledge is needed about shared viewpoints and principles in order to avoid water management and water treatment issues. Considering that the second goal of the WWTP's is the production on green energy, one of the water board values/principles is to be sustainable in all the categories mentioned previously. Moreover, the Energy Factory can be a potential economic profit for the water board because of the tax-payer.

3.3 Stakeholders Involvement

From the reviewed policy, four different stakeholders (Water Boards, Municipalities, Governament and users) have been outlined (see section 2.3). The participation between Water Boards (and between Water Boards themself, Government and Municipalities has been build up; however, users are not completely involved in the project. In particular, there has not been implemented yet a policy which states how users can first be informed, and secondly take part into the project.

3.4 Trade-offs between Social Objectives

As far as concerns the societal trade-offs, the Energy Factory has developed in its plan this aspect. The Energy Factory represents a) a source of green energy and b) a surplus energy available on the market. However, the project's service has to be widespread in order to gain confidence from the

public. Finally, also cooperation between other energy companies seems to be relevant. Common interests and objectives, in fact, allows to an increase among the public consensus.

3.5 Responsibility, Authority, Means

From the reviewed policy, there is no evidence that define the responsibility, authority and means on waste water. The Energy Factories are property of the Water Boards (see section?), but since Water Boards are semi-governmental institution, waste water is also property of the government and public. Thus, waste water ownership is still a of concerns. In particular, the main issue regards the potential incomes that come from the surplus energy produced, and if the users can benefit from the revenue. Since a top-down approach cannot be applied, we argue in favour of decentralize mode of governance and bottom-up approach. This allows to an increase on involvement and consensus among all the relevant stakeholders.

3.6 Regulations and Agreements

Regulations and agreements seem to be legitimate and appropriated. The Energy Factory allows to reduce the CO2 emissions. Additionally, surplus energy is generated from waste water. However, there is lack of transparency for what concerns the income derives from the surplus energy that can be sold. Which means that a transparent and cleat policy has to be developed.

3.7 Financial Arrangements

One on the main goals of the Dutch Energy Factory is to achieve the energy self-sufficiency production. This allows the Energy Factory to become self-proving in terms of costs. However, knowledge gaps about the real amount of energy that can be generated are still present. As a consequence, there is not information available about the pay-back costs.

3.8 Engineering and Monitoring

Economic analysis has been developed on the basis of the pre-existing Energy Factory. Economic analysis needs in order to assess the amount of the return investment costs. Thus, on the base of that new Energy plants can be constructed. Therefore, transparent economic analysis has to be done because the return costs come from the taxes. Finally, the monitoring phase seems to help the assessment of both the techniques and process that take place in the Energy Factory plants.

3.9 Enforcement

The Energy Factory's policy does not present clear goals and targets. As stated above (see section 2.9), in order to overcome this gap, objectives sharing and stakeholder's participation need to be promoted. This allows the Energy Factory to achieve a more efficient water and energy management.

3.10 Conflict Prevention and Resolution

Considering that t water is a shared value, it can create conflict between the users. There is sufficient conflict prevention because collaboration between the relevant stakeholders exists. However, there is not adequate information available about how the possible conflict may be solved.

4. Conclusion

The Dutch Energy Factory's projects aims to develop the possibility of self-sufficient WWTP's tro gh the production of green energy from waste water.

This paper assessed the informat on in order to implement the policy by using the ten building blocks assessment method. The results show that the Energy Factory's project is feasible in theory. However, there are still some gaps resulting from the ten building blocks in order to implement the policy. A po sible implementation may be related to an increase in participation among the relevant stakeholders. In particular users have to be more involved and informed. Furthermore, more information about the effectiveness of the energy production from the waste water is needed.

Responsibility, authority and means have to be developed in a more transparent and clear way. In doing so, the Energy Factory management can be improved and be more understandable for the interested parties. Sharing interests are, indeed, easier to implement in order to achieve a win-win policy. In doing so further inside into the already implemented Energy Factories can help to improve and enforce the project.

To conclude, the transparency of the economic analysis and the policy clearness have to be implemented in order to avoid conflicts and reach consensus within the stakeholders.

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