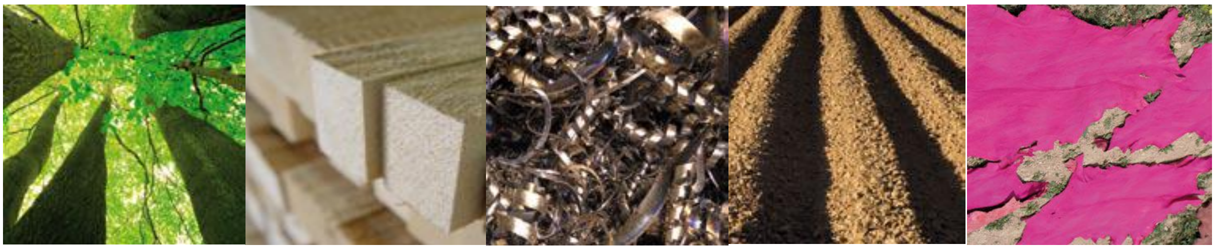

Eco-innovation
WHEN BUSINESS MEETS THE ENVIRONMENT

CIP Eco-innovation
First Application and market replication projects
Call 2011

Call Identifier: CIP-EIP-Eco-Innovation-2011

Final Report

IWEC
water reuse 3.0

Agreement number ECO/11/304469/S12.625202

Covering the reporting period from
01/07/2012 to 30/06/2015
Reporting Date
24/08/2015

Project coordinator: **André Reigersman**
Project website: **www.iwec-water-reuse.eu**

A collaboration between: Rwb Vitens EUROSTEEL Supported by: Co-funded by the Eco-innovation Initiative of the European Union

Index

1. ACHIEVEMENTS OF THE ACTION

1.1 General progress

The objective of the IWEC project is to break through the market barriers for a new technology RWB has developed. The technology uses ceramic membrane solutions for the treatment and **re-use of filter backwash water** produced by drinking water companies. During the project, the implementation of a first full scale ceramic membrane plant in Wierden (the Netherlands) has been realized.

All tasks foreseen for the 36 months of the project have been fulfilled although the time for (facts supported) acquisition was too short to mobilise a (wide) market uptake during the project. This lack of time is caused by a delay in work package 3 (Engineering and Construction).

The results from the LCA (Life Cycle Analysis) are very positive. Treating and reusing of filter backwash water with ceramic membranes results in significant environmental benefits, especially in Global Warming, Acidification and Human Toxicity.

1.2 Progress on all work against initial objectives

WP1 – Project Management

The project management activity is to ensure that the project goals are met, and that the project is carried out according to the guidelines of the EU, within the given timeline and budget.

The final results of the project were presented at the official opening of the plant on 3 June 2015. Mr Didier Gambier (Head of Department in the European Commission’s Executive Agency for Competitiveness and Innovation) did the official opening act of the plant. Stakeholders (also future customers) attended the ceremony to see the plant and to hear about its good performance.

The abolishment of the groundwater tax, contractual obligations to buy water elsewhere and higher investments due to pigging provisions to clean the network, made the business case for the backwash water plant in Wierden negative and resulted in a substantial project delay. As a result additional project management hours were required to get the project back on track:

- More meetings were required between steering committee and WP3 team to explore cost reductions. A breakthrough in cost reduction was achieved by the adoption of a new hygienic standard. This new standard relies on the fact that only one pass through a ceramic membrane would be enough to remove bacteria like E-coli, Enterococcus and Clostridium (single barrier approach).
- Meetings with other drinking water companies were required to find an alternative location in case the teams would not succeed in creating a positive business case for Wierden.

For partners involved in WP1 including their roles, major subcontractors and stakeholders see annex 1. For more details on progress see annex 2.

WP2 – Market definition and validation

In this work package the European market is defined. Based on experience in another project it was decided to hire one of Europe's leading consulting and engineering companies to conduct a professional market report on top of the report produced by RWB.

As this consulting and engineering firm requested actual performance of the plant, the market report was finalised after 6 months' operation of the plant. The professional market report is thus based on the validation report as presented in annex 8. This validation makes clear that the backwash water system performs better than predicted. According to the recommendations of the professional market report, IWEC will focus on a few countries: the Netherlands, Germany and Denmark. This submarket is smaller than assumed at the start of the project (Netherlands, Germany, Scandinavia and Belgium).

The market definition phase took more time than predicted because of following reasons:

- The market drivers differed from those assumed (legislation, water scarcity and Corporate Social Responsibility goals). The price per cubic meter of water as well as (in some cases) valorisation of residues are considered to be even more important drivers. This required additional man-hours (more visits to customers).
- More direct involvement in the professional market report (expert meetings).

For partners involved in WP2 including their roles, major subcontractors and stakeholders see annex 1. For more details on progress see annex 3.

WP3 – Engineering and construction

The objective of this work package is to realise the engineering and construction of the backwash water reuse system (first reference). As already stated in WP1 there was a substantial delay in executing WP3. Both test run and full scale test run were quite successful, no difficulty occurred.
For partners involved in WP3 including their roles, major subcontractors and stakeholders see annex 1. For more details on progress see annex 4.

WP4 – Operation and monitoring

The objective of this work package is the realisation of the backwash water treatment installation and monitoring of the results and therefore the realisation of backwash water re-use, less groundwater extraction, lower energy consumption and a lower chemical usage. Despite of the delay in WP3 the operation and monitoring process went smoothly. There were two deviations from the original operation and monitoring plan:

- Less monitoring was required as a check on membrane leaching was not required anymore because the ceramic membrane received a KIWA ATA approval.
- The re-use of the water was only started in May 2015 instead of January 2015. This was because of the fact that the new hygienic standard relies on only one pass through the ceramic membrane to remove bacteria like E-coli, Enterococcus and Clostridium (single barrier approach). Several months were required to verify whether this assumption is correct.

The delay in WP3, the longer time required to verify whether the new hygienic standard was realistic and the fact that there was less backwash water resulted in lower absolute environmental benefits at the end of the IWEC project (annex 9).
For partners involved in WP4 including their roles, major subcontractors and stakeholders see annex 1. For more details on progress see annex 5.

WP5 – Commercial exploitation and business plan

The objective of this work package is optimisation of the business plan with the results of WP2 and using the results from WP4 to break down the market barriers which have been identified. The business plan was made after 6 months of operation of the plant to have enough operational input (see annex 8). Due to the delay in WP3, the time for (facts supported) acquisition was too short to mobilise a wide market uptake during the project.
For partners involved in WP5 including their roles, major subcontractors and stakeholders see annex 1. For more details on progress see annex 6.

WP6 – Dissemination activities

The objective of this work package is spreading the results of the technology, project and results throughout Europe.
Mainly Vitens and RWB were active in dissemination, Eurosteel gave comments in project meetings. Project results have been presented on different fairs, sometimes with associated workshops. Policymakers have been addressed through national magazines and international forums like CORDIS, the Parliament Magazine and Adjacent Government.
Leaflets, case studies, presentations, monitoring reports, LCA, a movie, a Layman's report, etc. can be downloaded from the IWEC website (www.iwec-water-reuse.eu). Visitor statistics proof that the website has had over 10.000 visitors in the last three years.
At the formal opening of the backwash water plant stakeholders (and future customers) were present to see the plant and to hear about its good performance.
For partners involved in WP6 including their roles, major subcontractors and stakeholders see annex 1. For more details on progress see annex 7.

1.3 Deviations, problems and corrective actions

Deviations, problems and corrective actions have been summarised in annexes 2 to 7.

1.4 Progress regarding performance indicators

The performance indicators at the end of the project are given in annex 9. It is predicted that energy consumption can be optimised by extracting the backwash water at a higher lever from the buffer tank, switching of the mixers in this tank and transport the settled sludge in the buffer tank directly to the sludge thickener. The Performance Indicators for this optimised case are gathered in annex 10. A comparison with the expected Performance Indicators at the start of the IWEC project is given in self-explanatory table 1.

Table 1: Performance Indicators for IWEC at optimised energy scenario (prediction)

Objective	Indicators			Relative Impact Realised	Relative Impact Expected	Comments
Improved Environmental Performance	Greenhouse gas emissions	CO_2 (CML2013)	change to baseline	90% reduction	not specified	
		Methane (CML2013)	change to baseline	86% reduction	not specified	
	Air quality	Particulate matters, (ReCipe)	change to baseline	64% reduction	not specified	
	Reduction / substitution of dangerous substances	Irritant / Corrosive		not applicable	not specified	
		Mutagenic / Carcinogenic (Eco indicator 99 Carcinogenic)	change to baseline	158% reduction	not specified	
		Toxic (CML2013)	change to baseline	89% reduction	not specified	
		Persistent / Bio accumulative		not applicable	not specified	
	Waste management	Prevention	change to baseline	99% reduction	99% reduction	As predicted.
		Waste minimization	tons/year	212.620	not specified	Reused backwash water.
			tons/year	33 reduction	not specified	Iron sludge, 42 tons/year if reduction of $FeCl_3$ would have been taken into account.
		Reuse of waste / Substance recovery		no changes	not specified	Waste is already reused (except of supernatant), valorisation of iron sludge is possible (future research).
		Material recycling		no changes	not specified	See above.
		Waste diverted from landfills		no changes	not specified	No waste goes to a landfill.
		Hazardous waste	ton/year	0,035 increase	not specified	This is caused by the installed infrastructure, would have been nil or negative for a greenfield application.
Better use of natural resources	Reduced resource consumption (excluding energy)	Abiotic depletion, non fuel (AD) CML2013	change to baseline	115%	not specified	
	Water	Reduced water consumption	change to baseline	3,1%	5,0%	The average iron content in the groundwater was expected to be higher (newly installed well fields have lower iron contents than expected).
		Waste water reuse	change to baseline	99%	99%	As predicted.
	Energy	Energy from RES	change to baseline	25% reduction	30% reduction	The lower reduction is caused by the fact that it costs less energy to extract groundwater (0,15 kWh/m3 instead of 0,23 kWh/m3).
		Reduced energy consumption	change to baseline	25%	30%	See above. Compared to base case without reuse
		Reduced energy consumption	change to baseline	81%	80%	Compared to state of the art solution. As predicted.
Economic Performance / Market Replication	Business development / Market replication	Replication		0	not applicable	It was expected that at the end of the project 2 new installations in the Dutch market were realised. Due to delay in project not feasible.
	Market potential	market size in million Euros		250	565	Less BWW than expected (5-10% changed into 3-5%). Standardization will lower the sales price, which makes the technology more competitive.
		market size in number of customers		14	10	
	Entry in new transnational markets			3	not applicable	Netherlands, Denmark, Germany

	Entry into different sectors			1	not applicable	This specific systems is only applicable at the production process of drinking water, however the ceramic membranes have a larger market potential.
	Reduction of cost per unit or process			65% reduction	not specified	Compared to state of the art solutions.
	Payback Time	capital invested / net income		5 years	not specified	
	Patents			not applicable	not applicable	
Others	Chemical usage reduction	all chemicals	change to baseline	90%	not specified	
		FeCl3 42% solution	change to baseline	90%	90%	
		cleaning chemicals	change to baseline	83%	50%	Higher than predicted
	Less transport	reduction in movements	change to baseline	11%	50%	Less than predicted because no measures were taken to increase the dry solids content of the sludge. Increasing the dry solids content of the sludge makes no sense as it reduces valorisation potential.

The following can be concluded:

- The amount of backwash water in Wierden is lower than expected for following reasons:
  - Less backwash water per m^3 of groundwater is produced: 3,1% instead of 5,0%.
  - Less groundwater is extracted: 7 million m^3 per year instead of 7,6 million m^3 per year (both values without backwash water re-use).
  - Evaluation on relative impacts is therefore better than evaluation on absolute impacts.
- The backwash water system performs equal or better on following indicators:
  - Wastewater re-use: 99%.
  - Reduced energy consumption compared to state of the art solutions: 81% instead of 80%.
  - Reduction in chemical usage: 90%.
  - Reduction in cleaning chemical usage compared to state of the art solutions: 83% instead of 50%.
- The backwash water system performs worse on following parameters:
  - Reduced energy consumption: 25% instead of 30%. This is caused by the fact that it costs less energy to extract groundwater (0,15 kWh/m^3 instead of 0,23 kWh/m^3).
  - Less reduction in transport: 11% instead of 50%. This is caused by the fact that no measures have been taken to increase the dry solids content of the sludge. This is not done to avoid a reduction in valorisation potential.

  Both items have nothing to do with a lower (perceived) performance of the backwash water system, but can be clarified by insufficient estimates or changing circumstances compared to the start of the project.

The LCA shows interesting results concerning the comparison between the base case (backwash water not reused), the backwash water treatment system with ceramic membranes and the optimised energy case with ceramic membranes (see table 1). The life cycle impact is visualised in figure 1. For more details see LCA report.

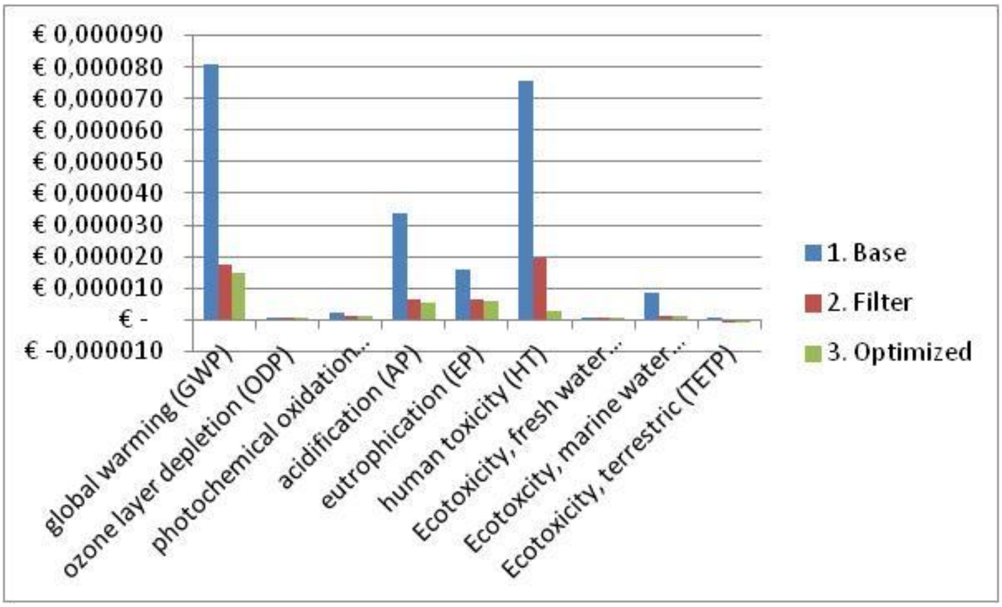

Figure 1: **Endpoint analysis for base case, reuse with ceramic membranes (filter case) and reuse with ceramic membranes with energy optimisation (optimised case)**

Finally it has to be mentioned that just at the end of the project the membranes have been cleaned with citric acid. This was done exactly after operating the plant for half a year. The cleaning had the expected and desired result. The amount of citric acid used, fits in the consumption data used in the LCA (see also performance indicators).

2. EXAMINATION OF RESULTS

2.1 Results regarding market uptake and exploitation

A detailed economic and environmental benefits analysis concerning backwash water treatment with ceramic membranes has been carried out. This has been done later than expected due to a substantial delay in WP3.
Although this delay could be perceived as negative the opposite is true. The delay has resulted in substantial cost reductions for future plants and a newly adopted hygienic standard.

As stated earlier the market drivers differed from those assumed (legislation, water scarcity and Corporate Social Responsibility goals). The price per cubic meter of water as well as (in some cases) valorisation of residues are considered to be even more important drivers.
The delay with resulting cost reductions therefore has a very positive outcome. Over 30 company visits confirm these findings.

Based on the recommendations in the professional market report IWEC has decided to initially focus on a few countries: the Netherlands, Germany and Denmark. The excellent performing reference plant in Wierden will be crucial in this approach. This approach is considered to result in enough critical mass for a wide market uptake.

2.2 Environmental benefits

The environmental benefits are presented in paragraph 1.4. Treatment and re-use of filter backwash water with ceramic membranes significantly improves the Societal Cost Indicator (SCI), a measure for environmental impact. This improvement is predominantly in Global Warming, Acidification and Human Toxicity.

The proposed treatment and re-use fits in the following legislative and policy frameworks:

- Flagship initiatives of Europe 2020. The IWEC project helps in creating a more resource efficient Europe, stimulates innovation, and promotes SME's.
- Water Framework Directive. The IWEC project (theoretically) helps to improve the quality of surface waters as (treated) backwash water is not discharged anymore into it.
- Natura 2000. The IWEC project helps in prevention of desiccation through less extraction of groundwater. This positively contributes to nature protection areas where often groundwater is extracted.
- The 6th environmental action plan
    - Protection of natural systems, the IWEC project contributes to this.
    - Reduction of carbon footprint, the IWEC project contributes to this.
    - Sustainable use of natural resources, the IWEC project contributes to this.
    - Recycling and reuse of water, the IWEC project contributes to this.
    - Higher level of living environment (no new buildings required due to the small footprint of the backwash water installation).
- Local policies
    - Legislation: stricter regulations for discharge of treated backwash water. The IWEC project can fulfil these.
    - Strict building regulations: the small footprint of a ceramic membrane plant allows placing it in an existing building.

- Permits: renewing permits for extraction of groundwater require optimal water use. The IWEC project will help with this.

In order to make the technology an acknowledged and recognised standard also the European Committee for Standardisation (CEN) is of interest to IWEC. CEN states to promote a horizontal approach for protecting the environment by integrating objectives such as sustainability, resource efficiency and climate resilience into a wide range of standardisation activities. CEN also states that they together with their national members actively engage with research and innovation communities and encourage the initiators of research/innovation projects to consider standardization at an early stage during the development of their projects.

In their Environment Campaign 2015 CEN promotes the above and askes for ideas, remarks and request. IWEC will do so and refer to her advertisements in the Parliament Magazine and Adjacent Government and of course her website.

2.3 Economic benefits

The economic benefits of treatment and re-use of filter backwash water with ceramic membranes are visualised in figure 2.

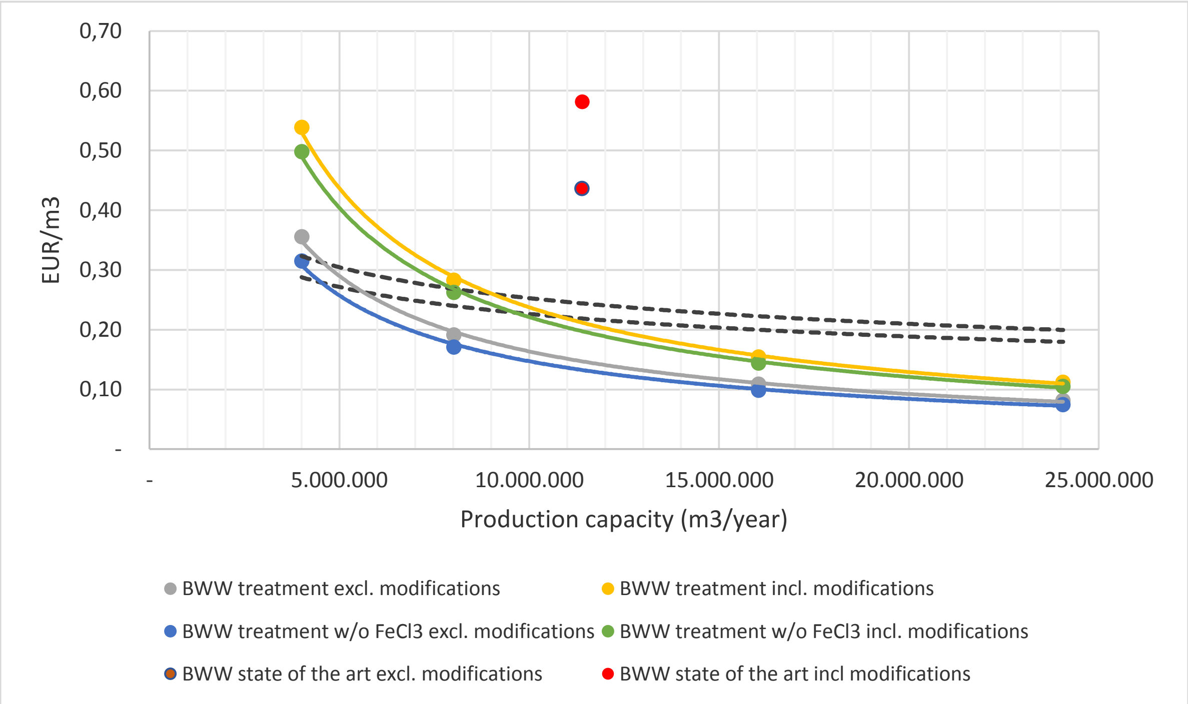

Figure 2: **Total costs for production of drinking water from groundwater (dotted lines) and associated amount of groundwater that is not extracted due to backwash water treatment and reuse. Starting point is a Wierden type of production plant with 3,16% backwash water, amortization over 15 years and a 5% discount rate.**
10 million m³/year production capacity on the horizontal axis corresponds with 313.000 m³/year groundwater that is not extracted when reusing backwash water with ceramic membranes (and 262.000 m³/year with state of the art polymeric submerged membranes).

The following can be concluded:

- For greenfield applications the cost of backwash water treatment and reuse with ceramic membranes is not exceeding the production cost of drinking water from ground water for drinking water production capacities > 4,5 million m^3/year (equals 142.000 m^3/year backwash water).
- For existing applications the cost of backwash water treatment and reuse with ceramic membranes is not exceeding the production cost of drinking water from ground water for drinking water production capacities > 9 million m^3/year (equals 284.000 m^3/year backwash water). This depends of course on cost of modifications in infrastructure (rather high for Wierden).
- Backwash water treatment and reuse with ceramic membranes results in substantial lower costs per m^3 (65% lower) compared to state of the art technologies (with submerged membranes). Replacement of these installations towards their life end is attractive as modifications in infrastructure are not required.
- The variable (or operational) costs of backwash water treatment and reuse with ceramic membranes are nil due to the fact that the savings in energy and chemicals as well as other outside boundary gains outweigh maintenance cost (in comparison with the base case where backwash water is not being reused). The costs presented in figure 2 are thus capital costs only for backwash water treated and reused with ceramic membranes.

2.4 Measures taken to ensure the autonomous economic viability of the business program

In almost all groundwater treatment plants backwash water is being produced. Since backwash water cannot be directly discharged, treatment of this water is mandatory. In order to become aware of the economic viability of the technology, IWEC researched the possibilities for substitutes and the economic performance of the technology compared to those substitutes. For the purposes of backwash water treatment, two alternatives have been studied. The first alternative to treat backwash water is the settling tank, where treated backwash water is being discharged and no drinking water is being produced out of backwash water. The second alternative is backwash water treatment by polymeric membranes (state of the art).

The base of this comparison is to map out the annual Capital Investment Costs (hereafter 'CAPEX') and the annual Operational costs (hereafter 'OPEX'). The three methods of backwash water treatment have been compared and the results are very positive for IWEC's technology that uses ceramic membranes.

For drinking water plants with a capacity > 4.5 million m^3/year (or 142.000 m^3/year backwash water) it is interesting and economically viable to treat and reuse backwash water by the IWEC technology. For smaller production locations, the economic argument loses validity, but still the environmental footprint is being reduced. For details, see figure 2 and annex 10.

The most important benefits of using the IWEC technology that ensure the economic viability are:

- Less groundwater is needed to produce the same amount of drinking water.
- The ceramic membranes have a lifetime of >15 years, are fully integer, have a high flux and result in a compact installation that complies with hygienic standards. This results in lower capital costs (CAPEX) compared to state of the art submerged polymeric membranes (65% lower).

- Also the operational costs (OPEX) are lower compared to not reusing the water or reusing it with a state of the art solution, due to a reduced energy consumption for the entire drinking water plant, less waste that is produced, less waste water that is discharged into surface water and less chemicals that are required. These economic advantages also result in significant environmental benefits, especially in Global Warming, Acidification and Human Toxicity and fit in European legislative and policy frameworks. The OPEX for reusing backwash water with ceramic membranes is nil for the somewhat bigger installation (100% reduction compared to state of the art).
- Depending on the (future) outcome of valorisation of iron and possibly lime sludge (see next chapter) further outside financial boundary gains will be obtained.

Residual treats and barriers are:

- Perceived overabundance of groundwater.
- Conservative sector with hesitancy to new technology. This will be handled by showing the performance of the Wierden plant and trying to get the technology an acknowledged and recognised standard (CEN).
- Limited IWEC marketing capacity. This will be handled by a focussed market approach to create the required critical mass for a wide market uptake.

3. WORK PLAN FOR THE NEXT PERIOD

After project end IWEC will focus on following items:
- Energy reduction by extracting the backwash water at higher lever from the buffer tank, switching of the mixers in this tank and transport the settled sludge in the buffer tank directly to the sludge thickener (Vitens/RWB).
- Valorisation of iron sludge and possibly lime sludge (Vitens).
- Further standardisation of design, production as well as material minimisation (RWB/Eurosteel).
- Full speed ahead with facts supported acquisition as described in previous paragraphs.
- Contact CEN.

4. OVERVIEW ON HOURS SPENT

An overview of the hours spent (foreseen and actually spent) is enclosed in annex 11.
The most significant deviations are related to:

- More hours spent than budgeted on WP1 due to unforeseen meetings and visits to keep the project on track.
- The market definition (WP2) required more hours because of changed market drivers and change in personnel.
- Due to the delay in WP3, the time to monitor the performance of the installation (WP4) ran short.
- In WP6 less hours are spent compared to annex 1, although lots of activities have been organised.

No transfer of budget was required for these deviations.

The deviations per work package are presented below.

WP1 – Project Management

The general progress has been monitored during the three years of operation. This contributed to a successful project. Not all circumstances had been foreseen at the start of the project. Compared to the budget, more hours have been spent to stimulate the start of WP3. On the other hand, the budget for project assistance (€22.500) has not been used, since the project assistance has been carried out by personnel of RWB. The deviations are considered necessary to improve the progress in the project. More details can be found in annex 2.

WP2 – Market definition and validation

The main activities in the market definition and validation were the market study, writing of the report and hours spent on meetings to validate the market report with Royal HaskoningDHV. The budgeted hours were based on a subcontracted market report (€20.000) and validate those results by personnel of RWB. The market study and writing of the market definition report has been performed by RWB, whereas the validation report has been generated by Royal Haskoning DHV. Moreover, changing market drivers influenced the required effort. Therefore, more hours have been spent than originally budgeted. More details can be found in annex 3.

WP3 – Engineering and construction

Although WP3 started more than one year later than planned, the targets of the work package have been reached. The estimated budget has slightly been exceeded in amount of hours, which can easily be explained by all unforeseen hours of research to find cost reductions in order to make the business case positive. More details can be found in annex 4.

WP4 – Operation and monitoring

This work package had a planned duration of 30 months. Due to delay in WP3, most activities related to this work package became relevant after the installation started up. In the last months of the project a lot of effort has been spent to monitor the results of the installation, but this is not proportionate to the budget spread over 30 months. Therefore, not all budgeted hours have been used. More details can be found in annex 5.

WP5 and 6 – Commercial exploitation and business plan and dissemination activities

Although not fact supported, over 30 company visits have been made during the IWEC project in order to promote the developed technology of RWB. In addition, RWB has visited 8 fairs where it presented the IWEC technology. After the installation was in operation, RWB wrote a business plan about the strategy of marketing, the sales targets and the potential of the selected countries. The dissemination activities of WP6 have an overlap with the means of WP5's commercial exploitation, where both activities aim to share knowledge to (potential) stakeholders of the technology.

Annex 1: Partners involved including their roles, major subcontractors, stakeholders etc.

Work package	Contribution to the project goals	Results	Partners and roles
WP1: Project Management	To ensure that the project goals are met, and the project is carried out according to the guidelines of the EU, within the given timeline and budget.	Most project goals are met. Installation is running. Project schedule has been delayed. Costs are below budget.	RWB coordinated the IWEC project as work package leader. Vitens and Eurosteel participated.
WP2: Market definition and validation	To define the European market. Identification of market drivers and sales opportunities per country/region as needed input to create and effectuate a successful business plan.	European market research has been conducted by RWB in 2012. In 2015, Royal HaskoningDHV made the final market report based on actual performance of the plant. Positive results, with a market potential that can be raised by standardization of the technology. Input of this WP has been very useful for the business plan.	RWB conducted a market research and Eurosteel participated herein (in project meetings). Royal HaskoningDHV validated the market research as major subcontractor.
WP3: Engineering and Construction	Construction of the backwash water reuse installation. Necessary to create a reference project in Europe.	Installation has been constructed and is running successfully. Since December 2014 the installation is operational and it is meeting the requirements.	Vitens is the launching customer and was work package leader. Eurosteel (skid) and RWB (design, engineering and installation) participated, Major subcontractors were Rook (underground piping) and Stork (process automation).
WP4: Operation and monitoring	Realisation of the backwash water treatment installation and monitoring of the results and therefore the realisation of - Backwash water reuse; - Less groundwater extraction; - Lower energy consumption; - Lower chemical usage. Monitoring and reporting the performance is crucial for dissemination and acquisition activities.	The monitoring time has been decreased from 27 months to 6 months, due to delay in WP3. Therefore the monitoring results cover a significantly shorter period. However, the results are very positive. Targets are met.	Vitens (work package leader) and RWB worked together in this work package. The Life Cycle Analysis has been generated by Search Consultancy B.V. (major subcontractor).

WP5: Commercial exploitation and business plan	Optimisation of the business plan with the results from WP2. Using the results from WP4 to break down the market barriers which have been identified in this proposal and thereby creating and serving a substantial European market.	The business plan and acquisition plan is ready and input from the market research has been used. More than 30 company visits have been made at potential customers to disseminate the technology. No new projects have been awarded as facts supported acquisition was not possible (yet). RWB expects two projects in 2016.	RWB was the work package leader, mainly in man-hours. Eurosteel participated in costing.
WP6: Dissemination activities	Spreading the results of the technology, project and results throughout Europe.	RWB has visited 8 fairs in the last four years where it has been promoting IWEC. Leaflets, posters and a Layman's report have been produced. Advertisements in regional and international magazines have been published and a scientific article will follow, probably in H2O. The website is online and contains various progress reports of the IWEC projects. Visitors statistics proof that the website has had over 10.000 visitors in the last three years.	RWB was work package leader and Vitens participated. The role of Eurosteel was giving comments in project meetings. RWB designed of materials and Vitens organised the opening of Wierden and wrote articles. Major subcontractors were: Ruud van Uden (production of fair stands), Decron (printing) and SlagBijAlmelo (layout of Layman's report).

Annex 2: Assessment of deliverables WP 1 - Project management

Deliverable N°	Deliverable name	Type	WP N°	Delivery date from Annex 1	Delivered (yes/no) and status (draft/final)	Submission with report	Comments on progress
D1.1	Report of kick off meeting	report	1	M1 jul12	Y final M2 aug12	PR + electronically	The delay of 1 month was caused by the fact that due to holidays not all members of the (work package) teams were available. Request to keep this document CO (see PR).
D1.2	Report of project meeting	report	1	M7 jan13	Y final M7 jan13	electronically	It became clear in this meeting that there is a serious possibility that Vitens would cancel the project due to fact that the business case became negative because of abolishment of groundwater tax. A meeting with Vitens' asset management took place a few days later. Request to keep this document CO (see PR).
D1.3	Annex to report of project meeting (confidential technical information)	report	1	M7 jan13	Y final M7 jan13	electronically	
D1.4	Technical progress report (PR), to be submitted to the EACI.	report	1	M10 apr13	Y final M11 may13	PR + electronically	The delay in the project (and corrective actions taken) were reported and accepted by EACI.
D1.5	Report of project meeting	report	1	M13 jul13	Y final M13 jul13	electronically	Request to keep this document CO (see PR).
D1.6	Annex to report of project meeting (confidential technical information)	report	1	M13 jul13	Y final M13 jul13	electronically	

Deliverable N°	Deliverable name	Type	WP N°	Delivery date from Annex 1	Delivered (yes/no) and status (draft/final)	Submission with report	Comments on progress
D1.7	Report of project meeting	report	1	M20 feb14	Y final M15 sep13	electronically	This meeting was organised after several meetings (with WP3 team, WP4 team and steering committee) to find cost reductions and possible alternative sites (also at other drinking water companies). Request to keep this document CO (see PR).
D1.8	Annex to report of project meeting (confidential technical information)	report	1	M20 feb14	Y final M15 sep13	electronically	
D1.9	Interim report (IR) (technical and financial) including performance indicators to be submitted to the EACI.	report	1	M20 feb14	Y final M20 feb14	IR + electronically	The delay was reported but not accepted by EACI as crucial deliverables could not be delivered. Request to keep this document CO (see PR).
D1.10	Report of project meeting	report	1	M26 aug14	Y final M30 dec14	electronically	This meeting was organised around the IWEC mission by Mr Lionetti of EACI. Request to keep this document CO (see PR).
D1.11	Annex to report of project meeting (confidential technical information)	report	1	M26 aug14	Y final M30 dec14	electronically	A plan was presented how to fulfil the requirements in a (very) condensed timeframe.
D1.12	Report of project meeting	report	1	M33 mar15	Y final M35 may15	electronically	Request to keep this document CO (see PR).
D1.13	Annex to report of project meeting (confidential technical information)	report	1	M33 mar15	Y final M35 may15	electronically	
D1.14	Final report (FR) (technical and financial) including performance indicators to be submitted to the EACI.	report	1	M38 aug15	Y final M38 aug15	FR	

Annex 3: Assessment of deliverables WP 2 – Market definition and validation

Deliverable N°	Deliverable name	Type	WP N°	Delivery date from Annex 1	Delivered (yes/no) and status (draft/final)	Submission with report	Comments on progress
D2.1	European market definition	report	2	M6 dec12	Y final M10 apr13	PR + electronically	Delay of 4 months initiated by overall delay in project. The final professional market report is made after 6 months' operation of the system. This is as per request of the company that made the professional marketing report.
D2.2	Validation report	report	2	M12 jun13	Y final M36 jun15	electronically	The validation report was made after 6 months operation of the plant to have enough operational data. The delay is caused by the delay in WP3.

Annex 4: Assessment of deliverables WP 3 – Engineering and Construction

Deliverable N°	Deliverable name	Type	WP N°	Delivery date from Annex 1	Delivered (yes/no) and status (draft/final)	Submission with report	Comments on progress
D3.1	Draft blueprint of design	Blueprint	3	M2 aug12	Y final M4 oct12	PR + electronically	Delay of 2 months as mentioned in Kick-off meeting. Caused by redefinition of scope, required to obtain new permits (WABO)
D3.2	Final blueprint and design specifics	Blueprint	3	M4 oct12	Y final M16 ,17 oct13	PR + electronically	First version of M10 has been sent with PR. Delay of another 11 months is caused by decision of Vitens in M13 to finally stop the project as the business case became negative, mainly due to the abolishment of groundwater tax. From M13-M17 the WP3/WP4 teams and the steering committee looked into possible cost reductions. Simultaneously alternative sites were evaluated (also at other drinking water companies).
D3.3	Installation for reuse of backwash water.	Full scale installa-tion	3	M6 dec12	Y final M29 nov14	electronically	Delay of another 10 months is caused by time required for approval of the board of Vitens (1 month), redesign to the new hygienic standards (4 months) and for building the reuse installation (5 months). The building time took 7 months instead of 2 months. This is caused by the fact that the plant was built in an engineered to order way, requiring additional upfront engineering.
D3.4	Report of test run	Report	3	M7 jan13	Y final M29 nov14	electronically	The test run went very smoothly, gaining 1 month time. This reduced project delay from 23 months to 22 months.
D3.5	Report of first full scale run	Report	3	M9 mar13	Y final M30 dec14	electronically	The full-scale run also went smoothly, again gaining 1 month time. Total project delay diminished from 22 months to 21 months.

Annex 5: Assessment of deliverables WP 4 – Operation and Monitoring

Deliverable N°	Deliverable name	Type	WP N°	Delivery date from Annex 1	Delivered (yes/no) and status (draft/final)	Submission with report	Comments on progress
D4.1	Monitoring plan	Report	4	M3 sep12	Y final M27 sep14	PR + electronically	First version of 01-2013 sent with PR. In M27 the monitoring plan was adapted to the new hygienic standard and to the fact that the membrane received a KIWA ATA approval which reduces the need for extensive chemical analyses to check the membrane (leaching) itself.
D4.2	Base line results	Report	4	M6 dec12	Y final M32 feb15	electronically	Baseline monitoring started from the beginning of the project. There was no need to report earlier due to the delay in the project.
D4.3	Monitoring reports	Report	4	M12, 18,24, 30 jun13, dec13, jun14, dec14	Y final M34 apr15	electronically	Due to the project delay the time for monitoring is drastically reduced from 27 to 6 months. As the membrane is KIWA ATA approved, the process did run very stable and the groundwater source (as usually) delivers a constant water quality frequent reporting was not required. It was decided to have only one intermediate and one final report.
D4.4	Expert meeting minutes	Report	4	M6, 12,18, 24,30 dec12, jun13, dec13, jun14, dec14	Y final M32 ,35 feb15, may15	electronically	For the same reason as above only two expert meetings were held.
D4.5	Final monitoring and evaluation report	Report	4	M36 jun15	Y final M36 jun15	electronically	Due to successful and efficient monitoring (smoothly running plant and no need to check membrane leaching) the project delay is partly neutralized. Further monitoring will of course take place and will focus amongst others on further energy reduction.
D4.6	LCA	Report	4	M34 apr15	Y final M36 jun15	electronically	LCA has been updated on 30-june-15 to make it better readable (with outside system boundary gains). It arrived too late to be uploaded. Therefore included in Final Report.

Annex 6: Assessment of deliverables WP 5 – Commercial exploitation and business plan

Deliverable N°	**Deliverable name**	**Type**	**WP N°**	**Delivery date from Annex 1**	**Delivered (yes/no) and status (draft/final)**	**Submission with report**	**Comments on progress**
D5.1	Business plan	Plan	5	M12 jun13	Y final M36 jun15	electronically	The business plan was made after 6 months operation of the plant to have enough operational input. The delay is caused by the delay in WP3.
D5.2	Intermediate acquisition plan	Plan	5	M18 dec13	Y final M36 jun15	electronically	Delay as for same reason as above.
D5.3	Quotation for membrane installation	Quotation	5	Starting from M12 jun13	Y final M1 jul12	electronically	Started earlier, but not yet successful due to absence of reference plant with operational data.

Annex 7: Assessment of deliverables WP 6 – Dissemination activities

Deliverable N°	**Deliverable name**	**Type**	**WP N°**	**Deivery date from Annex 1**		**Delivered (yes/no) and status (draft/final)**				**Submission with report**	**Comments on progress**
D6.1	Project information updates(pre-defined)	text, ppt	6	M1 and together with reports	jul12	Y	final	M3,11 ,26,36	sept12, may13, aug14, jun15	PR + electronically	
D6.2	Inputs to additional common information material related to eco innovation actions (pre-defined)	input to posters, articles for newsletters, visuals, interviews	6	Upon request		Y			sep13	electronically	-
D6.3	Project presentations (pre-defined)	ppt, presentation,	6	Upon request		Y	final	M11, 11	may13, may13	IR + electronically	Seminar Utrecht/ Brussels
D6.4	Layman's report (pre-defined)	Brochure	6	M32	feb15	Y	final	M36	jun15	electronically	
D6.5	Evaluation report including performance indicators (pre-defined)	Report	6	2 years after project	jun17	N				To be agreed upon	
D6.6	Dissemination plan	Plan	6	M2	aug12	Y	final	M4	oct12	PR + electronically	
D6.7	Website	Report with prt scrn of website and statistics	6	Website online in M3 and report on statistics at M34	sep12, apr15	Y	final	M8,36	feb13, jun15	PR + electronically	
D6. 8	Project folders, brochures and Leaflets	Folders, brochures and leaflets	6	M11	may13	Y	final	M38, 34	oct13, apr15	IR + electronically	
D6. 9	Project Posters	Poster	6	M10	apr13	Y	final	M36	jun15	electronically	

Annex 8: (Market) validation to verify functioning of the system after six months of operation (optimised scenario)

<table>
<tr><th>Objective</th><th colspan="2">Performance parameter</th><th>Relative Impact Realised</th><th>Relative Impact Expected</th><th>Comments</th></tr>
<tr><td rowspan="5">Water and Energy</td><td rowspan="3">Water</td><td>Reduced water consumption</td><td>3,1%</td><td>5,0%</td><td>The average iron content in the groundwater was expected to be higher (newly installed well fields have lower iron contents than expected).</td></tr>
<tr><td>Waste water reuse</td><td>99%</td><td>99%</td><td>As predicted.</td></tr>
<tr><td>Utilisation rate</td><td>40%</td><td>80%</td><td>Lower groundwater consumption, lower % of backwash water and additional safety margin.</td></tr>
<tr><td rowspan="2">Energy</td><td>Reduced energy consumption</td><td>25%</td><td>30%</td><td>Compared to the base case (no reuse). The lower reduction is caused by the fact that it costs less energy to extract groundwater (0,15 kWh/m3 instead of 0,23 kWh/m3).</td></tr>
<tr><td>Reduced energy consumption</td><td>81%</td><td>80%</td><td>Compared to state of the art. As predicted.</td></tr>
<tr><td rowspan="2">Chemicals</td><td rowspan="2">Chemical usage reduction</td><td>FeCl3 42% solution</td><td>90%</td><td>90%</td><td>As predicted.</td></tr>
<tr><td>Cleaning chemicals</td><td>83%</td><td>50%</td><td>Higher reduction than predicted.</td></tr>
</table>

<table>
<tr><th>Objective</th><th colspan="2">Performance parameter</th><th>Impact Realised</th><th>Impact Expected</th><th>Comments</th></tr>
<tr><td rowspan="2">Investment</td><td rowspan="2">Capital costs</td><td rowspan="2">EUR/m3</td><td>0,329</td><td>0,40</td><td>Ceramic membrane in standardised execution @ 35% Utilisation Rate whereas expectation was 80% utilisation (over dimensioned).</td></tr>
<tr><td>0,387</td><td>0,58</td><td>State of the art @ 49% Utilization Rate.</td></tr>
</table>

The backwash water system performs better that predicted with the exception of energy usage. This is caused by the fact that baseline monitoring reveals that it costs less energy to extract groundwater and has nothing to do with the performance of the ceramic membrane plant.

Based on experience of the company that made the professional market report the European backwash quantity will be 3-5% of the groundwater extraction instead of 5-10%. This results in a backwash water quantity of 37 billion m^3/y (drinking water consumption in Europe * 3-5% * 60% (drinking water from groundwater) = 0,67 – 1,11 billion m^3/y. This is lower than predicted. However if industrial consumption is included, the backwash water quantity will exceed 6,8 billion m^3/y, which is much more than predicted.

The submarket size has been calculated with 5% backwash water, which should be 4% (80%). As can be seen in the table above the capital costs are lower than predicted (0,329/0,400 = 82%). When standardisation of the installation takes place and utilisation rate increases from 35% to 80% investment will be lower (67% on average). This results in a submarket volume of EUR 565 million * 0,80 * 0,82 * 0,67 = EUR 250 million.

Annex 9: Performance indicators at the end of the project

Executive Agency for Competitiveness and Innovation CIP Eco-innovation first application and Market Replication Projects Call 2011 Call Identifier: CIP-EIP-Eco-Innovation 2011							
INDICATORS					**IWEC**		
At the end of the project							
Objective	**Indicators**		**Absolute Impact**		**Relative Impact**		**Comment**
Improved Environmental Performance	Greenhouse gas emissions	CO2 (CML2013)	-1,43	tons	87%	change to baseline	
		Methane (CML2013)	-0,0027	tons	79%	change to baseline	
	Air quality	Particulate matters, (ReCipe)	-2,30	kg PM10 eq	61%	change to baseline	
	Reduction / substitution of dangerous substances	Irritant / Corrosive			not applicable		
		Mutagenic / Carcinogenic (Eco indicator 99 Carcinogenic)	-0,0001	DALY	149%	change to baseline	
		Toxic (CML2013)	-79,50	tons 1,4-DB eq	86%	change to baseline	
		Persistent / Bio accumulative			not applicable		
	Waste management	Prevention	33.295	tons	99%	change to baseline	33.295 tons/year reused backwash water
		Waste minimization	33.295	tons			Water
			5,2	tons			Iron sludge
		Reuse of waste / Substance recovery	no changes				
		Material recycling	no changes				
		Waste diverted from landfills	no changes				
		Hazardous waste	0,005	ton			Increase due to installed infrastructure
Better use of natural resources	Reduced resource consumption (excluding energy)	Abiotic depletion, non fuel (AD) CML2013	-0,013	kg SB eq	105%	change to baseline	
	Water	Reduced water consumption	34.380.396	litres	3,1%	change to baseline	Reduced groundwater intake
		Waste water reuse	33.294.890	litres	99%	change to baseline	Reuse of backwash water
	Energy	Energy from RES	2.110	kWh	-25%	change to baseline	Energy is green with guarantee of origin
		Reduced energy consumption	2.110	kWh	-25%	change to baseline	Compared to current practices
		Reduced energy consumption	26.460	kWh	-81%	change to baseline	Compared to state of the art solutions
Economic Performance / Market Replication	Business development / Market replication	Replication	0		not applicable		It was expected that at the end of the project 2 new installations in the Dutch market were realised. Due to delay in project not feasible.
	Market potential	market size per year in million Euros	250	mln euros	-56%	change to baseline	Less BWW than expected (5-10% changed into 3-5%). Standardization will lower the sales price, which makes the technology more competitive.

		market size in number of customers	14	customers	40%	change to baseline	
	Entry in new transnational markets		3	markets			Netherlands, Denmark, Germany
	Entry into different sectors		1	sector			This specific systems is only applicable at the production process of drinking water, however the ceramic membranes have a larger market potential.
	Reduction of cost per unit or process		0,33	Euros / m3	65%	change to baseline	Compared to state of the art solutions.
	Payback Time	capital invested / net income	5	years			
	Patents				not applicable		
Others	Chemical usage reduction	all chemicals	4.312	kg			Reduction of FeCl3 and NaOH, introduction of 10 % HCl , 35 % H2O2, 15 % NaOCl and 48% Citric acid
		FeCl3 42% solution	2.284	kg	90%	change to baseline	
		cleaning chemicals	4.081	kg	83%	change to baseline	Compared to state of the art solutions
	Less transport	reduction in movements			11%	change to baseline	See fig 4 LCA report

Annex 10: Performance indicators at the end of the project for one year of operation at optimised energy scenario

Executive Agency for Competitiveness and Innovation CIP Eco-innovation first application and Market Replication Projects Call 2011 Call Identifier: CIP-EIP-Eco-Innovation 2011							
INDICATORS					**IWEC**		
During one year operation at optimised enegy scenario							
Objective	**Indicators**		**Absolute Impact**		**Relative Impact**		**Comment**
Improved Environmental Performance	Greenhouse gas emissions	CO2 (CML2013)	-9,42	tons / year	90%	change to baseline	
		Methane (CML2013)	-0,018	tons /year	86%	change to baseline	
	Air quality	Particulate matters, (ReCipe)	-15,54	kg PM10 eq / year	64%	change to baseline	
	Reduction / substitution of dangerous substances	Irritant / Corrosive			not applicable		
		Mutagenic / Carcinogenic (Eco indicator 99 Carcinogenic)	-0,0010	DALY / year	158%	change to baseline	
		Toxic (CML2013)	-524,14	tons 1,4-DB eq / year	89%	change to baseline	
		Persistent / Bio accumulative			not applicable		
	Waste management	Prevention	212.620	tons / year	99%	change to baseline	212.620 tons/year reused backwash water
		Waste minimization	212.620	tons / year			Water
			33	tons / year			Iron sludge
		Reuse of waste / Substance recovery	no changes				
		Material recycling	no changes				
		Waste diverted from landfills	no changes				
		Hazardous waste	0,035	ton / year			Increase due to installed infrastructure
Better use of natural resources	Reduced resource consumption (excluding energy)	Abiotic depletion, non fuel (AD) CML2013	-0,09	kg SB eq / year	115%	change to baseline	
	Water	Reduced water consumption	219.552.000	litres / year	3,1%	change to baseline	Reduced groundwater intake
		Waste water reuse	212.620.000	litres/ year	99%	change to baseline	Reuse of backwash water
	Energy	Energy from RES	-10.153	kWh / year	25%	change to baseline	Energy is green with guarantee of origin
		Reduced energy consumption	-10.153	kWh / year	-25%	change to baseline	Compared to current practices
		Reduced energy consumption	-127.320	kWh / year	-81%	change to baseline	Compared to state of the art solutions
Economic Performance / Market Replication	Business development / Market replication	Replication	0		not applicable		It was expected that at the end of the project 2 new installations in the Dutch market were realised. Due to delay in project not feasible.
	Market potential	market size per year in million Euros	250	mln euros	-56%	change to baseline	Less BWW than expected (5-10% changed into 3-5%). Standardization will lower the sales price, which makes the technology more competitive.

		market size in number of customers	14	customers	40%	change to baseline	
	Entry in new transnational markets		3	markets			Netherlands, Denmark, Germany
	Entry into different sectors		1	sector			This specific systems is only applicable at the production process of drinking water, however the ceramic membranes have a larger market potential.
	Reduction of cost per unit or process		0,33	Euros / m3	65%	change to baseline	Compared to state of the art solutions
	Payback Time	capital invested / net income	5	years			
	Patents				not applicable		
Others	Chemical usage reduction	all chemicals	16.068	kg	90%	change to baseline	Reduction of FeCl3 and NaOH, introduction of 10 % HCl , 35 % H2O2, 15 % NaOCl and 48% Citric acid.
		FeCl3 42% solution	3.915	kg	90%	change to baseline	
		cleaning chemicals	6.996	kg	83%	change to baseline	Compared to state of the art solutions
	Less transport	reduction in movements			11%	change to baseline	See fig 4 LCA report

Annex 11: Overview of hours spent (foreseen and actually spent)

Project Hours (Partner / Workpackage)	
Project Number and Acronym	**ECO/11/304469/S12.625202 / IWEC**
Reporting period (M1 to MX)	**2012-07 to 2015-06**
Deliverable (PR, IR, etc)	**Final report**

Total Project Hours:	**20.526,0**
Total Spent Project hours:	**18.205,3**

Hours x Partners	WP1		WP2		WP3		WP4		WP5		WP6		WP7		WP8		WP9		**Total hours x Partner**	
	Annex I*	Spent**	Annex I*	Spent**	Annex I*	Spent**	Annex I*	Spent**	Annex I*	Spent**	Annex I**	Spent**	Annex I*	Spent**	Annex I*	Spent**	Annex I*	Spent**	Annex I*	Spent**
RWB	720,0	1.371,0	400,0	599,0	5.234,0	5.601,7	1.240,0	789,3	1.080,0	1.141,5	1.860,0	1.169,8							**10.534,0**	**10.672,3**
Vitens	600,0	718,0			4.950,0	3.488,0	2.000,0	493,0			740,0	557,0							**8.290,0**	**5.256,0**
Eurosteel	198,0	476,0	40,0		1.310,0	1.801,0					154,0								**1.702,0**	**2.277,0**