NEW URBAN ENERGY

CITY-zen

Surface water regeneration monitoring for district cooling network

MONITORING REPORT D7.3

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N° DoW	Organization	Acronym	Country
1	Vlaamse instelling voor technologisch onderzoek	VITO	BE
2	Stichting Amsterdamse Economic Board	AIM	NL
3	Universiteit van Amsterdam	UVA	NL
4	Westpoort Warmte B.V.	WPW	NL
5	Alliander	LIAN	NL
6	HESPUL Association	HESP	FR
7	The Queens University of Belfast	QUB	UK
8	Th!nk E	THNK	BE
9	KEMA Nederland BV	KEMA	NL
10	Technische Universiteit Delft	TUD	NL
11	Stichting Waternet	WAT	NL
14	AEB Exploitatie BV	AEBE	NL
15	Daikin Airconditioning Netherlands B.V.	DAIK	NL
16	Siemens Nederland NV	SIEM	NL
17	Universita'degli Studi di Siena	UNIS	IT
18	Ville de Grenoble	MUNG	FR
19	Commissariat a l'Energie Atomique et aux Energies Alternatives	CEA	FR
20	Compagnie de Chauffage Intercommunale de l' Agglomeration Grenobloise	CCIA	FR
21	Gaz Electricite de Grenoble	GEG	FR
22	SAS ATOS Worldgrid	ATOS	FR
23	Clicks and Links Ltd&L	C&L	UK
24	Sanquin	SANQ	NL
25	Grenoble-Alpes Métropole	METRO	FR
26	Greenspread Projects BV	GREE	NL
27	Agence Locale de l'Energie et du Climat de la Métropole Grenobloise	ALEC	FR

DELIVERABLE INFORMATION

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Title	**Surface water regeneration monitoring for district cooling network**
Lead organization	AEBE
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1.0	18/10/2019	Jannis van Zanten	Final version

ABSTRACT

Surface water regeneration for district cooling network

A plant pumping cold water out of the river IJ in winter and storing the cold for cooling apartments during hot summer days for 2700 apartments and utility in a new build district Houthaven in Amsterdam.

In this report the results of the cooling plant and CO2 reduction over 2018 will be reported.

Main results 2018:

- The Seasonal Performance Factor (SPF) of the Comfort Cooling in Houthaven was 33,5.
- The goal in 2014 was a COP of 3,5.
- The reduced CO2 for 1555 dwellings was 280 tons of CO2 in 2018.

Future results

The results of the monitoring of the system are required by Dutch law. These results will be shared with EU as well. To make a comparison in years and view the results of a complete comfort cooling system with 2700 connections.

EXECUTIVE SUMMARY

Key Partners
Who are our key partners (suppliers, public authorities, etc.)?
Public authorities which decided to make an obligation to connect to the comfort cooling site

For which key resources do we rely on partners?
None
For which key activities do we rely on partners?
None

Key Activities
What key activities does our VP require?
- Production of cold by storing cold in ATES during wintertime harvested from surface water.
- Delivering cold in buildings during summertime out of ATES

Key Resources
What key resources does our VP require?
- Cold surface water during wintertime
- Sustainable power for pump energy

Value Proposition
Which citizen need(s) are we satisfying? How important is this to them?
Need of cooling during summertime

What is our Value Proposition (VP), i.e. our concrete solution to solving the aforementioned problem?
Sustainable cold

Is our solution better than any alternative? Yes, cheaper, more sustainable and reliable in comparison with conventional chillers

Customer Relationships
What type of relationship does each of our customer segments expect us to establish and maintain with them?
- Customer relation
Which ones have we established?
- Over 600 customers today, and estimate over 3000 in 2020
How are they integrated with the rest of our business model?
- They are also heat customers

How costly are they?
We earn money

Channels
How are we reaching customers? Comfort cooling is an obligation in the building process. Customers are informed from the beginning.
Which ones work best?
Which ones are most cost-efficient?
How are we integrating them with customer routines?
Obligation to connect is common in the heat business in Amsterdam

Customer Segments
For whom are we creating value?
Sustainable comfort cooling for inhabitants of Houthaven neighborhood, utilities, schools and the city of Amsterdam.

Who are our most important customer
Customers

Project Internal Cost Structure
Which costs do we have? Which ones are fixed? Which ones are variables?
- Fixed: Investments in comfort cooling plant and network
- Variable: energy for pumps

Which are the most important ones?
- fixed

What scope is there for cost reduction (e.g. streamlining processes, rethinking provider network, economies of scale and/or scope)?
This project was possible because of scale. The obligation to connect of the city was necessary!

Project Internal Revenue Streams
What are our different revenue streams (if variation across products, customer type, distribution channel, geography, etc.)?
- connection fee
- fixed fee annually of 162,- euro in 2016

There is no Gj-price.
How much does each revenue stream contribute to overall revenues? (For each stream, a value can be obtained through the following equation "Revenue = Price/Unit * Volume Sold")
- connection fee almost covers the investments in production and network. Fixed fee covers operational costs.
What scope is there for revenue maximization (e.g. better price points, information campaign)?
-Speeding up building process in Houthavens

Additional community costs/disruptions
Does our VP lead to socio-environmental disruptions/harms?
No

Can we precisely measure the impact (ideally, monetarily)? For our enterprise (financial, brand, regulators)? For society by enlarge? What scope for improvement is there?
The most important question is of comfort cooling is necessary and the city obligate to connect. The system is available in the city and is sustainable.

Additional community Benefits
What socio-environmental contributions does our VP make?
- sustainable cold
Can we precisely measure the impact (ideally, monetarily)? For our enterprise (financial, brand, regulators)? For society by enlarge? Can we maximise this?
Yes when the system is fully operational in a few years time. The impact can be precisely measured.

Overall assessment
What is the community impact?
Sustainable comfort cooling for Houthaven

Is our BM financially sound? What are the promises and risks here?
Largest risk is the building speed. The others are known techniques: ATES and pumping water, which are combined for the first time.

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CHAPTER 1 – Introduction

1.1. Comfort cooling in the Houthaven

City-zen partners Westpoort Warmte and AEBAmsterdam have developed a plant which enables the use of cold from the adjacent river IJ for cooling of buildings in the Amsterdam Houthaven district. About ten years ago the City of Amsterdam decided the Houthaven district had to become a 100% climate neutral area. The entire energy demand of the over 2000 new-build homes, offices, school and other buildings had to be as sustainable as possible, based on the principle of 'trias energetica'. Back then the city believed cooling would be in high demand for comfortable living. So it decided that all newly-build apartments had to be connected to a central cooling system. That's how the idea for the comfort cooling system – a plant pumping cold water out of the river IJ in winter and storing the cold for cooling apartments during hot summer days – was born. In addition the apartments were connected to the city heat system in which heat is generated by the waste-to-energy plant AEBAmsterdam.

1.2. The installation

The installation of the comfort cooling plant is build in 2014 in the basement of one of the new blocks in the Houthaven.

In 2015 the first users were connected to the comfort cooling system and the district heating. Ultimo 2018 more than 1500 dwellings were connected.

1.3. THE RESULT

Combining the sustainable cooling and district heating system, every home in the Houthaven district emits 80 % less CO2-emission than apartments using a gasfired boiler and air-conditioning. But, more importantly, it creates comfortable living. The public goals of a reliable, sustainable and affordable energy system for the inhabitants of Houthaven have been achieved.

1.4. THE EXPANSION

Ultimo 2018 1550 dwellings and other buildings were connected tot the comfort cooling. The housing market in Amsterdam is booming and there is shortage of development areas. The total planned number of 2200 dwellings is raised to almost 2700 and will be build in the coming years. The outlook is that the comfort cooling system will be used at its maximum capacity. This extra capacity of wells, heat exchangers and pumps is under construction.

Pontsteiger is added to the Development in the Houthaven District in 2015 and is a development of circa 350 dwellings.

1.5. MAIN LESSONS LEARNED

- Main question is comfort cooling needed? Cooling is in the Netherlands for the premium housing sector. It's not a common product in new build houses.
- The system is a collective system so obligation to connect is needed to make a feasible business case. WestpoortWarmte only offers comfort cooling if the developer or City are demanding comfort cooling and guarantee a certain amount of connections.
- Surface water and ATES must be available to create the system. The capacity of both determine the scale of the system in a (new) development.

CHAPTER 2 – Task 6: Surface water regeneration for district cooling network (AEBE, M1-M42)

2.1. DESCRIPTION OF WORK OF TASK 6

2.1.1. Original description

Amsterdam Waste to Energy Division (AEBE) will implement a sustainable district heating and innovative comfort cooling solution in a brown field development area, Houthaven. The cooling will be done with surface water regeneration and shall form the cooling extension of the district heating that is sourced from the waste incineration plant of AEBE. With this combination 77% CO2 emission reduction can be realized compared to traditional heating and cooling and a target number of 2000 residential units will be connected.

The cooling system will generate cold water in wintertime through free cooling with the outside air, which is being stored for usage during summertime using Aquifer Thermal Energy Storage technique. The system is planned to be equally sized to the distribution grid of heat, servicing approximately 300 houses (600 kW) per system.

Due to usage of a natural cooling source (cold air in wintertime) and low energy requirement, a very high COP of 8.5 should be feasible. The geographic positioning of Houthaven at the river IJ provides a possibility to make the cooling system even more sustainable by connecting the system with the surface water to generate cooling. By monitoring the system for a period of 3 years, knowledge can be obtained about the usage of the system and the future systems. The estimated savings are summarized in the table below.

This concept is called “comfort cooling” and guarantees the dwellings to stay a few degrees under the outside temperature in summertime which gives a comfortable feeling. The sustainable part comes from wintertime cooling of the ATES water reservoirs by surface water of the IJ instead of using rooftop air cooling. Therefore roof space is saved for solar PV and electricity for the air coolers. The add on of surface water coolers gives the additional cost. The whole concept is an unique combination of different types of cooling to give cityzens a comfortable house at low costs and prevents them from buying energy expensive split units.

	Amount	Unit	Comments
Investment	14,000,000	€	
Yearly income/savings	150	€/year	Per household

Duration of income/savings	> 30	Years	
Simple pay-back time	16	Years	
CO_2 savings per year	3,500	Tonne/year	
Total CO_2 savings	105,000	Tonnes	
CO_2 abatement cost effectiveness	133	€/tonne	Based on the investment and total CO_2 savings (much lower or even negative if the energy savings for the inhabitants are included)
General comments			

The work consists of:

- the detailed design of the cooling system with sizing of the components;
- design of measurement/monitoring system;
- design of the surface water subsystem;
- realization of the cooling system;
- realisation of the surface water connection;
- realisation of monitoring facility;
- realization of cooling network.

Total costs approximately:

Partner	AEBE	WPW
Effort Other costs, including travel (€)	14	 810000

Additional cost: cooling network € 3.6 M, (non-eligible)

surface water connection € 540 000

monitoring facility € 180 000

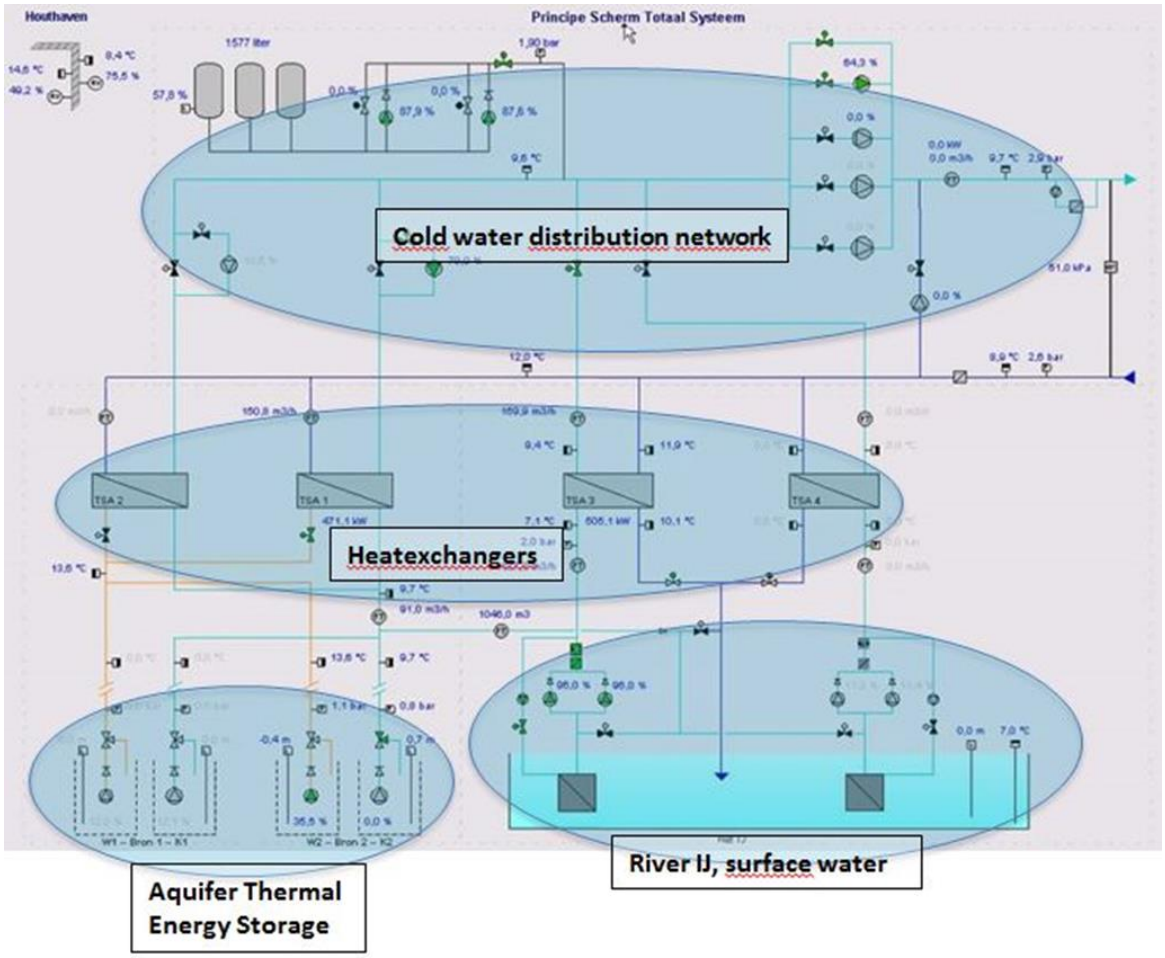
connection to smart metering platform € 90 000

2.1.2. No adjustments or changes were made in the description of work

No adjustments or changes were made in the description of work during the realisation of the project.

CHAPTER 3 – Design and monitoring

3.1. SYSTEM DESIGN COMFORT COOLING HOUTHAVEN



3.1.1. Financials: building and costs

The bulding cost of the installation were in budget. The main parts of the system are proven technology. So the pumps, ATES and network were build in budget.

The building of the cooling plant bij subcontractors costed in the years 2014 and 2015 almost € 1,2 million. The projectmanagement hours by Westpoort Warmte are not included in the Cityzenproject subsidies.

The maintenance of the system is expected to be similar to the district heating part of the neighbourhood. Normal maintenance is done. The whole system is brand-new no unexpected maintenance was needed.

3.1.2. Technical lessons

The system operates well, cold is delivered at the customers. The problems in the control and monitoring of the system are solved in 2018. The problems were a lack of meters and validation problems of the results. This problem is solved by adding and validating the meters of the system.

3.1.3. Business case: possible by larger scale and obligation to connect

The system is build to be cheaper and more sustainable than conventional chillers. Users paid in 2018 a fixed fee of 182 inc. VAT. There is no variable fee per GJ. There is also a connection fee when the building is build. The city of Amsterdam obliged all buildings to connect to the district heating and comfort cooling system. The combined connection fee is € 8.500 exc VAT. The cold part costs around € 3.500 exc.

The main costs are the initial cost of the network and the installations. During operations there are costs for electricity and maintenance.

The main risk of the project are the numbers and the speed of the connections. The numbers are covered by the obligation to connect imposed bij the City. The scale of the project in combination with the obligation made the project possible.

The speed is a risk that is covered by the company. A slower building speed increases the cost of capital.

3.1.4. Is is possible to duplicate the comfort coolingsystem?

The system is proven technology and easy to duplicate, but there are boundary conditions.

- Surface water must be available to harvest cold during wintertime;
- Aquifer thermal energy storage must be possible;
- Obliation to connect to reduce the financial risk of implementing the system.

The project needs a certain size but is easy to scale with more storage and network.

But, before solving or investigation the boundary conditions, the main question has to be answered: Is comfort cooling wanted or needed? In Amsterdam the latest buildingprojects are without cooling. Only the topsector of new build homes have some sort of cooling for the few days a year it is needed.

3.2. MONITORING ACTIVITY

3.2.1. Description first objective – general performance

- Incoming temperatures heat exchangers [°C]
- Outgoing temperature heat exchangers [°C]
- Flow rate through heat exchangers [m^3/month]
- Derived from above CO_2 reduction, energy savings and heat production are measured, respectively [Tons/year, €, GJ/year]

Note: CO_2 reduction and energy savings are related to alternative ambient cooling systems such as electrical chillers.

The general performance will become clear in the SPF of the current system and will be compared with the scenario's as written in the IF report (february 2019). (Attached, in Dutch)

A standard chiller has a Coefficient of Performance of 3,5. This means that a kWh of electricity produces 3,5 kWh of cold This will be used to calculate the avoided CO_2.

3.2.2. Second objective – financial competitiveness

The alternative ambient cooling systems will also be compared to conventional cooling systems in terms of investments and operational costs.

The connection fee for a conventional chiller for around 60 m2 costs around € 3.500 inc taxes and installation. But the installation has to be replaced after ca 15 years at the expense of the owner. The cost of electricity is paid by the owner and depends of the usage.

The connection fee of the cooling system is part of the total package for district heating as well. But the amount is € 4.200 including VAT. On top of that there is a fixed fee of € 165 per annum. But there are no maintenance costs, replacementcosts or GJ-fee. The comfort cooling is cheaper than a chiller, but of course more expensive than no chiller at all.

3.2.3. Period and frequency of monitoring

The monitoring results shall be released monthly for a period of at least three years. Monitoring has started in 2017. But due to problems only from 2018 will be reported. The upcoming years will be reported for City-Zen.

The monitoring of the system is obligatory for two reasons:

- City-zen
- ATES systems are obliged by Dutch law to monitor and justify the results of the operation.

The monitoringsystem is very basic and the minimum required under Dutch law. This is because there is no commercial value of all the monitoring. The costs of the monitoring and the system are higher than the profit. The customers used, in comparison with heat, a very small amount of cold. The costumer pays an annually fixed fee and no GJ-price.

3.2.4. Monitoring results 2018

Houthaven **2018**

	Koudeopwekking (WKO)			Koude aan bronnen ontrokken			Koude geladen in de bronnen WKO				Directe koudelevering vanuit oppervlaktewater			
Maand	Koude productie (kWh)	E-verbruik (kWh)	COP	Gemiddelde temp. koude Bron (°C)	Gemiddelde temp. warme Bron (°C)	Debiet (m^3)	Koude regeneratie (kWh)	Gemiddelde temp. warme Bron (°C)	Gemiddelde temp. koude Bron (°C)	Debiet (m^3)	Directe koudelevering (kWh)	Gemiddelde aanvoertemp (°C)	Gemiddelde retourtemp (°C)	Debiet (m^3)
jan.-18	30.013	3.165	9,48	9,48	11,67	11.772	0	-	-	-	0	n.v.t.	n.v.t.	0
feb.-18	25.545	2.694	9,48	10,53	12,64	10.376	71.738	12,8	7,4	11.335	0	n.v.t.	n.v.t.	0
mrt.-18	3.629	4.640	0,78	7,90	9,15	2.548	97.452	12,2	8,5	22.576	0	n.v.t.	n.v.t.	0
apr.-18	30.192	3.214	9,39	9,33	12,78	7.586	18.724	12,5	9,2	4.875	0	n.v.t.	n.v.t.	0
mei-18	153.552	2.595	59,16	10,14	15,98	21.694	1.133	13,4	11,2	546	0	n.v.t.	n.v.t.	0
jun.-18	210.078	3.496	60,09	11,83	16,99	34.930	0	-	-	-	0	n.v.t.	n.v.t.	0
jul.-18	406.530	7.078	57,44	12,72	17,25	77.174	0	-	-	-	0	n.v.t.	n.v.t.	0
aug.-18	385.033	6.834	56,34	12,90	17,31	74.976	0	-	-	-	0	n.v.t.	n.v.t.	0
sep.-18	200.769	3.893	51,57	12,95	17,13	41.474	0	-	-	-	0	n.v.t.	n.v.t.	0
okt.-18	141.841	3.406	41,64	12,94	16,66	32.708	3.676	16,2	12,9	993	0	n.v.t.	n.v.t.	0
nov.-18	47.865	7.818	6,12	12,84	16,37	11.643	171.998	16,5	10,1	23.128	0	n.v.t.	n.v.t.	0
dec.-18	52.773	1.528	34,55	10,58	14,79	10.630	4.528	14,2	9,5	944	0	n.v.t.	n.v.t.	0
Totalen (jr)	1.687.820	50.361				337.511	369.249			64.397	0			
							22%							
		SPF=	33,5											

Comments about the system and the year 2018

- The neighbourhood is in development. The cooling plant is oversized for the current moment. In 2018 extension and modification for extra capacity has been build. This reduced the Seasonal Performance Factor (SPF).
- The SPF is high because not all the produced cold is regenerated in 2018. This effects the SPF in a positive way. The law requires that an ATES is balanced. So that will be adjusted in 2019 and later.
- The cooling system didn't use direct cold from the surfacewater. All the produced cold was stored in the ATES. This reduced the SPF.

3.2.5. CO2 Reduction 2018

Reduced CO2 in 2018 by using Comfort Cooling instead of a conventional chiller (COP 3,5)

The reduced amount of CO2 by using the comfort cooling in 2018 is 280 ton CO2 for 1.555 dwellings in Houthaven ultimo 2018.

	Cold SPF 33,5	Airco COP 3,5
Cold production (kWh)	1.687.820	1.687.820
E-use (kWh)	50.361	482.027
Extra E (kWh)	-	431.666
CO2 kg per kWh 2018	0,649	0,649
CO2 emission (ton)	32,6	312,8
Avoided emission (ton)	280,2	-

The common data is CO2-emissions for electricity per kWh. This number depends of the annual calculated national electricity-mix.