RUGGEDISED
Designing smart, resilient cities for all

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02 - UMEA KOMMUN (UME) - SE
03 - GLASGOW CITY COUNCIL (GCC) - UK
04 - RISE RESEARCH INSTITUTES OF SWEDEN AB (RRI)- SE
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Executive summary

This report provides insight in one of the thirteen Smart Solutions that are implemented in the Heart of South area in the City of Rotterdam. These innovative solutions are part of the RUGGEDISED program, which is subsidised by the European Union, and aims to test, implement and accelerate the Smart City model across Europe. Smart Cities include places were traditional networks and services are made more efficient with the use of digital technologies, for the benefit of its people. The smart solution this document further elaborates on is 'the feasibility study for providing high performance servers to homeowners as cost free heating facilities', also known as 'Nerdalize' (D2.14).

First it is explained what the solution includes. In short, the plan was to provide high performance servers (Nerdalize Cloud) to the homeowners as cost free heating facilities, thereby creating a business model for highly distributed computing power while significantly reducing overall CO2 emissions.

The second part of this document contains a detailed description of what the feasibility study entailed, and which aspects have been examined.

In the last chapter it is concluded that Nerdalize is technically/physically quite feasible. External factors, however, have unfortunately forced Nerdalize to declare bankruptcy due to lack of sales.

Contents

1. Introduction

RUGGEDISED is a Smart City project funded under the European Commission's Horizon 2020 research and innovation program. The European Commission defines a smart city as: "A place where the traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses". The goal of the project is to test, implement and accelerate the Smart City model across Europe.

1.1 Lighthouse cities

The current period in which we live, is characterised by rapid technological development, strong globalisation of (social and economic) activities, a need to protect our living environment and to ensure social stability. In the European-funded Smart City project RUGGEDISED, the three lighthouse cities of Rotterdam, Umea, and Glasgow work together with a number of partners from academic, business and consultancy backgrounds to develop and test solutions to exploit and explore sustainable urban development opportunities offered by smart solutions.

The three overall aims of RUGGEDISED are:

- Improving citizens' quality of life by offering a clean, safe, attractive, inclusive and affordable living environment.
- Reducing the environmental impacts of activities, amongst others by achieving a significant reduction of CO2 emissions, a major increase in the investment and usage of renewable energy sources and an increase in the deployment of electric vehicles.
- Creating a stimulating environment for sustainable economic development, by generating more sustainable jobs, stimulating community involvement in smart solutions (as consumers and as producers) and to boost start-up and existing companies to exploit the opportunities of the green digital economy and Internet of Things.

Within Rotterdam the main focus is on Smart Energy systems, with the goal to reduce import of energy from outside the area and produce as much as possible energy within the area itself. Besides two smart grids

Figure 1: An overview of the Heart of South implementations

(STG and SEG) Figure 1 shows Housing free of natural gas. Deliverable D2.14 aims to be part of the heating solution for these homes.

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1.2 Smart thermal grid in Rotterdam

The City of Rotterdam played an important role in the RUGGEDISED project. Rotterdam is the Netherlands second-largest metropolis and is characterised by its diverse, multi-ethnic community and Europe's busiest port. The City of Rotterdam introduced the Heart of South, the city centre of the South side of Rotterdam, as their lighthouse district. Through RUGGEDISED the area is undergoing a transition, consisting of renovating event centre Ahoy and building new facilities like a shopping mall and a cinema.

Figure 2: Map of the city of Rotterdam

Figure 3: An overview of the Heart of South area and the Housing area for Nerdalize pilot.

One of the goals of the project in Heart of South is to reduce CO2 emissions and apply renewable energy sources. Implementing the Nerdalize solution in the newly built houses would contribute to heating these houses in a sustainable manner, reducing overall CO2 emissions for heating.

In total thirteen innovative solutions are implemented in the Heart of south area, of which this (D2.14) is the only one that is added to individual houses. The solutions, however, are highly related; for example, some solutions focus on extracting energy, while other solutions focus on the storage of that energy or generating energy.

This deliverable elaborates the solution that contributes to reducing heating demand from home owners, by providing high performance servers (Nerdalize Cloud) to home owners as cost free heating facilities, thereby creating a business model for highly distributed computing power while significantly reducing overall CO2 emissions. Please have a look at chapter 2 for a more detailed description.

Figure 4: an example of a high performance server installed in a home

Producing heat in homes for free, which would otherwise be wasted in a centralized data center not only reduces CO2 emissions, but also reduced heat demand from other (external) (non-sustainable) sources.

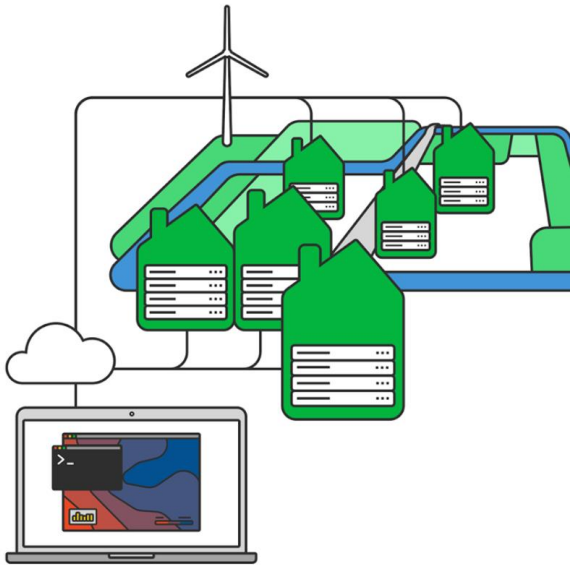

Figure 5: Schematic overview of Nerdalize solution

2. Nerdalize

The Nerdalize Cloud is a sustainable and affordable high-end computer platform. Because the servers are distributed over many homes you don't have to pay for the overhead of a datacenter. This means that costs per computation job is up to 55% lower when computing with Nerdalize and computations are more sustainable, as the heat produced heats people's homes. As of today, the Nerdalize heater can produce 1kW, 24 hours a day, 365 days a year.

Figure 6: The Nerdalize Cloudbox

The Nerdalize Cloud Box can be installed into existing heating systems, as can be seen in the scheme below. Please take notice of the following translations of the (Dutch) word used in the scheme:

- Afleverset: Delivery set for heating

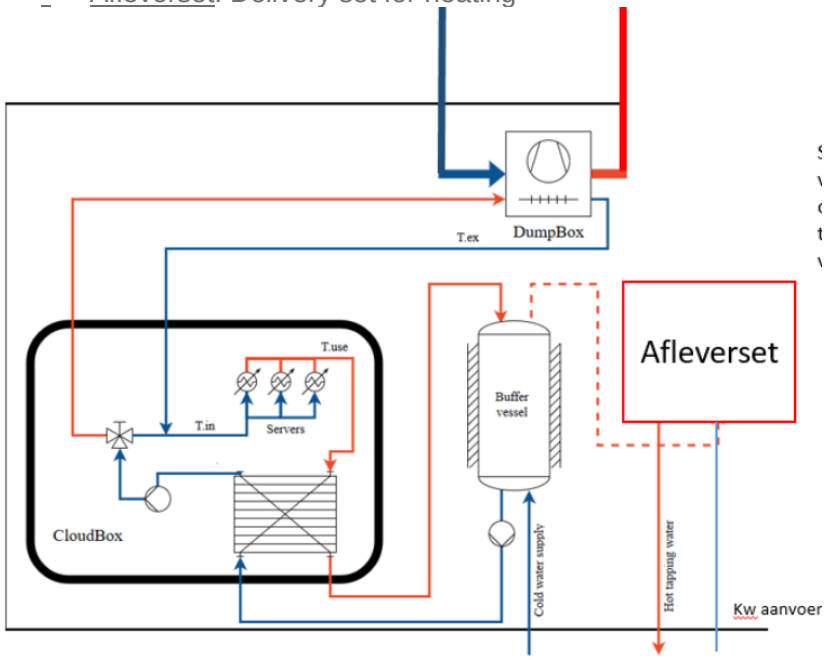

Figure 7: Scheme of principle installation in existing heating system

As can be seen, the concept is simple. With a Cloudbox in the home, a certain amount of heat is produced. This heat is stored in a buffer vessel. When the house demands heat, it is first extracted from the buffer vessel, before the rest of the demand is extracted from an external (less sustainable) source. When the buffer vessel is full, the heat which is produced by the Cloudbox can be dumped via the Dump Box, which is basically a mechanical fan which blows the heat out of the home.

3. Implementation

This was introduced in Horizon2020 project RUGGEDISED as SMART SOLUTION R12: High performance servers in homes. The promised goal was a feasibility study, but all parties were committed to realize a pilot project.

3.1 The feasibility study

In August 2018 a feasibility study was started by Eneco and the start-up Nerdalize (partially owned by Eneco) whether high performance servers in residential buildings (built by Ballast Nedam/Heijmans), could provide highly distributed computing power (computing facilities, data centres) while heating homes for free at the same time and drastically reducing overall CO2 emissions. The start of this feasibility study was delayed because the development of the new residential buildings built by Ballast Nedam/Heijmans, was delayed. Ballast Nedam's plans for the housing development consisted of 95 ground-level homes consisting of 3-4 floors. A team of specialists of Eneco, Nerdalize, Ballast Nedam and Heijmans was formed to conduct the feasibility study. A representative / advisor of the municipality was also included in the team.

The following aspects have been examined:

1. Technical: how does the cloud box work and how can it be physically / technically fitted into the homes so that a contribution is made to supplying the home's hot water?
2. Sustainability: does this yield sustainability benefits?
3. Financial: what revenue model is possible for the cloud box? what financial benefit does the Cloudbox provide for the resident? And for the developer / builder Ballast Nedam / Heijmans?
4. Legal: who will own the Cloudbox? Which obligations do the parties agree on both sides? And what rights and obligations will lie with the resident?

4. Business plan

4.1 Financial concept

With regards to the financial concept, several questions would need to be answered:1) what revenue model is possible for the cloud box? 2)what financial benefit does the Cloudbox provide for the resident? 3) And for the developer / builder Ballast Nedam / Heijmans?

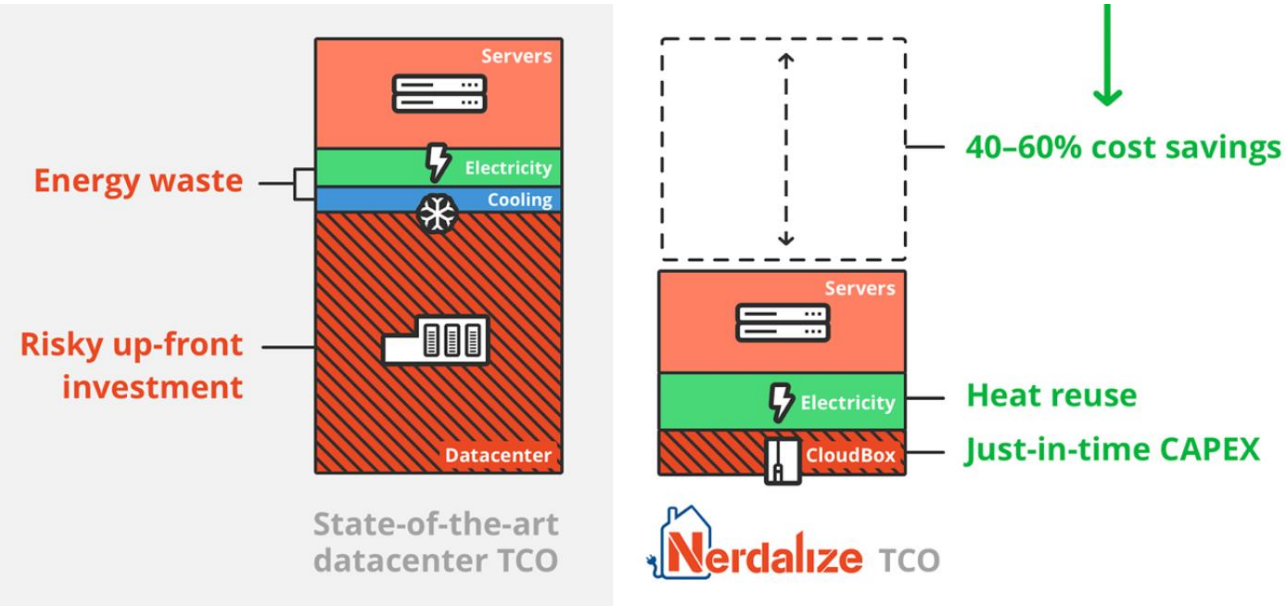

Figure 8: Revenue model Nerdalize versus normal revenue model of SotA Datacenter

The revenue model for the “investor” in datacentres is clear. There are large and risky up front investments when creating a new centralized datacentre. With the Nerdalize solution these investments are a lot lower, thereby reducing the risk involved in the alternative.

When looking at the resident / home owner, we see the following financial benefit:

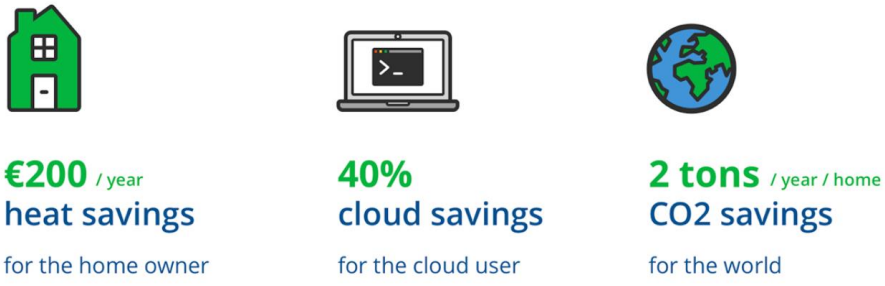

Figure 9: Value for all – key figures on savings for different stakeholders

In the figure above, it also becomes clear that the CO2 savings are significant, thereby yielding sustainability benefits, which otherwise are much harder to obtain. The savings are expressed as opposed to the base case costs with best possible alternative heating system for newly built homes.

4.2 Technical and legal concept

Technical details can be found in chapter 2 of this document.

The legal / ownership concept has been briefly explored in the project. In principle the proposition that was agreed upon consisted of a one-time fee for the home owner. The ownership of the Cloud Box stays with the heating provider, since the heating provider also guarantees back up heating via the district heating system in case demand is too high for the Cloud Box. An example of the commercial proposition can be found below:

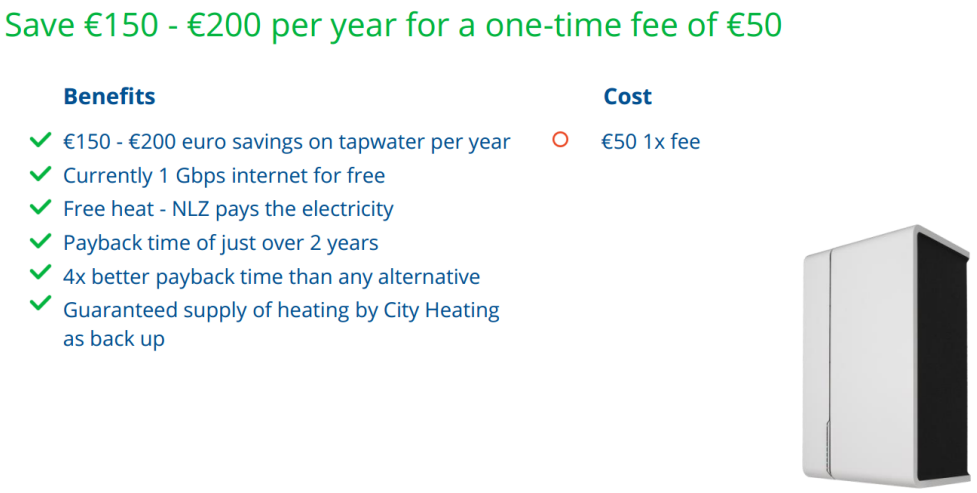

Figure 10: Value for all – Costs and benefits for the home owner

5. Conclusions and recommendations

The results of this feasibility were quite promising. Technically / physically the implementation of the Cloudbox in addition to connection of the district heating seemed possible. The Cloudbox would ultimately provide heat that would decrease the need for heat of district heating. Based on an initial proposal from Eneco / Nerdalize, a financial offer also seemed possible that would be attractive for both the resident / end user and the developer Ballast Nedam / Heijmans. Therefore, Ballast Nedam and the municipality were both enthusiastic. Ballast Nedam / Heijmans indicated that they would try to sell the Cloud box as an extra option when selling the 95 houses to the end users / private buyers. The selling of the houses was planned for the summer of 2019. This would mean that there wasenough time to finalize the design of the houses, finalize the contract Eneco-Ballast Nedam / heijmans, make standard contract Nerdalize -home owner / end user and get everything in the selling leaflets of the houses.

Unfortunately, the whole pilot project was interrupted by ‘outside’ forces: the start-up Nerdalize had to declare bankruptcy due to a lack of sales growth and the necessary extra funding in final quarter of 2018. A restart of the startup was investigated, but it did not materialize. Among other reasons, the liability issue was reason for not materializing. It could not be decided who would be responsible if damages would occur to the system itself, or to the house in which the system was placed. A lesson therefore is that in case such a solution is considered, the liabilities need to be well defined prior to investment. Therefore, the whole pilot project of implementing the Cloudboxes in the 95 ground-level homes of Ballast Nedam / Heijmans at RUGGEDISED came to an abrupt stop.

Appendix List

Nerdalize presentation RuGGEDISED B2B Cloudbox_vd.pdf

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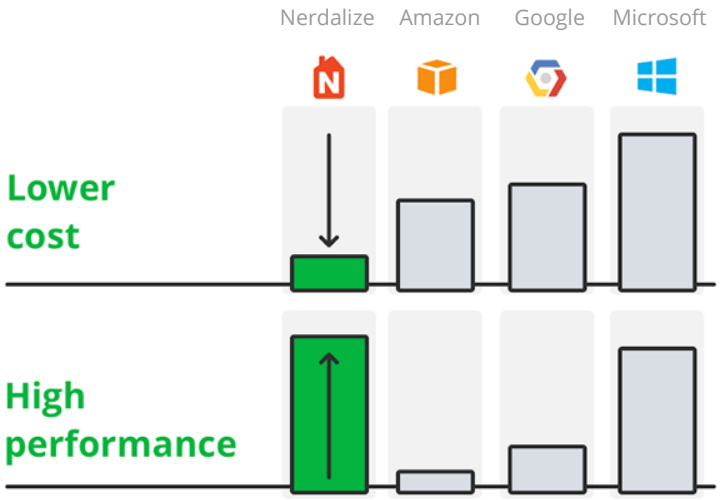
Eneco

Nerdalize

Building the cloud one house at a time!

Nerdalize sells cloud at 40% lower costs than the competition



Customer benchmarks:
video transcoding, bioinformatics, hydro simulation

click the links!

We sell our cloud services to **compute-intensive businesses**

READAAR

Deltares

LUMC Leids Universitair Medisch Centrum

AON

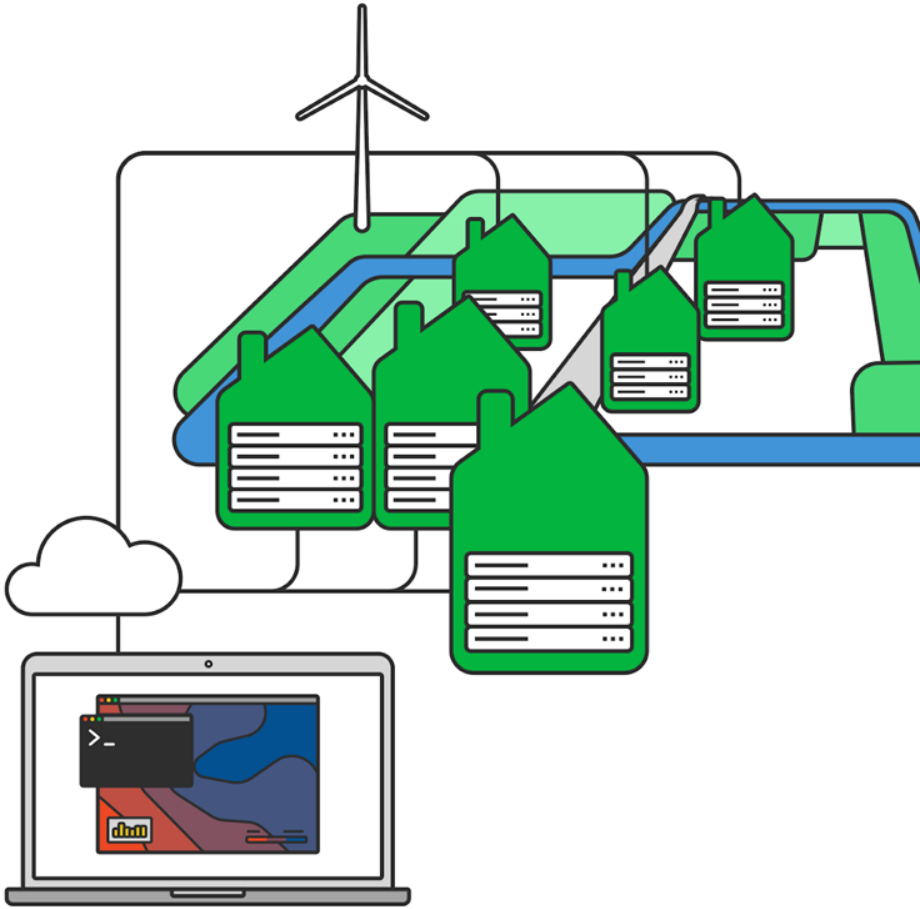
DELFT INVERSION

There is one difference:

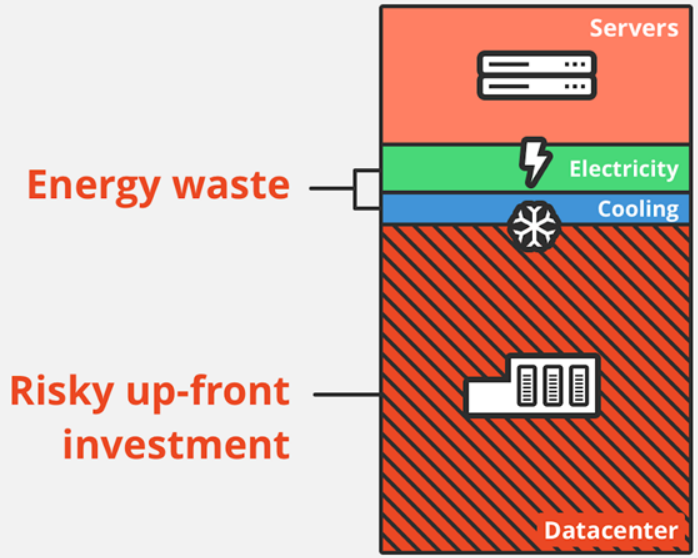
We place our cloud servers in homes instead of a datacenter

Our CloudBox
converts heat produced by the servers
inside into free heating for a home

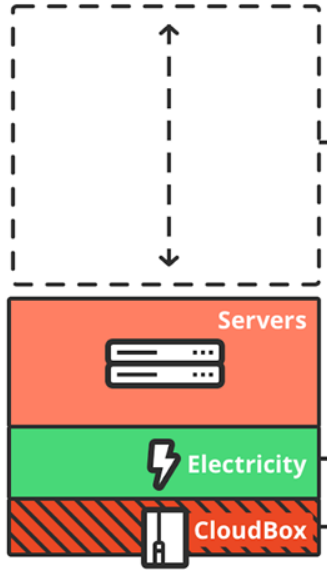
Placing servers in homes
creates a datacenterless cloud
that is more affordable, social
and sustainable



What if you could eliminate the datacenter entirely
and put servers where heat is needed?



State-of-the-art datacenter TCO



40–60% cost savings

Heat reuse

Just-in-time CAPEX

Nerdalize TCO

Going **datacenterless** creates a
unique value proposition with only winners

€200 / year
heat savings

for the home owner

40%
cloud savings

for the cloud user

2 tons / year / home
CO2 savings

for the world

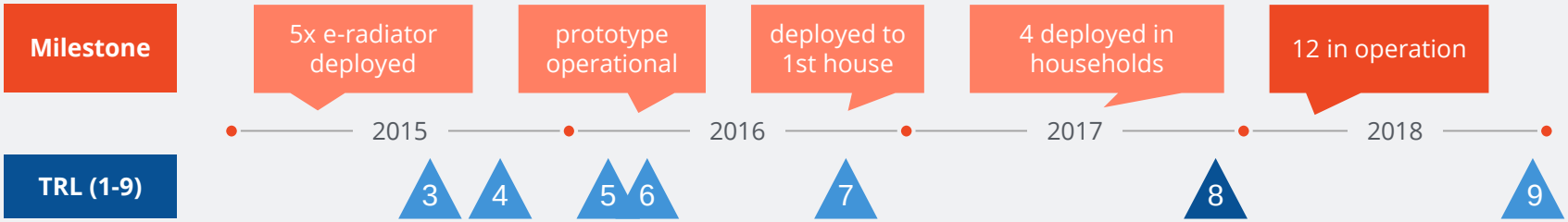
The Nerdalize CloudBox

- **Supplies free heating**
  57°C water - Nerdalize pays for the electricity
- **Is always-on**
  runs servers 24/7/365
- **Is energy efficient**
  2% cooling overhead (PUE 1.02)
- **Is silent**
  No vibrations during operation
- **Can be installed easily**
  Each component <20kg

The CloudBox — Technology Readiness Level

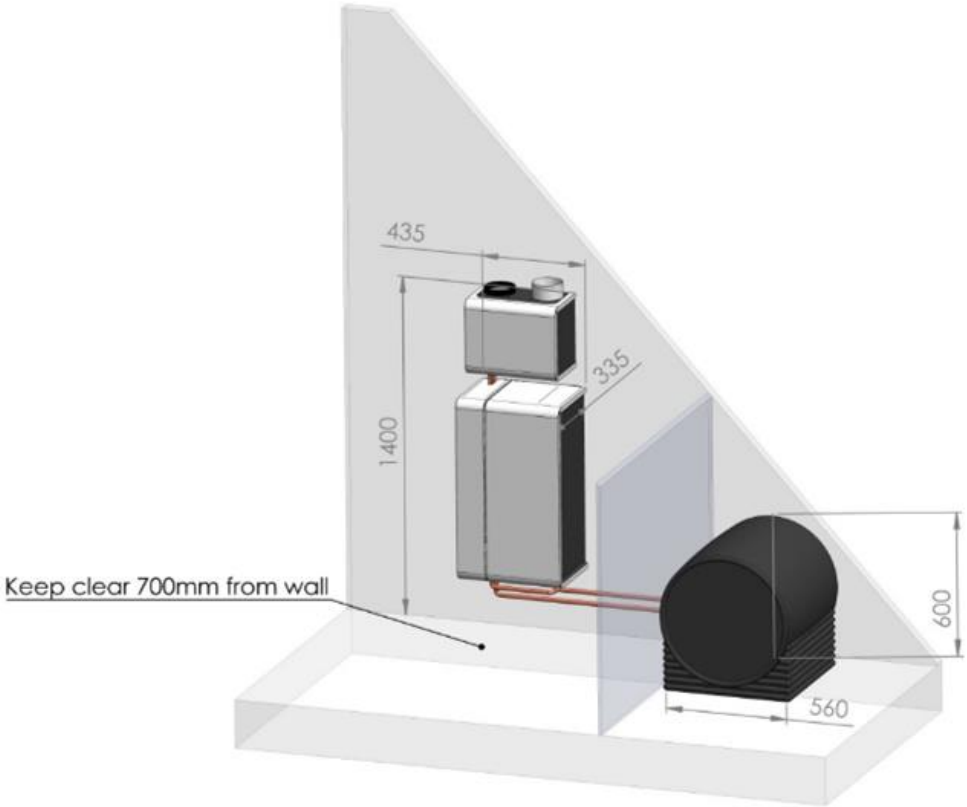
Where are we now?

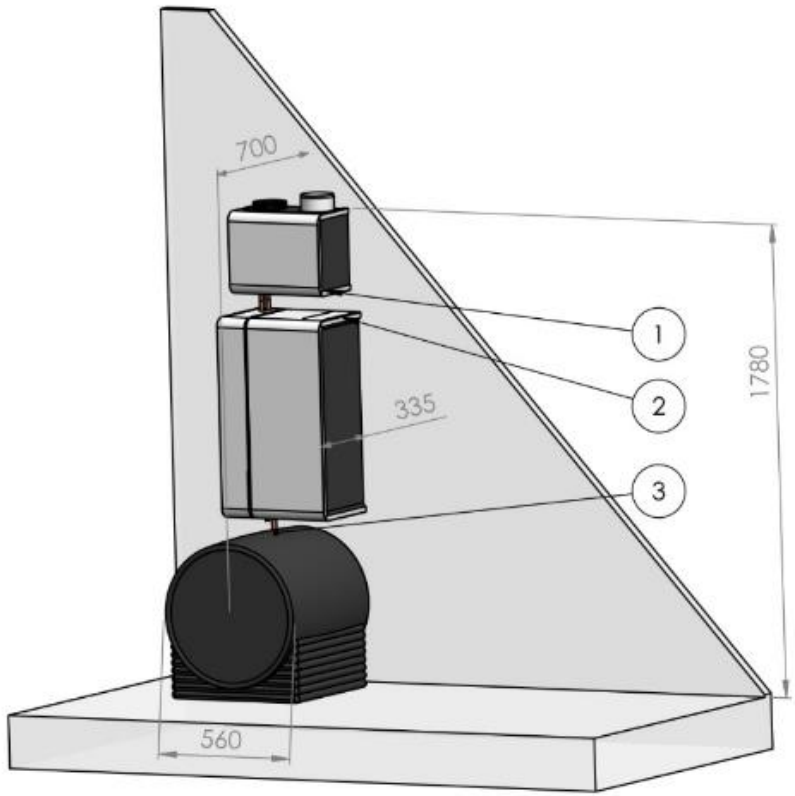
- ✓ Technology Readiness Level[1] 8 out of 9
- ✓ 45000+ total testing hours since 2016
- ✓ 12 CloudBoxes in active operation
- ✓ 4 CloudBoxes installed in households since 2017



[1] according to US DOE TRL definitions; DOE G 413.3-4; 10-12-09; pg 22

Installation can be optimized for vertical or underutilized space





Additional components: Boiler & DumpBox

Boiler

- Continuously heated by CloudBox
- 100l capacity
- Tap Water spiral - Legionella safe
- Optimized for underused spaces
  - Slanted roof
  - Below staircase

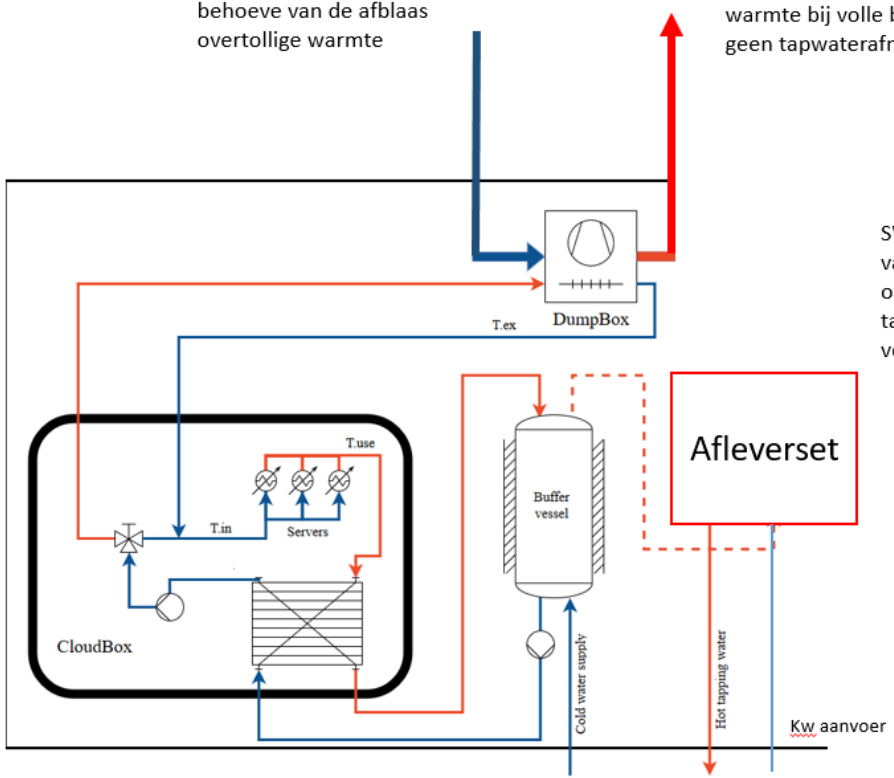
DumpBox

- Connects to existing pipes
- 80-125mm diameter
- Only in use when boiler is full
- Avoids unwanted heat in the home

Principeschema

Aanvoerlucht ten behoeve van de afblaas overtollige warmte

Afvoerlucht overtallige warmte bij volle buffer en geen tapwaterafname



SW Afleverset voorzien van uitstroomthermostaat om te hoge tapwatertemperaturen te voorkomen.

Water uit de buffer verwarmt het kw voor. Kw beveiliging toevoegen conform legionella regelgeving

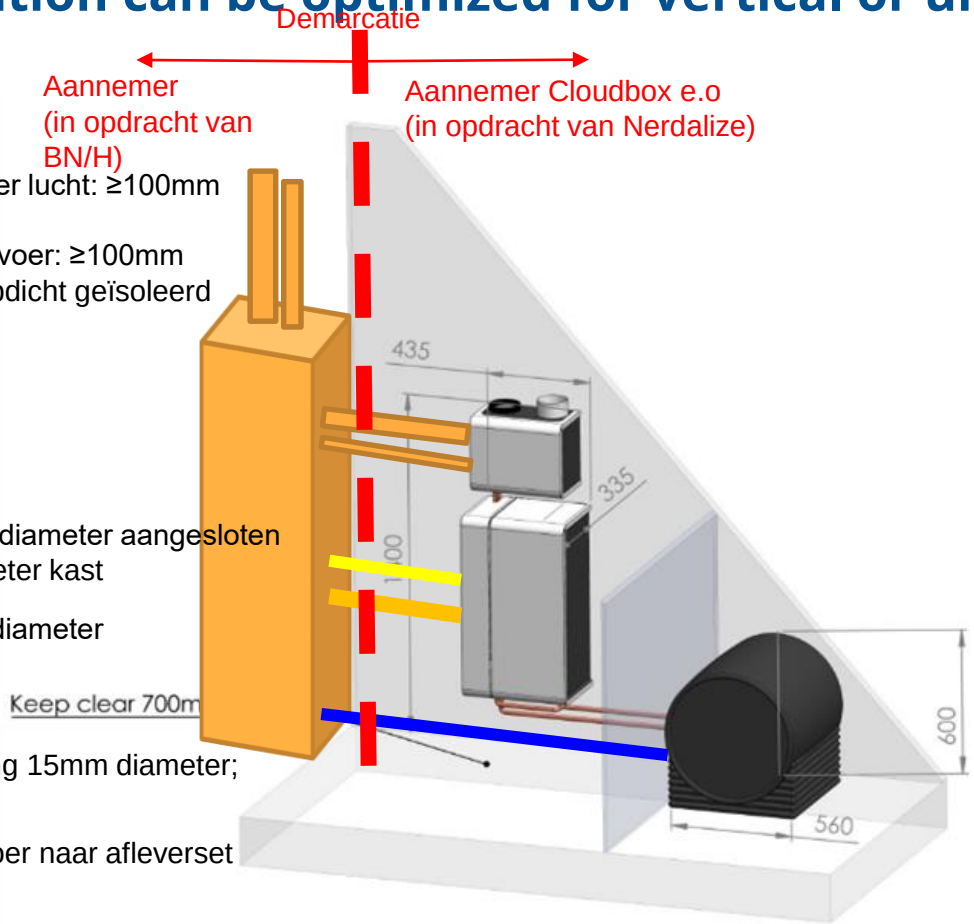
Functioneel principe

Nerdalize verwarmt het koude tapwater voor tot ca 50-57°C door de SW wordt de eventuele extra temperatuursprong verzorgd.

De afleverset regelt de SW toevoer op basis van de gewenste uitgaande warmtapwatertemperatuur. Hiermee is er geen gevaar voor een te hoge warmtapwatertemperatuur.

Indien de Nerdalizeboiler leeg is, verzorgt SW de volledige warmtapwaterbehoefte.

Installation can be optimized for vertical or underutilized space



1. (Warmte) afvoer lucht: ≥100mm diameter.
2. Verse luchttoevoer: ≥100mm diameter dampdicht geïsoleerd

3. Elektriciteit: 5/8” diameter aangesloten op vrije groep in meter kast

4. Glasvezel: 5/8” diameter

5. Koudtapwater voeding 15mm diameter; dampdicht geïsoleerd.

6. Warmtapwater aanvoer naar afleverset 15mm diameter

Toelichting

Cloudbox en bolier liefst direct naast SW afgiftepunt

Dumpbox direct of indirect aangesloten op buitenlucht

1 loze E-leiding 5/8” van meterkast naar cloudbox tbv elektriciteitsvoorziening Cloudboxaangesloten op vrije groep in meter kast

1 loze E-leiding 5/8” van meterkast naar cloudbox voor glasvezel aansluiting Cloudbox

1 extra inlaatcombinatie tbv wateroverstort (indien niet aanwezig in afleverset).

1 extra uitgaande tapwaterleiding naar afleverset.

CloudBox

Future Integration options

Hot Water

Storage
Regeneration

Combi

Larger
Systems

Floor heating

Space Heating

Heatpumps

Nerdalize pays for the electricity

So the heat is really for free

- Electricity consumption of the CloudBox is measured with a certified meter
- Measurement data is transferred through certified system to ensure accuracy
- Nerdalize reimburses the home owner for the electricity used by the CloudBox

Alternative: a 2nd measurement point with own EAN

This is what we offer to homeowners

Save €150 - €200 per year for a one-time fee of €50

Benefits

- ✓ €150 - €200 euro savings on tapwater per year
- ✓ Currently 1 Gbps internet for free
- ✓ Free heat - NLZ pays the electricity
- ✓ Payback time of just over 2 years
- ✓ 4x better payback time than any alternative
- ✓ Guaranteed supply of heating by City Heating as back up

Cost

- ○ €50 1x fee

An internet offer you can't refuse

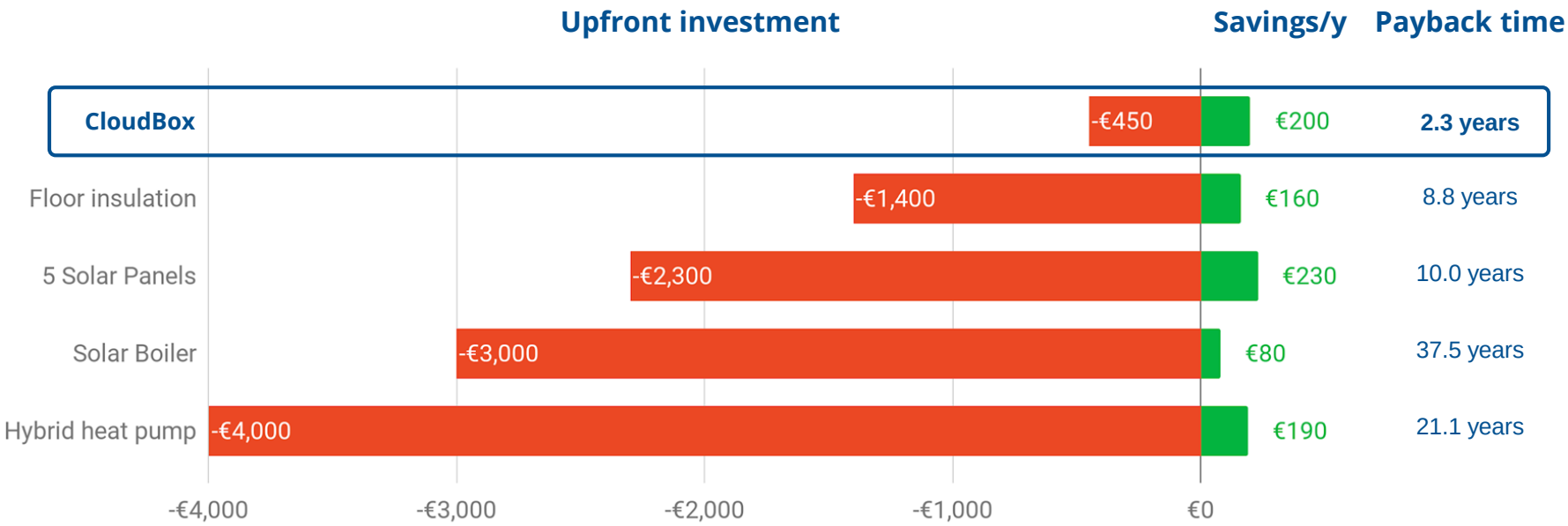
20x faster for the same price

Internet (only)	Internet & TV	Internet & Interactieve TV
€32,50 p.m.	**€42,50** p.m.	**€47,50** p.m.
Glasvezel	Glasvezel	Glasvezel
1000Mbit/s download	1000Mbit/s download	1000Mbit/s download
1000Mbit/s upload	1000Mbit/s upload	1000Mbit/s upload
Gratis WiFi-modem	Gratis WiFi-modem	Gratis WiFi-modem
	80 TV-zenders (52 HD)	80 TV-zenders (52 HD)
		Interactieve TV, ook op je tablet & smartphone

Vaste prijs per maand, geen bijkomende kosten.

The CloudBox beats the competition hands down

Less investment cost and faster payback time than the best selling alternatives



For reference: **Dutch households bought ~1 million solar panels in 2016 (Source: CBS)**

Source: Milieu Centraal

Proposition Project Developer

€500 aanbrengfee per woning * 95 woningen = € 47.500 Winst BN/H

Vroegtijdige afstemming over 3 extra bouwkundige voorzieningen

1 loze leiding van meterkast naar cloudbox tbv elektriciteitsvoorziening Cloudbox

1 loze leiding van meterkast naar cloudbox voor glasvezel aansluiting Cloudbox

1 extra loze wateraansluiting Bolier tbv wateroverstort

2 varianten installatie cloudbox:

- Na afstemming en realisatie loze leidingen en extra wateraansluiting, laat Nerdalize haar cloudbox, de boiler en dumpbox door eigen installateur in alle woningen installeren
- BN/H neemt de installatie van de cloudbox, de boiler en dumpbox mee bij de bouw van alle woningen voor obv installatiekosten €500/woning

Our goal: **to outgrow Google Cloud** by creating a datacenterless world

IaaS/Cloud market share

5% +

Homes

850,000

Servers

3.4 million