Name of the system: Stadsverwarming Purmerend B.V. (SVP)
Location of the system: Purmerend, The Netherlands

Name of the owner: Municipality of Purmerend
Type of ownership: 100% shareholder of the B.V. (Limited Liability Company)

Name of the programme:

District Heating 2.0

Supported by INTELLIGENT ENERGY EUROPE

Peter Odermatt, CEO
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The Netherlands
+31 299 410 514
p.odermatt@svpbv.nl

Motivational letter

District Heating 2.0: the future of District Heating is now

"This project is a good example of how cities can contribute to meeting the European Union's climate goals and we hope it will set an example for others to follow."
(European Investment Bank Vice President Simon Brooks about SVP's *District Heating 2.0*)

Imagine a DH grid of 30 years old… High heat losses, water leaks, disruptions in heat supply, complaining customers, no profit for the shareholder who wants to sell it but no buyer is interested…

Many European DH grids will soon face these problems as they near a certain age. SVP developed a solution. Join us in upgrading your grid to ***District Heating 2.0*** and get ready for a sustainable future!

SVP is a municipal scheme with 25.000 users (24.000 households and 1.000 companies). Founded in 1980, SVP was privatized in 2007. Under new management a turnaround took place starting in 2008. See page 4 for turnaround results on: CO_2-reduction, energy-efficiency, suppletion water, financials.

District Heating 2.0 entails the modernization of the existing scheme to next generation district heating, securing heat generation and supply in a sustainable way for the next 25 years.

District Heating 2.0 is implemented in 3 subprogrammes:

- Sustainable heat production – ***Energy Transition***
- Sustainable heat distribution – ***SlimNet***
- Sustainable heat consumption – ***Purmer end-use***

Energy Transition covers the switch from fossil fuel residual heat (CHP) to renewable heat (RES). The base heat demand will be supplied by geothermal energy (first NL feed-in of geo in existing grid). The seasonal demand will be generated with locally sourced biomass (first NL large scale use of biomass heating in existing grid). Peak demand will be covered by natural gas heated boilers, later by green gas: a 100% sustainable character. Implementation started in 2010.

SlimNet is an energy-efficiency and total smart re-engineering programme including: dynamic grid model, replacing hotspots with sustainable piping material, lowering the average temperature in the distribution grid and cascading the return heat. Result will be that, despite the projected substantial growth in heat demand over the next decennium, the required heat volumes will strongly diminish. Implementation started in 2009 (results: page 7).

Purmer end-use combines early replacement of units, smart metering, modern marketing and local cooperation with installers, housing corporations and NGO's to stimulate end-use efficient behaviour.

Total results of ***District Heating 2.0*** once fully operational (1^{st} January 2014):

- **CO_2-reduction**: 100.000 ton p/a (= 78% compared to conventional Dutch heating solutions)
- **Primary energy savings**: 43 million m^3 natural gas
- **RES-use**: first 80%, later 100%

As a public owned company, SVP can afford open and transparent cooperation with EU parties.
SVP is willing to lead the way in upgrading European DH grids and serve as:

- An 'open source' model for all other ageing DH grids wishing to upgrade their grid's energy efficiency and/or shift from fossil to RES
- A 'lessons learned' overview (in NL transferred by NGO's Urgenda and EnergyValley)
- Knowledge transfer & joined innovations (SlimNet currently actively shared in NL and presented at 12^{th} International Symposium on DHC, Tallinn, September 2010)

We invite District Energy companies to join us in creating a sustainable future!

District Heating 2.0 has been approved by the European Commission and received funding from the European Local Energy Assistance (ELENA) facility under the Competitiveness and Innovation Framework Programme (CIP) - Intelligent Energy Europe Programme (IEE).

250 words summary for the award website
and logos (system owner/operator and municipality) in high resolution (jpg, gif, tiff)

***District Heating 2.0*: the future of District Heating is now**

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Supported by INTELLIGENT ENERGY EUROPE

Stadsverwarming Purmerend B.V.

PURMEREND
van groei naar bloei

System history, configuration of production units, distribution network, etc.

Company situation

In 2007 the new company Stadsverwarming Purmerend B.V. (SVP) took over the responsibilities of the district heating grid from the municipality in Purmerend, the Netherlands. With 25.000 customers (24.000 households and 1000 companies) it is the fourth largest grid of the Netherlands. District heating Purmerend started in 1980. The grid expanded organically following the city expansions. While daily operations were outsourced to external and changing partners, the final responsibility stayed with the municipality until 2007. Cumulative loss 1980-2007: € 120 million.

A comprehensive business analysis performed by the new management in 2008 showed severe problems. In the present state the company would remain structurally loss giving, future heat delivery was not ensured, and sustainability and customer satisfaction were below benchmark standards. Fall 2009 a new business plan was presented that set course for a future proof company, based on sustainable, cost-effective and 80-100% renewable heat. On the technical side this is achieved by two major project programs: 1) improving grid efficiency, *SlimNet*, and 2) incorporation of sustainable energy sources, *Energy Transition*. As the current heat supply agreement ends January 1st 2014, implementation is necessary before 2014. SVP's mission is to become the most sustainable district heating company of the Netherlands.

Network description

The 520 km district heating grid is fed by a CHP (CCGT) plant of 65 MWth and seven natural gas fired auxiliary boilers with a total power of 131 MWth. During the last 6 years 64% of the total heat production came from the CHP plant. The heat sources are operated by a third party.

The production units feed the heat to the system via buffering tanks to the primary grid. The heat is then directly transported through substations and a secondary grid to the 25.000 customer installations. Specific to the secondary grid are the post-insulated steel distribution pipes and connections to customer installations hanging in narrow crawl spaces under blocks of buildings.

In the distribution process no heat exchangers are used except from the production of hot tapping water in the houses. Hydraulics are controlled by decentralized pressurizing valves, differential pressure valves and pumps compensating for hydraulic deficiencies. The supply temperature from production is directly related to the ambient temperature (i.g. 95°C at T_a=-10°C and 75°C when T_a=15°C). The maximum supply pressure to the primary grid is 6,8 bars and to the secondary grid 4,5 bars.

SVP successfully transformed its business

Shortly after the privatization, the new SVP management defined an integral improvement program, covering practically all areas. First priority was to improve operational, technical and customer processes which all have been redesigned, a new ICT structure was implemented and many formerly outsourced processes were insourced again (explaining the personnel growth). *(See attachment 1.)*

Operational aspects	**Unit**	**31-dec-07**	**31-dec-08**	**31-dec-09**	**31-dec-10***
Network connections	[#]	24.330	24.478	24.601	24.980
Heat loss as % of volume purchased	[%]	35,30%	33,60%	31,60%	< 28%
Suppletion water	[000 m3]	-	33	31	24
Employees	[# fte]	15	20	34	40
Net profit	[000.000 €]	- 3,4	- 1,2	+ 0,6	positive

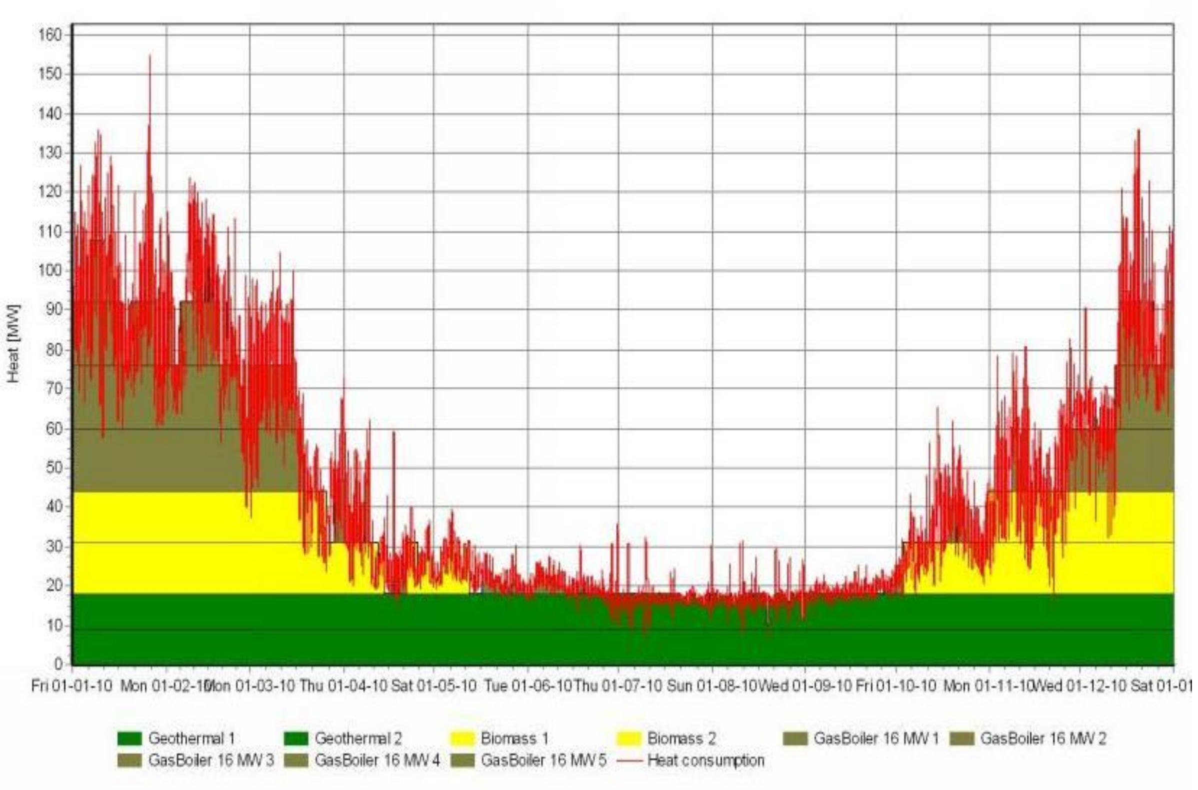
The grid has slightly grown over the past years and will grow by 6.000 housing equivalents during the next decennium. SVP currently sources its heat from a CHP that supplies residual heat from its steam and gas power plant in Purmerend; a plant that has been operational since 1989. Next to improvements on operations and customer satisfaction, the improvement program has resulted in a steadily improving financial performance. The table above also illustrates the significant heat loss, a metric that is steadily improving due to better maintenance and the current implementation of *SlimNet.* *(See attachment 2.)*

* Estimates for 2010.

The systems overall energy efficiency (measured in CO_2) and specification of energy input mix

The proposed set-up for the ***Energy Transition*** is as follows:

Energy source	**Capacity**	**1000 GJ/annum**	**Average utilisation**	**Objective**
Geothermal	18 MWth	533 (45%)	0,94	Base load
Biomass	26 MWth	403 (34%)	0,49	Seasonal demand
Green gas boiler	Tbd	249 (21%)	Tbd	Peak demand
Energy efficiency		**100% RES**		**Zero CO_2**



For the base heat demand two geothermal installations are planned, generating a total of 18 MWth. This technology is promising in Purmerend and will be a first for an existing DH in The Netherlands. End of 2010, the Dutch ministry granted an exploration permit to determine the feasibility on the identified locations. An advanced feasibility study is currently executed. A large part of the seasonal demand is envisaged to be generated with a biomass installation (soon to be tendered in Europe). This installation is expected to work on biomass, locally sourced from Staatsbosbeheer*, with which a letter of intent was signed in December 2010. In addition, peak demand will be covered by gas heated boilers and buffers - first natural gas, later green gas, thus 100% renewable.

** Staatsbosbeheer is commissioned by the Dutch government and manages a large part of the nature reserves in the Netherlands.*

What makes your programme outstanding and innovative?

Overall
SVP developed ***District Heating 2.0*** for her own 30 year old grid. However, ***District Heating 2.0*** is a useful model that can be copied by all DH grids that face or will face similar problems.
***DH 2.0* gives a second life to DH grids and shows and uses their full potential for sustainability.**
As a public owned company, SVP can afford open and transparent cooperation with EU parties.
SVP is willing to lead the way in upgrading European DH grids and serve as:

- An 'open source' model for all other ageing DH grids wishing to upgrade their grid's energy efficiency and/or shift from fossil to RES
- A 'lessons learned' overview to disseminate to all interested parties (in NL transferred by NGO's Urgenda and EnergyValley)
- Knowledge transfer & joined innovations (*SlimNet* currently actively shared in NL)

Energy Transition covers the switch from fossil fuel residual heat (CHP) to renewable heat (RES). The base heat demand will be supplied by geothermal energy (first NL feed-in of geo in existing grid). The seasonal demand will be generated with locally sourced biomass (first NL large scale use of biomass heating in existing grid). Peak demand will be covered by natural gas heated boilers, later by green gas: a 100% sustainable character. Implementation started in 2010.

New in NL:

- Feed-in of several renewable energy sources in the same (existing) heat grid
- Purmerend will be the first municipality in The Netherlands to use geothermal energy in (high temperature) existing buildings and in an existing heat grid
- Strategic cooperation between DH company and national manager of nature reserves
- SVP and Staatsbosbeheer will match supply and demand of biomass by local precision measures and will thus be able to speed up implementation of the *Energy Transition*
- SVP and Staatsbosbeheer will R&D innovative biomass techniques
- SVP will survey and manage the sustainability of the complete biomass chain: it concerns a residual current of responsibly managed woods, if possible locally or else regionally sourced, with efficient logistics and low carbon transport, and used as energetically efficient as possible

SlimNet is an energy-efficiency programme to reduce heat loss by implementing a total smart re-engineering programme including: dynamic grid model, replacing 4000 hotspots with sustainable piping material, lowering the average temperature in the distribution grid and cascading the return heat. Result will be that, despite the projected substantial growth in heat demand over the next decennium, the required heat volumes will strongly diminish. Implementation started in 2009 and will finish in 2014 (first results on page 7). *(See attachment 2 for article on SlimNet.)*
The combination of smart renovation & redesign of the grid and smart chain management will reduce heat loss by 36% and thus result in overall primary energy savings of 10%. By tackling the 4000 hotspots, the number of unplanned (emergency) repairs in the entire grid will be reduced by 50%.

New in NL:

- Dynamic grid model
- Demand driven heat production
- Implementation of alternative temperature curve
- Cascading: applying latent heat in return pipes
- New sustainable plastic piping material
- New pipe fitting technique

Purmer end-use
New in NL:

- combining early replacement of customer units, smart metering, modern marketing and local cooperation with consumers, installers, housing corporations, municipality and NGO Urgenda to stimulate end-use efficient behaviour.

How was the programme financed?

- *Energy Transition*: € 65 million – R&D partly funded by EC (IEE - ELENA); investment subsidy of € 1 million by Dutch State; still looking for other investors and/or loaning possibilities
- *SlimNet*: € 25,5 million – financed by SVP
- *Purmer end-use*: € 2,8 million – financed by SVP

How has the programme reduced greenhouse gas emissions in your community?

First results of ***SlimNet*** already showed in 2010:

- **CO_2-reduction**: 20.000 ton in 2009 → 35.000 ton in 2010
- **Primary energy savings**: 0,75 million m^3 in 2009 → 8 million m^3 in 2010
- **Energy-efficiency**: heat loss 31,6% in 2009 → less than 28% in 2010
- **Suppletion water**: water loss 31.000 m^3 in 2009 → 24.000 m^3 in 2010
- **Emergency repairs**: 135 in 2009 → 95 in 2010

Total results of ***District Heating 2.0*** once fully operational (1st January 2014):

- **CO_2-reduction**: 100.000 ton p/a (= 78% compared to conventional Dutch heating solutions)
- **Primary energy savings**: 43 million m^3 natural gas
- **RES-use**: first 80%, then 100%

How has the programme improved the quality of life of your community?

- Improvement customer satisfaction (fewer disruptions and fewer emergency repairs)
- Change of public image: SVP from ugly duckling to swan, from financial burden to good utility
- Change of public image: municipality revaluates DH as key to reaching sustainable goals
- Change of public image: Purmerend from dormitory town to most sustainable city of NL
- Cleaner air (NOx-reduction)
- Job creation

What were the challenges you faced and how were they overcome?

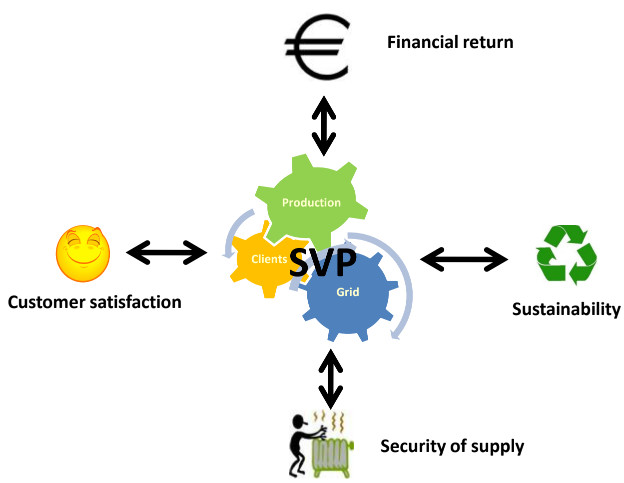
Key conditions for success:

- Use from start to finish an integral evaluation and decision making framework. SVP's criteria are: security of supply, sustainability, financial return and customer satisfaction *(image below)*
- Innovation and adoption of best practices (often international)
- Partnerships for innovation
- Chain management and optimisation

Lessons learned:

- Full potential of DH for sustainability not recognised (at least not in The Netherlands)
- Cost effectiveness: ***District Heating 2.0*** is more CO_2-reduction for less euros
- Local scale is ideal for energy transition and innovation
- Persistence and long term vision are needed
- Don't build your business case on subsidies
- Capex, but don't forget Opex (customer service, grid maintenance, credit management)

Integral evaluation and decision making framework



Purmerend, 1982: building the auxiliary gas boiler for DH Purmerend


Purmerend (Copyright: Sky Pictures)


SVP’s Customer Service

SlimNet

SlimNet trademark

Mai 17th 2010: Peter Odermatt (SVP) and Berent Daan (Municipality) shake hands at start SlimNet

June 2010: SlimNet work in progress

Stadsverwarming Purmerend B.V.

EMPOWERING SMART UTILITIES MECOMS™

SVP USES MECOMS™ TO INCREASE SERVICE WHILE LOWERING COSTS

Stadsverwarming Purmerend provides district heating to the city of Purmerend in North-Holland. Stadsverwarming Purmerend chose MECOMS™ to insource its front and back office activities and gain back control. MECOMS™ enabled Stadsverwarming Purmerend to increase customer satisfaction and payment rates while reducing the operational cost by approximately 20%. It also allows Stadsverwarming Purmerend to be more flexible and quickly cope with any future changes.

At a glance

CUSTOMER

- Stadsverwarming Purmerend B.V.
- Provides district heating for the city of Purmerend
- 24.000 B2C and 1.000 B2B customers
- Sells around 900.000 GJ of energy

KEY CHALLENGES

- Insource front and back office activities to regain control
- Improve business insight to make better decisions
- Prepare for regulatory changes
- Turnaround business operations
- Improve customer relations

BENEFITS

- Cost reduction of approximately 20%
- A single, integrated solution for all activities
- Higher customer satisfaction
- More and quicker payments by customers
- An agile system to rapidly cope with future changes

CERTIFIED FOR Microsoft Dynamics™ AX

Company

Stadsverwarming Purmerend (SVP) is the district heating company of Purmerend, a city in North-Holland (The Netherlands). SVP was founded in 1981 as a municipal company and gained independence in 2007.

SVP provides heat and hot water to around 24.000 households and 1.000 businesses. Its strategy focuses on sustainability, security of supply, customer satisfaction and an adequate financial return. Key values of SVP are quality, innovation, cooperation and a service-driven approach. SVP has the ambition to become the most sustainable district heating company of The Netherlands within a few years. Therefore SVP developed the currently running program 'DH 2.0'. This program consists of three major parts: 'Slimnet' which makes the distribution of heat more efficient, 'Energytransition' which focuses on setting op new sustainable production facilities and 'Purmerend bespaart' which helps our customers to use less energy.

Before MECOMS™

Before the privatization, the municipality of Purmerend had outsourced the front and back office activities to a third party with its own, external, IT platform. The financial accounting was done on the IT systems of the municipality. Under these arrangements, getting insight into business performance was complicated. Walter Verdonk, Chief Financial Officer of SVP recalls: *"The business fundamentals were not right. Our lack of business insight made it difficult to make decisions and adequately control our business. The outsourcing arrangement resulted in subpar credit collection and inadequate customer satisfaction ratings. Moreover, the high cost of outsourcing contributed to an operational loss."*

Furthermore, the Dutch government was preparing a comprehensive new legal framework for district heating which required a flexible approach. Therefore the newly appointed management of SVP decided to insource its front and back-office activities as a first important step to turnaround the company performance.

Insourcing activities

In 2009, SVP decided to insource these activities and take the reins. SVP would establish its own customer care organization and handle all operational and financial processes itself with a new, integrated IT system. Guided by external consultancy, SVP created a shortlist of solution providers in early 2009.

Walter Verdonk: *"Each provider was allowed to present his solution. In the spring of 2009, after a thorough comparison of providers, we decided to implement Ferranti's MECOMS™ product. Key factors in our decision were the impressive track record, mainly the implementation at Essent Heat, and the neat integration of all modules in MECOMS™ and Microsoft Dynamics AX. And of course a very good fit between our needs and the strengths of MECOMS™."*

MECOMS™

"MECOMS™ has played a crucial role in taking control and turning our business operations around.

The satisfaction and payment rate of our customers is higher than ever, while our operational costs have gone down significantly.

Our company is now well prepared to cope with any future changes."

— **Walter Verdonk**, CFO at Stadsverwarming Purmerend

Rapid implementation

Implementation was started immediately. MECOMS™ would be used to handle CRM, billing, credit management, meter reading and meter data management. A new online portal would give customers access to their data. The underlying Microsoft Dynamics AX platform would be used for general ERP processes, such as finance, procurement, stock management and projects.

Walter Verdonk: *"The first pilots were demonstrated in June 2009. Meanwhile, the existing data had to be extracted from the third party. A complicated and delicate process which had to be done in a short period of time. Thanks to the dedicated efforts of the staff of Ferranti and SVP all went well and the system could go live as scheduled: the financial processes in January 2010, followed by the utility processes in February 2010."*

Business value

Walter Verdonk: *"Since we adopted MECOMS™, we were able to drastically improve our performance on several fronts. Our call center, for example, is now located in our main office, together with all other departments. The integration of our activities into one single system has empowered our staff to be more effective and our customer care agents are much more involved with our customers. Customer satisfaction has increased substantially. For example, in 2010 complaints amounted to less than 1% of all customer inquiries. A remarkable result, especially in a 'go-live' year."*

"MECOMS™ also made our procedures smarter and reduced the distance between us and our customers. For example, the rules for credit management are now very clear and customers can consult their metering and billing data online. Meanwhile, we can differentiate between different kinds of overdue payments and swiftly take the appropriate action for each customer. As a result, the payment rate has gone up significantly."

Marco Konijn, assistant controller at SVP, adds: *"MECOMS™ offers us an integrated system to manage and analyse our own data. It enables us to take informed decisions, based on sophisticated statistics. For example, we can combine quantitative data of sub stations and customer groups to take targeted follow-up actions. This business intelligence enables us to take actions, not only in credit management, but also in maintenance and the optimization of our heating network."*

Walter Verdonk: *"The flexibility of MECOMS™ has enabled us to rapidly adapt some of our processes since the new system went live. And last but not least: our costs have gone down by approximately 20%. MECOMS™ has played a crucial role in turning our business operations around. The satisfaction and payment rate of our customers are higher than ever, while our operational costs have gone down significantly. Our company is now well prepared to cope with any future changes."*

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SLIMNET: AN INNOVATIVE INTEGRAL APPROACH FOR IMPROVING EFFICIENSIES OF DISTRICT HEATING NETWORKS

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ABSTRACT

This paper describes the innovative integral approach improving district heating network efficiency, SlimNet. SlimNet consists of five phases which lead to annual energy savings of about 227.000 GJ and almost 37.000 ton CO_2 savings for the city of Purmerend in 2015.

INTRODUCTION

Company situation

In 2007 the new company Stadsverwarming Purmerend B.V. (SVP) took over the responsibilities of the district heating network from the municipality in Purmerend, the Netherlands. With 25.000 customers the grid is the fourth largest grid of the Netherlands. District heating Purmerend started in 1980. The network expanded organically following the city expansions. While daily operations were outsourced to external and changing partners, the final responsibility stayed with the municipality.

A comprehensive business analysis performed by the new management in 2008 showed severe problems. In the present state the company would remain structurally loss giving, (future) heat delivery was not ensured, and sustainability and customer satisfaction were below benchmark standards. Fall 2009 a new business plan was presented that sets course for a future proof company, based on sustainable, cost-effective and 80% renewable heat. On the technical side this is achieved by two major project programs, a. improving network efficiency, SlimNet, and b. incorporation of sustainable energy sources, the Energy transition. The company mission is to become the most sustainable district heating company of the Netherlands.

Network description

The 520 km district heating network is fed by a CHP (CCGT) plant of 65 MWth and seven natural gas fired auxiliary boilers with a total power of 131 MWth. During the last 6 years 64% of the total heat production came from the CHP plant. The heat sources are operated by a third party.

The production units feed the heat to the network via buffering tanks to the primary network. The heat is then directly transported through substations and a secondary network to the 25.000 customer installations. Specific to the secondary network are the post-insulated steel distribution pipes and connections to customer installations hanging in narrow crawl spaces under blocks of buildings.

In the distribution process no heat exchangers are used except from the production of hot tapping water in the houses.

Hydraulics are controlled by decentralized pressurizing valves, differential pressure valves and pumps compensating for hydraulic deficiencies.

The supply temperature from production is directly related to the ambient temperature (i.g. 95°C at T_a=-10°C and 75°C when T_a=15°C). The maximum supply pressure to the primary network is 6,8 bars and to the secondary network 4,5 bars.

NETWORK CONDITION

Part of the business analysis was an extensive technical research program covering all technical aspects of the grid and finally entire district heating chain. The main conclusions were:

1. The network characteristic had become uncontrollable: Network build out has occurred without a master plan. Effectively SVP had no control on the characteristics of customer installations. Furthermore, hydraulic problems in the grid had been masked with decentralized pumps and control systems.
2. Heat production capacity was critical, reaching a critical limit under the conditions of the winter of 2008. There was certainly no spare capacity to facilitate the planned expansion of the grid and thus the heat demand as shown in Fig 1.

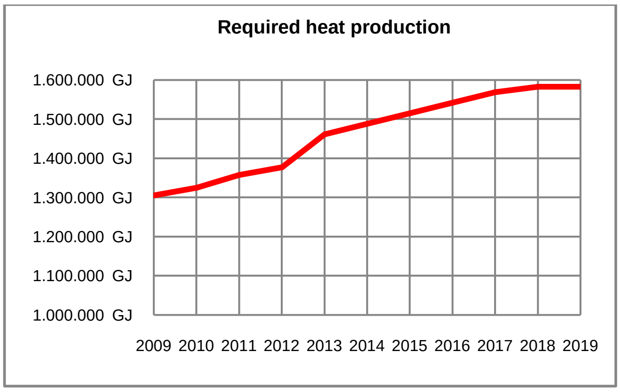

Fig. 1 Required heat production

3. In 2008 the network showed a heat loss factor of 33,6% (with a Dutch benchmark of 25%). requiring 32.683 m^3 of water replenishment in the same year.
4. Parts of the network showed excessive heat loss and repairs, mainly due to high ground water table, exposing the pipes in crawl spaces directly to water for most of the year. Repairs with standard material proofed insufficient and innovation on material and building techniques was needed.

SLIMNET

SlimNet is part of a large restructuring program initiated in 2008. SlimNet does contribute to stopping the negative spiral glide of the above mentioned problems

SlimNet consists of the following phases:

A. Knowing where the heat flows
B. Defining key performance indicators (KPI)
C. Developing analyzing tools
D. Developing and defining measures
E. Quantifying KPI results from SlimNet

In the following those phases will be discussed.

KNOWING WHERE THE HEAT FLOWS

For SVP the heat losses are defined as:

$$Q_{loss} = Q_{produced} - Q_{sold} \quad (1)$$

The heat losses in the network, Q_{loss}, were 427.158 GJ (33,6%) in 2008. Causes for those losses[1] are:

1. Losses in buffering tanks
2. Losses in primary network
3. Losses in secondary network
4. Undefined losses

None of the above can be determined exactly within the boundary conditions of the network but the following describes the results of the research performed on this matter and the localization of "hotspots", parts of the grid with excessive losses.

Buffering tanks

In [1] an estimated calculation was made for the heat losses due to the buffering tanks, 5.562 GJ annually. There are four buffering tanks with a 4.000 m^3 capacity in the network which are used for peak shaving. A check upon this calculation [2], based upon an IR-scan of one of the buffering tanks resulted in an estimate of 14.032 GJ annually which is considered to be a maximum value.

Primary network

Most substations in the network are provided with a SCADA[2] system. This data in combination with a newly developed network model made it possible to calculating annual heat loss at 100.706 GJ.

According to [3] about 14% of this heat loss is caused by cross-linked polyethylene (PEX) piping material used in the early 90's.

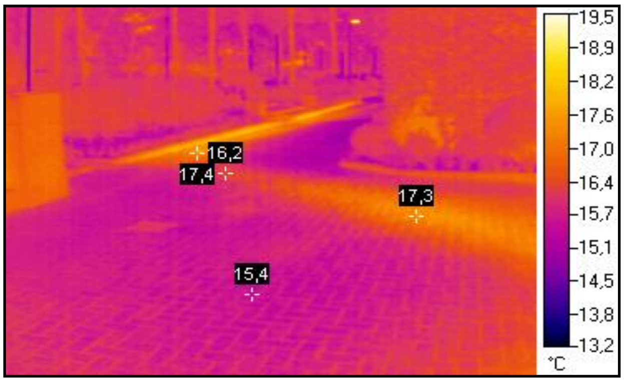

Fig. 2 IR scan of a PEX pipe constructed in 1990

Considering that those PEX pipes are applied in only 3,5% of the primary network, these may be referred to as "hotspots".

Secondary network

With four public housing companies, SVP conducted research on failures in the district heating related systems in Purmerend [3]. It became clear that during the period 2006-2008 74% of the unplanned repairs were caused by the high ground water level in the crawl spaces where post-insulated steel pipes with Armaflex insulation are installed. In total research identified areas of 4000 houses, where heat loss was extreme, i.e. "hotspots".

This research confirmed the conclusion of an earlier research [4] that the thermal conductivity *k* for the wet insulation in the crawl spaces will be close to 0,1 W/mK and 0,2 W/mK instead of the 0,02 or 0,03 W/mK for the current pre-insulated pipes. The total of heat losses in the secondary network are estimated at 304.041 GJ.

Conclusion addressing heat losses

Table 1 gives the overall results of the heat loss analysis.

Main network part	Loss(GJ)	% of total
Buffering tanks	14.032	3,3 %
Primary network	100.706	23,6 %
Secondary network	304.041	71,2 %
Undefined losses	8.170	1,9 %
Total	**427.158**	**100%**

Table 1: Overall results of heat loss analysis

[1] Losses from heat plants are not taken into account.

[2] Supervisory Control And Data Acquisition

It was concluded that replacing the PEX pipes in the primary network and post-insulated pipes in the crawl spaces of houses in the areas identified as "hotspots" was the most effective strategy for heat loss reduction.

DEFINING KEY PERFORMANCE INDICATORS

The main goal of SlimNet is improving network efficiency as part of the new business plan that sets course for a future proof company which provides sustainable, cost-effective and 80% renewable heat. The Key Performance Indicators (KPI's) can be divided in four main criterions:

1. Economics
2. Sustainability
3. Reliability
4. Customer Satisfaction

Economics

Every GJ of heat lost in the network cannot be sold and has therefore a negative effect on the balance sheet. Consequently the heat loss in the DH-network is an obvious and important KPI.
Another parameter that has a negative effect on profitability is the amount of water that is replenished.

Sustainability

The avoided CO_2-emissions are and should be an important driver for DH grids. According to subsequent directives in the Netherlands for assessing energy performance of buildings NEN 7120, the avoided CO_2-emissions has to be determined on the required primary energy sources and by referring to common state-of-the-art technologies. The HR-107 type (107% LHV efficiency) is the required and accepted common state-of-the-art reference technology.

Reliability

The condition of the network in terms of reliability presents itself in the amount of times that mechanics have to deal with unplanned repairs. It was apparent that SVP was facing an increasing trend curve. The actual deprecation of the replaced piping provided a another criterion for assessing system degradation.

Customer satisfaction

Reducing off time, during replacement was an important element of the SlimNet approach.

KPI summary

1. Heat loss
2. Water replenishment
3. Avoided CO_2 emissions
4. Unplanned repairs
5. Network degradation
6. Off-time during replacement

DEVELOPING ANALYZING TOOLS

Research had located the "hotspots" of unplanned repairs and heat loss in an area of 4000 houses. These "hotspots" were responsible for 50% of the unplanned repairs. In order to define and implement a suitable and cost-effective replacement strategy a set of tools was developed.

Upgraded network diagram

Analyzing networks requires reliable and comprehensive network diagrams. All required information such as dimensions, age, depth etc. should be available in the diagram. Many network diagrams are drawn using CAD-software. Analyzing from those drawings is costly. It therefore was chosen to revise the diagram completely and apply the possibility to add element attributes to the drawing connected to an integral database system. The upgraded network diagram had a catalytic effect on two other models, the network model and the grid valuation model.

Network model

In 2009 SVP replaced the outdated and inadequate network with a validated dynamic model (TERMIS), developed by 7-Technologies with COWI as system integrator. With the upgraded network diagram SVP had the first and validated model of the primary network within five months.

In combination with a new CRM system, operational since 2010, SVP will soon be able to tap into the information on customer behavior and consumption. This will allow SVP to dynamically calculate the current state of flow, pressure and temperature throughout the network at a configurable cycle time. Additionally, every real-time model calculation cycle will include a forecast simulation for a given period. This allows SVP to be abreast of demands, enabling optimization of operations and planning of the future.

Valuation model

The upgraded network diagram supplied database information on lengths, dimensions, age and type. With the following equations added to the database it was possible to develop a valuation model, that could help to prioritize and direct renovation efforts.

$$X = \sum_{x=1}^{network} R_x \cdot L_x \qquad (2)$$

$$Y = \sum_{x=1}^{network} \left(\frac{D - A_x}{D} \right) \cdot R_x \cdot L_x \qquad (3)$$

$$Z = Y - \sum_{x=1}^{network} \left(\frac{D - (A_x + 1)}{D} \right) \cdot R_x \cdot L_x \qquad (4)$$

X = value network in new state (€)
Y = current network value (€)
Z = required annual maintenance costs (€)
x = pipe
R_x = construction costs per meter pipe dimension x (€)
L_x = length of pipe x (m)
D = lifetime expectancy (year)
A_x = age of pipe x (year)

The network degradation is defined as factor β:

$$\beta = \frac{Y}{X} \tag{5}$$

From consultation with amongst others COWI, it was concluded that networks with a β< 0.5 are in a critical stage.

For the entire grid the β was above the threshold. Discriminating the β for separate grid sections helped to identify the hotspots and monitoring β will help to determine the effect of SlimNet.

Sustainability assessment model
To assess the current sustainability results of the network, SVP developed a sustainability assessment model in accordance with Dutch law and guidelines, resulting in Fig. 3 [5]. This model can also predict the effects of optimization in the chain from production, distribution and delivery to customer installations

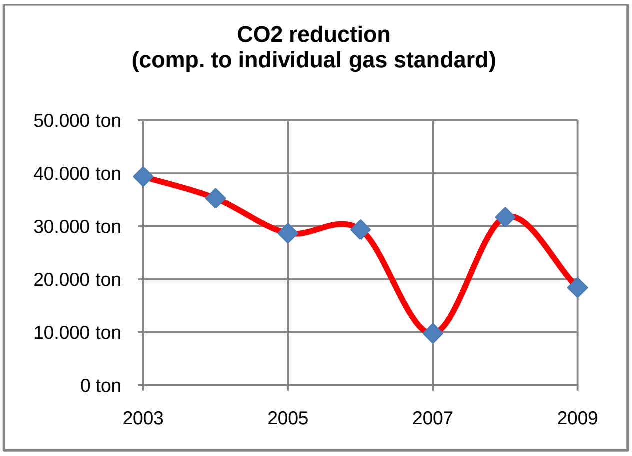

Fig. 3 CO_2 reduction DH-network Purmerend in past

It appeared that the ratio of CHP operation to the total of heat produced and the heat loss factor have the biggest impact on the sustainability results.

Strategic metering
It was concluded that actual data on heat loss on smaller scale (houses and clusters of houses) would facilitate decision making on future renovation projects and grid management. To get hold of this information SVP installed heat meters with radio transmission modules on strategic positions in the network. Together with the metering data from heat meters in customer installations this firstly gives accurate data on the heat loss in the corresponding part of the grid. This setup will also provide us with empirical data on the long term results of network improvement measures.

In order to make the data comparable, two areas where chosen. One with the new SlimNet approach (Using polybutene pipes and new construction techniques) and one with conventional material and construction techniques. First comparative results will be available by the end of 2010.

Leak detection
Most producers of pre-insulated pipe systems offer the possibility of leak detection wiring. Using a master plan with proper zero and recurrent measurements this would be a reliable method of leak detection. Unfortunately this is not applicable to the situation in Purmerend.

With one of its partners SVP developed a method using tracer gas to detect leakages. The detection devices proofed to be very sensitive and with this method almost 2.500 houses have been inspected this year and last year. Leakages were detected in 3% of those cases, mostly in an early stage, that otherwise would only have been detected through visual sighting of damp.

DEVELOPING AND DEFINING MEASURES

It became clear soon that the only way to improve network performance was to rigorously renovate the hotspots and to start implementing a structural maintenance program in accordance to Z, Eq. 4.

In sum the challenge was: a.) cost effectively renewing the steel pipes with wet insulation in narrow crawl spaces while b.) improving network efficiency.

To meet (a), SVP started the first two pilots in 2008 with pre-insulated steel flex piping material, using two different construction methods. Both pilots met the technical requirements but were too time consuming, costly and, because access to the crawl spaces had to be gained by digging in the gardens, meant huge inconvenience for customers.

Parallel to this SVP had challenged pipe manufactures to come up with innovative material construction methods, suitable for the Dutch situation (groundwater and retrofit in narrow crawl spaces). The only viable solution came from Flexalen of Thermaflex, using flexible polybutene (PB) carrier pipes. The producer of the PB material offers a 50 years plus life guarantee [6] for the pressures and temperature profiles of the SVP network.

A pilot with Flexalen was conducted in September 2009. The pilot used prefabricated joints of Flexalen, called Flexalinks, which were under research and development at that time. The pilot did meet all the requirements. Costs were reduced by 30% compared to the steel flex pilots, 16 houses were overhauled within a week and access could be gained by the crawl space hatches.

On the basis of this pilot decision has been made to retrofit 4000 houses within four years. Works has currently started at the first 309 houses, at a speed of 30 houses a week.

The second part of the challenge (b): improving network efficiency, is furthered by SlimNet through optimizing pipe dimensions and lengths (smart grid redesign)

Heat losses can be reduced by optimizing:

1. Thermal conductivity
2. Pipe lengths
3. Radial dimensions
4. Fluid temperature

These elements are captured in the following equation for heat loss in a pipe [7]:

$$Q_{loss\_pipe} = 2 \cdot \pi \cdot k \cdot L \cdot \frac{(T_{in} - T_{out})}{\ln \frac{r_{out}}{r_{in}}} \qquad (6)$$

k = thermal conductivity (W/mK)
L = length of pipe (m)
T_{in} = temperature of inside layer pipe (K)
T_{out} = temperature of outside layer pipe (K)
r_{in} = inner radius (mm)
r_{out}= outer radius (mm)

The first three of the above heat loss parameters can only be changed by renewing pipes. The last can only be changed by chain modification, i.e. production and customer installations. SlimNet addresses both.

SlimNet part I: Renovation and smart redesign
Applying Flexalen means an improvement of *k* from 0,1 of the wet post-insulated steel pipes to theoretically 0,031 W/mK (manufacturer information, at 50°C).

Key to the SlimNet approach was smart redesign. Calculations in TERMIS showed that many parts of the DH-grid in Purmerend are generally oversized, and that the common circular grid can easily be changed into a star shaped grid, whilst reducing pipe lengths. Using TERMIS redesign focused on reducing radial dimensions and pipe lengths by deleting obsolete pipes.

The results for the part of the grid that is replaced this year, Fig. 4 and Fig. 5, gave, Table 2 [8]:

	Heat demand	Heat loss
Current situation	100,0 %	100,0 %
New dimensions	93,0 %	76,3 %
Finger system	91,0 %	69,5 %

Table 2: Results from redesign 2010 area

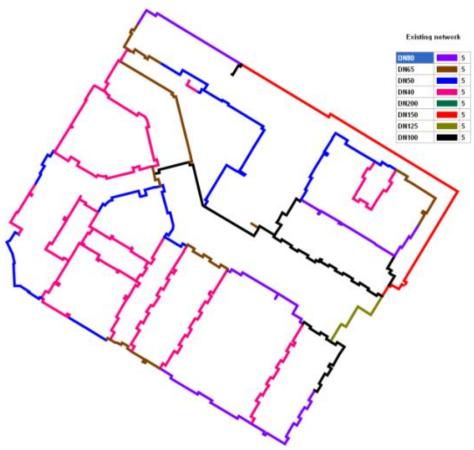

Fig. 4 Existing network part to be renewed

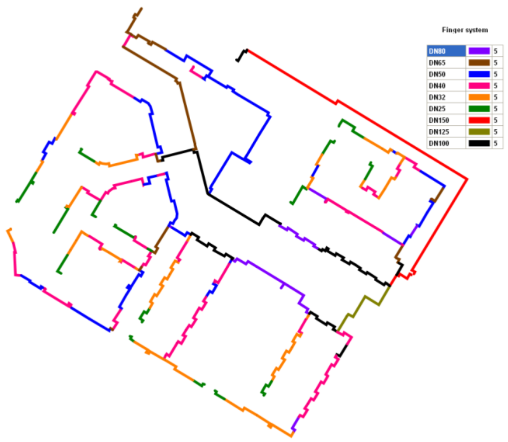

Fig. 5 Redesigned and renewed network

The actual effect of SlimNet on heat losses will be closely monitored in the grid, through the strategic metering project.

SlimNet part II: Smart chain management
The last heat loss parameter, fluid temperature (Eq. 6), can only be changed by modification of the complete chain.

To start at the production side, the current supply temperature is dependent on the ambient temperature, 95°C at T_a=-10°C and 75°C at T_a=15°C, Fig. 6. Lowering this curve, while still meeting the requirements of customer installations, would reduce the average network temperature hence the heat losses. It was calculated through the network model that the alternative temperature curve in Fig. 6 solely would reduce the heat losses with 4%. Further research will focus on matching the most effective temperature curve with production characteristics.

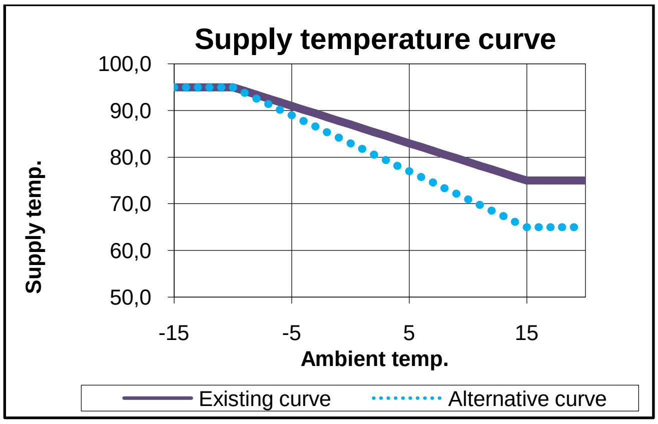

Fig. 6 Existing and alternative temperature curve

This research will also look upon the possibilities of implementing demand-driven heat production. This is achieved by using a real time network model connected to the substations and production SCADA. The model uses the weather forecast with customer information to adjust the temperatures and pressures just to meet the requirements of customer installations. It is expected that this will reduce the average fluid temperature even more.

Further research is done to implement cascading heating services, i.e. using the latent heat in the return pipes of the network with temperatures between 45°C and 60°C to the customer installations. This is however only possible to implement in new houses with low temperature heating installations. This research will focus on further reducing the heat losses.

At the other end of the chain are the customer installations. Since 1996 the district heating company in Purmerend has only accepted installations in new houses that have a 90-50°C characteristic during design conditions (-10°C). In most areas before that time SVP found return temperatures that are structurally higher than the required 50°C. Hence the flows in those areas are also much higher than necessary.

The high return temperatures and corresponding high flows are caused by absence of pressurizing valves in the customer installations and defective control valves in the hot tapping water installations. By the end of 2010 SVP starts a campaign to encourage house owners to improve or renew their installations, also for their own benefit. This campaign will make use of local approved installers of customer installations. Research indicated that in certain areas the peak flow can be reduced with 60% [9].

QUANTIFYING KPI RESULTS FROM SLIMNET

Summarized, the measures that SVP takes before 2014 to improve network efficiency:

1. Renewing the distribution pipes and house connections in the crawl spaces of 4000 houses, while optimized to dimensions and lengths.
2. Replacing 4,0 km PEX-pipes in the primary network, while optimized to dimensions and lengths.
3. Doing this with a minimum of off-time for customers
4. Implementing demand-driven heat production
5. Implementing cascaded heating installations
6. Encourage house owners to improve or renew their installations in accordance with SVP guidelines.
7. Eliminating arrears of maintenance an implementing a structural preventative maintenance program.

Heat losses will reduce from 33,6% in 2008 to 22,1% in 2015. While heat consumption prognoses stays the same, the corresponding required heat production falls, Fig. 8. This results in a energy saving of 227.000 GJ that year. In Fig. 9 the results of the sustainability assessment model are shown regarding CO_2 savings.

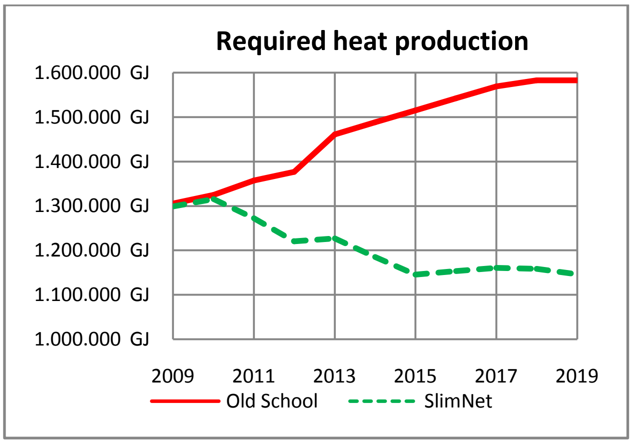

Fig. 7 Required heat production with SlimNet

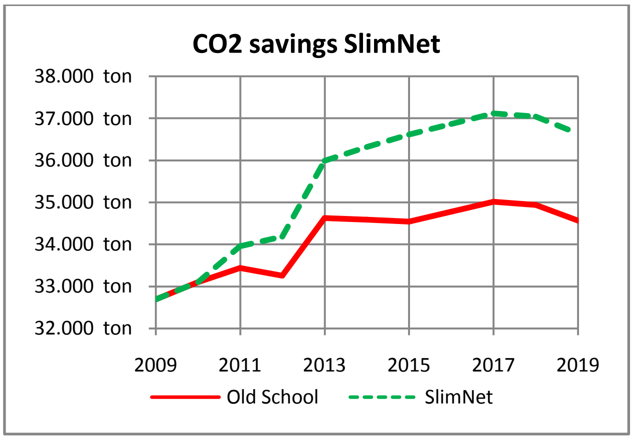

Fig. 8 CO_2 savings with SlimNet

Replacing the post-insulated steel and PEX pipes together with a maintenance program including leak detection will have a positive effect on the water replenishment. The leak detection actions have already resulted in a 30.285 m^3 replenishment in 2009, which is a 7% reduction compared to 2008.

It is expected that al measures will result in a 50% reduction in 2015. Unplanned repairs will also reduce 50% and consequently β is expected to improve significantly.

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