Concept and first results of the flagship EU smart city project City-zen

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Abstract

City-zen deals with the development of the city of the future. The project started its activities March 1, 2014 and has a duration of five years. Project targets are the realization of more effective collaboration models between stakeholders, a methodology for development of smart cities, connection with industry and the demonstration to society of ambitious pilot projects.

The approach taken is the set-up of stakeholder teams in the demonstrator cities, to accelerate the realization of energyefficient city development. This effort is supported by technology teams including industrial parties. Workshops aiming at decreasing the gap between innovation and implementation will be organized and knowledge-disclosing material will be developed by working groups in retrofitting, smart grids, and heating and cooling. Both technology and process improvement is included.

The demonstration cities Amsterdam and Grenoble have CO_2 reduction goals for 2050 of 80 %. All 22 demonstrators together have an estimated impact of 59,000 tonne/year CO_2 reduction. The demonstrators in Amsterdam and Grenoble include retrofitting to levels down to 53 kWh/m², as well as fully-functional smart grid development (in Amsterdam for 10,000 dwellings), electricity storage demonstrators, free cooling schemes and district heating efficiency improvements such as a low temperature water loop for using in connection with heat pumps.

The City-zen project recognizes the key position of citizens, so ample attention is paid to involvement, dissemination and education of this group. The development and utilisation of serious games is included to improve stakeholder collaboration. Key City-zen elements:

- A transparent cooperation model to allow for the transition towards the future integrated city for all infrastructure owners, the local authorities and housing companies.
- A flexible and future proof infrastructure which invites and enables industries and citizens to innovate, co-create and work together on new zero energy solutions.
- An (improved) methodology to validate and optimise zero energy solutions.
- A series of innovative demonstrations, including monitoring, showing that it all works.

The paper will describe the concept in detail and initial results.

Introduction

BACKGROUND

Grenoble and Amsterdam are both very ambitious in their goals to be eco-friendly cities. Both cities are not doing this only from a climate perspective, but also from an economic perspective: the availability and sustainable use of affordable and green energy is key for economic growth. Within the last years Grenoble and Amsterdam have emerged as cities where several local, national and European projects and programmes (ECOSTILER, STACCATO, TRANSFORM, ZenN, NEXT- Buildings, CUTE) have been executed successfully on topics such as district heating, energy grids, local energy generation, energy efficiency for housing and offices, water, waste, industrial efficiency or clean transport.

But now it is time for the next step where citizens play a major role, where end-users have a real choice in the source of energy they want. This means that three things need to change:

- infrastructures need to be intelligent, more flexible and designed as an integrated multi-energy system, capable of switching between energy carriers like electricity, gas, heat;
- users need to be involved in a structural way and take part in a new energy economy;
- businesses need to be challenged to provide new products and services, to re-think responsibilities and collaborations.

This will lead to a new energy market that needs to be developed. City-zen will not only demonstrate on large scale, but also challenge the industry to come up with new products and services and test them. Infrastructure and housing owners in Grenoble and Amsterdam are willing to invest in the transformation to reach low-carbon neighbourhoods. This project brings them together and demonstrates that the new energy market is a citizen-driven collaboration with focus on renewable energy and energy efficiency. People on the demand side (customers) will get the tools to act and industry will have the opportunity to respond and reach potential clients more effectively.

CONCEPT

The overall concept is: To move from the current city towards a sustainable, self-sufficient community. For this, essential changes in the energy system, related value development and technology are required. In every city this will take place in a different form and at a different speed. The project addresses how to do this in an existing urban context and how to speed up the process of change. Market models need to be changed and customers should be enabled to demand renewable and efficient energy.

Currently over 68 % of the Europeans live in cities and this will rise to about 80 % in 2050. Cities are centres of economic growth and innovation and responsible for a major part of all energy consumption. This means that the transition to renew-



Figure 1. Cooperation principle.

able energy needs to take place there. This is not only required to reach climate goals, but also simply because affordable renewable energy gives Europe the ability to remain competitive.

The objective of this project is to demonstrate, at the level of districts, an innovative integrated energy system, optimised both in terms of increase in energy efficiency and CO_2 reduction. The way to do this is to make sure that the balance of supply-side measures based on a high share of renewables and demand-side measures to reduce consumption is perfect. To reach the 20-20-20 targets this is the moment for large scale implementation of new solutions.

The citizen is put in a central position in order to use the capacity of change of society. The engagement of citizen is likely to be reached by insight plus innovative 'green' products and services. The government (and grid operators) should shape an ambitious consistent context where possible barriers are diminished.

So, in order to push the energy transition forward,

- 1. citizens should be engaged,
- 2. multiple (new) stakeholders should align their actions,
- 3. market deployment should be fastened.

Figure 1 shows the integration of the three issues mentioned above in combination with an abstract of main activities and actors.

- DO: Citizens are required to do (act), embrace (change) and by that make the transition a reality.
- DESIGN: knowledge partners are required to develop the strategy forward to define and ensure long term goals.
- PROVIDE: industry is required to provide the means to achieve the long term goals.
- FACILITATE: governmental and local administration is required to facilitate the transition.

Paul Gilding (2011) states that a (financial) market shift will direct the energy transition. The problem now is a market paradox: fossil market used to be very profiting as energy prices were high, but on the long term this industry will lose its value because of the depletion of fossil resources. The challenge of today is to increase value development in the new 'green' energy sector in order to initiate the market shift. Value will be distributed in a totally different way compared to in the conventional energy system. Therefore investment and revenues in the new (decentralized) system should be closely analysed. Figure 2 shows the idea behind it. A combination of technology development and process improvements brings energy performance to a higher level.

Smart city development methodology

There are three main scientific and technological elements in the project:

- To realize more effective collaboration models and a methodology for development of smart cities (Process innovation);
- To showcase to society ambitious pilot projects;

 To connect with industry, and have them develop technology to the benefit of smart cities.

The City-zen project aims to realise integrated change with strong involvement of all stakeholders: industries, decision makers, knowledge partners and citizens, see Figure 3. This figure shows the underlying logic of the City-zen project organisation. In this scheme, industry is given an important position: they make the transition. Industry is essential both for technological innovation and as a driver for a green economy.

City-zen is set up as a project starting from the key objectives: boost economy, cooperate and involve citizens, show demonstration pilots. Previous work in the Netherlands has led to the Rotterdam Energy Approach & Planning (REAP) [e.g. Tillie et al. 2009; Dobbelsteen et al. 2009] and the Guide to Energetic Urbanism (LES or *Leidraad Energetische Stedenbouw*) developed by the city of Amsterdam with the help of TU Delft. In Grenoble, there is very good experience with their Factor 4 Climate action plan, which builds on public private partnerships. In 6 years, no less than 70 stakeholders have signed the Local Climate Plan Charter, in which they commit themselves to implement concrete actions for fighting against climate change. Emphasis is on expanding the methodology, building on the lessons learned.

Demonstrations

The core idea behind the demonstrators is the city as a living lab. Pilots are chosen in Amsterdam and Grenoble with varying contextual conditions: the presence of smart grids or not/ presence of district heating or not/privately owned real estate or social housing. The demonstrators will underline the policy of the cities:

- Cost-effective solutions to upgrading of the housing stock. In an urban context this means through a combination of building envelope and system measures.
- Maximize the city capabilities for local renewable energy generation. This means by upgrading of the local heating and cooling and electricity grid structures.

AMSTERDAM WEST

Retrofitting to zero energy buildings

The objective is to improve the existing building stock considerably to ensure affordable total costs (rent + energy) for tenants now and in the future, while in the same time establishing better comfort in the dwellings. Average energy reduction target for all building typologies is about 30 % with respect to new build (and around 80 % with respect to the existing situation). CO, reduction target is 3,000 tonne per year.

Key in the approach is to involve tenants actively and to empower them to save energy and to co-design with other stakeholders innovative approaches for energy efficient renovation. Before energy efficiency technologies will be applied in already ongoing projects, a first scan will be made by an integrated group of experts to define improvements for coming projects. The eventual application will be monitored and the effects will be integrated in the small scale pilots (30 units) that will be available for experiments. These pilots are open for SME's, latest



Figure 2. City-zen at a glance.



Figure 3. City-zen: organisation.

technologies and non-preferred suppliers. Targeted dwelling typologies treated in the project reflect the majority of housing types found in Europe, like terraced housing, multi-level apartment buildings etc. because of replicability importance.

Innovative solutions for medium and low voltage grid

The objective in this area is to develop and implement a fully functional innovative medium and low voltage distribution grid, including advanced fault detection technology, bidirectional energy flow, demand response technology and software, to serve as a demonstration grid for innovative electricity production and consumption services.

Within the project, a number of specific technology demonstrators are defined:

- To demonstrate the feasibility of decentralized electricity storage systems in combination with photo-voltaic installations. See Figure 4 for a graph showing the benefits in the field of peak shaving.
- To test the benefits of Vehicle to grid (V2G) applications and technology on the Amsterdam New West smart grid.
- To explore the business case of using thermal buffers in the stabilization of the electricity grid.

This is done on the grid that serves about 10,000 of households making it the largest intelligent grid in the Netherlands. Specific focus is on enabling the delivery of smart services with an



Figure 4. Peak shaving and enhancing energy autonomy through PV combined with battery storage.



Figure 5. Map of Amsterdam activity area.



Figure 6. Map of Grenoble's activity area.

attractive business case. About 1,000 households are going to receive Energy Data boxes to enable information flow in the low voltage grid as well as energy feedback to the inhabitants.

Innovative solutions for heating and cooling

The objective is to improve the CO₂ performance of the heating and cooling supply at an acceptable cost for the clients. CO₂ reduction objective of demonstrators is 14,540 tonne per year

For this, the district heating company is expanding its grid to better utilize the waste heat from the Waste-to-energy company. Long term goal is making the system fossil fuel free by adding more renewable energy and waste heat streams. In 2012 the grid was awarded the "Best practice award" from the Dutch "Warmtenetwerk" because of their efforts in reducing CO_2 emissions and grid expansion.

All the demonstrator activities take place in the Amsterdam West area (Figure 5).

GRENOBLE

The EcoCité project is developed in the North polarity of the territory and covers ¹/₅ of the Grenoble city's global surface (Figure 6). Grenoble ambition is to develop **an energy positive and carbon neutral district** by combining the use of clean and renewable energy sources, saving and controlling energy flows, retrofitting existing buildings, but also promoting sustainable transportation modes and new services for citizens. Long-term objective is to replicate solutions found there in the two others polarities of Grenoble.

Retrofitting to zero energy buildings

The EcoCité development area will rely on both existing and new buildings. In the scope of City-zen project, the city will focus on the existing dwellings of the area with the ambition to reach after refurbishment the level of current thermal regulation for new buildings. The specificity of the Grenoble project is to focus on private co-owned multi-family buildings. Those are the main challenge to reach the 202020 objectives, as private owners are a difficult target group to address. To do so the city will develop a retrofitting intervention strategy based on buildings technical and architectural typologies as well as on the social and economic conditions of the families.

Innovative solutions for heating and cooling

The objective of the innovative thermal loop (Urban district heating & cooling system) is:

- To adapt the heat of the grid to the low-energy building needs, by designing a very low temperature district heating loop (25–35 °C) in order to avoid heat losses compared with the traditional Grenoble's district heating.
- To improve the overall district energy efficiency by connecting this loop to a heat recovery system from sewage water coupled with heat pumps.
- To demonstrate seasonal storage solutions with dry geothermal boreholes



Figure 7. Multi-energy territorial monitoring system.

Innovative solutions for medium and low voltage grid

In addition, the objective of this ambitious area is also to monitor and manage all the energy flows (not only the electric ones) in order to save energy and assess systems and policies efficiency with a Multi-energy territorial Monitoring system. All the components of a Smart Energy City are present in the Ecocité area so as to reach the ambitious objective of being an Energy Positive District. All energy flow and renewable energy production will be monitored and managed by the Multi-energy territorial Monitoring system (Figure 7).

Industry involvement

The objective for the industrial involvement is to provide better channels for products and services replication through Europe as well as speeding up the penetration of innovative products in implementation.

To reach the objective to provide better channels, industry partners are partnering in two specific ways:

- 1. Involvement in the further development of smart infrastructures enabling new products and services. A closer connection between infrastructure providers and industry ensures that new technological solutions, new products and services will be developed to meet the key demands. Working groups and knowledge exchange activities will be set up to ensure an increase of the innovation rate, and that infrastructures will be implemented in a way that they are as open and useful as possible to the needs of citizens.
- 2. Organizing the ecosystem that is needed for implementation of new products and services. Most solutions need several partners to implement them. In (for example) large scale implementation of electric vehicles: car manufactures, charging owners, grid operators, government and people who buy the cars. And then a whole industry around maintenance, payments, car lease, etc. will develop.

Citizen involvement

In many of the City-zen activities citizens are involved. For example, they are recognized as an important stakeholder in the smart city methodology development and they are a specific target group in the serious game development (a kind of business simulation game that mimics the interaction between stakeholders). In the demonstration activities of the project, citizens have an important role in the planning and realization of housing refurbishment activities and in the "smartification" of the energy system. Hundreds of households will receive smart meters and energy data boxes, enabling them to take better control over their energy consumption (and possibly production) and to embark on future energy services like time of use (TOU) pricing.

Yet, to stimulate engagement and to draw lessons from the project, monitoring of the societal impact is an important part. This will be done by surveys, but also through campaigns and behavioural change.

Outreach

As Amsterdam and Grenoble already have a significant history in sustainable development, their intention is to help other cities on the same path. Several instruments have been identified to do this.

- Field trips to interested cities: A group of experts will visit other cities to exchange knowledge and experience and discuss mutual approaches, their benefits and challenges;
- Serious gaming: Two games are planned, one as an educational tool for the general public and a decision making game for professionals. The latter targets the improvement of collaboration processes and mutual understanding;
- City conferences. These will be organized in Amsterdam and Grenoble. The aim is to stimulate direct interaction between experts, politicians and other stakeholders. The purpose is to bring people and organisations, sharing the interest for sustainability, together. The higher aim is that the participants are informed over the latest developments. This will be done by inviting leading personalities on the

subject of sustainability to take place in a forum and discus their expectations and ideal paths. The forum will be combined with presentation of both scientists and business people on their experiences.

Initial results and Conclusions

The project is based on ample experience of the involved partners with the key hurdles in sustainable city development. That has resulted in an approach not only based on demonstrators, but also on further development of the methodologies already emerging in Amsterdam and Grenoble. The project will be used to disseminate these methodologies to other cities in Europe.

One of the demonstrators, the regeneration of a cold source for a climate neutral neighbourhood by regeneration with surface water has recently been constructed. It will start operation upon arrival of the first inhabitants of the Houthaven neighbourhood during summer 2015. Other results so far:

- In the area of smart grid: Realization of a detailed map of the smart grid area at Low-Voltage level. This will assist the smart metering roll-out for Amsterdam Smart City housing projects.
- In technology: A "smart grid ready" hybrid heat pump has been developed.
- In the field of methodology development: Based on urban energy approaches that had been developed and applied earlier (REAP [Tillie et al. 2009] and LES [Kürschner et al. 2011]), City-zen's methodological activities elaborated a layered method that helps cities to make the energy transition. The method combines technical, spatial, political, legal, economic and social layers of intervention.

Glossary

CHP Combined Heat and Power CUTE Clean Urban Transport for Europe

- DH District Heating
- EBPD Energy Performance of Buildings Directive
- EPC Energy Performance Coefficient
- FP Framework Programme
- LES Leidraad Energetische Stedenbouw
- PV Photo-Voltaics
- REAP Rotterdam Energy Approach and Planning
- SME Small and Medium Enterprise
- V2G Vehicle to grid

Bibliography

Dobbelsteen A. van den, Tillie N., Joubert M., Jager W. de & Doepel D.: 'Towards CO₂ neutral city planning and low energy redevelopment – Presenting the Rotterdam Energy Approach and Planning (REAP)', in: Proceedings Fifth Urban Research Symposium (1–16); Worldbank, Marseille, 2009.

Gilding, Paul: The Great Distribution, 2011.

- Kürschner et al.: 'The Amsterdam Guide to energetic Urban Planning', in: Proceedings of Management and Innovation for a Sustainable Built Environment, 20–23 June 201, Amsterdam, The Netherlands.
- Tillie N., Dobbelsteen A. van den, Doepel D., Jager W. de, Joubert M. & Mayenburg D.: 'Towards CO₂ Neutral Urban Planning – Introducing the Rotterdam Energy Approach and Planning (REAP)', in: Journal of Green Building, Vol. 4, No. 3, summer, 2009 (103– 112).

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