CONCERTO

REPORT ON THE QUALITY OF INTEGRATION OF RENEWABLE ENERGY SOURCES AND ENERGY EFFICIENCY
EXECUTIVE SUMMARY

CONCERTO
is an initiative co-funded by the European Commission under the Research Framework Programme

CONCERTO

CONCERTO
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COMMISSION

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WHAT IS CONCERTO?

The CONCERTO initiative was established in 2005 by the European Commission. During its creation, the defining concepts in mind were sustainability, replication and cost effectiveness, and the project aimed at revolutionising and modernising communities' energy systems.

With an initial network of 27 cities, the CONCERTO concept ignited, and five years later 58 cities in 23 countries across Europe are demonstrating and over 70 associated communities benefit from the growing stock of knowledge. The CONCERTO initiative highlights the role and contribution of local authorities (primarily city administrations) as coordinators of integrated actions for sustainable urban development with a focus on energy issues. The cities have a mission to research and demonstrate how energy efficiency and renewable energy use can be incorporated into cities' buildings on a large scale. CONCERTO is itself in every sense on a large scale, with CONCERTO cities comprising a population of approximately 5 Million people with about 500,000 inhabitants directly – or indirectly - affected by CONCERTO activities.

In 2010, after five years of CONCERTO, the results, findings and recommendations are available in several reports and publications:

- The CONCERTO Guide
- Planning and implementation process assessment report & Executive summary
- Report on the quality of integration of renewable energy supply and energy efficiency measures & Executive summary
- Report on the assessment of the overall energy performance of the 26 CONCERTO I communities & Executive summary
- Report on the socio-economic assessment & Executive summary
- Publication on policy recommendations & Executive summary
- 3rd CONCERTO DVD, including all above mentioned publications in electronic format

The purpose of the publications is to share the results of the CONCERTO initiative. The different publications will provide information to relevant actors aiming to implement sustainability projects in cities across Europe. By sharing this knowledge, the publications will provide an outline of what can be done and how local sustainability can become a reality. All publications can be accessed via the European Commission's DG ENERGY website at http://ec.europa.eu/energy/renewables/concerto_en.htm

The CONCERTO initiative at a glance

- 58 cities in 23 countries, close to 70 associated communities
- 1,830,000 m^2 of buildings built or renovated
- 530,000 tons of CO_2 emissions saved per year
- 5,2 million people live in the CONCERTO cities

0. INTRODUCTION

The integrated approach in CONCERTO can be understood on a variety of levels, ranging from a policy and stakeholder perspective, to a thematic or energy point of view. A crucial aspect is integration from an energy point of view, which turned out to dictate other levels of integration mainly from a decision making and planning point of view (e.g. stakeholder involvement). In the CONCERTO context, "energy integration" consists of simultaneous actions on the demand and supply side of an urban energy system to improve the overall energy system performance. The main target is to achieve better results than if measures are applied only on the demand or the supply side.

Even if the word "integration" is commonly used, there is no standard procedure for assessing the "degree" or "quality" of integration in a given process. Hence there is a need to define indicators and criteria which take into account all integrated aspects. Indicators commonly used to assess the performance of energy systems are not suitable and do not clearly show the degree or quality of integration in the related process. Overall indicators (such as CO_2-emission reductions) are suitable when expressing the impact of different types of measures using a common denominator, but such indicators do not provide any details about integration.

As part of the assessment work done on the initiative, it is required to assess the "quality of integration between measures targeted to increase energy efficiency and use of renewable energy sources (RES)" (in the following text referred to as the "quality of integration"). To allow for benchmarking between participating communities, it is therefore necessary to elaborate an assessment methodology adapted to each community, i.e. one that leads to satisfying results given the quality and quantity of data available.

The Report on the quality of integration provides an overview and assessment on the quality of integration of renewable energy supply with energy efficiency measures implemented during the first generation CONCERTO projects. A major endeavour of this report is to provide common and objective criteria for assessing what can be considered as "good-quality integration" in different typologies of communities.

As the level of data quality and the amount of data varies greatly from one community to the next, the proposed simplified methodology is based on a multi-criteria approach which tries to cover the main quality aspects. This is done on both a quantitative and qualitative basis.

The report presents the assessment results for the quality of integration for each of the communities analysed. Comparative assessment is done directly for communities with similar typologies (new neighbourhood developments, neighbourhood renovation projects and integration at city scale). Conclusions can be drawn on how single measures could be integrated in different cases and what future challenges exist in relation to integration.

Relevance

As integration is the main characteristic of the CONCERTO initiative, it is worth defining an appropriate assessment framework which highlights the added value of the initiative. Using indicators commonly available to assess the impact of technology-oriented programmes (e.g. avoided CO_2-emissions) would be too restrictive. Similarly to what is done for the assessment of planning and implementation processes in CONCERTO (D1.3.5 Planning and implementation process assessment report), it is necessary to develop a dedicated methodology applicable to CONCERTO communities because there is no known suitable assessment methodology for this purpose.

The systematic analysis performed helps the understanding of what is "good-quality integration" at a neighbourhood and at a city scale. It then goes on to show how different types of communities deal with the many aspects of integration by taking into consideration the local context. The result is an overview on the combination of measures which were successfully implemented by CONCERTO communities.

Target group

The Report on quality of integration targets a diversified audience, predominantly those involved in local energy planning activities. It addresses in particular municipal authorities and local decision makers, as these stakeholders are in the position to initiate integrated projects and handle the highly complex processes required for their implementation (as presented in D1.3.5 Planning and implementation process assessment report). Other sections might be valuable for the academic community or practitioners designing and implementing sustainable energy projects in the urban environment. This could include project developers, utilities, urban planners and architects. The report provides local decision makers with a basic overview on how integration was interpreted in communities with different typologies. It continues on to outline ways of reaching high-quality integration, pointing out also the main benefits of an integrated approach. It mentions the challenges which were faced by communities, highlighting the aspects of integration which require future improvement.

Structure

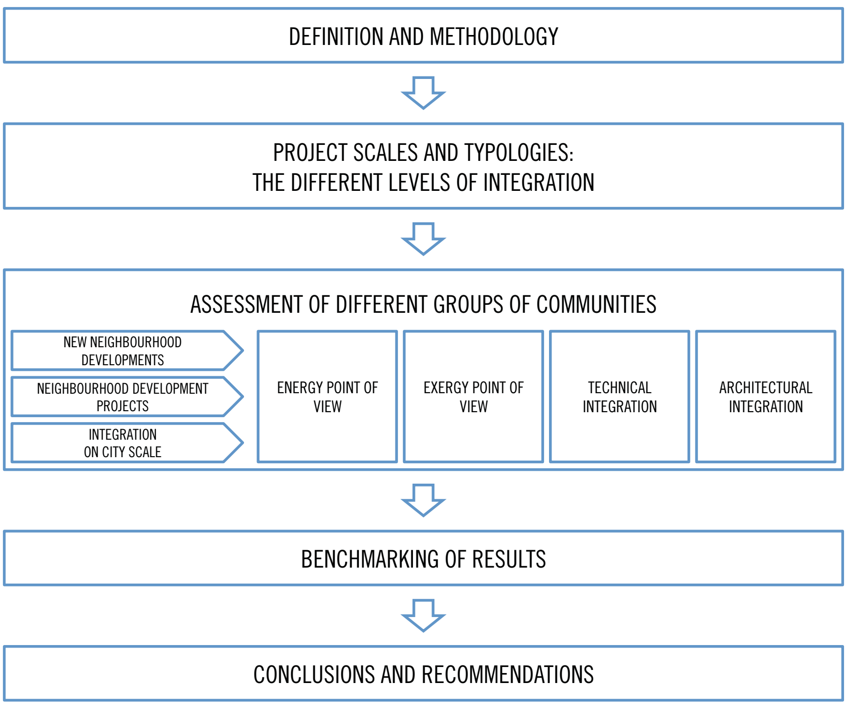
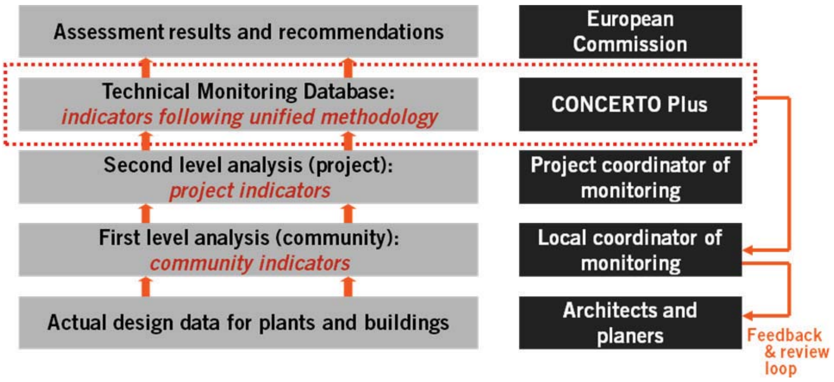


Figure 1: Data collection process for actual building and plant design data



1. DEFINITION AND METHODOLOGY

Criteria definition

Achieving "Good quality integration" is much more than having a community or building's energy demand entirely covered by renewable energy sources on a yearly basis. Looking both at academic reports on sustainable energy use and current practice in the field of sustainable building and energy systems, certain principles can be identified. All of them have been applied with different degrees of ambition in CONCERTO communities, even if all aspects where not explicitly requested in the initial call for projects:

1. Applying the "trias energetica" principle [Lysen, 1996]
2. In theory: finding the point at which the marginal costs for increasing energy efficiency in buildings are higher than for investing in renewable energy systems (economic aspects)
3. In practice: jointly reducing final energy and primary energy demand
4. Reducing exergy losses
5. Adapting the degree of centralisation of energy supply infrastructure to energy demand density
6. Managing peak demand and time-variable generation from renewable energy sources through demand side management and energy storage
7. Architectural integration

Usability of the proposed definition in the context of CONCERTO

All these criteria can be reduced and simplified in a way to be possibly answered by a yes/no-answer. For instance, all the sub-criteria defining the quality of architectural integration of solar technologies, the multi-functionality of solar panels is a characteristic which can be indicated by a yes/no answer. After having checked the feasibility of these criteria with regards to the CONCERTO situation and available data, it is proposed to limit the number of assessed aspects to the following:

- Integration from an energy point of view: are renewable energy technologies installed on energy efficient applications?
- Integration from an exergy point of view: are renewable energy technologies adapted to cover the energy needs in terms of temperature and installed capacity?
- Technical integration: Is the degree of utilisation of renewable energy technologies maximised through specific components and real-time energy management systems?
- Architectural integration: are renewable energy technologies physically integrated into the urban structure (multi-functionality)?

Definition of baselines

The assessment from an energy point of view requires a concrete definition of calculation baselines. A document has been written presenting the conventions and choices made, allowing for a comparative assessment between communities.

Assessment scenarios

Assessing the quality of integration in the light of the chosen methodology does not require any energy use monitoring data. The scenario "ex-post" based on calculated figures will therefore be used in the following. For new and existing buildings and new plants, it consists of calculating community energy performance based on the actual design data and the actual number of buildings and plans completed and/or renovated.

Challenges in carrying out a comprehensive assessment and limitations

The main difficulties in carrying out a comprehensive assessment are mainly due to:

- Differences in implementation stages between communities. In particular, some demonstration projects are not completed at the time of writing.
- Lack of a consistent and common data baseline for all communities. The main reason for this is the complexity of data communication flows, intrinsically linked to organisational and contractual aspects of large European projects as CONCERTO, as shown by Figure 1.

For reasons related to transparency, the following quantity and quality indicators for provided and used data were defined:

- A high data quantity corresponds to a high number of deliverables, reports and data communicated to CONCERTO Plus
- Criteria for high data quality are:
  - Clear and univocal data definition (including specification of units)
  - Explicit reference to external/internal sources
  - Critical comments on validity of data communicated
  - Consistency with CONCERTO Plus requirements (in particular with regard to monitoring)

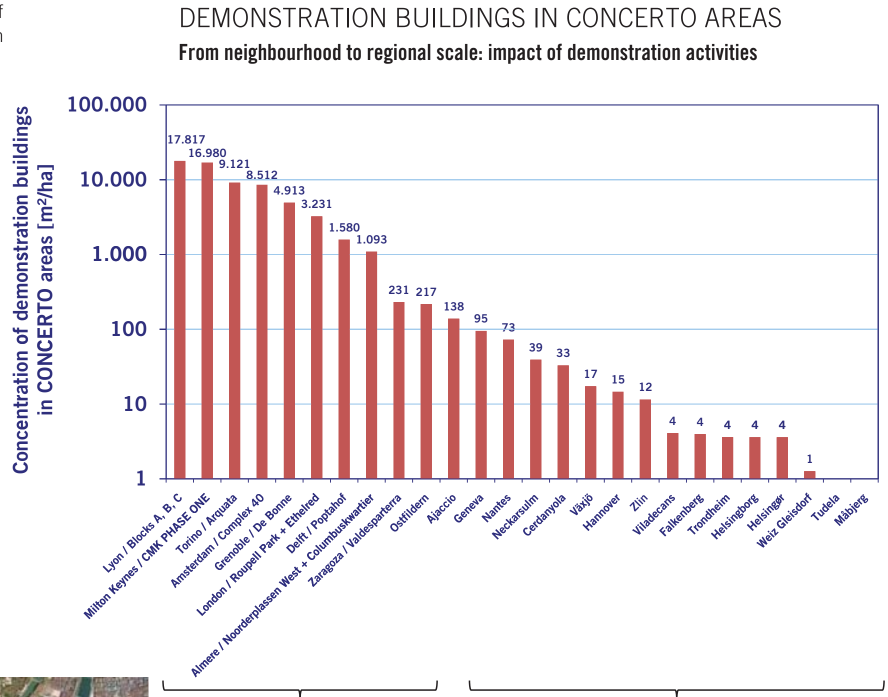
Over the 9 CONCERTO projects, data quality has been estimated as being high for 2 projects, low for 2 other projects, and medium (i.e. with data quality varying according to demonstration objects or communities) for the 5 remaining projects.

2. PROJECT SCALES AND TYPOLOGIES: THE DIFFERENT LEVELS OF INTEGRATION

Communities in the sense of CONCERTO

The CONCERTO programme was addressed to communities in general and, besides thematic and energetic requirements, the only practical requirement for demonstration projects was that they were all located in "clearly defined geographical areas or zones, within

Figure 2: Concentration of demonstration buildings in CONCERTO area



Lyon (F)

Altitude: 5 km [Google Earth Pro]

Highly concentrated neighbourhood projects: Entire neighbourhoods are concerned by demonstration activities

Distributed demonstration projects: Demonstration activities are distributed over extended geographical areas (from district to regional scale)

Energieregion Weiz Gleisdorf (A)

Altitude: 60 km [Google Earth Pro]

which all of the dynamic interactions and relevant energy flows between centralised and decentralised energy supplies and demands can be identified for measurement and assessment purposes" [FP6 work programme, 2003]. In the following paragraphs, the "clearly defined geographical areas or zones" will be referred to as "CONCERTO areas".

As the concrete extension and size of the clearly defined geographical areas or zones was not specified in the call, the CONCERTO area can include the geographical area of an entire municipality, a district or a neighbourhood. There are even communities following a mixed approach, where the CONCERTO area consists of entire municipal areas and include more than one neighbourhood as specific projects.

Figure 2 gives an idea on the density of CONCERTO demonstration buildings in the CONCERTO areas. There are few neighbourhood projects (Lyon, Torino, Amsterdam, Grenoble…) where all CONCERTO demonstration activities are concentrated in a small area. In other projects, the concentration of demonstration buildings is rather low given the large scale of intervention chosen for the CONCERTO project. The geographical areas range from districts (Ajaccio) to entire rural regions (Energieregion Weiz-Gleisdorf).

Physical-geographical boundaries and energy system boundaries chosen for assessment

Simply defining the geographical boundaries is not enough to provide an energy performance assessment. A consistent assessment is based on the definition of clearly defined energy system boundaries. In practice there is no "energy island" project in CONCERTO, and all demonstration projects are connected to an energy supply infrastructure (electrical, gas and/or district heating/cooling network), which usually also supplies objects which are not considered as demonstration buildings. The result is that there is no coincidence between the physical-geographical boundaries chosen (neighbourhood/district/city) and common energy system boundaries, corresponding for instance to an energy conversion plant.

That is why CONCERTO communities are assessed at two levels, allowing performing both energy performance assessment and impact assessment:

- Neighbourhood assessment
- Project assessment

Both assessment approaches are illustrated by Figure 3 (next page). They mainly differ from the way in which energy generated outside the geographical boundaries of a given neighbourhood is considered in the energy balance.

Consequences for energy balance and calculation method

The neighbourhood assessment approach is more suitable to the CONCERTO initiative, because it shows how the use of on-site energy generation systems improves the energy performance of a neighbourhood. This is therefore a starting point for an assessment on a city scale. However, as not all CONCERTO projects are neighbourhood projects, this assessment could not always be performed. A project assessment considers all demonstration activities, thus leading to a situation where large scale CHP, RES-e and RES-th plants have a more significant contribution than small plants installed within the urban structure of neighbourhoods in terms of avoided CO_2 emissions.

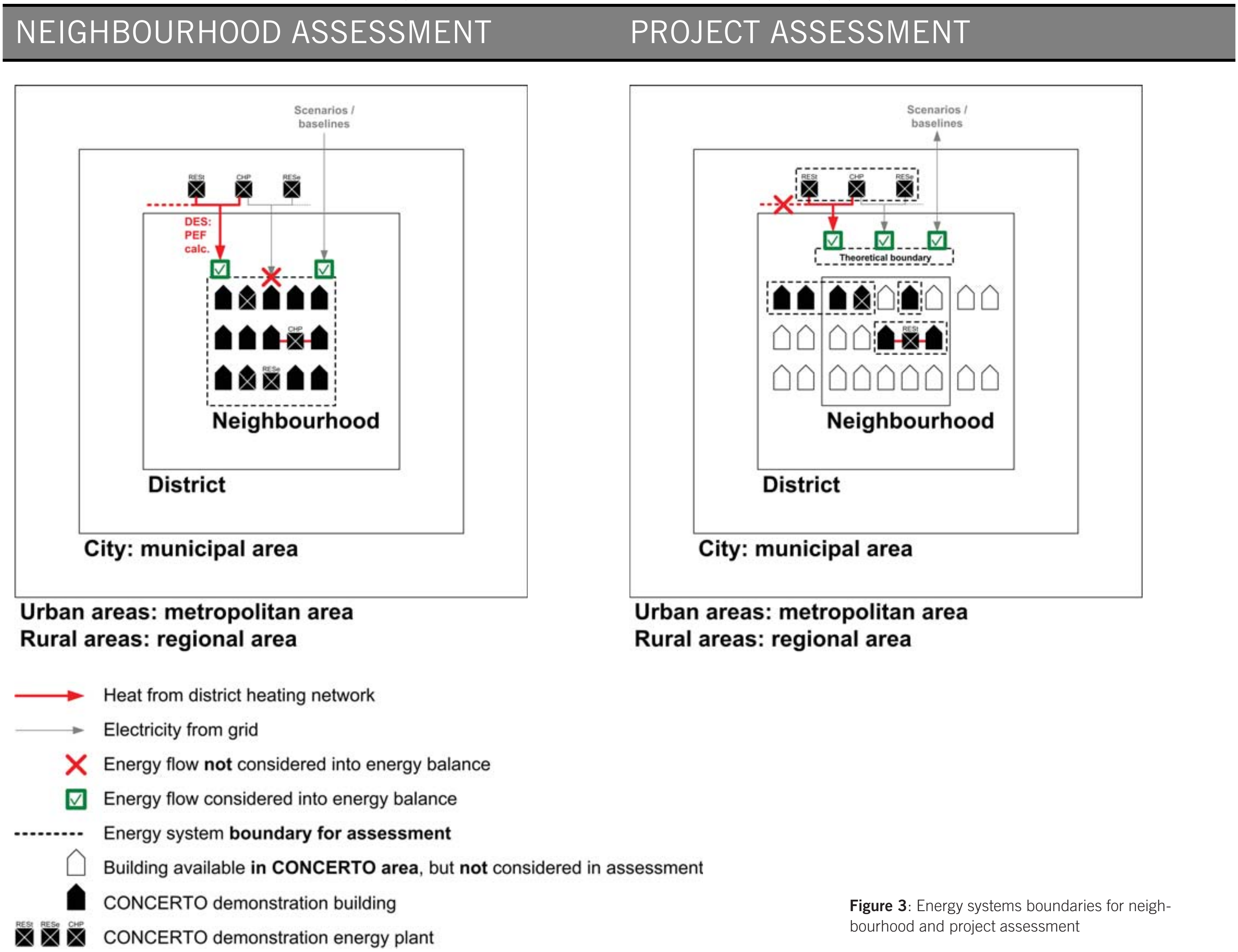


Figure 3: Energy systems boundaries for neighbourhood and project assessment

3. OVERVIEW OF THE QUALITY OF INTEGRATION IN ALL 26 CONCERTO COMMUNITIES

New neighbourhood developments

Table 1 (next page) provides an overview of all combinations of measures implemented in CONCERTOs' new neighbourhood development projects. The table presents only the demonstration activities located within the geographical neighbourhood boundaries, without mentioning energy efficiency improvements in buildings which are common to all projects.

According to table 1, the most common measures in new neighbourhood development projects are:

- Newly built or extended district heating networks (10 neighbourhoods over 14)
- Photovoltaics (4 neighbourhoods over 14)
- Solar thermal fields connected to district heating networks (2 neighbourhoods over 14)
- Individual solar thermal systems (2 neighbourhoods over 14)

Energy point of view: The combined improvements in terms of specific final energy and primary energy use reduction are illustrated in Figure 4. Normalising space heating energy use figures with heating degree days (HDD18/15 European average: 3386) is a way to map the relative efforts made by communities located in different climate zones (Figure 4). Even if all communities are located close to each other in the reference situation, different combinations of measures allow for reaching different energy performance standards.

- Using biomass boilers and solar thermal collectors directly in the neighbourhood allows covering the heating energy needs by a high share of renewable energy sources. Photovoltaic panels allow further improvement of the primary energy balance. The neighbourhoods implementing these technologies have reached the highest performance levels.
- High performance could be reached thanks to biomass-based district heating networks, when the use of back-up gas boilers could be limited.
- Neighbourhoods using more traditional district heating mix (with limited share of heat from CHP plants) have lower levels of overall energy performance.
- When only a small share of the total heating demand is covered by solar thermal collectors (used for domestic hot water preparation) and the rest of the heating demand is covered by natural gas boilers, it results to a rather high specific primary energy use. The overall energy performance in such situation could be significantly improved by

	Name of neighbourhood	RES-e measures	RES-th measures and CHP	DH available	new DH built	Technical integration measures	Architectural integration of RES
Almere	- 1 neighbourhood: Columbuskwartier	- PV on eco-buildings (solar houses)	NO MEASURE		X	NO MEASURE	- PV-field = projecting roof
Almere	- 1 neighbourhood: Noorderplassen West	NO MEASURE	- large scale ST connected to DH		X	NO MEASURE	- ST collector field placed on ground
Milton Keynes	- 1 neighbourhood: WEST END - CMK PHASE ONE [PA]	- small scale PV bus stop	- gas CHP		X	NO MEASURE	- PV-field = bus stop roof
Viladecans	- 1 neighbourhood Llevant [PA]	NO MEASURE	NO MEASURE		X	NO MEASURE	n.a.
Trondheim	- 1 neighbourhood: Granås Gård [PA]	NO MEASURE	NO MEASURE		X	NO MEASURE	n.a.
Tudela	- 1 neighbourhood: Campo de Golf [PA]	- PV - wind power plant	- ST	NO DH		NO MEASURE	n.a.
Neckarsulm	- 1 neighbourhood: Amorbach	NO MEASURE	- large scale ST connected to DH	X		- Seasonal ground coupled storage and heat pump	- ST panels replacing tiles
Cerdanyola	- 1 district/neighbourhood: Centre Direccional de Cerdanyola del Vallès	NO MEASURE	- polygeneration plant		X	- CEMS [PA]	n.a.
Ostfildern	- 1 district/neighbourhood: Scharnhauser Park	NO MEASURE	- ground coupled HP, if DH not available - absorption chiller connected to DH	X		Absorption chiller to use district heating in summer	n.a.
Lyon	- 1 neighbourhood: 3 blocks A, C and C in Confluence area	- PV on eco-buildings	- individual biomass boilers	NO DH		NO MEASURE	- PV-field = solar protection of flat roof
Zaragoza	- 1 neighbourhood: Valdespartera	NO MEASURE	- ST on eco-buildings	NO DH		NO MEASURE	- ST installed on flat roof
Grenoble	- 1 neighbourhood: De Bonne	- PV on eco-building	- individual gas CHP in eco-buildings - ST on eco-buildings	(X)		NO MEASURE	- PV-field = solar protection of flat roof - ST installed on flat roof
Delft	- 1 neighbourhood: Harnaschpolder area [PA]	NO MEASURE	NO MEASURE		X	NO MEASURE	n.a.
Växjö	- 1 neighbourhood: Biskopshagen	NO MEASURE	NO MEASURE	X		NO MEASURE	n.a.

1. In Almere, the large scale solar plant (solar island) is combined with a gas boiler to produce heat to the neighbourbood "Noorderplassen West". No seasonal storage is planned, as the solar thermal system is used to preheat the water entering the gas boiler.
2. District heating is available in Grenoble on the De Bonne area. For different reasons presented in the D.1.3.5 (Planning and Implementation Process Assessment Report), the buildings in De Bonne are not connected to it
[PA] Preliminary Assesment

Table 1: Combination of measures implemented in new neighbourhood development projects

using mini CHP-plants located directly in the neighbourhoods.

Exergy point of view: No low-exergy concept has been implemented in the assessed neighbourhoods. In the case of large solar thermal collector fields (Almere and Neckarsulm), the solar collectors are coupled with rather high-temperature distribution networks.

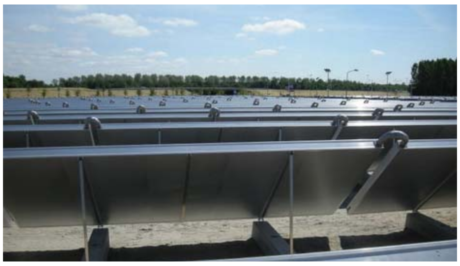
Technical integration: Technical integration measures on the community scale were rarely implemented in completely new neighbourhood development projects (green field development projects), but instead in recently developed areas (in the last 10-15 years) and areas where CONCERTO was considered as another milestone in the entire process. In these recently developed neighbourhoods, there was already sufficient experience from energy system operation in the years preceding CONCERTO. This meant that recommendations could already be made on specific technical measures for improving the overall energy system performance.

Architectural integration: Most of the active solar systems implemented in new urban developments have a relative high degree of integration in the urban structures, mainly directly integrated in buildings. There is one example of large scale solar thermal collector field integrated in the urban master plan (as "entrance door" into the neighbourhood).

Neighbourhood renovation projects

Table 2 provides an overview of all combinations of measures implemented in the neighbourhood renovation projects of CONCERTO. As there are very few comprehensive renovation projects (see D1.3.5 Planning and Implementation Process Assessment Report), an overview of the demand-side renovation meas-

INTEGRATION OF SOLAR THERMAL COLLECTOR FIELD IN URBAN MASTER PLAN:
Solar island in Almere
(Noorderplassen West)



	Name of neighbourhood	RES-e measures	RES-th measures and CHP	DH available	new DES built/ extended	Technical integration measures	Architectural integration of RES
Helsingør	- 1 neighbourhood: Kulturvaerftet [PA]	- PV on renovated buildings	NO MEASURE	NO DH		NO MEASURE	
Amsterdam	- 1 neighbourhood: complex 40 in the district New West	- PV on renovated buildings	NO MEASURE	NO DH		NO MEASURE	- PV-field on tilted roof
London	- 1 neighbourhood: Ethelred [PA]	- PV on renovated building [PA]	- CHP connected to DH		X	- Increasing temperature drop between supply and return line	- PV-field on vertical façade [PA]
London	- 1 neighbourhood: Roupell Park	NO MEASURE	- CHP connected to DH	X		- Increasing temperature drop between supply and return line	n.a.
Torino	- 1 neighbourhood: Arquata	- PV on renovated buildings	- CHP connected to DH	X		- CEMS	- PV-field on tilted roof - PV-field in façade of office building
Zaragoza	- 1 neighbourhood: El Picarral	NO MEASURE	- small scale ST	NO DH		NO MEASURE	- ST-panel on tilted roof
Grenoble	- 1 neighbourhood: Viscose	NO MEASURE	NO MEASURE		X	NO MEASURE	n.a.
Delft	- 1 neighbourhood: Poptahof area	- PV on renovated building	NO MEASURE		X	NO MEASURE	- PV-field on vertical façade
Geneva	- 1 neighbourhood: Lac Nations	NO MEASURE	- Hydronic lake water network		X	- adaptation of existing cooling systems	n.a.

Table 2: Combination of measures implemented in neighbourhood renovation projects

	Name of n eighbourhood	Thermal insulation of outside walls	Thermal insulation of roof or upper slab	Replacement of windows	Improvement of air tightness	Replacement and adaptation of heating/cooling system in buildings
Helsingør	- 1 neighbourhood: Kulturvaerftet [PA]					
Amsterdam	- 1 neighbourhood: complex 40 in the district New West		X	X		
London	- 1 neighbourhood: Ethelred [PA]	X	X	X		
London	- 1 neighbourhood: Roupell Park					X
Torino	- 1 neighbourhood: Arquata		X	X		X
Zaragoza	- 1 neighbourhood: El Picarral	X	X			X
Grenoble	- 1 neighbourhood: Viscose					X
Delft	- 1 neighbourhood: Poptahof area	X	X	X	X	X
Geneva	- 1 neighbourhood: Lac Nations					X

Table 3: Description of demand-side renovation measures implemented

ures implemented is given in Table 3.

Figure 5 (next page) shows that, as expected, the performance levels reached in neighbourhood renovation projects are not as high as in new neighbourhood developments; however, the use of CHP plants allows for substantial primary energy savings in some communities.

- The neighbourhoods with negative primary energy use figures reach significant primary energy savings due to the CHP plants located within the neighbourhoods and photovoltaic panels installed on the building roofs.
- When no thermal improvement is implemented on the building side, the connection

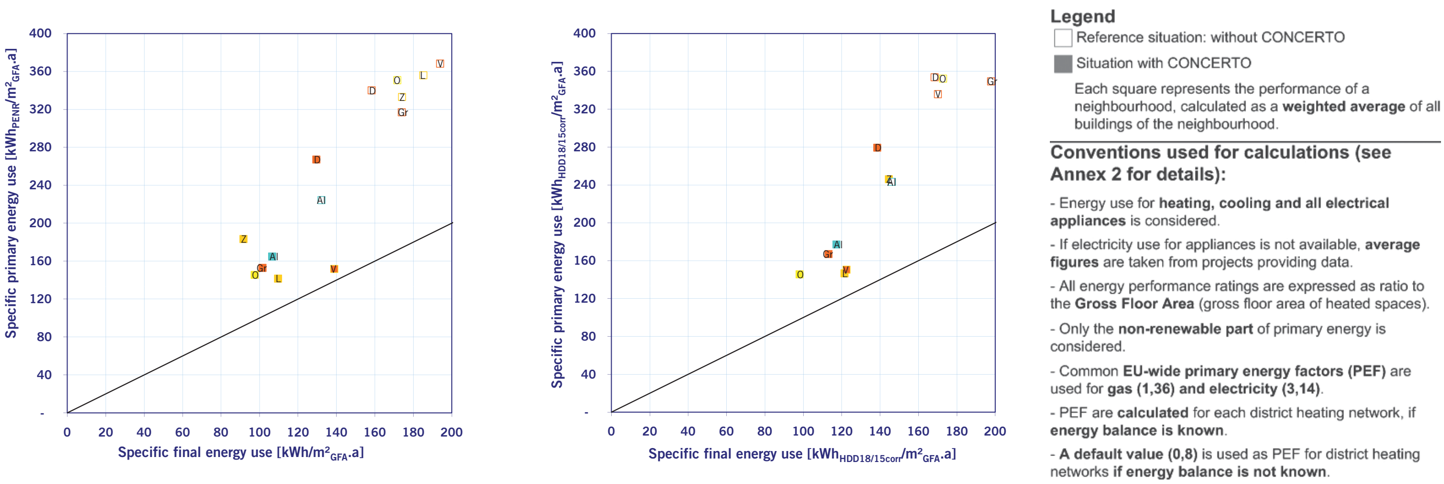


Figure 4: Energy assessment of new neighbourhood development projects (left: without HDD correction; right: normalised with HDD18/15 correction (European average: 3386))

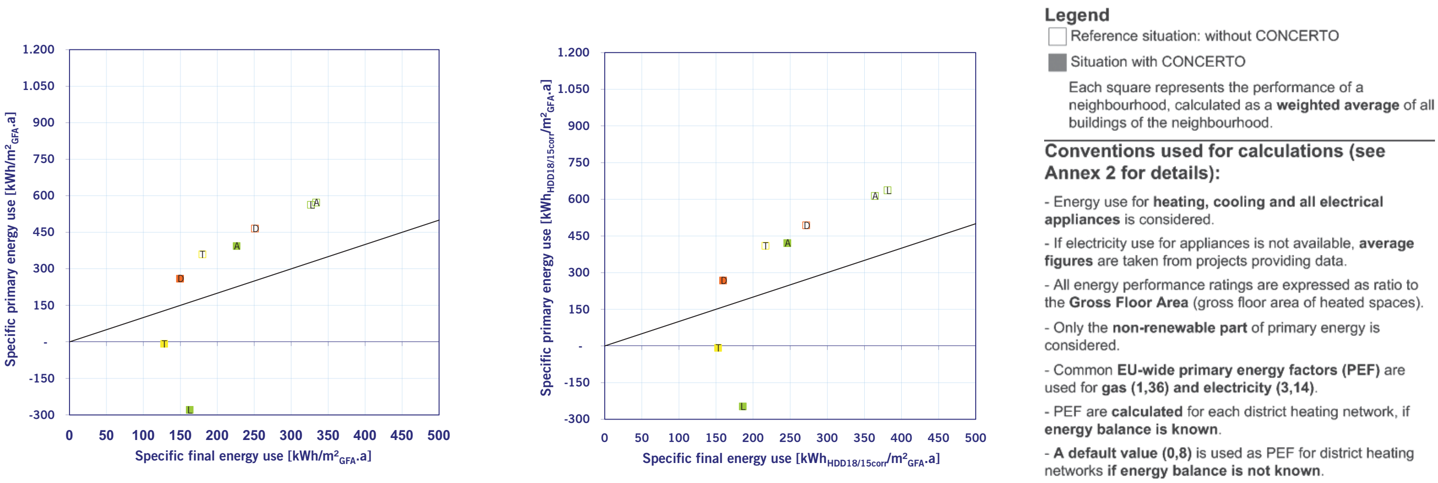


Figure 5: Energy assessment of neighbourhood renovation projects (left: without HDD correction; right: normalised with HDD18/15 correction (European average: 3386))

to an existing district heating network infrastructure leads to rather low overall energy performance levels.

- Keeping using natural gas for heating after renovation should be avoided, because the reached overall energy performance levels are still very low after having implemented the measures. Gas CHP should be used instead.

Exergy point of view: Working with low-exergy concepts in existing urban structures is more challenging than in new urban developments, as there are not many possibilities to adapt heating and cooling systems within buildings. However, there is only one example of a nearly low-exergy concept in CONCERTO, implemented in an existing urban environment. Pumping the lake water directly into a hydronic network to be used as a heat source for distributed heat pumps in new buildings and heat sink for existing chillers in existing buildings can be seen as one of the major innovations in CONCERTO.

Technical integration: There are much more technical integration measures in neighbourhood renovation projects than in new neighbourhood developments, mainly because of the necessary adaptation of existing building heating and cooling systems to new energy supply infrastructure.

Architectural integration: Multi-functionality of active solar systems was rather difficult to reach in renovation projects, mainly due to the fact that the total replacement of roofs has often been a lower priority than other thermal improvement measures.

Integration at the city scale

Table 4 provides an overview of the main measures implemented at this scale. As architectural integration has all possibilities available on the city scale, it was not included in the table.

The combination of measures available depends on the availability of RES and waste-to-energy potentials as well as the availability of a district energy infrastructure. It is therefore difficult to draw general conclusions from the combination of measures.

Energy point of view: A project assessment has been done for all these communities, since a neighbourhood assessment no longer holds any relevance. Because of the high variety of projects and the resulting differences when assessing energy performance at the project scale, the following groups of communities can be recognised when assessing the integration at a city scale:

- Communities with an energy generation surplus thanks to high heating and power plant capacities (wind turbines, biogas plants, gas and biogas CHP, biomass heating plants): these technologies usually have a significant impact on the overall energy balance of a city and provide primary energy benefits for a number of buildings much higher than the number of buildings concerned by energy efficiency improvements.

	Name and number of projects	RES-e measures	RES-th measures and CHP	DH available	new DH/DC built	Technical integration measures
Hannover	- 5 targeted districts (Ahlem, Nordstadt, Hainholz, Vinnhorst and Vahrenwald)	NO MEASURE	- co-firing of biomass in existing CHP	X		
Nantes	- 1 district: Ile de Nantes	- PV park house	NO MEASURE	X		
Ajaccio	- 1 district: Cannes/Salines - 1 building in the historical centre	- PV on flat roof of residential buildings	- ST	NO DH		
Helsingborg	- city scale project	-	- ST - Biomass boiler connected to DH		X	
Helsingør	- city scale project					
Trondheim	- city scale project	NO MEASURE		X	NO DH	- storage of domestic waste
Amsterdam	- 1 isolated building De Leeuw van Vlaandren		- biogas CHP plant connected to district heating	X	NO DH	
Måbjerg		NO MEASURE		NO DH		
Falkenberg	- city scale project	- wind turbines	- ST - pellet boilers	X	NO DH	
Neckarsulm	- city scale project	- PV	- ST - pellet boilers	X	NO DH	
Weiz Gleisdorf	- city scale project	- PV	- ST - pellet boilers	X	NO DH	
Zlin	- city scale project	- PV	- ST	NO DH		
Zaragoza	- 1 isolated school Colegio Candido Domingo	- PV on flat roof of school		NO DH		
Grenoble	- city scale project	- PV on roof of stadium	- co-firing of biomass in existing heating plant	X	NO DH	
Växjö	- city scale project	- PV on school roofs		X	X	- DSM initiated by local utility

Table 4: Combination of measures implemented at city scale

ROOF INTEGRATION
Left: stadium in Grenoble
Right: Amorbach neighbourhood in Neckarsulm

FAÇADE INTEGRATION
Left: KECO-building in Neckasulm
Right: solar air collectors in Falkenberg
(Vaxthuset neighbourhood)

SHADING OR PROJECTING ROOF:
Left: park house in Nantes
Right: Columbuskartier in Almere

Table 5: Architectural integration in urban environment

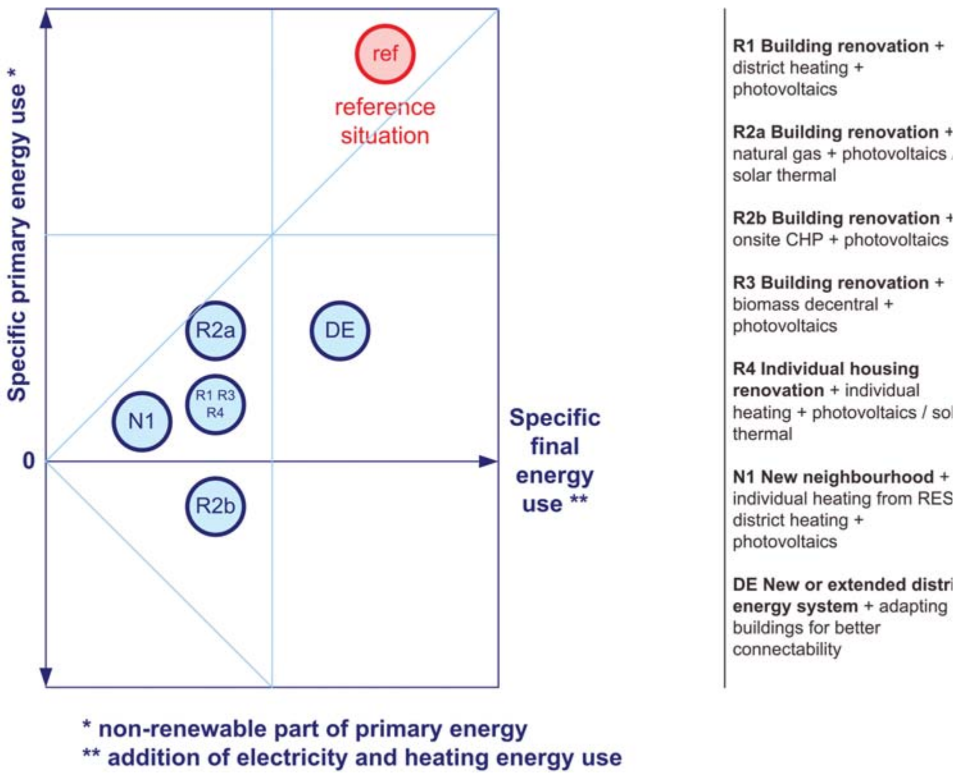


Figure 6: Performance improvements by applying different scenarios

- Communities starting with very low building energy performance standards: existing buildings having very low energy performance before renovation could reach good standards mainly by combining thermal refurbishment (usually not comprehensive) and use of district heating (mainly using heat from CHP plants).

- Other communities: this last group of communities encompass all other communities which could combine balanced demand-side and supply-side improvements. These communities usually used distributed and small-scale energy systems to supply locally single buildings or building groups (mainly pellets boilers and individual solar thermal systems).

Exergy point of view: At the time being, it is rather difficult to apply the low-exergy principles to the entire city level, mainly because it would require a sudden adaptation of the existing building stock to new supply temperature conditions from the existing district energy infrastructure.

Architectural integration: There is a high variety of possibilities for architectural integration at the city scale and many solutions where applied in CONCERTO cities as shown by Table 5.

4. CONCLUSIONS AND RECOMMENDATIONS

Scenarios proposed

Figure 6 represents the average performance improvements due to different combinations of measures in the "final energy/primary energy diagram" at the neighbourhood scale, as obtained in the different typologies of CONCERTO projects. Of course this is a simplification and the figure only shows general tendencies, trying to present the impact of different technology combinations in an objective way (i.e. based on the assessment results). There are variations which mainly depend on the share of energy demand covered by on-site renewable energy sources or the installed capacity of local CHP plants (these factors are commented in the final report on energy performance assessment). Nevertheless, it shows the possible impact of different integrated approaches from an energy point of view at the neighbourhood scale.

New neighbourhood developments (N1) are clearly offering the best opportunities to reduce specific final energy use towards ambitious levels and include ad-hoc technologies which use on-site renewable energy sources. Using individual biomass boilers or a district heating infrastructure which delivers heat from a CHP or renewable energy sources leads to different values for primary energy use. In CONCERTO, the neighbourhoods using individual pellet boilers attained the best levels of performance. Those using solar thermal for domestic hot water preparation as the only renewable energy technology and natural gas for space heating had the lowest performance.

Among urban neighbourhood renovation projects, combining thermal refurbishment measures with onsite CHP and photovoltaics (R2b) could allow in some cases for a negative value of specific primary energy use (because only the non-renewable part of primary energy is considered in the assessment).

Connecting existing buildings to existing, new, or extended district energy systems (DE) was a way to significantly reduce primary energy use for a high number of buildings. In these cases, if no comprehensive renovation measure could be implemented because of exceptional challenges (complex ownership structure, extraordinary energy requirements, urgency of acting because of health risks), the final energy savings were rather limited.

Added value of the integrated approach

Having presented the different integrated approaches followed by CONCERTO communities, it is worth mentioning the added value of such approaches compared to traditional and monothematic strategies. Added value is mainly available from a supply security and economic perspective. This is because acting simultaneously on demand and supply side brings major synergies when considering energy imports and investment costs. The CONCERTO approach brings three main contributions towards increased security of supply:

- the neighbourhood approach as missing link between building and city scale
- high energy carrier mix
- polygeneration and cascade use of resources

From an economic perspective, the following points are considered as added value from the integrated approach as demonstrated by CONCERTO:

- distribution of investment costs among different stakeholder groups
- reduction of investment costs

- use of synergies between funding schemes
- motivation of the local economy
- fighting against fuel poverty

General conclusions and further recommendations

Beyond the proposition of different technical combinations of measures which could be successfully integrated in CONCERTO communities and can be so far recommended, following conclusions and recommendations can be more generally formulated by considering the assessment results of the quality of integration.

Firstly, combining integration at the city and neighbourhood scale is seen as an element to be more systematically dealt with in the future. In particular, acting at neighbourhood scale brings synergies with other programmes and activities (not focusing on energy issues) implemented at neighbourhood scale, which can always be seen as an added value for the implementation of the CONCERTO principles. For many aspects however the city has to be considered as a whole and it would be artificial and counter-productive to try to build a city as a sum of energy independent neighbourhoods which would not be physically connected to energy distribution networks.

Then, the low-exergy approach at the community scale was never explicitly nor completely applied in the assessed CONCERTO communities. As a recommendation for future projects, there should be more examples of low-exergy principles applied in community projects, as this approach is a key element for supporting a broader use of on-site available renewable energy sources (solar, geothermal, thermal energy from lakes and rivers as heat sinks and sources).

From a technical point of view, further efforts will need to be put on community energy management systems.

Last but not least, from an architectural integration point of view, as well as the physical integration of renewable energy systems within urban structures, the integration of solar thermal systems is seen as the next step to put more efforts towards, adapting the urban master plan if so required.

NOTES

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