CONCERTO INITITIATIVE AND POLYGENERATION

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ABSTRACT

As a generalisation of the idea of cogeneration, polygeneration forms a fundamental component of sustainable communities since significant reduction in greenhouse gas emissions can be achieved through its application. The CONCERTO initiative, launched by the European Commission as part of the 6th Framework Programme, supports communities across Europe which implement integrated actions and demonstration projects in the field of energy efficiency and renewable energy. To this regard the CONCERTO communities present numerous different projects using a large variety of technologies and most of them include polygeneration. A rough general overview is given on the polygeneration technologies which are mostly suitable for different kind of communities (rural areas, small urban areas, large urban areas), depending on the primary energy sources available. An overview is also given for the CONCERTO communities, showing which technologies are mainly represented among the CONCERTO initiative. On the basis of this first experience, a list of support mechanisms for polygeneration systems is presented and the methodology to assess the energy performance of communities using polygeneration systems is introduced.

1. INTRODUCTION TO THE CONCERTO INITIATIVE

The CONCERTO initiative, launched by the European Commission as part of the 6th Framework Programme, is a Europe wide initiative proactively addressing the challenges of creating a more sustainable future for Europe's energy needs. CONCERTO supports local communities in clearly defined geographical areas in developing and demonstrating concrete sustainable strategies and actions. Throughout all participating CONCERTO projects the focus is primarily on demonstrating the environmental, economic and social benefits of integrating renewable energy sources (RES) together with energy efficiency (EE) techniques through a sustainable energy-management system operated on a community level. In the field of EE, thermal retrofitting of existing buildings, construction of new low energy buildings, increasing the efficiency of every kind of energy system and introducing polygeneration technologies are the most important actions to be undertaken. In the field of RES, large or small scale energy systems based on RES are to be built to provide single buildings or whole districts with electricity, heating and cooling energy. Another objective of the project entails operations such as awareness campaigns and training for encouraging the communities to take advantage of the high concentration of demonstration activities to locally increase the consciousness of citizens on energy relevant issues. The most important feature of the CONCERTO initiative is that all these activities are combined within an integrated approach. The CONCERTO initiative thus provides a large European wide platform for the exchange of ideas and experience between the CONCERTO demonstration communities, and other cities that are committed to introducing similar strategies. Communities participating benefit from the shared expertise of Europe's most advanced communities active in the field of energy sustainability.

Currently there are 27 communities in 9 projects from 12 countries which started in 2005 and 2006 (CONCERTO I communities) and another 19 communities in 9 projects from 12 countries which are currently starting in 2007 (CONCERTO II communities) involved in the CONCERTO initiative. The CONCERTO projects are

supported by CONCERTO PLUS which provides overall analysis on technical monitoring, socio-economic evaluations, dissemination, networking and policy recommendations [CONCERTO]. Figure 1 illustrates the connections and actions of the overall CONCERTO initiative based on the example of the CONCERTO I communities.

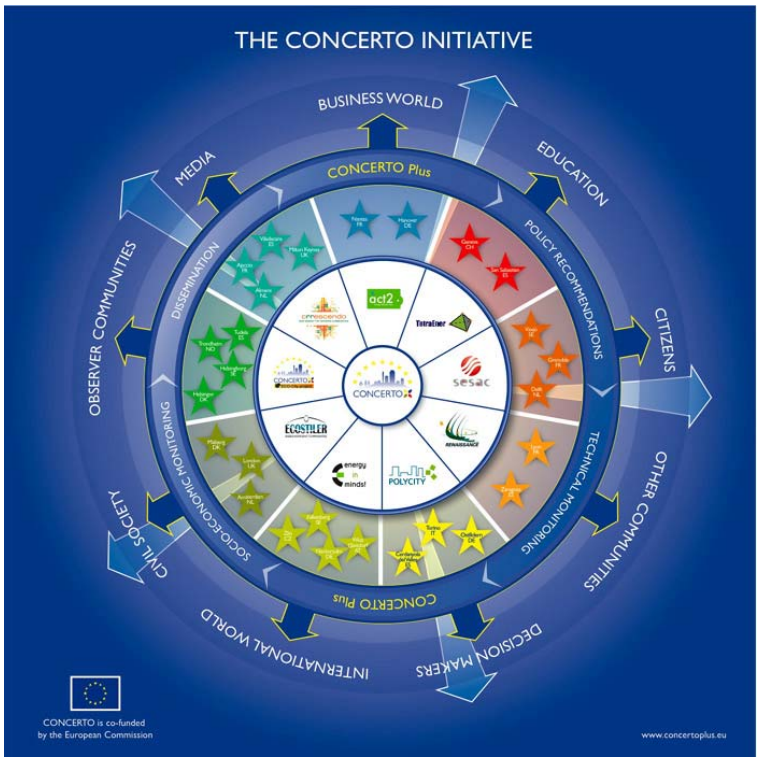


Figure 1: The CONCERTO initiative (based on the CONCERTO I communities) [CONCERTO]

2. DEFINITIONS OF POLYGENERATION

The term ‘polygeneration’ is most widely used to describe the generalisation of the idea of ‘cogeneration’ (i.e. the thermodynamically efficient use of fuel) in the form of systems which simultaneously produce electricity and useful heat.

According to [2004/8/EC], “‘cogeneration’ shall mean the simultaneous generation in one process of thermal energy and electrical and / or mechanical

energy". On the basis of this definition, 'polygeneration' would be the simultaneous generation in one process of more than two energy carriers. To understand this definition properly, two aspects should be considered:

- The definition of the term 'process' should be enlarged in order to refer also to multiple successive processes, where the output or by-product of one process is the input of another process. In the [CONCERTO Guidance], this succession of thermodynamic processes constitutes an 'energy supply system' which can be understood in a broader sense.
- If 'cogeneration' clearly refers to thermal, electrical and mechanical energy, the idea of polygeneration can also be enlarged considering fuel and material generation. In some technologies like gasification processes based on biomass sources, some by-products may be used directly as fuel.

2.1. Polygeneration in the European Commission

The European Commission published in 2004 the directive on promotion of cogeneration [2004/8/EC], with the purpose to "facilitate the installation and operation of electrical cogeneration plants in order to save energy and combat climate change." The European Commission states that "the potential for use of cogeneration as a measure to save energy is underused in the Community at present. Promotion of high-efficiency cogeneration based on a useful heat demand is a Community priority given the potential benefits of cogeneration with regard to saving primary energy, avoiding network losses and reducing emissions, in particular of greenhouse gases."

Although if there is no current directive related explicitly to polygeneration, the European Commission supports directly polygeneration, with the "objective of providing more than two energy vectors - any combination of electricity, heat, cooling, and biofuels (solid, liquid or gaseous) - for energy applications as well as materials." [FP7].

2.2. Polygeneration in the CONCERTO initiative

In the context of CONCERTO, the term ‘polygeneration’ is defined by DG-TREN in the [CONCERTO Guidance]: it is referred to as “an energy supply system, which delivers more than one form of energy to the final user, for example: electricity, heating and cooling can be delivered from one polygeneration plant. Polygeneration does not mean a combination of different energy supplies to a given system, such as more than one type of electricity generator supplying a group of buildings. Polygeneration can involve combined heat and power (CHP) and / or district heating, preferably by renewable energy sources. Such polygeneration systems should be designed and controlled with a view to optimising all relevant interactions between supply and demand in the CONCERTO community.” From the first call for proposals for CONCERTO projects, communities are encouraged to consider the benefits of polygeneration in their demonstration activities. To this regard, the CONCERTO initiative presents numerous projects by using a large variety of different advanced technologies.

3. THE IMPORTANCE AND SUITABILITY OF POLYGENERATION FOR SUSTAINABLE COMMUNITIES

3.1. Benefits of polygeneration

The main benefit of polygeneration is to save primary energy sources, e.g. to actively use the ‘waste’ heat of the power generation process. Figure 2 illustrates this fact considering the simple example of cogeneration and showing how much primary energy would be used in single plants to deliver the same amount of electrical and thermal energy of an equivalent cogeneration plant.

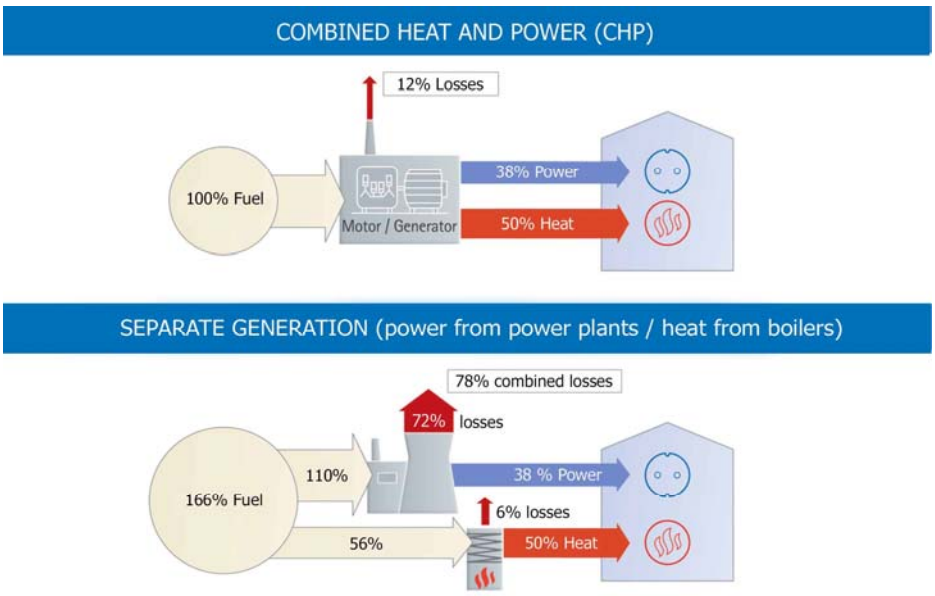


Figure 2: the primary energy benefit of cogeneration (@ Bundesverband Kraft-Wärme-Kopplung)

Communities are thus choosing polygeneration for two main reasons:

- Optimisation of the use of primary energy sources: one unit of primary energy source can be used to provide more useful energy than a single plant without polygeneration. In this way, the energy losses of the single processes are reduced and the energy balance of the community is greatly improved. In other words, there is no reason to get rid of the heat generated in a thermoelectric process if biomass has to be burned again to cover the heating needs.
- Polygeneration can be used to convert local available energy or material resources into other forms of energy or materials, which ideally should also be used at local level. Primary energy sources, high temperature heating energy or by-product of other processes can be used. The community should thus first check if any resources are already available at community level in order to cover community energy needs, before importing additional primary energy sources.

3.2. Suitability – Which type of polygeneration for which community?

There are a variety of polygeneration technologies and systems available. However the appropriate system must be selected based on the type of community and the local resources. In the design phase of a district energy concept, the ambition of the energy experts is to design an efficient energy system which covers the overall energy needs whilst at the same time minimising the use of primary resources. Following this approach, polygeneration technologies should be used to convert energy into energy carriers which are needed at local level and these needs in turn depend on the type of community.

Table 1 outlines a basic overview on the technologies which might be suitable for different community areas and the restrictions which should be considered. Other factors, like the climatic situation and general demand profiles also influence in a relevant way the choice of technology. It should be noted that this represents only an attempt to roughly associate technologies with communities' characteristics.

In order to also be suitable for an analysis among CONCERTO communities, characteristic features for the three described areas are considered as follows:

- Rural Area: residential area (detached one family houses, small estates), agricultural activities (farms), small tertiary buildings (offices, schools etc.)
- Small Urban Area: mixed use developments (residential, offices and tertiary use), small exclusively industrial areas
- Large Metropolitian Area: mixed use development, large exclusively residential areas, large areas exclusively for offices or other tertiary use, large exclusively industrial areas

Table 1: suitability of different polygeneration technologies for different types of communities

	TYPE	RURAL AREA	SMALL URBAN AREA	LARGE URBAN AREA
PRIMARY ENERGY SOURCE	**Gas**	gas network not always available in rural regions	available	available
	Oil	potential transport issue	available	available
	Biomass	high potential if locally available; low potential if biomass needs to be transported	high potential if locally available; low potential if biomass needs to be transported	biomass logistic in a large metropolitan area might induce an indirect primary energy consumption
	Solar energy	possible	possible	barriers because of shading aspects and roof surface limitations
	Geothermal energy (wells)	possible	possible	possible limitations if adjoining sites are already using this technology
	Environmental heat (ground, water, air sources)	possible	possible	possible limitations due to restricted accessibility to ground, water and air resources (environmental limitations)
	Renewable waste	see biomass above	see biomass above	possible use of waste heat
	Waste heat from industry	only in particular cases	possible	possible
SECONDARY ENERGY SOURCE	**Electricity**	- small scale CHP	- small scale CHP - large scale CHP	- large scale CHP
	Heat	- small scale CHP - solar thermal plant	- small scale CHP - large scale CHP - solar thermal plant	- large scale CHP - solar thermal plant

	Biofuel (biogas)	biofuel production processes (from biomass)	- biofuel production processes (from biomass)	potential transport and / or storage restrictions
USEFUL SOURCE	**Electricity**	small scale CHP from biofuels (biogas)	- small scale CHP from biofuels (biogas) - large scale CHP from biofuels (biogas)	- large scale CHP from waste
	Heat	small scale CHP from biofuels (biogas)	- small scale CHP from biofuels (biogas) - large scale CHP from biofuels (biogas)	- large scale CHP from waste
	Cooling energy	absorption chillers (small scale, small number) powered by solar thermal, waste heat or district heating	- absorption chillers (small scale, small number) powered by solar thermal, waste heat or district heating	- absorption chillers powered by solar thermal, waste heat or district heating

4. TYPES OF POLYGENERATION IN THE CONCERTO COMMUNITIES

Due to the positive impact on polygeneration on the overall energy performance of single communities, many CONCERTO communities have included various polygeneration technologies in their energy concept. Table 2 shows an overview on the single technologies available among the CONCERTO initiative (CONCERTO I) and the communities where these technologies will be demonstrated. Table 3 gives a graphic overview on the polygeneration concepts of the single communities.

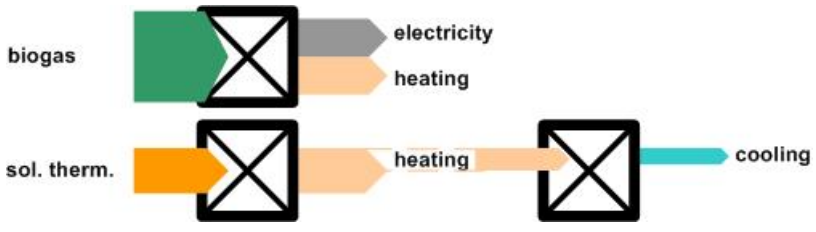
Table 2: overview on single polygeneration technologies in CONCERTO I communities (status: September 2007)

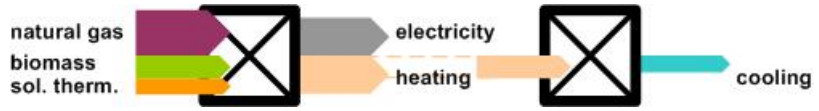
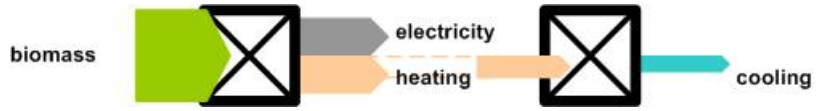
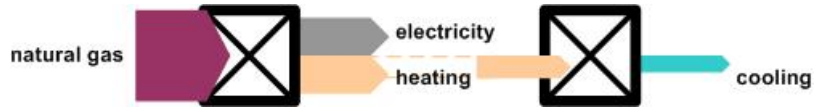
SOURCE	TECHNOLOGY	COMMUNITY	COUNTRY
Fossil fuel source	Gas CHP	Viladecans	ES
		Cerdanyola	ES
		Turin	IT
		San Sebastian	ES
District heating source	Absorption cooling powered by district heating	Trondheim	NO
		Cerdanyola	ES
		Ostfildern	DE
		Turin	IT
		Växjö	SE
Renewable source	Medium temperature network for simultaneous heating and cooling	Geneva*	CH
	Adsorption cooling powered by solar thermal	Helsingborg	SE
		Cerdanyola	ES
	Absorption cooling powered by solar thermal (direct, excluding district heating)	Tudela	ES
		Zaragoza	ES
	Biogas CHP	Helsingborg	SE
		Amsterdam	NL
		London	UK
		Måbjerg	DK
		Weiz Gleisdorf	AT

		Zlin	CZ
	Biomass CHP	Hanover	DE
		Milton Keynes	UK
		Almere	NL
		Cerdanyola	ES

*cooling realised directly by lake water, heating realised by heat pumps

Table 3: schematic overview of polygeneration types in the single communities

COMMUNITY	SCHEMATIC VIEW OF POLYGENERATION TYPE
Hanover	
Almere	
Milton Keynes	
Viladecans	
Helsingborg	

Trondheim	
Tudela	
Amsterdam	
London	
Måbjerg	
Weiz Gleisdorf	
Zlin	
Cerdanyola	
Ostfildern	
Turin	
Zaragoza	

Geneva	
San Sebastian	

4.1. Support mechanisms of polygeneration systems

As the components of a polygeneration system deal with different energy carriers, they also consequently provide the link between different energy markets (gas, electricity, heating, cooling and fuel). Due to these numerous interfaces with the energy markets and the technical complexity of such systems, polygeneration systems need to be supported by different technical and organisational mechanisms, which can all be found within the CONCERTO communities:

- Technical mechanisms: a polygeneration system may generate a by-product at a certain moment where this by-product is not needed within the local energy system. If this is the case, the by-product has to be stored in order to be used at a later time.
- Technical / Organisational mechanisms: load management and more generally energy management is an important tool to support the integration of polygeneration systems. Storage units can be very expensive and demand side measures can support an optimal operation of the polygeneration technology. Load management can be done at building level (for large buildings) as well as for the whole communities.
- Organisational mechanisms: because of the multiple aspects of polygeneration systems, an appropriate organisation has to be created for the management of the energy system. Energy Service Companies (ESCO) provide a legal and operational framework to cover investment and maintenance.

These activities form a crucial part in the support and implementation of polygeneration systems as the systems are not just dependant on environmental and technical conditions but also on organisational and management aspects.

5. POLYGENERATION IN THE ENERGY PERFORMANCE ASSESSMENT

One part of the CONCERTO PLUS activities consists in quantifying the benefit of polygeneration technologies in the CONCERTO communities. In particular, the contribution of polygeneration technologies on the overall community energy performance is to be assessed.

As the benefit of polygeneration consists in optimising the use of primary energy resources, the assessment also has to be done at the level of the primary energy sources. The main activity of the impact assessment thus consists in defining the baselines to which the community energy systems have to be compared to ([Pol 2007]). The baselines are defined following the process shown in Table 4. The values of conversion efficiency of the reference systems will be defined according to current national practice.

In a second step, the energy performances of both the demonstration technology and the reference technology are to be assessed. In particular the primary resource factors have to be calculated after having defined the system boundaries. For this work, CONCERTO PLUS intends to follow the methodology elaborated within the project [ECOHEATCOOL] and part of the [prEN 15316-4-5:2005]. In particular, the norm [prEN 15316-4-5:2005] clearly defines the data points where energy flows have to be considered and the way to consider imported and exported energy flows.

Table 4: process for baseline definition

DEMONSTRATION TECHNOLOGY	REFERENCE TECHNOLOGY	MOTIVATION FOR CHOICE OF BASELINE
CHP (new) combined with district heating network (new)	Small scale gas condensing boilers (decentralised)	The demonstration technology has to be compared with the best available alternative technology (no district heating exists before starting the CONCERTO demonstration activity).
CHP (new) combined with district heating network (old)	Gas condensing boiler Gas power plant	The demonstration technology has to be compared with the best available alternative technology (the district heating has been installed before starting CONCERTO demonstration activity).
Absorption chiller (new)	Compression chiller	
District cooling	Compression chiller (decentralised)	

6. CONCLUSIONS

The example of the CONCERTO initiative shows that polygeneration plays a fundamental part for sustainable communities. Using local resources and / or waste as well as generating 'useful energy' with the most efficient means minimises the use of fossil fuel of any single community and adds significantly to the overall reduction of emissions. The analysis of the various communities also shows that the choice of the most applicable type of the polygeneration system is as important as organisational mechanisms such as the legal framework for the wider implementation of such systems and technical mechanisms such as efficient load and storage management. The energy performance assessments which will be carried out for all participating CONCERTO communities and thus covering a variety of polygeneration systems across the European Union will provide added value through useful data and lessons learnt for other communities to follow suit. Based on

these results and on identified barriers and the consequential solutions, policy recommendations on European, National as well as Regional level will be developed as an integral part of the overall CONCERTO initiative thus paving the way for the increased use of these systems.

7. REFERENCES

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