Sinfonia

Low Carbon Cities for Better Living

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Credits: Eurac Research/Ivo Corrà

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How do you summarise almost a decade's work? Short interview with Sinfonia project coordinator

How do you summarise almost a decade's work? A process which has included large-scale energy efficiency investments, policy development and research analysis, over **30 organisations** from public, private and academic sectors from eight different cultures and encompassed over **€40 million**? The answer is: you can't. But through this publication we can at least describe some of our findings and experiences from this long and large project. They range from technical developments such as prefabricated façades to governance aspects such as capacity building, institutional collaboration, and policy development.

Since Sinfonia was conceived in 2012, Europe has seen new challenges emerge in the form of migration, political division and now the COVID-19 pandemic. However, during this long period, the need for **a transition towards sustainable energy systems** and cities has become even more important. And with the launch of the Green Deal at the beginning of this year, the European Commission has reinforced the need and ambition to make Europe and it's cities sustainable, energy efficient and inclusive.

Even though the missions of Sinfonia were drafted long before the Green Deal, the project is well-aligned with the ambitions set by the European Commission, and has already contributed to many of the Green Deal objectives. Together, project partners have shown the **benefits of large-scale deep refurbishment**, turning old residential and school buildings into modern, energy efficient and comfortable spaces for residents, pupils and teachers. Sinfonia has proven how energy supply to city districts can be efficient, local and sustainable through the use of integrated solar panels, the expansion of district heating, and several other solutions.

But Sinfonia was more than merely about energy efficiency investments. Sinfonia has also generated a substantial amount of **new knowledge and experience** about engagement processes and dialogue, systems analysis, and assessment of the replication potential of smart solutions. The ambitious objectives of this research and innovation project have to some extent been challenging, but have fostered a genuine culture of cooperation between the pilot cities Innsbruck and Bolzano, and within the whole consortium. In the end, this is what made it all possible.

Even if Sinfonia has ended, the work to build **smart, sustainable and inclusive cities** continues. Though the challenges are real, urgent and substantial, Sinfonia has created the knowledge and ability for new initiatives to rise. In this sense, we hope and believe that the end of Sinfonia means the beginning of another journey.

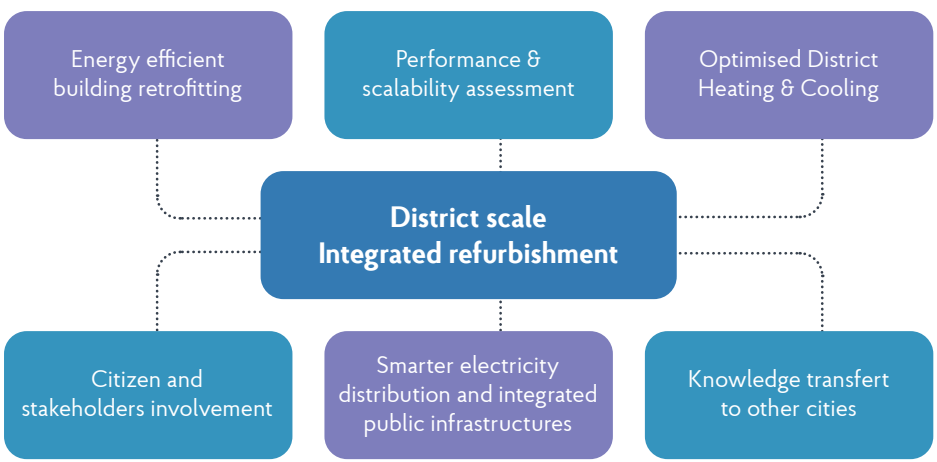
Gothenburg, June 2020

Håkan Perslow
Project manager at Research Institutes of Sweden (RISE).

The path towards low carbon European cities

With 80% of European citizens living in urban areas, cities have a crucial role to play in the transition towards a low-carbon economy. Faced with the challenge of ensuring the quality of life of their citizens while becoming more energy efficient, cities must develop integrated urban development strategies that will make them both sustainable and better places to live.

The Sinfonia project, a six-year initiative to deploy large-scale, integrated and scalable energy solutions in mid-sized European cities, reached its finishing line in July 2020. **At the heart of the Sinfonia consortium are the two pilot cities of Bolzano** (Italy) and **Innsbruck** (Austria), located within **100 km of each other in** the Alps' so-called **"green corridor". These two "sister cities" implemented a set of integrated energy measures** combining the retrofitting of more than 100,000 m² of living surface, with the optimisation of the electricity grid, and the development of innovative solutions for district heating and cooling. Working hand in hand, the cities reached and exceeded their initial goals of 40 to 50% primary energy savings and the share of renewables by 20% in two pioneer districts, leading to a 30% decrease of CO_2 emissions.



20% more RES

30% less CO_2 emissions

40-50% energy savings

Bridging the gap between demonstration and large-scale replication

A large part of the project has been dedicated to the **transferability and scalability** of the solutions deployed in the two pioneer cities. To achieve this, Sinfonia has defined a number of district typologies and corresponding refurbishment models, tested and validated with all public and private stakeholders – from citizens to energy regulators. Following the lead of Innsbruck and Bolzano, **five 'Early Adopter' cities**, representing a wide variety of regulatory environments and climatic zones across Europe, helped to further test and validate the scalability and transferability of the measures deployed in the two pilots: Pafos (Cyprus), Rosenheim (Germany), Seville (Spain), La Rochelle (France) and Borås (Sweden).

Sinfonia partners also made their expertise available to other cities through the **"Replication Cluster"**. A joint initiative of the EU-GUGLE and Sinfonia projects, the cluster shared the experience of eight pioneer and seven early adopter cities with **forty-seven cities** all over Europe through peer-to-peer support, events and recorded webinars.

Sinfonia has also been involved in the My Smart City District initiative, a common dissemination and communication outlet where eight EU projects joined forces for greater outreach. The platform shares solutions from **27 districts in 13 different countries**, leading to large-scale replicability of sound energy efficiency solutions.

Via Brescia after renovation.
Credits : Eurac Research/ Annelie Bortolotti

Scan to see the webinars
www.sinfonia-smartcities.eu/en/resources/webinars

At the project's core: Bolzano and Innsbruck as pilot cities

City of Bolzano, Italy

In Bolzano, **over 40,811 m² of social housing from the 1950s-70s were retrofitted**, benefiting 455 households. The technical solutions deployed included building envelope insulation, decentralised mechanical ventilation components, solar thermal and photovoltaic systems, thermal storage, heat pumps, and interconnection to the district heating network. The overall objective was to reach an energy performance target (Total Building Energy Use) of approximately 45 kWh/m²/year, renewable energy sources' contribution included.

The first monitored results in Bolzano are promising, as the city succeeded in reducing the energy consumption of renovated buildings by approximately **80%**. The renovated buildings have reached the energy target of approximately 45 kw/m2. Bolzano's analysis shows that around **60% of the energy consumed in the city** could be saved by scaling up those measures to all the buildings in the city.

On top of that, the city's cogeneration plant was upgraded to use hydrogen in combination with natural gas (hybrid cogeneration system), and a monitoring software (Termis) was added to the system in order to better forecast peak loads and optimise the district heating distribution (see p.14 and p.15).

Over 100 **Smart Points** and three **multifunctional interactive totems** (see p.16) were also designed and installed within the city, providing services such as electric recharging, SOS button, lighting, and information on local climate and environmental conditions as well as cultural sites and events.

- Citizens living in the refurbished area: **15,000**
- Total refurbished area: **40,811 m²+**
- Dwellings retrofitted: **455**

City of Innsbruck, Austria

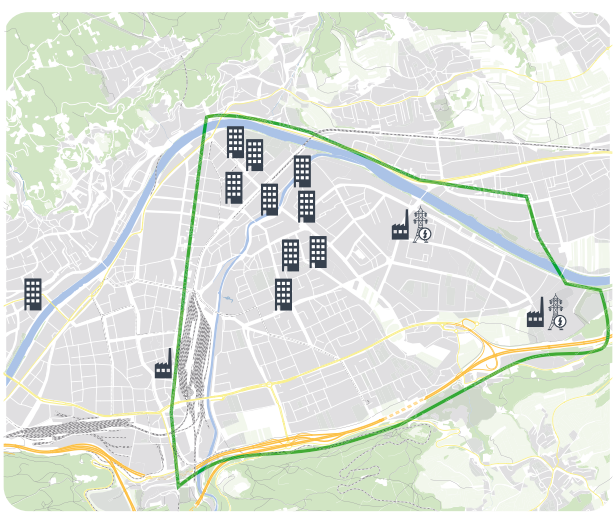
In Innsbruck, **57,000 m² of residential housing** (558 households) **were refurbished**, **together with 12,000 m² of public buildings** (three schools, part of which were historical buildings). The retrofitting projects dealt with improved building envelope (insulation, windows, thermal bridges, etc.), ventilation systems with high efficiency heat recovery, and the integration of renewable energy sources on-site (photovoltaic, solar thermal, heat pumps).

The first measurement results show that the smart city measures reach and, in some cases, exceed the predicted values. It is also estimated that upscaling those measures at city level would lead to an increase of the share of renewable energies by **59.1%** and to a primary energy consumption reduction in the building sector for heating and domestic hot water of about **57%**.

A **smart-district concept** was implemented, enabling the integration of electricity and heat systems of existing buildings at a **district scale**, including additional renewable energy technologies. Wastewater heat pumps, photovoltaic panels, power-to-heat and combined heat and power (CHP) as well as charging points for electric vehicles were commissioned in 2019. An energy management system (EMS) was installed to optimally dispatch heat and electricity supply and demand (see p.18).

To enable the storage of renewable electricity as heat, a **Power-to-Heat** system was installed at the public swimming pool Amras. With the heater substituting around 50% of the natural gas consumption, about 250 tonnes of CO_2 emissions can be avoided each year (see p.19).

Also, a **smart control system** was added to the district heating network, helping to increase efficiency and further expand the share of waste heat and renewables in the overall energy mix. In 2017, about 60% of the heat was obtained from industrial waste heat, renewable energies and gas-fired CHP plants.



- Citizens living in the refurbished area: **40,000+**
- Total refurbished area: **69,000 m²+**
- Dwellings retrofitted: **558**

New forms of collaboration

In a large-scale project like Sinfonia, with 40 partners from seven countries, cooperation has been an ever-present topic. New ways of working together have arisen – within the cities, and between municipalities and other partners, who have learned a lot from the process.

In evaluations, both Innsbruck and Bolzano consider the cooperation of local stakeholders for a common result, despite different modus operandi, administrative, financial and regulatory constraints, as a core benefit of Sinfonia as it will facilitate the management of future projects.

Collaboration has a key role in the Smart Cities concept, both in how it includes multiple stakeholder groups in decision making and as a co-design approach to address urban challenges. According to the project coordinator, Håkan Perslow, from Research Institutes of Sweden (RISE), "the *collaboration has been perhaps the largest challenge, but also one of the most interesting and rewarding aspects of the project".*

"On the surface, Sinfonia may look like a very technical project, focusing on the development and deployment of smart solutions for energy efficiency. However, to successfully achieve Sinfonia's goals, new forms of collaboration between the local project actors in Innsbruck and Bolzano were a prerequisite", he says.

If we look at the project as a whole, we can see the evolution throughout the years. Today, partners highlight as critical success factors the importance of getting a common view on the project early on, or the necessity to establish effective communication approaches, trust and mutual understanding between partners. *"In retrospect, a stronger emphasis on closer cooperation between the research actors and the local partnerships in the pilot cities could perhaps have added even more value to the work*", adds Håkan Perslow.

Credits: Eurac Research/Ivo Corrà

Sinfonia as a knowledge catalyst

The project has increased the knowledge base amongst the involved partners and cities; a great benefit which has informed the works and will foster future collaboration. Departments within partners' organisations and municipalities, which **were not used to collaborating**, established stronger bonds and shared knowledge thanks to Sinfonia. Does that mean that a demonstration project like this improves the level of organisational capacity within the municipalities and organisations?

"Absolutely, and we had to do it," says Sophia Neuner from IKB, Innsbruck's local energy provider. *"We had several departments that, when they had to work together before the project, were like two different companies."*

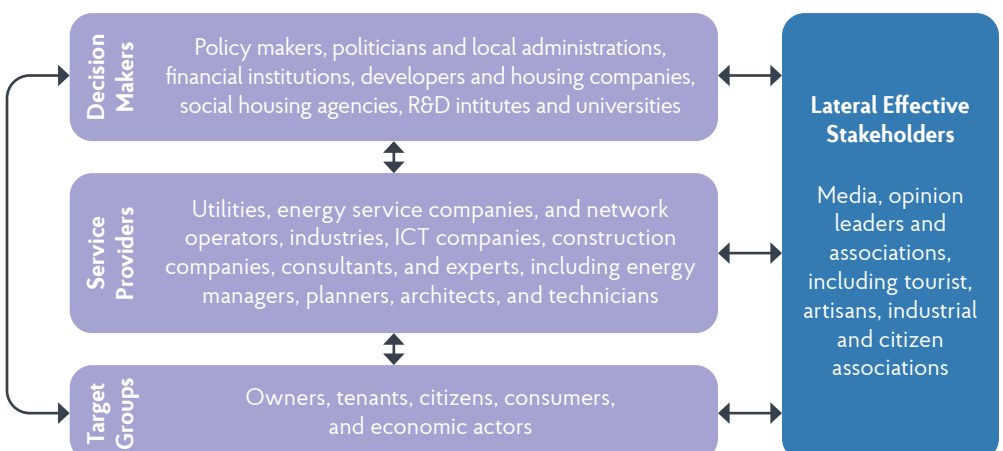
The secret of a successful cooperation

When asked about the secret of a successful cooperation, the partners stress the project set-up but also the partners' motivations to join the project.

"In Sinfonia, it has been a very good constellation of partners, of real experts, always ready to discuss different solutions," declares Alyona Zubaryeva, from Eurac, Bolzano. *"this was truly an opportunity to see how we work at European level, and to learn much on how we can improve, how we can work better."*

In parallel, the project coordinator Håkan Perslow underlines the importance of relationship building.

"Collaboration can't be forced or planned. It is a cultural process which builds on mutual trust and understanding. In a transnational consortium with partners from different cultures, this requires attention and patience to build. Despite all digital communication and meeting tools available, the only real way of building this is to meet physically and have some time and space away from the direct project related issues. In the end, this is an investment which has proven to be valuable in Sinfonia."



How to become a Smart City: tools and solutions

Sinfonia was not only focused on implementing energy-efficient refurbishment measures but also on the development and implementation of various innovative decision support tools and technical solutions, some of which will now be presented.

Decision support tools for smarter cities

Knowledge sharing tool on Stakeholder involvement

Stakeholder involvement is a prerequisite for the successful implementation of any refurbishment plan, though it remains a complex matter very dependent on the type of project and nature of stakeholders. Residential retrofitting projects require stepping into the tenants' private lives, respecting their individual circumstances and challenges.

In Sinfonia, the partners involved in the refurbishment plans conducted in the pilot cities of Bolzano and Innsbruck identified specific issues with regard to stakeholder involvement, developed and tested several tools and methods to tackle them, and drew up a set of **good practices and lessons learnt** from their experience. Capitalising on this, Sinfonia partner alpS developed a tool to capture and share all the knowledge gained by the Sinfonia partners.

The tool is a web portal freely accessible at www.sinfonia-smartcities.eu/en/stakeholder-engagement-toolkit/.

It gathers know-how on **social and socio-economic aspects**, as well as documentation and evaluation of **stakeholder involvement activities** in the two pilot cities. The tool also provides some generic lessons learnt, **challenges and recommendations** for other cities, with the ambition to facilitate replication in the future.

A user-friendly interface allows users to browse this knowledge base through five types of entries:

- Spatial scales: building, district, city.
- Process: from conception to implementation and follow-up.
- Methods, i.e. mode of interaction with the stakeholders.
- Stakeholder groups: from the general public up to end-users – tenants, schools and energy providers.
- Subjects: district heating, electricity grid and building refurbishment.

Example of best practice factsheets downloadable on the website:

- Design of a user manual for tenants
- Appointment of a tenants representative in refurbishment buildings
- Smart city lab – IKB Smart district
- Demo apartment tour "Better living"
- Real time feedback on energy consumption

CROCUS tool to help cities assess and select refurbishment plans

CROCUS (deCision suppoRt fOr distriCt refUrbiShment) is a prototype tool that helps simulate the energy use of a city's building stock and provides a cost/benefit analysis of different refurbishment strategies. **The tool aims to help the technical departments of cities in the elaboration of long-term refurbishment plans.**

CROCUS was developed by Sinfonia partners DOWEL, CSTB and RISE, combining several software bricks:

- The simulation of buildings' energy consumptions based on the buildings' characteristics;
- The optimisation of the district heating operation;
- The economic analysis of different retrofitting strategies.

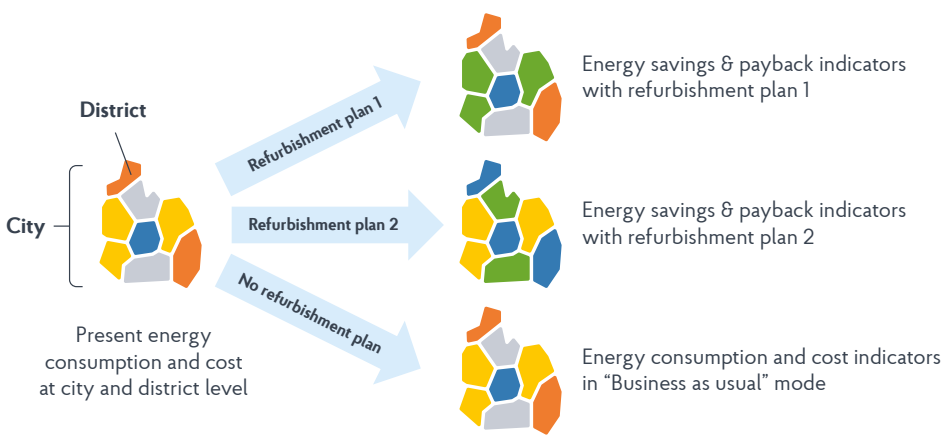
Two levels of retrofitting strategies are simulated at district scale, and compared with a "business as usual" case: the "light renovation" strategy aligns with the energy consumption targets set by the current regulation on renovation, while "deep renovation" aligns with the targets set by the latest (or upcoming) regulations for new buildings. In both cases, the simulation is focused on improving the building envelope. Different future scenarios (e.g. evolution of energy prices and CO_2 prices) can be simulated.

As its main output, **CROCUS provides a cost/benefit analysis** comparing the investment costs of different retrofitting strategies, the related energy and CO_2 savings potential, and associated economic indicators.

Tests with pilot cities highlight the criticality of input data availability

CROCUS was tested in the Sinfonia pilot cities (Bolzano, Innsbruck) and in the early adopter cities of Boras, Rosenheim and La Rochelle. The simulations performed helped identify the districts with the most potential for refurbishment.

During this testing phase, the main challenge was to access and collect from city departments the input data required to run the simulations (building footprint, age and height – collected as GIS (Geographic Information System) data sets, data on district heating networks, on building occupancy, local energy mix and prices, and local renovation costs). Due to the wide variety of data collected, significant resources were needed to pre-process them into a common format. **The data collection process thus represented a good opportunity for city services to better exchange and centralise the data coming from different departments.**



Crocus concept. Credits: Dowel

DistrictPH tool to assess district energy balance

The tool and associated courses developed by PHI allow city planning departments and energy advisors to perform a **district energy balance calculation**, with an emphasis on buildings, and investigate different refurbishment scenarios.

DistrictPH can be used to create energy balances for neighbourhoods, from smaller groups of buildings up to whole districts. The tool provides support on questions such as the appropriate energy supply options, the design of reasonable retrofit subsidies, and how a district may become zero-energy.

DistrictPH can also investigate the impacts of different scenarios of development and retrofitting, considering electricity and heat networks, renewable energies, electromobility and public consumers.

DistrictPH is available in Excel. It relies on input data about the district (building type, size, energy supply, public electricity consumers) and its expected future development (probabilities of refurbishment, etc.). It then calculates the current energy use in the district, including electricity and district heating networks, how it is covered, and its development over time. The tool considers the following contributions to the district's energy balance and their interactions:

- Heating, cooling, domestic hot water and electricity demand of buildings;
- Refurbishment scenarios;
- Energy production in buildings and at district level;
- Other electricity consumptions (street lighting, energy consumption of tramways and electric cars).

Ongoing beta tests show very promising results

PHI is currently running a beta test phase with several users. First feedback indicates that users like the capabilities, transparency and flexibility of districtPH, but still with some variability in the assessment of the complexity resulting from its capabilities. This topic is still subject of the beta test. Some accompanying training material was also developed and successfully tested during pilot workshops in 2019 and 2020.

The districtPH tool will be available online on PHI's website (https://passivehouse.com/) by the end of 2020, and PHI will plan and deliver the corresponding training courses.

Bolzano. Credits: Eurac Research

SWOT tool to assess Smart City plans

The SWOT tool developed by EURAC (European Academy of Bolzano), freely available online, is a self-assessment tool for city administrations to identify **opportunities and barriers** for the implementation of a Smart City project.

This web-based tool guides the user through a list of 38 simple questions – to be answered by "Yes", "No" or "I don't know", no numerical data is required – and provides a full analysis of a planned Smart City project by identifying **Strengths, Weaknesses, Opportunities and Threats** (SWOT).

The tool relies on a database of more than **150 analysed projects.**

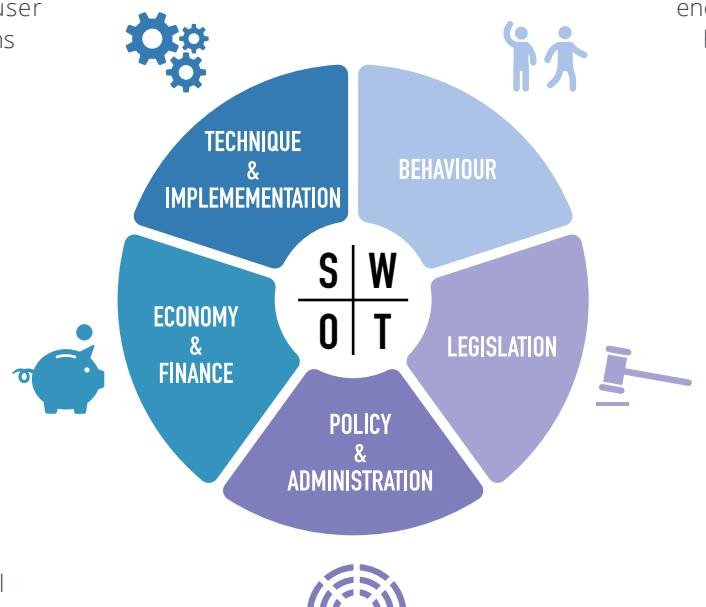
Strengths and weaknesses relate to factors that are internal to the project such as its participants or its financing, while opportunities and threats deal with the external environment of the project (macroeconomic factors, technological innovation rates, legislation, socio-cultural changes).

The outcome of the analysis takes the form of a matrix presenting the strengths, weaknesses, opportunities and threats identified according to five topics:

- Technique and implementation
- Behaviour
- Economy and finance
- Legislation
- Policy and administration

This analysis will help the city planners understand whether the implementation of the smart city project is likely to proceed smoothly or encounter difficulties. The user can then build up on how the identified drivers (strengths and opportunities) can be used to overcome the detected barriers (weaknesses and threats).

The tool is freely accessible by signing in on Sinfonia.eurac.edu/swot



Credits: Eurac Research

Scan to see the tool

Technical solutions: inspiration for success

Digital monitoring to optimise district-heating systems

In cities, district heating and cooling networks represent an ideal way to provide heat, air-conditioning, and domestic hot water to local customers. Through the use of heat pumps, these networks can distribute **sustainable energy** to a large number of citizens and businesses, in a **cost-efficient** manner. In Bolzano, the use of district heating and cooling goes back to 1986, when the first 7 kilometre network was built to supply a group of social housing buildings. Since then, the network has expanded to 20 km, and will grow further in the next years to reach **60 km in 2025**. At the beginning, energy was generated only by natural gas boilers, but today, nearly 40% of the heat injected in the city's network comes from the **Waste2Energy plant**, using energy from waste incineration since 2003. In 2008, the system was also supplemented with a cogeneration plant.

To **prevent heat losses** and optimise the system's efficiency, the district heating system has been upgraded by the local energy company Alperia, as part of the Sinfonia project. This upgrade included the **introduction of hydrogen** as alternative fuel in the city's CHP units (see p.15), but also a full **digitalisation process** to improve its efficiency. From production to consumption, digital monitoring systems have been added at every step, to optimise energy use and reduce the distribution system's electricity consumption. On the production site, a system to **forecast heat load** is used to schedule energy production. A **real-time monitoring system** has also been integrated in the district heating network, providing the data needed to adjust temperature, optimise the use of heat pumps, and detect potential heat losses in the system. Finally, end-users are provided with a clear and complete overview of their heat consumption data in real-time, enabling them to take action to **reduce their energy consumption**.

In parallel, consumption data also enables the operators to **forecast peak loads** and energy demand and adjust production accordingly.

Via Passegiata after renovation. Credits: Eurac Research/Ivo Corrà

Hydrogen-fueled cogeneration to reduce CO_2 emissions

In 2008, the city of Bolzano installed a **Combined Heat and Power (CHP) Plant**, using natural gas engines to supply heat and electricity to local citizens and businesses. The plant, operated by Sinfonia partner Alperia Ecoplus, feeds electricity directly into the grid. The heat produced is used to back up the local **district heating network** (see p.14). As in any combustion process however, the operation of a CHP plant produces polluting emissions, such as unburned methane, which is 22 times more polluting than CO_2 as a greenhouse gas.

In view of reducing these emissions, experts from Alperia's Engineering & Consulting decided to test **innovative gas blends** of hydrogen and natural gas at one of the two engines of Bolzano cogeneration plant. Within that experiment, Sinfonia partners managed to **replace up to 30%** of the natural gas with **green hydrogen** produced with renewable hydroelectricity. As a result, experts measured significant reductions in polluting emissions such as nitrogen oxides (NOx), unburned methane released in the atmosphere (CH_4) and carbon dioxide (CO_2) in the exhaust gas. On top of that, the special burning characteristics of hydrogen have enhanced the combustion process within the engine.

Since 2018, the Medium Combustion Plants directive from the European Union [(EU) 2015/2193] imposes stricter limits for the emissions of combustion plants with a thermal input between 1 and 50 MW. In that framework, Bolzano's "**smart cogeneration project**" shows that the use of hydrogen in combustion processes can be an effective measure to reduce emissions.

Bolzano thermal storage facility. Credits: *IDM Südtirol*

Reducing intrusiveness of renovation measures: prefabricated multifunctional facades

To get the tenants on board with energy-efficient renovation projects, minimising disturbances for building occupants and reducing refurbishment time was of particular importance for Sinfonia partners. In that regard, multifunctional prefabricated façades offer a very interesting and sustainable solution for building renovation. Within the Sinfonia project, partners from EURAC Research and NOI TechPark have developed new prefabricated façade modules for energy-efficient renovation, which can be easily installed on existing façades to improve their energy performance. To reduce renovation time, these façades are prefabricated off-site, using timber, an environmentally friendly material which facilitates the recycling process. The prefabricated façades are also multifunctional, and can integrate multiple components, such as new windows, decentralised ventilation units, or solar thermal panels. Within the Sinfonia project, 224 of these prefabricated multifunctional façade modules, covering a total surface of 3,000 m², have been installed for the first time in two renovated apartment buildings in Bolzano.

Via Passegiata dei Castani after renovation. Credits: Eurac Research/Ivo Corrà

Smart totem. Credits: Municipality of Bolzano

Data for citizens: sensors and interactive totems providing smart urban services

To increase the quality of life for citizens and visitors, the municipality of Bolzano created a network of over **100 Smart Points**. To build these Smart Points, the city first installed a multi-purpose **Urban Service-Oriented Sensible grid**, with the objectives of improving energy distribution and mobility, monitoring local climate and traffic conditions, and retrofitting the public lighting network into a smart lighting system, **saving up to 75% of energy** through the use of LEDs. Together with smart points, Bolzano implemented **three multifunctional interactive totems** acting as **charging stations** for electric cars and bikes, and providing at the same time a wide range of services to citizens, such as Wi-Fi connection, weather forecast and real-time traffic monitoring information. For these Smart Points to be adopted by citizens, it was essential for the city to identify the needs and desires of local stakeholders in order to define the list of **services** offered by the Smart Points, and make them truly useful in the everyday lives of citizens. Blended into the existing street lighting system, the Smart Points also have an attractive design, facilitating their integration in the city's landscape.

Wastewater to produce heat and power

The pioneer city Innsbruck has been intensively working on transforming its **wastewater treatment plant** (WWTP) from a consumer of energy to an energy supplier. The aim of this project was to fully exploit the **renewable energy potential** of the plant **to generate heat and electricity** and **produce activated carbon and dried sewage sludge**. This has required the combination of several technologies:

- **Biogas CHP (Combined Heat and Power)**: Two new biogas CHP units converting biogas into electricity and heat were installed onsite. Their electric and thermal capacities are respectively 1,702 kW and 1,866 kW.
- **Dryer for sewage sludge**: The implemented drying system reduces the sewage sludge mass by up to 75% resulting in a reduction of transport needs leading to considerable CO_2 emissions savings. The dryer, which is equipped with a highly efficient waste recovery system, is supplied by a biogas hot water boiler and the two CHP units. It produces around 4,000 tonnes of sludge granules with an energy potential of 13,000 MWh per annum. The granules can also be used as a substitute fuel.
- **Biomass gasification plant:** A novel biomass gasification CHP plant was installed to convert local wood residues into wood gas which is further converted into electricity and heat. This process generates activated carbon as a valuable by-product which can be used in organic agriculture.
- **Conventional and façade-integrated photovoltaic plants**: Both a façade-integrated and a conventional rooftop photovoltaic power plants were installed on the biomass gasification plant to cover a part of its consumption. Another rooftop photovoltaic power plant was installed on a nearby public indoor pool. A follow-up research project on biogas gasification plants has been started in Innsbruck.

The produced energy is used for both internal and external (public indoor swimming pool, restaurant at the public swimming lake, district heating grid Innsbruck) purposes. The heat is distributed through a **newly built district heating pipe**. As a result, 11,440 tonnes of CO_2 emissions are expected to be avoided annually.

Biomass gasification plant at Power House Rossau Including PV. Credits: IKB

IKB Smart District: Synergy effects give higher share of renewables

One important step on Innsbruck's pathway towards carbon neutrality is the implementation of a **Smart District** by Sinfonia partner IKB. To facilitate the management of the **intermittent energy** production from **renewable sources** and contribute to the replacement of fossil fuels in the energy system, Innsbruck succeeded in connecting at pilot scale the **electricity, heat and transport energy networks** of three major buildings into a smart grid. This innovative network allows **energy to be managed in a smart and effective way** thanks to a tailored demand response management system reacting in a timely manner to differences in energy production and consumption.

"*The software created to **control, regulate and optimise energy management**, is unique. In that way, our Smart City District is setting the scene for the emergence of innovative solutions for energy infrastructures in the cities of tomorrow. The objective is to replicate this system in other districts to expand its benefits to a large number of citizens, in the municipality of Innsbruck and beyond.",* says Reinhard Fohringer, Project Manager at IKB. In fact, various technologies have been combined and are fully operational in the hybrid grid, including Power2Heat, photovoltaics (installed on nearly all roofs), heat and power storage systems, heat pumps using sewage water, a biogas powerplant as well as charging stations for electric cars.

Moreover, a **showroom** in which some of the main technologies are situated is accessible to public. To increase **energy awareness**, the showroom regularly welcomes students and visitors willing to learn more about smart and efficient management of energy in the city. Together with other initiatives implemented as part of Sinfonia, this project contributes to increasing the **quality of life of citizens**, while supporting the transition towards a **low carbon economy** in the capital of the Alps. Beyond the significant reductions in CO_2 emissions, estimated at 270 tonnes per year, to be generated by the project, an efficient management of the produced energy leads to cost optimisations, while increasing the energy autonomy of the city.

IKB showroom. Credits: IKB

Power2Heat technology for greener swimming pools

Yet another **public swimming pool** became greener in Innsbruck as part of Sinfonia following the installation of a **Power2Heat plant**. This Power2Heat technology integrated in a local public pool transforms **excess electricity** from renewable sources in the grid into heat and stores it in a **heat storage tank** for later use (as space heating, water heating, ventilation). Excess electricity occurs either when the electrical power to the grid is exceptionally high or when the consumption of electricity is extremely low.

Start of the Power to Heat Amras.
From the left: the Mayor of Innsbruck and the two CEO´s of IKB. Credits: IKB

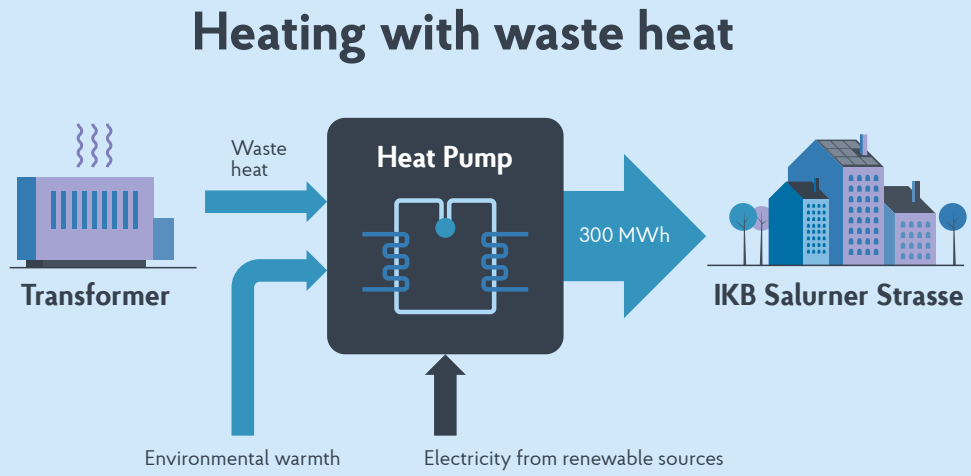
As explained by Thomas Pühringer, Director at the IKB *"The installation of this new Power2Heat system in the swimming pool enables not only the use of renewable energy sources in the facility, but is also used to* ***balance the excess of renewable energy*** *fed onto the grid"*. The total electricity output of the system is 1 MW corresponding to a thermal output of nearly 1 MW.

As a consequence, approximately 250 tonnes of CO_2 emissions are reduced, corresponding to a yearly consumption of 80 households, and around 980MW/h of heat energy is expected to be produced annually. A natural gas boiler is still left in the building and is only used as a backup solution in case not enough surplus electricity or heat is available respectively in the grid or heat storage tank.

Waste heat recovery in the power transformer

Innsbruck's local energy provider IKB had been constantly searching for **effective waste heat recovery solutions**. After persistent endeavours, the pioneer city Innsbruck managed to find a way to use the **excess heat** produced by the city's **power transformer**.

Together with the transformer, the system uses the **energy potential of the environment** as a primary source for a **heat pump process**. In fact, following the successful installation of the technology, the project partners decided to use **ambient heat** from the external air as an additional source of energy to multiply its efficiency. To attain this goal, **a smart monitoring system** for the multi-leaf dampers controlling the airstreams between external air and waste heat from the transformer was installed and connected to the heating system of the IKB offices located nearby. A gas boiler system was also installed to serve as backup to ensure that the peak demand is covered. An interesting aspect of the project is that the main IKB building is under heritage protection, making it a significant challenge to have a sustainable energy supply.



This is the first waste heat recovery solution of its kind to be implemented in the city. However, Bernard Hupfauf, Head of IKB Department, stresses an important aspect for a successful implementation of such solution: *"As a primary condition to replicate this innovative heating system, engineers and specialists have to make sure that this will not lead to* ***overheating and efficiency losses*** *in the transformer operation, mainly for safety reasons*". The project partners succeeded in avoiding such complications through an active collaboration with different actors from the electricity sector and comprehensive preliminary tests on the transformer.

The heat recovery transformer station covers approximately **75% of the IKB headquarters' annual heating demand**. The annual amount of heat produced by the heat pumps is estimated at 300 MW, helping to avoid 71 tonnes of CO_2 emissions per year. Finally, the system has inspired the utility company of Vienna (Wiener Stadtwerke) which intends to implement similar systems.

The results: why should cities invest in deep refurbishment

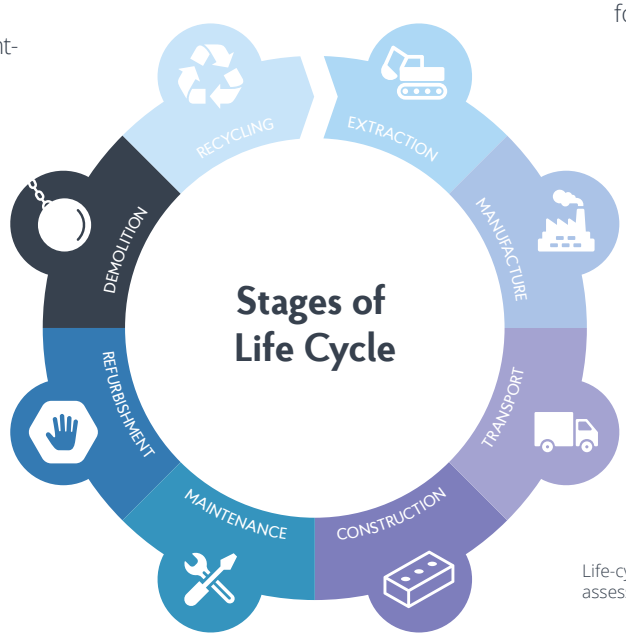
Life-cycle assessment (LCA) aims to assess the **environmental impacts** associated with all stages of the life-cycle of a product or process, from cradle (e.g. raw material extraction) to grave (final disposal of components).

In Sinfonia, Life-cycle assessments were conducted for the pilot cities of Bolzano and Innsbruck, respectively:

- on the energy saving measures implemented in a set of retrofitted buildings, using input data from the building owners,
- on the measures carried out on the district heating networks, using data provided by the local utilities.

The comparison of the environmental impacts of two scenarios (buildings with vs without renovation) for the whole life cycle demonstrated that, for **5 out of 8 indicators** studied – Energy Use indicators, Global Warming Potential, Acidification Potential, and Formation Potential of Tropospheric Ozone – the **environmental profile was substantially improved** by the renovation.

The 3 remaining indicators (Use of net fresh water, Hazardous and Non-Hazardous Waste) showed a relatively similar profile in both scenarios, except for a few buildings where the Waste indicators were deteriorated by the renovation, due to the substantial addition of new materials and equipment (solar thermal collectors for example). However, those negative impacts were largely offset by the gains on the Energy Use indicators.



Life-cycle assessment of a building. Source: D9.3 Life-cycle assessment report of the demonstrations

Availability and quality of data is essential

The main challenge in this LCA exercise was to find all **relevant data** required to perform the various analyses. A high-quality LCA at building level requires datasets on:

- Energy consumption before and after renovation, per energy carrier, based on real measurements or energy bills;
- Materials/equipment already in place before renovation, those removed and those installed during renovation works, with information on their lifetime;
- And, ideally, water consumption.

When those data were not available, simplified analyses using **proxies** had to be carried out.

“We are on the right way...” Bolzano and Innsbruck as Smart Cities

The main target of Sinfonia has been the transformation of existing urban areas into smart energy districts. This transformation process has developed in a complex framework in which multiple actors have been involved at several spatial and temporal scales. We gathered representatives from Bolzano and Innsbruck, to discuss how far the cities have come in their work. Is becoming a smart city still a desired target and to what account has the Sinfonia project contributed to that development?

Are Bolzano and Innsbruck Smart Cities now?

In late 2019, representatives from both cities gathered at a project meeting in Rosenheim to discuss their progress towards becoming Smart Cities. Can we now say that Innsbruck and Bolzano are smart cities, and are they moving towards being even “smarter”?

Sophia Neuner, project manager at IKB, has a positive view on the development:

“I would say that for Innsbruck we are moving towards it, and we are becoming smarter through Sinfonia, definitely. For instance, we are now working much more with synergy effects, and we are forming a smart city group with stakeholders from the energy side but also including others such as the mobility company and the local social organisation. We are not quite there yet, but we are on the right way.”

Sophia Neuner, project manager at IKB

Alyona Zubaryeva, Project Manager at EURAC, agrees that the development related to the project is positive but sees another angle:

“For Bolzano I think it’s a bit less at the city level, this topic of smart city as an interaction of sectors and more intelligent managements strategies. It is more related to energy refurbishment within the city.”

She points out a very positive but unexpected side effect; that the Sinfonia project also had impact on other cities within the region:

“We have been contacted by other cities like Murano and Brunico, and by small centres in the province, because they want to get on board with this topic. They are very interested, and so far we have organised several small conferences about different aspects of smart cities, including for example city integration and the general concept of smart cities. Somehow this is the main effect, as we see it by now.”

Nothing without tenants

Communication with tenants has been a crucial part of the project. In the early days of Sinfonia, the behavioral attitude of tenants and their disinterest in energy efficiency related values was identified as a **potential weakness**, something that could stand in the way of change. But this has instead taken a **positive turn**. Intensive information campaigns about the refurbishments and the energy efficiency goals have led to a **shift in mindset** which might not otherwise have taken place.

"Early in the project, when we asked in a questionnaire for the tenants' opinions towards energy efficiency, we could see that they had other, perhaps more urgent, priorities than that," says Gerda Embacher, from the housing company NHT in Innsbruck. "But with the new houses, the tenants pay a lot less for their heating, and now they are really convinced. When you look at the questionnaires, you see the difference before the renovations and after."

Tenants have been involved on several levels; information, consultation, co-decision-making and Sets of Solutions, for instance:

- Questionnaire survey
- Interactive workshops
- Tenants' Representative as a mediator between building owners and tenants
- Regular tenant assemblies
- Information brochures and journals
- User manual for tenants
- Possibility to visit demo apartments
- Building site inspections

Find more information at:
www.sinfonia-smartcities.eu/en/stakeholder-engagement-toolkit/stakeholder-groups/tenants/

Demo apartment. Credits: Eurac Research/Annelie Bortolotti

Sinfonia methods for cities to follow

Sinfonia's research has evaluated the long-term impact of the district retrofitting model, which was developed in the project beyond the demonstrations implemented in the districts located in Innsbruck and Bolzano. The replication potential of this approach has been studied at city, country, and European level and the results show the benefits cities can obtain from joining an EU funded project dealing with energy transition or refurbishment[1]. Studies also show that the Sinfonia methodology has a great potential ahead.

Within the project, a flexible methodology has been developed that can help medium-size European cities to assess their energy refurbishment readiness level. A nine step scale – inspired by the well-known TRL scale to assess technology maturity – guides a city in its continuous path towards the design, implementation and assessment of energy efficiency measures. The methodology combines the involvement with Covenant of Mayors as a first necessary step with other national and international based initiatives.

Via Aslago during renovation.
Credits: Eurac Research/Annelie Bortoletti

The replication potential of the district template model has been studied in the seven EU countries participating in the Sinfonia project: Austria, Cyprus, France, Germany, Italy, Spain and Sweden. Reports show that the very first value for cities joining a project like this is a leverage value which triggers cities to change people's minds and overcome barriers to develop energy efficiency actions. But more importantly, the study highlights a significant gap between energy plans at country level and local plans at city level. This can result in a lack of expertise, goals, and monitoring of results. Although there are plans at national and European level to reduce CO_2 emissions, there are big differences between countries in terms of how to facilitate measures and what resources to give to cities.

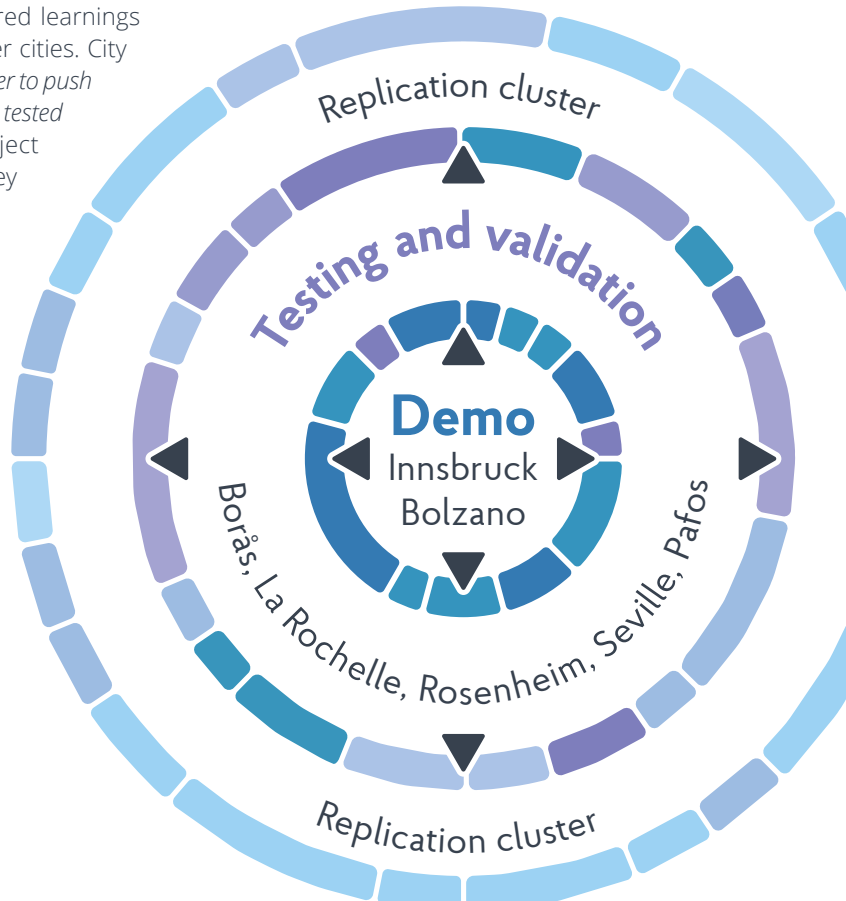
Innsbruck's classroom after refurbishment. Credits IKB

1 D9.5 Impact assessment for Austria, Cyprus, France, Germany, Italy, Spain and Sweden

Reports also show a lack of expertise in the cities to effectively carry out efficiency plans. Due to this lack of implementation, countries may not be able to comply with their energy efficiency targets.

One recommendation following this is that countries and their cities should **coordinate on the long term** how to effectively implement these national plans at city level, regardless of the changes in the national and local governments and institutions. In this work, the **district template** developed in the Sinfonia project can be a useful tool to guide cities on how to make decisions before implementing a retrofitting project, which can be especially useful in countries were cities have less expertise in energy efficiency.

Representatives from the Sinfonia follower cities of Borås and Rosenheim agreed that one of the great gains for their cities is access to a methodology to identify the co-benefits (e.g. increased air quality, health and well-being) of energy efficient refurbishment. Cities also highlight the **Crocus tool** (see p.11) and **Energy performance data** (see p.12), with proof of the effects as particularly important for them. For the City of Pafos, the methodology for **holistic planning**, together with **business models** for affordable refurbishment are the prime improvements resulting from the project. Also valued were the shared learnings from experiences made in other cities. City representatives say that it is *"easier to push for solutions when they have been tested elsewhere"*. In general, the project participation now means that they find themselves being better equipped for further projects in their own cities.



Smart Cities – a useful concept?

"A smart city is a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies for the benefit of its inhabitants and business."[2]

Though the Sinfonia project has brought about many positive changes, the city representatives agree that it's not particularly important what it's called. The main concern for them is that development is sustainable and integrated, not that it is smart as in IT-solutions. The smart city concept also has some limitations, and the next generations of development projects will most likely combine even more complex matters such as how the public space is designed for people to meet, green infrastructure and mobility.

"Though IT will always be a part, it is not the driving force. More and more people recognise that IT is probably good for big cities, but it has a less important role for smaller cities", says Alyona Zubaryeva.

Klaus Kleewein, Innsbruck Pilot District Leader, agrees:

"Smart City is probably not the right term anymore. Even if the city has become more intelligent and more connected, at the same time Sinfonia triggered the cooperation among the partners. This is the really smart thing"...

Klaus Kleewein

Why become a Smart City?

- Better quality of life for inhabitants of city
- More efficient energy distribution
- Faster transition towards low carbon society
- Positive cooperation with project participants – mutual learning
- Follow-up projects
- A change in the general innovation culture – important for the needed change of our cities.

2 Source: https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en

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- www.sinfonia-smartcities.eu

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- ATB-Becker e.U. . . . . (AT)
- E3 Consult . . . . . (AT)
- Neue Heimat Tirol . . . . . (AT)
- University of Innsbruck . . . . . (AT)
- alpS . . . . . (AT)
- Standortagentur Tirol . . . . . (AT)
- Innsbrucker Immobilien Gesellschaft . . . . . (AT)
- Tigas-Erdgas Tirol . . . . . (AT)
- TIWAG-Tiroler Wasserkraft AG . . . . . (AT)

European partners

- RISE Research Institutes of Sweden . . . . . (SE)
- Atlantis Consulting . . . . . (CY)
- Centre Scientifique et Technique du Bâtiment (CSTB). . . . . (FR)
- Greenovate ! Europe . . . . . (BE)
- Michael Heidenreich Consulting . . . (AT)
- Passive House Institute (PHI) . . . . . (DE)
- DOWEL Management (formerly TECHNOFI) . . . . . (FR)
- Urban Software Institute (ui!) . . . . . (DE)
- Zabala Innovation Consulting . . . . . (ES)

Pilot district Bolzano

- City of Bolzano/Bozen . . . . . (IT)
- European Academy Bozen/Bolzano (EURAC). . . . . (IT)
- Istituto per l'Edilizia Sociale (IPES) . . . (IT)
- Alperia. . . . . (IT)
- Agency for Energy South Tyrol - CasaClima. . . . . (IT)
- IDM Südtirol / Alto Adige . . . . . (IT)

Early Adopters

- La Rochelle. . . . . (FR)
- Rosenheim . . . . . (DE)
- Pafos . . . . . (CY)
- Seville . . . . . (ES)
- Borås. . . . . (SE)

Graphic design: Revolve Media

Sinfonia stands for "Smart INitiative of cities Fully cOmmitted to iNvest In Advanced large-scaled energy solutions".

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Credits: Andreas Friedle