Urban Insight
By Sweco

Resource-based communities, from wasteful to resourceful – optimizing energy, water and food systems

SWECO

Introduction

The agriculture sector accounts for approximately 30% of global greenhouse gas emissions. Add to this the fact that the food sector's prime markets are cities and urban areas, which occupy only 2% of the planet's landmass while also accounting for 70% of global C02 emissions.

Access to an adequate amount of nutritious food should be perceived as the most basic of all human rights; however, conflicts, climate change and population growth have doubled the number of citizens who are uncertain of where their future meals will come from. Recent crises such as the pandemic and conflicts are giving many cities a rude awakening about how sensitive today's global supply chains are and how much we depend on them. In addition to this, the long-term climate crisis has begun causing extreme weather events, which has made it abundantly clear what kind of major impact even a minor power outage could have on our societies.

This white paper explores the importance of ensuring access to energy, water and food in case of an emergency, a failure, a disruption, or any other risk, through principles and good practices that go beyond the crisis situation and seek to generate systemic change. Experts will show how planning and designing in order to optimise our resources and our supply networks will provide local redundancy and diverse alternatives to complement the great flows of global supplies. The aim with a decentralised local approach is to focus on the need to be interconnected while implementing actions that diversify our options, reaching a certain level of self-sufficiency, increasing the number of possible responses to a crisis and to moving forward towards a sustainable and integrated management of resources.

Image: Almanakken, A vision project by Sweco, rethinking the way we live – and the way we connect communities.

The Almanakken concept has been developed as a reinterpretation of the traditional location-based almanac calendar. The name of the project, the Almanac, makes reference to the changing seasons and the circular regularity of nature. Almanakken is a method and architectural approach that establishes the community at the same time as defining the architecture.

Equal access to resources and community building

Equal access to supplies and resources is an important part of our living standards. Communities that are better supplied and that have higher levels of social equality are less vulnerable and more resilient.

One example of this is a community based on collective production and optimisation of resources. A society organised around the management of resources creates intelligent symbiotic relationships between lifestyle, consumption patterns and the environment, while it consolidates fundamental models of cooperation, making it stronger and more resilient. Such bodies include energy communities (collective and decentralised energy management), communities configured around integrated water-management systems, communities organised around intensive agricultural production, and so on.

Moreover, community-driven utility networks and transformations that encourage shared resources, such as energy, water and food, can be powerful tools in our journey towards a greener future. In this future, a neighborhood could form an ecosystem. This ecosystem would strive to use and reuse as many resources as possible locally, creating a network of buildings cooperating to share resources.

Project: Self-sufficient cities

Sweco in the Netherlands, together with the Dutch Design Foundation, organised a 'What if' lab at the 2022 Dutch Design Week, the largest design event in northern Europe. Three designers explored what the world would look like if cities were self-sufficient. They were given a short time to work on the following assignment: design a trailblazing application for a self-sufficient city, five years from now. The application should make a valuable contribution in the fields of energy, food and water for optimum health, biodiversity and social connection for residents.

The designers worked together with an expert panel and were given access to Sweco's knowledge and network. The end result being their presentations at Dutch Design Week in Eindhoven. Altogether, we created an environment in which we researched, experimented and learned from each other.

Location: Eindhoven, The Netherlands
Team: Sweco Netherlands in collaboration with the Dutch Design Week
Designer: Studio Tjeerd Veenhoven, Studio Floris Schoonderbeek, Studio Bram de Vos
Role of Sweco: Organizer and curator of the What if Lab

Images: Rogier Boogaard, Sweco Dutch Design Week in Eindhoven.

Image: Tjeerd Veenhoven

Water – rainwater storage in facade panels
Rainwater is a precious commodity that we can make better use of. Rainwater is fresh, relatively clean and comes in large quantities. An average roof of a residential house can easily absorb 2,500 litres of water during a flood. Wouldn't it be a shame if we didn't do anything with it?

Tjeerd Veenhoven came up with a locally manufactured ceramic facade panel that can hold rainwater. Once stored, this rainwater is absorbed over a period of three days by the ceramic material and evaporated through the outside of the wall. The transition from liquid to vapour helps cool the surrounding area in the hot summer months. This ceramic facade panel, therefore, offers two solutions: being able to store rainwater during extreme rainfall and cooling the urban environment through evaporation. The panel can be used both in new constructions and to make post-war neighbourhoods more sustainable.

Image: Floris Schoonderbeek

Food – circle farming: looking for more farmers
Small farmers used to settle near a river so that they could grow their food in this fertile soil. The inhabitants were in close contact with their natural environment. Villages, however, grew into cities and became diametrically opposed to nature. Agriculture moved inland, grew to a large-scale industry and the fertile soil was covered with tiles and concrete. The countryside industrialised, in terms of layout and as a habitat.

The circle-farming project by Studio Floris Schoonderbeek softens these hard dividing lines between urbanised areas and agriculture at both the landscape and cultural level. Circle farming offers space for rich land, nature, food forests and housing. After all, by creating circular fields, you create space for recreation, life and animals. At the same time, within the boundaries of the city, circular fields are much closer to the inhabitants and they can participate more easily in the agricultural processes. 'The compass' is a smart tool that makes this agricultural system economically feasible and workable. The necessary automation saves time for the farmer, allowing them to engage with nature, stimulate biodiversity and transfer valuable knowledge.

Image: Bram de Vos

Energy – the material energy transition
Instability in the world is increasing. We can make great gains by finding a way for the population to provide itself with energy. This creates more independence and people will be able to deal more easily with the consequences of energy instability. Can a country like the Netherlands become more independent in the field of energy in the future?

Studio Bram de Vos thinks so. In 'The material -energy transition', Bram proposes a number of possible solutions depending on the location of the material to be used. His proposal is a new combination of innovative and older systems, with a mix of recycle/upcycle for energy generation and storage. The proposal is set in and around the recently purchased Wielewaal estate in Eindhoven, where the advantages and disadvantages of material use in the energy transition can be balanced for the best results.

Energy communities, towards resilience through collective energy districts

Self-sufficient, smart, and interconnected energy districts are the cornerstones of resilient societies. Maximising energy production and consumption of locally generated resources at the district level is key, with heat networks transferring energy from renewable sources either as electricity or as green hydrogen. Positive energy districts (PEDs) embody this ideal, generating more energy than they consume, reducing grid congestion and accelerating the transition to renewable energy sources. Through interconnecting PEDs via the grid, we can create interdependent communities that collaboratively work towards a sustainable future by sharing surplus energy.

Actions on a neighborhood level

It is vital to establish smart, self-sufficient, interconnected and renewable energy districts to achieve resilient societies. In order to realise these, the following aspects should be kept in mind:

- Maximising energy production and self-consumption at a district level is key. Smart urban planning can maximise energy synergies between complementary urban functions and promote equitable and sustainable energy usage. For instance, heat networks can transfer energy from different renewable sources: geothermal, aqua thermal, riothermal and residual heat from the neighborhood.

- Increasing the possibility of implementing alternatives. In districts where gas infrastructure is already in place, there is the potential to transition to green hydrogen.

- Optimisation of technology with the support of smart solutions and artificial intelligence could enhance energy-use efficiency and storage. Countries like the Netherlands are leading in the use of smart electricity grids and vehicle-to-grid technology, storing excess energy in cars and supplying it back during shortages.

- Prioritising equitable access and inclusion is crucial to sustainability initiatives to ensure benefits for all community members, especially for those from marginalised social groups.

- Community-driven energy projects could encourage the use of local renewable resources and shared-energy distribution.

A successful example of a community-energy initiative is the Terbekehof business park project by Sweco in Belgium, which uses local green-energy storage and sharing to increase sustainable-energy production and usage.

Image: Antifragile City District: A Vision by Sweco. Location: Belgium, Ghent. Visualisation by Lisa Debeer.

Project: Terbekehof Business Park Energy Community

In Belgium, Sweco together with the client transformed the business park by renewable energy systems and community engagement to create a green energy sharing community in Terbekehof, Wilrijk. This innovative project showcases the capability to utilize local resources, in this case, green energy, to increase resilience and sustainability within local business communities.

The project's primary focus is to future-proof the Terbekehof industrial site by establishing an energy community among the on-site businesses. Sweco facilitated informative workshops, sharing their findings and engaging in discussions with businesses to gauge their interest in participating. Through collaboration with three companies, the energy community was successfully established. Sweco remains committed to monitoring operations and optimizing procedures for seamless growth.

This project showcases solutions in energy communities, solar panels, future scenarios, stakeholder participation, and reporting.

Location: Wilrijk, Belgium
Team: Energy For Society, Sweco in Belgium
Client: POM Antwerpen
Role of Sweco: Conducted research on the contribution and benefits of an energy community among the businesses on the site. Collected data and analyzed the potential of an energy community. Facilitated workshops with companies to explore their willingness to participate in the energy community. Established the energy community in collaboration with three companies. Monitored the operation of the energy community and automated procedures for future growth. Provided reporting and communication within the project.

Energy efficiency, a collaborative approach

Adopting energy-efficient strategies and focusing on demand-side management could greatly reduce urban heat stress and decrease overall energy demand. This includes actions such as upgrading appliances to more energy-efficient ones, ensuring that lights are turned off when not in use, scheduling the charging of electric cars during periods of abundant sunlight and incorporating green-infrastructure elements such as green roofs and trees.

Orchestrating all the drivers of the energy transition at district level into a cohesive community transition project can be a complex task. However, the rewards of an integrated approach are worth the effort. For this, collaboration around partnerships and joint ventures, as well as through financing and management models between different promoters, public authorities and multiple service operators (energy companies) is crucial in accelerating the implementation of self-sufficient and renewable energy production.

Multi-actor cooperation frameworks are, therefore, essential. Through initiatives like Senergie, Sweco in Belgium supports a consortium of companies in the conception and implementation of affordable climate-robust solutions and services by seeking optimal synergies in common basic services around heat, energy, water, waste, raw materials, ecology and mobility.

Senergie stands for carefree customisation throughout the entire project, from design over investment and financing to maintenance and management.

Project: The Senergie projects

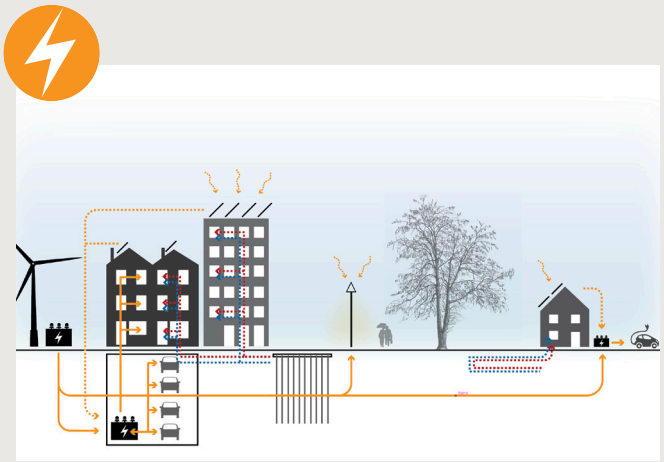
Resources-as-a-service
Sweco in Belgium and Senergie, a consortium of companies, are joining forces to develop integrated, eco-friendly systems relating to heat, energy, water, waste, ecology and mobility for urban areas. Customers can easily access these services on a pay-as-you-go basis, while Senergie takes care of the technical and financial aspects. This collaboration ensures maximum environmental impact and offers a seamless experience for customers.

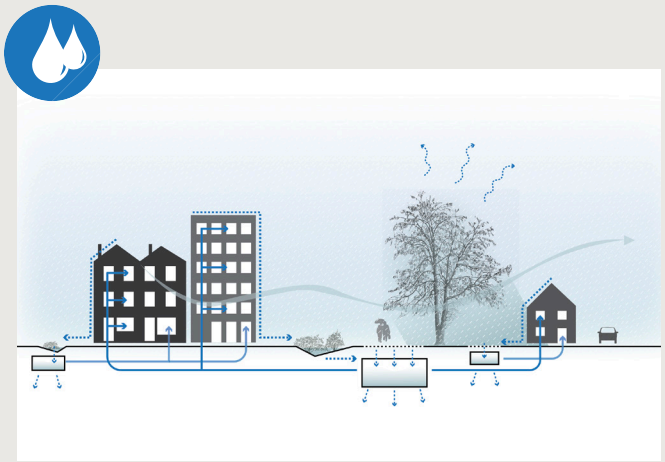
We call it Senergie-as-a-service. Senergie helps partners to realise the transition to affordable climate-robust solutions and services by seeking optimal Senergie in common basic services relating to heat, energy, water, waste, raw materials, ecology and mobility. Senergie stands for carefree customisation throughout the entire project, from design to maintenance and management.

Location: Belgium
Team: Triple Living, Im-pact and Sweco in Belgium
Role of Sweco: Part of a consortium of companies to develop integrated, eco-friendly systems relating to heat, energy, water, waste, ecology and mobility for urban areas.

For energy-as-a-Service
- Energy Consulting: Expert advice and guidance on energy management, efficiency improvements, and renewable energy integration.
- Renewable Energy Solutions: Tailored solutions for implementing renewable energy systems such as solar power, wind energy, and biomass.
- Energy Efficiency Assessments: Comprehensive audits to identify areas of energy waste and develop strategies for improved efficiency.
- Energy Monitoring and Control: Advanced systems for tracking energy consumption, identifying savings opportunities, and optimizing energy usage.
- Sustainable Energy Planning: Assistance in developing long-term energy plans aligned with sustainability goals.
- Energy Financing and Incentives: Support in accessing financing options and incentives for renewable energy projects.

For water-as-a-service
- Water Storage: Design and implementation of water storage systems
- Water Purification: Expertise in water purification technologies
- Water Reuse: Strategies and solutions for water reuse
- Water Harvesting: Systems for collecting rainwater
- Water Buffering: Implementation of buffering systems
- Water Infiltration: Techniques for groundwater replenishment
- Individual Water Solutions: Tailored water management solutions
- Collective Water Solutions: Collaborative approaches to water management





Project: The Senergie projects

For ecology-as-a-Service

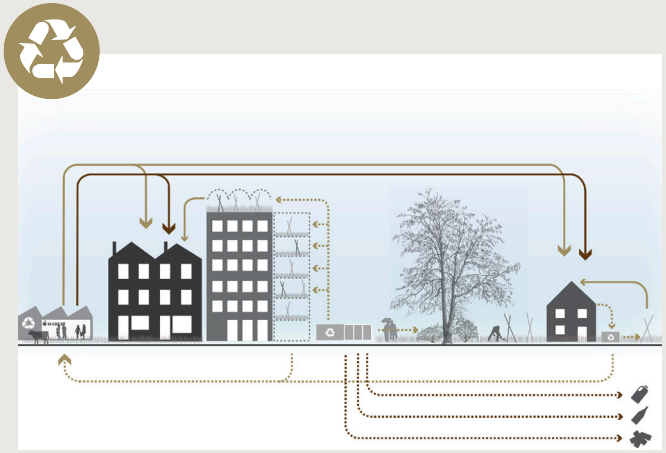
- Decentralized Greening: Implementing strategies to reduce paved surfaces and increase green spaces
- Heat Stress Mitigation: Designing solutions to mitigate the effects of heat stress in urban areas
- Biodiversity Enhancement: Implementing measures to promote and enhance biodiversity
- Livable Living Environment: Creating environments that prioritize the well-being and quality of life for residents
- Green Maximization: Maximizing the presence and benefits of green infrastructure in urban areas

Waste-as-a-Service

- Recycling: Providing waste recycling services to effectively manage and process recyclable materials
- Composting: Offering composting services to convert organic waste into nutrient-rich compost for soil enrichment

Mobility-as-a-Service

- Rental: Offering mobility rental services, providing convenient access to vehicles or transportation options as needed
- Sharing: Facilitating shared mobility solutions, encouraging collaborative use of vehicles or transportation resources
- Charging: Providing charging infrastructure for electric vehicles, supporting the transition to sustainable transportation
- Flexibility: Promoting modal shift and flexible transportation options to reduce reliance on single-occupancy vehicles
- Protection: Implementing measures to protect and enhance mobility infrastructure for safe and efficient transportation



A holistic approach encompasses a range of strategies in addition to the collective-energy transition. This includes, for instance, encouraging soft modes of transport in combination with collective district batteries and smart charging infrastructure; coupled with de-paving strategies to boost rainwater infiltration and collective rainwater-collection systems while reintroducing nature.

Water communities, circular water as a neighborhood resource

The exact same logic applies to water, with tremendous untapped possibilities for becoming more resourceful and sustainable. Moving beyond the integrated rainwater-management systems of retention, temporisation and infiltration, water is also a powerful resource at a neighborhood level.

In many parts of Europe, we are experiencing a growing threat from long droughts and extreme weather, which could cause emergencies such as fresh-water shortages – while we continue to flush our toilets with potable water.

The current end-of-pipe approach to the handling and transportation of wastewater was invented centuries ago and solved the problems for the people of that time, but it is simply unfit for the challenges and needs of the 21st century. A decentralised and self-sufficient neighborhood-based water system is a way to meet these challenges and could lead to more resilient communities.

Following this principle, Sweco in the Netherlands is designing a circular water system for the city centre of Nieuwegein. The main goal is to reduce the usage of drinking water by providing a part of its own supply, contributing to their goals for greater climate resilience. To achieve this, extra facilities will be provided including new infrastructure to collect grey and black wastewater, an underground water buffer and a new distribution net to deliver non-potable water which can be reused (for irrigation or toilet flushing).

Project: circular water Nieuwegein-City

The Nieuwegein municipality has the ambition to convert their city-centre to the most sustainable one in the Netherlands. As part of this ambition, Sweco is investigating the possibility of delivering a preliminary design for a circular water system for the area.

The main goal is a water system that leads to a reduction in the usage of drinking water. Ultimately, the system will provide a portion of the city's own drinking water and will also contribute to climate resilience. Sweco is responsible for investigating five research questions, which the client will use for a final go/no-go decision on the implementation of the circular-water principle.

Extra facilities need to be provided including new infrastructure to collect grey and black wastewater, an underground water buffer and a new distribution net to deliver non-potable water which can be reused (for irrigation or toilet flushing). Further activities include delivering a risk file and a governance proposal for realisation and ownership.

Location: Nieuwegein, The Netherlands
Team: Sweco Netherlands (Laurens van der Schraaf, Patricia Clevering, Wilmer Noome, Maarten Geist, Renske ter Horst, Paul Telkamp (TAUW))
Role of Sweco: Deliver expertise and projectmanagement and answer 5 research questions so the client can choose for a final go/no-go on the final design. We work together with TAUW.
Client: Municipality of Nieuwegein

Rainwater – an untapped resource
When thinking of water as a neighborhood resource, we can split it into different flows. The first one is rainwater. Rainwater could be used for infiltration to resupply the groundwater level, for irrigation for plants and trees or for recreation, as it can help cool the city. Established methods include purifying rainwater with filters or natural systems like helophytes. By using purified rainwater instead of freshwater for flushing toilets, up to 35 litres of a person's daily usage of water could be saved.

Greywater could almost halve freshwater needs
Another water flow that could be used for flushing is recycled greywater. By using recycled greywater for purposes such as flushing, irrigation or even laundry, the daily requirement for freshwater could be reduced by up to 45%. Today's technology includes membranes, biological treatment, filters and UV-C disinfection that make it possible to treat greywater until it becomes non-distinguishable from freshwater. One great advantage greywater has over rainwater is that greywater is available every day, providing a continuous flow of water that can be recovered and reused.

Water as a source of energy
Furthermore, greywater has the potential to become a source of energy. Water from sinks, showers and baths typically remains heated when discarded, and this heat can be recovered using a heat exchanger. The amount of this reclaimed energy can be higher than the energy needed to operate a greywater recycling plant. This aspect has become increasingly interesting as current energy prices are soaring.

Blackwater – even the last drops could be circulated
Blackwater is the water from toilets. While usually considered a waste, it is actually a versatile resource, as it contains nutrients such as phosphorus (mostly in urine) – a limited yet crucial source for plants, which could be recovered by struvite precipitation (Struvite precipitation cleans wastewater, producing crystals that can be used as fertilizer) – and carbon (in the fecal matter), which could be digested in a biogas reactor, the resulting biogas is capable of being used for energy.

To summarise, there is real potential for water management both in public spaces and at home to turn untapped water into resources. By separating and harvesting the potential of the different water-resource flows, we will be able to initiate a far-reaching transformation of our cities. Through recycled greywater, harvested rainwater and recovered nutrients from blackwater, we could even grow our own food right in the middle of our urban neighborhoods.

The wide possibilities of using water as a resource were explored in a pre-feasibility study for a circular water chain carried out by Sweco in the Netherlands as part of the efforts to transform the Merwe-Vierhavens area in Rotterdam from industrial use to a mix of urban/small industrial. This study investigates how water, energy and raw materials can be recovered from the water cycle and reused within the area. The Merwe-Vierhavens area aims to have a circular water chain by 2050.

Project: circular water M4H, a circular water chain by 2050

The Municipality of Rotterdam and the Port of Rotterdam Authority are jointly developing the Merwe-Vierhavens area (M4H) into a new area where the manufacturing industry, housing and other supporting facilities reinforce each other.

The area is being converted from industrial to a mix of urban/small industrial. The municipality and the drinking water company have high ambitions to develop a circular urban water system. The main reasons for this are urbanisation (the increase of wastewater) and a desire to stimulate innovation while becoming more climate resilient. Sweco, therefore, carried out a pre-feasibility study and investigated the possibilities for harvesting and reusing water, energy and raw materials within the area.

The aim is for the M4H area to have a circular water chain by 2050. A circular water chain (or system) in M4H will ensure the optimal use of water (including raw materials or energy in the water) by linking users and providers and aiming for closed systems in the area. Industrial users are required to make their (waste) water available in the area. In this way, the water chain will have a positive impact on its environment.

One of the aims for all new housing in the area is that only 80 liters per person per day of water will be produced.

Location: Rotterdam, The Netherlands
Team: Sweco Netherlands
Role of Sweco: Investigate how water, energy and raw materials can be recovered from the water cycle and reused within the area so that a circular water cycle is created
Client: Alliantie Waterkracht Consortium (Municipality of Rotterdam, Municipality of Capelle aan de IJssel, Delfland Water Board, Schieland and Krimpenerwaard Water Board, Hollandse Delta Water Board and drinking water company Evides)

Images: M4h

Food communities and food planning for cities

The origin of cities is closely linked to the production and trade of food, which is what motivates the planning of the global food system presented here. Excavated foundations at Çatalhöyük in Turkey, one of the earliest examples of urban settlements (dating from 7000 BCE), clearly indicate that agricultural activity was its driving force. It is also well established that many of our current cities have a history linked to marketplaces and trading routes. Today, we understand that food is an important catalyst for urban life through its contribution to lively restaurant quarters, thereby also generating important real-estate value in our cities.

The downside is that the seemingly efficient large-scale food production system of our society also created an extreme impact on the environment (waste, transportation, chemical industrial processes etc.) which cannot be overstated.

The recent pandemic mercilessly shone a spotlight on the weaknesses in the food supply chain and its logistics and production, while also displaying its vulnerability in terms of shortage of labour. We also know that the agriculture sector accounts for approximately 30% of the global greenhouse gas emissions. Add to this the fact that the food sector's prime market of cities and urban areas only occupy 2% of the planet's landmass while also accounting for 70% of global man-made CO2 emissions. Today, 75% of European citizens live in cities or smaller urban communities; this is a percentage that is expected to rise to 80% by 2050.

While we agree that access to an adequate amount of nutritious food should be perceived as the most basic of all human rights, conflicts, climate change and population growth have doubled the number of citizens who are uncertain of where their future meals will come from. Novel urban resilience approaches in terms of food and food systems will, in our view, need to include food production at an urban level. Sweco's recent practice-based research examined urban food planning in a city with 90,000 citizens. We found that a city district with 15,000 citizens could easily deliver the nutritious greens needed by the city of 20 kg of produce per person/per year (i.e., double today's standard amount) and 10 kg of future food per person (the equivalent of future foods, e.g., urban fish production) by renewable energy sources.

These figures uncover the unexplored potential of urban centres for food production. However, to access this potential, it is necessary to elaborate ambitious visions that reveal possibilities and bring to the table innovative alternative solutions for urban development.

To illustrate this, we use selected examples from Sweco's practice-based research portfolio: **AIFOOD** by Sweco Architects in Sweden to dive into the benefits of integrating AI in food production; and **FoodLoop**, a vision by Sweco Architects in Denmark which explores the possibility of designing a unified, closed, underground food-supply chain in the middle of the city to address the question of food self-sufficiency in our future cities.

To include food production as a fundamental urban feature, agricultural and urban development should be integrated into system resilience. **Sweco's research on Gothenburg's food flows revealed that a large city could become self-sufficient in vegetables.** In addition, the project shows that there is the potential for a city to become semi-self-sufficient in all edibles.

Image. Swegreen.

Project: AIFOOD – AI for sustainable food production from farm to fork

How can artificial intelligence (AI) and the circular economy be applied to optimise resource flows at a neighborhood level? A resilient, integrated energy system can be achieved by ensuring that production capacity is balanced to match local current consumption needs in real-time and in relation to e.g. the availability of excess carbon dioxide from office-floors, local solar energy production from roof-tops, vehicle-charging capacity in garages, water/energy supply etc.

Aiming for a 'sharing city' approach, AIFOOD has explored the potential for collaboration and the sharing of resources and data between stakeholders in a circular supply chain based around a food production unit with a high level of automation. AIFOOD's use case has centred on Swegreen, a Stockholm-based AgTech company that specialises in hydroponic urban farming with a minimum of environmental impact, targeting local production and consumption through in situ production models. Swegreen occupies a 500 sqm underground facility in a building neighbouring Sweco's Stockholm Headquarters in the city district Marieberg, both buildings are owned by the real estate developer Areim, also a partner in AIFOOD.

A multi-agent based resource and climate model was developed based on the flows of information, nutrition and resources between Swegreen and its host-building and other actors in the value chain, which naturally includes local citizens. AIFOOD has demonstrated a proof of concept for autonomous orchestration, as well as a design prototype for a digital twin that visualises the availability of resources in real-time

Team: Researchers and experts from Sweco SE (Sweco Architects), Mälardalen University, Swegreen, RISE, Areim AB, Paul Taylor Lanthandel, Bjerking and Ica Fokus Gothenburg
Role of Sweco: Project partner in this research and innovation project funded by Vinnova.
Responsible: Charlie Gullström
Funding body: Vinnova, Sweden's Innovation Agency

Image: Swegreen

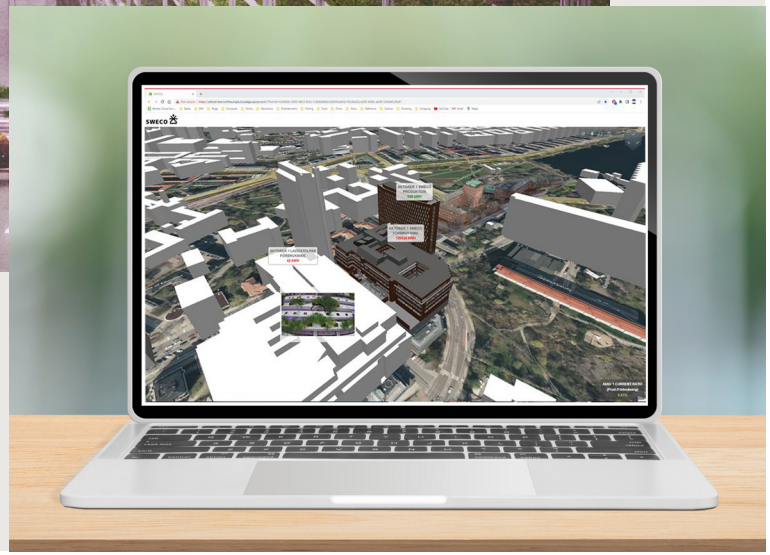


Image: Sweco

Project: FoodLoop, an underground food chain for the future

The vision project FoodLoop draws the contours of the food-producing cities of the future with a large-scale underground village farm. The project explores the possibilities for designing a unified, closed, underground food supply chain in the middle of the city and raises the question: in the future, can our cities become self-sufficient for food?

FoodLoop is one of several projects where Sweco is looking at a new self-sufficient city model for the world's cities with over a million inhabitants. The ambition is to minimise the impact of the cities' climate and resource footprint on the planet's nature and rural areas.

Food has always been a quiet but powerful player in the development of our cities and countryside. Increasing urbanisation, quantum leaps in technology and the green transition all point to an understandable paradigm shift in our food consumption habits. A shift that also calls into question whether the cities of the future can be developed in a greener way to protect the overall well-being of the planet without food production being part of the big cities' planning strategies. The FoodLoop project challenges the unequal relationship between cities and the countryside and looks at how food production can systematically reformulate our cities and communities.

Designer: Sweco Architects Denmark
Responsible: Karl-Martin Buch Frederiksen

Images: Sweco

Project: Gothenburg's food flows, Sweden's second largest city, could take large steps towards self-sufficiency in fresh food

It is very unusual for a large city to be self-sufficient in freshly grown food. To understand the current situation and to take leadership in identifying solutions, the City of Gothenburg commissioned a mapping exercise which was carried out by Sweco. It mapped, visualised and quantified flows of food resources in, through and out of the Gothenburg area, including consumption and waste disposal. The calculations enabled climate and financial impacts of the food system to be understood. The research showed that there is potential for the city to become semi-self-sufficient in all edibles.

"In Gothenburg, there is a lot of agricultural land and they are also way ahead with urban farming. If you maximise the area where it is possible to grow circularly and measure what could be produced, it is clear that Gothenburg can become self-sufficient in vegetables. Also, there could be many different kinds of food – not a mono-culture in the cultivation but instead a variety on the plate. We also see that no artificial fertiliser would be needed because there is, for example, plenty of horse manure from farms in the area", says Emma Danielsson, Head of Sustainability at Sweco Energy & Industry.

Although Gothenburg and the surrounding municipalities produce large quantities of food, much of the city's food is transported in from other parts of the country and the world. To investigate current flows , Sweco collected data and conducted interviews with key players in the food production chain. Farmers, urban growers, workers from the fish auction and the sewage treatment plant contributed information about what is produced within the area, what happens to wastes, and offered options to make the food system more local, circular and self-sufficient.

In terms of potential for improvement, Gothenburg is at the forefront of urban farming which can be further developed to produce locally-grown food. A lot of food waste is currently incinerated and nutrients that could be extracted from waste are transported to other municipalities. There are also several farms whose manure could be used more for cultivation.

The projections estimated that the proportion of food produced locally could be increased from around 1% to 40%, achieving savings of around EUR 2 million and 75,000 tonnes CO2e per year.

The local food system

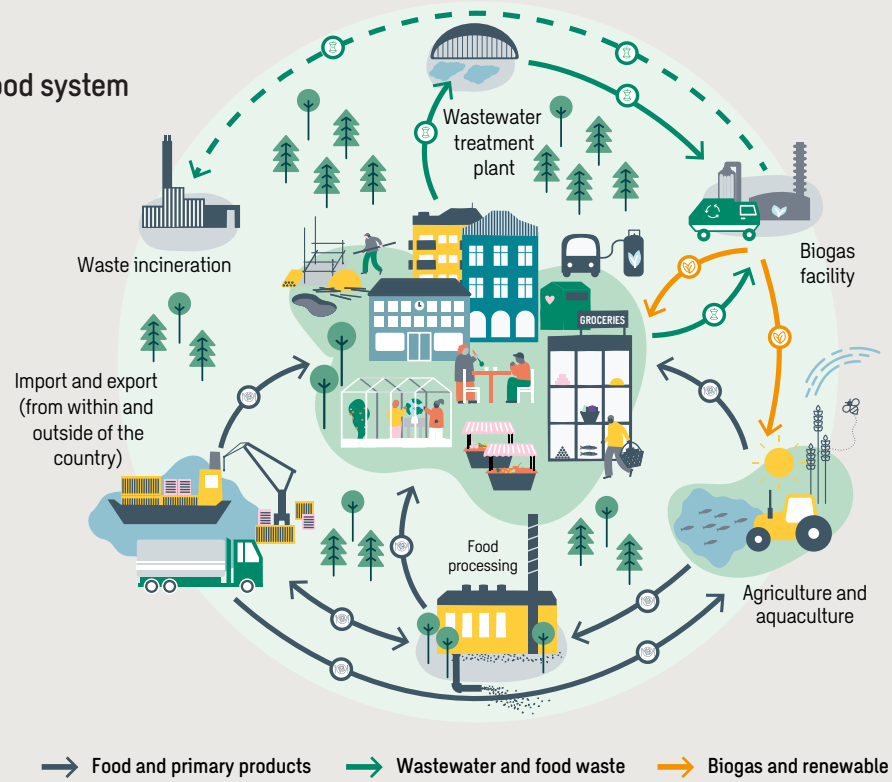


Illustration: Environmental Management for Gothenburg City, 2022:03 A sustainable food system from a circular economy perspective.

Location: Gothenburg, Sweden
Role of Sweco: Food system mapping, visualisation, quantification and recommendations
Client: Gothenburg City

Conclusion: systemic approach, behavioral change and technological support

A resilient urban system that includes food production as part of the planning strategies of big cities cannot be separated from the complex network of synergies between other resource flows and management models, such as energy-positive districts and circular water systems. In a resourceful society, local supply, production efforts and synergies between food, water, energy and materials must be fundamentally linked to the values of sustainable development. The progressive and systematic reduction of resource consumption, in combination with integrated strategies to manage resources, reduces dependence on supplies while improving environmental performance. This requires increasing ambitions and moving towards a comprehensive vision, which anticipates risks, but which also responds to

multiple other societal and environmental needs. These efforts might include alternative logistics and distribution models (local networks), new production models (circularity), new governance models (collaborative cross-sectoral models), adequate long-term, cost-effective investments (new financial models) and new social organisations as described above (resource-based communities).

Sweco's experience of integrated city planning through the Symbio-City methodology by Sweco Architects in Sweden, which considers the synergies between water, energy and material flows, along with larger scale food system planning, highlights how this approach can influence a significant systemic change. It also emphasizes the importance of engaging a wide pool of stakeholders, including citizens, to effect behavioral change.

In this sense, engaging with local community members and leaders in the planning and implementation stages is necessary to identify unique resource needs and to craft tailored solutions that benefit everyone in the community.

The concept of resource-based communities bridges the current disconnection between production and consumption of resources. By incorporating the management of resources into the daily life of citizens, resource-based communities reinforce local potential and promote behavioral change.

However, in a highly technological society, fundamental changes in production and consumption patterns (on a household level and a neighborhood level), as well as the optimisation of supply chains, calls for new, more efficient and diversified technological innovations.

Through the AIFOOD project, Sweco explores how AI can optimise an urban-food system by creating symbiosis between the different stakeholders involved in the resourcing, production and consumption of hydroponically produced nutritious greens, thereby improving energy and resource efficiency of the city district as a whole. These technological ventures reveal the potential for collaboration and the sharing of resources and data between stakeholders in a circular supply-chain around a food production unit with a high level of automation.

The impact of urban food in terms of resilience reveals the complexity of our resource flows and supply networks. How should we plan our cities in the future? We believe that more efficient planning of energy resources, water management and local-food production will be increasingly important issues in the current context of poly-crisis. Aiming for a 'sharing city' approach, the resource-based communities principle should applied to optimise resource flows at neighborhood level while reinforcing social engagement and local capacities. Technological innovation is needed to optimise complex systems, but to also plan and even predict inflows and outflows of resources in a city. The concept of resource-based communities is about using dormant resources and surpluses from other processes within a strong network of engaged citizens.

Key Takeaways:

- By developing resource-based communities, we could ensure access to food, energy and water in case of an emergency, a failure, a disruption, or any other system crisis.
- In a resourceful society, local supply and production efforts for food, water, energy and materials must be fundamentally linked to the values of sustainable development.
- Equal access to supplies and resources creates communities that are better supplied and have higher levels of social equality, and which are, therefore, less vulnerable and more resilient.
- Resource-based communities help incorporate the management of resources into their citizens' daily lives, promoting behavioral changes, which in turn are extremely important in order to achieve resilience.
- We need a systemic approach. For instance, in order to achieve food-system resilience, agricultural and urban development should be integrated into the process.
- Self-sufficient, smart and interconnected energy districts are the cornerstones of resilient societies.
- By using purified rainwater instead of freshwater for flushing toilets, up to 35 litres of water or 25 % per person per day could be saved.
- By using recycled greywater for purposes such as flushing, irrigation, or laundry, the daily need for freshwater could be reduced by up to 45%.

Recommendations

- **Collective stewardship of energy, water, and food:** a holistic approach to climate and resilience action.
- **Establish climate and resilience departments:** create dedicated departments in municipalities for climate and resilience policy and action, with particular emphasis on energy, water and food sustainability and resilience.
- **Revamp recruitment:** enhance the recruitment process to attract skilled individuals committed to the stewardship of your energy, water and food resources.
- **Build capacity:** develop capacity-building programmes for municipal staff, emphasising the management of policies and action plans related to energy, water and food security in the face of climate change and resilience.
- **Integrate strategy:** incorporate climate change and resilience considerations, especially regarding energy, water and food sustainability and resilience, into the strategic planning process of municipalities.
- **Engage stakeholders:** initiate active stakeholder engagement programmes and raise public awareness on the urgency of sustainable and resilient management of energy, water and food resources
- **Promote collaboration:** encourage collaboration across departments and stakeholders, ensuring a unified approach to managing energy, water and food resources under the umbrella of climate action and resilience.
- **Upgrade infrastructure:** plan infrastructure upgrades that support sustainable and resilient practices in energy, water and food systems, in line with the architectural landscape requirements of climate and resilience actions.

About the Authors

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Urban
Insight
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Urban Insight by Sweco is a long-term initiative that provides insights into sustainable urban development as, seen from a citizen's perspective. The initiative is built on a series of reports, based on facts and research and written by Sweco's experts. The initiative provides society and decision-makers with the facts needed to understand and meet both current and future challenges.

This report is part of a series of reports on the topic 'Action Towards Resilience', in which our experts highlight specific data, facts and science that are needed to plan and build safe and resilient future urban environments.

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