European Commission

Science for Environment Policy

# Urban self-sufficiency: how rooftops could contribute to cities' energy, food and water demands, Spain

**A recent study helps city planners find the greenest and most effective way of producing renewable energy, crops and water on rooftops.** The researchers developed a method for analysing the performance and environmental impacts of different combinations of rooftop rainwater-harvesting-, energy- and food systems. It could aid efforts to promote urban self-sufficiency and a sustainable circular economy, they suggest.

**Rooftops in cities can provide valuable space for producing food and clean energy, and for capturing rainwater.** Used for these purposes, rooftops could help cities move towards an efficient and circular economy that promotes urban self-sufficiency.

This study presents a framework for analysing the technical feasibility and environmental impacts of renewable-energy, crop-production and rainwater-harvesting systems on city rooftops. Previous studies have explored individual systems on rooftops, but this study is the first to consider multiple systems across multiple roofs in a relatively large area, such as a neighbourhood. The researchers call this resource-production arrangement the 'Roof Mosaic'.

Integrating the three systems could bring synergies within the 'food–energy–water nexus', which represents the complex interactions between the supply and use of the three key resources. For example, harvested rainwater could irrigate crops grown on the same rooftop.

The method assesses different scenarios for the Roof Mosaic implementation in a three-to-four step process:

**Step 1:** Characterise the area for the Roof Mosaic. For example, planners must consider the type and availability of rooftops, the local climate and suitable crops for local conditions and diet.

**Step 2:** Define local legal conditions and planning regulations. These could help determine whether open-air or greenhouse farming is more viable, for instance, or the most suitable energy technology.

Planners then use information from step one and two to create the Roof Mosaic 'scenarios', i.e. specific combinations of water-, energy- and food production, with specific technologies for each. Scenarios are combined to bring optimum overall benefits across an area.

**Step 3:** Assess the environmental impact and performance of proposed combinations of scenarios. This is achieved through a life-cycle assessment (LCA) methodology that judges the scenarios against nine indicators. These include the environmental burdens of carbon dioxide ($CO_2$) emissions and energy consumption, but also key performance indicators, such as $CO_2$ emissions avoided each year per inhabitant, and energy payback time — i.e. the time it takes for a rooftop energy system to produce the same amount of energy needed to produce and maintain the system throughout its lifecycle.

The self-sufficiency of the scenarios is a further indicator. This is assessed in terms of how much supplementary energy and water, and what quantity of crops can be supplied from these scenarios, thus partially replacing conventional sources. Step three can be performed for a single reference building, neighbourhood or area.

*Continued on next page.*

**18 April 2019**
**Issue 524**

**Subscribe to free weekly News Alert**

**Source:** Toboso-Chavero, S., Nadal, A., Petit-Boix, A., Pons, O., Villalba, G., Gabarrell, X., Josa, A. and Rieradevall, J. (2018). Towards Productive Cities: Environmental Assessment of the Food-Energy-Water Nexus of the Urban Roof Mosaic. *Journal of Industrial Ecology*. DOI:10.1111/jiec.12829. This study is free to view at: http://doi.wiley.com/10.1111/jiec.12829.

**Contact:**
xavier.gabarrell@uab.cat; susana.toboso@uab.cat

**Read more about:**
Agriculture, Climate change and energy, Green infrastructure, Urban environment, Water



**To cite this article/service:** "Science for Environment Policy": European Commission DG Environment News Alert Service, edited by SCU, The University of the West of England, Bristol.

# Science for Environment Policy

## Urban self-sufficiency: how rooftops could contribute to cities' energy, food and water demands, Spain

## *(continued)*

**18 April 2019**
**Issue 524**



**Source:** Toboso-Chavero, S., Nadal, A., Petit-Boix, A., Pons, O., Villalba, G., Gabarrell, X., Josa, A. and Rieradevall, J. (2018). Towards Productive Cities: Environmental Assessment of the Food-Energy-Water Nexus of the Urban Roof Mosaic. *Journal of Industrial Ecology*. DOI:10.1111/jiec.12829. This study is free to view at: http://doi.wiley.com/10.1111/jiec.12829.

**Contact:**
xavier.gabarrell@uab.cat; susana.toboso@uab.cat

**Read more about:**
Agriculture, Climate change and energy, Green infrastructure, Urban environment, Water

**Step 4:** Scale up the impacts of a single reference building across a neighbourhood to create a neighbourhood plan. This is only performed if step three only assessed a reference building, and not a larger area. The design and analysis of the best options for the food–energy–water nexus on rooftops would be a collaborative effort between stakeholders, such as the residents of the municipality/neighbourhood, public organisations and experts on the subject.

The researchers demonstrate the method by applying it to a residential district of Barcelona, Spain. Steps one and two defined four plausible scenarios for the neighbourhood. Each included rainwater harvesting plus either a form of tomato growing (open-air or greenhouse) or energy production (photovoltaic or solar thermal). These scenarios were combined into eight possible neighbourhood mosaics.

The environmental assessment's results indicated that the configurations could each meet 23% of local demand for water for laundry and irrigation, 17–35% of tomatoes, 7–10% of energy and 34–50% of hot water (provided via energy systems). In addition, they could avoid between 109 and 157 tons of $CO_2$-equivalent emissions per year, per inhabitant, compared with conventional sourcing of these resources.

The assessment highlights different impacts and benefits of different combinations of scenarios and can provide basic guidelines for addressing the food–energy–water nexus through rooftops. The results of the assessment will vary by location. Ensuring connectivity at neighbourhood scale in this way can help towards achieving an urban circular economy.



**To cite this article/service:** "Science for Environment Policy": European Commission DG Environment News Alert Service, edited by SCU, The University of the West of England, Bristol.