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Natural Water Retention Measures

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Case Study

Green Roofs of Vienna

ACTeon environment research & consultancy

Office International de l'Eau

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Environment

This report was prepared by the NWRM project, led by Office International de l'Eau (OIEau), in consortium with Actéon Environment (France), AMEC Foster Wheeler (United Kingdom), BEF (Baltic States), ENVECO (Sweden), IACO (Cyprus/Greece), IMDEA Water (Spain), REC (Hungary/Central & Eastern Europe), REKK inc. (Hungary), SLU (Sweden) and SRUC (UK) under contract 07.0330/2013/659147/SER/ENV.C1 for the Directorate-General for Environment of the European Commission. The information and views set out in this report represent NWRM project's views on the subject matter and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this report. Neither the Commission nor any person acting on the Commission's behalf may be held Key words: Biophysical impact, runoff, water retention, effectiveness - Please consult the NWRM glossary for more information.

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I. Basic Information

Application ID	*AT02*			
Application Name	**Green Roofs of Vienna**			
Application Location	Country:	Austria	Country 2: *In case of transboundary applications*	
	NUTS2 Code	*AT13 Wien*		
	River Basin District Code	*AT1000 Danube*		
	WFD Water Body Code			
	Description	*The city of Vienna encourages since 2003 its citizens to install green roofs.*		
Application Site Coordinates *WGS84*	Latitude: 5340351	Longitude 33U 602067 (E)		
Target Sector(s)	Primary:	Urban		
	Secondary:	Select sector		
Implemented NWRM(s)	Measure #1:	*U1 green roofs*		
	Measure #2:			
	Measure #3:			
	Measure #4:			
	Measure #5			
	Measure #6			
	Measure #7			
Application short description	Since 2003 the city of Vienna supports financially the implementation of green roofs with 8-25 € per m². The maximum subsidy can be 2200€. By 2010 16000 m² roof were transformed and 150 000€ invested.			

II. Policy context and design targets

Brief description of the problem to be tackled	*The more people are moving to cities, the more surface needs to be sealed and green areas are disappearing. In Austria 15 to 25 ha of usable ground gets sealed every day. However green areas are important for recreation, mood lifting and health. Green roofs are a possibility to regain green areas and offer a manifold of advantages. A cadastre of potential roofs was developed; it indicated that 20% of Vienna's roofs could become green roofs.*	
What were the primary & secondary targets when designing this application?	Primary target #1:	Buffering and attenuation of mass flows
	Primary target #2:	Regulation of hydrological cycle and water flow
	Secondary target #1:	Natural assimilation (purification) of effluents
	Secondary target #2:	Biodiversity and gene-pool conservation in riparian areas

	Remarks	*Moreover green roofs are able to buffer "electro smog" by 99.4%, a climate regulation for the underlying rooms is achieved, in combination with solar cells a power increase of 4% is achievable*	
Which specific types of pressures did you aim at mitigating?	Pressure #1:	WFD identified pressure	*Diffuse urban run-off*
	Pressure #2:	WFD identified pressure	*Diffuse atmospheric deposition*
	Pressure #3:	Floods Directive identified pressure	*Defense or infrastructural failure: here failure of the sewage water system*
	Pressure #4:	Select the relevant Directive	
	Remarks		
Which specific types of adverse impacts did you aim at mitigating?	Impact #1:	WFD indentified impact	*Chemical pollution*
	Impact #2:	WFD indentified impact	*Elevated temperature*
	Impact #3:	Floods Directive identified impact	*Human health*
	Impact #4:	Floods Directive identified impact	*Community*
	Remarks	*Third WFD impact: altered habitats* *Further FD impacts: property, infrastructure*	
Which EU requirements and EU Directives were aimed at being addressed?	Requirement #1:	WFD-mitigation of significant pressure	*Retention of runoff*
	Requirement #2:	WFD-achievement of good chemical status	*Adsorption of air pollutants, purification of rain water*
	Requirement #3:	Other EU-Directive requirements (Specify) Bird and Habitat directive	*Creating new habitats and connections of living space*
	Requirement #4:	Floods Directive-mitigating Flood Risk	*Less risk of failure of the sewage water system. Peak flows are retained 15 minutes.*
	Due to sealing 15 – 25 ha get lost as potential habitats every day in Austria. Green roofs therefore have the potential to serve as replacement habitats and support biodiversity in strongly urbanized areas. With reference to Swiss investigations those responsible for the Viennese project act on the assumption that the installation of green roofs provides habitats and food/nesting material for the following birds: Northern lapwing (peewit), Eurasian skylark, Little ringed plover, Crested lark (endangered), Black redstart, Common redstart, Sparrow and Tit. It is moreover possible to create an animal food chain. Green roofs incorporate a variety of plants that attract different kinds of insects. In combination with solar panels a variety of habitats with different light intensity is achievable.		
Which national and/or	Several Austrian requirements/ challenges are addressed.		

regional policy challenges and/or requirements aimed to be addressed?	1. National Water Act: Any intervention which might have a significant effect on water quality/ecology (hydropower, flood protection, water abstraction, waste water discharges, …) needs authorization 2. Negative ecological effects have to be minimized, ecological functioning has to be ensured 3. RIWA-T (technical guidelines for flood protection): One general principle is the preferential use of near-natural building methods that correspond to the latest development in technology. 4. Improvement of Vienna's living quality

III. Site characteristics

Dominant Land Use type(s)	Dominant land use	*111 continuous urban fabric*
	Secondary land use	*Type in the relevant Code Level3*
	Other important land use	*Type in the relevant Code Level3*
	After the transformation to a green roof, the area becomes sparsely vegetated (333, extensive green roof) or a garden with flowers, vegetables and sometimes even trees growing (intensive green roof)	
Climate zone *Select from the drop-down menu*	cool temperate dry	
Soil type	*Type in the relevant soil type (FAO class) from the list in Annex 3*	
Average Slope	gentle (2-5%)	
Mean Annual Rainfall	0 - 300 mm	
Mean Annual Runoff	0 - 150 mm	
Average Runoff coefficient (or % imperviousness on site)	Select the Average Runoff Coefficient value	Select the % imperviousness on site
	Remarks	
Characterization of water quality status (prior to the implementation of the NWRMs)	Normal flat roofs aren't able to retain pollutants such as Cu, Pb, Zn, Cd and N. Green roofs can retain 96-99% of Cu, Pb, Cd and N pollution. The amount of Zn in rain water is reduced by 16 %. Moreover plants are increasing air humidity by transpiration. Thus dust is easily adsorbed.	
Comment on any specific site characteristic that influences the effectiveness of the applied NWRM(s) in a positive or negative way	*Positive way: When a roof has a slope of less than 20% no special constructions are needed that prevent slipping. In this case one has the most creative freedom to design an intensive green roof. A good ratio between roof surface and rest of the house permits a transformation of the roof into a green area at low costs. For instance the costs to transform the roof of a multiple-family house are low, since the can be divided by many tenants. Skyscrapers only have small roofs-so the transforming costs are low as well. However due to the height of the building only extensive solutions are possible. Elevated costs have to be considered for single family houses.*	
	Negative way: Extensive green roofs are possible on every house. To create a real roof garden on existing houses, roof structures have to be re-considered and adapted, as roof gardens are much heavier than simpler green roofs. The thicker the soil layer and more complex the plant composition the more water can be retained.	

IV. Design & implementation parameters

Project scale	Large (e.g. watershed, city, entire water system)	*City of Vienna*	
Time frame	Date of installation/construction (MM.YYYY)	*2003 until now*	
	Expected average lifespan (life expectancy) of the application in years	*35 years, Then renovation of the roof is needed*	
Responsible authority and other stakeholders involved	*Name of responsible authority/ stakeholder*	*Role, responsibilities*	
	1. Wiener Umweltschutzabteilung (city's authority for environmental protection)	Initiation of the project, subsidies for house owners	
	2. die umweltberatung	Facility of Vienna's adult education center. Consulting office for a near-natural life style. Publicity and information material	
	3.Verband für Bauwerksbegrünung	Austrian section of the European Federation of Green Roof Associations Publicity, implementation of green roofs, certification system for green roofs, Creation of technical standards	
	4.		
	5.		
The application was initiated and financed by	Vienna's city government (Umweltschutzabteilung) However the house owners have to be reached. They take the decision and take over the majority of the costs		
What were specific principles that were followed in the design of this application?	*Extensive green roofs: soil layer of 2-10 cm thickness, layer for protection, drainage and filtration, layer for separation from the roof* *Intensive green roofs: soil layer of 20 - >50cm thickness, layer for filtration, layer for water retention and drainage, protection layer, layer for separation from the roof*		
Area (ha)	Number of hectares treated by the NWRM(s).	*1.6*	
	Text to specify	*Recording to the city government 20% of the roofs shall be transformed to green ones.*	
Design capacity	The water retention capacity of a green roof depends on several factors such as: intensity of a precipitation event, annual precipitation, and amount of precipitation events. Moreover the individual design of the roof (plant composition, soil type and thickness of soil layer) determines the water retention capacity.		
Reference to existing engineering standards, guidelines and manuals that have been used		*Reference*	*URL*
	1.	ORN 121131 No open source, document has to be ordered (218€)	http://www.bdb.at/Service/NormenDetail?id=317491
	2.		

during the design phase	3.		
	4.		
	5.		
Main factors and/or constraints that influenced the selection and design of the NWRM(s) in this application?	The lack of useable land in big cities such as Vienna and the ongoing sealing force responsible authorities and citizens to think in a third dimension. Green recreational areas are created now on roofs. Due to sealing the amount of rainwater increases. It has to be treated in sewage water plants and pipe systems have to be adapted. During storm-floods critical amounts of waters can be reached. By taking up 50% of rain water and retaining peak flows for a certain time green roofs contribute to reduce flooding risk and ensure the purification standards in sewage water treatment plants		

V. Biophysical impacts

Impact category	**Impact description** (Text, approx. 200 words)	**Impact quantification** (specifying units)	
Runoff attenuation Peak flow rate reduction Impact on groundwater Water quality improvements Reducing flood risks Creation of new habitats	The runoff attenuation depends on local precipitation characteristics and the individual design of the roof but can reach up to 90% for intensive roofs. The peak flow is retained 15 Minutes which means a relief for the sewage water system. Since the runoff of green roofs is filtered, the water can be used for groundwater recharge or as tap water in the household. Moreover electro smog is filtered by 99.4 %. Normal roofs filter 50% of the high frequent waves. The microclimate improves. That means: the increased evapotranspiration leads to an ambient temperature. The underlying rooms profit from this "natural air condition". This balancing effect increases also the lifespan of a roof. Usually a roof needs to be renovated every 20 years. A green roof reaches the age of 35. During summer the cooling effect of green roofs increases the power of photovoltaic modules by 4%. A combination of green roofs and solar power should be considered. The photosynthesis done by vegetation is moreover a sink for CO².	Parameter value; units *Up to 60% runoff attenuation (extensive) 90% (intensive)*	99 % less Cu, Cd, Pb and N in rainwater passed by green roofs 16% less Zn in rainwater. 49% less electro smog
Runoff attenuation / control			
Peak flow rate reduction			
Impact on groundwater			

Impact on soil moisture and soil storage capacity	
Restoring hydraulic connection	
Water quality Improvements	
WFD Ecological Status and objectives	
Reducing flood risks (Floods Directive)	
Mitigation of other biophysical impacts in relation to other EU Directives (e.g. Habitats, UWWT, etc.)	
Soil Quality Improvements	
Other	

VI. Socio-Economic Information

What are the benefits and co-benefits of NWRMs in this application?	Air condition for underlying rooms Longer lifespan of the roof due to balancing environmental impacts (heat, cold, UV rays…) CO^2 storage, purification of water, mitigation of runoff and peak flows, creation of recreational areas for humans, creation of habitats for birds and insects, connection of different populations, decrease of electro smog		
Financial costs	***Total:***	*0,5 €/m²*	*Extensive green roof with a slope <10° on a multi-family house with 7 floors*
	Capital:	*0,31 €/m²*	*Implementation of the green roof, without potential adaptation of the roof structure*
	Land acquisition and value:	*0 €*	
	Operational:	*0 €*	
	Maintenance:	*0,19 €/m²*	*Inspection twice a year, removal of growing trees, cutting grass*
	Other:	*0 €*	
Were financial compensations required? What amount?	*Was financial compensation required: Yes* *Support is given by the city's authority*		
	Total amount of money paid (in €): depends on the individual roof 8-25 €/m² and up to 2200€		
	Compensation schema: The house owner installs the green roof and sends bills to the authority. The work has to be done after ÖNORM 1131. The project mustn't supported by other official funds.		

	Comments / Remarks:
Economic costs	*Actual income loss: none* *The contrary is the case: energy savings and less cost for roof renovation*
	Additional costs: for the example: 0,2 €/m²
	Other opportunity costs:
	Comments / Remarks: The most economically effective are (intensive) green roofs on multifamily houses. The additional costs of extensive green roofs are quickly compensated by energy savings and the other benefits
Which link can be made to the ecosystem services approach?	Water provision: filtered water from green roofs can be used for groundwater recharge Flood security and protection: peak flows from heavy precipitation are mitigated, rain water retained Biomass production: growing plants store CO^2 by photosynthesis Amenities: recreational space (only on intensive green roofs), habitat for insects, birds Air quality benefits: green roofs are filtering air pollutants Local climate regulation: green roofs are improving the microclimate

VII. Monitoring & maintenance requirements

Monitoring requirements	Is not required
Maintenance requirements	Extensive green roofs: inspection twice a year, removal of tree seeds and shooting trees
What are the administrative costs?	For a seven floor multifamily house: 0,19€/m² For a two floor one family house: 0,91 €/m² For a skyscraper (24 floors): 0,07 €/m²

VIII. Performance metrics and assessment criteria

Which assessment methods and practices are used for assessing the biophysical impacts?	
Which methods are used to assess costs, benefits and cost-effectiveness of measures?	First of all only the installation of an extensive roof is seen. Adaptation of statics and the planning of intensive green roofs depend on the individual project and can't be generalized. Moreover the costs are broken down to the gross-floor-surface (sum of the surfaces of the single floors). The actual prices were gained by asking architects and firms specialized to green roofs.
How cost-effective are NWRM's compared to "traditional / structural" measures?	During the first 10 years house owners with green roofs have to face additional costs compared to traditional flat roofs. Energy savings and the longer lifespan of a green roof compensate the additional costs
How do (if applicable) specific basin characteristics influence the effectiveness of measures?	Not applicable
What is the standard time delay for measuring	Months: retention of water, purification Years: cost effectiveness

the effects of the measures?	

IX. Main risks, implications, enabling factors and preconditions

What were the main implementation barriers?	Publicity: Citizens lack sufficient knowledge about the many advantages given by green roofs. They only associate a garden on the top of a house with it Architects/planners: Green roofs bear the risk of not being leak proof. Architects are liable for their green roof projects for 30 years. Due to this risk many avoid including green roofs in their plans.
What were the main enabling and success factors?	The manifold advantages of green roofs The support by the city of Vienna
Financing	Private fortune of the house owners, financial support of the city's government
Flexibility & Adaptability	Depending on the slope (extensive) green roofs can be installed on every house. Local soil material is chosen and local plants are chosen as vegetation.
Transferability	Slope <45°

X. Lessons learned

Key lessons	Green roofs provide many advantages that have to be communicated more intensively to the public. They cause only little additional costs (extensive) compared to a traditional flat roof. These costs are often compensated by the longer lifespan of the roof and energy savings

XI. References

Source Type *Select from the drop-down menu*	*Project Report*		
Source Author(s) *Provide the Name of the author(s)*	Pendl, Manfred; Hüfing, Gerda; Muerth, Petra; Tributsch, Ingrid; Jäger-Katzmann, Sophie		
Source Title *Provide the Tile of the reference*	Logisch gedacht ist ökologisch bedacht Ein Leitfaden für die Dachbegrünung		
Year of publication *Provide the year in the format (YYYY)*	2009		
Editor/Publisher *e.g. Journal/Volume/Issue*	Die Umweltberatung Wien		
Source Weblink *Direct weblink(s) of the reference*	http://images.umweltberatung.at/htm/leitfaden_dachbegruenung.pdf		
Key People *List names, affiliation and contact details of key people who have communicated*		*Name / affiliation*	*Contact details*
	1.	*Pendl, Manfred*	*service@umweltberatung.at*

important information presented in this factsheet			

Source Type *Select from the drop-down menu*	Scientific Article		
Source Author(s) *Provide the Name of the author(s)*	*Erlach, Norbert*		
Source Title *Provide the Tile of the reference*	Dachgrün (study for the environmental authority of Vienna)		
Year of publication *Provide the year in the format (YYYY)*	2012		
Editor/Publisher *e.g. Journal/Volume/Issue*	Architecture office Erlach		
Source Weblink *Direct weblink(s) of the reference*	https://www.wien.gv.at/umweltschutz/pool/pdf/dachgruen.pdf		
Key People *List names, affiliation and contact details of key people who have communicated important information presented in this factsheet*		*Name / affiliation*	*Contact details*
	1.	*Erlach, Norbert*	*architect@erlach.at*

XII. Photos Gallery

Figure 1: Extensive green roof with pond, source (© OPTIGRÜN)