Design Project - SIE 2015

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

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Objectives

The **challenge** is to have a good overview of material fluxes and to raise some important problematics and issues to consider, **designing** waste and water networks from the ground up. Moreover having the **global picture** in mind, focus is given to propose an innovative and **efficient** wastewater treatment adapted to the **vision** of Hill City.

Hill City

A new vision of the city emphasizing on **ecology**…

…**Efficient**

….Working and living under the same roof

Healthy and Sustainable…

…Improved connection to **nature**

Maximizing **recovery...**

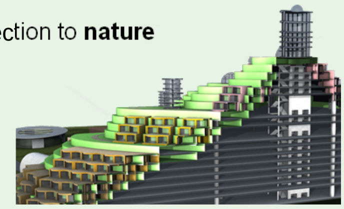
… A very **flexible** city.

Hill City saves about a third **land space**….

Low pollution…

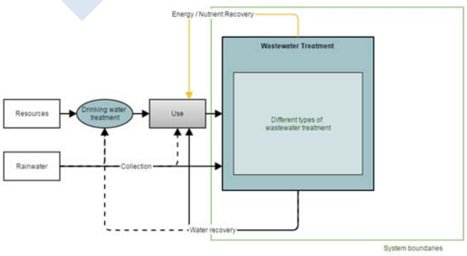
…minimum traveling times

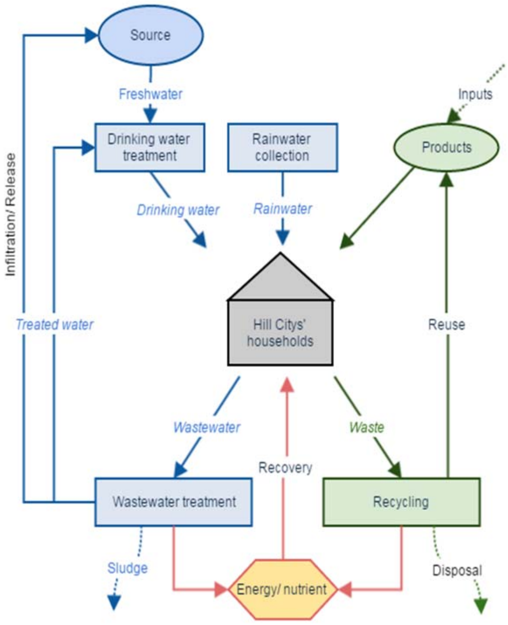
…**Great life** quality, enhancing the sense of **community.**



Water Network

Architectural specificities have to be taken into account for the design and the optimization of the water network. We emphasize on **Wastewater Treatment** since this topic opens a large range of possibilities and improvements for energy and nutrients recovery. An ideal network tends towards a **closed-loop** system.





Waste management

Potential for recovery from urban waste

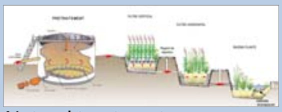
Size of Hill City [inhabitants]	Energy recovery from incineration	Valorisation of compost	Energy potential (in form of heating) from biogas produced	
Quantity per capita	*Domestic waste: 347 kg*	*Organic waste: 222 kg*	*Organic waste: 222 kg*	
Rate of recovery	1400 kWh/ t	*60% composted sold 0,3CHF/ L*	*Conventional Methanisation* (125 m^3/t)	*Hydrothermal Methanisation* (147m^3/t)
5000	2 429 GWh	333 kCHF	1028 GWh	1209 GWh
10 000	4 858 GWh	666 kCHF	2056 GWh	2418 GWh
20 000	9 716 GWh	1332 kCHF	4113 GWh	4836 GWh
30 000	14 574 GWh	1998 kCHF	6169 GWh	7255 GWh
50 000	24 290 GWh	3330 kCHF	10 281 GWh	12 090 GWh

Pneumatic waste collection system

Aspiration in tubes under vacuum avoiding disturbances of dump trucks

Wastewater Treatments

Filtering Gardens®

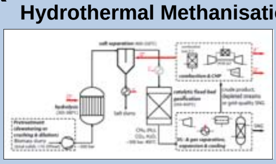


☺ Beautiful city parks
☺ Promotes biodiversity
☺ Easy maintenance
☹ Long treatment time
☹ Need a lot of space

Natural treatment by phytoremediation (based on the action of plants)

OR

Hydrothermal Methanisation



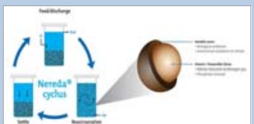
☺ Biogas production
☺ High nutrients recovery
☺ Small land use
☹ Still at pilot scale

- Needs a concentrated influent: 10-20% TSS

Chemical removal of pollutants in hypercritical conditions

OR

Nereda®

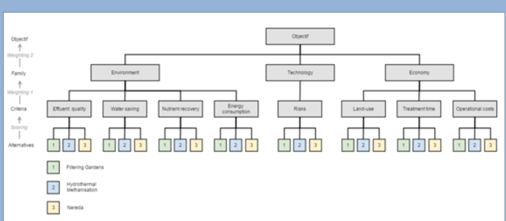


☺ Small land use
☺ Little energy requirements
☺ Operational experience

- Sequencing Batch Reactor

Aerobic granular biomass treatment based on microbiological metabolisation

Multi-Criteria Analysis



Method of the multi-criteria analysis comparing the wastewater treatments

Comparison

Scoring

Good →

Extremely	Very strongly	Strongly	Moderately	Equally	Moderately	Strongly	Very strongly	Extremely
-9	-7	-5	-2	0	2	5	7	9

Family	Criteria	Filtering Gardens®	Hydrothermal Methanisation	Nereda®
Environment	Effluent quality	-2	2	0
	Water savings	0	5	0
	Nutrient recovery	2	9	0
	Net Energy consumption	7	9	5
Technology	Risk	-5	-9	-2
Economy	Land-use	-9	7	5
	Treatment time	-9	5	2
	Costs	7	-2	2

Evaluation matrix
(Colours show robustness of scores)

Results

Relative weight of families	Total scores		
Scenario	Filtering Gardens®	Hydrothermal Methanisation	Nereda®
Emphasizing on environmental aspects	0.25	**1.3375**	0.9
Emphasizing on technological aspects	-1.575	-2.6	**0.025**
Emphasizing oneconomical aspects	0.025	-0.1375	**1.175**

Weighted Scores depending on priorities

Outcomes

From an environmental perspective, **Hydrothermal Methanisation** is best,

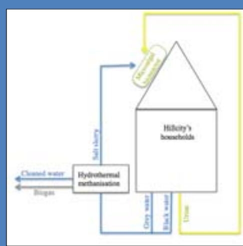
Emphasizing technological and costs aspects, **Nereda®** is best,

From the stakeholder priorities, the most adapted wastewater treatment for Hill City is **Hydrothermal Methanisation** as it allows the best energy and nutrient recovery rate.

Our Suggestion

Potential for nutrients recovery from urine is enormous. The system can be improved by separating fluxes from the source. Microalgae growth offers many opportunities.

Urine would be diverted and used as fed for migroalgae. Black water and grey water are treated by Hydrothermal Methanisation.



Optimized network with valorisation of all fluxes

Outputs are valuable microalgae, cleaned water and biogas.

Key takeaways

- Material fluxes network design is of primary importance,
- As many fluxes interact **Global vision** is essential,
- **Closed loop** is key for sustainability,
- The dimension of the **risk** should always be kept in mind during the choices and the design of the material fluxes. Compromises always have to be made between the most efficient technologies that are yet, still a pilot scale, and the more safe ones that do not promise such results.