OPTIMIZE FLOWS AND SOLUTIONS IN A VERTICAL CITY

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ABSTRACT

This research paper demonstrates the optimization of the flows in a mixed-used, vertical building, including water, heat and bio-waste flows. The research bases on the context of Amstel III, which was a business land, and a lively city district with accessible public facilities and beautiful public space is expected in 2027. An integrated energy calculation and system are introduced in this paper to increase energy performance, and the calculations could act as a guideline for the other vertical projects.

Keywords: *Amstel III, Energy neural, Mixed used, Flows, System*

I. INTRODUCTION

1.1. Vertical City (100-step-building) and the Amstel III

Thanks to the internet and express business, nowadays more and more people can limit their daily steps within several hundred. If checking the ranks in pedometer APPs like Google Fit or Runkeeper (in China, it is WeChat), there is always a group of people sinking at the bottom EVERY DAY while 12,000 steps are daily life for some others.

Consumer pattern has changed because of the rise of E-commerce (*Fig.1*). Big shopping malls have been dead, while some of them had to transform into other functions. Big volumes were broken down and the time of driving for groceries passed. “Click and delivery” gives homebodies the opportunities to stay at home forever *(Fig.2,3)*.

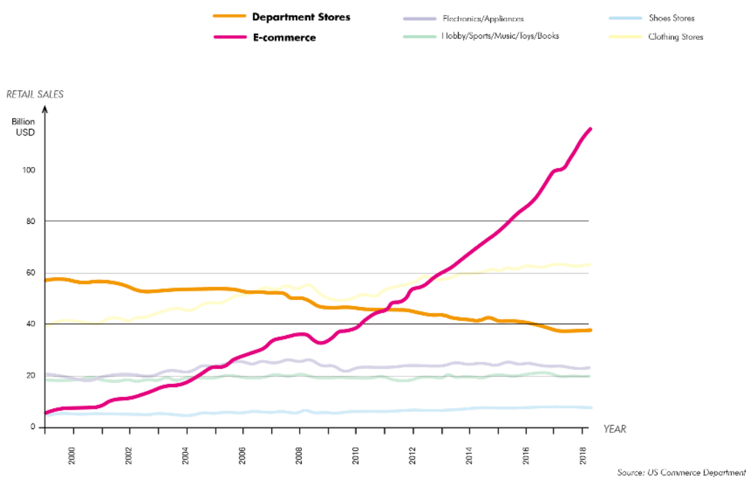

Figure. 1 Retail sales (US Commerce Department)

It is sarcastic when society encourages people to walk in nature while more and more young people are running away from social activities and parties. But the creative industries offer such possibilities. Architecture, fashion, games, media, etc., these sectors are shouting loud for young also for the future: Finally, they will rule the world. Among these, freelancers are a big part of the employees, which means, two-thirds of over 170,000[1]. These artists and designers need something

[1] Ministerie van Buitenlandse Zaken, ‘Dutch Creative Industries Infographic - Publication -

productive, not aggressive, and without social pressure. Thus, here comes the project of 100-Step-City, a vertical self-sufficient complex construction.

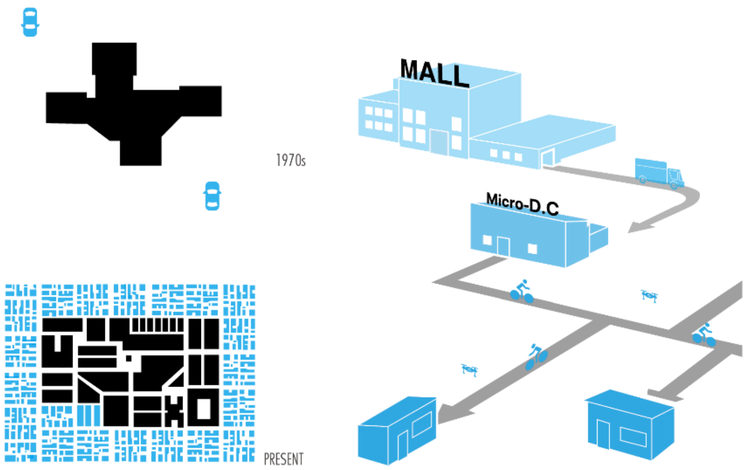

Figure. 2 Consumption patterns

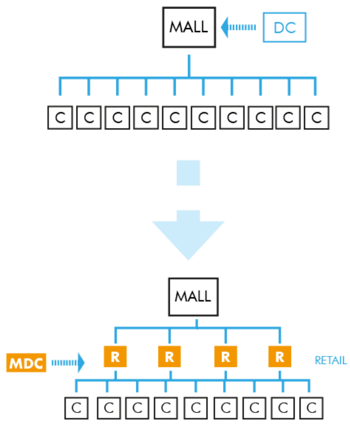

Figure. 3 Retail and Logistic Chain

Amstel III in Amsterdam, the most important creative hub in the Netherlands, is a perfect test field. When talking about the old trees, the dog-run-area, the monuments, the market -- nothing happens on this land. Most of the constructions here are companies and offices, built during the 1970s and 1980s and the only “funny” stuff is IKEA.

But it can still breath because of the business distinct on the north side, and the Arena Station may be changed into a hyperloop station, even the hyperloop itself is an experimental “train”. No infrastructure, no greens, no human being, but (really) has a good potential for solar and wind energy: Yes, it is ready to be added some elements and to be youthful.

Responding to the issue, a new-built project will be introduced to Hullenbergweg 1-3, with an integrated energy system. The research focuses on the energy calculations and the flows of the bio-gas, the thermal exchange, and the CO_2 circulation, and these will impact on the final design and architectural appearance.

1.2. Methodology

The guidebook by Gemeente Amsterdam, *Roadmap Circular Land Tendering: An introduction to circular building projects,*[2] illustrates four principles of circular building: *Reduce, Supply,*

Netherlandsandyou.Nl’, publicatie, 5 August 2018, https://www.netherlandsandyou.nl/documents/publications/2018/08/05/dutch-creative-industries-infographic.

[2] Amsterdam, ‘Roadmap circular land tendering’, webpagina, Amsterdam.nl, 13, accessed 18 December 2019, https://www.amsterdam.nl/wonen-leefomgeving/duurzaam-amsterdam/publicaties/roadmap-circular/.

Synergize, Manage, and a decision tree is also provided. If corresponding the Amstel III to the decision tree, the major research efforts which should be devoted to, are the energy reused and ecosystems (*Appendix 1*).

To further explore these issues, a calculation and study on the current energy consumption and flows are made in the first step. Based on the present energy performance, three systems are introduced, while each of them has the corresponding calculation of the re-used and recycled energy, and the case study. Among them, the Biogas Boat (for the bio-gas system) is in Amsterdam and the articles and literature of thermal systems are from German. The CO_2 refrigerator system is from a Canadian Company, but since the system is based in the indoor climate, the differences between the outdoor climate condition in the Netherland and Canada could be acceptable.

After the improved systems for organic waste, thermal system and cooling system, a new calculation and system designing are done, coming up with an energy mapping for the new situation showing all the figures in the construction systems, which, may save the grid electricity up to 46%. After that, the footprint of each program can be settled.

II. Current Energy Consumption Calculations and Flows

To clarify the situation and to establish a standard flow for further research, the current energy consumption needs to be calculated and to present the degree of reusability clearly, the conclusion is shown by the energy consumption(kWh) per square meter.

The initial data is a set of total energy consumption excel tables *(Appendix 2)* sourced from the official website of EIA, well-categorized by principal building activities, energy sources, regions, and the total floorspaces. Considering the character of the 100-step-city, several programs are selected: training court & fitness suite, reception & common area, changing room, lounge & bar, retail, housing, office, kitchen & food service, and the end uses below: space heating, lighting, domestic hot water, equipment (cooking for foodservice and kitchen), cooling and ventilation.

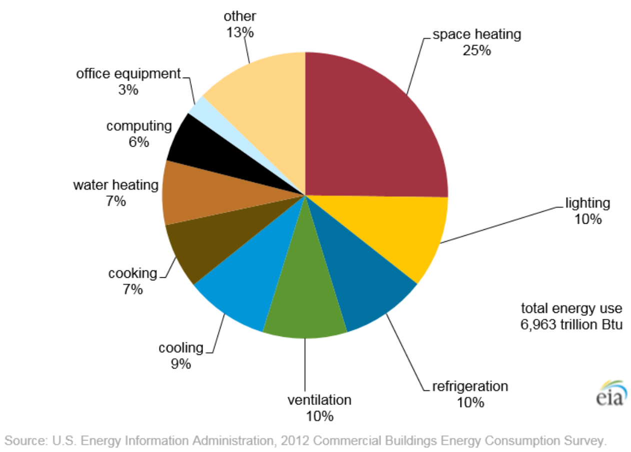

Figure. 4 Office Energy Consumption Proportion

To confirm the figures for the end-use, there are two main sources. The chart for the proportion of the office energy consumption is well-done by EIA[3] *(Fig.4)*, and for the rest programs, the figures can be calculated from the report: *Energy Consumption Survey* from EIA[4] *(Appendix 2)*.

Here are several interesting sectors as in the conclusion (*Fig.5*): heating is the most end-use in most of the programs; the cooling sector is incredibly high when touching the refrigerator, especially for food (both foodservice and retailing); the cooling system takes a lot because of the poor ventilation situation.

Figure. 5 Current Energy Consumption (per M^2)

Based on the calculation, the current flow is as shown below (*Fig.6*). The diagram categories the wastes into three sectors, greywater, heat, and organic waste and sum up the income energy source (gas, electricity, oil) as electricity.

Some data shortcomings must be addressed. First, since the footprint of the program (the 100-step-city) should be given after the final improved calculations, the energy mapping only shows the property of each square meter instead of the precise numbers of the whole system. Second, all the figures are from 2013 and though there is no huge energy crisis to change the total energy

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[3] 'Energy Information Administration (EIA)- Commercial Buildings Energy Consumption Survey (CBECS)', accessed 18 December 2019, https://www.eia.gov/consumption/commercial/.

[4] 'Consumption & Efficiency - U.S. Energy Information Administration (EIA)', accessed 2 January 2020, https://www.eia.gov/consumption/index.php.

strategy, there may still be some progress. Also, the heating and cooling(office) numbers may vary from different insulation materials and areas, and here we take the average. In further calculations, since the heat loss from the equipment and lighting are hard to collect, storage and reuse, limited attention would be paid to.

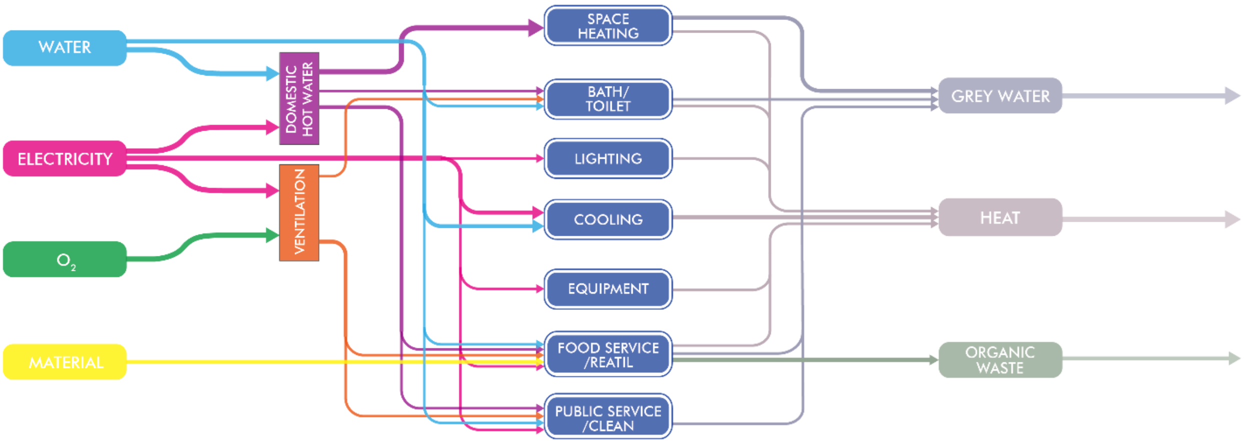

Figure. 6 Current Energy Flow

III. UPDATED FLOWS IN THE MIXED BUILDING

3.1. Bio-gas: A System for Organic Waste

About one-third of all the world 's food is wasted and makes up 20 percent of all landfill waste[5], while all these could contribute to global warming with the methane gas-producing, which, could be fuel and energy source. To recycle food waste, the anaerobic digestion process is needed.

After the organic waste, such as food, agricultural waste, biosolids, and organic wastewater, collected and pre-processed (chopped and mixed), all these products are put together in a container, named as "anaerobic digester". With the help of oxygen, microorganisms, and water, the waste is transformed into biogas, and after the purified, the gas will be the electricity and thermal energy, also fuel for pipelines and vehicles. During the fermenting process (*Fig.7*), byproduct can be acquired, and among which, the solid products could be used as animal bedding and compost, while the liquid products fertilize the farm.

During this process, two kinds of installations are needed (*Fig. 8,9*), containers and tanks for dissolved, ferment, purified process and pipes for transportation, of course. A case study of Café de Ceuvel[6] could be found in *Appendix 3*.

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[5] 'Food Waste Recycling & Disposal | Rubicon's Solutions for Food Waste', *Rubicon Global: Waste, Recycling, and Smart City Technology Company* (blog), 20 May 2016, https://www.rubiconglobal.com/food-service/.

[6] 'De Biogasboot', De Biogasboot, accessed 28 December 2019, http://www.biogasboot.nl.

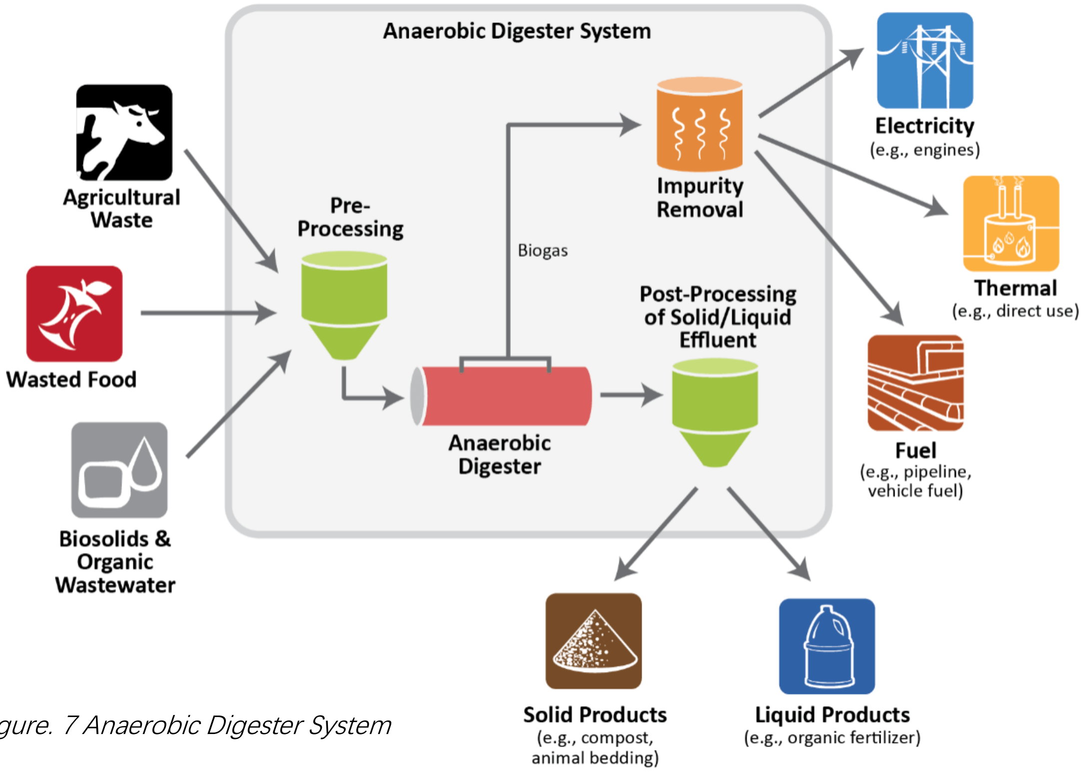

Figure. 7 Anaerobic Digester System

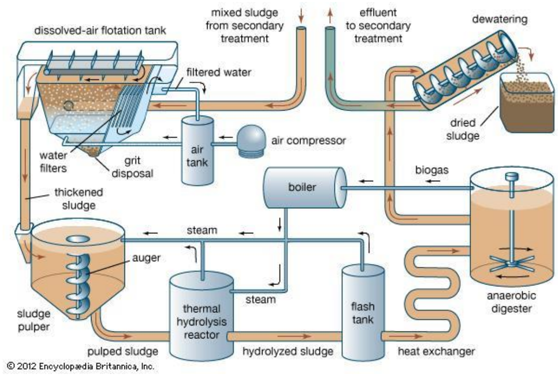

Figure. 8 Anaerobic Digester System Installation

Figure. 9 Bio-gas installations Photo

Here are some figures for the bio-gas system:

There are *160* NM^3 biogas and *370* kg compost coming from per 1000 kg of organic waste, which means *1125*kwh energy and *370*kg solid production.

The food waste from a small and medium restaurant is 20kg/day and 41kg/day, so based on the figures above, there will be 22.5 kWh/day and 46.125 kWh/day energy recycled. Considering the IKEA is right beside the project plot and they always claim themselves sustainable and climate positive, the IKEA restaurant will be paid attention to in this project, where the food waste is

89.19kg/day[7]. Besides, the residual organic waste is 41kg/year[8] in the Netherlands (well-performed!), counted in the housing program.

Figure 10 shows the original organic flow and an optimization, introducing a new program: urban farm, as a consumption for the byproducts in the bio-gas system and a food source.

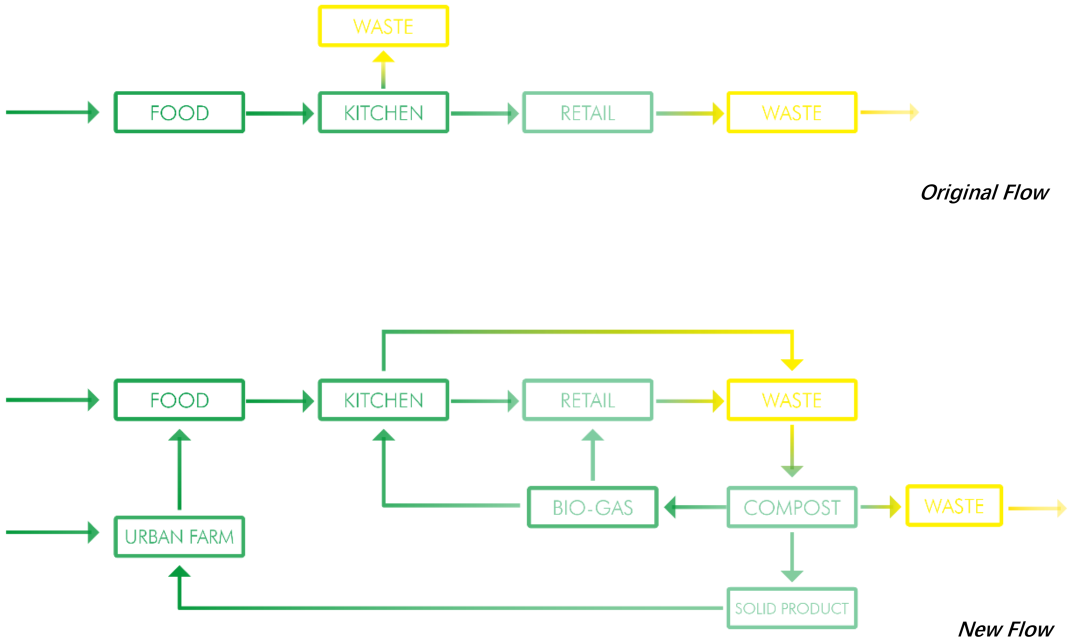

Figure. 10 Organic Flow (Current and New)

3.2. Thermal System

The enormous heat demand will be lower if the energy exchange among different contexts and services can be more efficient since most of the consumption is one-off and the energy flow is single-pass (*Fig.11*).

Three re-use systems are introduced for the thermal energy benefit.

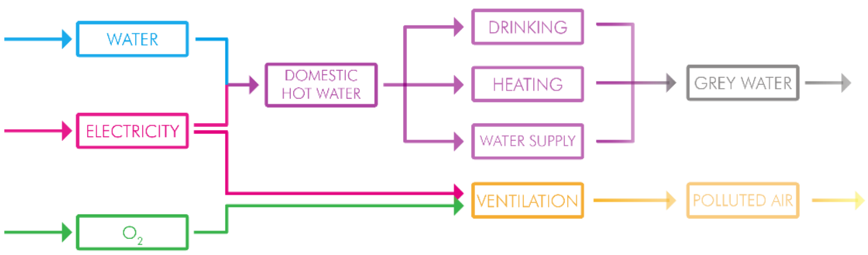

Figure. 11 Original Thermal Flow

[7] Posted on November 2 and 2017- Hospitality/Foodservice, 'IKEA Food: "Food Is Precious" Food Waste Initiative', Food Loss and Waste Protocol, accessed 28 December 2019, https://flwprotocol.org/case-studies/ikea-food-food-precious-food-waste-initiative/.

[8] Do you have a question? Ask our expert: ir AJMTimmermans Contact form, 'Dutch Agenda against Food Waste Aims to Cut Food Waste by Half', WUR, 21 March 2018, https://www.wur.nl/en/newsarticle/Dutch-agenda-against-food-waste-aims-to-cut-food-waste-by-half.htm.

3.2.1 Seasonal thermal storage with solar heating

Seasonal thermal storage with solar heating system can be understood as the combination of solar panels and the normal seasonal heat storage. The solar panels have contributed to the environment a lot, reducing CO_2 emissions and global warming while over 50% of the energy consumption of housing is used for heating and domestic hot water preparation. Hence the great potential is offered.

In this system, the heat gained from solar panels (collectors) and transported to the central solar heating plant, which may supply more than 100 flats by the heating net if needed. The collectors installed on the roof and façade is also possible, with the seasonal thermal energy stores underground (*Fig.12*) and a backup boiler of gas or electricity could be added. For the thermal storage installation, four types can be selected depending on the geological and hydrogeological situation. With the combination, the seasonal mismatch between high solar irradiance in summer and high heat demand in winter is balanced by seasonal heat storage, and the solar energy efficiency is designed up to approximately 50%, which, in practical, maybe lower. There are the reasons: the return temperature may be higher than design (40ºC), causing more heat loss; the thermal energy store installation may not be fully thermally insulated; the heat demand of the housings is higher than expected, etc..[9]

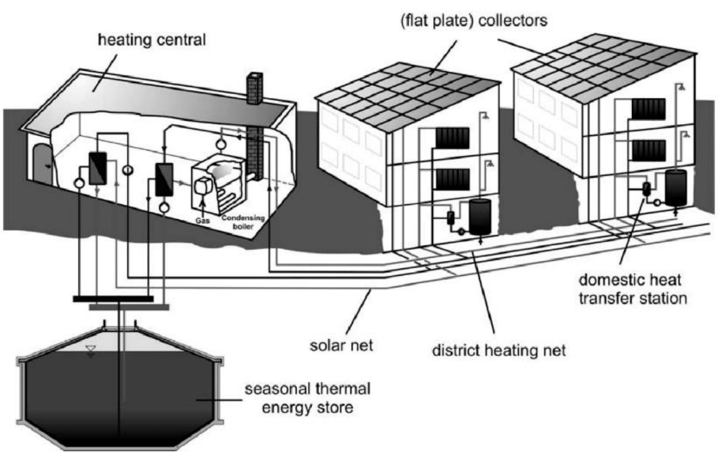

Figure. 12 Typical Central solar heating plant with seasonal heat storage

3.2.2 Drain-water heat recovery

The drain-water hear recovery system saves energy via the heat exchange, storage, and pre-heat between the hot grey water and new water supply.

The drain-water hear recovery technology is merely based on a small unit with storage capacity for use on the drain system, including bath, shower, dishwasher, sinks, and laundry instead of a huge project like the seasonal thermal storage, and without the storage capacity, the energy flow could only be recycled simultaneously while using hot water.

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[9] D. Bauer et al., 'German Central Solar Heating Plants with Seasonal Heat Storage', *Solar Energy*, International Conference CISBAT 2007, 84, no. 4 (1 April 2010): 612–23, https://doi.org/10.1016/j.solener.2009.05.013.

The polluted hot water will preheat the incoming cold-water flows, through a wrapped copper spiral tube (*Fig.13*) for non-storage systems, or a reservoir with a coil at the top. The polluted water provided the necessary heat, and lower the settled water heating temperature in the normal domestic hot water system without destroying the experience in winter. For a temporary system, 1.1kwh/shower in winter (0.4kwh/shower in summer, 10minutes, 5L/min flow) could be saved and the storage system performs better.

The price for the installation is also friendly, with a one-time installation fee ranging from $300-$500, and annual maintenance cost about 60-70$, which could be higher at the present (via the feedbacks at the housing decoration BBSs).

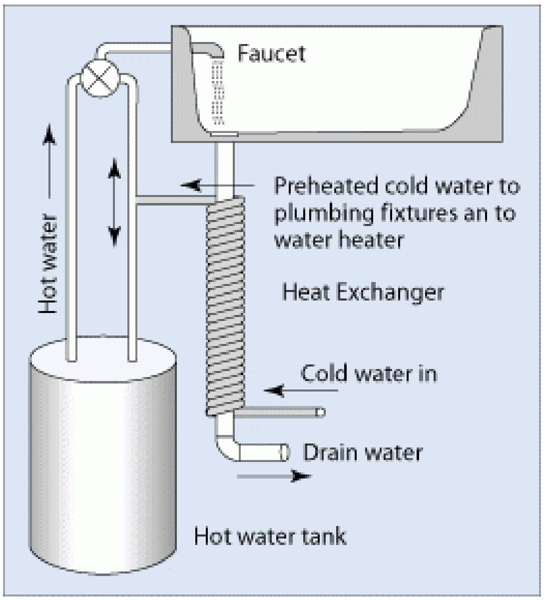

Figure. 13 Typical Unit for Drain-water Heat Recovery

3.2.3 MVHR (Mechanical Ventilation with Heat Recovery)

In the office, retail and food service (including selling and kitchen), the cooling/ventilation/and heating consumes a lot. The MVHR is a solution, which provides filtered fresh air while recovering the heat from waste air. It extracts the polluted air from different programs (kitchen, office, bathroom, etc...) to a central heat exchanger (*Fig.14*), and after filtered and heat recovered, the newly-fresh hot air will be supplied to a new room. If in the summer, it works the same way to keep the cooler air than outside within the room (*Fig.15*).

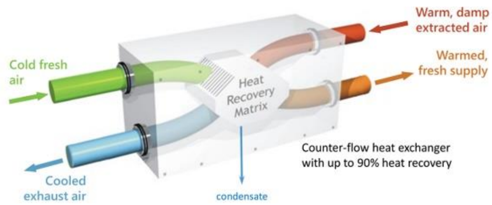

Figure. 14 A Central Heat Exchanger

But there is a rule that the air permeability of the thermal envelope is at or below 3 air changes per hour when tested at 50 Pascal (equivalent approximately to 3 m3/m2.h @ 50 Pa for average

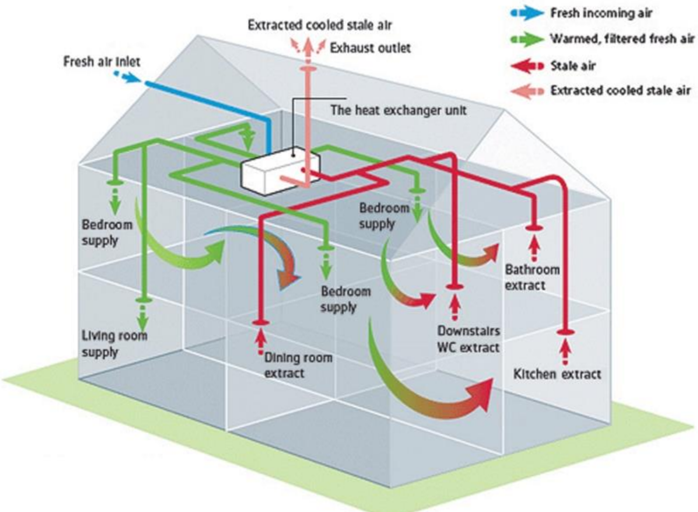

Figure. 15 MVHR system

dwellings)[10], or else alternative strategies to ventilation could be more appropriate, though MVHR can be installed in any building. So for the enclosed environment like an office, cooling room for retail, or an enclosed atrium, MVHR performs better, and get a 38%-saved-energy on both original heating (room cooling) and ventilation end-use.

For the thermal systems, the optimized flow shows in *Figure 16*, mainly closing the loop of domestic hot water and ventilation.

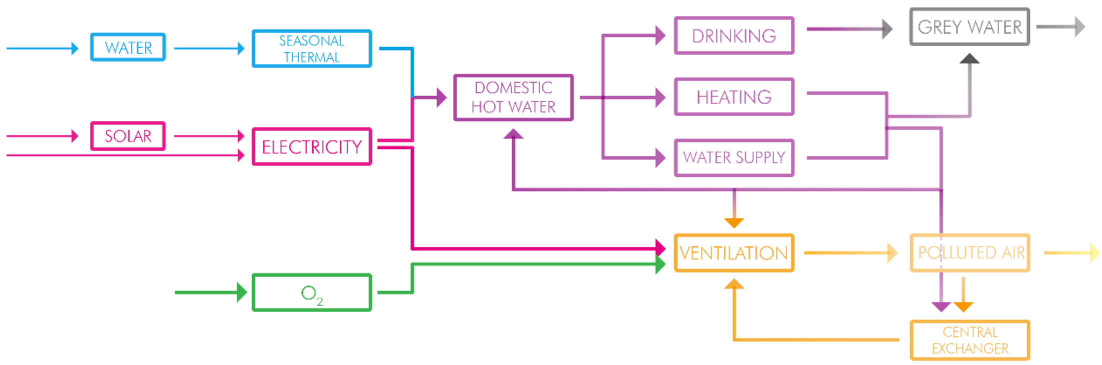

Figure. 16 New Thermal Flow Mapping

3.3. Cooling and CO_2 Refrigerant

The retailers, also the wholesalers always have a big bill for the refrigerators, both the installations and the maintenances, as well as super high energy consumption and the enormous greenhouse gas. For both environmental and energy consumption, the CO_2 refrigerant could be an option (*Fig.17)*.

CO_2 is addressed to be a *Natural Refrigerant* because it can be easily gotten from the natural environment and a lot of industrial processes, and CO_2 can help the vegetables and fruits keep fresh because of the inhibition of respiration. A great challenge is that CO_2 needs a higher operating pressure, but luckily, the operation even above the pressure is currently practiced in the trans-critical system[11].

High heat transfer in evaporators and condensers allows lower temperature differences between the refrigerant and the air (the main waste heat coming from), therefore improving efficiency or therefore using smaller evaporators and condensers to save area. Also, high discharge temperatures due to the high index of compression provide good potential for heat reclaim.

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[10] 'What Is MVHR Heat Recovery Ventilation? - Information Hub', *Green Building Store* (blog), accessed 29 December 2019, https://www.greenbuildingstore.co.uk/information-hub/heat-recovery-ventilation-mvhr/.
[11] 'Commercial-Co2-Refrigeration-Systems-En-ca-3592874.Pdf', accessed 30 December 2019, https://climate.emerson.com/documents/commercial-co%E2%82%82-refrigeration-systems-en-ca-3592874.pdf.

The CO_2 refrigerators could save 22% energy consumption on its own, and the high temperature, high-pressure gas with super waste heat, the pre-heat water system and the MVHR system could be combined and gain higher energy efficiency.

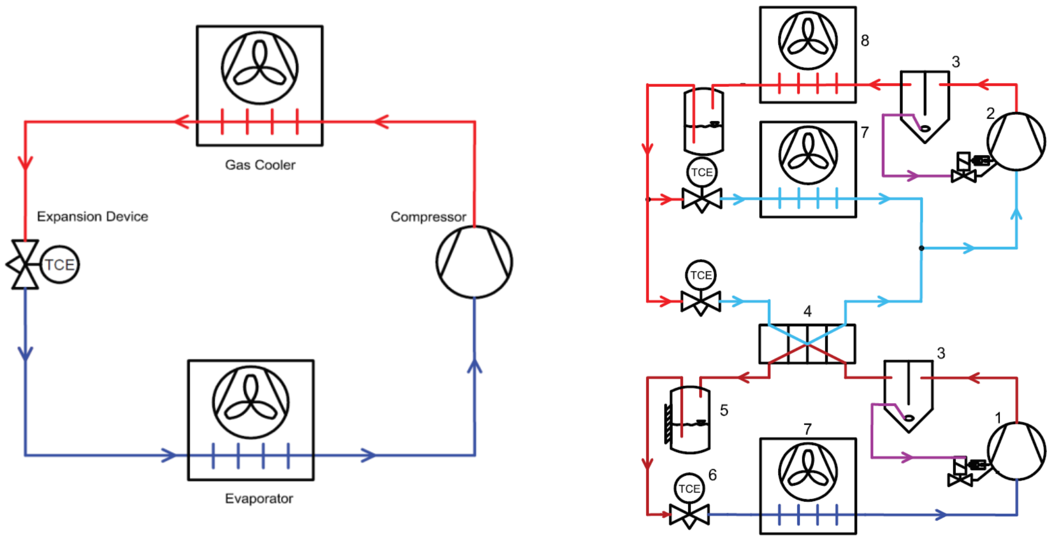


Figure. 17 Typical Compression Refrigeration System (Left)/Retail Cascading CO_2 System (Right)

3.4. Energy Exchange

Figure 18 shows the new energy exchange logic after the improved-system research. The position of each dot presents the different functions' abilities of consumption and re-production, and the arrows give the hints of where the "wasted energy" should go to. The end uses with high productivity performance will be the welcomed programs in the new vertical city project.

Note: the diagram shows only the property of the end uses instead of the precise numbers of energy flow.

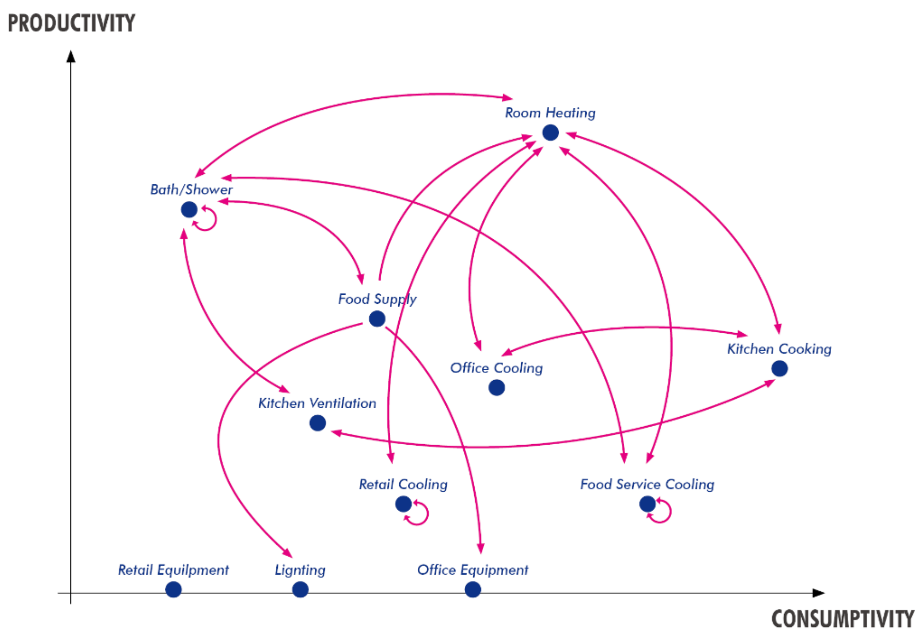


Figure. 18 Energy Exchange Summary

3.5. Programs Footprint Calculation

After the data collection and calculations above, considering the property of the 100-step-city, programs could be settled. To make the most use of energy (recycle), the areas of each function are modified based on the original design specification. The new-calculation based on a 4000 m^2 unit, which is basically 4-floor-unit with 1000 m^2 footprint, is done (*Fig.19*), and the number 4000 is more than flexible, which means what matters in the final footprint is the proportion of each function, instead of the exact area.

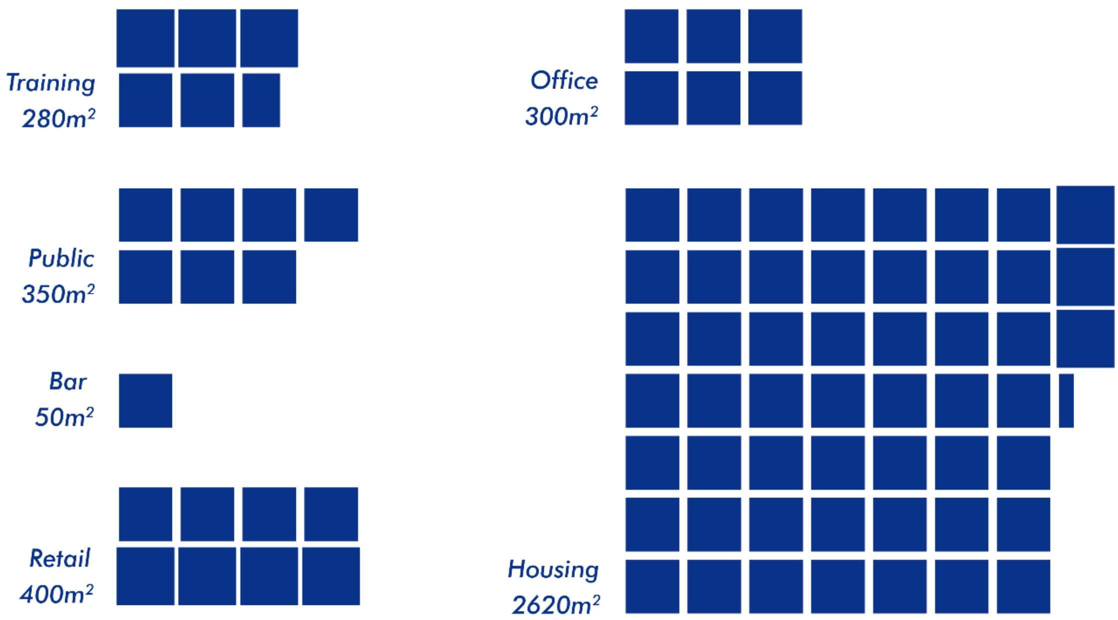


Figure. 19 Programs and Footprints

IV. CONCLUSION

To conclude the research, a new, fully energy mapping is made to show both the flows and the exact saved energy *(Fig.20)*. Via the new systems, the electricity from the local electricity grid is **54%** of the original energy supply and the raw calculation progress (data) could be found in *Appendix 4*.

In the mapping, after recycling and optimizing the existing energy, solar panels are added. Considering the big roofs and the façades potentials for the panel installation, 1500M^2 is settled, and of course, this may change in the further design phase. Also, as address above, there is little attention paid to the equipment, lighting, public service sectors, but definitely, there could be some climate control and passive methods applying to.

This paper mainly focused on system design and calculations for energy efficiency. However, the performance may be different in the practice and be interfered by the design strategy. In the later design phase, the research will be carried out as a basic principle and the exact footprints number may be changed, and hence the reduces energy could be different.

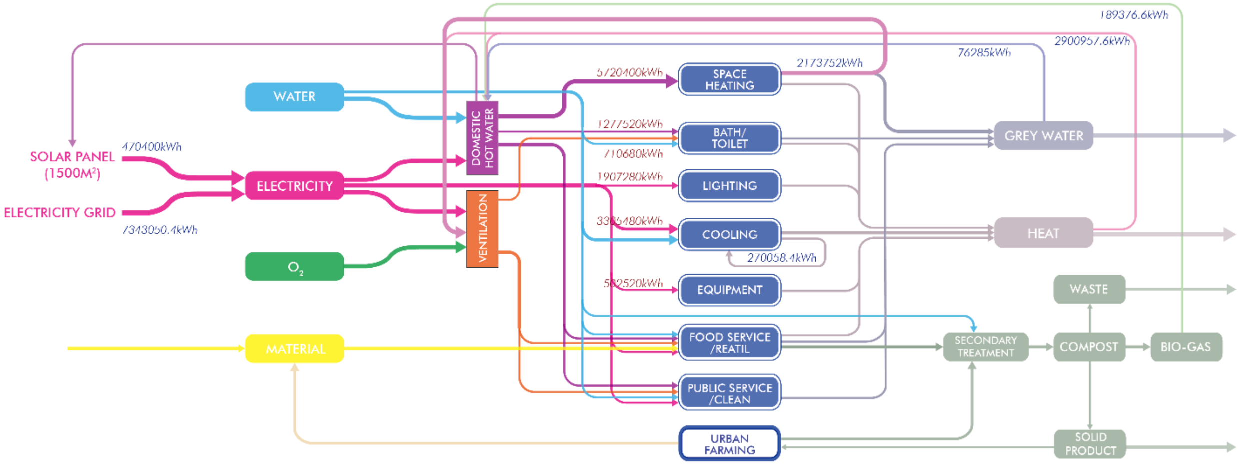


Figure. 20 Energy Mapping

BIBLIOGRAPHY

‘0554(2012).Pdf’. Accessed 18 December 2019. https://www.eia.gov/outlooks/aeo/assumptions/pdf/0554(2012).pdf.

Amsterdam. ‘Roadmap circular land tendering’. Webpagina. Amsterdam.nl. Accessed 18 December 2019. https://www.amsterdam.nl/wonen-leefomgeving/duurzaam-amsterdam/publicaties/roadmap-circular/.

Asmar, Mounir El, and Claire Tilton. ‘Student Housing Energy Consumption: A Comparison of Chilled Water, Heating, and Electricity Use’. In *Procedia Engineering*, 1038–43. Elsevier Ltd, 2015. https://doi.org/10.1016/j.proeng.2015.08.546.

Bauer, D., R. Marx, J. Nußbicker-Lux, F. Ochs, W. Heidemann, and H. Müller-Steinhagen. ‘German Central Solar Heating Plants with Seasonal Heat Storage’. *Solar Energy*, International Conference CISBAT 2007, 84, no. 4 (1 April 2010): 612–23. https://doi.org/10.1016/j.solener.2009.05.013.

‘Commercial-Co_2-Refrigeration-Systems-En-ca-3592874.Pdf’. Accessed 30 December 2019. https://climate.emerson.com/documents/commercial-co%E2%82%82-refrigeration-systems-en-ca-3592874.pdf.

‘Consumption & Efficiency - U.S. Energy Information Administration (EIA)’. Accessed 2 January 2020. https://www.eia.gov/consumption/index.php.

De Biogasboot. ‘De Biogasboot’. Accessed 28 December 2019. http://www.biogasboot.nl.

Deng, Z., and S. Mol. ‘Shower Heat Exchanger: Reuse of Energy from Heated Drinking Water for CO2 Reduction’. *Drinking Water Engineering and Science* 9 (27 January 2016): 1–8. https://doi.org/10.5194/dwes-9-1-2016.

‘Energy Information Administration (EIA)- Commercial Buildings Energy Consumption Survey (CBECS)’. Accessed 18 December 2019. https://www.eia.gov/consumption/commercial/.

enviropaul. ‘Thermal Hydrolysis (When Sludge Goes Pssh – Boom!)’. *The Culture of What We Flush* (blog), 12 January 2018. https://flushitblog.wordpress.com/2018/01/12/thermal-hydrolysis-when-sludge-goes-pssh-boom/.

Rubicon Global: Waste, Recycling, and Smart City Technology Company. ‘Food Waste Recycling & Disposal | Rubicon’s Solutions for Food Waste’, 20 May 2016. https://www.rubiconglobal.com/food-service/.

form, Do you have a question? Ask our expert: ir AJMTimmermans Contact. ‘Dutch Agenda against Food Waste Aims to Cut Food Waste by Half’. WUR, 21 March 2018. https://www.wur.nl/en/newsarticle/Dutch-agenda-against-food-waste-aims-to-cut-food-waste-by-half.htm.

Khadivi, Samira, and Mohammad Ali Moradi. ‘Cost-Benefit Analysis of Energy Saving Strategies Adopted by the Commercial Sector in Tehran’. *Environmental Progress & Sustainable Energy* 34, no. 3 (2015): 850–57. https://doi.org/10.1002/ep.12069.

Allan Corfield Architects. ‘MVHR: Benefits of Mechanical Ventilation with Heat Recovery’, 4 February 2016. https://acarchitects.biz/self-build-blog-mvhr-systems/.

November 2, Posted on, and 2017- Hospitality/Foodservice. ‘IKEA Food: “Food Is Precious” Food Waste Initiative’. Food Loss and Waste Protocol. Accessed 28 December 2019.

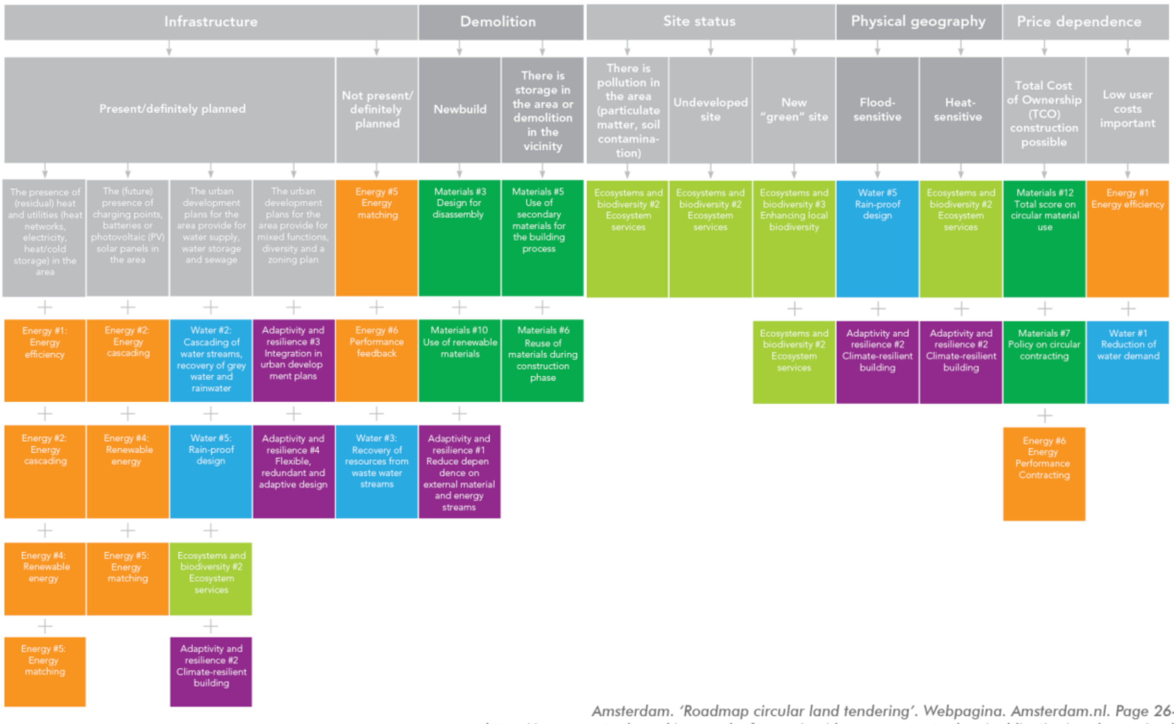
https://flwprotocol.org/case-studies/ikea-food-food-precious-food-waste-initiative/.

Sinopoli, Jim. *Smart building systems for architects, owners, and builders*. 1 online resource (xiv, 231 pages) : illustrations vols. Amsterdam ; Elsevier/Butterworth-Heinemann, 2010. http://public.eblib.com/choice/publicfullrecord.aspx?p=569298.

Green Building Store. 'What Is MVHR Heat Recovery Ventilation? - Information Hub'. Accessed 29 December 2019. https://www.greenbuildingstore.co.uk/information-hub/heat-recovery-ventilation-mvhr/.

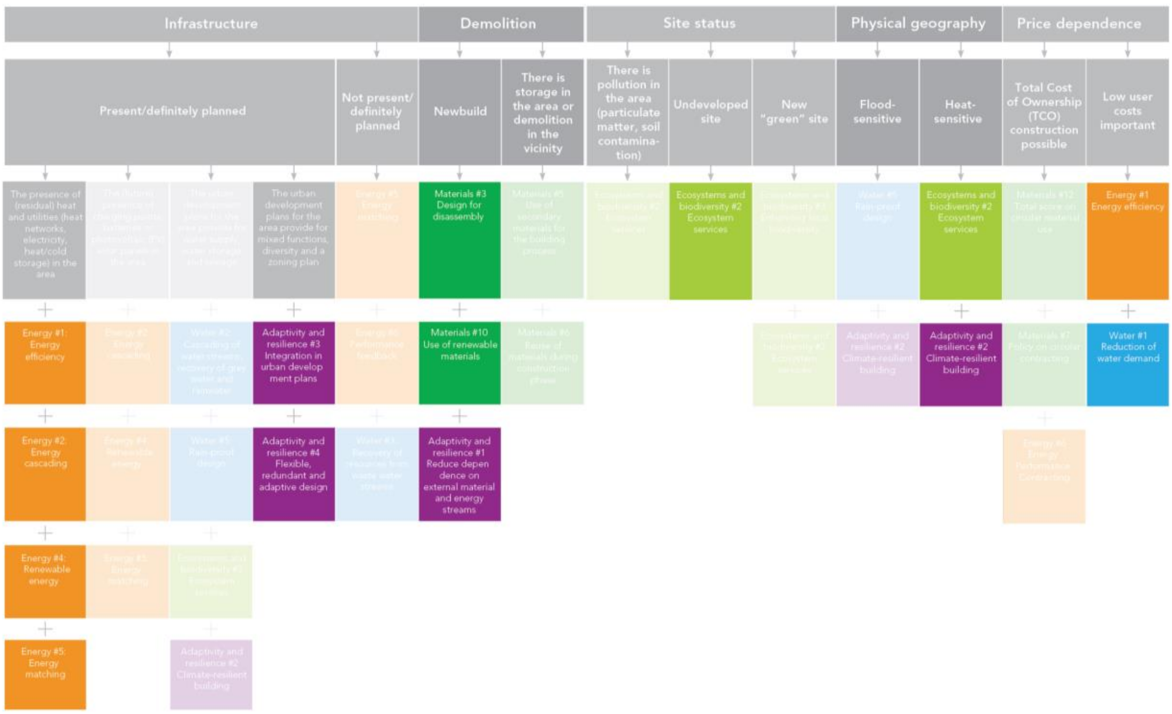
Zaken, Ministerie van Buitenlandse. 'Dutch Creative Industries Infographic - Publication - Netherlandsandyou.Nl'. Publicatie, 5 August 2018. https://www.netherlandsandyou.nl/documents/publications/2018/08/05/dutch-creative-industries-infographic.

APPENDIX I: DECISION TREE



Amsterdam. 'Roadmap circular land tendering'. Webpagina. Amsterdam.nl. Page 26-27. https://www.amsterdam.nl/wonen-leefomgeving/duurzaam-amsterdam/publicaties/roadmap-circular/.

Decision Tree Based on Amstell III

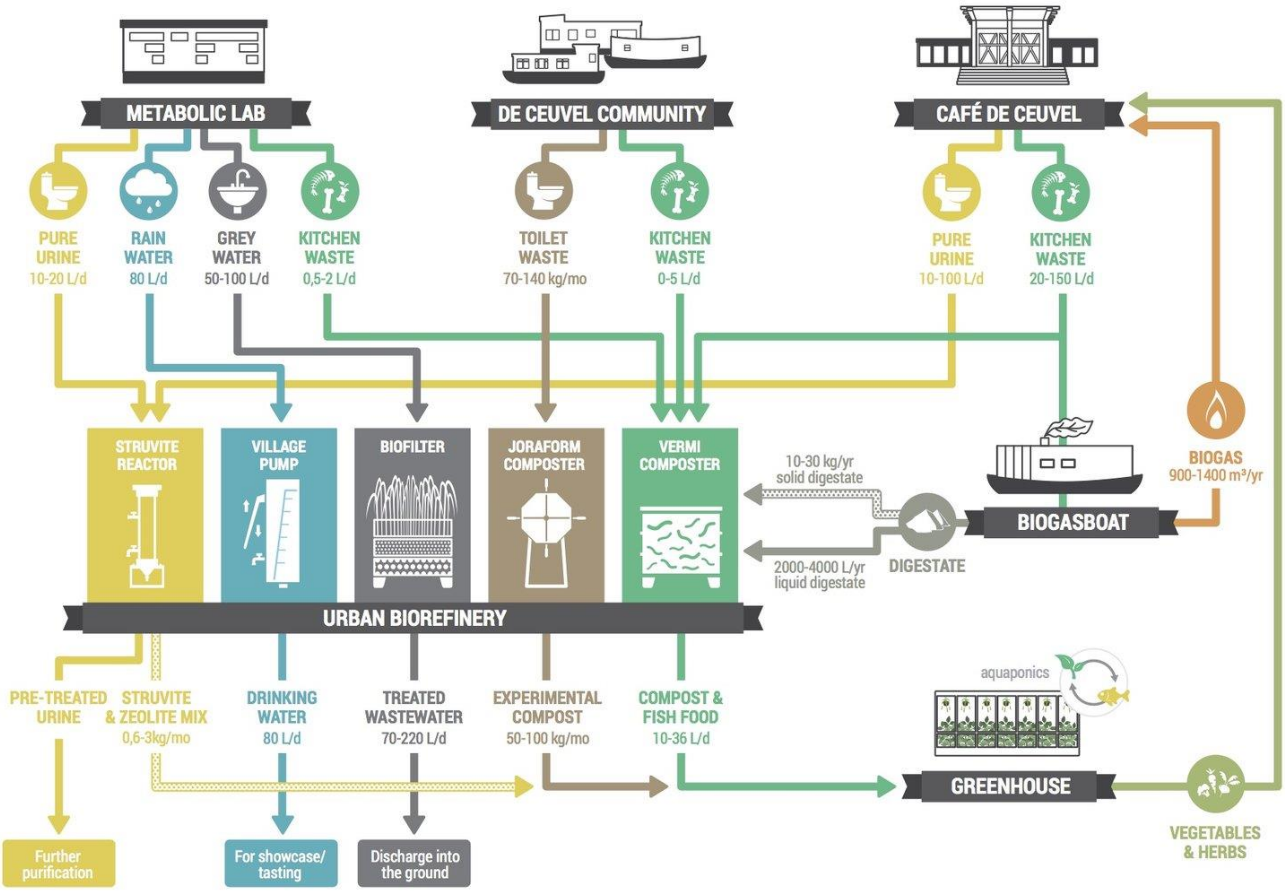


Appendix II: Energy Consumption Raw Data

v			All buildings	Consumption by energy source (trillion Btu)					v
	Number of buildings (thousand)	Total floorspace (million square feet)	Sum of major fuel consumption (trillion Btu)	Elec-tricity	Natural gas	Fuel oil	District heat		
All buildings	5,557	87,093	6,963	4,241	2,248	134	341		
Principal building activity									
Education	389	12,239	842	458	291	28	Q		
Food sales	177	1,252	262	208	53	Q	N		
Food service	380	1,819	514	279	227	Q	Q		28.26
Health care	157	4,155	718	365	265	20	68		
Inpatient	10	2,374	549	251	219	16	62		
Outpatient	147	1,781	169	114	46	Q	Q		
Lodging	158	5,826	564	304	221	8	Q		9.7
Mercantile	602	11,330	1,008	705	291	9	Q		
Retail (other than mall)	438	5,439	364	281	74	7	Q		6.7
Enclosed and strip malls	164	5,890	644	424	217	Q	Q		10.93
Office	1,012	15,952	1,241	865	282	18	76		7.77
Public assembly	352	5,559	480	275	135	7	64		
Public order and safety	84	1,440	133	73	41	2	Q		
Religious worship	412	4,557	173	81	87	5	N		
Service	619	4,630	272	127	122	16	Q		
Warehouse and storage	796	13,077	429	284	139	Q	Q		
Other	125	2,002	286	191	81	Q	Q		
Vacant	296	3,256	41	26	13	Q	Q		

Consumption by end use,											
	Total electricity consumption (trillion Btu)										
	Total	**Space heating**	**Cooling**	**Ventilation**	**Water heating**	**Lighting**	**Cooking**	**Refrigeration**	**Office equipment**	**Computers**	**Other**
All buildings	4,241	85	633	668	22	724	93	670	172	405	769
Principal building activity											
Education	458	10	90	68	3	78	4	40	21	78	66
Food sales	208	2	6	12	0	16	10	23	2	2	12
Food service	279	5	30	31	3	19	46	114	7	4	21
Health care	365	4	69	82	1	61	8	19	17	34	70
Inpatient	251	2	58	46	1	40	7	14	12	21	50
Outpatient	114	2	11	37	0	21	1	4	5	13	20
Lodging	304	8	39	49	3	40	10	33	43	6	74
Mercantile	705	13	91	121	7	140	6	191	18	23	94
Retail (other than mall)	281	5	40	47	1	72	2	53	7	11	44
Enclosed and strip malls	424	8	52	75	7	68	4	139	11	12	50
Office	865	19	116	214	2	148	2	28	37	167	132
Public assembly	275	9	82	24	0	35	4	25	7	16	73
Public order and safety	73	1	15	5	1	15	1	3	3	8	20
Religious worship	81	3	15	13	0	9	1	4	3	3	28
Service	127	3	16	14	0	37	0	5	4	8	39
Warehouse and storage	284	4	34	13	1	85	0	47	6	16	78
Other	191	3	26	16	0	37	0	15	2	40	51
Vacant	26	1	2	4	0	5	Q	1	0	1	12

APPENDIX III: BIO-GAS SYSTEM & CASE STUDY



Appendix IV: Energy Calculation for the Project

	A	B	C	D	E	F	G	H	I
1	kwh/m^2	space heating-consumption	lighting-consumption	domestic hot water-consumption	equipment-consumption	cooling-consumption	ventilation-consumption	SUM	area
2	training court	86.3	39	13.25				138.55	200
3	fitness suit	201.3	41.4	13.25				255.95	80
4	reception/common area	168.4	41.4	13.25				223.05	350
5	changing room	299.4	29.6	16				345	0
6	lounge/bar	109.5	45.6	11				166.1	50
7	retail	122.3	91.72	6.37	26.75	93	59.87	400.01	400
8	housing	113.6	54.1	39.6		6.97		214.27	2620
9	office	154.5	61.8	43.26	98.88	179.2		537.64	300
10	kitchen&food service	174.8	72.2	163.4	756.2(cooking)	547.2	117.8	1075.4	
11									
12	SUM	1430.1	476.82	319.38	125.63	826.37	177.67	3355.97	4000
13									
14					food				grid
15	produce-energy	2173752		76285	189376.6	727205.6	2443810.4	5610430	7343050.4
16	%	0.29602847							0.547014
17									

Sheet1

K	L	M	N	O	P	Q	R
	heating	lighting	hot water	equipmer	cooling	ventilation	
consumption -total	17260	7800	2650	0	0	0	
	16104	3312	1060	0	0	0	
	58940	14490	4637.5	0	0	0	
	0	0	0	0	0	0	
	5475	2280	550	0	0	0	
	48920	36688	2548	10700	37200	23948	
	297632	141742	103752	0	18261.4	0	
	46350	18540	12978	29664	53760	#VALUE!	
	0	0	0	#VALUE!	0	0	
	0	0	0	0	0	0	
	5720400	1907280	1277520	502520	3305480	710680	13423880

panel area	kwh	solar energy
1500	156.8	470400