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Energy Saving and Emission Minimization by Means of Semicentralized Integrated Supply and Disposal Systems in Rapidly Growing Urban Regions

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Currently, the development of the world population is characterised by two trends: absolute population growth and rapid urbanisation. Especially rapid urbanisation, taking place in Asia, Latin America and Africa, poses major pressure on the affected regions. The development of Asian countries today is characterised by a combination of urbanization with high economic growth rates. At the same time the climate change is accelerating and the energy supply is going to become an existential problem.The rapidly growing cities therefore face the issue that infrastructures and public services (energy, water supply and disposal, etc.) are unable to keep pace with the rapid urbanisation, the increasing energy costs and the imperative to reduce the CO2 emissions.

The semicentralized integrated approach offers a sustainable solution to cope with these developments. The approach enables to be more flexible in planning and operation, plays on the strengths of reliable and compact structures and proceedings, reduces the investment and operating costs for the supply and treatment systems and, above all, enables a high efficiency in resource use, surplus of energy instead of energy consumption and finally a reduction of emissions.

In Hanoi, as in other urban areas of Vietnam, the situation is characterised by a lack of wastewater treatment plants, serving only a small fraction of the accumulating wastewater. Prevalent means of sanitation are septic tanks installed under the buildings for the collection of domestic wastewaters, with the overflowing liquids draining uncontrolled into the groundwater. The combined treatment of sludge and biomass and the integration of existing and new structures in Hanoi is a new challenge within the semicentralized approach going to be applied in China as well.

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1. The semicentralized approach – Integration of material flows

The semicentralized concept is a new approach to integrated water supply and treatment of solid waste and waste water. A main feature of the concept of semicentralized supply and treatment is that it is not inevitably linked to one special treatment technique, but it has to be flexible and adapted to the situation of a specific spatial and political context of an urban region.

It aims at the integration of nowadays separated waste flows, always regarding actual local situations. This has been applied in China up to now, regarding the cities of Qingdao and Shanghai. Technically the aim of the current project in Hanoi, Vietnam is to optimise the co-fermentation of organic waste and sewerage sludge for the production of biogas. This technology as such is not new, but it has to be developed further to be applicable for relatively large populations in Hanoi, Vietnam. On the basis of earlier research, it is assumed, that the biogas generated from this technology is able to produce enough energy to run the plants in Hanoi and eventually to produce surplus energy. A central issue with regards to the actual situation of Hanoi is, whether there is enough organic waste available to compose the ideal mixture of organic waste and sewerage sludge for the production of biogas. Availability in this regard depends not only on absolute masses but also on the management of the flow of these masses through the urban system. (Schramm and Bieker, 2009)

A further central issue concerning the design of a semicentralized supply and treatment system is the scaling. In accordance to the concept of adaptation to specific contexts, the actual size of the population supplied by one unit has to be assessed from case to case, but has to be guided by the principle “as small as possible as big as necessary”. Generally, proximity between consumers and treatment facilities allows for the separation of municipal wastewater from industrial wastewater and offers convenient conditions for water reuse in households as toilet flushing or intra-urban irrigation. Close-by waste treatment facilities minimize the transport ways and thus optimize the recycling of resources for energy recovery. (Bieker et al., 2008)

The combined treatment in Semicentralized supply and Treatment Centres (STC) includes the implementation of new technical solutions and treatment methods to optimize mass and energy flows. In this context, the optimization of the treatment of organic waste, wastewater and sludge for maximum biogas production by co-fermentation is of central interest, apart from related technological innovations, such as seasonally adapted operation for water reuse and optimized use of interconnection of heating and cooling. As the costs of comprehensive solid waste and waste water treatment systems cannot be covered by the budget of public utilities at the moment and as the capability of consumers to pay for services is limited, saving costs is crucial for actual implementation. A technical means to save energy is the use of biogas generated by the co-fermentation of organic wastes and sewerage sludge as well as septic tank sludge. These techniques probably lead to a decrease in the amount of residues to be disposed. To achieve this, the currently separated sectors of waste water and solid waste need to be integrated on a district level. This requires the re-direction of existing material flows within an urban region.

2. Urban and Rural Hanoi – The relevance of the region

In Hanoi, the urbanization process takes place via inner city densification and most notably a rapid extension of the urban fringe, taking the form of large scale renewal and smaller scale densification. Large scale renewal is characterized by new residential estates often featuring modern high rise developments for the emerging middle- and upper classes (Waibel 2006). These developments are officially planned under the Hanoi People's Committee (HPC) with the provision of detailed urban plans. Small scale densifications take place via the transformation of former peri-urban villages. With rising urbanization pressure, formerly agricultural areas or low density housing plots are covered with dense building structures according to general master planning but without a detailed plan and often without the preliminary provision of infrastructures. The building structure follows the typical Vietnamese pattern of a narrow road system with smaller roads diverting from the bigger roads, ultimately ending in cul-de-sacs often not more than one meter wide. These developments are mostly individually designed and financed, as opposed to the large scale renewals that are financed by investment companies. This process has been identified as "a new type of urbanism (…) at the edge of the city" (Leaf 2002).
As the area of the built city expands, the formerly politically intended sharp distinction between urban and rural is blurred. The recent extension of the administrative boundary of Hanoi reflects the official government policy supporting the built city's rapid expansion. This boundary is nowadays including the former Ha Thay province, so that the city's number of inhabitants jumped from 3.5 m to 6.2 m in 2008. Subsequently, four characteristic areas within the city of Hanoi can be identified: the urban core, large scale renewal, small scale expansion and peri-urban areas. These feature different building styles and different constellations with regards to waste and waste water technical infrastructure, service provision and governance.

3. Solid and liquid waste flows of Hanoi

From the technical point of view, the energetic potential of organic waste is much higher than that of sludges from sewerage lines or from septic tanks so that the limiting factor for gas production is the availability of solid organic wastes. While the perfect mixture of organic waste and sludge has yet to be determined in the pilot plants, a first assessment of the materials available in the urban fringe of Hanoi has been carried out by literature review and on site research in Hanoi. In order to find out the best ways of combining the flows of solid waste and sewerage sludge, these need to be analyzed in detail.

3.1 Flows of waste water – controlling confused cycles

An important feature of Hanoi's sewerage system is the use of septic tanks installed under the buildings. The size of the septic tanks in Hanoi varies from 2 to 6 m^3 for single houses up to 200 m^3 for new high rise buildings. The overflow of Hanoi's septic tanks flows into the sewerage system that just covers parts of the urban core and is gradually extended to the formal suburban areas. Peri-urban areas are normally not served by a sewerage network. The coverage of septic tanks varies among the different areas, with the formal suburban areas having a full coverage, while in the informal

expansion and the urban core, the coverage can be assumed to be 50 - 80 %. (Viet Anh et al. 2005) In peri-urban areas the coverage of houses connected to septic tanks is lower than 50 %.

Septic tank drainage is an issue, with a wide range of service providers operating in this field, with varying legal forms. In the urban core, the Urban Environmental Company (URENCO – a limited liability utility with 100 % public shares) of Hanoi is officially responsible for this service, while the Hanoi sewerage and Drainage Company (HSDC) is also partly carrying it out. Outside the second ring road, in the informal and formal suburbs, there are affiliated companies, such as Thang Long, a joint stock company with a majority of public shares or Tay Do, a mostly private joint stock company. These enterprises are unable to cover the whole area, which is why they are supplemented by smaller private service providers. In the peri-urban areas, households solely rely on these enterprises. They offer cheaper services, but do not adhere to environmental standards and often discharge the septic tank sludge into the rivers and canals, where they are dredged by HSDC in turn. Therefore, an environmental police has been established in 2006 to control this "confused flow".

3.2 Flows of solid waste – a regional recycling industry

Every person in Hanoi produces approx. 1 kg of solid waste per day, of which 60 % is organic. It is expected that in the future more total waste but a lower organic rate will be produced. (MOC 1999) Waste is brought from households to local transfer points by URENCO workers, where it is loaded on a truck and brought to one of the landfills located in the nowadays rapidly urbanizing urban fringe. Generally, URENCO and affiliated formal companies handle about 80% of waste in Hanoi and about 60% in the suburban and peri-urban areas.

Especially with regards to recycling of materials and separation of organic and non-organic wastes, informal waste pickers play a crucial role. At every level, that is household, transfer stations and landfills, they look for recyclable materials such as plastics papers and metals and either buy them from households or just collect them from transfer points or the dumping sites. (Mitchell 2008) There is a well organized industry of waste recycling, with the waste being recycled in specialized villages in the outskirts of Hanoi. It is estimated, that 30 % of the waste produced in Hanoi goes to recycling villages, where 80 – 95 % of the material is recycled. (DiGregorio 1998) This means, that a large part of non-organic waste is separated by waste collectors and that the share dumped or landfilled by formal companies or is largely organic. This makes Tay Do, Thanh Long and URENCO main actors in the re-direction of material flows as intended within the semicentralized concept for Hanoi.

3.3 The availability of materials - implications for a semicentralized system

A challenge for the aim of re-directing material flows is on the one hand the question, what technically exists and on the other hand, which materials would actually be available for redirection. A close look at the flows of organic materials in Hanoi shows that they are often not readily available for reuse or recycling. This might be because of transportation issues with regards to sludges from septic tanks. Traffic congestions make long transportation routes inefficient, which is why sludges are regularly dumped in canals. Therefore, the distance from households to treatment facilities of septic tank sludge should be relatively short. The solid waste industry in Hanoi on the other hand

shows that regional organization of long distance waste flows can function with decentralized management and without government support. Due to separation of wastes by small scale enterprises, the official utilities handle waste with a high percentage of organic material – an estimated 90%. This material can directly be co-fermented – a process rendering it suitable for soil conditioning or landfilling without environmental risks. This means that organic waste for co-fermentation is generally available in Hanoi. For the future development of the private waste industry it has to be taken into accout though, that it has been surveyed by researchers in detail (DiGregorio 1998, Mitchell 2008, Mitchell 2009) but not yet included in official waste management strategies. (MOC 1999) These strategies largely ignore the contribution of the informal waste industry to recycling of wastes but concentrate on extensions of the formal sector's responsibilities into this field. (Michell 2009) Therefore, the future of this informal industry is in question, even though it contributes to an effective separation of flows.

4. Conclusion – Semicentral management of flows in Hanoi

To find a solution for the semicentralized management of flows, different levels have to be regarded, depending on the urban structure and actor constellations in management of infrastructures. Concerning the location and layout of treatment facilities, the processes handled should vary according to the location within characteristic areas. Co-fermentation of organic waste and sludges requires open building structures, as the plant needs a certain distance from residential areas. This can best be implemented in formally planned large scale investor developments. There, also the septic tank from adjacent small scale renewals that often lack public open spaces can be treated. For inner city areas, smaller plants with treatment of septic tank sludges only are more convenient – they do not require large distances from plants to residential areas and shorten transport ways. The treated septic tank sludge could in turn be brought to the larger facilities in the large scale expansions. In peri-urban areas, where service provision is lower, low-tech solutions and management concepts are required. By-products of the co-fermentation process cannot be handled on the district level. Either, they have to be landfilled or they can be marketed as soil conditioner. Toxic by-products have to be landfilled. In short, this means that the semicentral approach can not only rely on treatment of materials on a local level, but the different material flows are to be handled on different spatial levels within the urban region – from household-based pre-treatment in septic tanks over district-based co-fermentation plants to centralized landfills for by-products. Even if nutrient cycles are closed by the use of a by-product as soil conditioner, this cycle includes at least the whole urban region.

Even with the aim to decentralize specific flows, these considerations shows the need for regional planning of infrastructure development for the location of landfills and peri-urban as well as new large scale expansions, as material flows are region wide. Regional infrastructure planning should take into account existing waste industries. This regional management of flows is a complex task - for their re-direction the various actors and institutions involved in governance and management of water, waste water and waste flows need to be studied. While there is a lot of information about the mechanisms of the waste industry, less is known about the private emptiers of septic tank sludges and

their relations to institutions and state owned enterprises as well as new urban areas and the institutional changes with regard to service provision and local governance in these areas.

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