Case study of sustainable sanitation projects

Urine diversion dry toilets in multi-storey buildings

Erdos City, Inner Mongolia Autonomous Region, China

Fig. 1: Project location

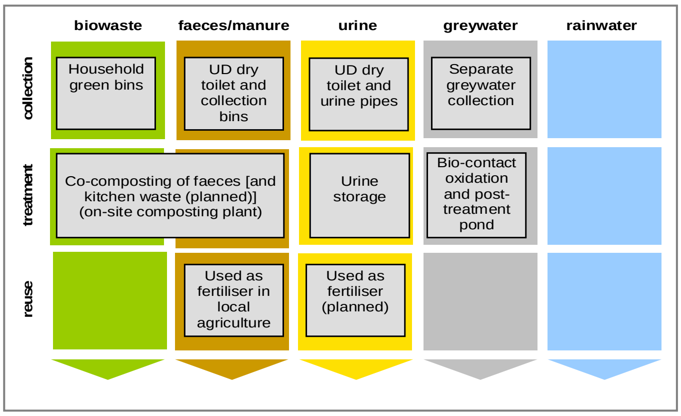

Fig. 2: Applied sanitation components in this project (note: the urine diversion (UD) dry toilets were only in place from 2007 until mid 2009).

1 General data

Type of project:
Full-scale urban residential area with urine diversion (UD) dry toilets, recycling of human excreta, and greywater treatment.

Project period:
Start of project: February 2003
Start of construction: July 2004
Start of operation: January 2006
Project end: December 2009

Project scale:
3,000 residents (832 apartments in 42 buildings with 4-5 stories and one building with 2 stories)
Total investment: ca EUR 1 million for urine diversion dry toilets, greywater treatment and composting systems; EUR 12 million for the apartment buildings and associated infrastructure

Address of project location:
Haozhaokui village, Dongsheng District, Erdos City, Inner Mongolia Autonomous Region, People's Republic of China

Planning institutions:
Stockholm Environment Institute (SEI), Sweden and Erdos Hongtu Architecture Designing Co., Ltd., China

Executing institutions:
Dongsheng District Government, Erdos Daxing Estate Development Co., Ltd., and SEI

Supporting agencies:
Dongsheng District Government
Swedish International Development Agency (SIDA)

Arrangement
Public-private partnership between the municipal government and the households as represented by the estate developer.
The households paid 70% of the housing project, the government 25% and SEI/Sida 5%.

2 Objective and motivation of the project

The project aimed at sanitizing and recycling the wastes from residents under urban conditions. It attempted to generate the data, technologies and policies required to bring about a major change in the way in which urban settlements relate to the environment. The project was meant to provide opportunities for meeting high environmental ambitions and conserving water through implementing a dry ecological sanitation (ecosan) system in this semi-arid region.

3 Location and conditions

Dongsheng District is the largest district in the Erdos Muncipality and located in the south-western part of the Inner Mongolian Autonomous Region on the central part of the Erdos plateau at an altitude of 1,500 m. This part of China has a cold semi-arid climate with warm summers. The winters are cold and dry with an average temperature of -10℃ in January. The annual precipitation of 300-400 mm is low and the area tends to have high potential evaporation (2000-3000 mm).

Fig. 3: One of the 42 apartment buildings for approx. 70 inhabitants each (source: SEI, 2006).

When the project was initiated, about one third of the Dongsheng District was forced to ration water, making it available only three times per day for periods of 60 to 90 minutes. The main source of drinking water was from fossil groundwater aquifers, supplemented by seasonal surface water sources.

In 2005 a 100-km pipeline from the Yellow River was being constructed to supply 100,000 m³/day of water to the city by the end of 2010. Yet even with the new water supply scheme there was a lack of 3,000 m³/day water and water prices were expected to be rising in the future.

In 2004, of the 60,000 households in the Dongsheng District about 20,000 households had flush toilets while the rest of the population used 300 public, mainly outdoor, unlit and unheated pit latrine toilets which were poorly maintained. The limited and only partially connected sewer system resulted in groundwater contamination. The poor sanitation conditions were further complicated by the poorly functioning water supply system.

There was a significant urbanisation trend in the city since the 1990s which led to a decline in the population of the surrounding small towns and villages. The district is rich in natural resources, and coal mining is one of the major drivers behind economic development and the subsequent urbanisation in the area. Erdos City has a total population of 1.4 million, while the Dongsheng District as the largest district within Erdos City has 430,000 inhabitants.

Agriculture is still considered one of the five economic pillars of the district, however at a significantly lower scale than industrial production. In 2000, total agricultural and total industrial production was valued at EUR 12 million and EUR 633 million respectively. It was envisioned at the start of the project that many of the future residents of the Eco-Town would be rural farmers, who were resettled into cities. But with the quick rise in coal prices and the standard of living, the project quickly became a mainstream market-based urban building project.

In 2003, the project was conducted through cooperation between Dongsheng District government and Stockholm Environment Institute (SEI) with Daxing Estate Development Co., Ltd. as contractor. An agreement was signed between the Dongsheng District Government and SEI stipulating the responsibilities and fund sharing of the two parties. SEI was responsible for technical solutions, management aspects, institutional dimensions, community sensitization, policy promotion, cost-benefit analyses and monitoring. The role of the Dongsheng District was related to the coordination with the developer, the project promotion, the construction of the infrastructure and operation of the sanitation system.

The Dongsheng District, with its water shortage problems and sanitation challenges, appeared to be a good candidate for testing such a system in an urban setting. The land was subsidised by the government and the apartments were sold somewhat below market prices.

4 Project history

The project started in February 2003 and finished in December 2009. Project milestones were:

- *Feb. to Sept. 2003*: Project investigation and signing agreements with local government.
- *Oct. 2003 to July 2004*: Town planning and ecological sanitation (ecosan) system planning, contracting project builder by local government.
- *July 2004 to Dec 2007*: Construction of 43 buildings finished, R&D and installation of eco-toilet conducted and greywater system built.
- *Jan. 2006 to June 2007*: Households moved in using the dry toilets. Part of the R&D programme implemented, agricultural field trials, upgrading and improvement of technical problems with ecosan system and greywater piping, fixed construction errors and started operation.
- *August 2007*: International Conference on ecosan held in Erdos to showcase the project (see Section 9).
- *2007-2008:* On-going R&D to fix problems with toilet mechanisms, ventilation and faulty construction and plumbing.
- *End 2008:* Compost plant started operation.
- *Jan. 2009:* Lobbying efforts started by households for change to flush toilets.
- ***Sept. 2009:* Work begins to remove urine diversion dry toilets and install flush toilets with onsite DEWATS instead (see Section 11 at the end).**
- *Dec. 2009*: Official end of the EETP and evaluation workshop in Beijing (see Section 13)

5 Technologies applied

The design of the Erdos Eco-Town Project (EETP) was meant to showcase a sophisticated ecosan system with dry urine diversion toilets and solid waste facilities in an urban environment. The concept behind the system design was that the separation of waste streams would increase the efficiency of treatment and facilitate the recycling process. The system design therefore focused on the separation of four main waste streams: faeces, urine, greywater and solid waste.

The sanitation system of the EETP consisted of (details are given in Section 6):

- 832 urine diversion dry toilets
- 832 low-flush urinals
- 832 faeces collection bins in the basements (with ventilation systems)
- One greywater treatment plant
- One composting plant
- 22 urine tanks in the basements of some of the buildings

We refer to these toilets here as “urine diversion dry toilets”. They are very similar to UDDTs (urine diversion dehydration toilets), except that the faeces bins in the basements do not give the same degree of drying as would be achieved in conventional faeces vaults with ventilation pipes.

The onsite eco-station had an area of 7,500 m² and contained the greywater treatment system, storage pond, composting facility, additional urine storage tanks and the O&M office plus a demonstration garden.

6 Design information

Basic design specifications:

- Population: 3,000
- Number of households: 832 (3.6 people per household)
- Type and number of buildings: forty-two 4-5 storey buildings and one 2-storey building
- Urban water consumption: 80 L/person/day (National urban water consumption in China: 326 L/person/day)
- Greywater treatment designed capacity: 250 m^3/day
- Frozen depth of the ground: 150 cm

- Urine: 500 L/person/year
- 22 underground urine tanks: size between 3.5 and 13.5 m³
- Storage time of urine: 3 month
- Faeces production: 50 L/person/year
- Faeces collection: one 120 L bin for each toilet
- Bin emptying is once per month
- Average distance to compost plant: 400 m
- Compost plant has 2 chambers with a total size of 12 m³
- Sawdust added to toilets: 50 L/person/year
- Onsite storage pond for treated greywater: 3,700 m³

Specifications for planning, design and construction as well as the criteria of the effluent and reclaimed water were based on the China National Code.

The urine and faeces flow streams started at the urine diversion dry toilets and waterless urinals which diverted the liquid and solid excreta from each other. The toilets, urinals, and related equipment were developed by SEI consultants and manufactured in China for this project by Chauzhou Meilong Ceramics Industry in Chauzhou, Guangdong Province.

A "turning bowl faeces receptacle" in the dry toilet was connected to a vertical pipe chute with a diameter of 280 mm so that after use the faeces dropped vertically down into the basement where they were collected in 120 L bins. 60 to 80 ml of sawdust was manually added to the faeces after each toilet use in order to keep the contents of the bins dry and reduce odour. The faeces collection bins were connected to a ventilation system that was meant to vent odour from the bins to vent pipes on the roof.

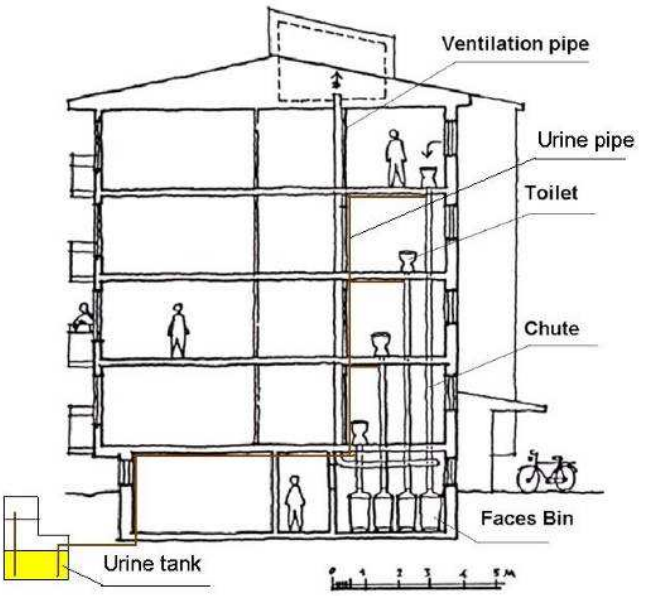

Fig. 4: Sanitation system for urine and faeces collection in a 4-storey building of EETP (source: SEI).

The pipes from the urine section in the toilet and the urinals were led to the urine tanks where the urine was collected and stored for 3 months. A tanker truck was used to empty the urine tanks and the stored urine could be applied as a fertiliser to local agriculture. The urine reuse was not fully realised at a large scale (see Section 7) and was discharged at the local landfill (acting in effect as remedial fertilizer for composting processes).

Fig. 5: Tanker truck to empty the urine tanks (source: Olt, 2008).

The greywater in the system came from the kitchen sinks, showers and bathtubs. It flowed into a separate pipe system to an on-site greywater treatment plant with a capacity of 250 m^3/d, or about 80 L/person/day. The plant used primary sedimentation, anaerobic treatment, activated sludge and aerobic bio-film treatment, secondary sedimentation and a holding pond (3,700 m^3) to treat the water to the National Code for Grade II effluent standards[1].

The plant was also designed to be able to meet reclaimed water quality standards through an additional step, during which flocculation agents were added and the water filtered through a high-efficiency fiber filter before disinfection. However, this last step was not put into operation.

Composting plant

The bins were collected with a truck by the maintenance workers (see Section 10) and taken to the on-site indoor thermal composting plant where the faeces were processed into an organic fertiliser product for agricultural application.

The composting cycle took 35 days in 6 m³ chambers. The screened material was mixed with additional sawdust and compost starter (effective microbes) and reached a temperature 50-60°C with additional heating if necessary and floor aeration. After 18 days the mass was transferred to a second chamber for an additional 17 days. This process was quite energy intensive due to the heating and aeration. Composting should normally be self-heating and not relying on external heating, but low temperatures in fall and winter made additional heating necessary to achieve the required temperatures for pathogen kill.

It was planned that the solid waste would be separated into compostable and non-compostable fractions at the household level. The compostable waste would then be added to the faecal compost. However, the source separation of solid waste was only partially implemented and the rest went to the municipal landfill. The city later built a mixed solid waste biogas plant that also produced fertiliser pellets from the sludge.

Pathogen removal

The treatment measures within the system, i.e. urine storage and thermal composting at 50-60°C, all resulted in a reduction

[1] China's national wastewater discharge standards for Grade II: COD 100 mg/L, BOD_5 30 mg/L and TSS 30 mg/L (source: Flores, 2010).

of pathogens. However, from a risk perspective, one area of concern for the EETP dry system was the handling of faecal matter by the maintenance personnel during collection and transportation. In spite of protective clothing and masks there were still possibilities of exposure. Washing and showering was carried out in the maintenance building. No incidences of disease were reported throughout the project period.

7 Type and level of reuse

Field trials of reuse as part of the EETP showed that with an application of 7.5 t/ha of faecal compost plus 6 t/ha of urine, corn yields were raised by 33% (and with an application of 22.5 t/ha of faecal compost plus 12 t/ha of urine, the corn yields increased even by 68%).

As part of the research program, a series of demonstration and training courses was carried out to demonstrate the benefits of using sanitised human urine and faeces as fertiliser. Between January 2005 and early 2006, 15 training courses were held, in which about 300 local farmers participated. In addition, the maintenance team of EETP was trained and encouraged to use the demonstration gardens near the eco-station. The maintenance workers grew a variety of vegetables for their families in these gardens, and used urine and compost as fertiliser.

Large-scale urine reuse was not achieved during the project period. The use of urine as a landscaping fertiliser for lawns was discouraged by the local government mainly due to odour, and there was no demand from local agriculture. Therefore, urine was delivered by the maintenance team to the municipal landfill and various locations outside the Eco-Town.

Reuse of composted faeces from EETP was more successful than reuse of urine, although the system did not reach the potential envisioned at the beginning of the project. Prior to the compost plant coming on-line at the end of 2008, the faeces were composted outdoors on a farm approximately 30 km from EETP and eventually incorporated into the fields. However, due to the distance to the farm, some of the faeces were also taken to the municipal landfill.

After the compost plant became operational, bags of the compost were given to several local farmers for use in their greenhouses. Since the compost did not meet Chinese standards for organic fertilisers because of low nutrient content, EETP was unable to sell it. However, as a free product the farmers willingly used it to cultivate a variety of vegetables.

The farmers reported being satisfied with the EETP compost, although project staff doubted that they would purchase it. The fertilizer content would probably have been improved if organic kitchen waste had been included in the process, but the green-bag program only began in 2009 when the push to remove the dry toilets had already reached its peak.

Fig. 6: Experiment in reuse of human excreta in a corn field (1,000 m²) was carried out at the demonstration station for “Agriculture Water Saving” of the “Soil and Fertiliser Station” of Pojainghai Township in 2006 and 2007 (source: SEI Project Office).

8 Further project components

The EETP included a comprehensive R&D programme: including development of the faeces and urine collection system, greywater monitoring and treatment alternatives as well as the reuse of reclaimed water, ventilation system study, economic evaluation of EETP, composting study, agriculture reuse of human excreta, social study (household acceptance), policy study and environment impact assessment. A detailed Life Cycle Analysis (LCA) was carried out by Flores (2010) (see Section 13 for details and link).

9 Costs and economics

The costs for operating the sanitation system at the EETP included the salaries of the maintenance workers, electrical costs for the basement fans, greywater and compost plants, purchasing sawdust for the toilets, fuel for transport of reuse products, and the running of the project office. The institutional arrangements for paying the operation and maintenance costs are explained in Section 10.

Table 1: Capital and operational costs for the dry sanitation system and the greywater treatment (source: Flores, 2010).

Total capital costs (EUR)	1,030,000
Capital costs per household (EUR)	1,238
Total operational costs (EUR/year)	66,019
O&M costs (EUR/year/household)	79
Estimated value of fertiliser (EUR/year/household)	8
Estimated value of reclaimed water (EUR/year/household)	8
Net O&M costs with reuse (EUR/year/household)	65

Based on the Life Cycle Analysis by Flores (2010) it was concluded that the current design of the dry system was quite *material-intensive* because of the basements required for faecal collection and storage. The dry system’s transport requirements were also quite *energy-intensive* as the receiving farms for compost and treated urine were on average 60 kilometers away from the EETP.

A cost-benefit analysis was carried out by Prof Zhou Lu of Tsinghua University (reported in Rosemarin et al 2012). The overall ecosan system from this project was compared with a similar sized conventional waterborne system. The current capital costs for the dry system are about 2.17 times that of the conventional one mainly due to the cost of building the basements for the collection system. The results also showed that the O&M cost of the dry system was 3.6 times greater than that of the conventional system. However the water savings and recyclable water and nutrients make the ecosan variant both a feasible and attractive alternative. Water prices are not yet a cost driver in Erdos City[2] but when they are, the dry system will be very competitive. Also the market for urine and composted humanure in urban agriculture still remains to be developed. The project has therefore successfully shown that the dry system can be fully viable from an economic point of view.

10 Operation and maintenance

Management of the operation and maintenance of the EETP sanitation system was jointly controlled by the SEI Project Office (SPO) and the Dongsheng Project Office (DPO) that was staffed and financed by the local government. The two management teams were responsible for the logistics and running of the project office. The SPO consisted of 2-3 staff members who were in charge of reporting, communication, purchasing and day-to-day management. The SPO communicated closely with the SEI project manager in Stockholm and with the DPO.

Since all of these facilities were on-site, the eco-town had its own maintenance team that was responsible for operating and maintaining the system. The maintenance team consisted of 10 workers and a crew leader responsible for coordinating the activities of the team. The costs were shared by the DPO and SPO and the team leader was part of the staff and pay-roll of the SPO.

Two options for long-term operations and maintenance were envisaged for the project: the creation of a private company that could also serve a number of EETP-type settlements or a household cooperative committee. Neither of these were pursued however by the local government.

Fig. 7: Faeces collection in the basement (photos by Rüd, 2007 and Olt, 2008).

In general, the maintenance team was in charge of the daily operation of the system. They were also responsible for responding to complaints from the households and assisting with user education. The maintenance team was also responsible for operating the compost treatment plant. Operation of the greywater treatment plant was contracted out.

[2] Water costs for households in 2008: EUR 0.37 per m³ including EUR 0.04 for sewage.

The maintenance team was in charge of cleaning the basements, emptying and transporting the faeces bins (approx. once per month), and repairing/adjusting the toilets. At the household level the residents were supported by the project maintenance team. A 24-hr telephone hotline was established at the eco-station so that households could report problems with their toilets and get immediate service.

Fig. 8: Removal of basement faeces bins by using a simple hoist installed on a light truck (source: SEI).

From the maintenance team perspective, the urine collection and disposal system as well as the faecal collection, treatment, and disposal system were fairly easy to operate and maintain. The procedures were not technically complex, although they were somewhat labor-intensive and unpleasant in the case of the faecal management system.

Sometimes it was smelly in the basement caused by improper working ventilation system or an overflow of the bins due to household misuse through pouring water into the dry toilets.

The operation and maintenance of the greywater treatment plant required a skilled worker, but operation of the entire system was well within the capacity of the local utilities to provide. Problems with system robustness mostly arose because of inadequate plumbing and building skills, poor building materials and lack of inspection during the construction.

11 Practical experience and lessons learnt

The workshop in 2009 gave a multi-stakeholder perspective of the factors leading to the eventual failure of the project, in terms of reaching a “tipping point” where flush toilets and a decentralised wastewater treatment solution were installed, and the dry toilets removed. Mini-flush toilets were connected using the already functioning small greywater pipes to an onsite treatment plant using effective composting microbes, all gravity fed.

The “failure” of the Erdos eco-town project with urine diversion dry toilets does not mean a failure of the urban ecosan concept in general. There are several similar projects of smaller scale that have been successful and are permanent. Sustainable sanitation needs to be promoted, given the problems of water and resource scarcity and the need for environmental protection and sustainable urban development. The following are the main lessons learned for this project.

Technology

- User interface is the key! The toilet must be the right design and convenient to use. One of the key problems identified was the seat riser, which was immature in its development and not convenient to use or acceptable by the households. The turning-bowl mechanism and urine pipe connection were particularly troublesome if the toilet was not installed properly over the chute pipe. The manufacturer took no responsibility to repair these errors.

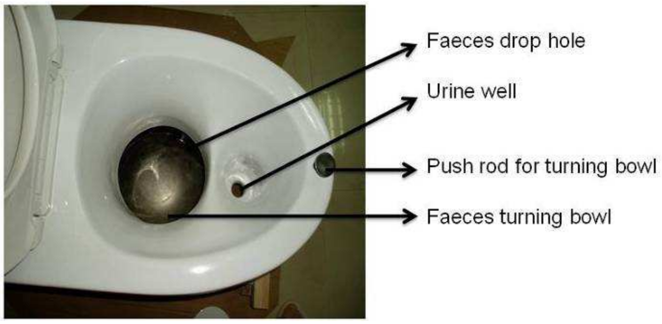

Fig. 9: Urine diversion dry toilet pedestal (source: SEI).

- *A proper feasibility study with different technology options should have been carried out*. The developer was rushing the development so that the units could be sold as quickly as possible. It seems that there was a disconnect between the stakeholders, with some of them not realising or accepting that this was experimental technology. For greywater treatment, different options were considered, and also for composting. But the lack of fully comparable scenarios made it difficult to predict how the system would perform at EETP. For example, actual greywater quality was different from the design due to the low amount of water used by the households.
- *Supervision on construction quality control and inspection is crucial*. The project was characterised by improper construction and plumbing, e.g. urine and greywater pipes were particularly bad and the ventilation system did not always work according to design. Blueprints weren't followed carefully and inspection was inadequate.
- *Start on small scale, before going to large scale*. An R&D Project should demonstrate and test the feasibility and effective operation and maintenance before going to scale. This would make necessary modifications less costly and workable (the timing of the project was dictated by the building company which did not allow for adequate testing and development in one building first, nor prior inspection of the work done).
- *Households and developers need a mature and standardised sanitation technology*. The source separation system is often a new technology and standards do not exist yet. Considering the R&D character of the project it was important to communicate this issue to all relevant stakeholders, especially the households, beforehand and make sure the project could tackle problems in the short time.

Socio-cultural and institutional

- This type of ecosan technology puts the sanitation system closer to the user, therefore user awareness of benefits and their acceptance is crucial.
- It is important to involve households more in project development, management and maintenance, especially if they are also owners of the apartments. This is also expected to assure a smoother handover of the project at the end.
- Establish a continuous and truthful communication strategy between all stakeholders and especially for the households. This can be supported by involvement of a professional public relations officer. The project did have a social worker who worked within the maintenance team which had major positive impact but the capacity could not be made permanent.
- Identify local champions as these persons can lead the remaining community in awareness and acceptance.
- If possible select the target group well, but otherwise consider the needs of a "floating/migrating" population with different backgrounds, attitudes and habits. The technology and a communication strategy must cater for this.
- Consider that changes in mindset and behaviours take a long time, especially when introducing a new sanitation system.

The weakest link in this project was household acceptance and as a result the sustainability of the solutions was in question because of user resistance. The households had very different expectations. A common comment from households was that the toilets were awkward to use, and explaining their function to visiting family relatives and friends was considered an embarrassment and unnecessary burden.

These residents were relatively well-off, with expected increased "westernised" standards of living. Another major problem was the cost of collection and maintenance which the local government did not want to take on and the households had to cover themselves. This is one of the reasons for shifting to the waterborne system.

Project Management Needs

- Regarding the link with the building company, special efforts should have been made by the local government to agree on responsibilities and additional costs due to construction mistakes.
- Long-term and continuous technical support by experienced experts is a necessary component for such projects.
- Establish a single project management unit including one chief engineer and other well trained staff with sufficient technical expertise and responsibilities in managing the project. The project suffered from the fact that a local chief engineer dedicated to the project did not exist.
- Capacity building for all stakeholders is necessary throughout the project. There was training of all stakeholders including households. There was essentially no time for builders and plumbers to learn from initial trials.
- Assure timely and good O&M service to address problems. This also includes ensuring the availability and stock taking of spare parts. The project had an excellent maintenance team along with a 24 hr hotline.
- Proper reporting and databases are necessary in R&D projects that can identify crucial points on construction, O&M and user satisfaction/complaints and can help to improve overall project management. It will also support the technical, economic and social evaluation of the project. These were done within this project.

External factors

External factors can be "killing" but also driving factors for projects, and should be considered with enough flexibility to account for potential changing conditions in project design and during implementation. In the EETP, the following external factors changed during the project duration:

- Changes in local development and standard of living (a sharp rise in standard of living with the increase in value of coal)
- Changes of target group with different aspirations, expectations and awareness. Originally the project targeted lower-income displaced farmers moving into urban areas, but ultimately many tenants were higher-income people who were familiar with the urban lifestyle and had higher expectations.
- Changes in local political support, e.g. governmental representatives and the governor changed several times during the project period.
- Changes in beneficial and hindering boundary conditions, for example climate, water availability, water price, policies, etc. (in this case, water scarcity was no longer a problem, at least not for the short term, once the pipeline to the Yellow River was built and fossil groundwater supply was increased).

The location of project should be carefully chosen:

- Locations with pressing environmental concerns and/or high ambitions for environmental protection and water saving should be chosen. In Erdos there were definitely pressing environmental problems like water stress, but people surveyed generally did not care much for the environmental benefits of a dry system.
- Proximity to agriculture should be sought to keep transport distances between the generation and use of the ecosan products short. The distance was about 30 km which might have been too far.
- Governmental support should be guaranteed and favourable policies for sustainable development are crucial. Governmental support clearly declined over time. Also, note that the District government had invested quite heavily in the conventional waterborne system infrastructure. Zhu (2008) describes the EETP as “an island of eco-town surrounded by the sewage system”. There was really not much incentive for this kind of new development.

Fig. 10: Private bathroom with urine diversion dry toilet pedestal (source: C. Olt, 2008).

In 2009 four modified Separett urine-diverting dry toilets www.separett.com were test-installed in one stairwell. They were connected via the chutes to the basement bins by sawing off the bottom of the toilets and inner pails. These functioned well from the summer of 2009 to the end of 2010 when the trial was ended. The owners were happy with the toilet performance. So in the end, a toilet model with self-contained ventilation features proved to be a workable solution. Future projects are therefore advised that self-ventilating toilets will help ensure odour management at the user level – much similar to the water lock that flush toilets have.

12 Sustainability assessment and long-term impacts

A basic assessment (Table 2) was carried out to indicate in which of the five sustainability criteria for sanitation (according to the SuSanA Vision Document) this project has its strengths and weaknesses (to the end of 2009).

Table 2: Qualitative indication of sustainability of system. A cross in the respective column shows assessment of the relative sustainability of project (“+” means: strong point of project; “o” means: average strength for this aspect and “–“ means: no emphasis on this aspect for this project).

	collection and transport			treatment			transport and reuse		
Sustainability criteria	+	o	-	+	o	-	+	o	-
• health and hygiene			X	X				X	
• environmental and natural resources			X		X				X
• technology and operation		X		X				X	
• finance and economics			X		X				X
• socio-cultural and institutional			X		X				X

Sustainability criteria for sanitation:

Health and hygiene include the risk of exposure to pathogens and hazardous substances and improvement of livelihood achieved by the application of a certain sanitation system.

Environment and natural resources involve the resources needed in the project as well as the degree of recycling and reuse practiced and the effects of these.

Technology and operation relate to the functionality and ease of constructing, operating and monitoring the entire system as well as its robustness and adaptability to existing systems.

Financial and economic issues include the capacity of households and communities to cover the costs for sanitation as well as the benefit, such as from fertiliser and the external impact on the economy.

Socio-cultural and institutional aspects refer to the socio-cultural acceptance and appropriateness of the system, perceptions, gender issues and compliance with legal and institutional frameworks.

For details on these criteria, please see the SuSanA Vision document "Towards more sustainable solutions" (www.susana.org).

Regarding long-term impacts, the following is concluded: Although the EETP is now terminated (i.e. the dry sanitation system is no longer in place), the lessons learnt from the project continue to provide a showcase for green construction in water-scare areas of China. The EETP will continue to act as a learning and showcase project for ecological sanitation.

A book describing the findings was published in 2012 (Rosemarin et al., 2012).

The following conclusions about this project are from the PhD thesis of Flores (2010):

- Despite the fact that the EETP ultimately did not realise its vision of a dry system with complete resource recovery, it signifies a great leap forward in understanding the practical realities of a resource-oriented sanitation system in an urban setting. It is also a sharp reminder that much work needs to be done towards making sanitation systems more sustainable. How the fate of the EETP will ultimately affect the future of ecosan in an urban context in China, and in the rest of the world, remains to be seen.
- It has undeniably raised more awareness of the challenges and disadvantages of urban ecosan, particularly amongst those who have been its most resolute supporters. And it seems likely that the Chinese government - and its citizens -would be wary of innovative dry, or perhaps even waterborne, sanitation systems in the near-term. This is unfortunate, given that China's new urban areas offer such ripe potential for breaking away from conventional sanitation systems and their sustainability limitations.
- For those who have been harsh critics of ecosan, it may be tempting to point to the EETP as proof that ecosan cannot work and therefore should be abandoned - but this would be misguided. The resource-oriented principles at the heart of ecosan remain fundamental to the movement towards more sustainable sanitation solutions; there simply needs to be a broader, longer-term, and more practical view of how these principles can be implemented.

13 Available documents and references

- Rosemarin, A., McConville, J, Flores, A., Zhu, Q. (2012). *The Challenges of Urban Ecological Sanitation: Lessons from the Erdos Eco-town Project,* Practical Action Publishing, UK. 101 p. http://developmentbookshop.com/the-challenges-of-urban-ecological-sanitation.html?dm_i=10U,UW70,3FY8TC,2JK50,1
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14 Institutions, organisations and contact persons

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Director of Dongsheng Project Office, Local Project Manager, Madame Sun Lixia
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Manufacturer of the original porcelain UD toilet, urinal and other ecosan installations: Chaozhou Meilong Ceramics Industry, Guangdong, China.

Case study of SuSanA projects

Urine diversion dry toilets in multi-story buildings, Erdos City, Inner Mongolia Autonomous Region, China

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