ApaSan Proiectul Elveţiei de Apă şi Sanitaţie în Moldova

Designing Water Supply Systems for Rural Moldova:

Experiences from the ApaSan Project

Dealing with High Demand for WSSs and Local Limitations

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Picture: New water tower under construction in Târgul Vertiujeni that will replace the old tower in the back

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1 Introduction

In low-income countries, raising the funds necessary for infrastructure development can be a struggle, especially in rural areas. In the case of water supply, engineers have to deal with the high demand for drinking water, legal frameworks that may not be well-adapted to rural contexts and a lack of funds. This makes choosing the most cost-efficient design of crucial importance in order to reach as many people as possible with the available resources. Compromises between country norms and actual needs have to be found (at least temporarily) in order to improve people's quality of life and avoid health problems related to the consumption of contaminated water.

Within this context, the Water and Sanitation Project in Moldova (ApaSan) (2008—2019) was implemented by Skat Consulting Ltd. (Skat), with funding from the Swiss Agency for Development and Cooperation (SDC) and co-funding from the Austrian Development Cooperation (ADC). The aim of the project was to develop and promote sustainable models for water and sanitation services in rural areas of Moldova. As part of the project, Skat implemented several water supply systems (WSSs) in a number of Moldovan villages. This document describes Skat's practices through the ApaSan project in the context of the actual norms and general practices for the implementation of WSSs in Moldova.

2 General Moldovan Practices for WSS Design and Approval

The general practices for WSS design in Moldova have not changed much since the country's Soviet era. While several new regulations in the construction of WSSs were developed and have been officially adopted in Moldova (including some European norms), the main guiding norms for the sector (SNiP 2.04.02-84) are still the ones directly-inherited from the former Soviet Union.

In general, these norms are applied as a basis for design, with authorities reluctant to approve projects not designed according to them. However, construction authorities have become more open to adapting designs and construction regulations to the real contexts in recent years thanks to the involvement of the development partners and local design engineers.

3 Problems Identified by Skat

3.1 Actual Water Consumption in Rural Moldova

In rural areas, the guiding norms require the design to dimension for a minimum water consumption of 125 liters per capita per day (l/cap/day). However, if households do not plan to have tap water inside their house, a minimum consumption of 30-50 l/cap/day can be considered.

Skat conducted several studies to better understand actual water consumption patterns in rural areas and found that they are highly-divergent from the guiding norms. By comparing these figures and understanding how they relate to rural contexts in Moldova, an accurate picture of water consumption in these areas can be formed, and the most appropriate design parameters for WSSs can be selected.

In 2014, Skat carried out a general household survey on water and sanitation in 26 Moldovan villages having a WSS that had been implemented with support from Skat in order to further investigate water consumption habits in rural areas. Water consumption was estimated by the inhabitants themselves, without cross-checking their water meters. On average, a water consumption rate of 83 l/cap/day was estimated in households connected to a WSS, from which 53 l/cap/day were from piped water and 30 l/cap/day were from shallow wells or other non-piped sources that are still used to reduce water bills (Skat Consulting Ltd., 2016).

In 2015 and 2016, Skat completed a water consumption study in 7 villages having a WSS implemented within the framework of the ApaSan project. The goal of the study was to identify the actual water consumption from tap in order to design future WSSs in a more cost-efficient way. The data was acquired each month from the Water Consumer Association through their monitoring of individual water meters. The average daily per capita water consumption (over a one-year period) was found to be 36.7 l/cap/day (Skat Consulting Ltd., 2018).

Table 1 shows a direct comparison of water consumption expectations from the three sources discussed above (i.e. guiding norms, the 2014 survey and the 2015-2016 study).

Table 1: *Comparison of Moldovan water consumptions norms and Skat findings*

Source	Expected water consumption from tap	Remarks
SNiP 2.04.02-84 (Moldova)	125 l/cap/day	Based on Soviet norms
2014 household survey (Skat)	53 l/cap/day	Estimated by households
2015-2016 water consumption study (Skat)	36.7 l/cap/day	Based on water meter readings over 2 years

3.2 Oversized Systems

When comparing the guiding norms with the realities found in the survey and study, a systematic over-dimensioning of WSSs is to be expected if the guiding norms are followed. This, in turn, leads to systematic cost increases that add an unnecessary burden on local communities. Moreover, the inherent high retention time of water in such oversized systems can lead to particles settling and biofilm developing within the pipes and reservoirs, ultimately leading to water quality and health safety concerns.

This high difference between the guiding norms and actual consumption also presents a problem for designing sanitation systems as oversized wastewater treatment plants may not work properly with too little generated wastewater[1].

3.3 Over-Supplied Systems

The Moldovan guiding norms provide clear instructions on the equipment that should be installed in a WSS. However, some of these instructions do not adequately take into account real needs or do not take into account the possibility that a WSS could be developed in several phases over time. As a result, WSSs designed strictly following these guiding norms are often too expensive to be supported by local communities. Moreover, the extra components/facilities do not improve system sustainability in general and are often lost, stolen or degraded over time.

3.4 Bad Water Quality

Whenever a village mayor requests that a design company prepare necessary documentation for building a WSS, the standard request regarding the water source is usually a deep well. In most cases however, deep well water in Moldova is geologically contaminated (with elements such as fluoride, sulphates, iron, etc.) and cannot be used as potable water. In these cases, an expensive system is usually built. Residents, however, then tend to not make use of the new system and consume non-potable (technical) water instead, refusing to pay for the more expensive water and believing it to be of bad quality.

4 Skat Practices for WSS Design and Implementation

In order to optimize the use of limited available funds, Skat set specific priorities for the development of new WSSs that would keep investment costs reasonable and operational costs sustainable for local communities.

Obviously, the main priority was to supply water safe for consumption and in sufficient amounts to support the basic needs of all (or at least parts) of the villages in which they are implemented. With this in mind, the systems were planned and implemented in such a way that they would provide access to water in sufficient quantity and quality for all households in each village. Furthermore, the systems were implemented with all necessary components (reservoirs, pumping stations, protection areas, etc.) to provide service but without additional cost-increasing measures such as double piping, backup diesel generators and hydrants every 200 meters. Instead of the aforementioned additional components, Skat always planned and implemented individual connections for all households[2] that contributed financing to the construction of the system. This contrasts with the general practice in the country of leaving the individual connections out of the project and letting beneficiaries connect themselves later, whenever feasible/desirable for them[3].

Overall, the ApaSan project strived to support local authorities with the construction of basic (but carefully-designed, solidly-built and fully-functional) WSSs that supply potable water to 75% of all households from day 1 (and also provide

[1] See *Introduction of Constructed Wetland Technology for the Treatment of Wastewater in Rural Areas of Moldova,* available at http://apasan.skat.ch/sanitation-in-villages/

[2] A financial contribution was requested from at least 75% of the total number of inhabited households in the village.

[3] This usually leads to low connection rates (typically only 30-50%) and results in low investment efficiency (i.e. a high cost per actual connected household).

everything necessary for the connection of 100% of the households eventually). Local authorities can later, should needs arise, further extend the system.

The following chapters focus on how Skat implemented these basic WSSs.

4.1 Minimum WSS Capacity

The minimum delivery capacity provided by WSSs built through the ApaSan project was fixed at 50 l/cap/day. This number is based on an average yearly water consumption of 36.7 l/cap/day (see Table 1) to which was added the need of extra water during seasonal and daily peak consumption and the need to guarantee a minimum discharge of 5 l/s over a 3-hour period for firefighting purposes (derived from the guiding norms). It is important to note that the WSSs were not initially designed to sustain garden watering. In practice, many WSSs had capacity levels that exceeded 50 l/cap/day, guaranteeing enough water for firefighting and peak consumption during summer months.

As population levels in Moldovan villages tend to remain stable or decrease due to the emigration to larger cities and foreign countries, no population growth was considered in calculating WSS capacity.

4.2 Storage volume

The volume of reservoirs (water tanks or water towers) was calculated taking as basis the reserve required for firefighting, calculated according to the norms (a minimum of 5l/s for 3 hours, leading to a volume of 54m^3).

The norms foresee that the necessary buffer volume between inflow and outflow from the tank has to be added to the firefighting reserve. However, the project's practice, agreed with the authorities, was to limit the storage volume to the firefighting reserve, if the necessary buffer volume did not exceed 30% of the firefighting reserve. The volume would be increased only in cases where higher buffer capacities were needed, e.g. when big consumers (institutions, hotels, industry) are present. Keeping the storage volume within reasonable limits allows to keep costs low and minimizes the risk of water quality deterioration due to long retention times in the water tanks.

4.3 Spring Catchments

Considering the available potable water resources in the country, the ApaSan project actively promoted professionally-built spring catchments as main water sources for rural, decentralized water supply systems. Spring catchments were developed in places where springs with sufficient water quality and quantity were available. Before developing the sources, long-term yield measurements were completed, and water quality analyses were performed.

The main advantage of spring catchments compared to other water sources (i.e. deep wells and surface water) is that, in most cases, they provide potable water of excellent quality that does not require additional treatment.

The development of spring catchments has, so far, been less popular with Moldovan design engineers as their successful construction requires a lot of experience and catchments cannot be built within the existing rigid norms. It is expected that the more than 30 spring catchments built successfully through the ApaSan project have contributed to demonstrate the advantages of spring catchments and that the necessary capacities for their construction are now in place in several local companies.

4.4 Water Treatment

For locations where potable water sources were not available, Skat conducted research for appropriate water treatment technologies. In this regard, Skat identified a cost-efficient water treatment solution for ammonia, iron and manganese removal from groundwater, all of which are common in Moldovan groundwater. The technology is known as in-situ ammonia, iron and manganese removal[4] and has been successfully and sustainably implemented in two villages. It consists in the injection of oxygen-enriched water into the underground aquifers, which allows for the oxidation and precipitation of the contaminants. The technology has the advantages of needing only a minimum amount of time and money to maintain. Moreover, it does not involve the use of any chemicals and is fully-automated.

Another successfully-applied simple treatment technology for the removal of ammonium,

[4] See *Experience with In-Situ Groundwater Treatment for the Removal of Iron and Manganese in Moldova* http://apasan.skat.ch/water-supply-in-villages/

manganese and iron was aeration followed by filtration (ex-situ technique).

4.5 Adaptation of the Pumping Station

According to the guiding norms, a second source of electricity should be present in WSSs in order to ensure operation of the WSS in case of failure of the electrical grid. Typically, this second source of energy is an electric generator; however, the high risk of the theft of such equipment and the generally low readiness and/or ability of local operators to perform preventive maintenance led Skat to take the decision to not provide a generator as a backup.

Also according to the guiding norms, a second pipe should link the pumping station to water reservoirs as a backup. Considering that the unused pipe would undergo degradation while not in use and, thus, rarely be able to fulfill its intended purpose, Skat elected to not implement such double piping either.

4.6 Pipe Diameter

The pipe systems were designed to ensure a minimum pressure of 1 bar and a maximum pressure of 6 bar, ensuring enough water pressure for delivery to all customers and avoiding contamination in the case of leaking pipes. The pipe diameters were calculated using state-of-the-art methods and adapted to the actual capacity of each WSS. Whenever the calculated pipe diameter was smaller than the minimum diameter required by the guiding norms (75 millimeters for looped pipelines and non-looped pipelines which must not be longer than 200 meters), a pragmatic solution was sought with the verification agency to accept the smaller diameters, where reasonable.

4.7 Hydrants for Firefighting

According to the guiding norms, hydrants should be provided every 200 meters. With the agreement of fire security authorities, Skat implemented hydrants close to big public buildings (schools, hospitals, town halls, etc.) and at least one additional hydrant in each village's sector.

4.8 Acceptance by Authorities

As the final designs did not always follow all the requirements of the guiding norms, local designers and authorizing authorities were sometimes reluctant to authorize the proposed WSS designs for implementation. However, the required permits and documents were all obtained as all chosen design adaptations were well-justified and the WSS capacity was based on actual water consumption.

All WSSs implemented within the ApaSan project were officially-approved (with or without further technical considerations) and were legally commissioned. Moreover, the executed works were often qualified by inspecting authorities as being of exceptional quality.

5 Advantages and Disadvantages

By designing WSSs as described above, Skat considers it was possible to reduce costs by at least 20%. This savings enabled more people to receive access to safe drinking water via a fully-functioning "source to tap" system. The implemented systems have the advantage of preventing health risks as a high enough pressure is ensured in the pipes to avoid external contamination by pathogens and chemicals. Another advantage of these lower capacity systems is that the retention time in the pipe is much lower, minimizing the risk of biofilm development and sand deposits.

Nevertheless, the systems do have some drawbacks. Due to the lower capacity, water shortages can occur in summer months, especially when people use water from the WSS to water their gardens and animals when shallow wells are dry, or when the spring catchment dries out due to a lack of precipitation. Those shortages may lead to pressure drops as well, allowing the infiltration of non-potable water from the nearby environment into the WSS. Several solutions have been adopted by WSS operators to face those shortages, including:

1. Additional water sources (where available and possible) were connected to the system.
2. Water is provided by village sector (e.g. sector 1 is supplied on odd days of the month and sector 2 is supplied on even days of the month). This solution does, however, present a health risk as pipes are emptied, allowing the infiltration of potentially contaminated water into the system. This solution is not recommended by Skat.
3. In some villages, incremental fees (block tariffs) have been introduced in summer months in order to discourage big water consumers. This solution is often effective but also often leads to discontent among consumers.

6 Conclusion

The WSS designs proposed through the ApaSan project allowed water to be provided to a larger number of people than if the WSSs strictly followed the guiding norms. Skat placed an emphasis on ensuring safe drinking water by implementing sustainable treatment units when needed. However, these infrastructural adaptations have drawbacks as water shortages are more likely to occur (mainly due to the limitations of water sources and excessive irrigation in summer months). Moreover, an upscaling of the existing WSSs will also add extra costs as pipes may have to be replaced.

In 2019, the government began efforts to improve the legal framework for WSS designs in rural areas. The order dated April 4, 2018[5] is a good example of adaptation, mitigating several of the aforementioned problems by decreasing the minimum required amount of water provided to 50-70 l/cap/day for systems with a capacity lower than 200 m^3/day. It should be noted that the order also adapted authorized concentration levels of certain chemicals in the water.

[5] *Ordin nr.179 din 04.04.2018 cu privire la aprobarea Regulamentului privind principiile de bazăîn proiectarea și construcția sistemelor exterioare de alimentarecu apă a localităților mici cu un consum sub 200 m3/zi*, Ministerul Economiei si Infrastructurii al Republicii Moldova