Cost analysis of sewage collecting network

VEIJO PÖNNI
BRAHEA CENTRE
UNIVERSITY OF TURKU
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1. Introduction

Visiting leisure boat harbors in the Baltic Sea area fascinates both national and international visitors, many of whom explore the coastal and archipelago areas using small leisure boats. Boat tourism is an important and popular way to spend a summer holiday in archipelagos and coastal areas, which provide beautiful and peaceful maritime nature experiences. However, staying and living for weeks in a leisure boat requires similar kind of community services to what we usually have at home, but those require a somewhat different way to be organized. Usually, it is the small boat harbor, which provides and sells most of these services to boaters.

The possibility of emptying toilet waste from leisure boats can be considered a fundamental service for boaters, which, when neglected, has a crucial impact on boaters' comfort during their boating holiday. In Finland, releasing toilet waste into sea or lake was forbidden already in 2005 and in Sweden, the same ban was introduced in 2015. Ever since those times, a network of sewage pump-out stations has been built. However, this basic service still suffers from problems, such as lack of easily accessible and functional pump-out stations; non-harmonized sewage collection equipment; and lack of easily accessible information regarding location and functionality of stations. It is also important to reduce visitor detours (having to make extra trips to other stations, when the nearest station is full or malfunctioning) by improving information regarding the pump-out station network and its' operability. Moreover, it can be difficult for international visitors to know what kind of waste handling and pump-out services that exist.

Both Sweden and Finland have an extensive archipelago with an active leisure boat life where boaters commonly cross between the borders of countries, over the Sea of Åland or the Baltic Sea, including Estonia as well. There is an active leisure boat traffic between Helsinki area and Tallinn Estonia. Although toilet waste collecting systems have been in place already for several years, there is still a need to address both technical and managerial challenges. In Estonia, where the boating culture is very young and not so common as in Finland and in Sweden, and the coastline is open and waters are shallow, the coverage of sewage collection services is low. Thus, it is important to upgrade the service level in Estonia. Cross-border collaboration and exchange of

experiences has the potential to facilitate mutual support, good examples and a more systematic approach to the management of toilet waste from leisure boats across the Central Baltic region.

The BATSECO-BOAT (Best Available Technologies of Sewage Collecting for Boat tourism) project is a collaborative project between three countries in the central Baltic region: Finland, Sweden and Estonia. The aim is to 1) increase boating tourism across the Central Baltic Region by investing in best available technologies for sewage collection and management and 2) create improved service facilities for all leisure boats visiting small boat harbors in the Baltic Region.

By installing new pump-out stations, the BATSECO-BOAT project also contributes to the objectives of EUSBSR (EU Strategy for the Baltic Sea Region) in keeping the sea cleaner by facilitating collection of nutrients from toilet waste from leisure boats and thereby reducing a source of algal growth and eutrophication. The project supports the tourism industry with a cross-border approach that benefits both entrepreneurs and public authorities, and the Baltic Sea environment as whole.

The main results of the BATSECO-BOAT project includes an upgrade of the sewage collection services in 18 leisure boat harbors in Estonia, in Finland and in Sweden. The upgrade is realized by investments into the best available technology of sewage collection, including both new (altogether nine devices) and renovated (altogether nine devices) pump-out stations. This upgrading ensures good level of unified sewage collection services in the participating leisure boat harbors across the Central Baltic region for the next 15-20 years, way beyond the duration of BATSECO-BOAT project.

The BATSECO-BOAT-project duration is three years (2018-2020) and it is coordinated by the Brahea Centre at the University of Turku. The other Finnish project partner is Keep Archipelago Tidy association. The Swedish partners are Ecoloop AB, UCV/Campus Roslagen and Norrtälje municipality. The Estonian partners are Hoia Eesti Merd (Keep the Estonian Sea Tidy) and Viimsi municipality. The BATSECO-BOAT project is funded by EU's Interreg Central Baltic program, and the total budget of the project is 1,48 million euro.

2. Method of cost analysis

Cost analysis is a typical method for internal accounting process of companies and other organizations. It is used to determine all relevant costs starting from setting up the organization and continuing to costs emerged from its operational or other business activities, either on yearly, monthly or even daily basis. Costs can be analyzed also on the level of different products or services, on department or divisional level or at the top on organizational entity level. Sometimes, even the exit costs of a business are analyzed, to determine whether is it worth trying to keep the business somehow running, or should it be just closed down. In certain businesses, there are legislative requirements to deconstruct the physical facilities of the business, or clean the ground, or fix the landscape and this emerges closing down costs, which can be substantial. Cost analysis aims to reveal the accumulated costs at any of these levels or sectors, so that it can be defined how much incomes, or turnover are needed to cover the accumulated costs. For any business, the ultimate purpose is to create profits and thus the target with incomes is to maximize those and at the same time minimize the costs.

Costs are generally considered as resources sacrificed or forgone to achieve a specific objective. It is in the interest of the organization how to manage those costs in a beneficial and rational way. This is called cost management and it forms an essential activity in organizational management. Operational activities usually refer to productive value added activities of an organization, which produces and provides products or services and then supplies those to their customers, who then have a willingness to pay for acquiring those products or services. That is the rational justification why the organization exists. Cost cutting as a managerial activity is easier and quicker way to adjust organizational performance, than increasing the organizational sales and cash flow, which usually requires even more costs to be sacrificed.

Cost information can be typically collected from the financial systems of an organization. This includes such as purchase ledger, salary payment programs, accounts payable and financial statements of previous accounting period. It is notable that only financial statements of registered

companies are publicly available (in Finland from the Finnish Patent and Registration Office), and most commonly from companies of limited liability. Thus, for a more precise cost analysis made by an external evaluator, organization must share its internal financial information. This data collecting is usually based on interviews of organizations financial officers and internal data collection made by them. In these cases, cost information can be pre-elaborated so that for example personal information is not disseminated or company level business secrets revealed. This is also the case with BATSECO-BOAT project and especially Keep Archipelago Tidy associations cost information.

The time span of the cost analysis and the nature of activity divides the emerged costs into variable and fixed costs. Variable costs are usually related to the volume of outputs the organization creates or service activities it implements, but in a very long time period, all costs can be regarded as variable costs. Fixed costs on the contrary are not dependent on the volume of outputs or operational activities by nature and are thus related to the existence of the organization or cost center. Cost calculations and analyzes of costs are also implemented with individual investment projects, which can be analyzed as a separate entity. Time span also means, that the future identified costs over the life cycle of an investment project or cost center needs to be discounted with suitable discount rate. Thus, we can reveal the current value of total accumulated costs over the life cycle.

Cost analysis aims to reveal and analyze what costs are relevant and what are irrelevant in terms of each accounting situation in question. It also looks to the categorization of costs as fixed and variable, and thus it is looking for different cost drivers. When the cost drivers are identified, it is in the interest of the organization to manage and control these drivers. The whole cost structure of an organization is also in the interest of managers and accounting people. Internal accounting processes can thus be turned to an external accounting activity, when companies compare their own cost structure with industry averages.

Commonly pricing of a service or a product is based on this cost analysis. Usually the price is set to cover at least the variable costs of providing that service or product, and then a share of the fixed costs is allocated in the form of overheads. This is the case with cost based pricing and it is

typically used when the level of competition is low. If the level of competition is high, and markets set the price levels, then it is the organizations task to seek cost cuttings to meet the market price.

In the case of BATSECO-BOAT project and its investments into new pump-out stations, it is more relevant to analyze the operational costs related to maintenance of floating pump-out stations, than to include the actual investment costs into calculations. Floating pump-out stations are quite expensive devices as investment objects and because the collecting system does not yield any direct cash flow to the owners of the system, the initial investment costs can thus be regarded as irrelevant. Investment costs are then called as "sunk costs" - lost resources, which do not yield any future income. It is more important to analyze what form of sewage collecting network can be operated and maintained efficiently, with smallest amount of accumulated operative costs.

When there are several locations for new pump-out stations to be considered, the long-run or life cycle service costs of pump-out stations in different locations can be regarded as the relevant decision making factor. The usual operational life cycle of a pump-out station is 15-20 years and thus the discounting of the future costs should be relevant as well. Assuming that the annual service costs remain on same level through the life cycle, including larger service work, say every five years, and taking into account the change in value of money, and that way forming the discounting rate, generates the current value of those accumulated life cycle service costs. Location and service costs can also effect to the actual investment decision of selected model and size of the floating pump-out station. In remote but still popular locations, it is reasonable to invest into larger models of floating pump-out stations, so that those can be serviced less frequently with fewer costs.

3. Cost analysis of floating pump-out stations in Finland

In Finland the responsible project partner of BATSECO-BOAT investments is Keep the Archipelago Tidy (KAT) association. KAT owns around dozen of floating pump-out stations around the Sea of Archipelago in Finland. Floating stations are located in such places where no similar services are available and usually this means the outer archipelago. There are no sewerage network nor wastewater treatment facilities available either. Yet, at the summer time, there are plenty of larger leisure time boats with their crews spending holiday in the archipelago and coastal areas. These boats commonly have a water closet with holding tank on board and thus they need to use the sewage collecting services every now and then. With these services, KAT responds to this demand.

Picture 1. Floating pump-out station in the Sea of Archipelago, Finland

KAT owns and runs their own service vessels, which takes care of the service of their floating pump-out stations. Just recently, for the Sea of Archipelago area KAT acquired a new Roope service vessel, which has an integrated maintenance system for servicing their pump-out stations. Earlier KAT used subcontracted entrepreneurs to do the service of some of the floating stations. These service agreements were usually made very well ahead in January and thus the service schedule of floating pump-out stations was fixed already way on beforehand. This is challenging for the usability of collecting network, because the fixed service schedule does not always meet the demand for service of the floating stations.

Picture 2. The new service vessel Roope, owned and operated by Keep Archipelago Tidy association

In Finland, also private and public marinas and guest harbors have sewage collecting services in their service portfolio. This part of the collecting system has commonly fixed electronic pumps, standing either on a floating pier right next to the shore or on a fixed pier, and connected to the local sewerage network. In these cases, the responsible owner of the pump-out station is either a

private organization or a municipality. Operating and service costs of these stationary pump-out stations are usually marginal in relation to the network of floating pump-out stations, and thus those are excluded from this analysis.

Based on the study made in 2016 for Tankkivahti –project and concerning the operational costs of servicing KATs network of floating pump-out stations located on the Sea of Archipelago, we could determine that the overall servicing costs of the local network were at highest around 16.800,- euros in 2016. This highest value is based on assumption that each of those twelve floating stations would be serviced individually and at least once a year, some of them are serviced 2-3 times per year. In 2016 KATs personnel serviced their floating stations altogether 19 times. Based on the total annual servicing costs and number of servicing times, we can constitute an average price for one service time:

	2016
Total annual servicing costs, €	16823,20
Number of services times	19
Average cost / service time, €	**885,43**

KATs service port is located in Hirvensalo Turku and the distances to each floating pump-out station were measured as optimal navigational route, with a priori assumption that each station would be serviced individually. The return transportation is usually made to the nearest port at the road end. A sewage truck then collects the amount of sewage collected from floating stations. Such ports are Vikom in Nauvo and Korpoström. Based on these measured distances, we can calculate a unit cost per traveled distance unit between the floating stations and the service port of KAT:

	2016
Sea transportation (€/NM)	9,74
Sea transportation (€/km)	5,26
Land transportation (€/km)	7,65

This calculation provides us a maximum of unit cost that can be used with the cost driver for decision-making criteria when evaluating the locations for new floating pump-out stations. Such

drivers are the distance of the new location from KATs home harbor and the nearest road end, and the amount of collected sewage.

Following amounts of sewage were collected during years 2014-2016 from floating stations located in the area of Finnish Sea of Archipelago:

	2014	2015	2016
Sewage collected, m3	46,7	41,8	56,2

In 2016 the average total cost of collecting a cubic meter of sewage from leisure boats to a network of floating pump-out stations and transporting it to wastewater treatment facility in Turku accumulated an average total cost of 300 euros per cubic meter.

	2016
Total annual servicing costs, €	16823,20
Amount of sewage collected	56,2
Average cost / cubic meter collected, €	**299,35**

This average cost includes the operating costs of a service vessel, including salaries of personnel working time and consumed fuel, land transportation and reception at the wastewater treatment facility. Estimated costs represent the maximum of accumulated cost because the calculation is made with pre-assumption that each floating pump-out station would be serviced separately.

4. Cost analysis of floating pump-out stations in Sweden

In Sweden the structure and situation of sewage collecting network is somewhat similar than in Finland, though the collecting network in Sweden is fairly new and it still needs constant improvement, especially with the operational reliability. The sewage release ban in Sweden was introduced in 2015 and ever since then the collecting network has been built very quickly. The coverage of network can be considered good, but the problems arise with the functionality of the

service, since at worst times during the high season in July, every third pump-out station has been out of order.

In BATSECO-BOAT project, the investing Swedish project partner is municipality of Norrtälje, which will acquire two new floating pump-out stations to be located in the Norrtälje archipelago. The similar idea of comparing different options for new locations based on the actual service costs of floating pump-out stations could be relevant in Sweden as well. Decision making of the new locations should be based on lowest life cycle service costs, in accordance with revealing the boat traffic nodes lacking the proper sewage collecting services. A sheltered location should be found, so that the washes of passing boats or rough weathers do not disturb too much the usage of floating pump-out station.

In Norrtälje, as surely in many other coastal municipalities of Sweden, the service agreements of collecting the sewage from floating stations are made very well in advance and on a slightly different basis. The municipality of Norrtälje has agreed with a service vessel operator, that they will service the floating pump-out stations located in the municipality area, despite where those are located. The only driver for the billing is the amount of sewage collected. Following fixed prices (on page 11) have been agreed[1]:

	Emptying price	
Volyme of sewage collected per floating station, m3	**SEK**	**EUR**
<3	2900	273,6
3-15	3500	330,2

The schedule of service is agreed very early before boating season and typically the pump-out stations are serviced during weeks 18 and 35. This can be regarded as quite early and quite late moments in relation to the boating season and when it is at the highest. Because it is very difficult to foresee which pump-out station and when will get filled up, it is thus very well possible, that the

[1] Cost information is collected with an interview of Fredrik Klingstedt

floating stations might get full already in mid-July and then be out of order at the highest point of the boating season. This, of course, is not a pleasant situation for boaters looking for a possibility to empty their boat toilets holding tank. If there is no other pump-out station nearby, boaters are highly tempted to discharge their sewage into the sea.

In Norrtälje and Stockholm archipelagos it is also possible to order a specific service on demand for the floating pump-out stations whenever needed, but the cost of this service is substantially higher – SEK 18.000,- which equals 1.655,20 euros[2] per service time. Because the service on demand is so expensive, and on the other hand pre-agreed service times are so cheap, it is obvious, that the municipality will choose the pre-agreed service schedule due to price reasons. This stiff service system mostly explains why so many pump-out stations are out-of-order or full already in July, at the highest boating season.

[2] Calculated with exchange rate EUR/SEK 10,8748 on 28.4.2020

Picture 3. The service vessel operating in Norrtälje archipelago

Not all pump-out stations in Sweden are floating ones. Quite a large number of stations, for example all stations owned by Stockholm Archipelago Foundation, are stationary i.e. fixed pump-out stations standing on a pier. Service costs of fixed stations are marginal, only occasional spare parts. In these cases, it is more important to have a stock of spare parts nearby or a good delivery chain, so that when the parts are needed, those can be delivered quickly and thus minimize the time the pump-out station is out-of-order.

5. Cost analysis of pump-out stations in Estonia

In Estonia, quite many private and public marinas and guest harbors have sewage collecting services in their service portfolio, though there are still holes in service network and those holes are to be filled by BATSECO-BOAT project. Due to the open coastline of Estonia, no floating constructions cannot be used, and thus all pump-out stations are stationary. These sewage-collecting stations are equipped with electronic pumps and they are standing on a fixed pier.

In some small boat ports, the pump-out station is connected to the local sewerage network and to the local or regional wastewater treatment facility. In other ports, a buffer tank of several cubic meters is needed, for collecting the leisure boats sewage for temporary storage. When the buffer tank is full or needs service for other reasons, a sewage lorry will come and empty the buffer tank.

Some small boat ports, and tourism destinations they belong to, have their own local wastewater treatment facility. In these treatment facilities, if those are operating with biological processing, the risk of boat owners sewage distorting the treatment process is similar than what is in the small treatment facilities in Finnish and in Swedish archipelagos. The composition of sewage collected from leisure boats is usually very strong, because water toilets in leisure boats use so little flushing water. That strong sewage might then cause damage to the bacterial flora of the biological processing.

Picture 4. The stationery pump-out station in TOP-marina in Tallinn Estonia

Also in Estonia, the responsible owner of the pump-out station is either a private company or a municipality. Operational and service costs of these stationary pump-out stations are again marginal when compared to the floating ones. Operating costs include only electricity consumed and occasional service parts for the pump itself or the hose with nozzle.

Any specific cost information from Estonia is not available since operating costs depends solely on each pump-out station, where it is installed and how much it is used. Information on scattered Estonian pump-out stations network is neither available. A local emptying service of the buffer tank is estimated to cost between 50-100 euros per service time, which depends on the amount of collected sewage and the distance of transportation to the wastewater treatment facility.

6. Conclusions

Cost analysis of sewage collecting network is an essential part of decision making when considering the locations for new floating pump-out stations. Especially, if we have several locations to be compared, it is meaningful to include the estimated life cycle service costs into the decision-making process. As one of the key decision criteria's, the lowest life cycle service costs should then matter. Different methods, such as discounting of the future service costs should be used to find the total accumulated cost over the life cycle of a pump-out station.

This short report provides some examples and estimated figures for these comparisons, as a guideline to be implemented in similar processes. Still, we must keep in mind that euros are not the only thing that matters when building or improving the sewage-collecting network, though they make investments possible.

Usually, the primary criteria's for decision-making are the lack of service in certain areas and the nodes of boat traffic i.e. where boaters commonly move during their summer vacation. Sewage collecting network should be improved wherever there are boaters moving around and there is demand for the service. Thus, the primary target for improving the sewage-collecting network is to provide the service for boaters and protect the maritime nature efficiently. The monetary matters come as a secondary level decision factor.

The BATSECO-BOAT project aims to create an upgrade of the sewage collection services altogether in 18 leisure boat harbors in Estonia, in Finland and in Sweden. The upgrade is realized through investments of around 300.000 euros into the best available technology of sewage collecting services, including investments into both new and renovated floating pump-out stations. This upgrading ensures better level of unified sewage collection services in the participating countries and small boat harbors across the Central Baltic region for the next 15-20 years, way beyond the duration of BATSECO-BOAT project.

7. Sources:

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Perkins Frances C., ***Practical Cost Benefit Analysis***, Macmillan Education Australia, 1994

Pönni Veijo, University of Turku, Brahea Centre - ***TANKKIVAHTI – Huviveneiden jätevesien kelluvan keruujärjestelmän digitalisoimisella saavutettavat hyödyt***, 2016

Interviews of following people and organizations they represent:

- Fredrik Klingstedt from Norrtälje municipality, Sweden
- Marek Press from KEST, Estonia
- Oscar Johanson from Stockholm Archipelago Foundation, Sweden

Glossary

Black water	Toilet wastewaters generated by humans
Central Baltic	Geographical area which includes land and sea areas around Northern Baltic Sea, southern Bay of Bothnia and Gulf of Finland
Deck fitting for boat toilet waste	Connecting part mounted on the deck of a leisure boat, where the pump-out nozzle penetrates to pump-out the boat toilet waste
Diaphragm or membrane pump	Pump which creates vacuum with the help of rubber film
Dry toilet	Toilet that operates without water flush
Eccentric pump	Eccentric disc pumps consist of a cylinder and pumping element mounted on an eccentric shaft. As the eccentric shaft is rotated, the pumping element forms chambers within the cylinder, which increase in size at the intake port, drawing fluid into the pumping chamber. The fluid is transported to the discharge port where the pumping chamber size is decreased. This action squeezes the fluid out into the discharge piping
Eutrophication	Process of where water is overly enriched mainly by nutrients (P and N) leading to excessive growth of algae and oxygen depletion.
Evacuation column	Vertical pipe for ventilation of a pump-out station's holding tank

Grey water	Water resulting from washing or cleaning, but does not contain toilet waste
HELCOM	HELCOM (Baltic Marine Environment Protection Commission - Helsinki Commission) is the governing body of the Convention on the Protection of the Marine Environment of the Baltic Sea Area
Holding tank	Fixed tank mounted in a leisure boat where sewage or toilet waste is collected for temporary storage
Impeller or centrifugal pump	Pump, which uses an impeller (a vaned rotating disk) to move the fluid around in a circular movement. The rotational energy typically comes from an engine
Leisure boat	Watercraft or recreational craft with hull length commonly less than 24m, that are intended for leisure or sport use
Leisure boat harbour	Refers to home or guest harbour, port or marina
Nozzle	Cone shaped head or tip of a hose connected to the deck fitting of a leisure boat and with a hose to a pump-out station
Peristaltic pump	In a peristaltic pump, the fluid is contained within a flexible tube fitted inside a circular pump casing. A rotor equipped with rollers compresses the fluid as it turns, facilitating the movement of the fluid. Moreover, as the tube opens to its natural state after the passing of the cam fluid flow is induced to the pump
Pump-out station	Device designed to extract and collect sewage (toilet waste) from leisure

	boats. Can be either floating or stationary
Sewage collection system	Network of different kind of pump-out stations for the use of boaters
Sludge	Semi-solid matter that is produced by a wastewater treatment process or by a sanitation system
Wastewater	Water polluted by human waste (incl black and grey waters) or by other human activity, excluding bilge waters generated by the water craft and collected separately