**Property name: Tampere Hall**
**Property owner: The City of Tampere**
**Consultants: Bionova Ltd**

# Total Concept method

Step 3. Follow-up

## Building and its use

**Year built**: 1990
**Area:** 28 357 m² Heated area
**Type of building**: Congress and concert centre

Tampere Hall is a congress and concert entre located in the city centre of Tampere, Finland. A venue for congresses, fairs and concerts, it hosts a restaurant, a café and cultural facilities for theatre, exhibitions. It was built in 1990 and is since then the largest congress centre in northern Europe with over 28 000 $m^2$. Virtually all of the building's surface is considered to be heated, apart from the ventilation engine rooms. Shortly after the building's completion, an adjacent hall was built, the Sorsapuisto hall (areas 10 and 11). In 2005, the Sorsapuisto hall was connected to the main building with a glass tunnel (area 9).

An extension between Sorsapuisto hall and the main building is to be built between 2015 and 2016. During the currently ongoing phase of the renovation, a museum (Muumilaakso) will move to the building. The facilities currently used by Rondo and Studio in the basement and first floor totaling 1020 $m^2$ will be renovated for the museum. According to the demands related to galleries, the museum requires special facilities with an extensive automated, mechanical ventilation in order to control humidity and temperature. Additional facilities are also created by adding an 800 $m^2$ multi-purpose area and by constructing an intermediate floor to restaurant Soolo in order to increase the restaurant area on the second floor. Dressing and backstage areas will also be realized in the small hall during the changes in the building use. Additional office spaces are also to be constructed.

The building is currently used as congress and fair centre and as a music concert and rehearsal hall. Lectures and theatre plays also happen there. There is also a restaurant and a café open to the public during the working hours of the centre. In the future, a permanent museum and a new restaurant will open on the ground floor. All these different activities imply that the use of the premises varies a lot and the schedule of the lighting and ventilation are very difficult to model for average use without very precise monitoring.

## Indoor climate

Presently, the indoor climate is satisfying in the building and improving indoor climate was not target of the renovation. In the winter, warm masses of air escape the ground level towards the higher levels of the main lobby, and this causes draft as well as important energy losses to replace the warm air downstairs. In the summer, the indoor air in the southern wing gets hot, while the basement has to be heated. Inside the conference and concert halls, working environment standard conditions and comfort requirements are guaranteed for the workers and the visitors. The building's cooling system has been improved by switching to district cooling in 2014.

## The status of the building and its technical systems before measures

### Building envelope

The building envelope is original from the respective building year (1990, 1992, 2005). The walls are concrete sandwich walls with mineral wool (125 to 175 mm) thermal insulation in the core. The facade is ceramic brick, glass and Kuru granite. The roof structure is mainly made of hollow core slabs with expanded polystyrene thermal insulation and bitumen finish. Windows display a wide scope of variations (glass walls, fixed/open windows, aluminium/wood framed windows).

The building envelope is protected by the Finnish National Board of Antiquities, so changes to the structure and to the outside appearance are impossible. The envelope is also of good condition. Due to this reason the main focus was on the windows for which the improvements would be possible without interfering with the protected appearance.

### Ventilation

The ventilation system are mostly original ones. 119 devices are distributed along 10 ventilation circuits leading to different areas of the centre. The system works with variable air flows. Only 5 systems are fitted with a heat recovery unit. The ventilation system fulfils the current requirements but is nearing the end of its service time. Concepts for renewing the system have been drafted but not implemented yet.

The ventilation is manually controlled by timing it to operate according to planned use/events in the building. Due to this reason there is no regularity in the use times as they depend on the events and use of the facilities each year.

### Heating

The building uses the district heating network to heat the premises. All areas are heated by hydronic radiators and warm supply air. The heating system is original from the construction. In the large building the heating/cooling requirements can differ between spaces and thus the building might be heated and cooled at the same time.

### Cooling

Until the summer of 2014, the centre was cooled by two electrical cooling units. They were shut down when the building was connected to the district cooling system. When switching to district cooling no changes were made to the cooling radiators but the system was created by lowering the temperature of the district heating with a booster pump when necessary. The kitchen, the café and the restaurant have their own electrical cooling equipment (fridges, freezers).

### Lighting

The lighting system is the one that has changed the most since the construction of the building. About 70 % of the 5700 lamps have been changed to LED-lights in the past years and this change is still ongoing. In the concert halls, precise lighting requirement and design conditions have made the switch to LED impossible until recently. A suitable model was found and change is now planned in both concert halls.

For the moment, there is no automatic control of the lights in the building. Many lights stay on all day in storage rooms, toilets, hallways etc. The installation of motion detector lighting is complicated by the lights switching off when people are in the facility.

### Equipment

The electrical equipment is very varied, ranging from coffee machines to sound amplification installations. It is difficult to assess the exact energy consumption of each device or even of groups of devices because there is no submetering in place. The kitchen holds a list of all its devices, but their usage is complicated to model since the activity varies greatly according to the number of workers, musicians and visitors in the centre.

### Water supply and warm water

The building is connected to the city's water supply network and water consumption is documented by the maintenance crew. Metering was included for hot water use during summer 2014. Based on the estimates of the building users approximately 35 % of the water is heated. The water is heated using district heating.

20 % of the faucets in the building have been replaced with electronic ones. Flow limiters have been installed to the remaining 80 % during spring 2013.

### Control and monitoring system(s)

The ventilation, heating and electric systems are monitored in real time using a computer software by Schneider Electric. The HVAC is manually driven and rescheduled daily on the grounds of the upcoming activities in the centre. There are no automatic controls of the ventilation and heating system. Technicians have to operate the system to cool down or warm up the premises. Monthly statistics and maintenance schedule are stored on the facility maintenance web portal of the centre. Only the total electricity and district heating consumption of the entire building are metered. There is no submetering.

## Energy and resource use before measures

**Consumption measured in 2013:**

The total district heat consumption in 2013 was 3050 MWh (heating 2930 MWh and warm water 130 MWh). Measuring related errors have been corrected by Tampere hall Ltd. The information related to district heating has been weather-corrected.

The measured results for 2013 and 2014 do not represent the current consumption as technical changes have been ongoing. District cooling was installed into the building in summer 2014 and was implemented in October. During the implementation the settings of the booster pump did not work as planned which caused increased electricity consumption in the subsequent months (September-October). This has been fixed, however the electricity consumption measured for 2014 could not be utilized in estimating the post-implementation consumption. In addition, TK62 was replaced in August. There has also been other changes in 2014; flow limiters have been installed in faucets and showers, few waterless urinals have been installed and the number of LED lights have been increased.

The change in the building's use also affected the evaluation of the energy and resource use. During the renovation the purpose of use will partly be changed into museum which causes tightened demands for the ventilation. Because the equipment need to be replaced due to the changed purpose of use, their replacement with minimum requirement ventilation equipment has been included in the new energy consumption baseline.

The equipment would be installed with coil heat exchangers fulfilling the yearly efficiency of 45 % required by legislation and a system with an SFP-value of at least 2 kW/m3/s.

**Calculated baseline of energy consumption in step 1 (including the changes of 2014 as well as the change in use) before presented measures:**

| | |
|---|---|
| Specific energy use before measures | 190 kWh/m², year |
| From which | |
| • Heat energy | 108 kWh/m², year |
| • Electricity | 72 kWh/m², year |
| • District cooling | 10 kWh/m², year |
| • Water consumption | 6 230 $m^3$, year |

The electricity use for ventilation purposes was extrapolated from the nominal consumption of the 50 biggest ventilation devices. This gives a total electricity consumption of 950 MWh or 33 kWh/$m^2$ in 2013.

The electricity consumption of the lighting was computed based on estimated utilization profiles and energy profiles of each lamp type. The result is 630 MWh, or 22 kWh/$m^2$.

The electrical consumption of the restaurant is based on the average electrical consumption of a restaurant per square meter according to RakMK 2013. The electrical consumption of the restaurant is 140 MWh or 5 kWh/$m^2$.

Because of the amount of user equipment and the changing use profiles, the electricity consumption of the equipment could not be calculated reliably. Therefore it was roughly estimated based on other known electricity consumptions and average consumption of commercial buildings. The electricity consumption of the equipment was calculated to be 340 MWh per year or 12 kWh/$m^2$.

District cooling was estimated based on realized values of August, September and October of 2014. The impact of the booster pump on the total electricity consumption of the cooling system was not separated. This is due to the fact that the electricity consumption of the booster pump will depend on the control method and its impact on the total consumption was estimated to be minor. Total district cooling was 290 MWh.

Information concerning water consumption was delivered by Tampere hall Ltd based on their own follow-up. Total water consumption in 2013 was 6306 m3 and 29 litres per visitor or 35 litres per userday. On the other hand, the consumption is affected by the flow limiters installed during spring 2014. This was estimated to affect the consumption by approximately 15 %. Metered data for the warm water was not yet available, but based on information from the building's maintenance and few metering results from spring 2014, the warm water consumption was estimated to be 35 % of the total water consumption. Based on this, the calculated baseline water consumption is 6230 $m^3$ per year.

**Corrected baseline in step 2:**

In Step 2 and Step 3 it was noticed that the estimated district cooling consumption of the building after the renovation in 2014 was a lot less than expected when creating the baseline. This had also an effect on the estimated electricity consumption in the baseline as the cooling energy was previously produced by cooling compressors. In Step 2 this was corrected to the baseline. The new baseline for energy saving measures was:

| | |
|---|---|
| Specific energy use before measures | 185 kWh/m², year |
| From which | |
| Heat energy | 108 kWh/m², year |
| Electricity | 72 kWh/m², year |
| District cooling | 6 kWh/m², year |
| Water consumption | 6230 $m^3$, year |

## Identified energy saving measures

Structural renovations are restricted by the protection of the building as well as its architecture. On the other hand the building's structures are in good condition which made related renovations are unnecessary. From the structural changes, mainly the ones in the vicinity of the extension were included in the package as the ongoing renovation can reduce their costs and on the other hand enable the implementation considering the use of the building.

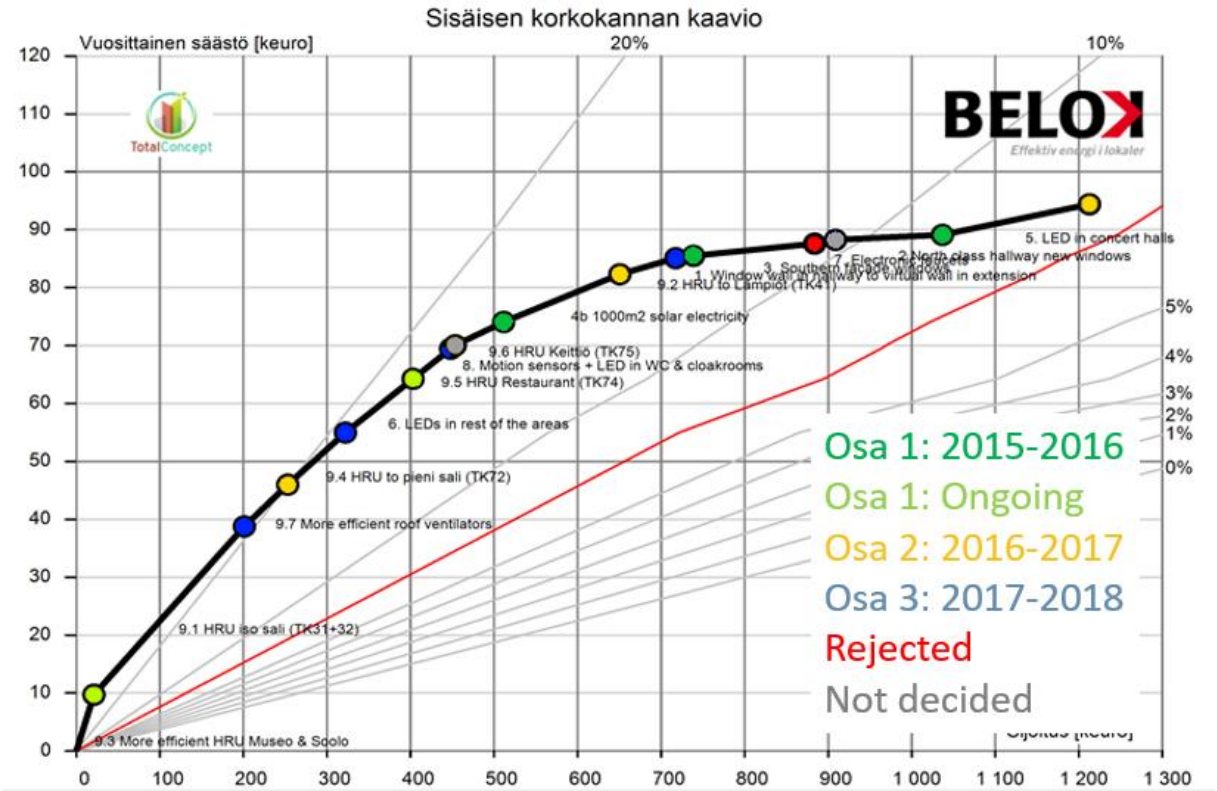
The Tampere Hall has invested in improving the lighting and the measures related to lighting play a major part also in this package. The package considers the benefits from both replacing the lights with more energy efficient ones and changing the control method. Implementing such measures is also possible during the renovation even when the building is being used.

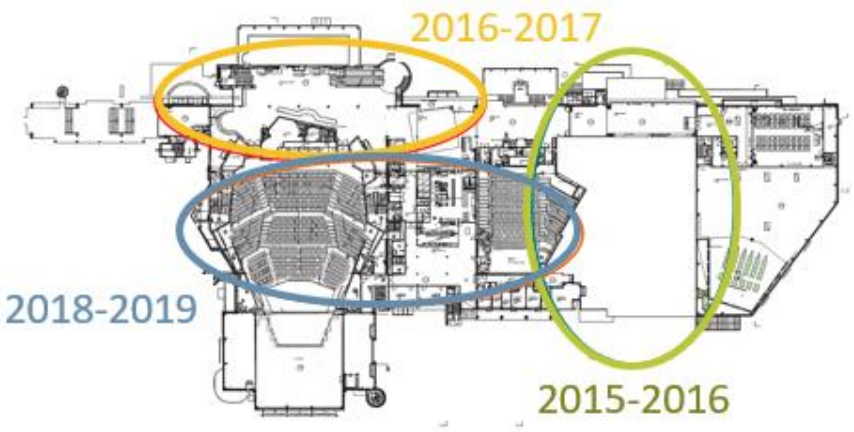
The solar panels were an important part of the package as they help Tampere Hall in the transition towards renewable energy, which reduces the energy bill. The panels also fit in the image of the building and were put forward by the building's management.

The most significant saving potential lies in the ventilation equipment, because of the 119 ventilation units in the Tampere Hall only 5 currently have heat recovery. In addition, most of the units have come to the end of their lifetime. The saving potential of the chosen ventilation units was found to be significant regardless of the challenges related to the structures of the building. Implementation of such changes was however hindered by the continuous use of the building.

## Summary of the measures in the action package

Due to building owner's and users' business targets and financial reality it is not possible to close the whole building at once for a renovation. Therefore, it was decided to divide the measurement package into several parts that affect a certain part of the building at a time. The renovation was planned to be executed in three different stages, each of them focusing on a certain part of the building. The whole action package, the stages of the renovation and the areas of building they are related to are shown in the figures below.





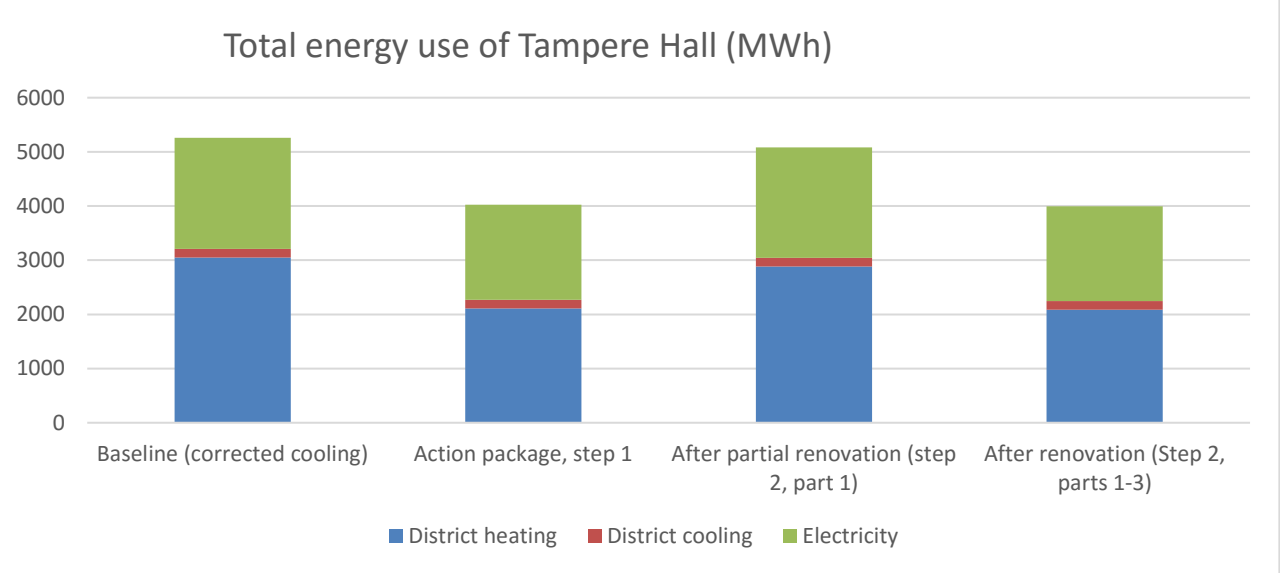

Up until now the first part of the measures have been carried out, some of them are still ongoing or under planning. The planned first part of the renovation included measures that were located close to the extension area, Rondo and Studio, which is turned into a museum or otherwise were possible to link to this renovation without harming the use of the other parts of the building. These measures included:

- *Measure 1: Replacing the southern glass window in hallway,*
- *Measure 2: Replacing northern glass window in hallway*
- *Measure 3: Replacing southern facade windows,*
- *Measure 6: Switching to LEDs in remaining areas,*
- *Measure 9.3: More efficient heat recovery for new ventilation for Moomin Museum,*
- *Measure 9.6: Adding heat recovery for kitchen ventilation unit*
- *Measure 9.7: Replacing roof extractors with more efficient ones.*

A number of further adjustments were made to this package in Step 2. It was decided to move Measure 9.7 to move to the later stages because of the tight renovation schedule due to demands of the extension, and measure 3 was left out because of the same reasons and because it was not deemed profitable enough as it was one of the least profitable measures in the original package. The other measures were carried out but technical adjustments were made. Calculated total energy and cost saving potential and profitability of the action package carried out in Step 2 compared to the proposal in Step 1 are presented in the table and graph below.

| Measure | | Step 1. measures chosen for part 1 of the renovation | | | Step 2. part 1. already finalized measures | | |
|---|---|---|---|---|---|---|---|
| | | Investment cost [kEuro] | Cost saving [kEuro] | Energy saving. [MWh] | Investment cost [kEuro] | Cost saving. [kEuro] | Energy saving. [MWh] |
| Part 1 | Replace the Southern glass wall with an opaque wall | 21 | 0.4 | 7.3 | 105 | 0.13 | 2 |
| Part 1 | Improve the Northern glass wall | 128 | 0.9 | 15.4 | 89 | 1 | 17 |
| Part 1 | Replacing the southern windows with more efficient ones | 145 | 2.1 | 38 | Rejected | | |
| Part 1 | Switching the lighting system to LED in the whole building* | 81 | 1.3 | 80 | 5* | 0.26* | 1* |
| Part 1 | Efficient heat recovery in the Muumin museum | 21 | 9.7 | 172 | *Step 2 ongoing. will be executed as planned by 4/2017* | | |
| Part 1 | Installation of heat recovery in the kitchen's AC system | 45 | 4.0 | 72 | 74 | 9.9 | 152 |
| Part 1 | Installation of more efficient roof extractors | 52 | 0.7 | 8 | Postponed | | |
| | Installation of 500 $m^2$ solar panels on extension's roof postponed | 70 | 4.1 | 45 | | | |
| | Switch to LED in concert halls | 176 | 5.3 | 42 | | | |
| | Installation of IR-faucets in workers' WC & cloakrooms | 18 | 0.7 | 5 | | | |
| | Installation of motion sensors in WC & cloakrooms | 5.6 | 0.6 | 5 | | | |
| | Installation of heat recovery in main concert hall | 180 | 30 | 520 | | | |
| | Installation of heat recovery in main concert hall's lobby | 67 | 2.8 | 50 | | | |
| | Installation of heat recovery in small concert hall | 69 | 9 | 161 | | | |
| | Installation of heat recovery in restaurant | 43 | 5 | 90 | | | |
| | Total | 1 230 | 94 | 1 233 | 273 | 11 | 172 |

**Measure is still ongoing. contains already replaced part of the lights*




| Net energy use [kWh/m$^2$] | Baseline (corrected cooling) | Action package, step 1 | After partial renovation (step 2) | After renovation (Step 2, parts 1-3) |
|---|---|---|---|---|
| District heating | 108 | 74 | 102 | 74 |
| Electricity | 72 | 6 | 72 | 6 |
| District cooling | 6 | 62 | 6 | 62 |

**Figure 12.3** Measured energy consumption of the different stages in the whole action package.

The profitability of the whole action package with the adjustments made in Step 2 as well as the action package that only contains the already executed measures are shown in Figure A and Figure B below.

According the adjusted action package in Step 2, the calculations show that after the execution of those measures that were completed during 2016, the total energy consumption of the building will decrease slightly to about 179 kWh/m$^2$. The estimated heat consumption will be approximately 5.8 % lower compared to the baseline and will be about 101 kWh/m$^2$ per year. Annual electricity will be approximately the same, 72 kWh/m$^2$ per year compared to the new baseline for electricity consumption. Total annual costs savings will be about 11 kEuro/year.

In 2019 after completing all the measures, the energy consumption is estimated to decrease up to 23 % being finally 142 kWh/m$^2$, which is a bit less than estimated in Step 1. The profitability of the whole action package will be 8.5 %, which is higher than 7.8 % that was calculated in Step 1 and clearly fulfils the client's requirement of 7 % profitability.

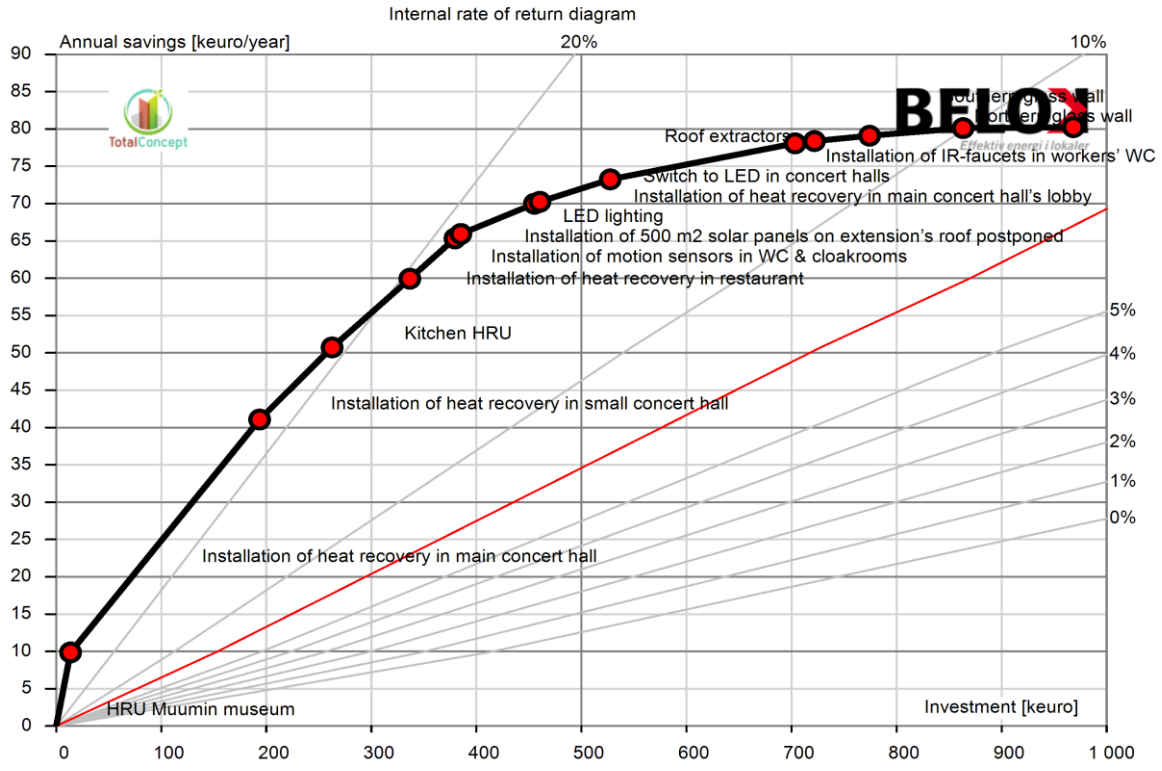



**Figure A**. Profitability of the whole action package with the adjusted data from Step 2.

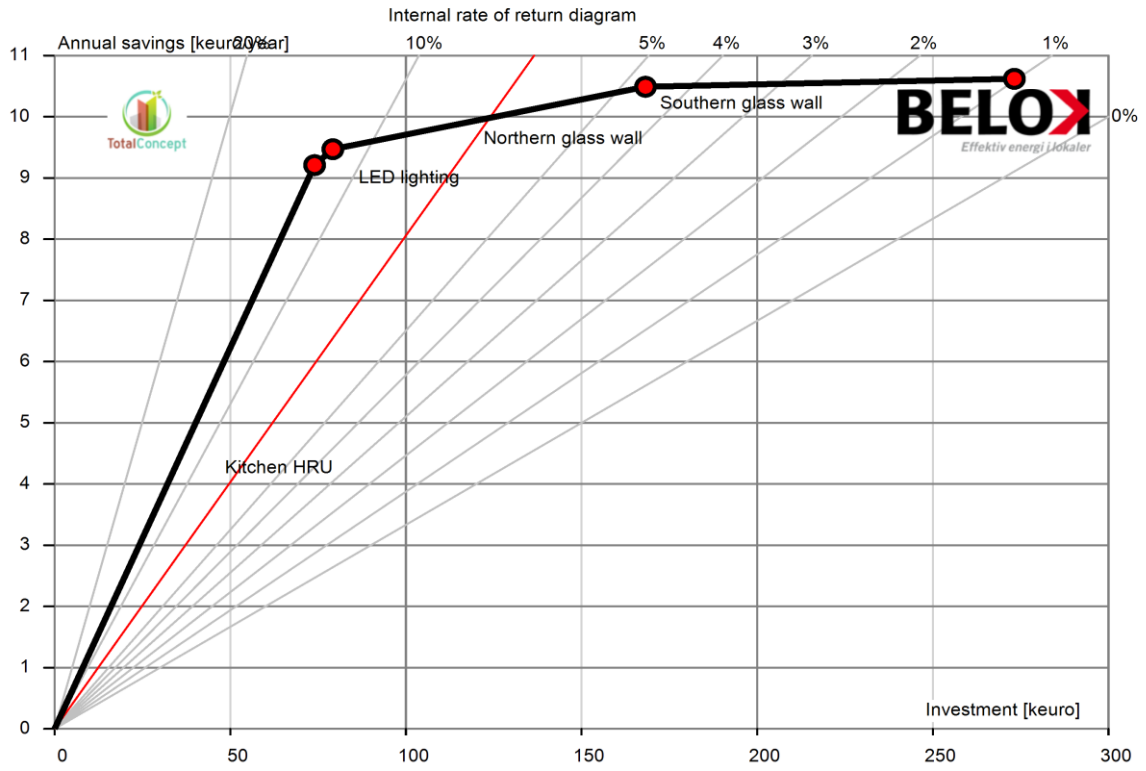


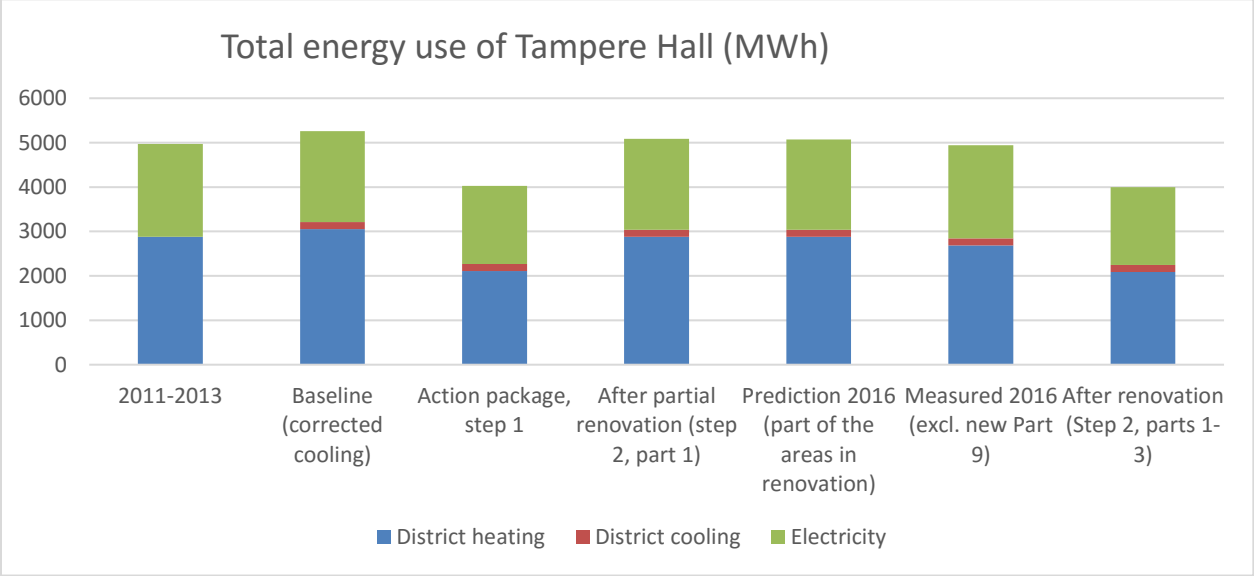

**Figure B**. Profitability of the already executed part 1 of the action package with the adjusted data from Step 2.

## Summary of the outcome of measurement and follow-up in Step 3

Three measures were completely implemented by spring 2016 close to the new extension of the building. The renovation is still ongoing in the other parts of the building and measure 9.3 will be finalized as part of that by spring 2017. Additionally, measure 6 which involves switching to LED lights in the building was partially implemented by spring 2016 and is still ongoing. The follow up for those measures that were finished by spring 2016 was carried out from May 2016 to December 2016.

As part of the building is still under renovation, a prediction for the energy consumption during the measurement period in 2016 was done and the measured results were compared to the estimated values to analyze the results of the energy saving measures. Generally, the prediction and the results in 2016 were quite close to each other. However, as the actual heat consumption in the building in 2016 was somewhat lower than expected being 7 kWh/m$^2$ and 7 % less, the electricity consumption was 3 kWh/m$^2$ and 4 % higher. The likely reasons for the difference in heat consumption lies in the areas that are under renovation as they have not been heated as much as the rest of the building. This was taken into account in the prediction but as the renovated areas moved during the year and different building parts are linked to each other, estimating this was possible only in a rough level. Therefore, the difference between the results can be considered to be within the error margins. Also, the changes in the electricity consumption are estimated to be linked to the renovation. The construction site electricity consumption was measured separately but it could be possible that not all of it was tracked. The tracked site electricity consumption was 37 MWh.

Because of the ongoing renovation in the building during the measurement period, the changing use patterns, the big size and complexity of the building, it is impossible to draw final conclusions on the energy savings yet. Instead the building should be reassessed in spring 2017 after the first part of the renovation has been completed.




The measured outcomes of those individual measures that could be measured were concluded to be approximately in line with estimations done in step 2. Therefore, the profitability of the final package with tcurrent informhe ation was concluded to be in line with Step 2 estimations: cost saving is approximately 11 kEuro/year and the energy saving 172 MWh.