Renovation and Energy Evaluation

Viiprurinpuisto Residential Project

Bachelor's thesis

Construction Engineering

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ABSTRACT

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ABSTRACT

This thesis topic is chosen according to the demand of the author's employer company which holds a renovation project related to this field of work. It is done with the help of a university lecturer as supervisor - Olli Ilveskoski.

The main objectives of this thesis is to examine whether ArchiCAD software energy evaluation system is functional or practical and to what extent can this system provide help in a real renovation/construction project. In addition, suggestions are made for possible future improvements of the system.

Theoretical parts of this thesis are mainly related to the building's thermal problems. Most of the formulas are based on the EU's recast Energy Performance of Buildings Directive and the National Building Code of Finland.

Research methods include using ArchiCAD software to create a BIM model of the object building and utilize the energy evaluation add-on to simulate and calculate the energy consumption of the building as well as its maintenance. Comparison is made between ArchiCAD data and real energy data from inhabitants.

The conclusion of this thesis indicates that ArchiCAD energy evaluation add-on is very helpful and it makes it easy to calculate the data which can be essential for improving the building's energy-efficiency, but its lack of ability to take more complicated situations into consideration may lead to inaccuracy of the results and final report to some extent.

The length of the abstract is 1 page.

Keywords energy evaluation, comparison data

Pages 30 p. + appendices 11 p.

CONTENTS

1 INTRODUCTION

1.1 Background

The topic of this thesis is based on a real project which is located in Viipurinpuisto, Hämeenlinna. Six of the 2-3 storied buildings are built in the 1970s. After more than 40 years the buildings need to be renovated and the habitants demand less energy cost including district heat and electricity.

Figure 1 The outlook of the project buildings

Since the rapid development of society, the demands for energy are increasing dramatically every year. And most of the energy comes from fossil fuels which will not be sustainable in the long term. The pressure and urge have forced society not only to find new, renewable, replaceable and clear energy, but also to improve the efficiency of current energy usage.

According to the Finnish Ministry of the Environment, there is in process an Environmental Decree on improving energy performance in connection with renovation and alteration, and of the promotion of systematic building management supporting the improvement. The objective of this decree is to reduce energy consumption and carbon dioxide emissions of the existing buildings by approximately 25% and 45%, respectively, by 2050. Savings are gained, for example, by reducing heat losses, by adopting more efficient heat recovery systems, by more efficient use of electricity, and by increasing the use of renewable energy sources, such as ground-source heat. A more short-term objective is to reduce the energy consumption of existing buildings in the building stock by approximately 6% by 2020 (Kauppinen, Ministry of the Environment Memorandum, 2013).

Therefore software related to calculating the energy consumption based on the latest regulations has been carried out. Above all these, ArchiCAD software draws most interests for the writer. Not only is it the first software that allows the combination of 3D-modeling and energy evaluation at the same time, but also entirely new technology which allows architects to perform reliable dynamic energy evaluation of their BIM model within ArchiCAD, relying on BIM geometry analysis and accurate hour-by-hour online weather data of the building's location.

1.2 Objectives

The primary objective of this thesis is to finish the 3D-BIM of these project buildings and produce an energy-consumption report based on a 3D model to the supporting company. This will be checked by studying the EU's recast Energy Performance of Buildings Directive and the use of previous experiences. Another main objective is to test the usability and liability of the ArchiCAD energy evaluation tool by comparison with real energy consumption data.

The scope of the thesis is limited in the following way:

1. Only the situation in Finland is taken into consideration, so other countries and circumstances are out of the study.
2. Only the renovation situation is considered, new projects with brand new 3D-design are not included.
3. Only one software is used in the thesis, no parallel comparison with other similar software.

1.3 Process and Content

First of all, the thesis objectives are defined by the supervisor and supporting company. Then the thesis plan is carried out.

Data needed for 3D-modeling the building was provided by a company with hand-draft drawings, including a section plan, floor plan for six buildings separately. Later the hand-draft papers (more than 100 pages) were scanned and converted to PDF for a more convenient check. Another important demanded data was acquired by inhabitants who live in the buildings, concerning the amount of hot water and electricity used from 2006 to 2008 every month, also the local price of these two energies respectively. In addition, several visit tours were held by inhabitants to the inside of the houses and basements for measuring and checking the data. Material properties and environment data were extracted from official company websites.

Based on the data collected and studied, first the ArchiCAD 3D BIM was created by using the company hand-draft papers. Next step was to send the modeling profile to the supervisor to be checked and re correction started by visiting the site.
The third step was putting the material properties and environment data into the software model, as well as calculating, following the Finnish regulation. Finally an energy consumption report was created which led to the main part of the thesis: comparison with real data. At the very end of the stage, a conclusion was reached to indicate the advantages and disadvantages of this ArchiCAD energy-consumption tool. Advices and suggestions are carried out for this software for further improvement and research.

1.4 Supporting Company

A-Insinöörit is a skilled, growing and internationally operating professional in construction management and design. Customer needs are their first priority. Their references prove that they succeed in even the most demanding projects by combining fifty years of solid experience with the most up-to-date expertise. The company's fields include infrastructure design, Structural design services for residential buildings, schools and educational institutions, hospitals, commercial structures, offices, logistic centers, as well as industrial facilities and structures, Development during all project stages by designing the working progress more smoothly flowing and cost-effectively.

A-Insinöörit is one of Finland's leading experts in the construction industry. In recent years they have helped implement, the Port of Vuosaari, the Helsinki-Vantaa Non-Schengen Terminal, several power stations, the Helsinki Metro, and many other projects. (A-Insinöörit)

Figure 2 company front page

2 ARCHICAD MODELLING

First of all, the software ArchiCAD is one of the major BIM software in the world that has been widely applied. BIM refers to *Building Information Modeling* , a process involving the generation and management of digital representations of physical and functional characteristics of places. BIMs make possible for designer and engineering technician work together and give answers for problems which appeared in BIMs, given a solid foundation for cooperation between design, construct and management. In addition, BIMs improves proficiency dramatically and reduces risks during whole building construction process.

In general, BIM is a 3D building model with detail information data which is a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. It has been widely used by individual businesses and government agencies who plan, design, construct, operate and maintain diverse physical infrastructures, from water, wastewater, electricity, gas, refuse and communication utilities to roads, bridges and ports, from houses, apartments, schools and shops to offices, factories, warehouses and prisons.

The concept of BIMs started from the 1970s, while ArchiCAD was created by the *Graphisoft* company in 1982 as the first 3D-Virtual Building design idea software in the world. For the professionals involved in a project, BIM enables a virtual information model to be handed from the design team (architects, surveyors, civil, structural and building services engineers, etc.) to the main contractor and subcontractors and then on to the owner/operator; each professional adds discipline-specific data to the single shared model. This reduces information losses that traditionally occurred when a new team takes 'ownership' of the project, and provides more extensive information to owners of complex structures. (Building information modeling, 2014)

2.1 Modeling Process

As a renovation project, the target buildings were built in the 1970-1974 period. During the time when no computer science or any digital data can be applied, the designer made 2D drawings including a floor plan, site plan, elevation plan, basement plan, foundation plan, plumbing plan, ventilation plan on papers by using only simple drawing tools.

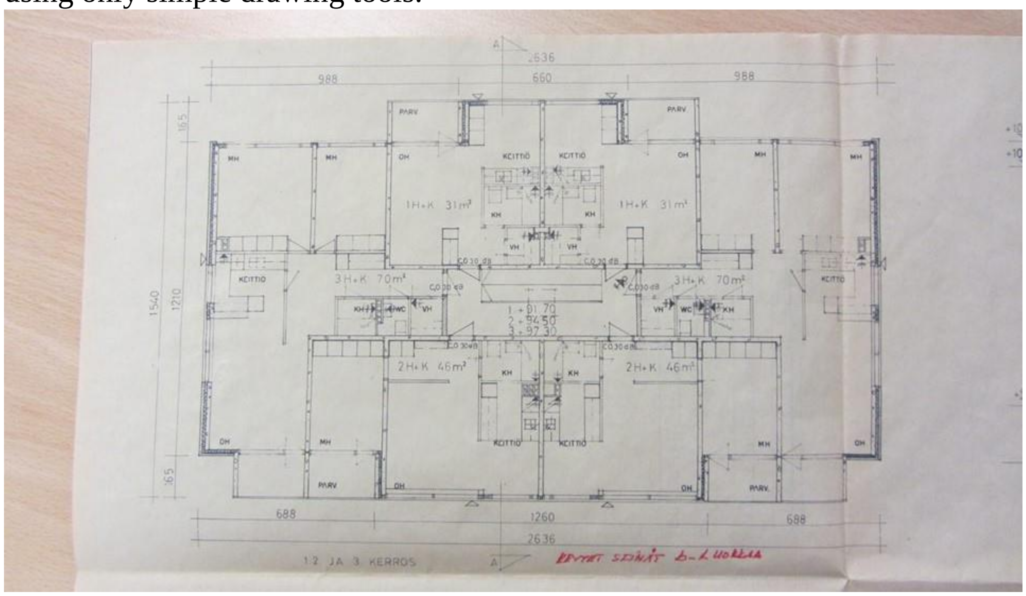


Figure 3 example of one floor plan

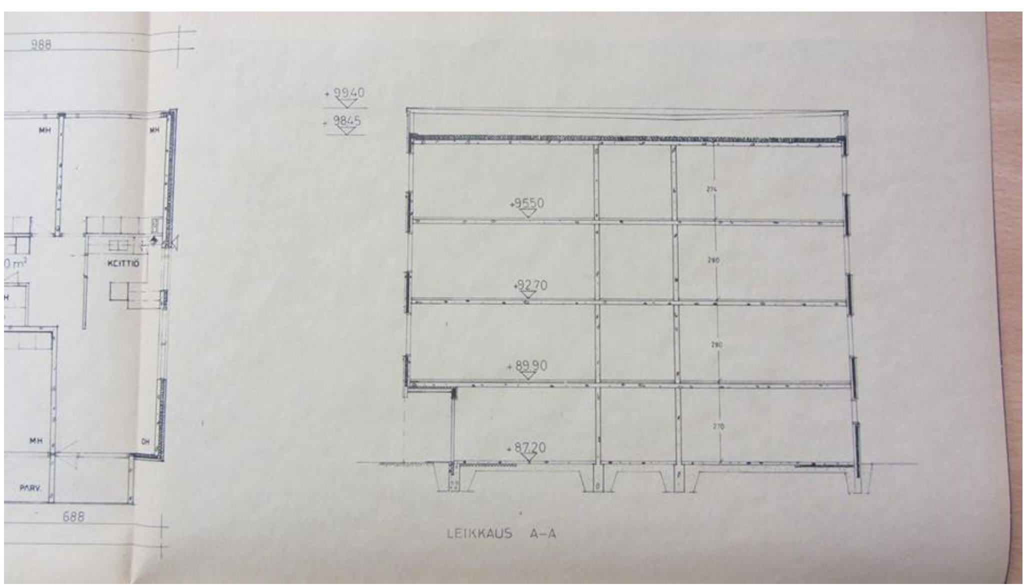


Figure 4 example of one elevation plan

Based on more than 200 pages of these 2D drawings, the Modeling started. In ArchiCAD software, instead of 2D lines the operating subjects are changing into walls, doors, windows, columns, beams, slabs and other building components.

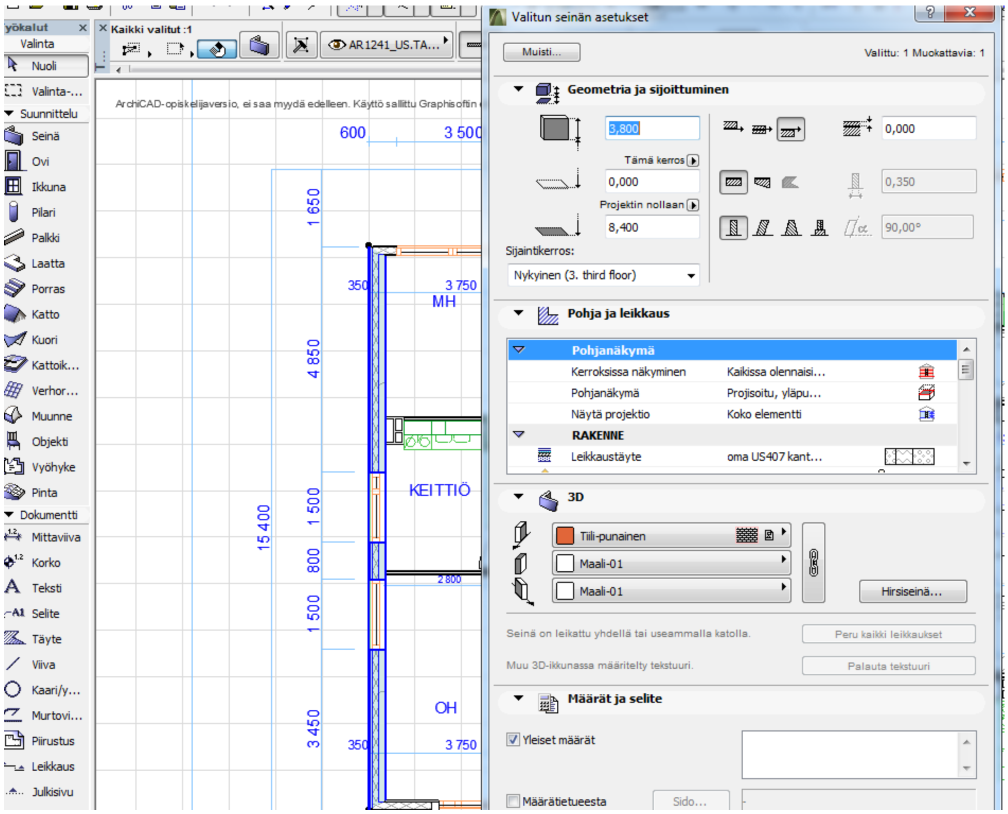


Figure 6 example of parameterization of one component(external wall) that is referenced

As the Figure 6 indicated, components are controlled by parameters. Their parameters are connected to a 3D model in both directions in two way, with some extent of intellectualization. For example, the windows are attached to the wall automatically; column cut overlapping wall automatically. The whole designing process is done by a parameterization method.

The most difficult part to model in ArchiCAD is that even when the software gives a 2D paper as a platform, it is not a real 2D paper that just draws a line on the X or Y coordinates without taking the height (the Z coordinate) of all components into account. Every component in this platform must need to put the parameter of height into consideration, even for something as simple as a wall, the height of a wall as a parameter needs to be specified. Windows need to settle the width, length, height, window/wall thickness ratio and the window frame separation parameter, rotation rate, style and more physical characteristics.

Therefore, in this case, one building that has 3 stories including a roof and a basement and a foundation layer may create thousands of individual components. Every single one of them needed to be specified with unique data. The amount of work is tremendous and it requires no small amount of sensibility and caution, since one mistake would have led to structure failure and human lives involved.

BIM allows the designer to process traditional 2D screen indication and 3D-visualization indication or even dynamic indication at the same time. Different 2D indications from floor plan to elevation plan remains highly relative and consistent. When the model needs to be changed or fixed, all means of indication will be updated and synchronized with high accuracy.

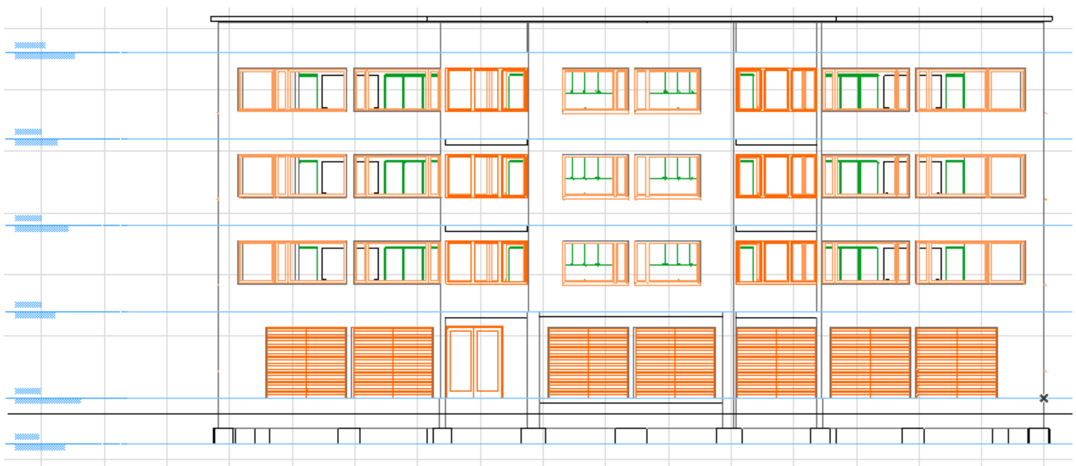


Figure 7 example of elevation indication

Figure 8 example of visualized indication

The core value of BIMs is the information data, all the data can be collected and reported both completely and systematically, for example, project amount list, window and door list, area statistics, facility chosen list, estimation of budget. Any changes to the model will lead to updates of these reports and list simultaneously with accuracy.

Seinäluettelo							
Seinätyyppi	Tilavuus	Paksuus	Korkeus	Seinän pinta-ala	Seinän ympärysmitta	Emäviivan pituus	Pinta-ala emäviivan puolella
Mineraalivilla 100	0,07	150	2 800	0,03	0,71	0,25	0,70
Mineraalivilla 100	0,14	150	2 800	0,05	1,01	0,25	0,70
Mineraalivilla 100	0,20	150	2 800	0,07	1,31	0,40	0,00
Mineraalivilla 100	0,42	150	2 800	0,15	2,29	1,00	2,80
Mineraalivilla 100	0,51	150	2 800	0,18	2,81	1,15	3,22
Mineraalivilla 100	0,79	150	2 800	0,28	4,11	1,95	5,46
Mineraalivilla 100	1,00	150	2 800	0,38	5,41	2,45	6,44
Mineraalivilla 100	1,01	150	2 800	0,38	5,40	2,55	6,72
Mineraalivilla 100	1,16	150	2 800	0,41	5,80	2,75	7,28
Mineraalivilla 100	1,20	150	2 800	0,43	6,00	2,85	7,98
Mineraalivilla 100	1,26	150	2 800	0,45	6,30	3,00	7,98
Mineraalivilla 100	1,41	150	2 800	0,50	7,00	3,35	9,38
Mineraalivilla 100	1,51	150	2 800	0,54	7,47	3,59	10,04
Mineraalivilla 100	2,44	150	2 800	0,87	11,99	5,89	16,49
oma US kevyt b...	0,33	200	2 800	0,54	5,90	2,65	1,30
oma US kevyt b...	0,53	200	1 000	0,53	5,70	2,65	2,60
oma US kevyt b...	1,37	200	1 000	1,37	14,35	7,05	7,05
oma US kevyt b...	1,38	200	1 000	1,38	14,35	7,05	7,05
oma US kevyt b...	1,49	200	2 800	1,39	14,45	7,10	7,92
oma US kevyt b...	1,49	200	2 800	1,39	14,45	7,10	7,92
oma US kevyt b...	1,56	210	2 800	0,56	6,54	2,30	6,44
oma US kevyt b...	1,56	210	2 800	0,56	6,54	3,00	7,56
oma US kevyt b...	1,06	210	3 800	0,28	3,27	1,15	4,37
oma US kevyt b...	1,06	210	3 800	0,28	3,27	1,50	5,13
oma US kevyt b...	4,60	210	2 800	2,98	29,54	14,50	22,12
oma US kevyt b...	4,62	210	2 800	2,98	29,54	14,50	21,28
oma US kevyt b...	2,57	210	1 000	2,57	24,88	12,25	12,25
oma US kevyt b...	3,79	210	3 800	1,49	14,77	7,25	18,16
oma US kevyt b...	3,79	210	3 800	1,49	14,77	7,25	17,59
oma US kevyt b...	8,51	210	2 800	5,32	51,44	25,30	40,22
oma US kevyt b...	5,95	210	2 800	2,57	24,88	12,25	28,42
oma US kevyt b...	6,91	210	3 800	2,66	25,72	12,65	32,74
oma US kevyt b...	0,88	150	2 800	0,82	11,62	5,60	7,16
oma US kevyt b...	1,16	150	2 800	0,92	13,02	6,30	7,10
oma US kevyt b...	0,83	150	3 800	0,41	5,81	2,80	6,23
oma US kevyt b...	3,03	150	2 800	2,52	35,04	16,20	20,70
oma US kevyt b...	1,03	150	3 800	0,46	6,51	3,15	6,20
oma US kevyt b...	3,24	150	2 800	2,58	35,40	17,25	17,49
oma US kevyt b...	0,29	250	1 000	0,29	2,80	1,15	1,15
oma US kevyt b...	0,33	250	1 000	0,33	3,33	1,50	1,35
oma US kevyt b...	0,73	250	1 000	0,73	6,55	2,63	2,58
oma US kevyt b...	0,80	250	2 800	0,29	2,80	1,15	3,22
oma US kevyt b...	0,93	250	2 800	0,33	3,33	1,50	3,78
oma US kevyt b...	1,39	250	1 000	1,39	11,83	5,40	5,15

Figure 9 example of wall list

Figure 9 indicates part of wall characteristics including thickness, height, U-value, and so on. If any of these walls need to be changed as the client required, the material list or wall list will automatically react at the same time.

However, the depths of statistics are related to the depth of the model itself. Take the column for example, usually columns which take the load from floors have reinforcement steel bars inside, and in this software, reinforcement steel bar parameter is not included, cause the lists for columns are only limited to the size or volume as general statistics, therefore it couldn't replace real engineering statistics, but just for basic reference data.

Most of BIMs can cooperate with other software like Revit or Tekla. And by cooperation, BIMs can transfer profiles to IFC mode (*industry foundation classes*) which can be recognized by other software. Most of the data can be reserved during the transfer, but some data will be missed mainly from the unstandard components like the customized wall.

Figure 10 example of final 3D-visual drawing

2.2 Calculation example

The Ministry of the Environment Decree on improving the energy performance of buildings undergoing renovation or alteration provides three options by which compliance of renovation or alteration work with the provisions on improvement of the energy performance of a building can be demonstrated. The options are as follows:

1. Improvement of the thermal resistance of building elements.

2. Reduction of the calculated energy use in the building to below a specific limit value specified by building category. Calculation instructions for new buildings can be applied for the calculation. Calculation is based on standardised use. The limit values for energy use are specified as calculated annual energy use per net heated area (kWh/(m2a)).

3. Improvement of the calculated overall energy use in the building. The limit values per building-category are specified as a relative change compared to the calculated overall energy use in the original building or, if the intended use of the building has changed, to the calculated overall energy use in the

building at the time of the latest change in the intended use. The same calculation tools and instructions as for new buildings can be applied for the calculation. The overall energy use limit values are specified as calculated annual energy use per net heated area (kWh/(m2a)). The energy carrier factors are issued separately by government decree, and are the same as for new buildings.

If the technical systems are updated, replaced or otherwise renovated, the limit values specified in the Decree should be followed irrespective of the options 1 to 3 selected.

The indoor temperature conditions in the summer must not be impaired as a result of the renovation or alteration. When the improvement of the energy performance of the building is planned, adoption of passive means to prevent overheating of spaces in the summer can be counted as a gain which reduces the energy need for cooling (Kauppinen, Annex to the explanatory memorandum for the Ministryof the Environment, 2013).
In this example only option 1 is considered.

For wall(oma US407-kantava betonisein+mineraalivilla+betonikuori)

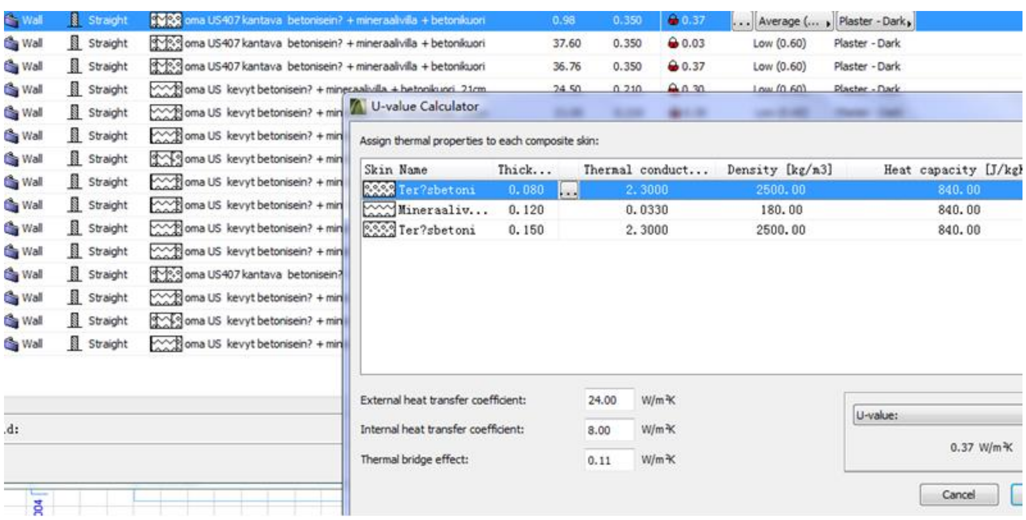


Figure 11 example of wall U-value

The concept of improving thermal resistance is to improve the material used in the composite wall. Different materials have different characteristics for thermal conductivity which is the property of a material to conduct heat and also the thickness.

Heat transfer occurs at a higher rate across materials of high thermal conductivity than across materials of low thermal conductivity. Correspondingly materials of high thermal conductivity are widely used in heat sink applications and materials of low thermal conductivity are used as thermal insulation. Thermal conductivity of materials is temperature dependent. The reciprocal of thermal conductivity is called thermal resistivity.

This wall has three composite skins - reinforced concrete, mineral wool, reinforced concrete.

Table 1 external composite wall layers

Layer material	Thickness(m)	Thermal Conductivity(W/mK)
Reinforced Concrete	0.08	2.3
Mineral Wool	0.12	0.033
Reinforced Concrete	0.15	2.3

External heat transfer coefficient: 24 W/m^{2}K
Internal heat transfer coefficient: 8 W/m^{2}K

U-value is reciprocal of all the resistance instead of a sum of all conductance because interaction of building element to outside environments is measured in terms of surface resistance, so for consistency, the behaviour of the built elements are also expressed in terms of resistances.

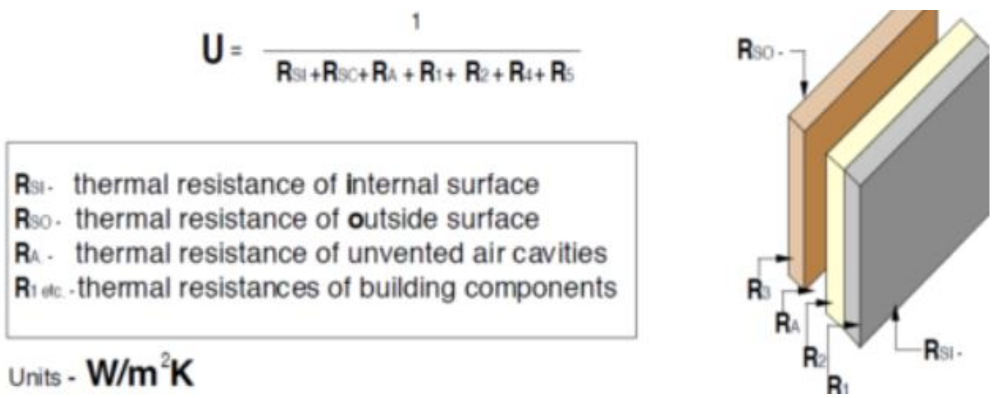


Figure 12 example of formula

And the thermal bridge effect in Finland is estimated as 0.11 W/m^{2}K

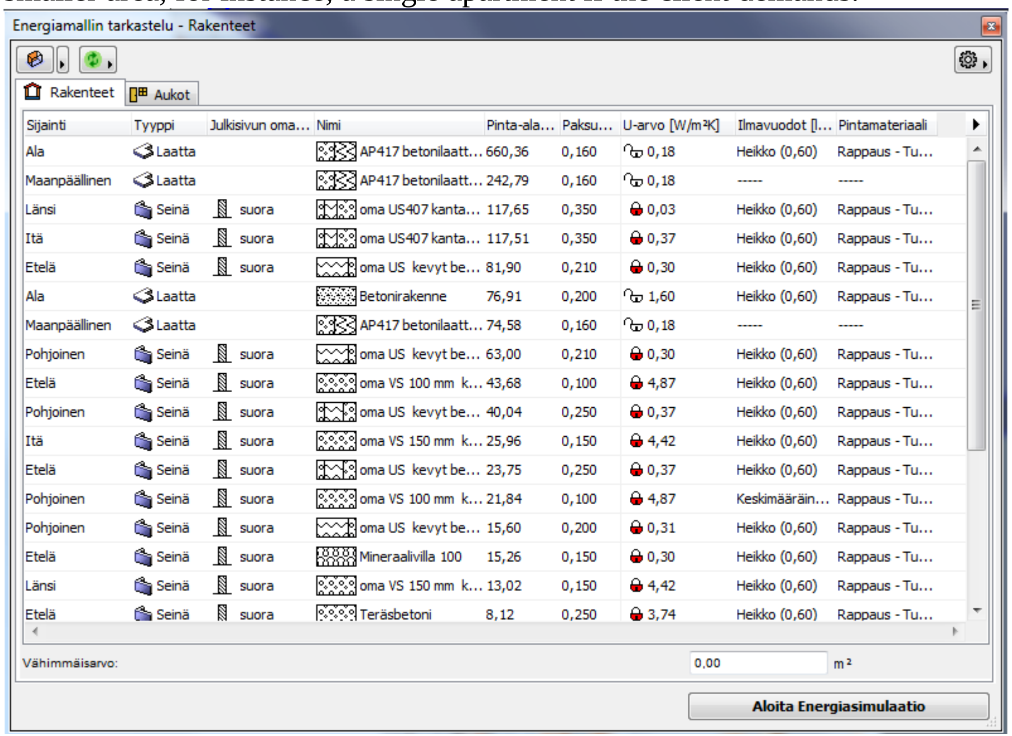
So the final U-value for this external wall is 0.37 W/m^{2}K

This is only an example of simple calculation related to the thermal energy consumption. Other methods are including window and door U value calculation and district heat transfer rate or ventilation system effect.

2.3 Energy Data Input

The built-in Energy Evaluation functionality of ArchiCAD 16 is similar to the former standalone EcoDesigner™ product, but is based on entirely new technology which allows architects to perform reliable dynamic energy evaluation of their BIM model within ArchiCAD, relying on BIM geometry analysis and accurate hour-by-hour online weather data of the building's location.(ARCHICAD WIKI)

Since the project building model has been created. Area tool has been selected for the whole building in this case. Although the area tool can be selected to a smaller area, for instance, a single apartment if the client demands.



Sijainti	Tyyppi	Julkisivun oma...	Nimi	Pinta-ala...	Paksu...	U-arvo [W/m²K]	Ilmavuodot [l...	Pintamateriaali
Ala	Laatta		AP417 betonilaatt...	660,36	0,160	0,18	Heikko (0,60)	Rappaus - Tu...
Maanpäällinen	Laatta		AP417 betonilaatt...	242,79	0,160	0,18	-----	-----
Länsi	Seinä	suora	oma US407 kanta...	117,65	0,350	0,03	Heikko (0,60)	Rappaus - Tu...
Itä	Seinä	suora	oma US407 kanta...	117,51	0,350	0,37	Heikko (0,60)	Rappaus - Tu...
Etelä	Seinä	suora	oma US kevyt be...	81,90	0,210	0,30	Heikko (0,60)	Rappaus - Tu...
Ala	Laatta		Betonirakenne	76,91	0,200	1,60	Heikko (0,60)	Rappaus - Tu...
Maanpäällinen	Laatta		AP417 betonilaatt...	74,58	0,160	0,18	-----	-----
Pohjoinen	Seinä	suora	oma US kevyt be...	63,00	0,210	0,30	Heikko (0,60)	Rappaus - Tu...
Etelä	Seinä	suora	oma VS 100 mm k...	43,68	0,100	4,87	Heikko (0,60)	Rappaus - Tu...
Pohjoinen	Seinä	suora	oma US kevyt be...	40,04	0,250	0,37	Heikko (0,60)	Rappaus - Tu...
Itä	Seinä	suora	oma VS 150 mm k...	25,96	0,150	4,42	Heikko (0,60)	Rappaus - Tu...
Etelä	Seinä	suora	oma US kevyt be...	23,75	0,250	0,37	Heikko (0,60)	Rappaus - Tu...
Pohjoinen	Seinä	suora	oma VS 100 mm k...	21,84	0,100	4,87	Keskimääräin...	Rappaus - Tu...
Pohjoinen	Seinä	suora	oma US kevyt be...	15,60	0,200	0,31	Heikko (0,60)	Rappaus - Tu...
Etelä	Seinä	suora	Mineraalivilla 100	15,26	0,150	0,30	Heikko (0,60)	Rappaus - Tu...
Länsi	Seinä	suora	oma VS 150 mm k...	13,02	0,150	4,42	Heikko (0,60)	Rappaus - Tu...
Etelä	Seinä	suora	Teräsbetoni	8,12	0,250	3,74	Heikko (0,60)	Rappaus - Tu...

Figure 13 Components data related to thermal calculation

Figure 13 displays the analysis of the visible structures and openings according to their orientations and positions relative to zones and generates the space boundaries for them. (Space boundaries describe the building's geometry in a format that works for energy simulation input.)

It populates the space boundary lists. Structures and Openings are automatically listed with their properties that are relevant for the energy evaluation.

The calculation of energy used for heat leaking into spaces is based on the air tightness of the building or building unit, expressed as air leakage rate.

The air leakage flow is calculated from the building envelope air leakage rate q50 as specified in Section D3 of the National Building Code. The air leakage rate q50 (m3/(h m2)) means the average air leakage flow of the building envelope per hour with a 50-Pa pressure difference per the overall building envelope area determined according to the overall inner dimensions.

The building envelope air leakage rate is determined by measuring or from the plans or up-to-date building documents.

If the building envelope air leakage rate cannot be determined with the methods referred to above, it must be determined by using the values provided in Table 4. The table also includes building air leakage rates n50, because that method has been previously used for indicating the air tightness.

The building envelope air leakage rate (q50) can be calculated from the building air leakage rate (n50) with equation:

$$q_{50} = \frac{n_{50}}{\mathrm{A}_{\mathbf{vaippa}}} V$$

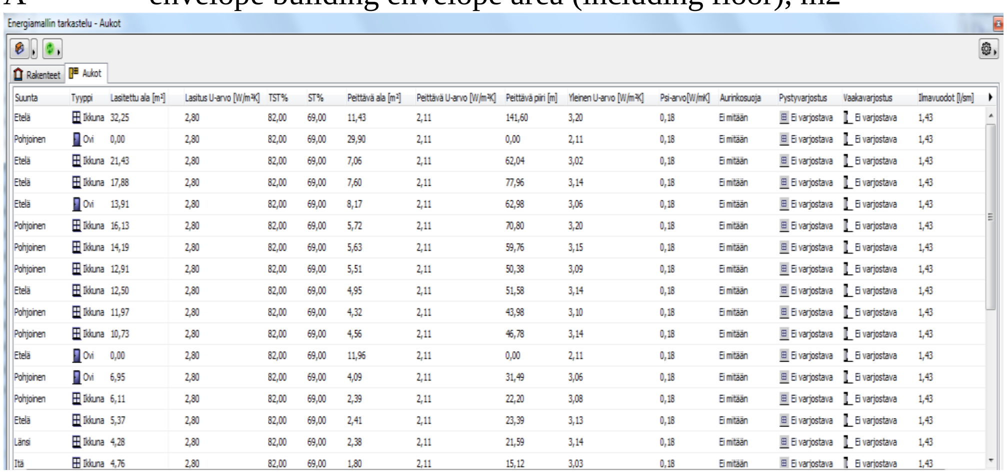
where

q50 - building envelope air leakage rate with a 50-Pa pressure difference, m3/(h m2)

n50 - building air leakage rate with a 50-Pa pressure difference, 1/h

V - air volume of the building, m³

A - envelope building envelope area (including floor), m2


Energiamallin tarkastelu - Aukot

Rakenteet | Aukot

Suunta	Tyyppi	Lasitettu ala [m²]	Lasitus U-arvo [W/m²K]	TST%	ST%	Peittävä ala [m²]	Peittävä U-arvo [W/m²K]	Peittävä piiri [m]	Yleinen U-arvo [W/m²K]	Psi-arvo[W/mK]	Aurinkosuoja	Pystyvarjostus	Vaakavarjostus	Ilmavuodot [l/sm]
Etelä	Ikkuna	32,25	2,80	82,00	69,00	11,43	2,11	141,60	3,20	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Pohjoinen	Ovi	0,00	2,80	82,00	69,00	29,90	2,11	0,00	2,11	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Etelä	Ikkuna	21,43	2,80	82,00	69,00	7,06	2,11	62,04	3,02	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Etelä	Ikkuna	17,88	2,80	82,00	69,00	7,60	2,11	77,96	3,14	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Etelä	Ovi	13,91	2,80	82,00	69,00	8,17	2,11	62,98	3,06	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Pohjoinen	Ikkuna	16,13	2,80	82,00	69,00	5,72	2,11	70,80	3,20	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Pohjoinen	Ikkuna	14,19	2,80	82,00	69,00	5,63	2,11	59,76	3,15	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Pohjoinen	Ikkuna	12,91	2,80	82,00	69,00	5,51	2,11	50,38	3,09	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Etelä	Ikkuna	12,50	2,80	82,00	69,00	4,95	2,11	51,58	3,14	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Pohjoinen	Ikkuna	11,97	2,80	82,00	69,00	4,32	2,11	43,98	3,10	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Pohjoinen	Ikkuna	10,73	2,80	82,00	69,00	4,56	2,11	46,78	3,14	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Etelä	Ovi	0,00	2,80	82,00	69,00	11,96	2,11	0,00	2,11	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Pohjoinen	Ovi	6,95	2,80	82,00	69,00	4,09	2,11	31,49	3,06	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Pohjoinen	Ikkuna	6,11	2,80	82,00	69,00	2,39	2,11	22,20	3,08	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Etelä	Ikkuna	5,37	2,80	82,00	69,00	2,41	2,11	23,39	3,13	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Länsi	Ikkuna	4,28	2,80	82,00	69,00	2,38	2,11	21,59	3,14	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43
Itä	Ikkuna	4,76	2,80	82,00	69,00	1,80	2,11	15,12	3,03	0,18	Ei mitään	Ei varjostava	Ei varjostava	1,43

Figure 14 Components(openings) data related to thermal calculation

For all the openings including doors and windows, the characteristic data has been extracted from one manufacturing company called Fenestra which is one of the most common companies in Finland.

Total solar transmittance (TST): The percentage of incident solar radiation transmitted by an object which includes the Direct Solar Transmission plus the part of the Solar Absorption reradiated inward. TST divided by 100 equals Solar Heat Gain Coefficient (SHGC) or g-value.

In addition, for openings, A Psi-value is mainly a value of adjustment during the calculation of energy loss of building surfaces. It quantifies the additional energy loss per degree Kelvin and linear meters which wasn't taken into account with the simplified approach of the energy loss calculation using U-values and areas.

The calculation of the Psi-value therefore depends strongly on the calculation method of the simplified approach. These are defined in international and national standards. (Air Infiltration Rates of New Housing, 2006)

2.3.1 Environmental Setting

The most interesting part of this ArchiCAD energy evaluation tool is not only calculating the materials themselves based on their characteristic data, but also the addition data which includes surrounding environmental data, which makes the final report more accurate and referenceable.

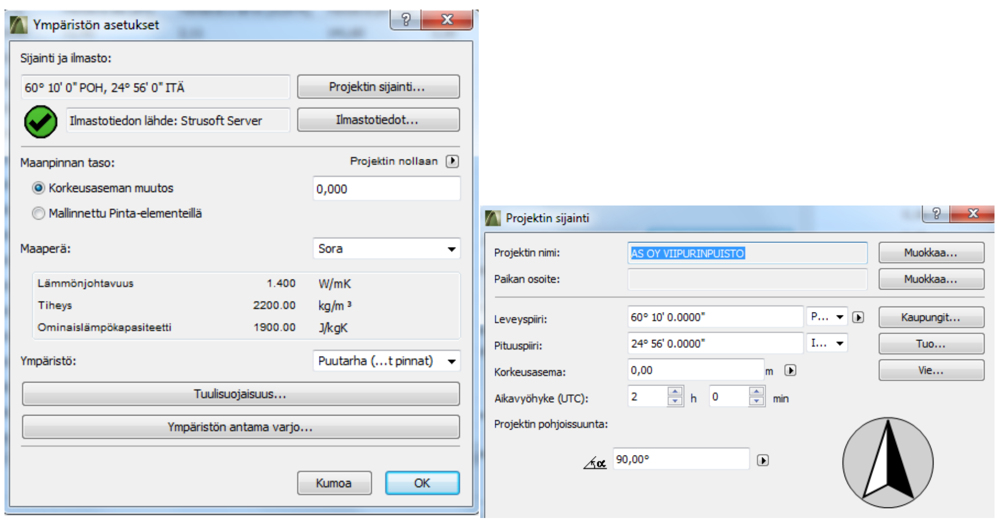


Figure 15 Environmental Setting

The first additional data is related to surrounding environment. The location of the project is shown as latitude and longitude data. The reason for this is that the location of the project will affect the sun position accordingly. There is no doubt that solar energy absorbed by the building is taken into account, also the colour and material of the external wall and roof affect this.

And for the soil type in Finland the geological position represents that after the small ice age and the glacier fade away left soil into gravel rather than rock or sand. The type of soil also affects the heat transfer speed by these factors: thermal conductivity, density and heat capacity.

From gravel type of soil, the thermal conductivity is 1.4 W/mK, comparing with reinforced concrete (with steel rebars inside) is 2.3 W/mK. Which means gravel is even a better material than reinforced concrete in an insulation aspect. This is because the reinforced steel bar in the concrete acts like a thermal conductor with a thermal conductivity around 50 W/mK, placed through the concrete layer.

The last consideration is surroundings, whether the building is located in a big city or near water or besides forest has a tremendous impact on the heat transfer. Since in the city, average temperature is higher due to the urban heat island effect. And near water, the temperature is lower while garden temperature (forest area) stays between it.

2.3.2 Climate Data

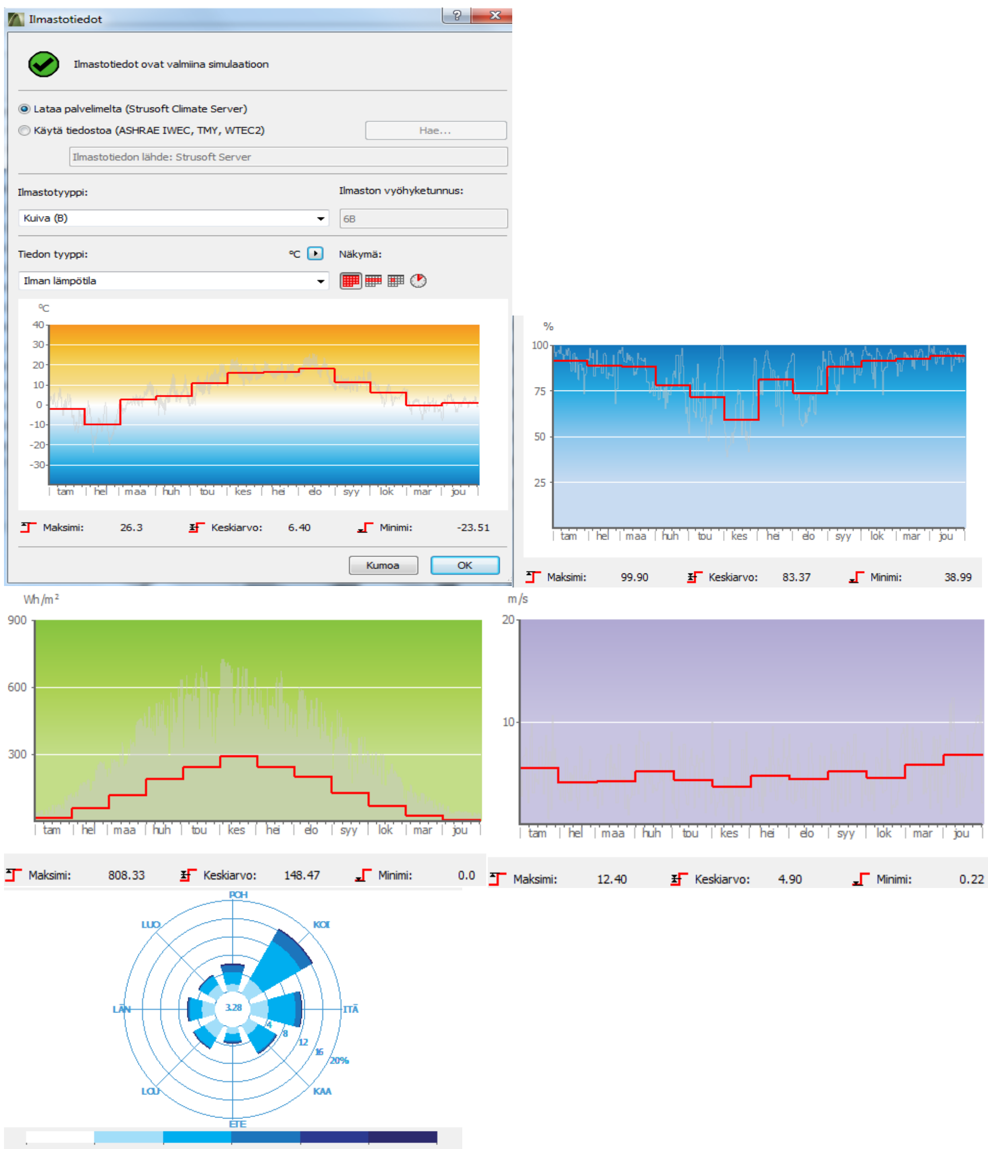


Figure 16 Climate Data

First of all, the climate data was extracted from Strusoft Climate Server which is updating the climate data all around the world with accuracy. And this annual data is based on 2013 statistics.

Secondly, the climate type in Finland is dry, even though the humidity rate is quite high, but the common temperature is below zero which leads to the dry air and powder snow.

Basically there are four data types that have been considered: Air temperature, Relative temperature, solar radiation and Wind speed. Due to the theory that the bigger the difference in external and internal temperature, the quicker the heat transfers, air temperature becomes an important factor. As well as the wind speed, the wind helps air to carry the heat away faster. And also it is essential to know in which direction comes the maximum wind velocity.

2.3.3 Operation Profile

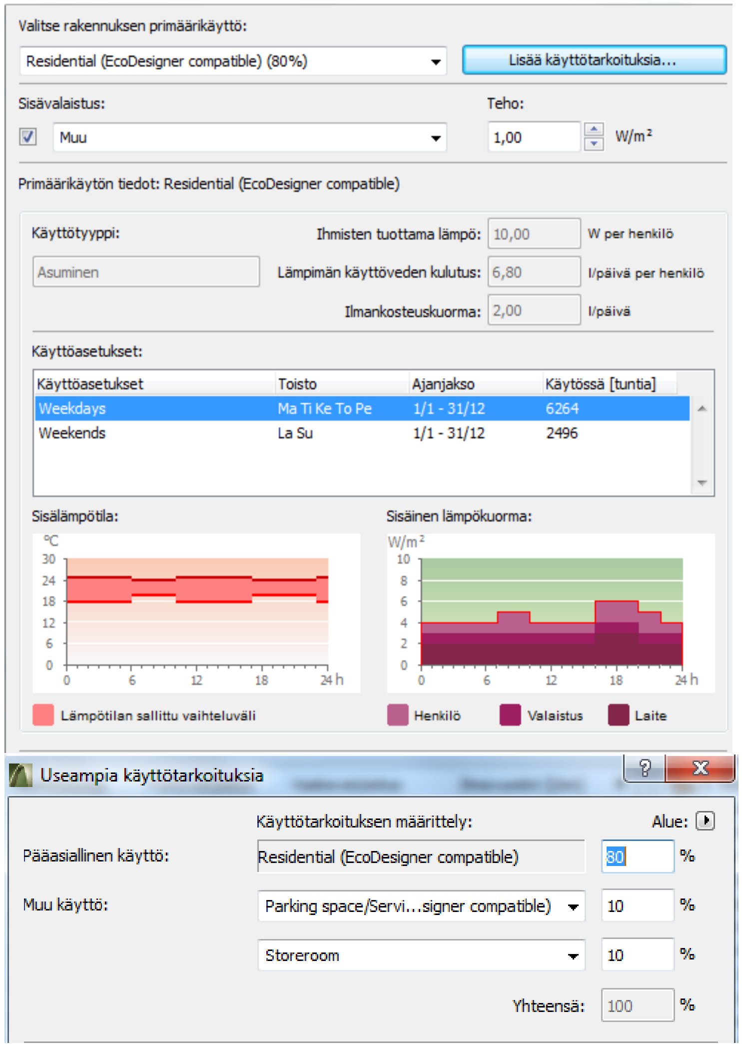


Figure 17 Operation Profile

The Operation Profile is the most difficult part to estimate and calculate. As in Finland, for the residential buildings built in the 1970s, during the Cold-war, the threat of an attack by bombing has influenced the design of the building. When it comes to this case, the original designer of these buildings designed multi-use basements for preparation in case of war. This leads to extreme complexity in order to determine the percentages between primary building functions and additional functions.

Since the basement is only used for garage and storage - both 10 percent equally, and for residential purposes - only 80 percent. For the interior lighting, suggestion from the supervisor is 1W/m^2. For the human heat gain, service hot water load and humidity load are 10W/capita, 6.8L/day, 2L/day respectively. All data has been approved by the supervisor.

Lastly, the daily schedules separate working days and weekends, when people stay at home, it is consuming more energy, although the tool didn't take into account the much longer amount of holidays in Finland compared to other countries.

The net heated area of the building is determined from up-to-date building documents, such as drawings or information models, or estimated on-site with sufficient accuracy. If no up-to-date documents are available, or estimating through measurement proves problematic, the net heated area of the building can be estimated to be 90% of the gross heated area. If the gross area of the building is unknown, this can be estimated from the building's outer dimensions and its number of storeys. The gross heated area is deter-mined by subtracting the area of unheated space from the gross area.

Semi-warm spaces, such as attics and other storage areas in the building, are considered as heated space. Unheated spaces are not within the scope of the assessment and their areas should be excluded from the calculation (Kauppinen, Ministry of the Environment Memorandum, 2013)

Within this case, the confusion appears at whether the storage room can be recognized as semi-warm spaces or unheated spaces.

Another problem is that only lightning has been taken into account as energy consumption.

2.3.4 Building Systems

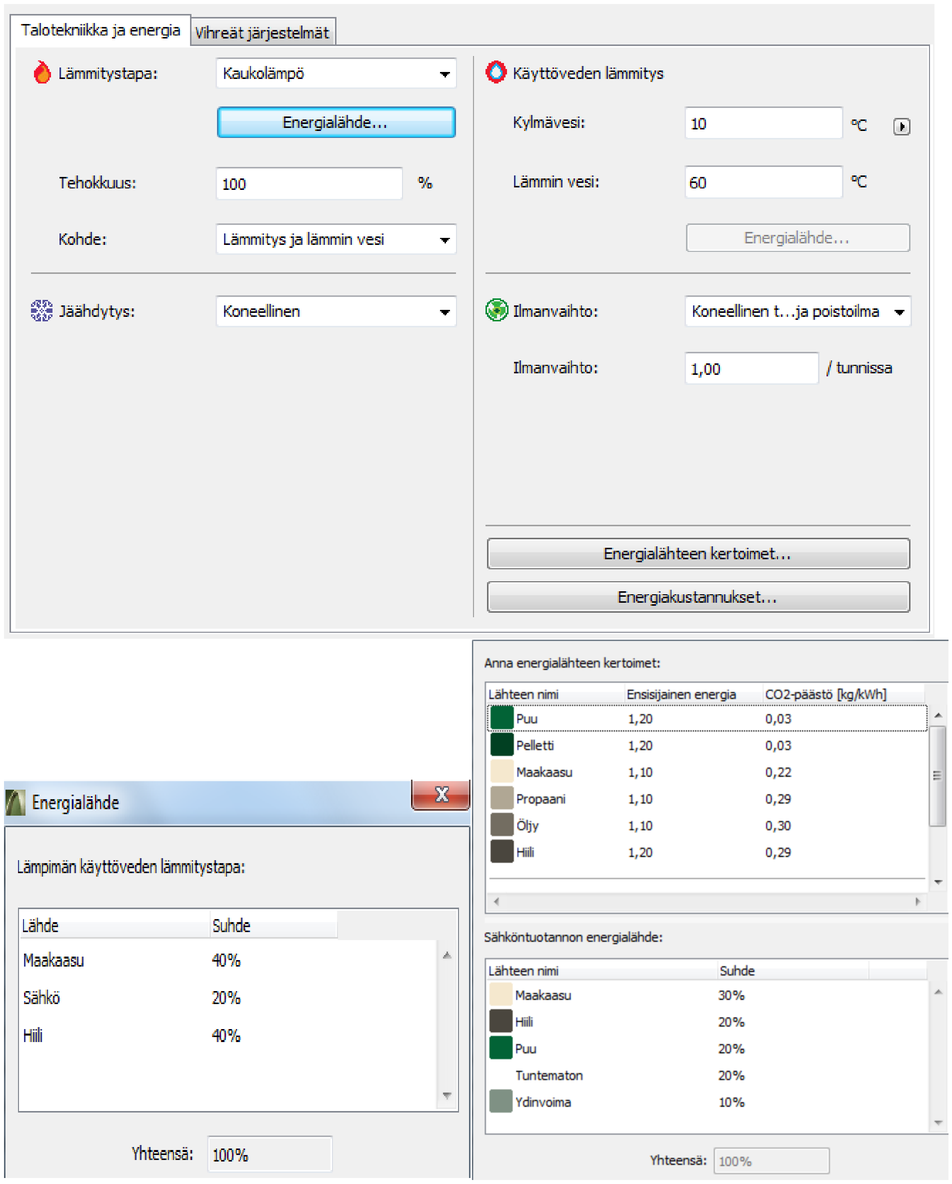


Figure 18 Building System

The building System indicates what kind of energy input and output system were implemented. In this project, the building is heated by district heated water and electricity. The hot water is used both for services and heating. Efficiency of the heating type can be recognized as 89%*85%, result is 75%, since during the transportation the water pipe is covered by 400mm thickness insulation material. But inside of the apartment the pipe is not insulated.

Table 2 Finland hot water distribution efficiency

Building type	Domestic hot water distribution efficiency, $\eta_{dhw, transfer}$				
		No circulation			
	Circula-tion	non-insulated	in a housing pipe	insulat-ed, basic level[1)]	insulat-ed, better[2)]
Detached houses and terraced and other at-tached houses	0.96	0.75	0.85	0.89	0.92

Table 3 Guideline values for annual efficiency of heat distribution and heat emission and for electricity consumption of auxiliary devices.

Heating solution	Annual efficiency η_{spaces} -	Electric e_{spaces} kWh/(m² a)
Water radiator 45/35 ºC		
insulated distribution pipes	0.90	2
non-insulated distribution pipes	0.85	
Water radiator 70/40 ºC		
insulated distribution pipes	0.9	2
non-insulated distribution pipes	0.8	
Water radiator 90/70 ºC		
insulated distribution pipes	0.85	2
non-insulated distribution pipes	0.80	

The energy sources that are used to conduct hot-water are Natural gas, coal and Electricity by 40%, 40% and 20% respectively.

Cooling type for residential area is Mechanical, however, for the basement in the storage room the cooling is done by air conditioner that uses electricity.

Service hot-water is 60 degree Celsius while cold water is 10 degree Celsius.

Ventilation type is supply and exhaust, air change factor is 1/day, approved by supervisor.

As for the energy source factors, it indicates for different raw resources, it conduct different amount of CO_2, one of the main substances that leads to the global warming effect.

While in Finland, although the Finnish environmental administration puts all effect to improve the atmosphere and reduce the CO_2 emissions. It is said: The production of electricity in Finland amounted to 67.7 TWh in 2012. The production went down by four per cent from the previous year. The production of district heat grew by eight per cent and that of industrial heat remained on level with the previous year. **Forty-six per cent of the production of electricity and heat was covered by renewable energy sources**. The amounts of electricity and heat produced with renewable energy sources grew from the previous year. The use of fossil fuels and peat decreased as in the year before (Production of electricity and heat, 2013)

However, the text above, which mentions about renewable energy, only indicates mixed fuel (divided into renewable and fossil fuels in ratio to the fossil and biodegradable coal contained in them), but it is still the same old method to use this source, which produces the same amount of CO_2.

Table 4 Electricity and heat production by production mode and fuel in 2012

		Electricity, GWh	**District heat, GWh**	**Industrial heat, GWh**	**Fuels used, GWh**	**Fuels used, TJ**
Combined heat and power production [6]	Oil	178	125	1 173	1 898	6 831
	Hard coal	4 061	7 445	764	14 433	51 960
	Natural gas	6 460	5 586	5 032	20 078	72 282
	Other fossil [2] 3)	220	560	678	1 834	6 603
	Peat	2 727	5 069	3 126	13 296	47 865
	Black liquor and other concentrated liquors	4 825	185	23 814	36 590	131 725
	Other wood fuels	4 142	6 726	8 321	23 441	84 389
	Other renewables [2] 4)	359	547	704	2 049	7 377
	Other energy sources [5]	314	214	1 273	2 263	8 146
	Total	**23 286**	**26 458**	**44 885**	**115 882**	**417 176**

As the table indicated, coal or liquor and natural gas emit massive amounts of CO_2 from the energy source factors.

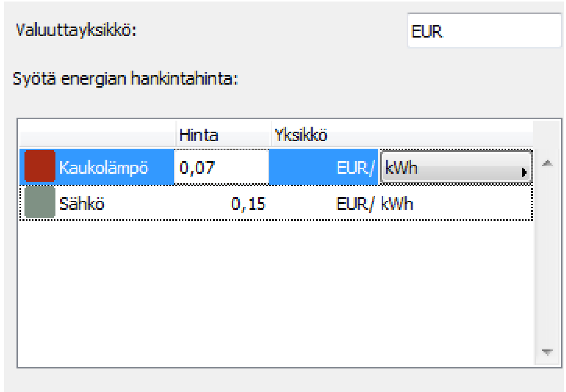


Figure 19 Energy Price Factor

Table 5 Consumer prices of heating energy in January 2013

Energy source	[1] **Price €/MWh**	**Annual change-%**
Light fuel (VAT 24%)	111.5	-2.2
Household electricity, K2 (VAT 24%)	154.7	0.0
Wood pellet (VAT 24%)	56.2	-0.1
District heat, terraced house / low-rise block of flats (VAT 24%)	74.31	8.7

From the table above, it can be seen that the data input for price in this tool is not accurate enough since it only accounts the number two decimal after the dot. Therefore the price here is a bit lower than in reality. (Prices of heating and transport fuels increased, 2013)

2.4 Result Sheet

Finally, after all the additional data input is finished, the system tool will start to generate the final report. The built-in, certified VIP-Core engine executes the dynamic energy simulation that calculates the building's hourly energy balance and outputs a Building Energy Evaluation Report. The report contains information such as the project's energy-related structural performance, yearly energy consumption, monthly energy balance and carbon footprint.

The Building Shell Performance Data section displays overall Air Leakage in the air change per hour (also called air exchange rate - the number of interior volume air changes that occur per hour in 1/h). Outer heat capacity (measures the capacity of building structures to store heat against changing outside air temperature) is also an important building envelope performance metric.
Also in the Key Values section, the minimum and maximum values of the Calculated heat transfer coefficients are listed for the entire building, for every Building structure group and for the openings on the building shell. (Energy Evaluation Workflow: Overview, 2014)

Energiatehokkuusarvio

101 AS OY VIIPURINPUISTO

Perustiedot

Projektin tiedot		
Projektin nimi:	AS OY VIIPURINPUISTO	
Sijainti:		
Ilmastotietojen lähde	Strusoft-palvelin	
Arviointipäivä:	26.3.2014 0:48:21	
Rakennuksen geometria		
Brutto lattiapinta-ala	**367,62**	m²
Lattiapinta-ala:	**328,87**	m²
Ulkovaipan pinta-ala:	**907,76**	m²
Ilmanvaihtotilavuus:	**3749,15**	m³
Lasitus:	**23**	%
Ulkovaipan ominaisuudet		
Ilmavuodot 50Pa:	**4.03**	l/h
Ulkop. lämpökapasiteetti:	**829.49**	J/m²K

Lämmönsiirtokertoimet	U-arvo	[W/m²K]
Vaippa keskimäärin:	**1.10**	
Lattiat:	--	
Ulkoinen:	**0.40 - 0.40**	
Maanalainen:	--	
Aukot:	**2.39 - 2.59**	
Lämmitysenergia (netto):	**373.70**	kWh/m²v
Jäähdytysenergia (netto):	**37.39**	kWh/m²v
Energia yhteensä:	**411.09**	kWh/m²v
Energiankulutus:	**497.71**	kWh/m²v
Polttoaineen kulutus:	**497.71**	kWh/m²v
Primäärienergia:	**492.30**	kWh/m²v
Polttoainekustannus:	**46.03**	€/m²v
CO_2-päästö:	**99.43**	kg/m²v

Energiankulutus lähteittäin

	Energia				CO_2-päästö
Lähteen tyyppi	**Lähteen nimi**	**Määrä** kWh/v	**Primääri** kWh/v	**Kustannus** €/v	kg/v
Sekundääri	Sähkö	5257	15773	525	1135
	Kaukolämpö	146129	146129	14612	31563
	Ei määritelty	12296	--	--	--
	Yhteensä:	**163683**	**161902**	**15138**	**32699***

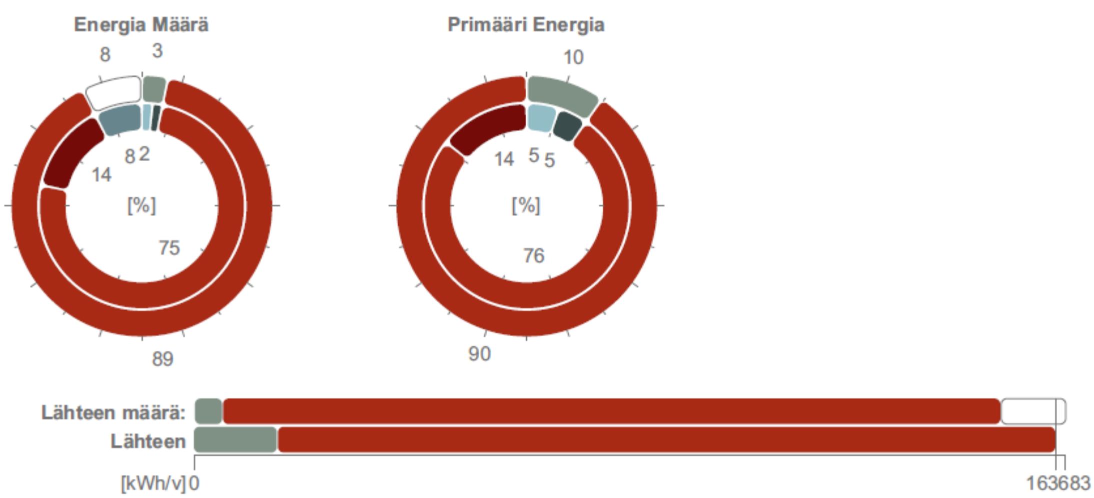


Figure 20 Energy Evaluation Report

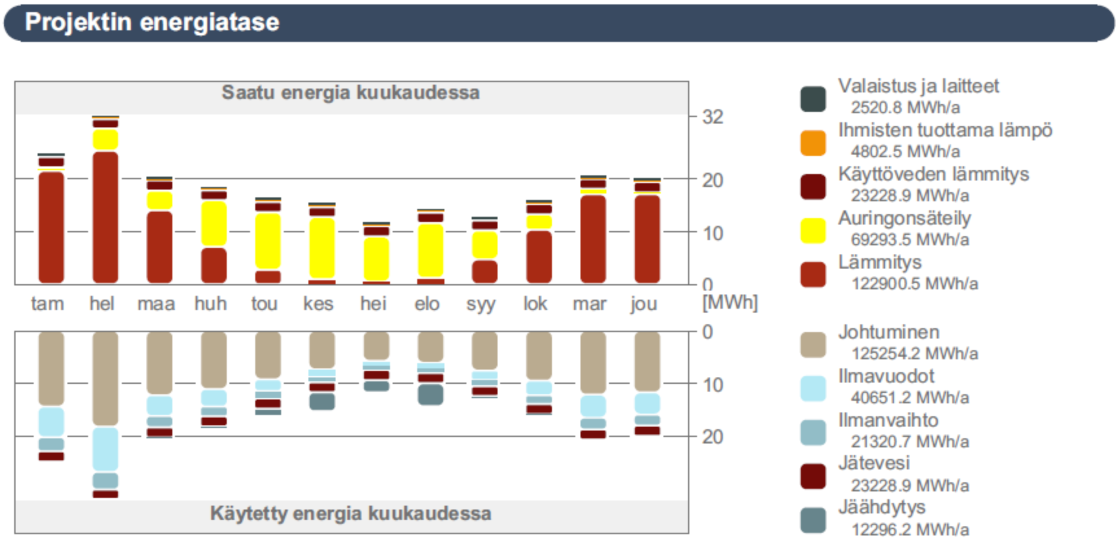


Figure 21 Energy Evaluation Report

The primary energy value is the 'common denominator' among different energy sources consumption types, when determining the building's total energy consumption. Not only does it indicate the net energy source consumed, but it also incorporates the energy needed for the manufacturing, transportation and the raw material processing of the energy source, as well as its transportation to the place of use. Minimizing the specific primary energy demand is a great way to improve the designed buildings' overall performance.

The primary energy factors assigned to the energy sources differ according to the building location.

The Monthly Energy Balance bar chart is a graphical display of the amount of energy the building emits (bottom part of the chart), as well as the building's Supplied energy: the amount of energy it absorbs from the environment and its own internal heat sources (top part of chart), by month.

3 COMPARISON DATA

Data from ArchiCAD energy evaluation report

Energiankulutus kohteittain

Kohteen nimi	Energia			CO_2
	Määrä	Primääri	Kustannus	Päästö
	kWh/v	kWh/v	€/v	kg/v
Lämmitys	122900	122900	12290	26546
Jäähdytys	12296	0	0	0
Lämmin käyttövesi	23228	23228	2322	5017
Ilmanvaihto	2736	8210	273	591
Valaistus ja laitteet	2520	7562	252	544
Yhteensä:	**163683**	**161902**	**15138**	**32699**

Projektin energiatase

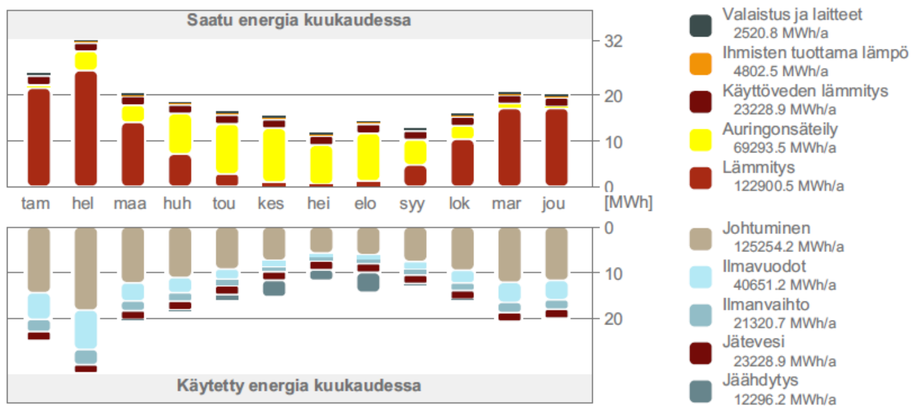


Figure 22 Energy Evaluation Report (partly)

Data from other energy company in 2010

VERTAILULUVUT (vuodelta 2010)	Tam	Hel	Maa	Huh	Tou	Kes	Hei	Elo	Syy	Lok	Mar	Jou	Vuosi
2010 kaukolämmön kulutus (MWh)	**138**	**112**	**94**	**61**	**31**	**11**	**9**	**17**	**34**	**63**	**91**	**131**	**793**
2010 Lämpimän käyttöveden osuus (m3)	153	153	153	153	153	153	153	153	153	153	153	153	1838
2010 Lämpimän käyttöveden osuus (MWh)	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	107
2010 Lämmityksen osuus (MWh)	129	103	86	52	22	2	0	8	26	55	82	122	686
[illegible]	1018	811	673	410	176	15	0	63	201	429	646	961	5403
[illegible]	18,8 %	15,0 %	12,5 %	7,6 %	3,3 %	0,3 %	0,0 %	1,2 %	3,7 %	7,9 %	12,0 %	17,8 %	
[illegible]	789	727	650	464	217	43	13	63	251	427	576	775	4945
2010 normeerattu kulutus, Q_{norm} (MWh)	109	101	91	68	36	14	9	17	41	63	82	101	735

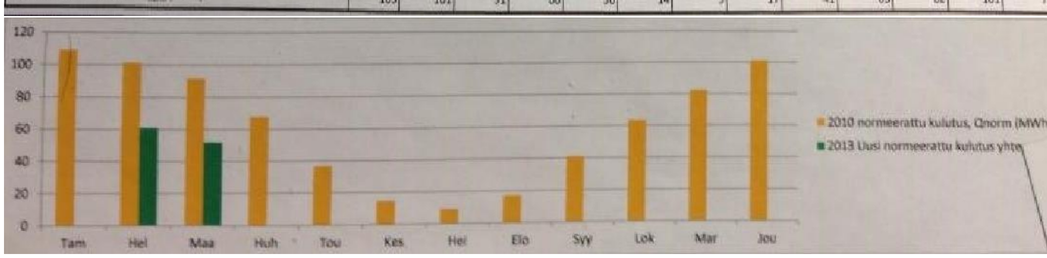


Figure 23 Energy Evaluation Report (company enermix,2013 ,partly)

To start with, the company report is correct and accurate and the data has been approved by the supervisor and also all the data and information that the company got is directly from a habitant whose responsibility is to record the district heat amount and water supply amount monthly for all six buildings.
There is no doubt that in this project, the Enermix company data profile is used as reference information to evaluate the functionality of the ArchiCAD energy evaluation tool.

And from ArchiCAD tool, total annual consumption is now about 160 MWh, so is 50 kWh/m3. The volume for this 3-stories + basement building is 3500 m3. And 120MWh of energy is consumed for 2-stories+basement building.

For the project, six buildings are included:
Two 3-stories buildings and four 2-stories buildings

For total energy consumption of all six buildings
160 + 160 + 120 +120 + 120+120= 800 MWh

The result is quite close to the measured 720 MWh, from the reference data of all six buildings, which considered as tolerable and understandable outcome. However, the difference remains at 80 MWh, after an inside visit of site buildings, it becomes clear what some of the main reasons for this difference are:

a. In every single building's basement, there are sauna rooms for the habitants to use. When a sauna room starts working, usually the temperature inside of it has been heated up to around 85-95 degree Celsius, which requires massive amounts of energy including district heat, electricity and coal or wood. Since every habitant has booked a different time to use this room, basically the room has been under use for 12 hours per day and 365 day per year which the ArchiCAD tool is not capable to take into account.

b. As mentioned before, these building were designed during the time of the cold-war. During that time most of the habitants were using the cooling storage room to store food including potatoes or even water for the time of need. And they still do, except when the storage room is inside of the building, heated to 18-24 degree Celsius (internal room temperature), installation of air cooling conditioner had implemented to make the storage room stay at 5-10 degrees Celsius, plus the insulation between the storage room and other room is not well functional after 40 years of use, it creates extra burden and consumption for the heating system of the building, and in ArchiCAD, the storage room is counted as a semi-warm area, while in this case it should be counted as a cold area.

c. In the basement of building B, there is a swimming pool, which is occupying 30% of the basement area. Maintaining the swimming pool water at a normal temperature all year around also demands tremendous amounts of energy input, which the ArchiCAD tool is not capable to take into account.

Although when comparing with the two bar charts of reports, they are quite similar, while indicating similar energy consumption for each month, both charts hit the lowest point from June to August, and reach a peak in January or February.

4 CONLUSION

4.1 Assessment of the ArchiCAD energy evaluation tool

Nowadays Directive 2002/91/EC of the European Parliament and of the Council on the energy performance of buildings issued on 16 December 2002 are in action. The original directive required setting minimum energy performance requirements for new buildings and large (over 1,000 m2) existing buildings that are subject to major renovation among other things. The directive also required energy certificates and obligations concerning inspections to assess energy efficiency of the cooling equipment used in air-conditioning systems in buildings.

In 2008, the strategic objective set by the Finnish Government in the national climate and energy strategy entailed halting and reversing the growth in final energy consumption so that, in 2020, final energy consumption will be approximately 310 TWh. In 2011, final consumption was 386 TWh.

Table 6 Finland Building Permit Changes

ıt	Building permit pending in year								
	–1969	1969–	1976–	1978–	1985–	10/2003–	2008–	2010–	2012–
Heated spaces									
External wall	0.81	0.81	0.40	0.35	0.28	0.25	0.24	0.17	0.17
Ground-supported floor	0.47	0.47	0.40	0.40	0.36	0.25	0.24	0.16	0.16
Floor with crawl space	0.47	0.47	0.40	0.40	0.40	0.20	0.20	0.17	0.17
Floor butting against out-door air	0.35	0.35	0.35	0.29	0.22	0.16	0.16	0.09	0.09
Roof	0.47	0.47	0.35	0.29	0.22	0.16	0.15	0.09	0.09
Door	2.2	2.2	1.4	1.4	1.4	1.4	1.4	1.0	1.0
Window	2.8	2.8	2.1	2.1	2.1	1.4	1.4	1.0	1.0
Semi-warm spaces									
External wall	0.81	0.81	0.70	0.60	0.45	0.40	0.38	0.26	0.26
Ground-supported floor	0.60	0.60	0.60	0.60	0.45	0.36	0.34	0.24	0.24
Floor with crawl space	0.60	0.60	0.60	0.60	0.40	0.30	0.28	0.26	0.26
Floor butting against out-door air	0.60	0.60	0.60	0.60	0.45	0.30	0.28	0.14	0.14
Roof	0.60	0.60	0.60	0.60	0.45	0.30	0.28	0.14	0.14

From the table above, it is clear that the Finnish government is raising the regulation year by year with more restricting rules. And this is the reason for the creation of many energy consulting companies in Finland. Circumstances forced the owner or the designer of the building to hire these companies for calculating the energy impact and consumption.

4.1.1 Advantages

a. Generally, the most important advantage above all others is the combination of designation and energy evaluation simultaneously. For the design companies which are using ArchiCAD as their BIMs modelling software, they can design the building in a way which already fits the regulation laws of energy limitation at draft building stage. If any data is over the limitation, the changes can be done immediately in the designing stage, instead of massive amounts of work after the building is constructed on site.

b. Since, with more upcoming updates, the localization of the ArchiCAD makes it cooperate better with domestic companies which manufacture windows, doors and insulations, there are data profiles on their website which can be downloaded and used by ArchiCAD, extracted their products characteristics directly to the energy evaluation tool, which saves a lot of time to modify it by designer.

c. Energy evaluation report indicates detailed information, when expressing the consumption of energy, it separates the energy which is used and which is wasted during the using period.

4.1.2 Disadvantages

a. Firstly, the addition data for this energy evaluation is not covered enough by the information which is required. For a complete evaluation, it demands more specific information, including more options about the heating system. The building can be heated by ground heat, water heat, or air conditioner heat, not just districted heat. In addition, the type of use of area is not explained, despite many different types of area use options, no information about what factors are changing, which makes impossible to customize the area use. For example, in this case, where garage takes 10% of the area, while there is no more specific information related to what kind of garage it is. Garages can vary a lot from different types by different energy consumption values.

b. Secondly, there is no doubt that the original purpose of this ArchiCAD energy evaluation report is meant to be as brief as it can for the costumer to understand more easily. However, for professionals in this field, it still gives the same roughly-made report (in a professional's aspect). There is no calculation or formula shown in the report to be checked by them. As a consequence, it makes it more difficult for engineers to fix values or supervise mistakes when something goes wrong.

c. Thirdly, to use this energy evaluation tool correctly is difficult to some extent. Especially when facing some complex buildings, not structural complex but functionally complicated. Again in this project, there are a sauna room and a swimming pool inside of the building, and ArchiCAD could not optimize part of the room to be 90 degree Celsius or even take water into consideration. And to get a precise result, plumbing needs to also be taken into consideration, and by doing that, it requires another add-on downloaded as a Cadimage, for plumbing design, for which the author does not have expertise. The cooperation within team work is also needed.

d. The Auxiliaries that have been calculated are only lights and others which cannot show what exactly are. Plus optimization of the number or kind of auxiliaries is not available.

4.2 Further Development/Improvement

Basically, this is the first version of energy evaluation tool whose main aim is to assess the functionality. Therefore, a test run with a real project is done in this thesis to examine the extent of completion.

Improvement can be done in the following steps:

1. Localization still needs to be enhanced, by cooperating with more component manufacturing companies with release free download of the

product data for ArchiCAD, which gives more alternatives for the designer to determine which material or product is best both economically and environmentally.

2. More specific information is needed to be shown and optimized for the designer to make the report as accurate as possible. Including the multi-functional area optimization, auxiliary numbering, methods of heating and so on. To allow this tool to deal with more complicated circumstances both structural and multi-functional.

3. Add a specific, detailed report only for professionals or designers themselves to check and compare the data. Including all the calculation processes, formulas and local legislation building code (in this case Eurocode).

   And a comparison can be made between the final result and the local building code requirement, which makes it much easier for the designer to understand what and where to modify.

This thesis has given the writer a lot of skills related to design the building structures and has inspired the thought to make the building environmental friendly. Undeniably, energy saving is the trend for future building design and may become a priority problem. Therefore, this ArchiCAD energy evaluation system has a lot of potential in it and it deserves a better use and serves the society well. The knowledge gained in the process will be utilized in the future daily working life. Hopefully this thesis will be a good start for the better improvement of this energy evaluation tool and its future development.

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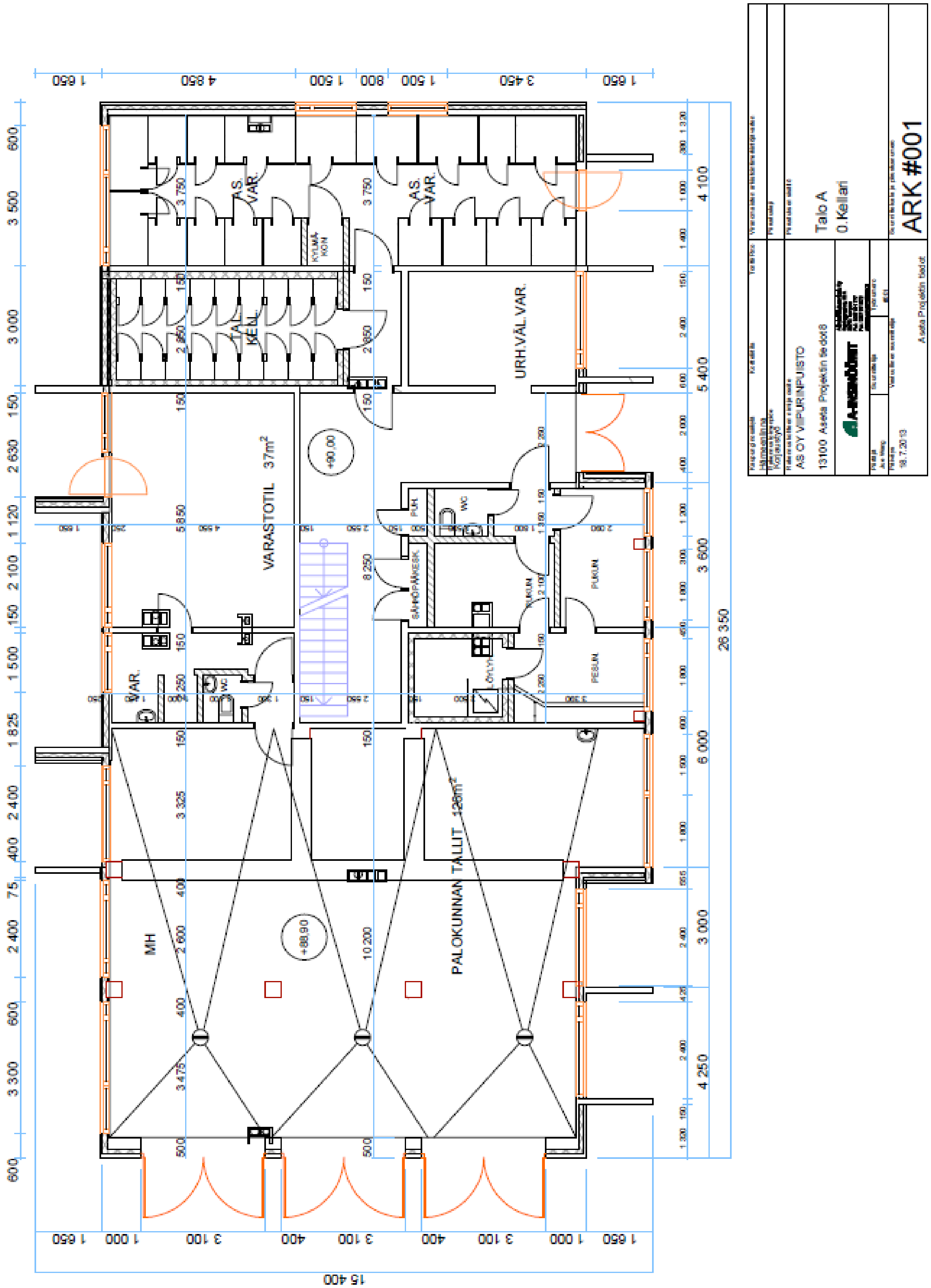
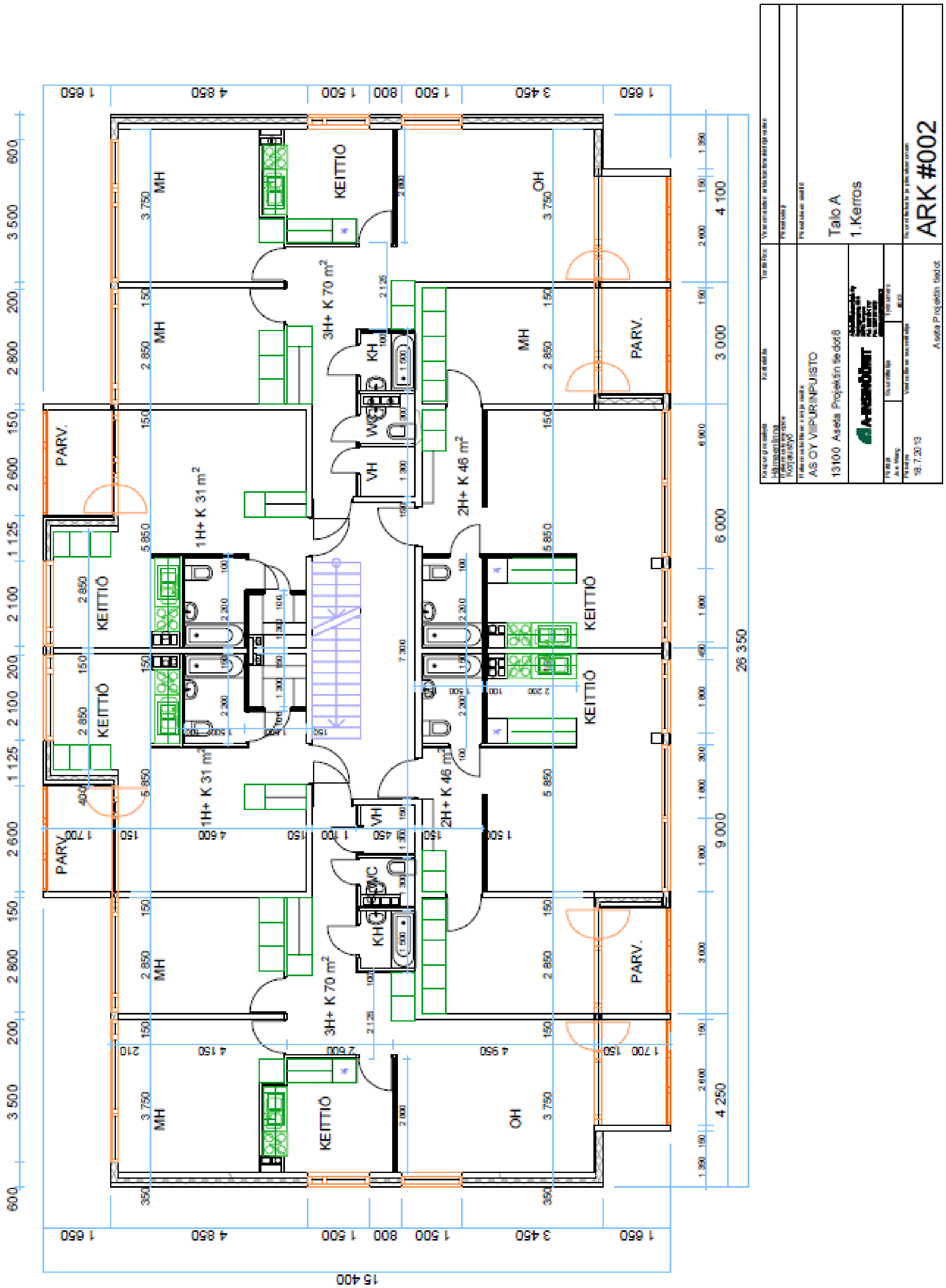
Appendix 1/1

ArchiCAD BIMs profile



Appendix 1/2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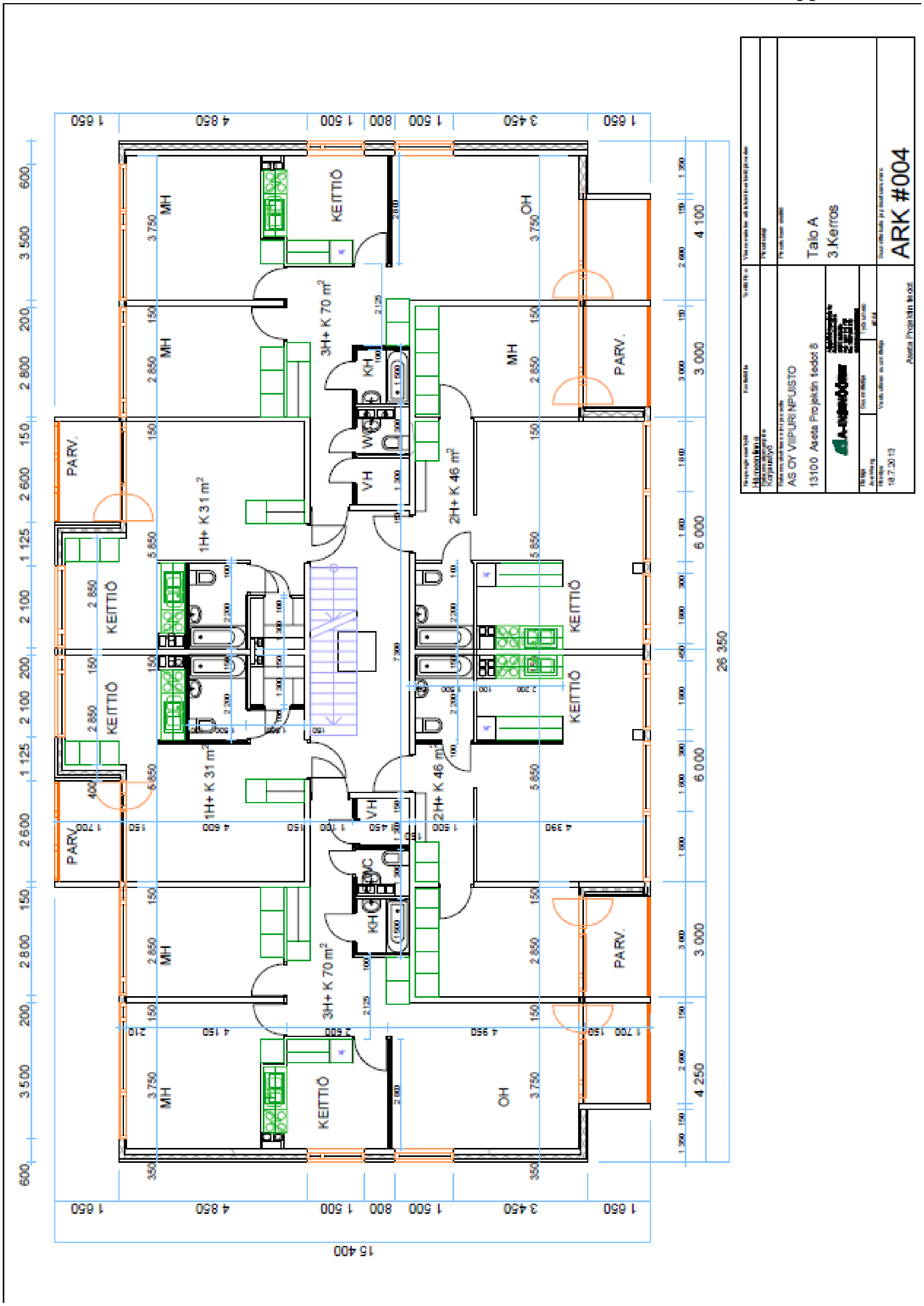
Talo A
1.Kerros
AS OY VIIPURINPUISTO
13100 Aseta Projektin tiedot8
KEITTIÖ
MH
OH
PARV.
3H+ K 70 m²
2H+ K 46 m²
1H+ K 31 m²
KH
WC
VH
26 350
15 400

Appendix 1/3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Talo A
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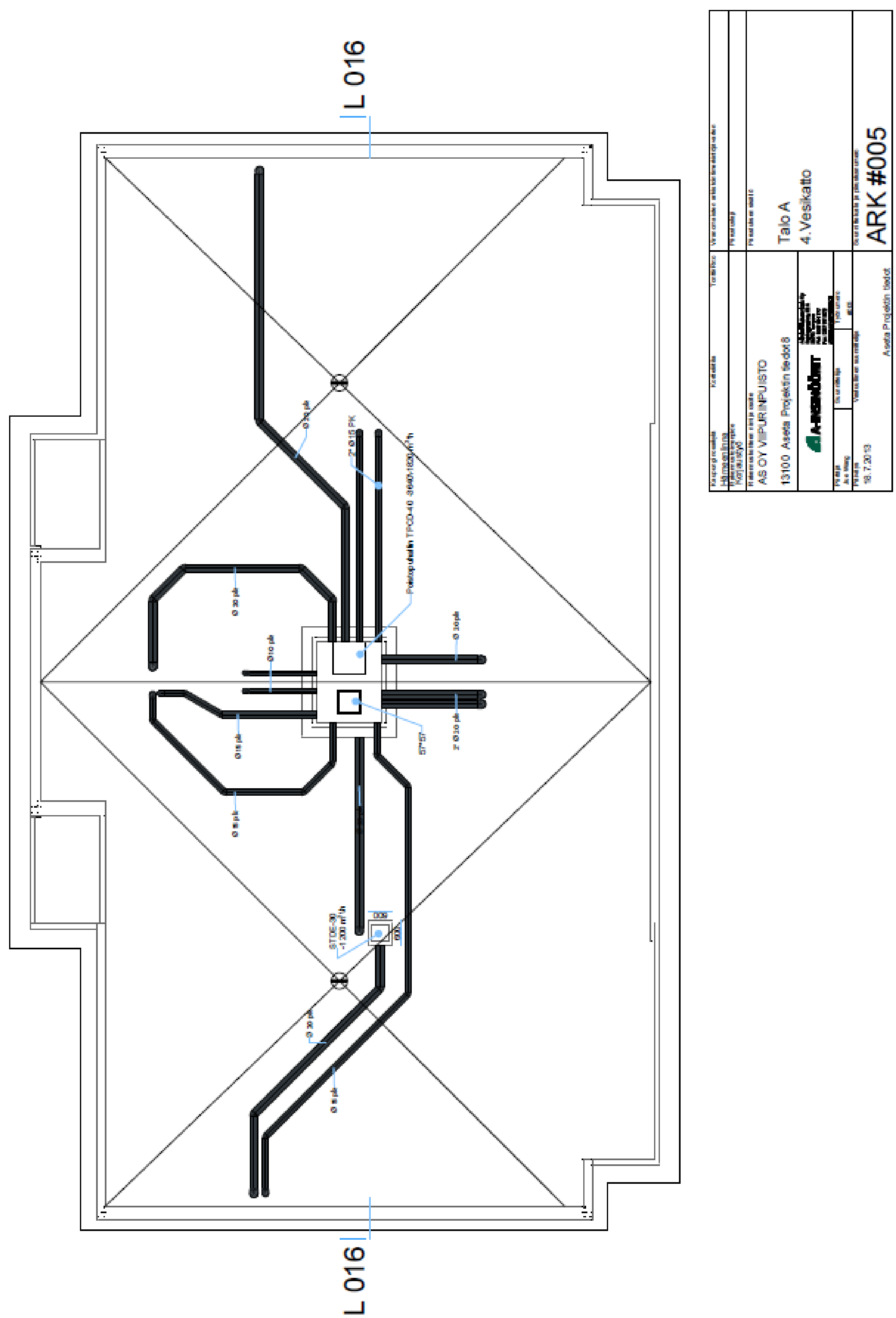
2H+ K 46 m²
1H+ K 31 m²
15 400
26 350

Appendix 1/4


L 016
L 016
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4. Vesikatto
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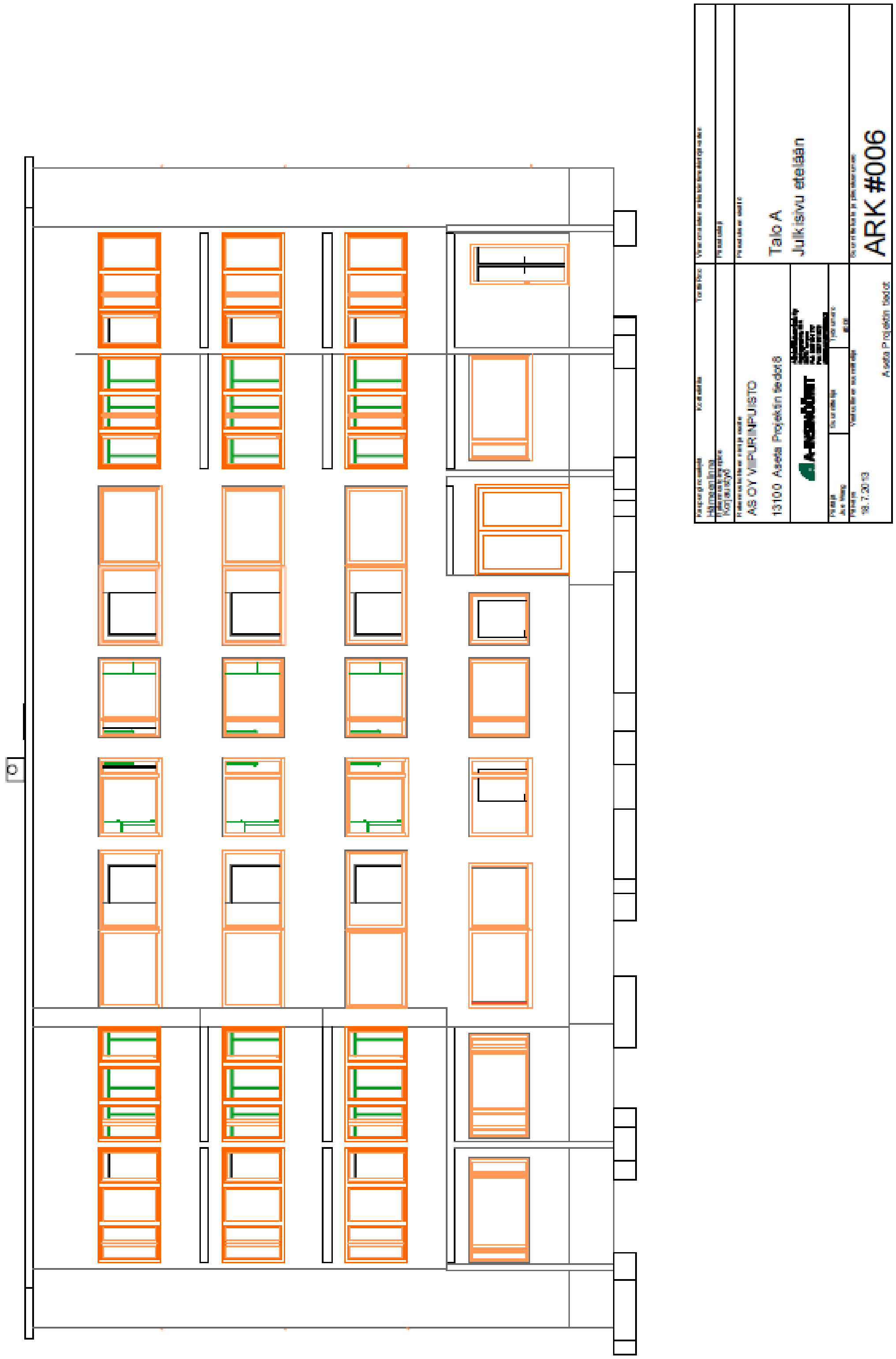
Aseta Projektin tiedot

Appendix 1/5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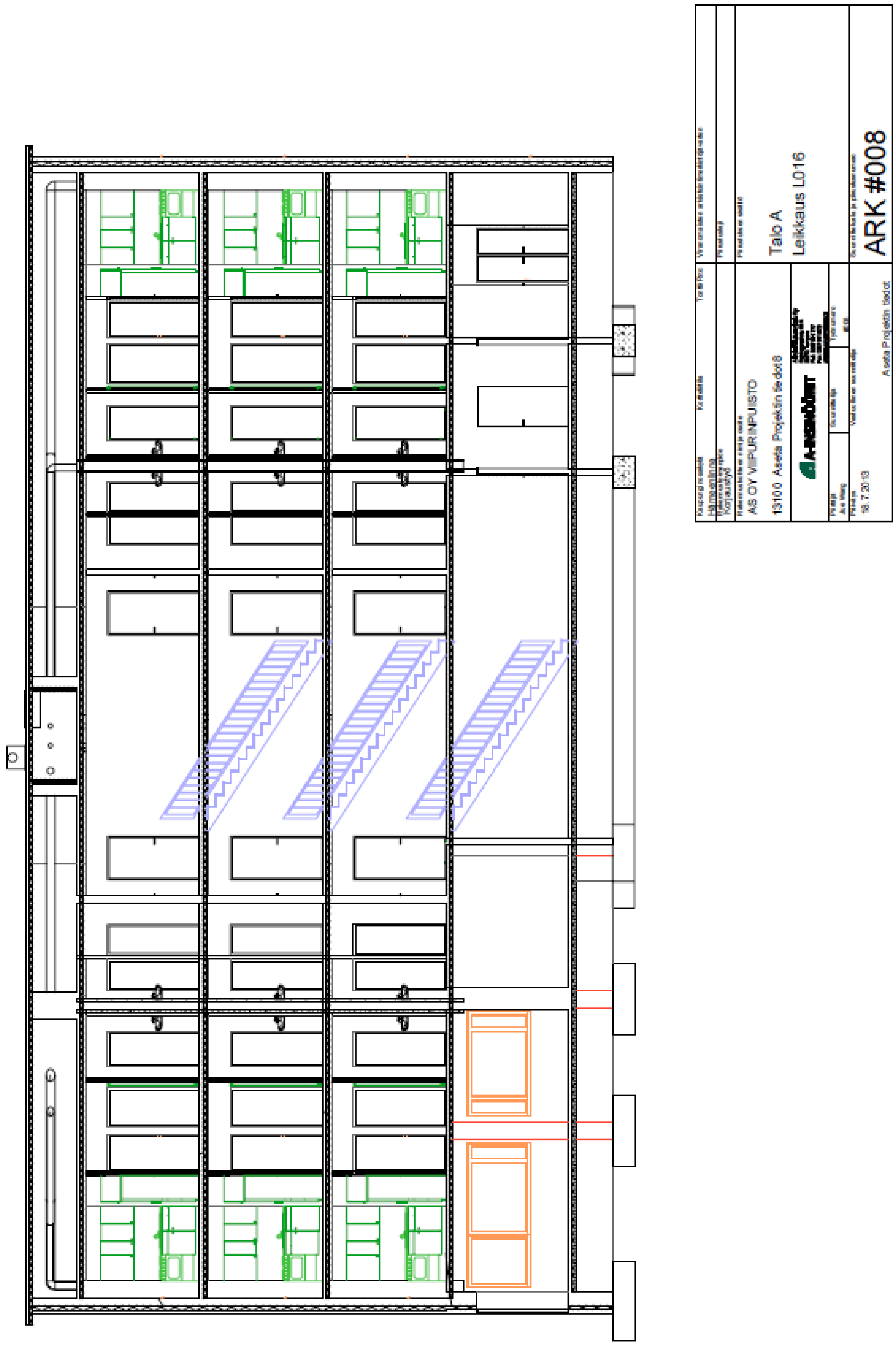
Julkisivu etelään
18.7.2013
Aseta Projektin tiedot
ARK #006

Appendix 1/6


Talo A
Julkisivu pohjoiseen
ARK #007
AS OY VIIPURINPUISTO
18.7.2013

Appendix 1/7


Hämeenlinna
Korjaustyöt
AS OY VIIPURINPUISTO
13100 Aseta Projektin tiedot
Talo A
Leikkaus L016
18.7.2013
Aseta Projektin tiedot
ARK #008

ArchiCAD report

Energiatehokkuusarvio

101 AS OY VIIPURINPUISTO

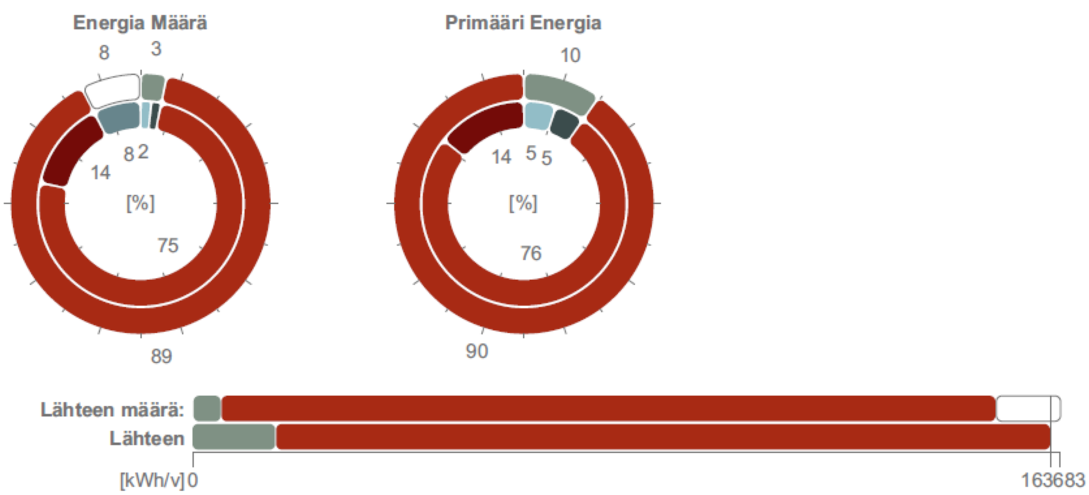
Perustiedot

Projektin tiedot		
Projektin nimi:	AS OY VIIPURINPUISTO	
Sijainti:		
Ilmastotietojen lähde	Strusoft-palvelin	
Arviointipäivä:	26.3.2014 0:48:21	
Rakennuksen geometria		
Brutto lattiapinta-ala	**367,62**	m²
Lattiapinta-ala:	**328,87**	m²
Ulkovaipan pinta-ala:	**907,76**	m²
Ilmanvaihtotilavuus:	**3749,15**	m³
Lasitus:	**23**	%
Ulkovaipan ominaisuudet		
Ilmavuodot 50Pa:	**4.03**	l/h
Ulkop. lämpökapasiteetti:	**829.49**	J/m²K

Lämmönsiirtokertoimet	U-arvo	[W/m²K]
Vaippa keskimäärin:	**1.10**	
Lattiat:	**--**	
Ulkoinen:	**0.40 - 0.40**	
Maanalainen:	**--**	
Aukot:	**2.39 - 2.59**	
Lämmitysenergia (netto):	**373.70**	kWh/m²v
Jäähdytysenergia (netto):	**37.39**	kWh/m²v
Energia yhteensä:	**411.09**	kWh/m²v
Energiankulutus:	**497.71**	kWh/m²v
Polttoaineen kulutus:	**497.71**	kWh/m²v
Primäärienergia:	**492.30**	kWh/m²v
Polttoainekustannus:	**46.03**	€/m²v
CO_2-päästö:	**99.43**	kg/m²v

Energiankulutus lähteittäin

		Energia			CO_2-päästö
Lähteen tyyppi	Lähteen nimi	Määrä	Primääri	Kustannus	
		kWh/v	kWh/v	€/v	kg/v
Sekundääri	Sähkö	5257	15773	525	1135
	Kaukolämpö	146129	146129	14612	31563
	Ei määritelty	12296	--	--	--
	Yhteensä:	**163683**	**161902**	**15138**	**32699***



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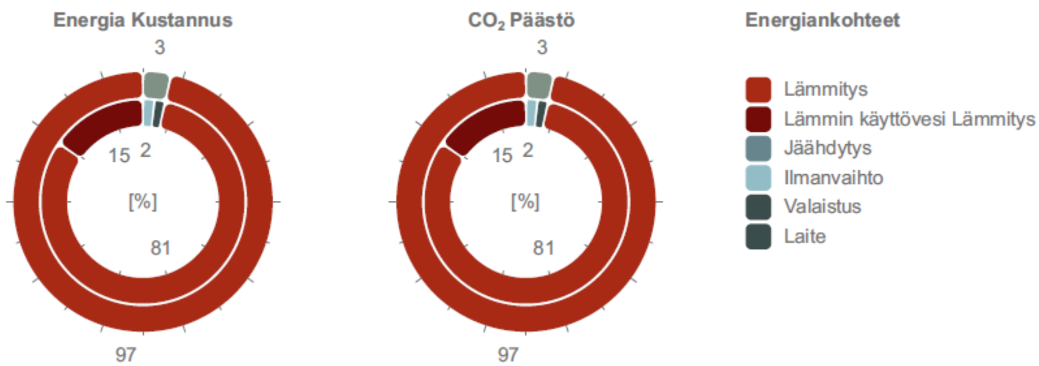
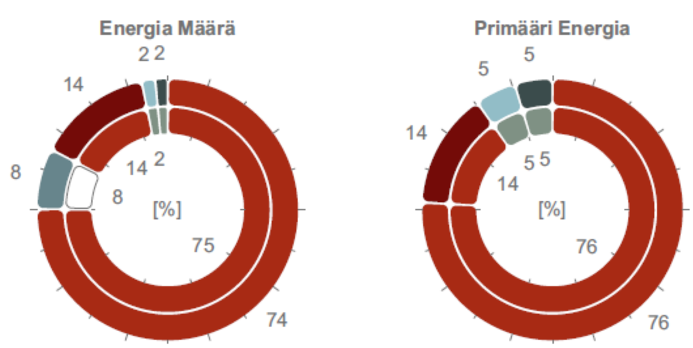
Energiatehokkuusarvio

101 AS OY VIIPURINPUISTO



Energiankulutus kohteittain

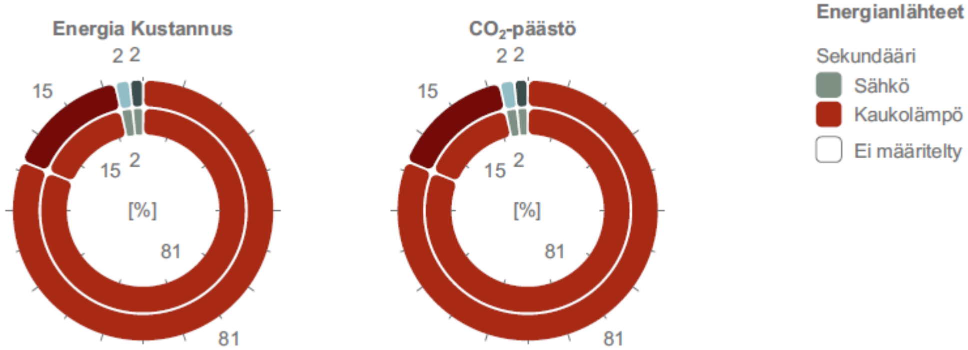
Kohteen nimi	Energia Määrä kWh/v	Energia Primääri kWh/v	Energia Kustannus €/v	CO_2 Päästö kg/v
Lämmitys	122900	122900	12290	26546
Jäähdytys	12296	0	0	0
Lämmin käyttövesi	23228	23228	2322	5017
Ilmanvaihto	2736	8210	273	591
Valaistus ja laitteet	2520	7562	252	544
Yhteensä:	**163683**	**161902**	**15138**	**32699**



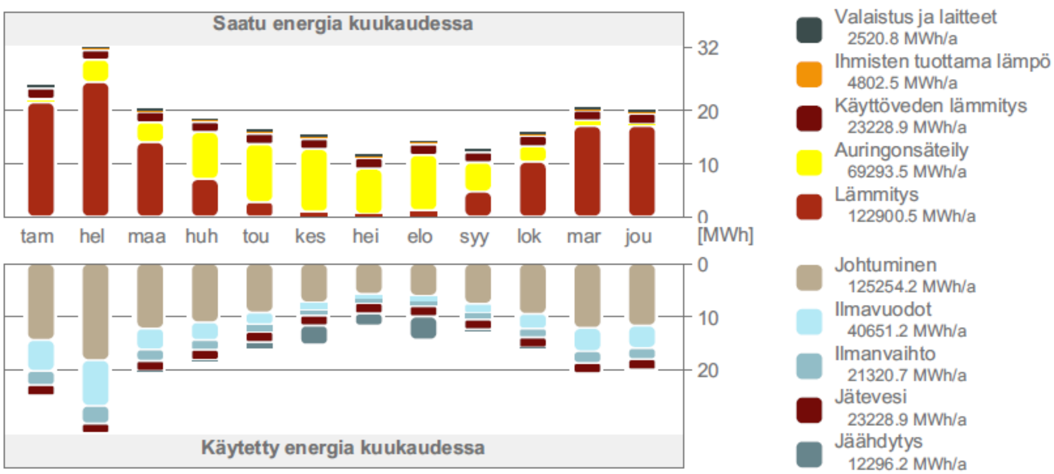
Appendix 2/10

Energiatehokkuusarvio

101 AS OY VIIPURINPUISTO



Projektin energiatase



Termodynaamiset tilat

Termodynaaminen tila	Vyöhykkeet Asetetut	Käyttötarkoitus	Brutto lattia-ala m²	Tilavuus m³
001 The whole building	4	Residential	367,62	3749,15
Yhteensä:	**4**		**367,62**	**3749,15**

Ympäristövaikutus

Lähteen tyyppi	Lähteen nimi	Primäärienergia kWh/v	CO_2-päästö kg/v
Sekundääri	Sähkö	15773	1135
	Kaukolämpö	146129	31563
	Yhteensä:	**161902**	**32699**

Appendix 3/11

Energy Evaluation Report, company enermix,2013

As Oy Vuoriklipi, Jyväskylä

Energiakulutuksen seuranta

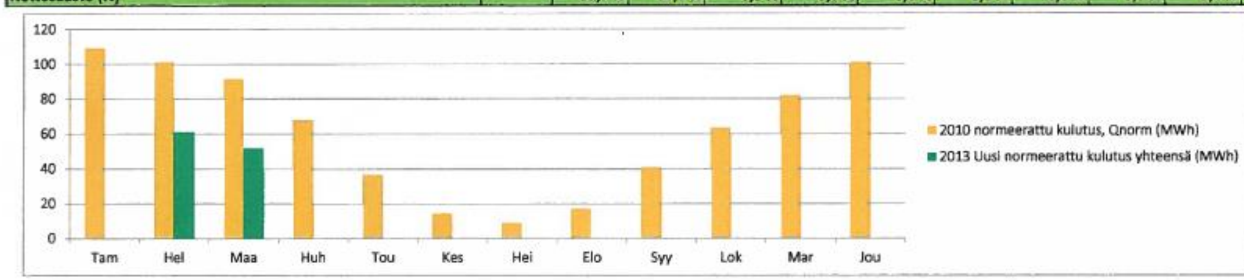
Enermix Oy, Janne Heinonen

Energian hinnat (sähkö €/kWh, kaukolämpö €/MWh sisältäen perusmaksun):

	Sähkö	0,12 €	0,12 €	0,12 €	0,12 €	0,12 €	0,12 €	0,12 €	0,12 €	0,12 €	0,12 €	0,12 €	0,12 €
	Kaukol.	75,93 €	75,93 €	75,93 €	75,93 €	75,93 €	75,93 €	75,93 €	75,93 €	75,93 €	75,93 €	75,93 €	75,93 €
2013 Kaukolämmön mittarilukema (MWh)		9462,889	9502,521	9551,759									
2013 Nibe lämpöpumppu ottoenergialukema (MWh)		0	7,814	15,258									
2013 LTO-laitteiden ottoenergialukema (MWh)		0	4,457	8,719									
2013 Nibe antoenergiamäärä, mittarilukema (MWh)		0	35,703	63,184									
Luentapvm		31.1.2013	28.2.2013	31.3.2013									

VERTAILULUVUT (vuodelta 2010)	Tam	Hel	Maa	Huh	Tou	Kes	Hei	Elo	Syy	Lok	Mar	Jou	Vuosi
2010 kaukolämmön kulutus (MWh)	**138**	**112**	**94**	**61**	**31**	**11**	**9**	**17**	**34**	**63**	**91**	**131**	**793**
2010 Lämpimän käyttöveden osuus (m3)	153	153	153	153	153	153	153	153	153	153	153	153	1838
2010 Lämpimän käyttöveden osuus (MWh)	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	107
2010 Lämmityksen osuus (MWh)	129	103	86	52	22	2	0	8	26	55	82	122	686
2010 lämmitystarveluvut (Jyväskylä)	1018	811	673	410	176	15	0	63	201	429	646	961	5403
	18,8 %	15,0 %	12,5 %	7,6 %	3,3 %	0,3 %	0,0 %	1,2 %	3,7 %	7,9 %	12,0 %	17,8 %	
Lämmitystarveluvut vertailukaudella, Jyväskylä SN vpkunta	789	727	650	464	217	43	13	63	251	427	576	725	4945
2010 normeerattu kulutus, Q_{norm} (MWh)	109	101	91	68	36	14	9	17	41	63	82	101	735

LTOH-JÄRJESTELMÄ		Tam	Hel	Maa	Huh	Tou	Kes	Hei	Elo	Syy	Lok	Mar	Jou	Vuosi
2013 mitattu kaukolämmön kulutus (MWh)			**39,6**	**49,2**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**89**
2013 Lämpimän käyttöveden osuus (MWh)			2,3	2,9										
2013 Lämmityksen osuus (MWh)			37,3	46,4										
2013 lämmitystarveluvut (Jyväskylä)			585	810										
2013 normeerattu kulutus, Q_{norm}	A		49	40										
Kaukolämmön kulutus pienentynyt (MWh)			-53	-51	-68	-36	-14	-9	-17	-41	-63	-82	-101	**-535**
Kaukolämmön kulutus pienentynyt (%)			-51,9 %	-56,2 %	-100,0 %	-100,0 %	-100,0 %	-100,0 %	-100,0 %	-100,0 %	-100,0 %	-100,0 %	-100,0 %	
Lämpöpumpun mitattu sähkönkulutus (MWh)	B		7,814	7,4	0	0	0	0	0	0	0	0	0	**15**
Lämpöpumpun energiatuotto (MWh)			35,703	27,5	0	0	0	0	0	0	0	0	0	**63**
Lämpöpumpun COP-luku			**4,57**	**3,69**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	
LTO laitteiden mitattu sähkönkulutus (MWh)	C		4,5	4,3										
Ilmaisenergian määrä (MWh)			**27,9**	**20,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**48**
2013 Uusi normeerattu kulutus yhteensä (MWh)	A+B+C		**61,0**	**51,8**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**112,7**
NETTOSÄÄSTÖ (MWh)			**40,3**	**39,7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**80**
Nettosäästö (%)			**36,0 %**	**42,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**10,1 %**
Vanha kustannus		10 494 €	7 687 €	6 945 €	5 150 €	2 768 €	1 089 €	674 €	1 282 €	3 096 €	4 793 €	6 231 €	7 668 €	**57 878 €**
Uusi kustannus			5 170 €	4 448 €	- €	- €	- €	- €	- €	- €	- €	- €	- €	
NETTOSÄÄSTÖ (€) / KK			**2 518 €**	**2 497 €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**- €**	**5 014 €**
Nettosäästö (%)			**32,7 %**	**36,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**0,0 %**	**8,7 %**



enermix