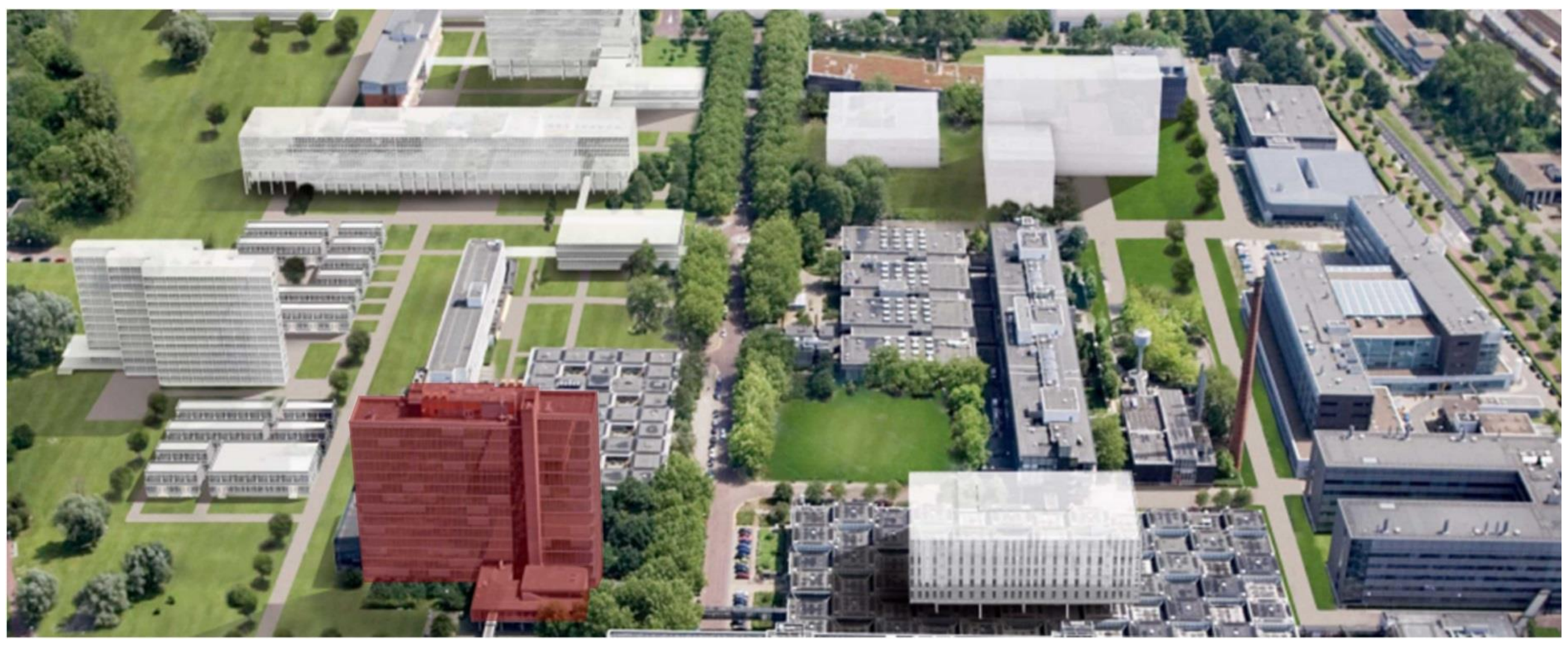
Potentiaal - Zero Energy Building

SEB&C 2013



Assignment

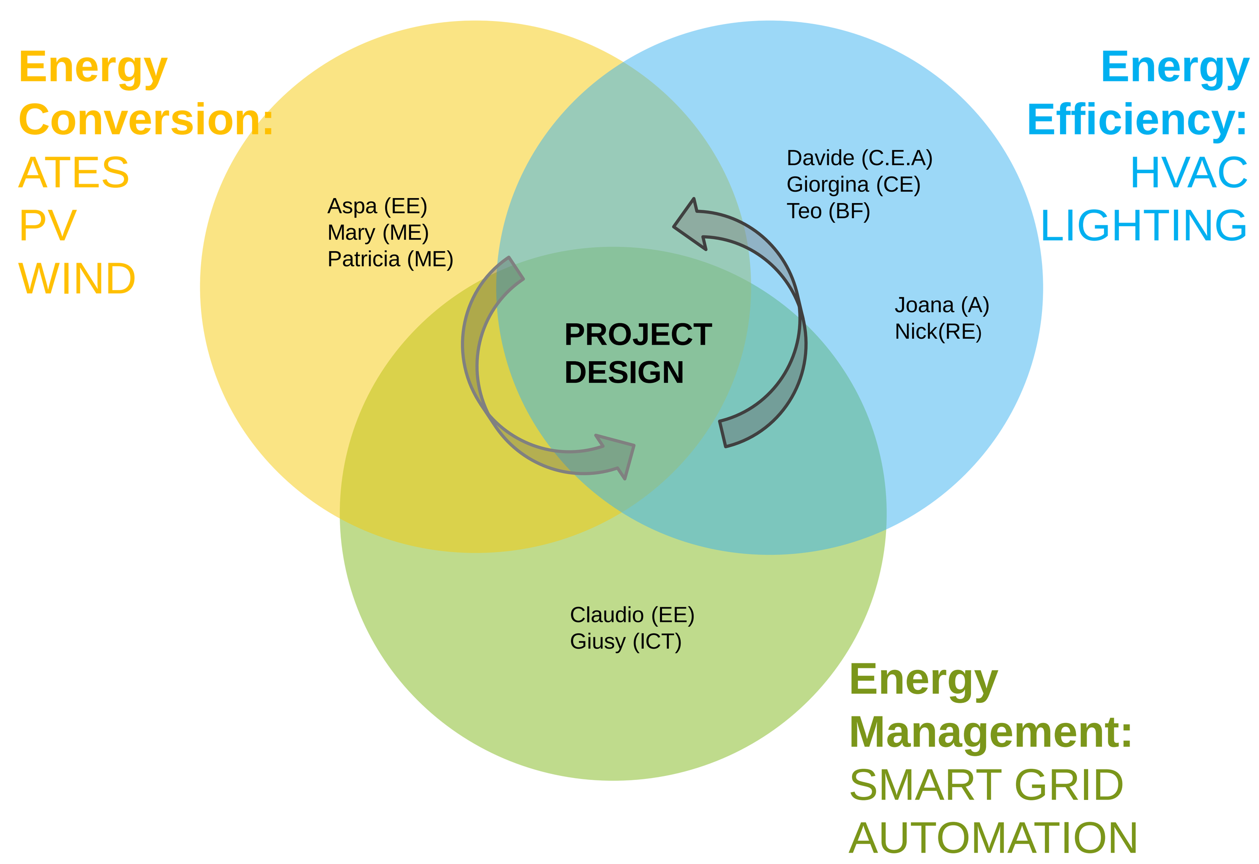
TU/e is undertaking a strategic plan called 2020, as the year in which the campus should become a sustainable Science Park. This plan comprises the refurbishment

Within this context, the Potentiaal building has become one of the sites involved in the European 11 competition, with young architects from all over Europe submitting their projects and competing for the award. The goal was to give the building a new life, more suited for the new function, and to promote sustainable development, while preserving the identity of the original plan of the campus. As part of the goal, the building should also become sustainable and Zero Energy.

The Potentiaal, now hosting the Electrical Engineering department, will become a residential facility with a University College, cultural areas and about three hundred residential units.

Goal: Zero Net Energy + Comfort

The Proposed Overall

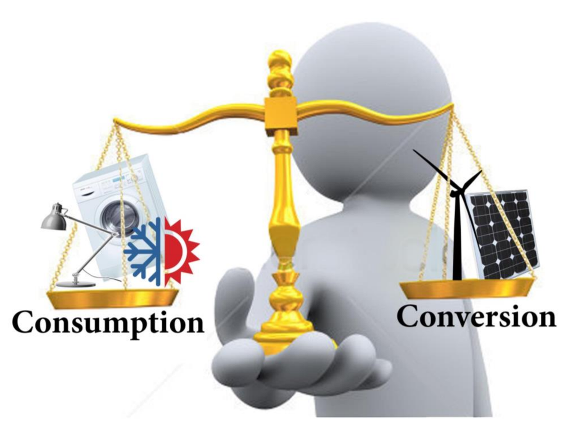


Team Description

In order to focus and achieve an integral design for this Case Study, the team will experience an active, cooperative and peer-learning oriented approach. According to the philosophy of SEB&C Post Graduate program, the team is composed by trainees of different educational backgrounds.

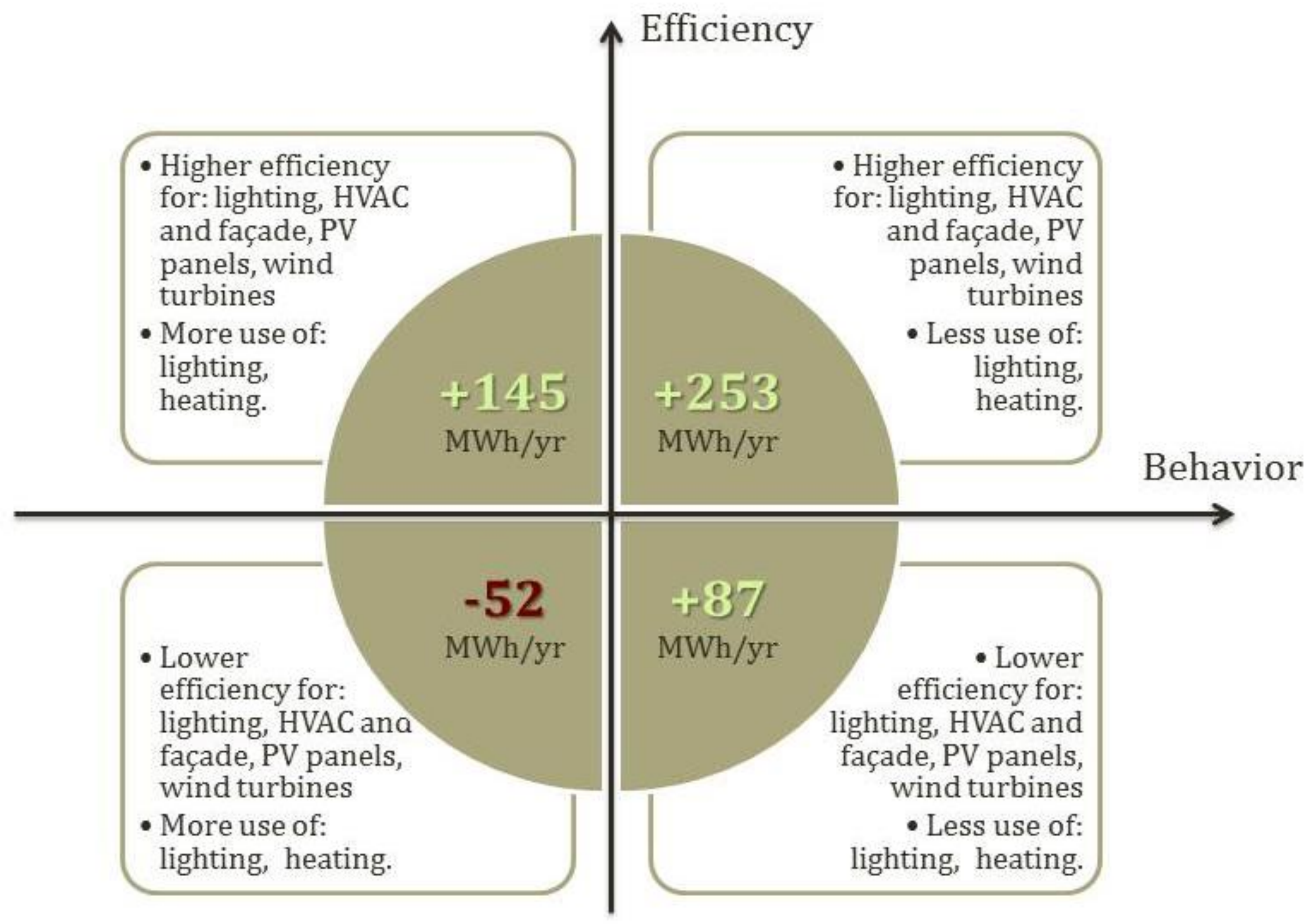
Costs & Conclusions

Net Energy: 115%
Comfort levels: Technical and Physiologic
Cost: 5.3 Millions
Pay Back: 18 years



Measures	Total surface / units	Initial costs	Future costs
PV-panels	1,576m2	€ 535,977	€ 214,391
Wind turbines	48	€ 202,363	€ 176,847
LED	2,190	€ 146,256	€ 14,856
Light tubes	462	€ 231,000	€ 184,800
Smart glazing	8,022m2	€ 3,008,250	€ 2,406,600
LSC	3,370m2	€ 337,000	€ 235.900
Underfloor heating (UH)	17,000m2	€610,000	-
Heat pump - UH	3	€44,472	-
Heat pump - DHW	5	€ 54,139	-
Automation	-	€ 198,500	€ 40,000
Total		€5,307,957	€3,309,916

Consumption & Conversion scenarios



3TU .School for Technological Design TU/e

SEBC

Mary Kolligri, Aspa Simouli, Claudio Bacchiani, Joana Pedro, Patricia McKula, Nick Opbroek, Theodoros Charitidis, Davide Garufi, Giusy Agueci, Giorgina Vompiri

TU/e Technische Universiteit Eindhoven University of Technology · KTH Royal Institute of Technology · Universitat Politècnica de Catalunya BarcelonaTech · ESADE Business School Ramon Llull University · eit KIC InnoEnergy

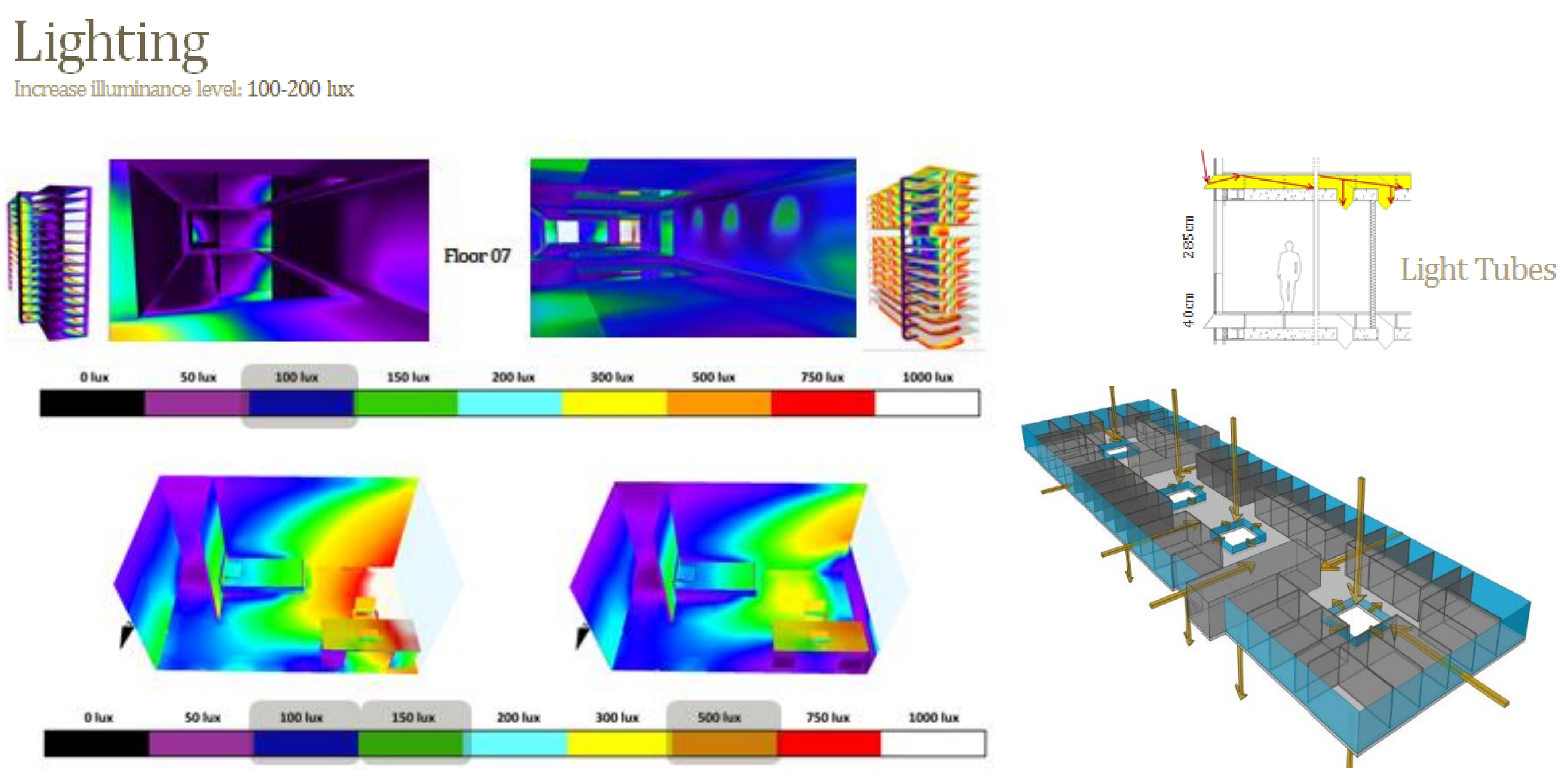
SEB&C 2013

Energy Consumption

Introduction

The services demanded by buildings require significant energy use. Energy consumption in buildings has been growing in aggregate over time. Our solution in order to deal with that problem is the combination of high-performance, smart façade, day-lighting integration coupled with energy efficient artificial lighting and low-energy cooling strategies .

Goal: Minimization of energy consumption towards the major target of creating a zero energy building without compromising the human comfort.

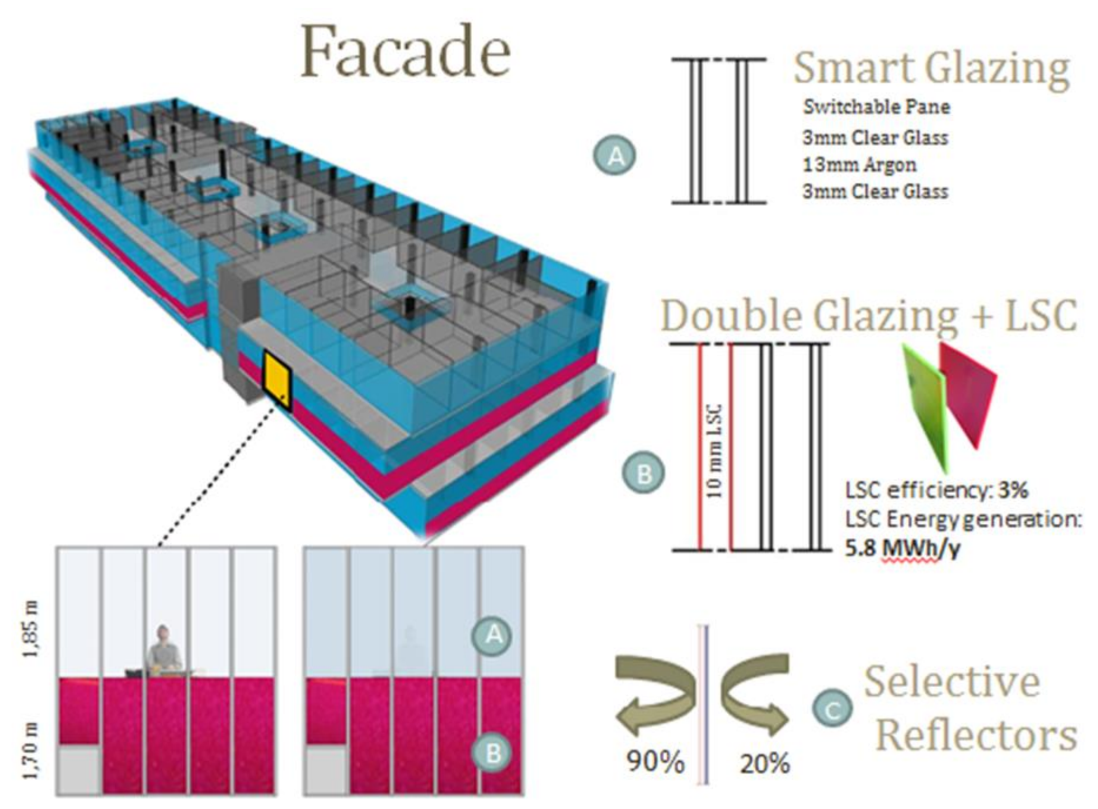


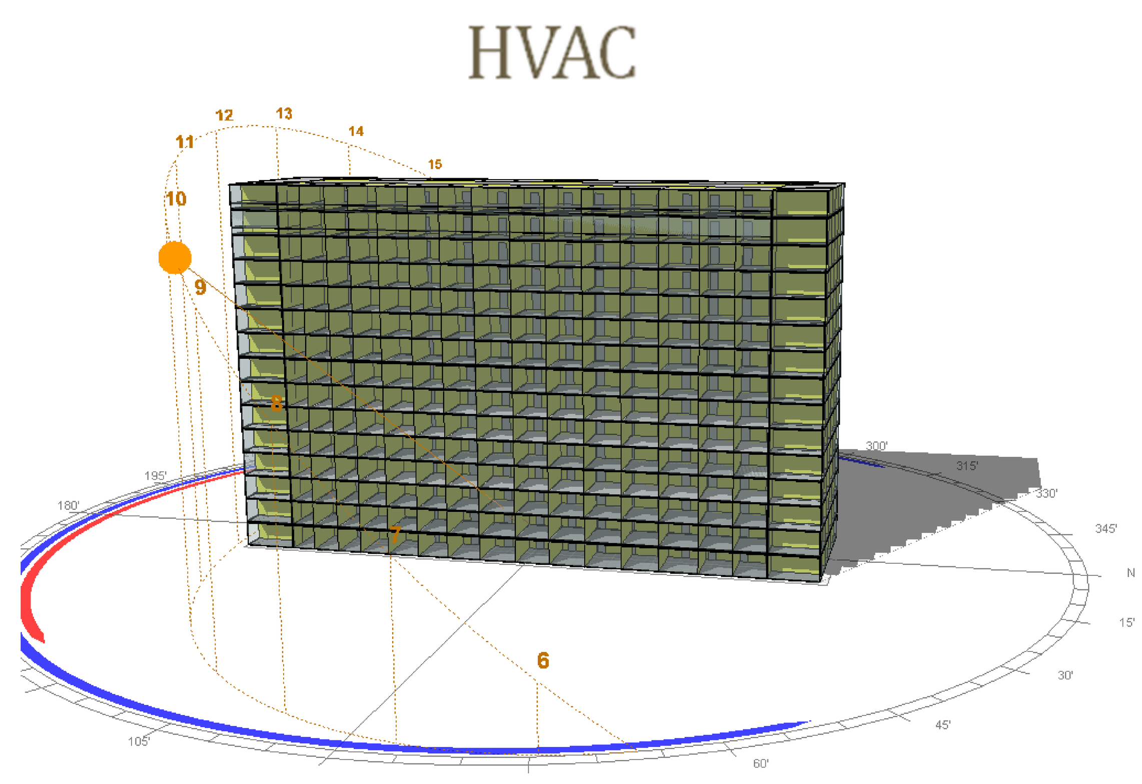
Lighting

To increase the comfort and productivity of the people and to use as minimal energy as possible natural lighting is increased as much as possible.
Four smaller atriums, equally divided over the entire length of Potentiaal, let natural lighting penetrate the building vertically. The common areas, located at the sides of the building with an open view to the outside, and numerous horizontal light tubes, directing natural lighting over a distance from 6.5m from the side of the building to the circulation areas, let natural lighting penetrate the building horizontally.

Taken all the measures into account the required light levels of at least 100 lux is assured during the day. Artificial lighting is necessary to maintain visual comfort when natural lighting is not sufficient.
LED technology surpasses all other lighting technologies when it comes to quality (50,000 hours) and efficiency (80-100 lm/W). minimum of 6 hours per day.

Energy Demand: 9%





Facade

Proposed façade system : Smart Energy Glass + LSC (Luminescent solar concentrator) components (24%). The LSC components are going to be implemented until one certain height at the projecting volumes of our building.

The benefits gained are good thermal insulation and at the same time conversion of energy by the LSC. The converting solar energy to electricity from LSC components is calculated to 90.228 KWh/year. Moreover with the implementation of the Smart Energy Glass in combination with the LSC components we provide the user with comfort in terms of natural lighting and privacy (shading system, from bright state to dark and privacy state.

Energy Conversion: 12%

HVAC

The HVAC proposal is a mixed mode ventilation system (mechanical and natural) so to decrease the cooling loads through summer. The calculated total amount of energy consumed by Potentiaal is 127 MWh_{th}/y, from which only 3,15 MWh_{th}/y are the cooling loads. The total reduction reaches *14%* approximately.
In the calculations natural ventilation, the new facade, the occupancy schedules, the operation hours of the HVAC system and the infiltration values are included. If we consider the mechanical ventilation which operates on winter, then we also have to take into account the electricity amount that is consumed by fans (134 MWh_e/y_1).

Energy Demand: 73%

Literature cited

Doe, P. (2011, May). LED fabrication roadmap targets packaged LED prices of $2.20/klm by 2015. Retrieved may 13, 2013, from LEDs Magazine: http://ledsmagazine.com/features/8/5/2.

Francis, T. (2002). Code for Lighting. Italy: Butterworth-Heinemann.

Garcia Hansen, V. a. (2003). Natural illumination of deepplan office buildings: light pipe strategies. . ISE Solar World Congress

Gerhard Hausladen, Michael de Saldanha, Petra Liedl. (2006). Climate Skin. Munich, Buchenberg, Hammamet: Birkhauser.

Michael G. Debije, Paul P. C. Verbunt. (January 2012). Thirty Years of Luminescent Solar Concentrator Research: Solar Energy for the Built Environment. Advanced Energy Materials, 12-35

Peerplus, S. E. (2009). Retrieved April 2013, from http://www.peerplus.nl/default/index/index/language/2.

3TU .School for Technological Design TU/e

SEBC

Joana Pedro, Nick Opbroek, Theo Charitidis, Davide Garufi, Giorgina Vompiri

Technische Universiteit Eindhoven University of Technology
KTH Royal Institute of Technology
UPC Universitat Politècnica de Catalunya BarcelonaTech
ESADE Business School Ramon Llull University
eit KIC InnoEnergy

Energy Conversion

SEB&C 2013

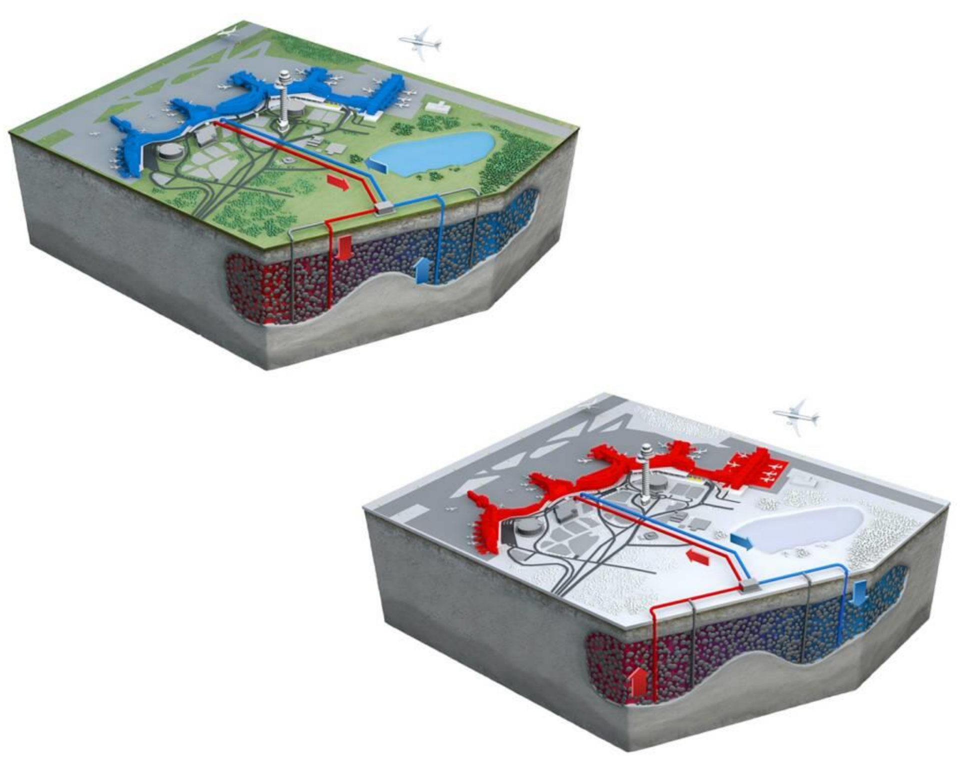
Introduction

One of the most important factors for transforming a building into zero-net energy building is to apply methods to harvest energy. The required energy for electricity should be provided by Renewable Energy Sources (RES) and this is aligned with the TU/e master plan. According to it, 10% of total energy should be provided by Renewable Energy Sources (RES) up to 2015.

Goal

The goal is to meet the thermal and electrical needs of the building without using conventional power systems. Different types of RES were investigated and the final proposal includes installation of geothermal, solar and wind systems. Furthermore, the scope is to increase the sustainable image and the added value of the building, by implementing these power systems.

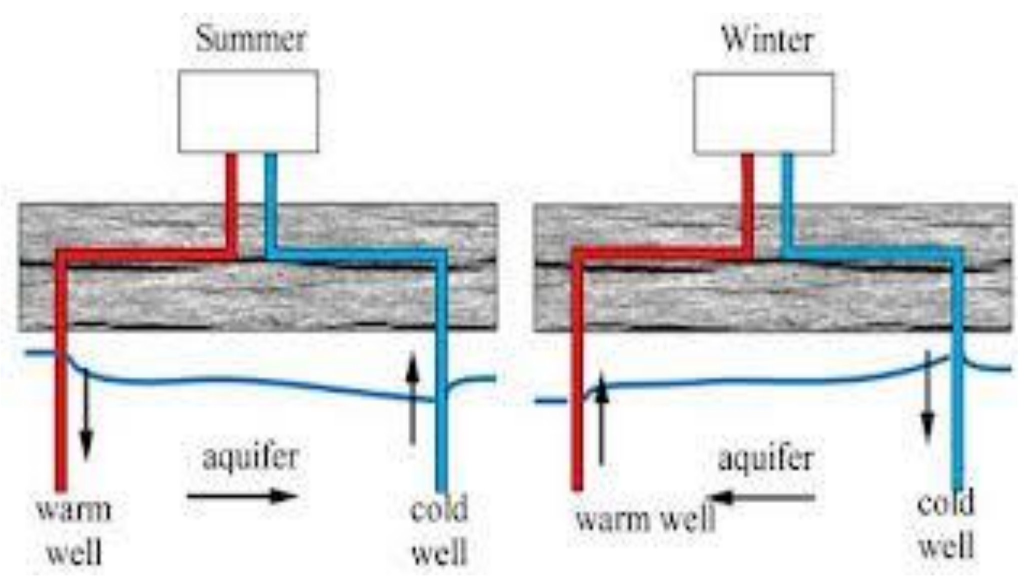
Aquifer Thermal Energy Storage



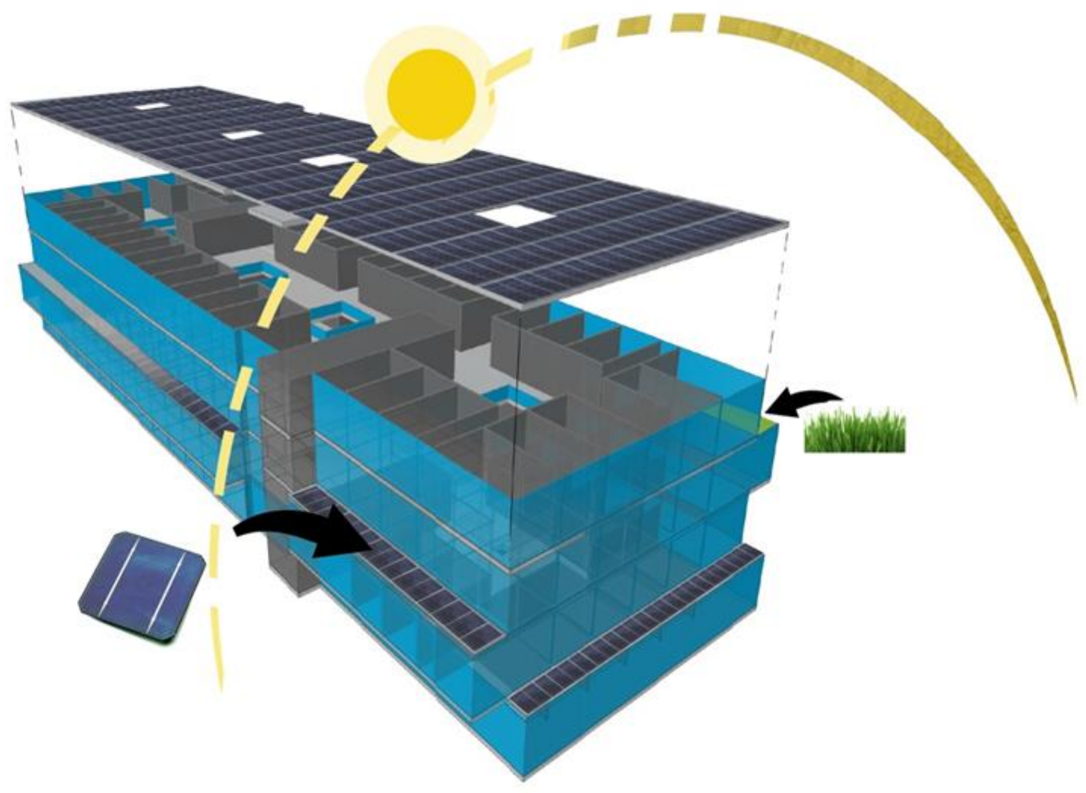
ATES is an innovative open-loop geothermal technology which relies on seasonal storage of cold and warm groundwater in an aquifer. This system already exists in TU/e campus and has currently an excess of heat of about 5 GWh [1],so connecting Potentiaal to it would be beneficial.

For this scenario, one type of heat pump is needed for water underfloor (low temperature) heating and cooling system and another type for the Domestic Hot Water needs. Totally, the building will need thermal energy of 380 MWh/year and, in order to achieve it, the system will consume 145 MWh/year of electrical energy.

Energy Conversion: 44%

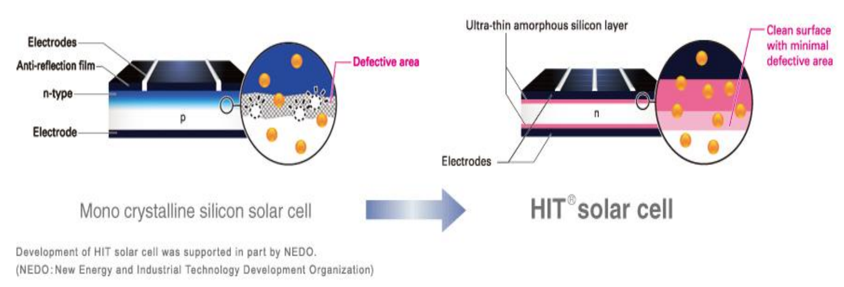


Solar Panels



The main benefit of solar energy is that it is renewable, clean and silent, so there are no emissions and pollution during its conversion into electricity [2].

The proposed solar modules are SANYO HIT (Heterojunction with Intrinsic Thin layer) and are made up of solar cells composed of a monocrystalline silicon wafer surrounded by extremely thin amorphous silicon layers.



Potentiaal is a quite tall building so a big area without any shadow from the surroundings is available for solar panels' installation [3].

The final proposal, considering innovation and all-around orientation, is to install them on the upper surface of the "external volumes" that can be constructed as shown in figure on south and east façade, while on north and west façade plants or flowers can be cultivated. Then, the total energy that can be converted to electricity is 225 MWh/year.

Energy Conversion: 30%

Wind Turbines

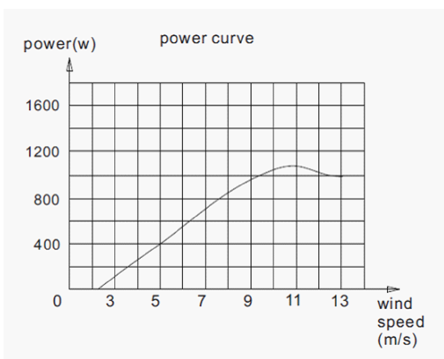
In order to take advantage of the wind energy, vertical axe wind turbines were selected, since they create less noise, have lower start-up speed and make use of turbulence and wind from all directions[4].

The maximum wind pressure point is located at 70% of the total building height, incrementing the wind speed with a factor of 1.5 to 2.5 [5]. The 9th floor of the building is dedicated to allocate an array of 48 wind turbines around the perimeter. The space is relocated on the corners of the building.

The model selected is "Small wind turbine X-H-1KW".

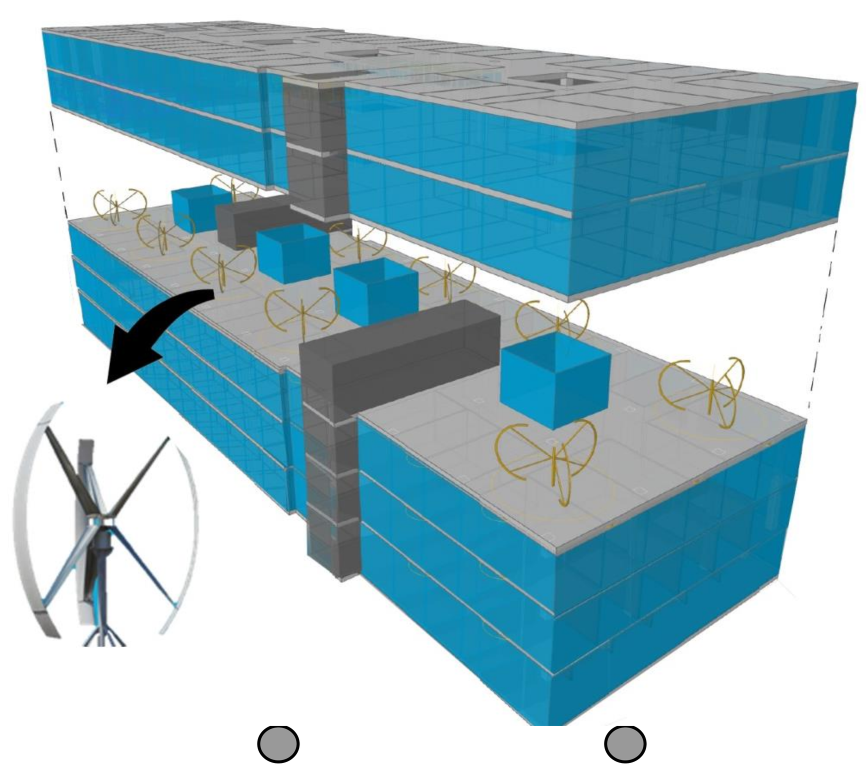
- start-up speed: 2.3 m/s
- working wind speed: 3-25 m/s.

The power curve can be seen in the following diagram [6]:



Considering the potential wind speed at this height and the power curve of the turbine, the energy harvested is of 302 MWh/y.

Energy Conversion: 40%



Literature cited

[1] TU/e. 2010. Benergy annual report. *Eindhoven*.

[2] Parker. 2009. *Microgeneration, low energy strategies for larger buildings.* Architectural Press.

[3] Lydersen, K. 2012. Retrieved 3 25, 2013, from Midwest Energy News: 1. http://www.midwestenergynews.com/2012/02/07/universities-become-natural-leaders-on-renewable-energy/

[4] Campbell, N. S., & Stankovic, S. *2001. Wind energy for the built environment. London: BDSP*

[5] Blocken, B., & Carmeliet, J. 2004. Pedestrian wind environment around buildings: literature review and practical examples. *Thermal environment and building science, 1097-1963*.

[6] Suzhou Newmeil. (2013). *Small wind turbine X-H-5KW*. Retrieved April 25, 2013, from http://www.newmeilwindturbine.com/product/wind-turbine-x-h-5kw.html

3TU .School for Technological Design TU/e

SEBC

Mary Kolligri, Aspa Simouli, Patricia McKula,

Technische Universiteit Eindhoven University of Technology

KTH Royal Institute of Technology

UPC Universitat Politècnica de Catalunya BarcelonaTech

ESADE Business School Ramon Llull University

eit KIC InnoEnergy

SEB&C 2013

Energy Management

Why automation?

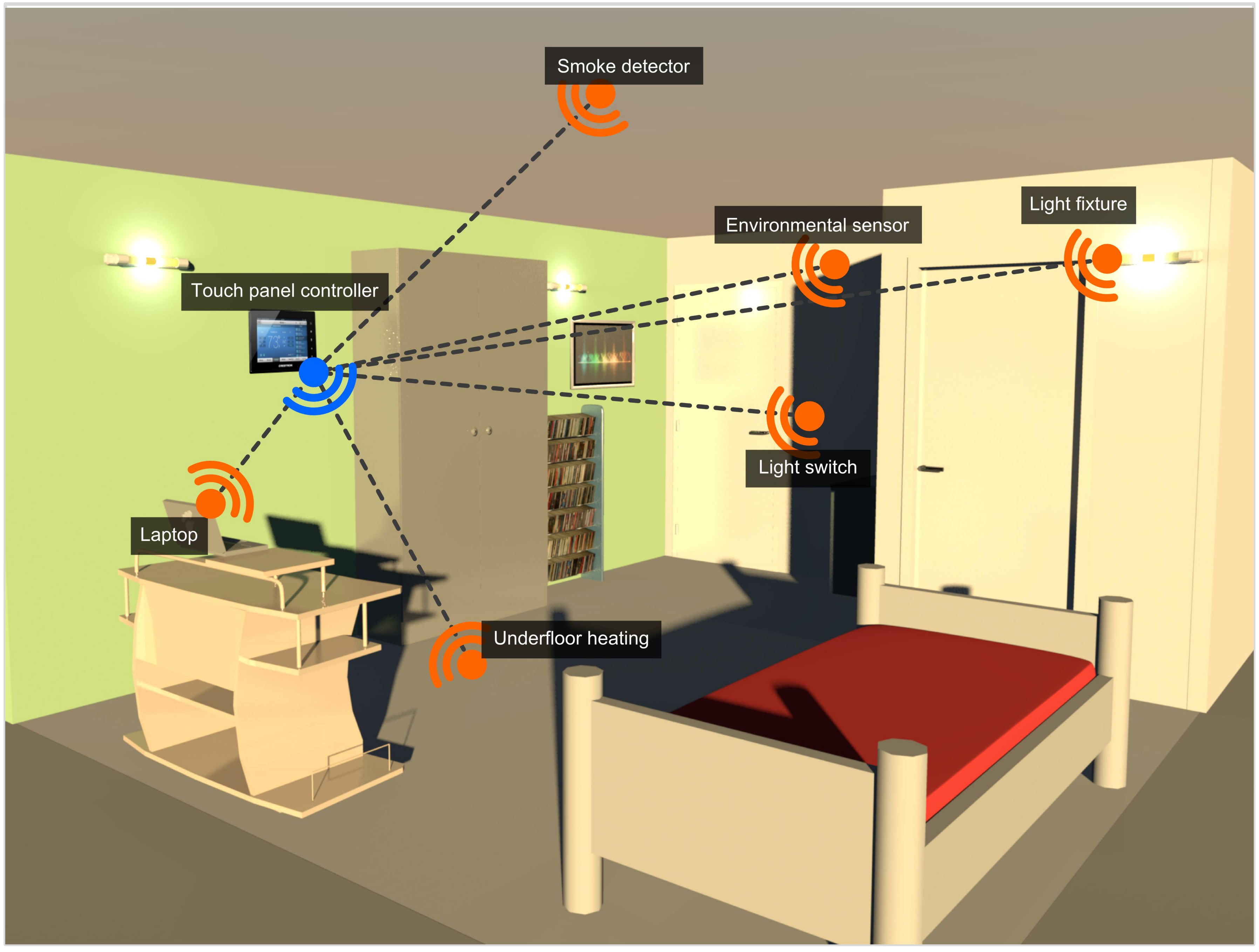
The smart grid incorporates a communication infrastructure that enables system components to exchange information and command in order to improve the efficiency, reliability and safety of power delivery and use while minimizing operational and maintenance costs. Above this layer automation is used to optimize the use of the installations in the building, such as the heating control system, the shading systems, lighting, fire safety and security.

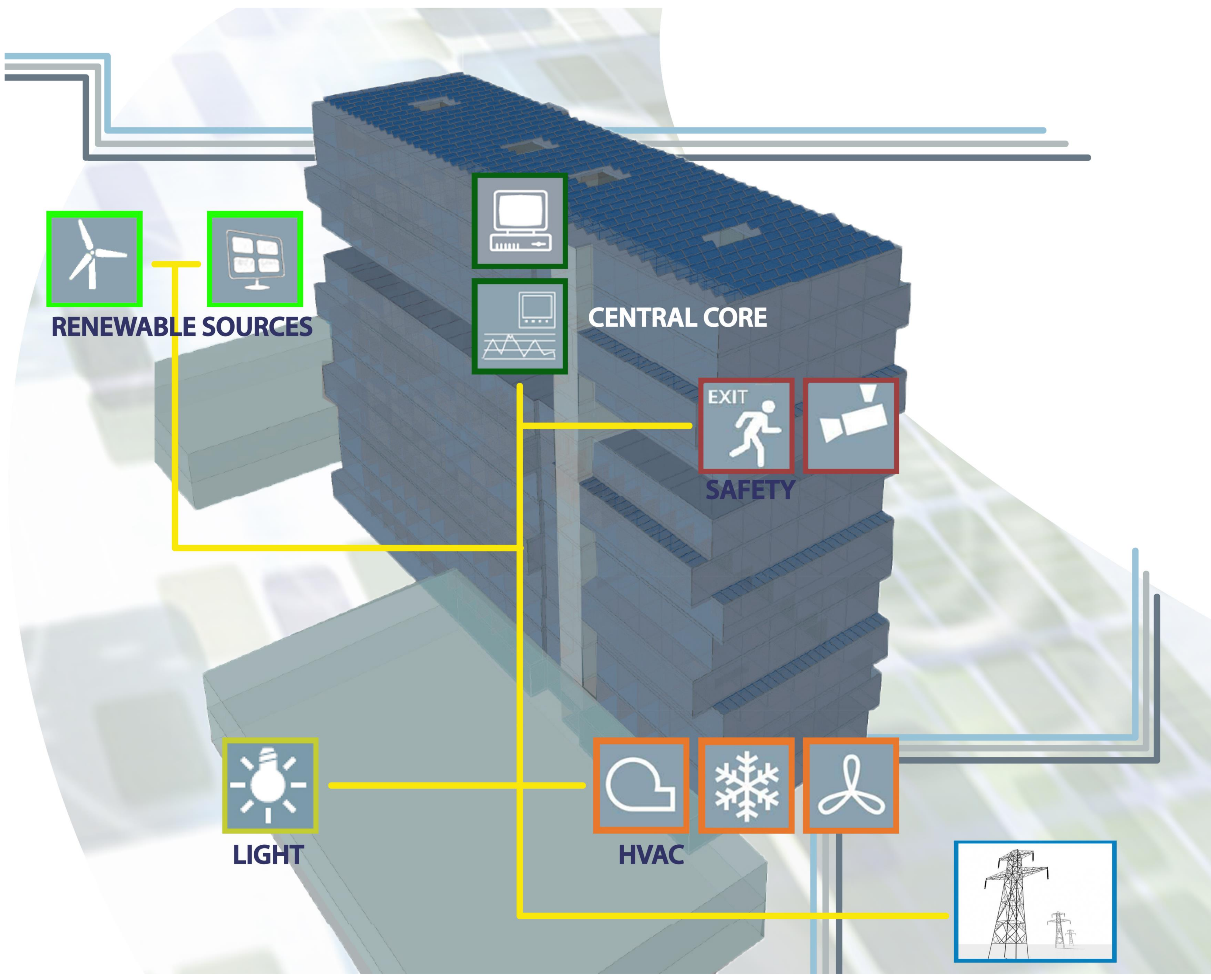
Wireless technology enables an extreme degree of flexibility that can be used to replace wired infrastructures like light switching and thermostats, and provide centralized access to all installations to the user, together with the energy consumption statistics.

What is it?

Users will be able to interact with the automation system via touch panels, that will show in real time the energy used in their room and the data regarding the room's climate and comfort settings. Through that interface, they will be able to change their preferences and directly see the impact on the energy bills. This will also make them aware about their energy needs and more conscious about sustainable behavior.

Using a wireless interface, the controls will also be available from mobile devices like tablets or smartphones, and users could also be able to control their system remotely via internet connection.





Description of the system

The automation system consists in a central unit called *Central core* that monitors the overall status of the building, and distributed control units in the apartments. These controllers are responsible for providing the desired comfort conditions to the living units and the public spaces.

The controllers gather data from the sensors and use it to perform adjustments to the heating and lighting system in order to guarantee the comfort conditions with the least use of energy. Presence detection is also used to optimize the comfort control depending on the presence of occupants.

The EN15232 standard

There is a European standard, EN15232, regulating building automation: it defines four classes of efficiency, distinguished by the number and type of automated functions.

For Potentiaal, we aim for the highest possible efficiency, therefore we want an A class automation system. Assuming that the standard reference for new building is Class C, and that Class A is achieved, we can estimate a 19% save in thermal energy and 8% save in electricity.

Thermal Savings: 19%
Electric Savings: 8%

Literature cited

ISO. (2012). *EN15232 Building automation and control.*

Siemens. (n.d.). *Building automation - impact on energy efficiency.*

Claudio Bacchiani, Giusy Agueci