+hytte | Team Norge

Delivery#3 _ Press Release

NTNU_PM#3_2011_09_14

ZEB NTNU SINTEF

sd europe SOLAR DECATHLON

GOBIERNO DE ESPAÑA MINISTERIO DE FOMENTO

POLITÉCNICA

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON

CON LA COLABORACIÓN DE:
WITH THE SUPPORT OF:

MADRID

IDAE

SUMMARY OF CHANGES

In this last stage of development of our project the +hytte evolved quite significantly but always coherently with the original concept. Most relative changes were determined by the need of solving transport issues from Norway to Madrid. In the attempt of minimizing the need for transport the students reduced the original concept into long functional cells that will attached in row on our site. This will permit also to accelerate the construction process and minimize the risk of accidents for health and safety. Reasons behind the development of the project are explained in detail in the architectural design narrative included in the first chapter of the project manual and have been done by a small groups of students during two months of summer job.

In this third semester of the MSc in sustainable architecture students have also been devided into five different groups and asked to solve different technical issues related to the project. Their work was not intended to solve to problematics arisen, but rather to let them "learn by doing" the challenges behind the construction of a complex hi-tech building such as the +hytte. Documents developed by the students will represent a really useful tools for the communication with extenal consultors of different nature. The five documents are:

- construction specifications
- detailed water budget
- health and safety
- cost estimate
- electric and photovoltaic chart report

They represent in the project manual the first draft of larger chapters that will be in the next months further developed thanks to the support of just recently acquired partners.

In the last weeks in fact SKANSKA confirmed its techincal support as building contractor of the project. Together with it other different partners confirmed their support as material provider and consultors. Among them: . Companies are trucked in the sponsorship manual contained in this document.

The ZEB research centre on ZERO EMISSION BUIDLIGS not only confirmed its techincal support to the project but also the economical one with the intention of transforming the +hytte into a Living Lab for active research once back from Madrid. The ZEB research centre approved also the construction of a second prototype for comparative analyses. This will be built next April and then attached to the one partecipating to the Solar Decathlon next september.

Energy calculations have been further implemented. Results are collected in the first draft of the Comprehensive energy analysis report.

Team Visual identity manual has been updated with informations regarding the logo and the first draft of the team uniform.

Architectural drawings collected in the Project Drawings NTNU_PD#3 represent the almost definitive appearence of the house. Future evolvement in the architectural design of the house might come from a new set of simulations that regard the use of shading and natural ventilation strategies. The location of a third module attached to the south facade and movable shading devices on the east and west facade will complement but not affect the present scenario. Intentions are explained in the bioclimatic strategies set of drawings collected in the Project drawings. The project drawings have been also complemented with the description of the suggested public tour, details about health and safety for circulation and universal design and construction process stages.

The +hytte project has been presented in many different occasions both by teachers and students. Presentations and details about the promotion of the project are collected inside the Press release document and folder that will be transmitted through the FTP system.

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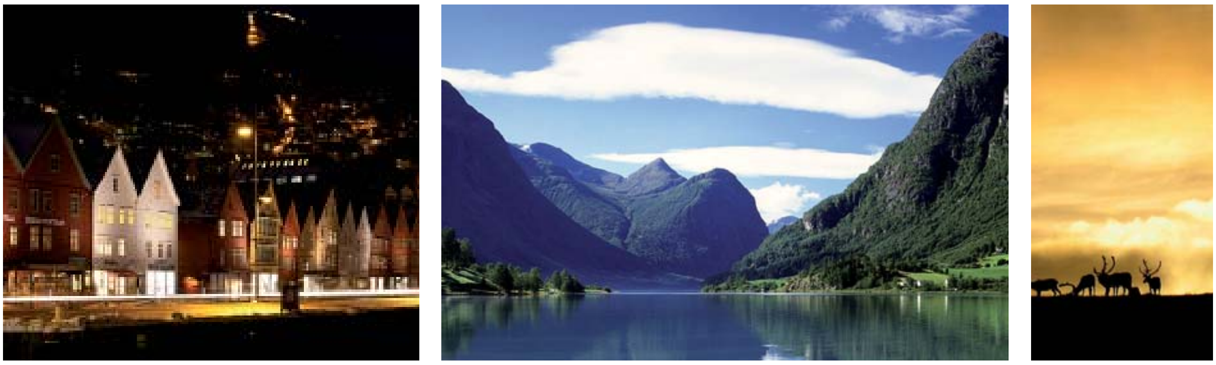


Fig. 1 - Norway: landscapes

PROJECT SUMMARY

NTNU UNIVERSITY — TEAM NORGE

1 PROJECT DIMENSIONS

Gross area	*(m^2)*	98.3		
Gross Volume	*(m^3)*	393.2		
Surface area	*(m^2)*	306.3		
Net floor area	*(m^2)*	63.2		
Conditioned Volume	*(m^3)*	199.1		

2 HOUSE ENVELOPE

Insulation	*Cellulose*	40cm			
	Aerogel	25cm			
	VIP	8cm			
Walls area and Thermal Transmittance	*(m^2)*	110.2	*($W/m^2 \cdot K$)*	0.09	
Floor area and Thermal Transmittance	*(m^2)*	110.0	*($W/m^2 \cdot K$)*	0.09	
Roof area and Thermal Transmittance	*(m^2)*	85.12	*($W/m^2 \cdot K$)*	0.09	
Glazing area, Thermal Transmittance & Glazing Solar gain (SHGC)	*(m^2)*	38.1	*($W/m^2 \cdot K$)*		50%

3 HVAC SYSTEMS

Heating system _ COP 2.6	*Compact unit*	*capacity (Kw)*
Cooling system _ COP 3.6	*Compact unit*	
Refrigerant	CO_2	
Heat Recovery Ventilation (efficiency 0,92)	*(Type)*	*capacity*

4 DOMESTIC HOT WATER

System _ Biofuel / solar thermal exchange	*Compact unit*		*Capacity*
Solar thermal Collectors area	*(m^2)*	6.0	
Storage Tanks	*(capacity)*	300 l	

5 ELECTRICAL ENERGY CONSUMPTION

PV Modules	*Polycrystalline*	
PV panels area	*(m^2)*	85.0
Installed PV power	*(kWp)*	9,90
Estimated energy production	*(kWh/year)*	13,79

6 ENERGY CONSUMPTION

Estimated energy consumption	*(kWh/year)*	45
Estimated electrical consumption per conditioned	*($kWh/year \cdot m^2$)*	20
Energy Use Characterization (% of total energy consumption)		
Heating	*(%)*	10
Cooling	*(%)*	18
Ventilation	*(%)*	13
Domestic Hot Water	*(%)*	25
Lighting	*(%)*	10
Appliances and Devices	*(%)*	24

7 ENERGY BALANCE

Estimated energy balance	*(kWh/year)*	.+330/-65
Estimated CO^2 emissions (embodied)	*(Tn/year)*	31,189

8 SINGULAR AND INNOVATIVE MATERIALS AND SYSTEMS

VIP	*(m^2)*	79,2
PCM	*(m^2)*	57,6

		Rule Description	Content Requirement(s)	Drawing(s)/Report(s)
□	3.2	Team Officers and Contact Information	Team officer's contact information completely fulfilled in Table 1 (SDE WAT)	
□	4.3	Lot Conditions	Drawing(s) showing the storage and unloading areas and corresponding load's calculations	
□	4.3	Lot Conditions	Calculations showing the structural design remains compliant even if there is a level difference, and drawing(s) showing shimming methods and materials to be used in case.	
□	4.4	Footings	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	
□	4.4	Footings	Drawing(s) showing the location, contact area and soil-bearing pressure of every component resting directly on the ground	
□	4.5	Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site and specifications for heavy machinery	
□	4.7	Generators	Generators' specifications	
□	4.8	Spill and Waste Products	Drawing(s) showing the locations of all equipment, tanks and pipes containing fluids during the event and corresponding specifications	
□	5.1	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	
□	6.1	Structural Design Approval	Structural drawings and calculations signed and stamped by a qualified licensed professional	
□	6.1	Electrical and Photovoltaic Design Approval	Electrical and Photovoltaic drawings and calculations signed and stamped by a qualified licensed professional	
□	6.1	Codes Design Compliance	List of the country of origin codes complied, properly signed by the faculty advisor.	
□	6.2	Maximum Architectural Footprint	Drawing(s) showing all information needed by the Rules Officials to digitally measure the architectural footprint	
□	6.2	Maximum Architectural Footprint	Drawing(s) showing all the reconfigurable features that may increase the footprint if operated during contest week	
□	6.3	Minimum & Maximum Measurable Area	Drawing(s) showing the Minimum & Maximum Measurable Area.	
□	6.4	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route, specifying the entrance and exit from the house to the main street of the Villa Solar	
□	7.3	PV Technology Limitations	Specifications and contractor price quote for photovoltaic components	
□	7.4	Batteries	Drawing(s) showing the location(s) and quantity of stand-alone, PV-powered devices and corresponding specifications	
□	7.4	Batteries	Drawing(s) showing the location(s) and quantity of hard-wired battery banks components and corresponding specifications	
□	7.6	Thermal Energy Storage	Drawing(s) showing the location of thermal energy storage components and corresponding specifications	
□	7.7	Desiccant Systems	Drawing(s) describing the operation of the desiccant system and corresponding specifications	
□	7.8	Humidification systems	Specifications for humidification systems and corresponding certifications of the different elements.	
□	8.1	Containers locations	Drawing(s) showing the location of all the water tanks	
□	8.2	Water Delivery	Drawing(s) showing the fill location(s), quantity of water requested at each fill location, tank dimensions, diameter of opening(s) and clearance above the tank(s).	
□	8.3	Water Removal	Drawing(s) showing the quantity of water to be removed from each fill location, tank dimensions, diameter of opening(s) and clearance above the tank(s).	
□	8.5	Grey water reuse	Specifications for grey water reuse systems.	
□	8.6	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems	
□	8.8	Thermal Mass	Drawing(s) showing the locations of water-based thermal mass systems and corresponding specifications	
□	8.9	Grey Water Heat Recovery	Specifications for grey water heat recovery systems.	
□	9.1	Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system.	
□	9.2	Watering Restrictions	Drawings showing the layout and operation of greywater irrigation systems	

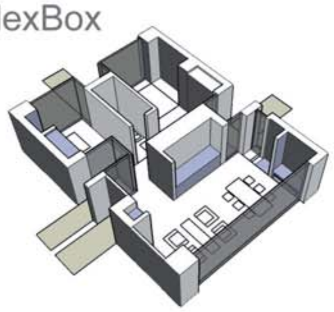
	Rule Description		Content Requirement(s)	Drawing(s)/Report(s)
□	10.2	SDE Sensors' Location and wire routing	Drawing(s) showing the location of bi-directional meters, metering box, sensors, cables and feed-through to pass the instrumentation wires from the interior to the exterior of the house.	
□	11.2	Use of the Solar Decathlon Europe Logo	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	
□	11.3	Teams' sponsors & Supporting Institutions	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	
□	12.5	Team Uniform	Drawing(s) showing the artwork, content and design of the team uniform	
□	12.6	Public Tour	Drawing(s) showing the public tour route, indicating the dimensions of any difficult point, complying with the accessibility requirements.	
□	20.0	Contest 6: Drying Method	Drawing(s) showing the drying Method. (ie the place where the clothes wire will be located)	
□	20.0	Contest 6: House Functioning	Drawing(s) showing the location of all the appliances and corresponding technical specifications.	
□	36.5	Photovoltaic systems design	Specifications of PV generators, inverters, wiring, cables, protections, earthing systems, interface with the electricity distribution network.	
□	36.5	Photovoltaic systems design	Inverters' certificates	
□	36.5	Photovoltaic systems design	Maintenance plan for PV generators, supporting structure, inverters, wiring, cables, protections and earthing system	
□	36.5	Photovoltaic systems design	The corresponding table "design summary" must be filled out	
□	51.3	Fire Safety	Specifications for Fire Reaction of Constructive elements, extinguishers and fire resistance of the house's structure.	
□	51.3	Fire Safety	Drawings showing compliance with the evacuation of occupants' requirements and fire extinguishers location.	
□	51.4	Safety against falls	Specifications of compliance with the slipperiness degree classes of floors included in House tour	
□	51.4	Safety against falls	Drawing(s) showing compliance with conditions for uneven flooring, floors with different level, Restricted Areas stairs, Public Areas Staircases,Restricted Areas Ramps and Public Areas Ramps	
□	51.4	Safety for avoiding trapping and impact risk	Drawing(s) showing compliance with conditions for avoiding trapping and impact risk	
□	51.4	Safety against the risk of inadequate lighting	Specifications for level of illumination of house tour areas light fittings	
□	51.5	Accessibility	Interior and exterior plans showing the entire accessible tour route	
□	51.6	Structural Safety	Specifications for the use of dead loads, live loads, safety factors and load combinations in the structural calculations	
□	51.7	Electrical and PV System	Specifications of the wiring, channels, panels and protections	
□	51.7	Electrical and PV System	One-line electrical diagram and drawings showing the grounding, execution and paths	

1.1. _ Architecture Design Narrative

Fig. 2 - *The ZE+hytte.*

HOM²E

FlexBox



Pf_H

Inside Out House

***Fig. 3 -** Concepts proposed by the students at the MSc*

1.1 _ Architectural design narrative

The MSc programme in Sustainable Architecture at NTNU is an interdisciplinary, international master programme aiming at educating students and professionals in the use and development of competitive methods and solutions for lowering GHG emissions in the construction sector in a life-cycle perspective. The curriculum consists of 3 consecutive semesters including both theory and project courses, and a fourth semester during which the participants write their MSc thesis. High demands are made within the courses towards integrated design strategies. The development of the ZE+hytte has been integrated in each semester of the MSc programme. In the first semester students developed concept design & detailing related to Climate and Built Form; the second semester will be used for energy analysis and materials, in co-operation with Faculty of Engineering Sciences and Technology and the programme for Industrial Ecology; the third semester will handle facility management and user interaction issues, in co-operation with Department for cross-cultural studies; in the fourth semester students will have the possibility of developing a master thesis intimately related to the SD project. The students will be continuously trained in interdisciplinary co-operation with engineering departments and research centres on the basis of already established collaborative relations between the different departments. MSc students in sustainable architecture will also co-operate with the Civil Engineering student group called "Bygg:verksted", working on wood construction, for detailing the SD module next spring (leader: Prof. Rolf André Bohne).

The prototype has been developed with great enthusiasm and a positive competitiveness among the different groups of students, including both architects and engineers. Each concept presented a markedly different character and solved the issues arisen in the call for proposal in a different way. Groups recurred to different tools and methodologies according to their abilities and background. Choosing one out of the four proposals was a hard task. Priority was given not only to the excellence of the design but also to the potential of the prototype for future development within the next eighteen months. Once chosen, the selected concept has been implemented by a smaller group of students in one week of intensive work where ideas coming from other concepts were, when possible and convenient, integrated. The resulting prototype was finally discussed again with all the students, which could recognise the project as representative of the whole course. We believe that this feeling of attachment will be positive for the future development of the prototype involving all the students again.

1.1.1 _ Architectural design concept

Norway is a country of outstanding natural beauty, whose fjords and mountains attract millions of tourists every year. Norwegians revere nature and cultivate an active relationship with it. Cabins - or *hytte* (s.) /*hytta* (pl.) in Norwegian - represent for many of them the necessary tool for conducting a life close to pristine nature, outside modernity. Attachment with nature is therefore transmitted into these small houses, where the entire family can "experience an extensive contact with the surroundings" (Thomas Berker). The hytte is far more than a physical structure: it is almost an icon, a salient trait in Norwegian culture.

With unequalled economic growth based on a relatively evenly distributed income from oil and gas, hytta have become more numerous. Nearly half of Norwegians have today regular access to a cabin often located within driving distance from population centres. Also their quality and size increased significantly in the last twenty years. Hytta measure averagely today 65 square meters and can be effectively considered proper second houses frequently used in summer and winter time for leisure purposes: outdoor activities include skiing, hiking, watching wildlife, picking mushrooms and berries, relaxing and sunbathing. “During the last two decades Norwegian cabin tourism has moved from “hard” forms of ecotourism (few, prolonged stays, strong identification with the site) to softer ones (shorter, more frequent stays, commercialization of the site)[…]. This has led to a steady rise of energy consumption and related CO2 emissions in this sector, shifting the desire to live close to nature from a core tenet of Norwegian culture to an unsustainable threat to nature” (T. Berker and H. J. Gansmo). Furthermore, cabins with improved standards demand the extension of grid infrastructures, putting a strain on local ecosystems. Second houses represent therefore today the most dynamic architectural typology in energy statistics in Norway.

Municipalities and developers have just recently discovered the green potential of more coordinated and denser forms of developments, resembling the image of villages but still trying to accommodate the existing desire to find untouched nature at the cabin. A significant majority feels anyway that the municipality needs to be restrictive and critical when they consider expansion or concentration of second houses areas, both for environmental and social reasons. These people would prefer minimal changes over the next years in infrastructure, extent, accessibility, amount of use, people in the area, etc. The clear preference for no, or small changes, can also be an expression of the desire to keep life at the second home as a predictable and stabilizing factor in an otherwise dynamic existence. Holidays at the hytte are still seen as a return to a pre-modern state of peace in a close relation to nature where any symbol of stress should be removed or minimized. The introduction of new technologies however only apparently contrasts this philosophy. There is a wide margin of action in stressing the use of advanced technologies in coherence with this philosohpy. The ZE+hytte - a small technologically advanced cabin offering a modern concept of living - is indipendent from the grid thanks to the use of natural resources, strengthening the desired feelings of distance from modern society and symbiosis with nature. The surplus of energy produced by the PV integrated systems will permit the use of a cable car and solve mobility issues – due to more frequent visits - and other problematics related to second houses.

Fig. 4 - *Section of the ZE+hytte: permeability of the roof, buffer spaces and solar protection.*

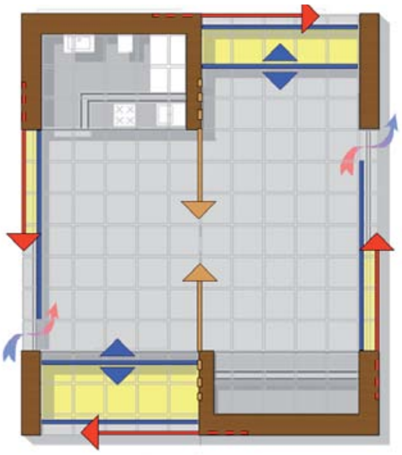


Fig. 5 - Environmental adaptability of the plan

On the base of researches previously conducted at NTNU and ZEB a high grade of uncertainty related to climate change and the development of new components and materials is today questioning traditional assumptions around bioclimatic design in cold climatic contexts and giving space to new architectural scenarios in such contexts. Passive strategies once peculiar of warmer climatic zones are now extending their geographic boundaries of applicability to our context. This is leading architectural design of energy efficient building into a new complexity. In-between spaces, a fundamental tool for environmental control and efficiency of the architectural form, are now becoming more and more important. In the ZE+hytte environmental sensitivity of form is maximized through an extremely simple but efficient flexible plan, sorrounded by a living buffer space. The designed modules can assume markedly different spatial configurations. The buffer spaces included between the outer layer and the living space will be able to assume different environmental behaviours according to different external environment conditions. This variety of possible circumstances will permit also to test in the next eighteen months a wide range of systems. On the base of a complex system of sensors, disposed both inside and outside of the house, the buffer space will expand or draw back itself and create a living breathing interior space in symbiosis with the external environment. The contribution of the buffer space can be occasionally cancelled through a system of valves included in the outer layer. The roof, conceived as a grid of valves and integrating both low and high tech materials, will act as a permeable skin and will adapt its environmental behaviour to the movements of the plan. The ZE+hytte is able to take advantage of different external resources maximizing natural ventilation possibilities through the compact volume and following the sun through advanced technology. The ZE+hytte will benefit from the sun in all possible ways: daylighting, passive systems, microclimate generation, and maintenance. Passive strategies efficiency will be implemented when required with integrated active systems.

1.1.2. _ Summary of reconfigurable features.

Flexibility of the hytte module is implemented through the use of reconfigurable features both in the envelope and inside the SD module. In the hytte spatial flexibility becomes a tool for environmental adaptability of the prototype. The house was conceived as an open system that can assume different configurations and environmental behaviour according to different external conditions. Hierarchization of components represented a fundamental issues for the implementation of this concept. Reconfigurable features, according to the concept, can be divided in:

- Movable internal partitions.
- Movable outer layer.
- Movable inner layer.

Coherently to whatpresented in the proposal document the movements of the outer and inner layer of the external envelope will allow the integration and investigation of different passive strategies, enhancing climate adaptability of the prototype.

Internal partitions will on the other hand divide the different functional zones (living room, bedroom, bathroom, etc). It is still under discussions if these internal partitions will include insulation materials or not, in order to permit a differentiation of comfort parameters values.

The building as a system.

Due to the continuous need for adaptation to the demands of the Solar Decathlon Europe competition, adopting an open system permitted us to let the +hytte project evolve freely seemed to be the most obvious answer to a complex integrated design process. The evolution from the original concept to the current status of the project is synthesized in a sequence of diagrams (Fig.6). Differences among the sequential solutions are carefully explained in the following paragraphs in a chronological sequence, explaining the choices at the basis of the evolution and giving evidence of a meaningful process towards low impact housing.

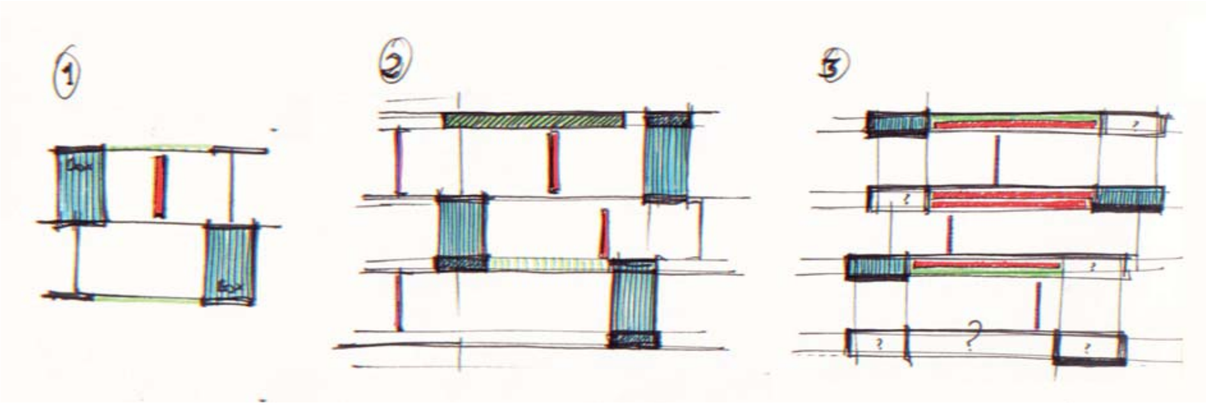


Fig. 6 - *Evolution of +hytte: the building as a system.*

The original concept.

Flexibility and elasticity.

In the original concept the plan of +hytte was characterized by a high degree of indeterminacy. Services like kitchen, bathroom and technical devices were concentrated inside two extremely compact boxes located in opposite corners of the plan. The open plan can therefore be organised in many different ways thanks to the movement of two secondary boxes containing various furnishings (beds, tables, etc). Floor and roof, represented the only timeless hard elements within the project. Their complexity contains most of the functional requirements of the project in opposition to all the vertical partitions, which are characterised by a rather simple construction and a high degree of mobility (Fig. 7). If needed, the surface of the house can also be extended simply by attaching new modules in row.

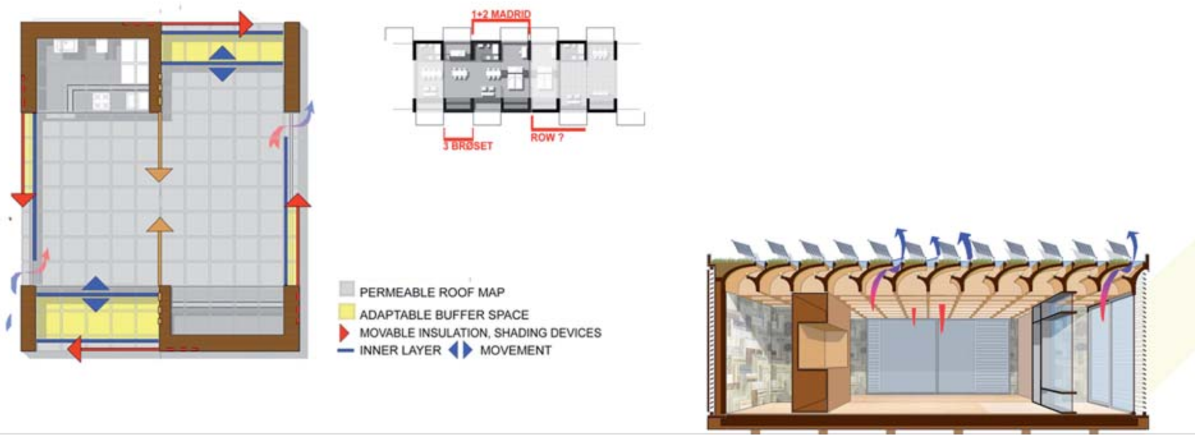


Fig. 7 - *+hytte original proposal. Flexibility, elasticity and climate adaptability.*

Climate adaptability.

Flexibility of the plan was also used as a tool for enhancing climate adaptability of the prototype, solving the contradiction of designing a Scandinavian house able to perform optimally the completely different climatic context of Madrid, Spain. Three different layers of movable devices integrated in the envelope shaped an extremely flexible

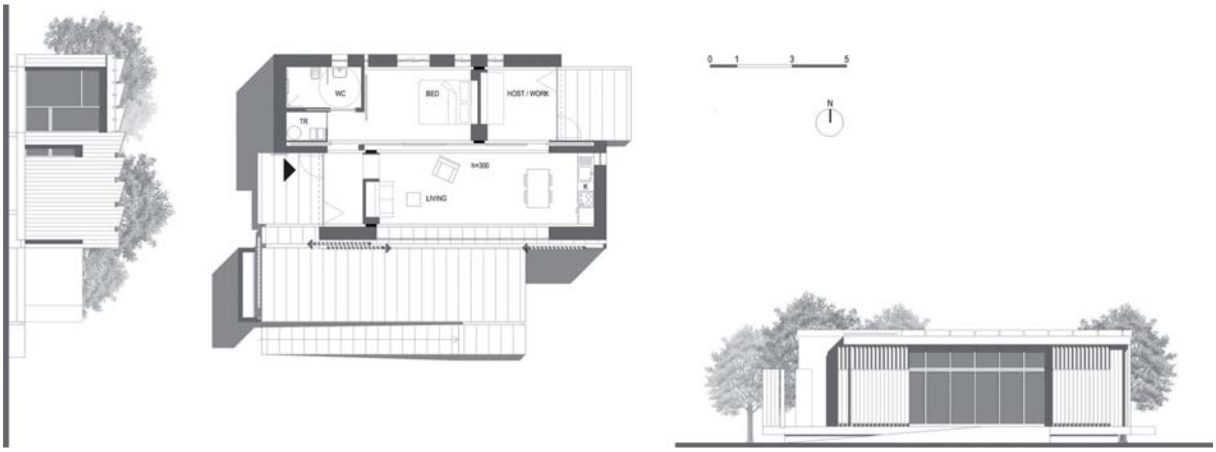


Fig. 8 - +hytte: second delivery. North and south façade are differentiated. Lower degree of mobility.

buffer space able to assume different configurations and behaviours according to the corresponding location and season. On the basis of a system of sensors, located inside and outside the house, buffer spaces are able to expand or draw back themselves letting the interior space to breathe in symbiosis with the external environment. The roof, made of a grid of valves can also adapt its environmental behaviour to the movements of the plan, filtering and diffusing solar radiation and air.

Deliverable 2

Flexibility and elasticity.

In the second stage of development the +hytte project evolved into a more detailed construction system based on a clear hierarchization of the architectural components, each characterized by a specific degree of mobility. Different expectations in the durability of the components were translated into different layers in the construction system. The indeterminacy that characterized the plan in the original concept was maintained only in the primary layer of the construction system, which represents the hard part of the plan and contains the two boxes located in the two opposite corners of the plan. The soft parts of the project are organized in a second layer made of light boxes containing appliances and furnishing that can be located in the plan according to customer desires. This second layer is intended to make the universal module of the primary system a custom made house. The elasticity of the original concept is maintained in the possibility of attaching different modules in row.

Climate adaptability.

Climate adaptability is instead expressed in a system of changeable components for environmental control of different nature (insulation, shading devices, special glasses, etc). All those components should have been located inside a gap running all along the module (Fig. 4). This gap was organized in two lines: one for fixed panels and one for movable devices provided of rails. In comparison with the original proposal the plan is now characterized by a lower degree of indeterminacy (North and South facades are now different).

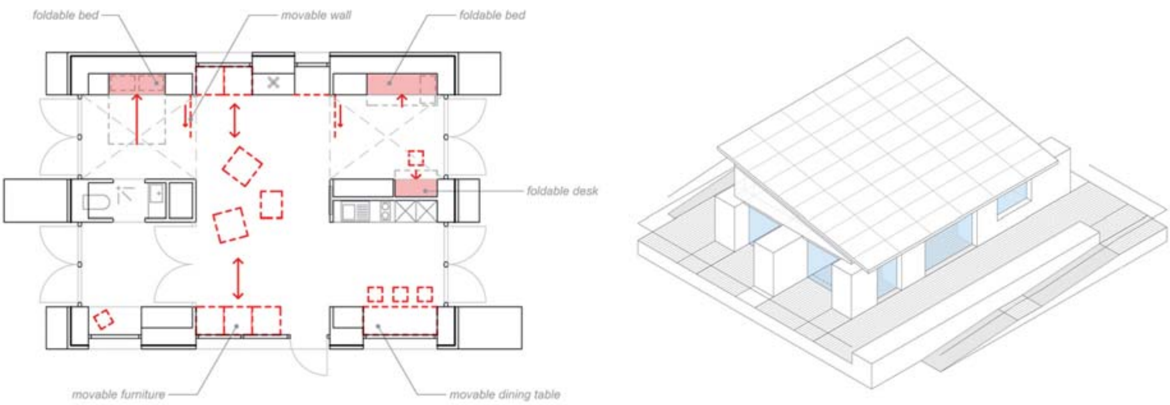


Fig. 8 - +hytte: third delivery. Boxes are reduced to the minimum into long functional cells in order to rationalize the transport process.

Deliverable 3.

Flexibility.

The third stage represents one of the most intense moments of evolution of the +hytte project. In this stage we give particular attention the need of minimizing the need for transport. We decided to reduce static, functional and environmental requirements to long functional cells dimensioned on the basis of a container dimensions and including both the primary and secondary layers of the precedent delivery. Their primary layer aims at satisfying basic requirements like static balance and general equipment (Structure and primary technical equipment are totally integrated in this layer). In the primary stage of the construction there is actually no relation between form and function. The space included between the functional cells is still undetermined and empty and potentially able to host any functional program. The secondary layer represents a collection of possible interventions that can be applied within the frame and include a wide range of components that can belong to different manufacturers. Modularity ensures in this case changeability of components without affecting the primary layer. When the user defines the secondary layer the undetermined space in between the cells acquires a functional identity.

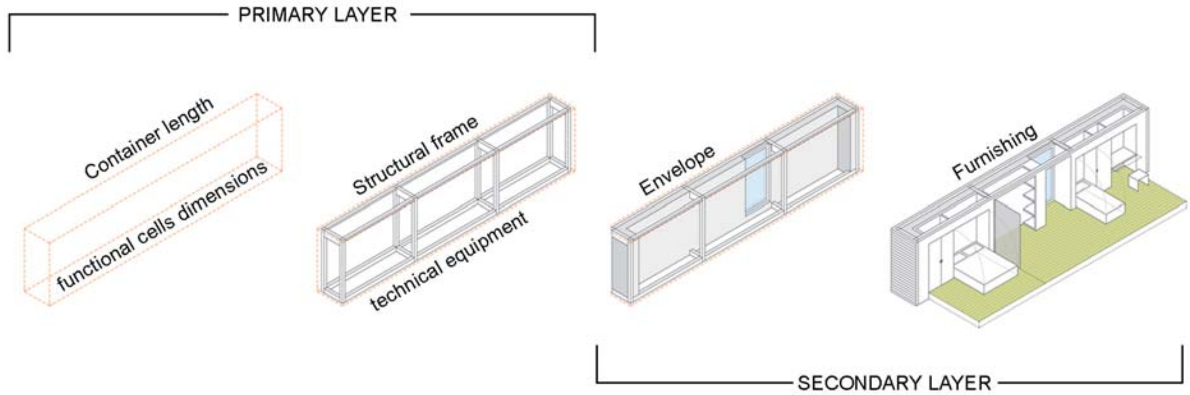


***Fig. 9 -** The functional cells: construction.*

Elasticity.

Elasticity is translated into a grid permitting to extend theoretically indefinitely the construction of the house in the three dimensions of space. The grid is not intended as a limitation to the growth of the building but as a framework that guarantees an order in its development. Each module can extend its surface along its length. Different modules can also be attached in row or vertically thanks to an overdimensioned structural frame. In shaping multi-residential housing +hytte requires the support of an extra infrastructural system, for static and circulation purposes, to which grasp all the different modules.

Climate adaptability

Climate adaptability of the house is based on a homogeneous distribution of skylight and air inlet all along the length of the module permitting different degrees of illumination and permeability. Such characteristics can be adjusted according to different climatic contexts. Hierarchization of the constructions system will be also related to the house environmental requirements. Thermal mass and skylights will be included in the primary layer of the construction system. While climate specific components will be included in the secondary layer. Integration of advanced phase changing materials in the inner layer of the roof will be investigated in order to stabilize temperature fluctuations inside the house. Flexibility of the plan becomes the opportunity for collecting inside the perimeter of the building interstitial buffer spaces able to improve the environmental sensitivity of form.

CONSTRUCTIVE AND TECHNICAL FLEXIBILITY. THREE SYSTEMS.

The house that will be brought to Madrid will represent a provisional configuration of an open building able to assume many different shapes. Its form can be read as the result of the logical layout of three independent but related systems that can be combined in a wide range of solutions. Such systems will be characterized by a high degree of industrialization and prefabrication and are: the functional cells, the roof and the space in-between. Their features are briefly described in the following paragraphs.

The functional cells

The functional cells represent to a certain extent the hard-core of the project. Their location and shape varied continuously during the design process. Their construction has been organized in two different layers. The primary layer is totally inelastic and characterized by a high degree of abstraction due to its universal nature. The second layer is instead customer-specific and made of interchangeable components dimensioned on the same modularity.

The primary layer is intended to satisfy all the basic requirements of the building like structural and technical primary needs. It is intended to survive any functional change and includes all the primary devices of the technical equipment totally integrated with the structural frame - a homogeneous distribution of ducts and electrical devices along the beam; vertical connection in correspondence of the pillars. In such a way ducts for ventilation, hydraulic and electric systems are potentially able to reach any point of the structure. Whatever technology is defined or adopted within the prototype can be attached anywhere and assessed for performance and cost effectiveness.

The secondary layer includes a series of customer-specific furnishing and is thus more subject to change. It intends to give the isotropic undetermined space of the primary layer an architectural meaning with spatial and sensitive values. This layer is based on a series on specific requirements related to the user and the context where the house is located. A wide range of components can be located in the width of the functional cells according to its position, internal or external (130 cm = 60+10+60, furnishing/envelope + partition + furnishing/envelope - Fig. 6). The most external layer will determine the façade of the house.

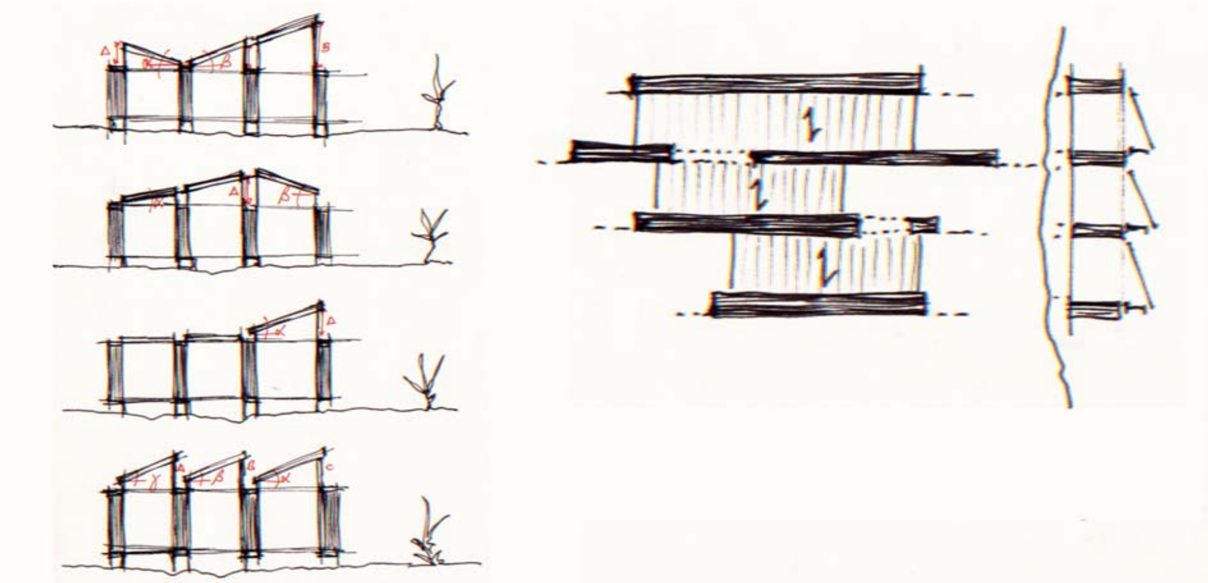


Fig. 10 - *The roof: site-specific variables.*

The roof .

Since the very early stage of development of the project the roof was conceived as a key component for environmental control of the building. In the original concept the roof was conceived as a homogenous distribution of skylights and valves for natural ventilation and lighting. The idea behind the concept was that of enhancing the flexibility of the plan creating an isotropic space in which any point of the structure was equally comfortable, thus able to host any sort of function. In such a way the plan could have been freely arranged in many different ways according to the customers desires. Coherently with the evolution of the project the roof aims now at providing a homogeneous distribution of lighting and air all along the linear modules (no more homogeneous distribution on two dimensions, but only one). Skylights and valves for permeability are homogeneously distributed along the linear system that characterizes the plan. In this way any transversal section of the module can be potentially able to integrate different passive strategies and provide environmental comfort under many different external conditions. Many different formal solutions are also possible thanks to a number of site-specific variables (the angle of the roof can be adjusted for example according to different climatic contexts and locations. This makes the roof a key component for landscaping).

The space in between.

As already mentioned, there is actually no relation between spatial and functional layout of the house in the primary layer of its construction. The space included between the functional cells is still in this stage an isotropic empty space able to host any function. The secondary layer of the construction with all its furnishings overlaps to the universal space a functional program (Fig. 8). Follow two kinds of interventions: the placement of a secondary technical equipment distribution and a series of transversal partitions. Both these components are specific to the functional program and are thus the most subject to change. Technical equipment distribution aims at letting pipes and ducts – if required - reach any point of the structure. Inter partitions aim at regulating visual, thermal, acoustic comfort and air quality.

TOWARDS LOW IMPACT HOUSING

In the next months the students will work with the detailing of the different components constituting the system. In this final stage of the design there is still a wide margin of action for stressing the potential of the +hytte concept towards low impact housing. Particular attention will be paid to:

- The reduction of waste. Industrialization will focus on the production of light components able to reduce need for raw materials, the need for transport and minimize waste generation. The structural frame will be conceived for example as a combination of two-dimensional wooden trusses.
- Relate the hierarchization of the construction system to its materiality. High-embodied emissions will be justified only in the primary layer of the construction system for which we expect a much longer life span. On the other hand use of recycled or recyclable materials will be maximized in the secondary and third layer of the construction system. Deconstruction process of these two layers aims at being as rational as the production itself.

CONCLUSION

During the design process of the +hytte project, flexibility, elasticity and climate adaptability have assumed more and more importance in the +hytte concept, opening new possibilities but also giving rise to many problems. Our main focus has been that of enhancing the potential of open building strategies for the production of high-quality low-impact housing. Architectural design of open buildings becomes thus a meaningful process towards sustainability. The idea of the custom home has been reinvented and implemented into a more environmentally and economically responsive and collective housing process. This was done avoiding in transforming the '+hytte' project into an anodyne box with no spatial and sensory value. Since the very early stages of the design +hytte had to be inspiring, provide the right atmosphere for an extensive touch with nature. Technical solutions and spatial values had thus to coexist in a project handled by many different actors. Such complexity was solved through the definition of the different layers of the construction system. While the first layer has a purely structural and technical function, the secondary layer has to give a spatial and sensory value to the house. The roof, conceived on the basis of site-specific parameters, serves to provide an added value to the landscape with the location of contextualised site-specific boxes. The second layer is not intended, however, to hide the real nature of the house behind a masquerade for pleasing the eye of the customer. In +hytte universal and custom-made coexist and complement each other.

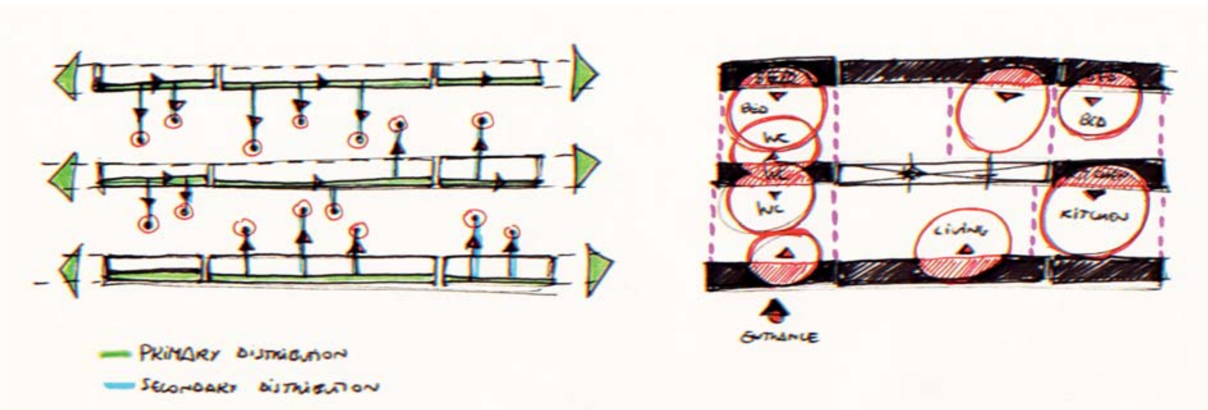


Fig. 11 - The space in between. Technical equipment distribution and functional program.

1.2. _ Engineering and construction Design Narrative

1.2.2. _ Constructive design

The ZE+hytte will be mostly constituted of wood, representing in Norway the most important locally available building material. The construction system of the architectural components constituting the ZE+hytte is characterized by a strong duality: the geometry of the roof module will be rather complex and will be controlled through advanced digital modeling. On the other hand all the vertical partitions will be rather simple and characterized by a rather "low-tech" nature. The use of the massive wood "Stavneblokka" (Fig. 7 and 17) made of cross-laid boards fastened by wooden dowels will be evaluated (component under development by Gaia Trondheim by Kristin Støren Wigum and Anne Sigrid Nordby. Stavne Center for Work and Competence (avd. Rebygg), by Kenneth Urdshals was responsible for its preliminary production). This material is based on the reuse of reclaimed wood coming from demolished projects, which would otherwise be shredded and burned. Wood is collected and reclaimed directly from companies' storage yards. The Klimablokka production is kept at a low or medium level of complexity in order to keep it as a labour- and cost-efficient building system. Blocks are suitable for self-building thanks to low weight, simplicity and safety of assembly. Walls will be constituted of one layer of blocks sufficient for the structural requirements of the ZE+hytte. An extra layer of insulation will be added for improving thermal performance. External cladding will be durable, low maintenance, relatively low cost and resistant to snow, ice and rain. External deck around the house will be designed in order to maximize potential use of natural resources: rainwater will be collected through a drain system, stored in a cistern disposed in the void beneath the house and then used for organic growth. The void beneath the ZE+hytte will also provide space for the batteries deck and the water supply system.

The outer layer of the roof will not only be devout to energy production but will also be responsible of filtering and diffusing the solar radiation both for thermal and luminous comfort. With the movable insulation skin closed the performance of the roof will be fundamental for the environmental behaviour of the SD module. The PV leafs and the ventilations valves disposed on the roof will be characterized by high flexibility of angle in order to maximize energy production and sensitivity of form to different external conditions. The inner layer of the roof will be on the other hand highly insulated, minimizing summer heat gain and preventing heat island effects thanks to the use of

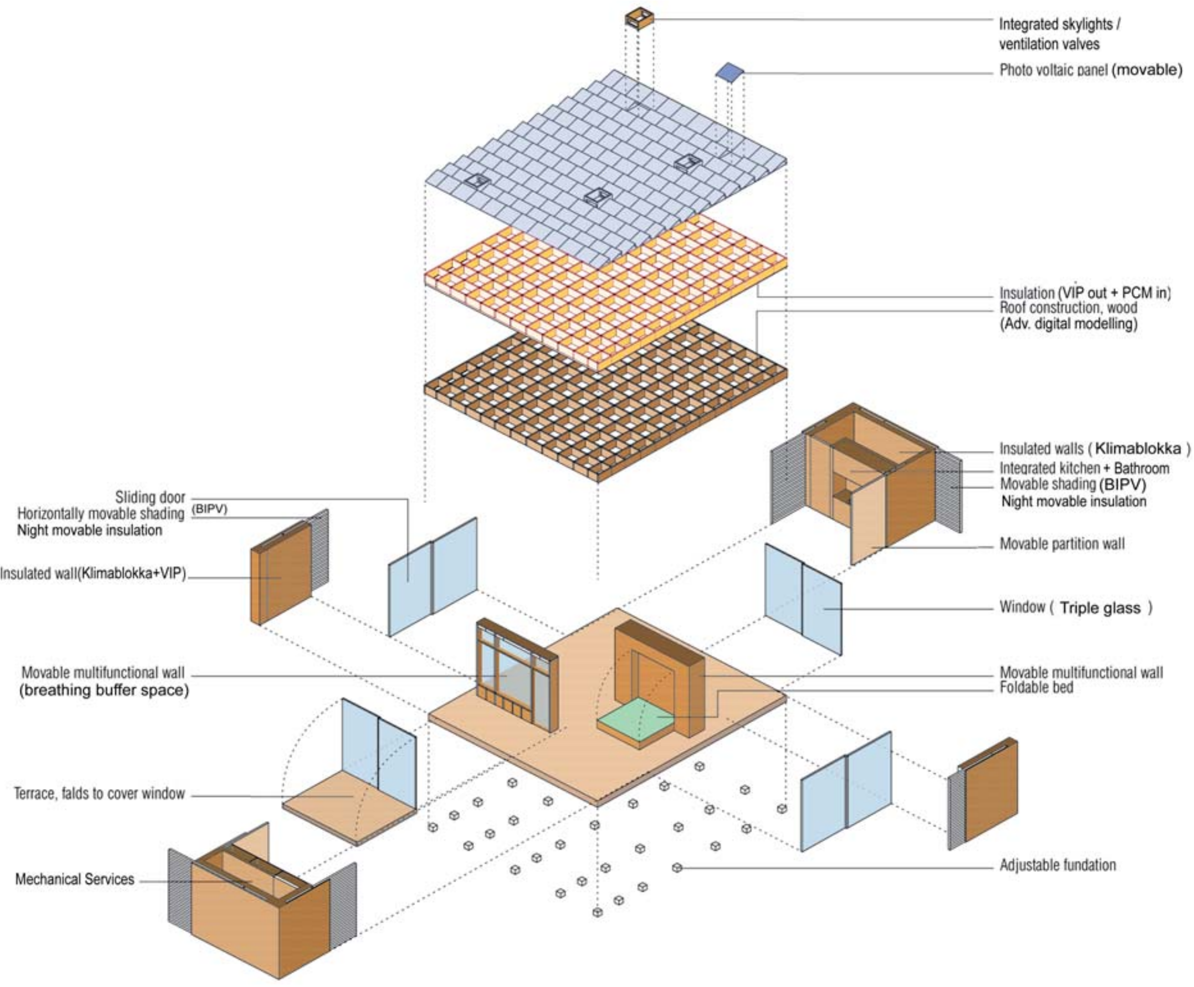


Fig. 6 - Architectural components constituting the ZE+hytte.

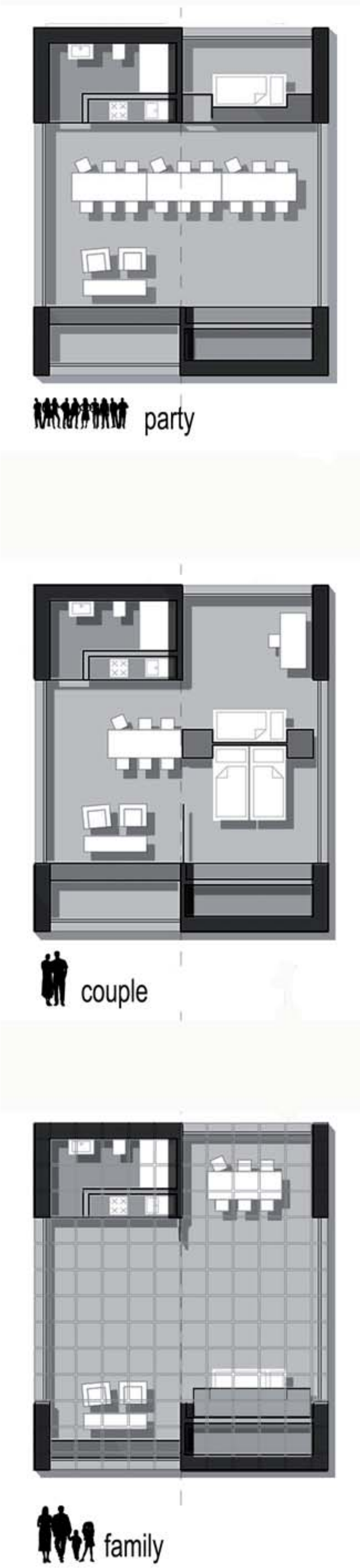


Fig. 7 - *Internal flexibility*

a thin layer of vacuum insulation panels. Integration of advanced phase changing materials in the inner layer of the roof will be investigated in order to stabilize temperature fluctuations inside the living space. Windows will be constituted by a triple glass respecting national regulations in force TEK10. Energate, German company with office today also in Norway, has just recently developed a new window with extremely low U-value=0,3 and has already offered its support to NTNU for the development of the ZE+hytte.

1.2.4 _ Electrical production simulation

We estimate the energy usage for a two people home to be, on average, 10-12 KWh/day. According to PVGIS- photovoltaic geographical information system developed by the EU community - PV panels are expected to produce 2.06 KWh per year of electrical energy (value per squared meter calculated for Trondheim - in Madrid 3.60KWh/y*m2). Electrical efficiency of adopted photovoltaics is of 125 Wp/m2 and 1.2 GJ/m2yr. We are planning to put 48m2 on the roof in a 10° angle towards south; this is a total of 6kWp which provides a daily average electricity production of 26 kWh/d in June.

Cumulative electricity production from the PV system is estimated to be 6545kWh (4780kWh in Trondheim). With estimated annual energy use of 4365kWh (4400kWh in Trondheim) this is a plus energy house in Madrid. Figure 1 below gives monthly energy use and production values.

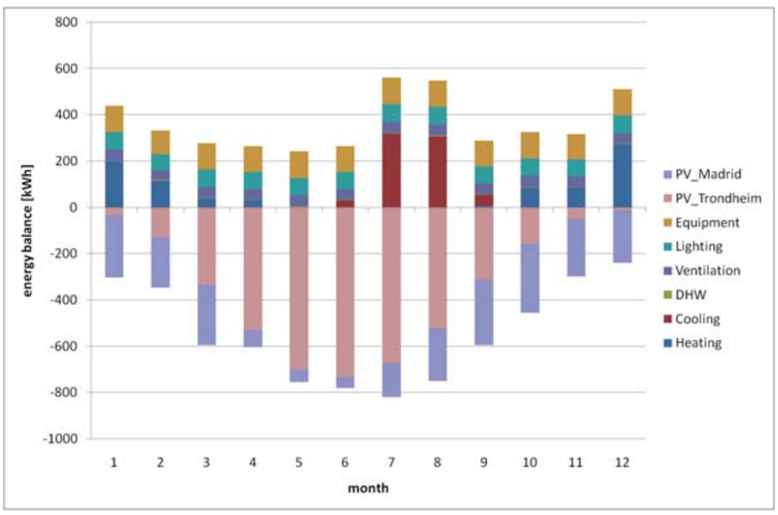


Fig. 8 - *Energy balance for the building*

1.3. Energy efficiency design narrative

1.3.1. _ List of appliances

Refrigerator

The refrigerator will keep the time-averaged interior temperature between 1.0ºC and 4.5ºC during the scored period. A temperature sensor will be located inside the refrigerator and will be continuously measuring.

a. The time-averaged interior refrigerator temperature is allowed to be between 0.0°C and 1.0°C or between 4.5°C and 5.5°C. (Reduced point values according to SDE Rules Figure 6.1).

b. The refrigerator volume published in the manufacturer's specifications is a minimum of 170 liters.

c. The refrigerator will be used to store food and beverages.

Freezer

The freezer will keep the time-averaged interior temperature between -29.0°C and -15.0°C during the scored period. A temperature sensor will be located inside the refrigerator and will be continuously measuring.

a. The time-averaged interior freezer temperature is allowed to be between -34.5ºC and -29.0°C or between -15.0°C and -9.50ºC. (Reduced points according to SDE Rules Figure 6.2).

b. The freezer volume published in the manufacturer's specifications will be a minimum of 57 liters.

c. The automatic defrost function will be disabled.

d. The freezer will be used to store food and beverages.

Clothes Washer

The clothes washer for washing laundry (organizer-supplied bath towels) through one or more complete, uninterrupted, ―Normalﬂ(or equivalent) cycle(s) (according to the operation manual) within a specified period of time. It will operate automatically and have at least one wash and rinse cycle.

A temperature sensor will be placed inside the clothes washer that must reach 43.5°C at some point in the cycle. The sensor will be continuously measuring during the washer cycle. Points are reduced if the temperature sensor reaches 41.0ºC, but does not reach 43.5ºC (according to SDE Rules 6.3).

On several days during contest week, two loads of laundry are required to be washed. We have the option to combine double loads and wash them in one clothes-washer cycle. The drying function in a combination washer/dryer will be disabled until the completion of the wash cycle.

Cycle completion will be confirmed by the observance of an audible or visible signal.

Clothes Dryer

A clothes dryer will be able to return a load of laundry to a total weight less than or equal to the towels' total weight before washing within a specified period of time. On several days during contest week, two loads of laundry are required to be dried. We have the option to combine double loads and dry them in one clothes-drying cycle. (Each load will be scored separately.)

It is possible that dryﬂtowel weight is between 100.0% and 110.0% of the original towel weight. (Reduced point values as specified in SDE Rules Figure 6.4).

The drying method is still to be agreed upon, possibilities for active drying (e.g., machine drying), passive drying, (e.g., on a clothes line), or any combination of active and passive drying are under investigation. (A load of laundry is eligible for clothes-drying points only if the load experienced a complete, uninterrupted cycle in an automatic clothes washer.)

In order to be able to use drying methods different to the drying machine, we must clearly indicate and explain it in the project documents and the drying place must be shown to the Architecture and Industrialization and Market Viability juries. (Drying the clothes in the floor or in other places not designed for that purpose is not permitted. Neither is permitted to wave the clothes to speed air drying.)

Dish Washer

A qualifying dishwasher will run through a complete, uninterrupted, ―Normalﬂ(or equivalent) cycle within a specified period of time (empty, partially loaded, or fully loaded), during which a temperature sensor placed inside the dishwasher must reach 49.0°C at some point during the cycle. The sensor will be continuously measuring during the washer cycle. (Points will be as specified in SDE Rules).

The dishwasher will operate automatically, have at least one wash and rinse cycle, and have a minimum capacity of six place settings according to the manufacturer's specifications.

If the dishwasher has a heated drying option, this option will be disabled.

Cycle completion will be confirmed by the observance of an audible or visible signal.

Oven

The oven temperature must be kept above or equal to 220°C during specified scored periods. A temperature sensor will be located inside the oven and will be continuously measuring every time it is turned on. It is possible that the time-averaged interior oven temperature during specified scored periods is between 180ºC and 220°C. (Reduced points according to SDE Rules Figure 6.6).

The oven volume published in the manufacturer's specifications will be a minimum of 55 liters.

Hot Water Draws

The Hot water tank will be capable of draws of at least 50 litres of hot water in 10 minutes during the times specified in the Competition Calendar at an average temperature of at least 43ºC. It is possible to deliver hot water with temperatures between 43ºC and 37ºC. (Reduced points according to SDE Rules Figure 6.7).

The schedule of hot water draws will most likely vary from one day to the next, just as it does in a typical home. The maximum number of hot water draws for one day will not exceed three, but they may occur consecutively. We will notify the Organization when we would like to realize the hot water draws, during the time specified in the Competition Calendar.

Cooking

A kitchen appliance will be installed that can vaporize 2.3 kg of water in its Normal configuration in a single pot and the starting water weight shall be at least 2.75 kg within a specified period of time. It is possible to vaporize between 0.5 kg and 2.3 kg of water. (Reduced point values according to SDE Rules Figure 6.7).

Home Electronics

Operating a computer, TV and a DVD player (or video player equipment) during specified periods of time will be evaluated (Event Calendar must be consulted for details regarding the number of points per home electronics task and the time periods designated for home electronics tasks).

The TV will be a minimum of 21 in. (48.3 cm) according to the manufacturer's stated display size. The computer display shall be a minimum of 17 in. (43.2 cm) according to the manufacturer's stated display size. We have not yet decided if the computer will be a notebook, laptop, or desktop computer. The computer and video displays will be able to be operated simultaneously and controlled independently of each other.

We will disable the functions of ―Screensaverf| ―Stand byf| or another mode that reduces the energy consumption of these devices during the public exhibit periods.

1.3.2. _ Schematic energy analysis report

Different preliminary evaluations have been run in order to estimate the environmental behaviour of the structure and the sensitivity of the model under different external conditions. Specific characteristics of architectural components have been in the first analyses fixed in accordance with the Norwegian regulations in force TEK10 assumed as a starting point (see appendices at page 20). Possibility of adopting new technologies and materials today under development in the different departments and research centres involved in the development of the ZE+hytte will be investigated. Initial energy modelling (using Simien - a simulation software developed in Norway and commonly used in research - and TRNSYS) of the conceptual model has indicated an optimal environmental behaviour of the house, with extremely low energy demand both for heating and cooling. Different climate analysis have been developed by the students during the conceptual design for defining the proper passive strategies and for detailing the models. Digital modelling will be in the future supported by the information flow coming from simulation tools of different nature handled by SINTEF expert energy modellers able to provide an accurate prediction of environmental performance. Architectural design is therefore converted into a multidisciplinary meaningful process towards a zero emission built environment. Students will co-operate with engineering students in the Integrated Energy design course at the climate engineering department, under the guidance of professors Matthias Haase and Hans Martin Mathiesen.

Different efficient HVAC systems, easy to install, commission and monitor, providing a wide range of functions will be tested. Prefabricated floor concrete slabs thermally activated through a reverse hydronic system - for both heating and cooling requirements - will be tested. The in-floor system functioning will be intimately related to a integrated heat-recovery system using exhasted air and grey water. Efficiency of the heat exchanger located in mechanicalservice box will reduce the demand for electricity and maximize advantages deriving from the use of external resources. Efficient lighting systems will be also adopted in order to minimize energy loads; its functioning will be connected to the system of sensors guaranteeing sufficient lighting for different purposes. Roof and walls will act as permeable skins able to react to impulses sent by sensors distributed both inside and outside the hytte, maximizing lumious and thermal comfort even in adverse climatic conditions.

The project is designed for Madrid climate and works fine as a passive house. This means that cooling demand for the building is less than 15kWh/(m2 a) as well as very small heating demand with 120 W coming from lighting and 180 W from the equipment. Thus, an active heating system was not needed, heating and cooling will be done by ventilation air. Domestic hot water (DHW) will requires 204 W and will be delivered by the solar thermal collector

Calculations according to the Norwegian calculation standard NS3031 were done. Here, fixed operation values have to be used in order to be able to evaluate the building only, 'neutralizing' the user. Results show that fans and pumps require 550kWh while lighting requires 873 kWh and equipment 1317kWh.

SCENARIO	1		2		3	
	madrid	ref.	trondheim	ref.	trondheim	ref.
occupation						
usage / mode	residence		residence		cabin	
number of residents	2		2		4	
lighting, equipment	16 – 07 – 52	ns 3031	16 – 07 – 52	ns 3031	16 - 07 - 52	
ventilation	24 – 07 – 52	ns 3031	24 – 07 – 52	ns 3031	24 - 07 - 52	
minimum airflow rate	1.2 m³/(m²·h)	ns 3700	1.2 m³/(m²·h)	ns 3700	1.2 m³/(m²·h)	
set-point temp. heating occupied	23 °C	contest 5	21 °C	ns 3031	21 °C	ns 3031
set-point temp. heating unoccupied	–		–	ns 3031	5 or 10 °C	ns 3031
set-point temp. cooling	25 °C	contest 5	26 °C	ns 3031	26 °C	ns 3031
indoor climate						
air temperature	23 – 25 °C (21 – 27 °C)	contest 5	21 – 26 °C		21 – 26 °C	
relative humidity	40 – 55 % (25 – 60 %)	contest 5	40 – 55 % (25 – 60 %)	contest 5	40 – 55 % (25 – 60 %)	contest 5
CO_2-level	800 (1200) ppm	contest 5	800 (1200) ppm	contest 5	800 (1200) ppm	contest 5
lighting level	500 (300) lx	contest 5	500 (300) lx	contest 5	500 (300) lx	contest 5
energy demand						
heating demand						
heat loss						
- overall heat loss factor	0.6 W/(m²·K)	ns 3700	0.6 W/(m²·K)	ns 3700	0.6 W/(m²·K)	ns 3700
ventilation loss						
- infiltration n	0.05 ach	-> Dokka	0.05 ach	-> Dokka	0.05 ach	-> Dokka
- infiltration n_{50}	0.60 ach	ns 3700	0.60 ach	ns 3700	0.60 ach	ns 3700
solar gains						
internal gains						
- lighting	1.95 W/m²	ns 3700	1.95 W/m²	ns 3700	1.95 W/m²	ns 3700
- equipment	1.8 W/m²	ns 3700	1.8 W/m²	ns 3700	1.8 W/m²	ns 3700
- occupants	–	ns 3700	–	ns 3700	–	ns 3700
	Σ = 3.75 W/m²		Σ = 3.75 W/m²		Σ = 3.75 W/m²	
> annual heating demand	15 kWh/(m²·a)	ns 3700	29.8 kWh/(m²·a)	ns 3700	29.8 kWh/(m²·a)	ns 3700
cooling demand	15 kWh/(m²·a)		–		–	
ventilation demand	–		–		–	
fans & pumps demand	?		?		?	
domestic hot water demand	5.1 W/m²	ns 3700	5.1 W/m²	ns 3700	5.1 W/m²	ns 3700
equipment demand	3.0 W/m²	ns 3700	3.0 W/m²	ns 3700	3.0 W/m²	ns 3700
lighting demand	1.95 W/m²	ns 3700	1.95 W/m²	ns 3700	1.95 W/m²	ns 3700
total energy demand						
primary energy demand	65 kWh/(m²·a)		79.8 kWh/(m²·a)		79.8 kWh/(m²·a)	
total energy demand	120 kWh/(m²·a)		120 kWh/(m²·a) ?		120 kWh/(m²·a) ?	
calculation time	one year	sde2010r+r	one year		?	
energy target (plus, zero, ...)	plus energy	sde2010r+r	?		?	
grid (feed-in, self-sufficient, ...)	yes	sde2010r+r	yes		no	

Table 1: *Scenarios simulated*

Daylight factor analysis was done for different facade configuration. This ensures that daylight is also sufficient when additional insulation panels are placed on parts of the facade. This is important when the building will be placed back in Trondheim after the competition. Here, higher insulation levels together with a heat pump (COP = 2.16) will be installed in order to minimize energy use to 4400kWh.

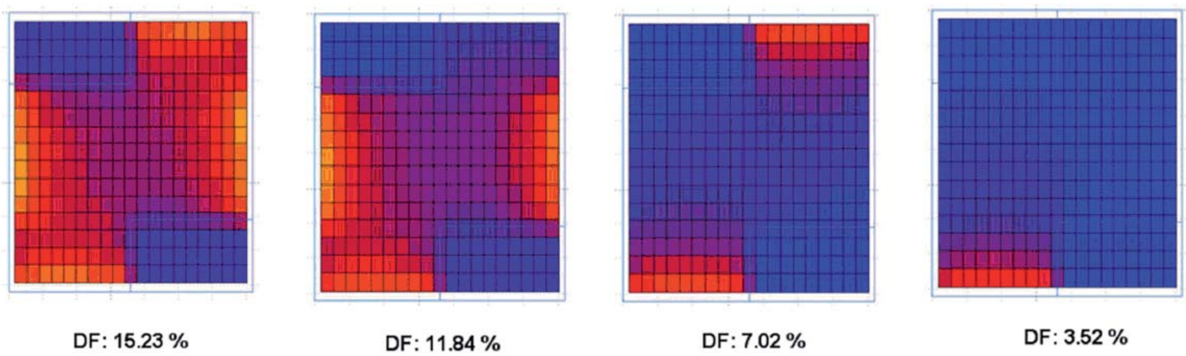


Figure 9: Daylight factor (DF) for different facade configurations

1.4. Communications Plan

1.4. _ Communication project _ Actions

The development of an energy positive hytte is inevitably going to attract a lot of interest from the public. The norwegian research centre on photovoltaics - IFE - gives evidence of the increased interest of the government towards this technology. Many persons are anyway still skeptical about applicability of these technologies in such a climatic context. Researches conducted at IFE and preliminary calculations - also performed in PVGIS - proofed anyway a wide margin of applicability and integration of solar technologies in norwegian hytta. Our intention is to maximize the potential of the project for increasing public awareness around these solar energy applications and how these can be used to enhance symbiosis with nature, reason of being of hytta. Different kind of public initiatives will be periodically organized in the next eighteen months; in already existing ones, like the KLIMAX frokost, the ZE+hytte will be focus of discussions increasing awareness around sustainability issues.

The WIKI-portal - during the design process accessible only to the members of the team - will provide the structure for the construction of a website where the public will be able to follow all the different stages of conception and construction of the ZE+hytte. Texts, images and videos will be available for download and will show not simply the result but also the process. Navigating the website will become a pedagogic experience. The ZE+hytte will also be built on a network of excellent media relations. The team will have daily press partners at national, regional and local levels. NTNU students have their own TV channel but national coverage will also be ensured through the support of NRK (Norwegian television). TV programs like Schrödingers Katt and Newton are already following the development of the Brøset project. The department of architectural design history and technology is already evaluating the possibility of publishing the first stage of the concept development in a report that will be used for making resonance of the event in both local and national networks.

- KLIMAX breakfast seminar.

The Industry Forum includes among the other activities a monthly breakfast seminar,called Klimax and financed by NTNU, in which researchers, policy makers and practitioners are invited to share and comment their professional experiences. The breakfast seminars provide a low-threshold meeting place for actors from different sectors to discuss challenges that often supersede traditional professional boundaries. Each session includes two presentations by invited experts, followed by discussions with the audience. The topics and lecturers are chosen in cooperation with Trondheim policy makers and other stakeholders, related to the progress made in the Brøset project. The seminars are usually attended by 50 to 80 participants (occasionally more) coming from academia, public organizations and the building industry. The SD module will be in three occasion - one for each stage of development - become focus of debates aiming at increasing awareness around sustainability and coping with different issues.

- Technoport

Technoport was founded in 2005 to promote Design, technology and research by the city manager of Trondheim and quickly generated enthusiasm among local businesses and industry, education and research institutions and regional governmental bodies. In its early years, Technoport was both an exhibition to show the citizens of Trondheim examples of the cutting edge technology produced in their city and a presentation of awards to celebrate the individuals or organizations that have generated this new technology and knowledge. In 2012, Technoport will arrange an international conference. The focus will be on “Transition towards a Green Economy” and how to implement innovative green technology into society. Technoport is potentially a financial source for the ZE+hytte that will become an exhibitions pavilions for advanced technologies developed at the ZEB centre and NTNU together with the support of SINTEF.

***Fig. 14 -** Aggregability of the module.*

***Fig. 15 - A view of Trondheim from the** Brøset area.*

- The Location in Broset-potential for communication.

The 35 hectars housing programme in Brøset provides for about 1200 units of different type and density and aims at shaping a piece of city of the future characterized by carbon neutrality, low energy demand, and efficient land use. High environmental standards and carbon-neutrality are qualities that will create attractive dwellings. The topography of Brøset, a slightly tilting site with good solar access, enables housing qualities such good possibilities for daylight and ventilation, comfortable and sunny balconies and outdoor spaces. The required density will most likely not allow for single housing, but rather for solutions like apartment blocks, terrace and row housing, 20% of which will be for market-controlled rent or affordable low joint debt. Trondheim aims for a varied resident composition within the neighbourhoods for age, gender, ethnicity and family composition. Quality and diversification of users and types will be ensured by different means of regulations and design guides. Collective facilities and services will enhance residents' sense of ownership to the neighbourhood and strengthen local quality.

Municipal ownership increases the potential for active guidance of the development and the construction of pilot projects that can be used for strengthening an alternative identity like the ZE+hytte. Upon the return from the solar decathlon context week in Madrid the ZE+hytte will be installed in the Brøset housing municipal development where will be accessible by the public and will also become a living Lab for action research on technology and lifestyles. If financial support will permit, a third but simpler SD module will be built during the first construction phase and left in the Brøset even during the context week in Madrid. On the way nack from spain the other two modules will be attached to the permanent one in the meantime used for public events (fig.14).

1.4.2 SWOT plan

The report is divided into three main sections:

Market Analysis: Market analysis is to identify interests, opportunities and market needs. We have tried to identify who will be staying in a house like this and what the +hytte needs to cover. We have investigated how the market for zero emission housing is today, and how it might evolve in the future. Here we have also seen what it takes for houses to promote health among those who live there.

Since the +hytte will be operated by solar energy, we have also looked at the number of hours of sunshine in different parts of Norway, in context with the density of holiday homes in Norway today.

Media strategy: We present some suggestions for what media can be used and in what way and what to consider when one wants to convey something to the public. The idea is that increased knowledge about the project will provide increased interest in contributing.

Potential investors and partners: What can the project give back?

Contains various strategies and ideas about how the project can attract businesses and investors, and what they can get back through participation in the project.

Identify potential investors and donors:

We present some proposals to potential investors and contributors, and what they can contribute, that is not already mentioned in the project application.

The problem and objectives

Issues: To find out how to attract investors and other contributors who can both participate in the development of the project up to the competition and afterwards. With this we saw it appropriate to analyze the market and the potential for the project as it is made today, and as a concept for development in the future. These factors will be important for the production of the project to investors. With this background, we arrived at this question: "How can we attract investors and other contributors to the development of the +hytte in the time leading up to the Solar Decathlon Europe and beyond?"

Objectives: The analysis should reveal whether there is a market in Norway for the +hytte, potential strategies to attract investors and partners, and how information about the project can be distributed to the general public.

What is a market?

A market analysis is a systematic collection of data about a market and then use these data to conclude what is a realistic goal for a product. The analysis is used to obtain information about changes and opportunities in the market, so that projects and enterprises can adapt to these changes. Opportunities and threats around the product are identified. Trends and new opportunities must be examined.

- Trends in the economy must be examined in order to say something about the consumer's willingness and ability to buy the product.
- Demographic factors must be mapped in order to say something about who the consumer is. For example, family size and moving habits are of interest.
- People's attitude to environmental issues is important to investigate in order to take advantage of the opportunities and threats that this entails.
- Identify new and competing technologies. New technology may soon outperform old technology, and it may happen sooner than you think.
- Development within politics and laws can provide opportunities or becoming a major threat.

SWOT: Strengths, weaknesses, opportunities and threats. Is a simple analysis tool to identify strengths, weaknesses, opportunities and threats. We have chosen to use a SWOT to summarize the findings we have made around the internal and external factors that affect +hytte.

Information gathering

The website of Statistics Norway were used to obtain an overview of factors related to housing, such as the area of new housing, how many people live alone or with someone and how many have cabins. Meteorological Institute's website was used to find information about weather stations in Norway and data on hours of sunshine from these stations. The web sites of various companies and organizations were used to assess whether they could be relevant to suggest that potential contributors to the development of + cabin, in what way they could help and find facts about the company or organization.

A GIS approach for the calculation of the different sun in Norway

In this calculation, it is applied in a geographical method of calculating the sun in Norway. The technological method is applied geographic information systems (GIS). The data in this method is based on information obtained from the meteorological department. These data are records of solar time at 14 different weather stations which are spread around in Norway (see Table 1). The data shows the average number of hours of sunshine per month, and year at various locations where it has been carried out measurements over a longer period (20-30 years during the normal period 1961-1990). The different weather stations (see Figure 1) was used to generate a cartographic visualization that shows a “trend surface” of the sun in Norway. This result can be seen in Figure 5 and 6 further down in this report.

SWOT analysis

Strengths
- High level of competence in research and development

Weaknesses
- Education and awareness
- Low electricity prices
- Cost
- Cabin Size
- Small Audience
- Few solar day in Norway

Opportunities
- Political factors
- Development of electricity
- New technology
- Few hours of sunshine in Norway

Figure 1: Weather stations

Threats
• Trend in people's views on residential / holiday
• The economic situation

Market analysis

The prospect of Solar Decathlon Europe competition project presented as a cabin. After the competition +hytte will be used as a research project. We have therefore looked at the potential development of the concept for the future, something that will be of great interest for potential investors and donors.

The situation in Norway today and future development

The current building standards:

All new buildings today must comply with applicable technical regulations for energy consumption (TEK 2010)[2]. The current standard regulations are a total energy demand for houses at 120 kWh per square meter plus a surcharge of 1600 kWh/BRA3 per year. To put this in perspective, this will lead to a 200 square meter house with an energy demand of more than 25 600 kWh per year. Houses of the same size built ten years ago have an energy demand of about 34 600 kWh per year. These energy requirements sharpened regularly, which would imply that there must be developed new solutions within the construction industry continuously to comply with these requirements. Building technology agency summarizes that the purpose of regulation is to reduce energy requirements for new buildings with about 25 percent. It is required that at least 40 percent of the energy demand for space heating and hot water has to be covered by other energy than electricity and fossil fuels.

Development of the buildings energy consumption:

Due to higher electricity prices in Europe, there has been considerable interest in energy efficiency in the building sector. In Norway, over a lon-

STED / MND.	Januar	Februar	Mars	April	Mai	Juni	Juli	August	September	Oktober	November	Desember	Hele året
Sørnesset, Stor-Elvdal	20,4	72	127,7	169,7	204,1	196,6	181,7	168	120	80,9	33,1	9,4	1388,6
Kise, Ringsaker	27,7	68,1	125,9	188,3	211,6	242,4	236,6	194,7	135,6	83,4	44,2	17,8	1596,3
Ås, Akershus	31,5	69,1	118,7	179,3	219,1	261,8	251,4	213,3	139,4	85,7	41,1	24,7	1639,1
Blindern, Oslo	40,5	76	126	178	220,2	249,6	245,8	215,8	144,3	86,4	51,2	35,2	1668
Kjevik	45,3	83,9	120,8	187	227,5	274,4	269,2	231,1	149,7	92,8	57,1	38,8	1777,6
Sola	40,8	74,6	120,6	172,2	214,4	224,2	204,9	188,1	119,1	81,1	45,5	29,6	1515,1
Florida, Bergen	19,3	55,6	93,7	146,5	185	188,6	167,1	143,7	85,7	60,1	27,2	11,9	1184,4
Bjørkehaug i Jostedal	10	36,4	78,2	130,6	202,4	196	186,5	152,3	72	40,3	13,5	5,9	1124
Fiskåbygd, Vanylven	17,5	54,6	98	134,4	184,1	169,9	128,9	137,2	70,3	55,3	25,6	5,4	1081,2
Tyholt/Voll, Trondheim	23,4	65,2	118,8	158,5	215,1	197,4	178	176	111,5	61,6	31,7	9,3	1346,5
Bodø	6,1	43	114	158,7	218,8	220,7	172	166,5	98,4	54,3	16,3	0	1271,2
Tromsø	2,1	31,8	112,4	160,1	218,1	220,9	205,1	167,2	92,1	47,6	6,2	0	1268,6
Karasjok	0,1	34,7	133,7	154,6	186,4	186,8	184,4	123,3	75,2	42,1	4,5	0	1105,8

Table 1:average number of hours of sunshine per month, and year, for 14 different weather stations in Norway.

ger period of time there has been low development in energy efficiency and renewable energy, this because of the large supply of energy resources with low prices. Internationally this gives the buildings in Norway a low carbon footprint, because 70-75 percent are renewable energy, mostly electricity produced by hydropower. Despite this, there are still circumstances that require a major effort for improving the efficiency of energy use in buildings such as the EU legislation through the directive “Energy Performance in Buildings Directive” [2]

Political factors:

Through the EEA cooperation, Norway is obliged to follow the EU renewables directive. Where member states are required to increase its average renewable share from 8.5 percent to 20 percent until 2020. Norway has a special position because approximately 99 percent of the country’s electricity production comes from hydropower. Of the total energy consumption in the country, this corresponds to about 60 percent[3]. Each EU country must increase its renewable share based on a given, calculated percentage. For Norway, this would imply that Norway should increase its share of renewable energy from 60 to in excess of 70 percent, according to Norwegian calculations.

When it comes to the Zero Emission vision of the project, the Climate Agreement adopted by the government in 2008 can contribute to a stronger position for further development of the project after the Solar Decathlon Europe. The Climate Agreement means that Norway opens to become a carbon neutral society in 2030. The objective is to reduce greenhouse gas emissions in Norway, with 15-17 million tons of CO_2 equivalents by 2020. From the press release of the decision, one can read: “It is set aside a significant amount for the development of renewable energy” and “The Government will present a Plan of Action for transition from fossil to renewable energy sources for heating. There will be demands for flexible energy systems in public buildings.[4]

Trends in electricity prices:

The chart below (Figure 2) shows a pretty clear trend that the power prices without taxes and tariffs rise over time. Average electricity price for 2010 was at 0,486 NOK/kWh8. The price of electricity in Norway is influenced by several factors whereas the filling of water reservoirs have the greatest impact. The high prices in 2010 was also due to a reduce in production at the Swedish nuclear power plants as a result of upgrades that led the production out of service.[5]

Energy historian Lars Thue at the Norwegian School of Economics BI believes electricity prices will continue to rise the following years [6] . His arguments are that we are being increasingly integrated into the power grid in Europe where prices are a bit higher than here in Norway. There are plans to build five new submarine cables from Norway to Europe by 2020. In addition, a Letter of Intent is signed to build a network of cables across the North Sea. Because Norway has a special position in Europe in terms of hydropower and we usually have a net export surplus of electricity, this could affect domestic prices in Norway in the future. In summary, the future electricity prices in Norway are very uncertain due to the correlation with water levels in reservoirs and it is expected that market trend will continue.

[[1] FOR 2010-03-26 nr 489: Regulations on technical requirements for construction (Construction Technical Regulations) http://www.lovdata.no/cgi-wift/ldles?doc=/sf/sf/sf-20100326-0489. html # 14-2 (taken 1/20/2011)]

[[2] Directive 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 - on the energy performance of buildings]

[[3] From “The consequences for Norway of the EU’s energy directive”]

[[4] Press release: Agreement on national climate volunteers (Published 1/17/2008) http://www.regjeringen.no/nn/dep/md/pressesenter/pressemeldinger/2008/enighet-om-nasjonal-klimadugnad.html?id=496878 (taken 23/01/2011)]

[[5] Electricity prices up 33 percent in 2010 (Published: 1/11/1911) http://www.kraftnytt.no/default.asp?page=2162&article=61470&tellfriend=1 (Retrieved: 23/01/2011)]

[[6] Dagbladet.no: Now comes the shock power (Published: 01/03/2011) http://www.dagbladet.no/2011/01/03/nyheter/strom/energi/innenriks/14930393/ (Retrieved 01/19/2011)]

Technological advances

Cost of solar energy:

Norwegian Water Resources and Energy Directorate (NVE) presented a report under the Energy Days in Oslo in 2009 which showed trends in the cost of producing one kWh of solar energy. In 1990, the rate was 4,50 NOK kWh, ten years after this award was reduced to 1,50 NOK [7]. As a result, many new companies and increased competition in the renewable energy sector is expected to focus on research and development will reduce the cost of production of finished PV panels. In addition, you will be able to increase the efficiency of the panels over time, as new innovations occur. This makes it possible to envision a future where electricity produced by solar energy is actually competitive with other energy sources. In the forecasts to the NVE, the price of one kWh of solar energy will be 0,25 NOK by 2030. Forecasts show that the costs of one kWh of electricity from solar panels will be lower than from wind power by 2020.

[[7] Fritjof Salvesen - Solar energy for heating purposes - soon profitable? (November 08) http://www.nve.no/Global/Seminar% 20to% 20foredrag/Energidagene% 202008/Sesjon% 208/Fritjof.energidagene.08.pdf (Retrieved 18/01/2011)]

The housing market in Norway and the Norwegian consumer

We have chosen to map the Norwegian housing and rental market and the Norwegian consumer's view of the environmental measures used in this analysis.

Property:

Norwegians currently use a lot of money on houses and apartment. In Norway the ideal is the detached house, the most energy-intensive living arrangement. It has also been a considerable increase in the average area of the Norwegian housing, from 91 square meters in 1973 to 119 square meters in 2006. Meanwhile, the average household has been reduced to 2.2 occupants per dwelling, compared with 2.7 in 1980 [8]. 53 percent of the dwellings in Norway are detached. 21 percent are duplexes, townhouses and row houses, while 22 percent are blocks or apartment buildings.

Type and size of the property changes with age and life situation. After you have moved away from home you live like in a small apartment that you either own or rent. You have less need for space and are generally in a worse economic situation. As you get older and get a job your need changes. Many people then want a larger home. One

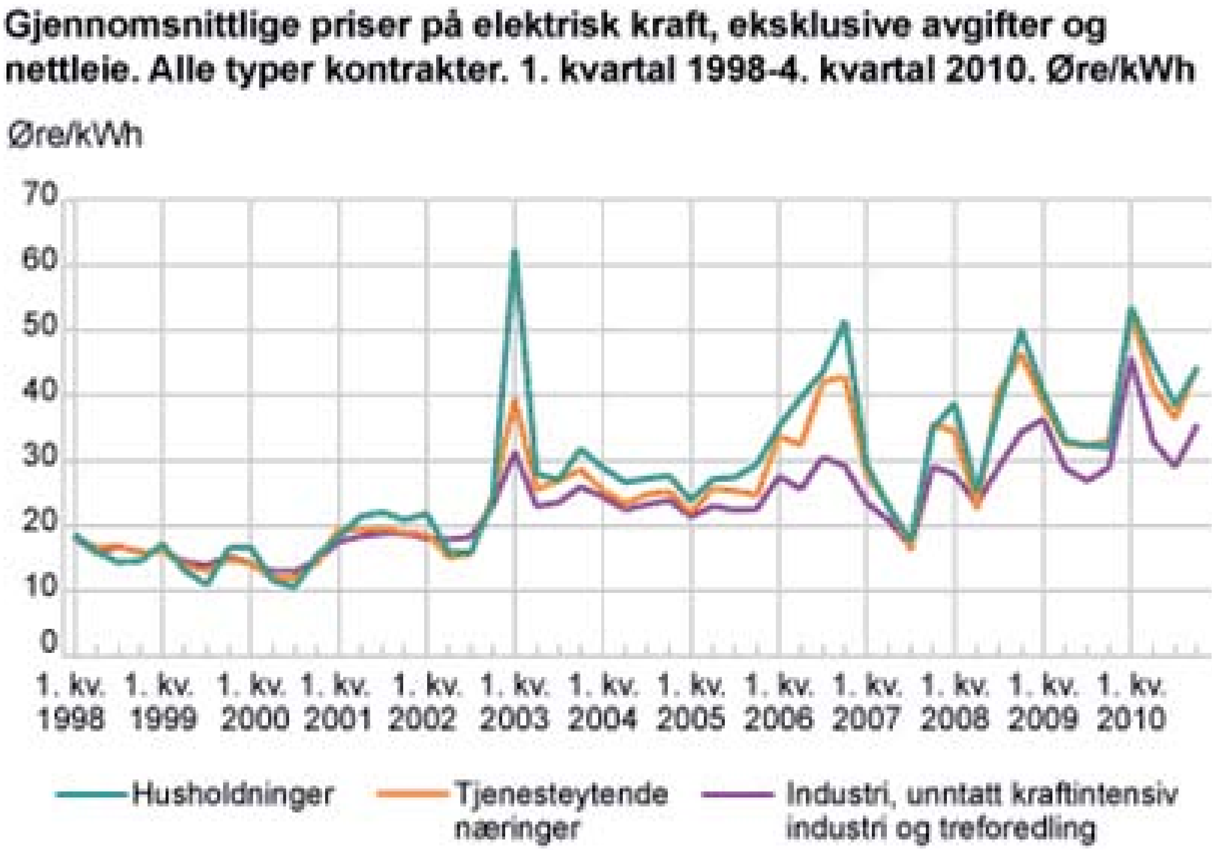


Figure 2: Overview of developments in electricity prices from 1998 to 2010. (Source: Statistics Norway)

interesting thing to note is that 46 per cent of the population has lived in the same house for over 10 years. In the initial phase of life the trend is to move around more. This is reflected in statistics from SSB by approximately 20 percent in the age group from 25 to 44 years has lived in the same house for 10 years. In the next group until retirement age has increased to just over 60 percent, and after retirement age, the proportion up in a total of 76 percent. After you have established a family it is commen to stay in the same house until you are no longer able to maintain it or have a less need for space. Then you can buy a smaller apartment or move to a retirement home.

[8 Population and Housing Census 2001. Housing: Nearly two million occupied dwellings in Norway (Published: 9/23/2002) http://www.ssb.no/fobbolig/ (Retrieved 01/20/2011)]

Cabins:

According to Statistics Norway, there were in 2008 almost 418 000 cabins and buildings that were used as holiday homes in Norway. More than 20 percent of all households report that they own a holiday home, and this proportion has remained almost the same since 1980. In addition, many have access to a holiday home, leading that four out of ten people own or have access to a holiday home.

In the mid-1980s, the newly-built homes were next to three times as large as the new holiday homes. The area of new holiday homes have heavily increased and there is now little difference in the size of new homes or cabins (see Figure 4). New cabins are 70 percent larger than the yuppie era in the 80s.

The cabin is no longer a place we go to seek the peace and solitude of nature. Now more and more are part-time residents at the cabin, which is a place to spend leisure time with family. Today people want it just as comfortable in the cabin like home. Much of the reason for this is that there are many people at the cabin at the same time living there for a longer period [9].

A survey conducted by Trysil Cabin Owner Association among cabin owners in Trysil, showed that people are at the cabin on average 62 days each year, and that there are seven people who use each cabin.

In contrast to the purchases of homes, the purchase of a cabin are often not dependent on life circumstances or age. It depends more on people's economic situation and interest. The trend is that one wants to have a large cabin that will be a gathering point for friends and family. Many currently has an equally large or larger cabin than a home, particularly those residing in the city.

[9 Large cabins eats of the wilderness (Published: 7/26/2010) http://www.vl.no/samfunn/article61607.zrm (Retrieved 01/22/2011)]

Awareness and attitudes

In Norway we have always been in the fortunate situation that we have been well endowed by nature with regard to energy resources. Hydropower, biomass and fossil fuels has been relatively accessible. On this basis, our view of energy consumption is reasonably relaxed.

Because of our open economy, we are largely dependent on developments in the rest of the world and our good economy is therefore heavily dependent on international energy prices.

The last decade has also given us serious warnings. Environmental awareness is rapidly growing in the world with daily topics such as air pollution and forest loss, greenhouse effects and ozone layer weakening and the acidification of lakes and rivers. More and more people realize that a threat to the external environment is also a threat to the internal environment.

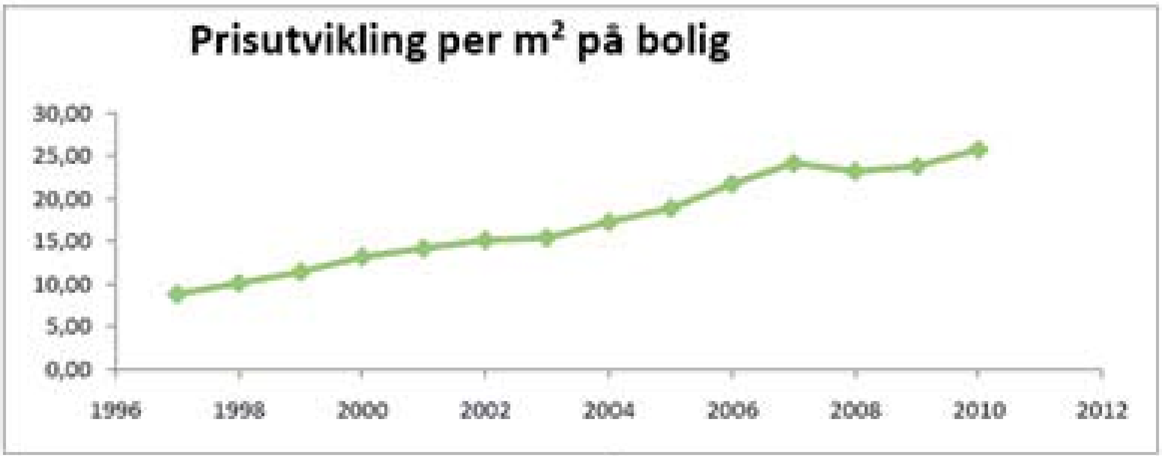
We are in a time when the world is facing great challenges with the terms of limited energy resources, while the natural balance in the external environment is about to be destroyed by excessive use of fossil fuels. World Commission on Environment and Development has stressed that the interests of the pollution of air, soil and water and in the interests of global warming, all countries especially the industrialized need an increase in energy efficiency and switch to renewable energy. The focus on energy and environmental issues also leads buildings and climate technical installations to be faced with increased demands of energy efficiency and reduction of environmental pollution.

How have these developments affected "ordinary people"and their interest in energy efficient solutions in their home?

The trend today is that the choice of housing is affected by the location, appearance and price. It is not customary to reflect on energy consumption when buying a home. In Norwegian homes are cozy and pleasant central values. Norwegians emphasize that the property should be light, peaceful, and that it should be snug and warm. Lack of interest in the home's energy use is also reflected in how the property advertised for sale. Real estate agents often give information about the heating system, but rarely about the building's energy technology state.

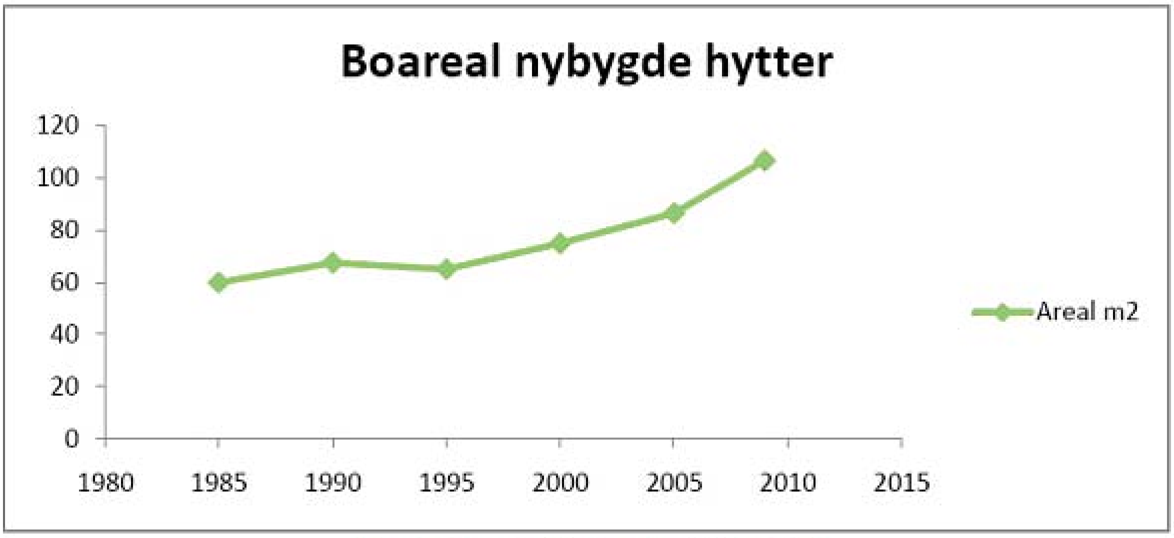
It is strange enough little correlation between the attitudes people have questions about energy use and energy and environment. One might live very energy efficient without being concerned about energy or environmental issues. Or, conversely, many who have positive attitudes toward energy conservation and use of alternative energy sources, even a high energy consumption.The home is not just a quiet haven in a troubled world. In 2003 it was refurbished for about 30 billion, and there is a strong focus on raising the standard of old homes. This has led to energy savings. The motivation is not to save energy, but to improve the comfort of home. Energy savings is an additional benefit. These are important points for energy and environmental engineers. Those who are keen to make the home more comfortable, can also be persuaded to invest in energy conservation measures if it helps to make your home more enjoyable and comfortable, perhaps even if these measures are profitable. Similarly, the interest of health and indoor environments work the same way. Health arguments will probably be more effective than the interests of sustainable energy use.

A survey conducted by NIBR, with support from the Construction Cost Program and the Housing Bank, showed that 65 percent of us will pay more for housing, if it is compensated in future savings in energy costs. There is also clear that the choice between two otherwise identical houses, two of ten unconditionally pay more for the home are the most environmentally friendly. Only 14 percent will not, under any circumstances pay more for environmentally friendly homes. This means that more information about alternative energy solutions and reduced operating



Figur 5: Prisutvikling per m² på bolig (Kilde: SSB)

Figure 3: Price evolution for housing per m^2



Figur 6: Boareal nybygde hytter (Kilde: SSB)

Figure 4: Living area in m^2 for new cabins (Source: SSB)

expenses will likely contribute to the Norwegian consumers choose more energy-efficient solutions. The survey also shows that few are willing to lower the standard and comfort in order to achieve more environmental-friendly solutions. Only 17 percent say they are willing to reduce the size of the dwelling, while only 35 percent are willing to reduce the temperature to save energy. 24 percent say it is appropriate to lower the standard of hardwood, fire-place, etc. for a more environmental-friendly housing. This shows that residents find it difficult to change habits and attitudes when it comes to their own home.

Health and climate

We have looked at the +hytte projects plans to use healthy materials.

An ideal abode for humans is in a building where we do not suffer from poor health or discomfort. When you have a good indoor climate, it will also achieve well-being. What is needed to achieve an adequate building to create well-being is that:

- The building must provide protection
- The building must be adapted to the function it is used
- The building must have acceptable construction and operating costs
- The building must meet basic hygiene requirements for health

By use of the term indoor climate, we think not only on heat, pollution, noise and light, but it also means the aesthetic and psycho-social environment. If you meet all these people will experience more than the absence of disease. You will achieve a state of good physical and mental health, a positive quality of life.

90% of the time we are inside. The youngest and oldest generation are inside up to 100%. For these even small concentrations of pollutants accumulate over time of great importance. It is therefore important in the building phase to think about issues from the products used. In addition, it is possible for moisture and microbiological upbringing.

Outdoor climate vary worldwide. In the cold north you are concerned about keeping warm in the house and find places to stay sunny. Local climatic conditions will affect the building's energy needs. When to find a building plot and develop it is important to take account of variations in air temperature, wind conditions and access to sun / day-light. The climate in Norway is hard with cool weather and heavy precipitation. This contributes to the development of impaired health, including more gout and rheumatic complaints and, in addition to more sitting down.

Calculation of the sun in Norway

There are undoubtedly large climatic differences in this country. For a concept as the +hytte, primarily focusing on solar power as main energy source is the location of the module of great relevance. The fact that today's cabins are constantly getting more comfort in the form of appliances, heating and other domestic goods, leading to a hi-gher power for many. Solar cells are known as limited capacity. If the cabin should only be driven by self-produced electricity will lead to severe limitations in the use of electrical appliances. Therefore it is of high significance where the module is placed in the country. This will also give a good indication of how any market will be located, and the restrictions in energy use that will apply depending on location.

We can see from the calculations that it is especially the southern and southeastern parts of the country (Sør-Nor-ge) that are most exposed to solar radiation. This result corresponds well with the density in relation to the number of cottages that are registered in Norway. By comparing the map that shows the average annual sun exposure with a map taken from Statistics Norway (SSB), we see clearly a trend that most cabins are located in sunny areas. This comparison is illustrated in Figure 5 and 6. Nevertheless, it is important to point out that one can get more specific results by comparing the energy needs within specific seasons by looking at the number of hours of sunshine within a specific time period. By looking at the map in Figure 8, we can also see that Finnmark, Troms and Nordland are exposed to about as much sun as Midt-Norge/Sør-Norge in the summer month of July. For example, the northern parts of Norway is a greater need for heating all year round, and thus it may be a market for solar cells here in the summer months. When we look at the winter month of January (Figure 7), we can see that large parts of northern Norway are not exposed to the sun and is thus a market that can be excluded for solar energy in winter.

It is nevertheless important to point out that all areas in Norway are exposed to such a large amount of solar radiation that it gives a new value for energy production for different purposes. With today's technology, this form of energy a competitive energy source for heating water and housing, but the usual power from solar cells is still more expensive than mains according solenergi.no. Nevertheless, in the future we are most likely to develop technolo-

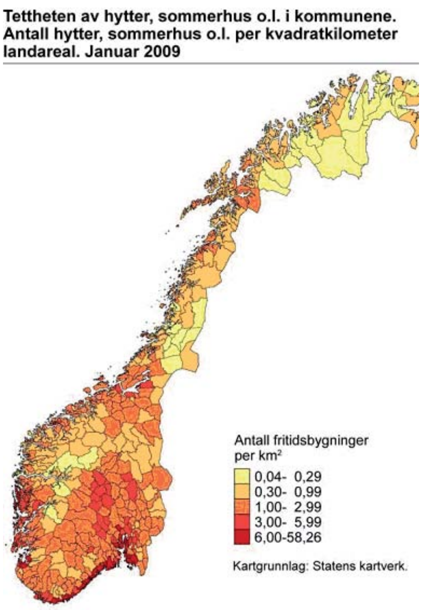


Figure 5: Density of holiday homes in Norway. (Source: Statistics Norway)

gies that generate more energy from the same amount of sunlight. Thus, solar energy in the long run be a very competitive energy source in several different areas. Another key element is that the use of solar energy as a grant to the energy supply is relatively uncommon in Norway, also in comparison with other Nordic countries like Denmark and Sweden[10]. The reason for this is partly due to lack of funding for the creation of the solar heating system. This is about to turn around at that as Enova has opened up more support for such projects. Furthermore, the technology for solar heating system are under constant improvement, and will most likely play a larger role in the future.

From the maps above, we see clear signs of the density among the highest in recreational buildings along the coastline to the south. From our weather, we have found that this particular area has the most hours of sunshine a year. This is a signal for a future market can be compared to better exploit the competitive advantages the +hytte holds. Higher energy production in the cabin will provide reduced costs in the form of lower power consumption if it is connected to a power grid. Cabins that are not connected to such networks will be able to use more power and thus make use of several devices that fit into each individual's lifestyle. This will here give a greater market potential for the cabin than for areas with less sun. One thought is to facilitate a future marketing to customer groups with an interest in acquiring a holiday home in sunny areas such as the southeast coast.

[10] Norsk Solenergiforening (Published: 22. October, 2009) Solenergi kan overta i Norge (collected 18.01.2011)
http://www.solenergi.no/solenergi-kan-overta-i-norge/

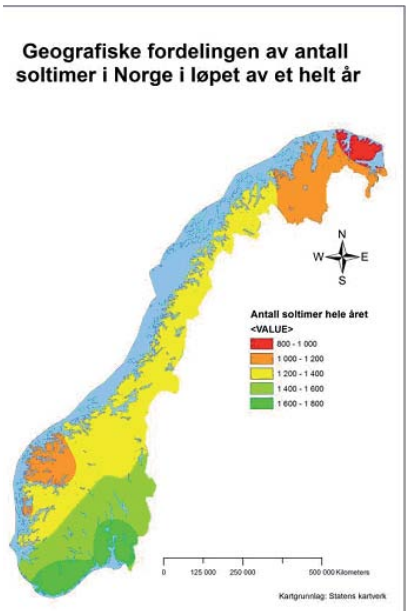


Figure 6: Sun hours in Norway during a year. (Source: Statistics Norway)

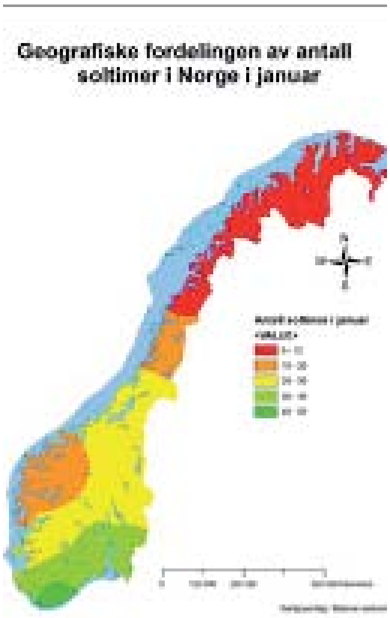


Figure 7: Sun hours in Norway in january. (Source: Statistics Norway)

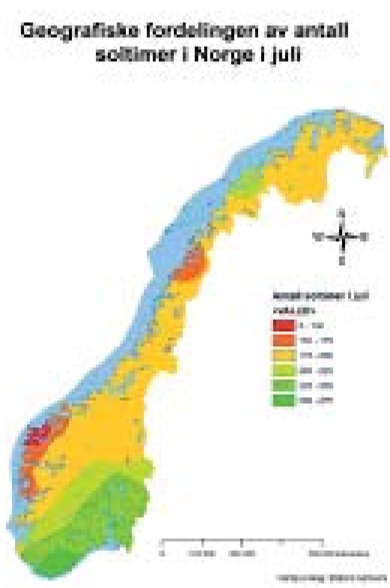


Figure 8: Sun hours in Norway in july. (Source: Statistics Norway)

1.4.2. _ Team visual identity manual

The Identity workshop.

Delphi and Media Analyses of ZE+hytta

The Delphi Exercise was performed with 10 architecture and engineering students, involved in the Norwegian SDE project, on 17 February 2011. The results of this exercise are discussed in this article, and compared to the main trends in the press releases on the ZE+hytta project in Norway since the SDE competition started.

Delphi Exercise Part 01 (15 minutes)

On this sheet of paper, please write down keywords and characteristics you relate to Solar Decathlon and our ZE+hytta project.

Be creative: The keywords can be related to performance criteria, feelings, identity, what the project means for various people, what it means for you etc. Anything that pops into your head when thinking about SDE & ZE+hytta.

Just write down the words freely on this sheet of paper, which will be collected after 15 minutes.

You don't have to write your name on this sheet.

Delphi Exercise Part 02 (45 minutes)

This sheet of paper contains all of the keywords all of the participants wrote down during the first part of the exercise. The keywords have been organized in categories.

Please write, for each Topic Box, whether you agree or disagree that this is an important characteristic for SDE2012 and ZE+hytta, and why.

After about 45 minutes, the sheets are collected again. If you need more time, you can hand it in later.

The results will be reorganized again, based on the answers in part 02, and used as a basis for the storytelling delivery in the SDE competition.

1. The Attractive ZE+hytta (Inspiring)

The absolute winner of this exercise, the only answer upon which everyone agreed, was related to the attractive and inspiring environment the house will be able to offer its inhabitants:

Breathable, Light, Warm, Cool, Bright, Nature, Sensitive, Open, Space, Free, Harmony, Inspiring, Tranquility.

A second range of qualities, with fewer votes but no objections, was related to the house and its interaction with the environment:

Living Organism, Osmosis, Dynamic, Adaptive to Different Climates, Changeable Skin, Transformation

2. The High-Performance ZE+hytta (Generic and Obvious)

Medium scores were obtained by a wide range of performance criteria more directly related to the SDE competition, mainly with objections of the 'obvious' nature of these criteria:

Innovative, Future Architecture, Potential

Sustainability, Ecological, Living Organism, Environmental, View, Nature Reflection, Home of Nature, Nature Inside/Outside

Universal, Multifunctional, Flexibility, Mobility, Adaptability, Interactive

Autonomy, Independent, Self sufficient, Energetic Connection

3. The Restrictive ZE+hytta (Highly Questionable)

At the bottom of the ranking were a few issues that, apparently, raised a lot of controversy. These are mainly related to the restrictions in lifestyle the house might require, restrictions in user groups the project might target, and the temporary nature of the project (rather than having a house for all stages of life):

Lifestyle, cabin, home, no TV

Strong Identity

Temporary Nature

Towards a High-Quality, Low-Impact Architecture

It was surprising to see so much focus on the ‘attractive’ and ‘inspiring’ qualities of the ZE+hytta, and so much agreement on the importance of these issues for the overall project. Particularly when coming from students that have been working intensively on the Integrated Energy Design of the ZE+hytta for the past few weeks.

This seems to be part of a general trend that is arising among students, industry and media: everyone is aware of the urgent importance of resource efficiency and climate challenges and knows that drastic measures need to be taken – the most vital question is, however, how to achieve resource efficiency and climate adaptation while increasing quality of life and restoring local, cultural and architectural values.

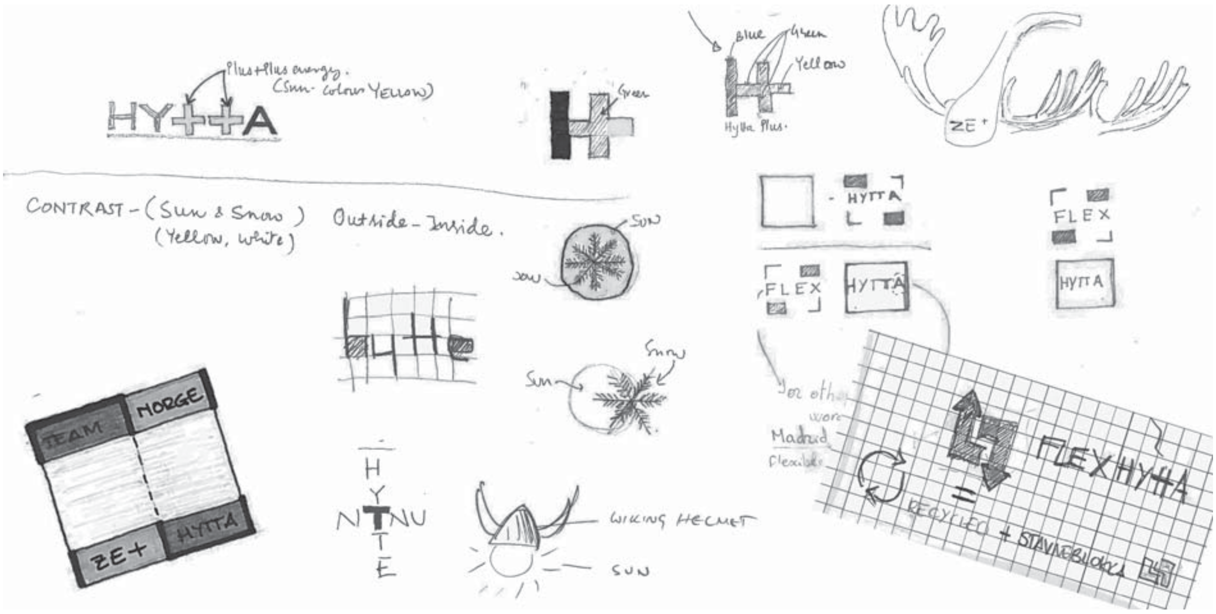


Fig. 15 - Some of the logos proposed by the students during the identiy workshop.

1.4.4. _ Sponsorship Manual

Selling Green report from the Experts in team workshop, January 2011.

“How can we attract investors and other contributors to the development of the +hytte in the time leading up to the Solar Decathlon Europe and beyond?”

The report presents different aspects that must be considered and investigated when one wants to attract investors and other contributors to the project.

Media promotion and branding

Think about what you can offer investors, and who they might be.

Website:

The website should be a place where one can find much information about the project. Information should be adapted to different actors and knowledge and should have a professional look that builds up under the idea about environmentally friendly. A web page’s visual imagery has a lot to be said for first impressions of many who have heard about the project, and locate the site because they want to find out more. The website is also a good place to market their business partners and sponsors through that they can have their logos on the website, and add links to the respective companies’ own websites.

Social media:

Social media can be self controlled, and it's free marketing. It can be used to sneak into people's awareness and provide small drip of information, so that people will want to find out more.

Facebook + Twitter, as long as you have the ability to respond quickly to inquiries.

Klimax breakfast seminars at Dokkhuset:

Breakfast meetings are a medium one has the ability to control much of yourself. They can be used to inform about the project, establish contacts and disseminate information to increase interest in contributing to the project. This is perhaps a forum where it is appropriate to inform what the project can give back to their partners and sponsors.

Model that can be moved around:

The idea of a traveling exhibition in Norway has been discussed, and one can then use ZE+hytte for SDE competition. The goal is to use the house as an opportunity to increase awareness of environmentally friendly buildings, also in connection with conferences and other events. It is also possible to create a smaller model that can be moved around before SDE competition is done to raise awareness about the project earlier this phase .

+ Techno Port 2012 (April 2012)
+ Brøset (after competition SDE)

Mass Media:

These media have limited ability to influence, but one must try to get them interested in what we are doing. Think on a regular basis if you have something that is possible to create a story about, and ask a journalist to ask if he / she would like to make a case for this. There is also a point that the project is part of a competition, and that therefore it will be things going on in the competition and that is worth communicating. We saw this when the news about NTNU being included in the Solar Decathlon competition were announced.

Many have learned that once you get some publicity then suddenly the ball starts rolling. Then it is important to be well prepared and have thought carefully about what you want to convey, and what you do not want to say too much about. Interview Preparation Form as presented below may be helpful in that regard.

Some suggestions: Forskning.no, Tekna, Teknisk ukeblad, Adresseavisen, Dagens næringsliv, Aftenposten, Newton, Schrödinger's katt.

Strategy for contact with media:

We have prepared a draft for strategy with the media, based on things the group members have learned about marketing and communication through their studies and experiences of occupational and organizational life.

1. Finding a relatively simple message about what the project is about, what is the end of it and why it's good. Make it so simple that most people can understand it, but thorough enough that it seems plausible for those who know little more about the various topics included in the project.
2. It is wise to merge into what potential contributors can get back, but this is not the main focus.
3. Use multiple channels to disseminate information. Here it is important to consider the profile of, and degree of seriousness with selected media. It may not be desirable to focus on communication through tabloid press.
4. Be prepared for negative publicity and discussion of the negative aspects of the project, and have a plan for what to answer. Making negative aspects a secret is rarely i good idea, so it is better to give a positive but realistic picture of the project rather than creating an illusion that sooner or later burst.
5. One thing that is important to be aware of when trying to recruit people for something is what does it takes for people to want to join? People usually want something in retur for the time or the money they invest. When it comes to giving their time and creativity, many people do it because it's fun, because it is an opportunity to achieve something great together and feel that a self is important for others. Therefore it is important to convey that they have fun together and that there is an inclusive environment where many types of people are welcome.

Seen from the investor side, it is important to communicate that you have a productive working environment with a broad education, where the conditions are right for something good worth investing in. These messages need to be thought through how you communicate, because it is often not credible enough if you just say it straight out. One should add elements to prove that what you directly communicate is true, or how to communicate the message without it be said straight out.

Interview Preparation Form:
Case:
Name:
Audience
The desired effect
Messages /Main Focus
Facts (figures, statistics, surveys, quotes, citations ...)
Experiences, examples, stories
The questions I would rather not answer
Illustrations

- Supporting institutions and companies tracking

What can a participation in the project give back to the companies:

By contributing to the project companies will participate as part of a great competition where 47 universities from around the world have delivered their contributions, 20 of the universities have been eligible to participate in the competition. NTNU is one of these, and your company has the opportunity to contribute.

Services for students

Companies that choose to participate in the project will have a unique opportunity to profile itself towards the students over a longer period of time, and gets the opportunity to attract prospective employees and prospective buyers of their products and services. Firms will also be able to use students to test out new products and ideas.

The project is an interdisciplinary collaboration between several majors, and one get to reach out to students from different and perhaps new fields of study. Interdisciplinary approach also provides the basis for developing new ideas that can be taken back to the companies. Several researchers are already contributing to the project, and companies have the opportunity to contribute to research with their own projects and to support research on environmentally friendly solutions.

Testing of new technology and product ideas

Since ZE+hytte is an ambitious and comprehensive project that will end in a complex product, the possibilities are good for support from several quarters, including the public sector. The cost of testing of new technology is reduced to the individual because there are more contributors. NTNU provide facilities and expertise in various disciplines.

Environmental Profiling

Through contributions to the project companies are able to profile itself as a company with a focus on the environment and research towards both customers and partners.

We also envision an offer to businesses that can not participate directly in the project. In connection with the competition in Madrid, we need help with transportation of the cabin and personnel down to Madrid. Here, for example, SAS provide transportation of personnel from Trondheim to Madrid16. Maersk Line has melt their interest in participating in the consignment of ZE+hytte modules down to Madrid.

For these companies, this will be a unique opportunity to use profiling project around its environmental commitment and show the customer that they are not afraid to think a little differently on environmental questions.

Profiling

By participating in the project companies will be mentioned in all matters involving the project and can also use the project in its own branding around the company’s environmental profile.

Direct marketing of the project / event:

• Web sites:
o The project must have a up and running website that will be updated with the development of the project and a detailed description of the background, facts and visions for the project.
o Provide logo and link to their website and vice versa. Can have a positive effect on customers of the partners in that they participate in an environmental competition.

• T-shirt:
o Delegation in Madrid will use t-shirts with the logos of the partners.
• Logo placement at the stand in Madrid:
o The information posters that describe and explain the project at the booth of Madrid will be a series of logos to all who have contributed to the project.

Indirect marketing:
Companies participating in the project will be able to use information about the project in its own marketing. For example, a company can write reports about ZE+hytte in its customer magazine to surprise their customers with a new type of environmental thinking. For the customer, this will create a new and positive image of the company, a company who dares to think environmentally friendly. As the housing and cabin has a large area of interference, the +hytte has the possibility to appeal to a broad customer base.

Companies participating in the project is part of a comprehensive international competition that runs for a long time. The competition is in itself a drive to bring the project forward, and motivates those who contribute to the project to provide a little extra. A sense of ownership of the project is also an important factor in getting people to provide something extra, and it is therefore important to bring in potential contributors as soon as possible and involve them in planning and development. People love to hear about contests, thus giving it greater opportunities for media coverage.
Thus we see for ourselves that companies can use internal competition to motivate and engage employees and customers about environmental issues.

Which companies may be of interest to involve in the project?

1. Why are they interesting for us
2. Why are we interesting to them

-Products used in the construction itself:

Wood as a structural timber:

Kjeldstad Lumber (Local sawmills in Trøndelag)
1.Having a large planing mill that supplies finished timber that can be used in a cabin module. Kjelstad cabins are part of the group that develops their own homes for the Norwegian market. [http://www.kjeldstad-trelast.no/index.php]
2. A local sawmill at a relatively large size like Kjeldstad Lumber will be able to promote itself more nationally through this competition that has already received some attention in the national media . This can be used to get closer to the major retail clusters in Norway. The big chains Byggmakker and Maxbo to name a few, are largely franchise concepts that sold out to groups of smaller lumber companies around the country that have separate purchasing contracts. Several of these clusters will be able to pick up the trend in SD contest and on its partners. If such a sawmill, for example, can develop an environmental product for use
in the cabin, this will be unique in this industry and the possibility of ending up on a potential supplier list will increase.

Moelven industries (National timber industry)

1. Moelven is one of Scandinavia's leading timber industry group, with headquarters in Norway. They have long experience in manufacturing of modular wood structures. These are produced today as the building blocks of such offices, kindergartens, hotels and housing projects. Several of the modules are delivered with complete kitchen and bathroom furnishings directly from the factory which can facilitate the transport and constructing of a ZE+hytte. These modules Moelven AS module might be developed to be used as a base for ZE+hytte in the event of industrialization process. In addition to modules they produce finished wood products such as cladding and framework that will also be included in the construction. Stavne block is intended as exterior cladding, a form of solid wood the company Stavne produce. These are just some of the points this company can contribute, so that the sail up on several fronts as a supplier of products and competence.

[http://www.moelven.com/no/Produkter-og-tjenester/Byggmoduler/Leiligheter/; http://www.moelvenmassivtre.com/]

2. Moelven group has much profiling to gain through such a project. Product development, for example, solid wood and other structural variants in collaboration with students and research around the +hytte will prove to be a very rewarding process for both parties. The use of solid wood in Norway is not particularly widespread, this is partly due to ignorance among the public and contractors, and that it is a costly method. Such a project could increase the knowledge of solid wood construction with both future engineers at NTNU, and for those who follow the project in other ways. Many of the same arguments can be used in the development of modular buildings Moelven already producing.

Insulation:

Rockwool (Insulation to walls and ceilings)

1. This company offers insulation mats of mineral wool. In contrast, the competitor Glava uses glass wool in their corresponding pads. One of the Rockwool major competitive advantage is an increased fire safety. They promote increased awareness of the greenhouse effect and using environmental issues in their markedsføring. [http://www.rockwool.no/bæredyktighet/klima+og+miljø]

2. Construction Product Suppliers Rockwool, Jackon and Isola, all need a certain amount of substance in its environmental profiling. They are privileged enough to produce goods that are automatically perceived as environmentally friendly because they make houses more efficient and reduces heat loss, among other things. That they often appear as environmentalists may seem cheap for many. Therefore, participation in this project a golden opportunity to show that they are a part of something real and not just doing product development behind their own closed doors. Another issue is the development of electricity prices. According to the earlier section “The situation in Norway today and future development”, there are good arguments for that electricity prices in Norway will increase significantly in the future. This suggests that the building materials producers with a focus on energy efficient products will see a significant growth in its turnover. By promoting itself heavily in advance of any demand shock due to high electricity prices, they will be able to capture the interest of major customer groups who are willing to take change seriously early in the process. To upgrade a house, for example, by insulating a cost-and time-consuming task. Many ordinary citizens will therefore use a relatively long time to put such projects into action to reduce energy costs.This may mean that to market now by being involved in the development of the +hytte can lead to big sales in the future of insulation products versus substitutes such as gas stoves.

Jackon (Foam and polystyrene boards that can be used for floors, walls and ceilings)

1. Have a clear environmental profile with a strong focus on recycling and greenhouse gas emissions when burned. They offer, among other things, product Jackofoam who informally called “environmental record “.

[http://www.jackon.no/eway/default.aspxpid=261&trg=MainPage_4926&MainPage_4926=5617:0:10, 1766]

2. See section 2 for Rockwool

Cardboard:

Isola

1. Currently there is no obvious environmental aimed at climate issues, but they focus more on efficient buildings through the use of surface products such as cardboard, boards and plastic. 21

[http://www.isola.no/om_isola/kvalitet_og_miljoe]

2. See section 2 for Rockwool

Windows:

Natre

1. Strong focus on heat loss from windows. This has resulted in the product UNO energy with good insulation and low value of heat diffuse. 22[http://www.natre.no/side3578-cid-3577.html]

2. Natre and NorDan and is one of many who try to assert themselves in the battle for the low diffusive values and energy efficient windows. They face stiff competition from large companies in Europe, which also focuses on many of the same competitive advantages. The other participating countries in the SD will also need to focus on heat loss from windows and several will thus initiate cooperation with various manufacturers in their respective countries. For the Norwegian producers it will be valuable to be able to showcase their contributions in the same arena as the big foreign manufacturers. This will create hype around the Norwegian windows both at home and abroad.

NorDan

1. Have a close cooperation with environmental organizations such as: Swan, Enova, PEFC, Green Building Alliance and Green Point. They have developed the swan marked N-tech window that is a triple window with a diffuse value of 0.7. [http://www.nordan.no/om-nordan/]

2. See section 2 for Natre

Solar Panels:

REC

1. One of the largest manufacturers in the solar cell industry. Much of the production is in Norway and is headquartered in Oslo. A relatively large part of the marketing is already aimed at reducing greenhouse gas emissions by using solar power. [http://www.recgroup.com/en/sustainability/]

2. The whole project depends on being able to produce enough power to carry out the various criteria in the competition. How to use solar panels best is probably one of the most important in the process towards Madrid 2012. REC is a large company that depends on interest in solar power to continually increase in the future. This competition is something that really puts this power in the form of focus, so what would be more natural than to contribute to the design of a solar powered module? In addition to the obvious interest that has already been mentioned, this will also be an opportunity to show off for potential future employees from NTNU. Another factor is that all the students who do not necessarily have a career in the REC will hopefully look at solar energy in a new light. There are many future engineers who at one point might make decisions on the energy supply to the buildings they are responsible of. This project will undoubtedly see a lot of value and the possibility of using solar energy as the main source of power.

Remote control of heating systems:

Sunwind

1. The company is one of the ultimate on holiday articles. They have a strong focus on solutions that are highly relevant to the +hytte concept. They include the complete supplier for cabins without access to electricity. Here is the use of solar power centrally. Because these cabins often have to limit their energy use they offer many products that have a very low power consumption. They also have systems for remote control of heating units that are already relatively common in today's cabins.

[http://www.sunwind.no/content/pages/news/showpage.asp?pid=93]

2. Remote control of heating systems is mentioned as a key part of energy savings in the module. Being able to, for example to turn off the heat when not at home, and could turn it on again before returning will be an effective measure in a Nordic climate with high heating costs. This technology has already been tried and is still used by Norwegian cabin owners. Sunwind is a major player in this market. This product is currently mainly aimed at the cabins. If this also can be used in the housing market it will create an entirely new and significantly larger customer base than they have today. They also manufacture many items that are very energy efficient. To contribute to this relationship it will give them an opportunity to showcase their products in a whole new light. They can use this in its branding to appear to be an innovative, environmentally friendly and dynamic company that focuses on product

development towards a sustainable society in collaboration with students and external research groups.

-Contents of the module:

Appliances:

UPO

1. Scandinavian white goods manufacturer with a competitive edge, consisting of energy-efficient products. [http://www.upo.no/]

2. During the competition in Madrid one of the tasks are to create a banquet for 20 people. Here you need appliances with low use in power. UPO specializes in exactly this, and have used it actively in their marketing. Being a Scandinavian company, it may be easier to get an agreement with the UPO versus the major manufacturers in Germany. Their environmental certainly fits well with such a project, and participation by showing off, among other major producers and potential customer groups.

Kitchen furnishing:

IKEA

1. Offering affordable and freight friendly kitchen packages that can fit well into a modular cabin. IKEA can also be used as a supplier of conventional furniture. They have received some criticism that they are the worst environment in the sense that they build up under an unsustainable consumer society. Perhaps are they more interested than others in supporting environmental projects because they have a reputation to change.

2. IKEA could have had an indoor model of the +hytte decor, such exhibitions at IKEA is often built up. This will also lead to more people to see and experience the module how it can function in everyday life.

Norema

1. Presented the first kitchen with eco-labeling and using innovative solutions that precisely one of its main advantages. [http://www.norema.no/ # / campaign / norema_svanemerking.swf]

2. Suppliers of kitchens can to some extent be interested in recruiting students of product design and construction, and participation in the project also provides an opportunity to

present themselves for the future students that will be responsible for major construction projects, including a choice of supplier of kitchen appliances.

HTH

1. Supplying total solutions in the kitchen and has a Danish certification. Being involved in a Norwegian environmental project would have positive effects for the Norwegian customers.

[http://www.hth.no/Default.aspx?ID=3809]

2. See section 2 for Norema

Bathroom Fittings:

Flisekompaniet

1. Nationwide total supplier is also established in Trondheim. They have no clear environmental profile today, which seems to apply to large parts of the industry.

[http://www.flisekompaniet.no/Privatkunde/Om+Oss]

2. Flisekompaniet has said that like many of its competitors no clear environmental profile. The fact that consumers increasingly place greater emphasis on environmentally friendly products in particular through energy savings, can give this company an advantage others in the industry have not yet used. Bathrooms are familiar for most people as a significant contributor to the energy bill. Previously mentioned electricity prices may rise sharply in the future. A custom-made bathroom with a strong focus on energy savings can therefore be a product for the years ahead. Such a concept might be appropriate to insert in the famous module and will function as a portable advertisement for the bathroom.

Furniture:

Ekornes

1. Scandinavia's largest furniture manufacturer with a focus on sustainable production in their industry. They boast eco-labeled products and trying to promote itself as a producer with a clear environmental responsibility. 30

[http://www.ekornes.no/no/omekornes/detteerekornes/miljopolicy/miljodokument/]

2. Furniture manufacturers will be able to gain promotion through contributions to the development of the +hytte as an environmentally friendly and innovative project.

It is possible they are also interested in promoting themselves as a future employer of students, particularly in the design, development and construction.

-Other services

Transportation of the module

Bring

1. They are a Norwegian postal and logistics company owned by Norway Post and operates with all types of transport within the corporate market. They have a strong focus on the use of modern transportation methods, and a fuel efficient fleet. Bring is concerned that the results of the environmental initiative will be measured in order to communicate to customers and awareness that they are constantly making progress.

[http://www.bring.no/Hele+Bring/Om+Bring]

2. Provides total solutions in shipping, and can assist with the transportation of +hytte to Madrid, either by the use of road, rail or sea transport. This industry is often seen as not environmentally friendly because of high consumption of fossil fuels. To contribute to this project they will be able to reverse this perception in the opposite direction. They are undoubtedly depended on some emissions to offer their services, but an involvement in a green and exciting project that as the +hytte can quickly lead to a better reputation on environmental issues.

Airline

SAS

1. They fly Trondheim - Copenhagen - Madrid and would therefore be able to help with the transportation of personnel down to the competition in Madrid. SAS is the only airline in the world who have been certified by two internationally renowned environmental certificate ISO 14001 and EMAS. ISO14001 focuses on identifying and reducing the company's impact on the environment. EMAS is a part of EU environmental action and means that employees involved in environmental work. The company must publish the most significant environmental aspects around business and what the company does on the environmental issue

[http://www.sas.no/no/Om-SAS-Norge/MiljoBarekraftighet/]

Insurance

Gjensidige

1. They are a big bank and insurance company that operates partly within house insurance. The company is concerned about climate and environment. In particular, their focus is the less resources they use, the more resources are available to the public. Gjensidige has recently adopted in videoconferencing, e-documents and purchase of carbon offsets to reduce emissions from its own operations.

[http://gjensidige.com/web/Forsiden/Samfunnsansvar/Klima+og+miljø]

2. Gjensidige has many residential customers . By writing about ZE+hytte such as in the customer magazine Gjensidige will bring the project out to clients who are either considering building a new home or refurbish.

Public nstitutions.

• The Norwegian Research Council - NFR - is Norway's official advisory body for the development and implementation of national research strategy and also works actively to encourage international research cooperation. The Research Council identifies research needs and recommends national priorities facilitating the translation of national research policy objectives into action. Renergy is a research programme recently established; it individuates energy efficiency and use of reneweable energy as prior interest for further research.

• Green Trøndelag is partner for Nyskaping and the Sør-Trøndelag Fylkeskommune and is a key-organ for getting fund from Innovasjon Midt-Norge. This last organization works to increase the competitiveness of Norwegian industry in the mid region, and stimulating innovation within this field, enhancing collaboration within and between industry groups, and between industry and research institutions.

• The Husbanken (Norwegian State Housing Bank - NSHB) is the main agency implementing Norwegian housing policy supporting private lenders in financing new homes and contrasting homelessness. The NSHB works closely with local authorities and the private sector to improve the quality of housing on a market mainly dominated by direct and indirect (co-operative) home ownership (77%). Particular weight is given to the promotion of universal design, aesthetics and environmentally friendly solutions in the building sectors and in design. After five years of co-operation with our MSc courses on energy- and environment-friendly architectural design (including international student competition with Chalmers in Sweden) the HusBanken is interested in supporting new projects and is going to open in June for funding for competency development. The SD that will be most likely located in the Brøset - where Hubanken already cooperate - will be inserted in a call for funding that will be forwarded to NSHB.

ZEB partners

BUILDING PRODUCTS / SUPPLIER:

• Weber: easy to apply products in the facades, construction mortars, flooring systems and tile fixing materials.
• DuPont: innovative products for building and construction.
• Glava: New superior insulation materials and thermal protection building systems.
• Protan: technology and solutions for sustainable roofing systems.
• Hydro Aluminium: active solar energy generation, passive energy efficient and building envelope solutions.
• Brødrene Dahl HVAC equipment supplier.

BUILDING CONTRACTORS AND DEVELOPERS:

• Skanska: sustainable construction company developing new quality concepts, components and materials.
• ByBo: housing contractor.
• YIT: technical installations contractor continuously developing energy-related technologies and solutions.

PROFESSIONALS AND CONSULTANTS:

• Multiconsult: development of analysis tools evaluating environmental impact of new products or services, leading to new standards, guidance, and analysis models.
• Snøhetta: The Centre currently expanding the office's competence in designing buildings with very low impact on the environment, with special focus on climate. Generation of sustainable solutions is implemented thorugh many projects all over the world.

GOVERNMENTAL INSTITUTIONS:

• Statsbygg (Directorate for Public Construction and Property). Innovation and higher efficiency in the Norwegian property, building, and construction industry.
• Forsvarsbygg (Norwegian Defense Estates Agency): NDEA as a public-owned building client is under considerable political pressure to act as a role model for private building clients. By applying the latest technology public construction activities are targeted to be demonstration objects for the whole construction industry.
• Husbanken (The Norwegian Housing Bank): The Centre has the potential to play a decisive role concerning reduced energy use and emissions from the building stock, both by research and other related activities. Husbanken especially sees a huge potential in using pilot projects as centre points and arenas for regional dissemination of ambitions, knowledge and for regional market development. This will be an essential foundation for innovation and value creation and implementation of results and experiences done by the ZEB Centre and its partners.
• BE (National Office of Building Technology and Administration): Development of building requirements regarding energy efficiency and energy supply, on the base of research results. Research on actions will be of funda-

mental importance for further development of building regulations and building practise.

FEDERATIONS:

• NORSK TEKNOLOGI (Norwegian Technology; Confederation of companies within the technical and technological sector): Norsk Teknologi is a federation of 1550 companies with a total of 32,800 employees and annual revenue of 3.8 billion Euros. It is relying on .. A significant potential for innovation and value creation is possible related to investments in energy efficiency measures.

• BNL (Federation of construction industries, incl. Construction products association): Rethinking construction and stimulating renovation is of utmost importance for a healthy development of the industry. The potential for social profit from increased innovation within the industry is considerable: the society itself will benefit from the innovative efforts to be addressed by the Centre.

1.5. Industrialization and Market Viability Report

Fig. 19 - *The ZE+hytte in a typical Norwegian landscape*

1.5.2 Construction report

Market viability of the product.

Second houses represent more than 10% of the Norwegian building stock and the most dynamic sector in energy consumption statistics. These numbers already give an idea of the potential of developing a market ready ZE+hytte. It is infact becoming more and more common to convert old cabin once detached from the grid into second houses. Once attached to the grid such buildings become energy thirsty structures: big use of photovoltaic is already registered in such projects. Indipendence from the grid as detachment from modern society and simbiosys with nature reflect the desire of most Norwegians. The design of the ZE+hytte will spontaneously generate a lot of interest around it. Recent researches proofed also that the second house issues recurs with similar characteristics not only in other scandinavian countries but also in spevific geographic zones of mid Europe countries. Further research will evaluate in the next months the commercial viability of the ZE+hytte in such geographic contexts.

The ZE+hytte can also be used for expanding existing detached houses. Such buildings represent, due to their high number, the most energy consuming typology in Norway (fig.10). Extensions of detached houses below 50 square meters don't require any official permission. Both the two modules constituting the ZE+hytte measure 37 square meters and can be adopted for such use. With their positive energy production they will compensate energy efficiency lacks of the existing building stock. People would be interested in buying one or more modules for improving the environmental performance of their house and save money in a not long term.

***Fig. 4 -** ZE+hytte can be attached to existing buildings and compensate their energy efficiency lacks.*

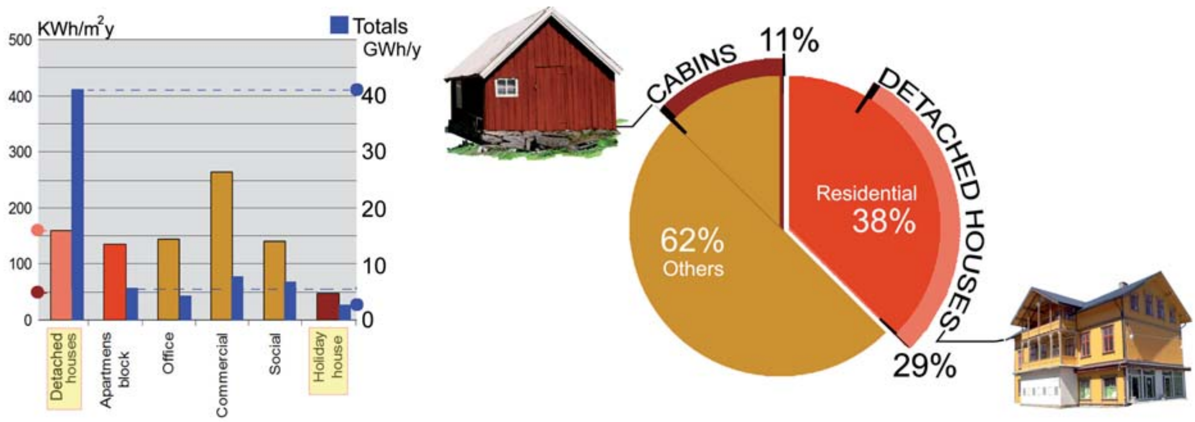


***Fig. 10 -** Energy consumption. Cabins and detached houses represent 40% of the total Norwegian building stock.*

Industrialization degree.

Detailing of all the architectural component constituting the ZE+hytte has been based on a modular system of dimensions that will facilitate the operations of assembly, disassembly and transport. Emphasis will be placed in the next months on the minimization of weight through the use of advanced materials able to ensure anyway best thermal performance like PCM or VIP. Students will be responsible of digital modelling of all the architectural components on the base of the results of experiments and analyses conducted by expert researchers and professionals. Pasi Aalto is today assistane professor at the digital fabrication Lab at NTNU and will cooperate in modelling the wooden structure that will require a more complex production process due to its geometry.

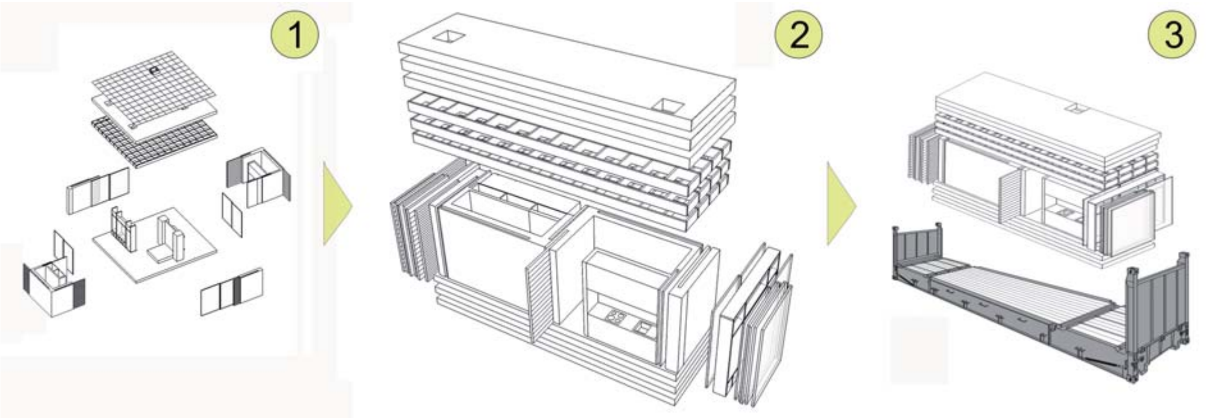


***Fig. 13 -** Disassemble of the modules and transport*

Possibilities for grouping - Experts in Team report

This assignment is an interdisciplinary project that is completed in spring 2011 in the subject Experts in Team (EIT), Sustainable Architecture (AAR 4912). EiT is a compulsory subject for all graduate and professional studies at the Norwegian University of Science and Technology (NTNU). "The goal of Experts in Team (EIT) is that students will apply their expertise and develop their interaction skills through working result oriented with relevant issues of social and working life. Students will develop their theoretical knowledge and practical skills in the interdisciplinary project work and get vocational training in relevant ways of working" (NTNU 2010). Our village consisted of about 25 students from different disciplines, which in turn were divided into three smaller groups. The village has been an intensive course, so the work presented here was performed within three weeks. '

NTNU project emphasized the Solar Decathlon criteria that the building will be flexible, easy to assemble and take down and that it should be energy positive. ZE + cabin would be a step in the direction of a zero emission society. There is also a desire that it should be ready for the market and be flexible in terms of usage and location. The cottage is built of a modular principle and flexibility takes place within fixed limits. The proposal is based on high ceilings and floors, while the walls may be more low-tech. It is designed to use and to test different materials, energy saving solutions and solutions for controlling the indoor climate in ZE + cabin. More permanent features (plumbing and industrial installations) into two "service boxes" on each side of the plan, diagonally across from each other.

This is the starting point for our EiT village. Our group gathered on the basis that we wanted to work with fle-

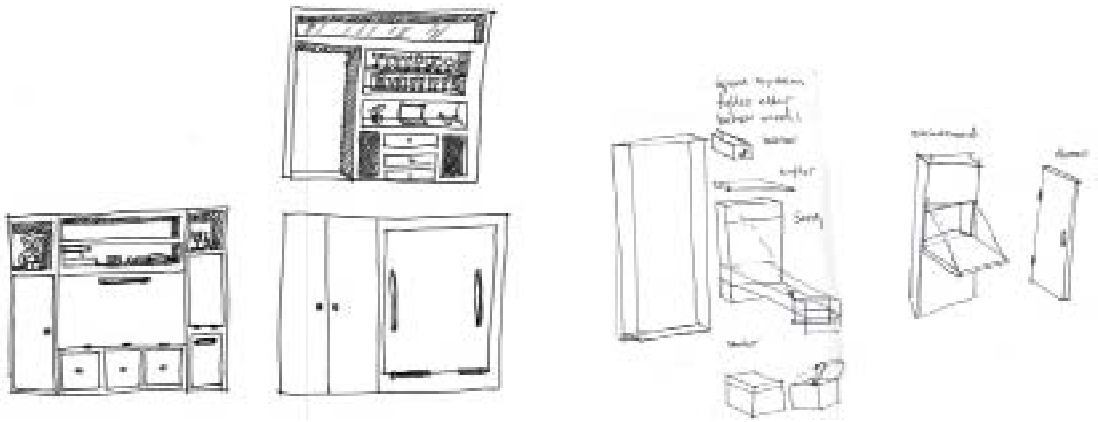


***Fig. 1 -** Interior design towards flexibility _ EiT students*

xibility in relation to the ZE + cabin. We wanted to explore whether the building really worked flexibly. Since we in our group has largely relied on architectural methods, we have not directly applied theory. We used information from NTNU's application and the Solar Decathlon website as background for the task. Our group wanted to work with the flexibility of ZE + cabin. Since the "flexibility" is a somewhat broad and vague concept, we started with a brainstorming to arrive at a common understanding and to find out what we wanted to work with (see mind map below). In this way, we were also quick overview of various aspects of flexibility.

After brainstorming, we had a need to refine the task. We discussed us therefore up to the premises and areas of focus for the task and formulate a research question. This was what we presented to the expert panel in our first presentation. We decided to extend the use of cottage housing. We did this because the increased complexity would give us better scope to explore the flexible use of ZE + cabin.

In 2009 it was built 20 000 households. This was the lowest figure since the start of the 90's. Therefore, it is expected that the number of homes being built will be over 20 000 in future years (SSB 2011). In 2005 there were 374,470 second homes in Norway and approximately 2.3 million homes in total, ie about 17% of the total number of households (SSB 2011). Given that the same ratio applies to newly constructed homes, it is reasonable to assume that the number of second homes being built will be about 15-20% of the 20,000-in the household in 2009.

In NTNU's Solar Decathlon suggestion is emphasized that the +cabin is off-grid, that is unrelated to water or electricity supply. This cottage niche will be a very limited market to launch a new product. If one looks at the cottage density, it is reasonable to assume that most of the cabins being built today are not within this niche (SSB 2011). We therefore believe that there will be more future-oriented if ZE + cabin further developed to the housing market. This can also lead to a lighter can get a larger number of units produced, and that restructuring costs from conventional housing to a holiday home is less than from the holiday home. The competition today is great both on both rental and residential arena. The easiest way into the market, we consider the housing projects.

We chose to focus on adaptation to life cycle standards. That is, to make the accommodation so that in principle could stay there all their lives. Accommodation must be tailored to the changing needs they have through changing life situations. This is an important sustainable strategy and was very interesting for us in order to achieve the standard lifecycle just depends on the flexibility in the home.

To approach the concept of life cycle standard we defined user groups in different life situations and examined their various needs. By working with users in the group could all easily contribute their own different experiences. Camilla has two children and live in detached houses. She knows a lot about what works and does not work for a nuclear family. Jorgen is a medical and have a good knowledge of some patient groups, how they live, what they require of a building and what a building might require of them. Mari has worked in nursing homes and day care and know the challenges young children and the sick / old people. Silje studying architecture and have experience in working with different user groups. Kine and Martin both have partners and good insight into what students and first-time buyers need. To further testing with the flexible system, we chose to focus on individual adaptation. We saw a lot of potential in the mobile-bearing walls and wanted to explore whether these could be developed into a system that gave the necessary flexibility for individualization.

Defining users and their needs

Ingrid is the first time buyer. She buys a house that is big enough that she can rent out a room to their girlfriends. That way she gets enough revenue to cover interest costs of their mortgage. After 5 years, Ingrid finally finish architectural studies, and she will immediately job with Snøhetta. This means that her financial situation improved dramatically. When her friend decides to move out Ingrid decided to live alone for the first time in his life. On a hut-to-hut trip over Hardangervidda Ingrid will be familiar with Even - and by year's end, they have been cohabiting.

Student

Two became fast for four. After Amalie (1 year) and Tobias (3 years) came into the world of home life changed much for Ingrid and Even. They stay more at home with two small children, it is always full of activity and at home. There are many things to keep track of a small family and Ingrid and Even have a greater need for storage space than before. When Amalie and Tobias come home from kindergarten, it is good to have input in relation to the laundry room, so they do not have to take loads of dirt and sand into the apartment. While the kids are young prefer Ingrid and Even having kids bedroom near his own. Then they can hear after everything is in order and if someone wakes up at night and yells at my dad is a short distance into them.

As kids get older they have greater need for privacy and want to have any room as far away from their parents as possible. That year, Tobias begins in high school, and differs Ingrid Even team. They share the care for the kids. Ingrid gets a new roommate. His son Kristian stay with them another every weekend and once a week. It's a big difference in terms of space when all the kids are in the house and when Ingrid and her partner are alone.

Family

It's over between Ingrid and her partner about the same time as Even going from his girlfriend. In the aftermath of the violations they find back to each other again. Amalie and Tobias have moved and just live at home while on vacation. Even Ingrid and need less space. In the years after Even has retired, notice that Ingrid Even starting to have problems with memory. He is diagnosed with Autism. Ingrid wants him to stay home with her as long as possible. But it is challenging that Even can no longer imagine the way from the bedroom to the bathroom and that he forgets to turn off the hotplate after use. Ten years later dies Even and not long after falling asleep Ingrid set. Ane Amalie's oldest daughter (20 years) takes over the apartment after their grandparents - and so the cycle starts again.

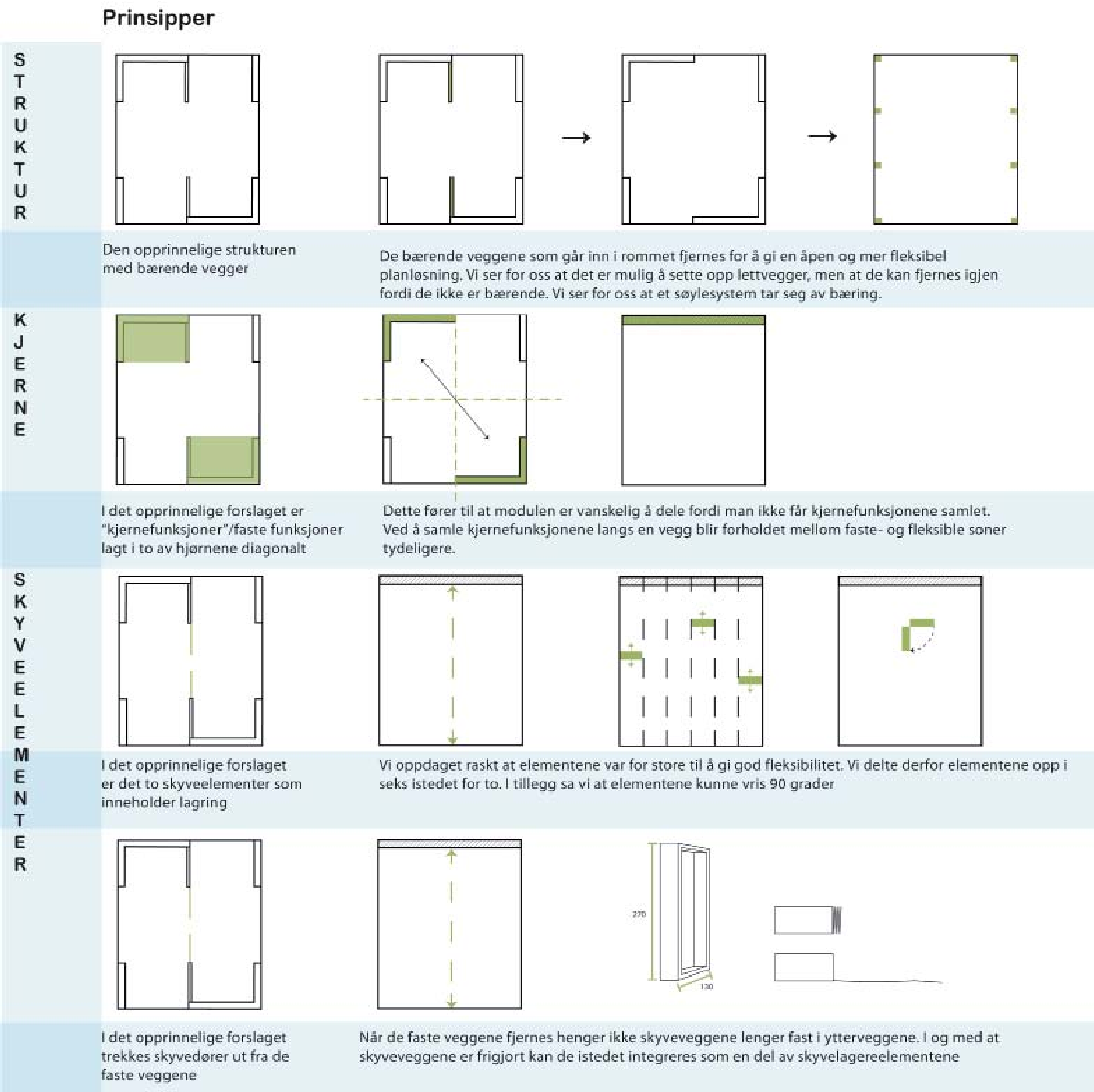


Fig. 2 - Structure, modules and flexibility _ EiT students

Exploration in the planning of user groups.

After some discussions about how the work should be carried out, we ended by sharing the group in two. We placed an architect of each group and they introduced a method of exploring the flexibility to draw plans for different situations.

Group A

We focused on the user group family. We concluded that the original module was too small for a family of four. We added an additional module where we could accommodate a large hallway / utility room and two bedrooms. The kitchen was also too small for a family, but we did not want to change the principle of having piping of one zone. We keep the kitchen against the wall to the bathroom. We let all the other features of the sliding walls. Beds, tables, cabinets and shelves were added as removable walls that could be pushed and also moved from one end of the building to another. This was a principle that we brought forward for evaluation.

Group B

We started by looking at the older user. Jørgen, who is studying medicine, gave the other an introduction to three of the most common aging diseases develop and the challenges associated with them (see next page). With this background, we sketched out a plan that responded to these needs. Once that was done we tested the planning proposal to the other user groups. After some adjustments, we came with a proposal for how the building module could be adapted so it could meet all the user groups' needs.

Retirees are a big user group Flexbox could be interesting for. They are a group of people who have much free time and can require a lot of his apartment in everyday life. Seniors may wish to have a house that they will only use part of the year, a house that can cope with an active lifestyle, have the opportunity to receive visits from family and friends from far and near, or maybe just having a house with the simplest functions and where the rest of the features shared by other people in a common collective.

Meanwhile, pensioners an uncertain future. The physical condition may suddenly or slowly changing, both for themselves and for their partner. So we took the basis of two common groups of patients that we did live in the house. We tried to find out how old they will be able to exploit the flexibility in the apartment so that it can handle a new situation and that the sick elderly can stay home longer. If patients can continue to live at home without having to move to an institution, even after they become ill, it will lead to big savings for the welfare state. Moreover, patients have a higher quality of life.

Cardiovascular disease is the most common cause of death in Norway. One consequence of cardiovascular disease may for instance be a heart attack. At a heart attack reduced heart muscle gets access to oxygen which causes the parts of the heart muscle is converted into scar tissue. Therefore, a common consequence of heart attack that the physical capacity is reduced. You become short of breath and soon becomes tired during physical activity. Those who are affected by heart attack can get different degrees of impaired physical fitness, ranging from not notice any difference compared to before the heart attack that he is not able to get out of bed. An important part of rehabilitation and to prevent new heart attacks are lifestyle changes such as exercise. We envisage that the apartment of a heart attack patient must be able to shrink so that the distances between the required functions is less, and that it is possible to work out in everyday situations in the apartment. It is also natural to expect that patients get better eventually. It is therefore important that the distances and the rooms can be changed after the form is better, or worse.

Dementia is a growing group of diseases in Norway. Since the expected life expectancy rises, it is expected that the number of people with dementia in Norway will increase. Alzheimer's is one of many diseases that can cause dementia. Alzheimer's disease is characterized by the fact that nerve cells in the brain slowly dies and the amount of brain tissue becomes less as time passes. There is currently no cure for this disease. The first change in the brain in Alzheimer's disease is that the links between memory center in the brain and the brain part that combines the visual impression of the room disappears. This means that the first symptom of Alzheimer's patients is a reduced ability to combine memory with what one sees around him.

For example, a patient know that he is going to the bathroom. But since the bathroom door is closed and he does not see the bathroom, the patient will never remember the way there. During seen a picture drawn by a patient who has received a blow in the same hjernedel as the first affected by Alzheimer's. The patient has the big problem with remembering how landmarks are placed in relation to their own home. To the right shows a map drawn by his healthy son. This illustrates how an Alzheimer's patient can perceive the world. Alzheimer's disease also has major problems to tackle major environmental changes. Environmental Change provides a large amount of new impressions that are difficult for Alzheimer's patients to process and store. It is therefore important that Alzheimer's patients live at home as long as possible. We've created a flat where all functions are visually apparent. This will make it easier for Alzheimer's patients to cope with everyday life. In addition, the apartment without shrinking the spatial relationships among the permanent features changed.

When we had concluded completed in small groups, we sat together, presented the proposals we had arrived at and discussed the solutions that worked best. Based on the work that was done we decided to work with Group A's proposal for the removable storage devices that can be individualized and built up after each user's needs. From Group B's work further, we conducted the principles of the module should be split into smaller units, that all the "standard " features (bathroom, kitchen and technical rooms) would be added along one short wall and the removal of the load-bearing walls that stuck out in the room arrangement. We discussed on and so we signed out all the principles to clarify the concept. We also designed proposed floor plans for all the different user groups. This was what we presented to the expert panel in our second presentation.

We wanted to briefly mention some of the aspects that we have not worked much with, but who has been with us in mind as we worked. One thing we've talked about an adaptation to different climates. Since the module to function both in Madrid and in Norway, a country of great climatic differences, this is important. How the building meets the ground and how it adapted to the varying topography? Here there is already a pretty good solution in the original competition entry, which will also provide small footprint. Another question is the adaptation to different cli-

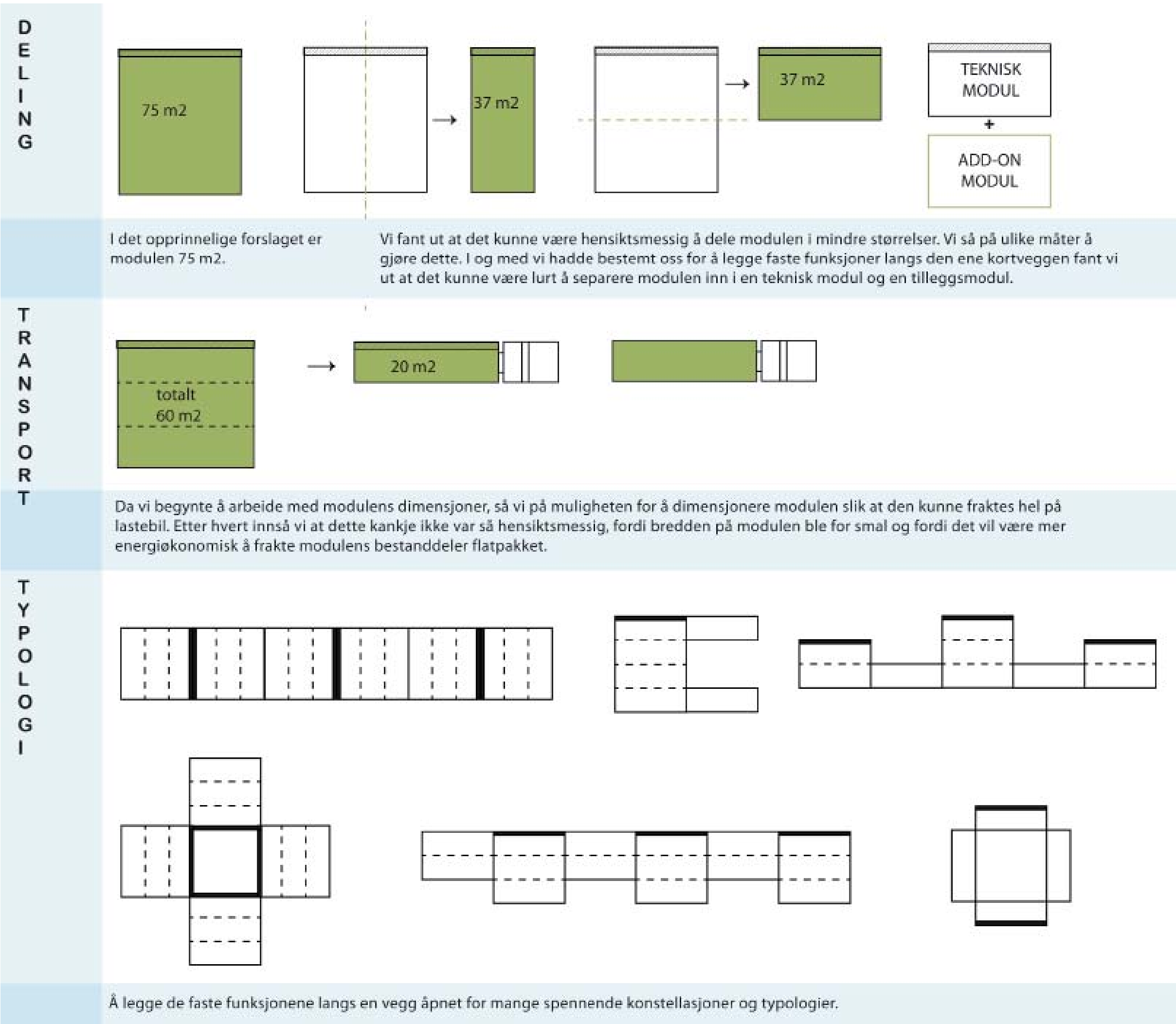


Fig. 3 - Aggregability and typologies: preliminary studies _ EiT students

matic / building / need for individualization. We envisage that this can be solved by using the various wall elements we have outlined below. We were unfortunately not far enough to examine the wall system properly. We envisaged that the walls consisted of dense and transparent elements - and that the composition of the wall created compositions that could respond to different climatic conditions, building traditions and the need for individualization. If the module should be in a typical coastal climate, one could buy modules with underlying lung lining and thus be well adapted to the site and building climate change. If module should be in a very cold climate, you could for example book wall modules with extra much isolation and build module with a higher degree of proof walls than we would have a warmer climate. The transparent walls could similarly vary in insulation and materials.

Another aspect which we wish we had come closer to solving the structure / design. This is due largely to the development of wall elements and by working more with these aspects, we could again received feedback to the revaluation of selected dimensions. Unfortunately we did not get that far, but we have some very general thoughts on the structure / design. In principle, then we expect that the modules were designed to carry its own weight, and that for example, used an "independent" frame construction, either as a so called wine rack system (see photo) in order to stack them in a vertical typology, or as a frame that could define and structure the grounds. The transition between outside and inside is certainly something that needed to be worked on. We envisaged that the framework structure could continue past the bomodulens edge and thus be used as such pergula or drying rack.

In conversations with the expert panel was the idea of a leasing system for sliding storage elements. This is definitely something we wanted to take on. With such a system would have been easier to replace, vary and adapt the residence of both long-and short-term needs change. We also envisage that the sliding storage elements could be rolled out and be saved uklimatisert when there is a need to have them inside the apartment, or that parts of the kitchen can be installed in such items and rolled out on nice summer days.

The other feedback we received from the expert panel was that it would be interesting to look into the possibility of sharing the technical module. The ability to separate bathroom and kitchen apart would have the opportunity to provide such a module, two bathrooms, but only one kitchen. We had this in mind when we placed the functions of the core wall. The wall between the bathroom and technical room is in the middle of the module, so it would be easy to split again in a bad-module and a kitchen / plant room module. However, this would have resulted in challenges to how the module is constructively built up. The pillar system we have outlined, we would suddenly have pillars in the middle of the room and thus destroyed the open plan that is so important that the sliding element system to work.

When the core wall, we see in retrospect that it might have been appropriate to let the washing machine and toilet switch places, so you had the opportunity to have an input situation of non-standard connection to the washroom, and a laundry room with direct access to such outdoor drying rack. Originally, we placed the toilet as it is in the plans to get it as far from the kitchen as possible. But there must be enough, by regulations, a fixed partition wall between bathroom and kitchen, so it is perhaps not so important anymore.

Efforts to develop the architecture is not a linear process, nor is it a kind of spiral movement, a perpetual adjustment. When one is able to examine and find solutions for one aspect, then let it play with other aspects. The question ultimately is all about, we have been able to answer our question. It might not be answered with a simple yes or no. The answer is perhaps that we have come to a certain extent. We hope at least that we have provided input that gives ideas on new opportunities. We are excited about where the road goes on and they want to take the stage, good luck.

1.6. Innovation report

1.6. Innovation report.

Research is a driving force behind the advancement of Norwegian society and is vital to promote scientific development towards sustainability. Renewable energies and energy efficiency represent two of the seven national priorities individuated by the Norwegian research council that established a scheme for eight national centres for environment friendly energy research. NTNU hosts today one of them: ZEB - Zero Emissions Buildings - built on 30 years of interdisciplinary cooperation at NTNU and relying on a budget of 38 millions Euros until 2016. The Solar Decathlon competition was included as a key innovation project when the ZEB centre was founded in 2009. Highly motivated master students and faculty leaders have today initiated an integrated design process aiming at developing a prototype of an energy positive hytte able to solve energy issues of second houses, today representing the most active typology in energy statistics. The development of the ZE+hytte, fundamental step towards a zero emission environment, has been totally integrated with the MSc calendar on sustainable architecture. Three peer reviews, involving external professionals and researches, have been organized during the 8 weeks of development of the concept. Students gained awareness of ongoing researches and a first understanding of future challenges.

SDE represents a unique opportunity for the ZEB centre; the ZE+hytte will become a shared platform for strengthening internal relations and implementing the external ones. Once back from Madrid the ZE+hytte will become a Living Lab for action research on technology and lifestyles in co-operation with private industries and public institutions. Research proposals will be forwarded in the meantime to the Research Council and other institutions in the next months in order to implement co-operation with industries and support the development of the project. In the Klimax frokost, a dissemination event monthly organized by NTNU involving external professionals, the SD module will be focus of debates increasing awareness about sustainability. ZEB, together with SINTEF, is the biggest scandinavian research centre on embodied emissions and energy efficiency. "Grønne Trøndelag", in co-operation with South-Trøndelag County Authority, is promoting Sør-Trøndelag as the greenest region in Europe and will significantly contribute in supporting and promoting the event. With the municipality of Trondheim, we are already discussing the possibility of locating the module inside the Brøset site, a new housing development with a marked environment friendly identity. In the Technoport exhibition, that will be held in Trondheim in 2012, the module will become an exhibition pavilion of advanced technologies developed at NTNU and ZEB.

1.6.1. Innovation in architecture.

In 2007 Abram noted that Norwegians often assume a strong moralistic authority when talking about what hytta are and what they should or should not be. This narrative describes hytta as simple, family owned wooden cabins characterized by a "charming rusticity" and without connection to public utilities. Detachment from the grid, as distance from modernity, and symbiosis with nature are two musts of the hytte philosophy. In the ZE+hytte symbiosys with nature is implemented through the maximum of use of natural resources. Detachment from the grid is made possible by the extra energy produced by BIPV. A challenge exists to enhance, on the basis of the last years development, the boundaries and the levels of performance and integration of solar cells technologies in the design of a hytta able to reduce the distance between research and market. The ZE+hytte, developed in the first 2 months of the MSc in Sustainable Architecture at the Department of Architectural Design, History and Technology of NTNU, coherently with the SD rules and regulations, aims to be:

- **Flexible** - able to satisfy different functional requirements varying its spatial configuration.
- **Easily assembled and disassembled** - Modularity of the construction system should solve transport

Fig. 17 - Ongoing research at ZEB and NTNU: Klimablokka, cable car and nano structures

issues.

• **Energy positive** - able to reduce its thermal demand through the use of passive strategies optimizing the environmental behaviour of the prototype. Maximizing PV energy production and minimizing the energy demand of the internal apparatus through the use of energy efficient equipment.

In agreement with the philosophy of the ZEB centre the ZE+hytte will represent:

• **A step towards a zero emission built environment** - controlled embodied emissions.
• **Market ready** - A detached hytte in symbiosis with nature reflects the desire of most of Norwegians.
• **Elastic** - Possibility of altering the external perimeter through aggregations or modifications of the module in order to obtain bigger blocks or settlements. The ZE+hytte can be also attacheed to "detached wooden houses"(Fig. 4), representing the most energy thirsty architectural typology in Norway (fig.10) and compensate energy efficiency lacks of the existing building stock.

Flexibility and environmental adaptability.

A hytte is not something personal, it is an object you share with your dears and friends, each of whom can have a different way of experiencing and living inside it. Flexibility is therefore a fundamental requirement: the plan of the ZE+hytte will be able to accommodate very different situations. Inside the extremely compact footprint, able to minimize the outer surface of the skin, (almost a square of 8,4 meters of side with a footprint area<75m2) the plan of the SD module is conceived as a living organism able to assume different configurations in extremely short time. As mentioned above flexibility of the plan is conceived to enhance environmental sensitivity of the prototype. The intermediate space included between the two external layers will be able to assume different physical configurations and environmental behaviours according to the exterior conditions. The living space can expand its boundaries to the outer layer able to breath either reduce itself into an extremely compact and highly insulated volume (conditioned space will anyway measure more than the required 42 square meters).

Hierarchization of architectural components was fundamental in the development of the concept in order to enhance flexibility. The two horizontal slabs, floor and roof, represent the only timeless primary elements within the project; they are characterized by a high degree of abstraction creating an isotropic functional space in between. Everything included between them can be moved and easily arrenged in a different position. The location of the two service boxes in two opposite corner of the plan was strategic to solve technical issues like integration of the outer movable skin (for shading and insulation), but also enhance indeterminacy of the orientation and environmental adaptabity of the prototype.

1.6.2. Innovation in Engineering and construction.

Innovation in communication and social awareness

The inner layer of the ZE+hytte, facing the living space, is conceived as an extended interface between the user and the exterior, between Nowegians and nature. It is through this layer that users acquire awareness of the potential of the integrated building systems in using external resources. A system of sensors displaced inside and outside the module will provide diagnostics of thermal demand, performance and desired correction and monitor all the architectural components. Integrated systems filtering the access of solar radiation and air, like shading devices and roof valves, will respond both to automatic and user-driven controls. Private Norwegian companies provide already today remote control of the heating system of hytta through the mobile phone. Such service will be implemented into a more complex control systems able to ensure simultaneous control of all the integrated passive and active systems. Some of these companies might be interested in supporting NTNU in the development of such system. The department of Product Design has already developed a user friendly interface aiding decision making about energy use choices by providing visualization of energy use in context; this interface will be used as base for further development under the guidance of the same department in collaboration with ZEB work package 4.

Architectural design on the basis of a multidisciplinary information flow.

One of the targets of the architectural design is to maximize the involvement of industries and research centres and permit the simultaneous development of different researches even if located in different part of the country. In order to ensure efficiency is fundamental to provide a common physical framework where all the individuals involved will be able to share informations and access data coming from other sub-teams regarding all the architectural components constituting the ZE+hytte. NTNU IT support group Orakel has just recently developed a wiki system for internal use. This system will constitute the platform on which will be built the web-portal for sharing information during the design process. The WIKI system will act as a distance-reducing technology able to facilitate internal communication and interaction. anyway supported beyond physical meetings. The efficiency of the web-based platform will be essential in order to guarantee collaboration and communication within a multidisciplinary team comprising individuals with different expertises. The integrated design process will help in testing design assumptions through the use of energy simulations throughout the process, provide aid in decision making and performance evaluation, give voice to subject specialists within the design team, and facilitate clear articulation of performance targets and strategies from which work will proceed, improving results from conception to the delivery of the project.

Energy Efficiency Design Narrative

On the base of researches previously conducted at NTNU and ZEB a high grade of uncertainty related to climate change and the development of new components and materials is today questioning traditional assumptions around bioclimatic design in cold climatic contexts and giving space to new architectural scenarios in such contexts.

Passive strategies once peculiar of warmer climatic zones are now extending their geographic boundaries of applicability to our context. This is leading architectural design of energy efficient building into a new complexity. In-between spaces, a fundamental tool for environmental control and efficiency of the architectural form, are now becoming more and more important. In the ZE+hytte environmental sensitivity of form is maximized through an extremely simple but efficient flexible plan, surrounded by a living buffer space. The designed modules can assume markedly different spatial configurations. The buffer spaces included between the outer layer and the living space will be able to assume different environmental behaviors according to different external environment conditions.

This variety of possible circumstances will permit also to test in the next eighteen months a wide range of systems. On the base of a complex system of sensors, disposed both inside and outside of the house, the buffer space will expand or draw back itself and create a living breathing interior space in symbiosis with the external environment. The contribution of the buffer space can be occasionally cancelled through a system of valves included in the outer layer. The roof, conceived as a grid of valves and integrating both low and high tech materials, will act as a permeable skin and will adapt its environmental behavior to the movements of the plan. The ZE+hytte is able to take advantage of different external resources maximizing natural ventilation possibilities through the compact volume and following the sun through advanced technology. The ZE+hytte will benefit from the sun in all possible ways:

daylighting, passive systems, microclimate generation, maintenance, and food production. Passive strategies efficiency will be implemented when required with integrated active systems.

Different efficient HVAC systems, easy to install, commission and monitor, providing a wide range of functions will be tested. Prefabricated floor concrete slabs thermally activated through a reverse hydronic system - for both heating and cooling requirements - will be tested. The in-floor system functioning will be intimately related to a integrated heat-recovery system using exhausted air and grey water. Efficiency of the heat exchanger located in mechanical service box will reduce the demand for electricity and maximize advantages deriving from the use of external resources. Efficient lighting systems will be also adopted in order to minimize energy loads; its functioning will be connected to the system of sensors guaranteeing sufficient lighting for different purposes. Roof and walls will act as permeable skins able to react to impulses sent by sensors distributed both inside and outside the hytte, maximizing lumious and thermal comfort even in adverse climatic conditions.

Fig. 5 - Section of the ZE+hytte: permeability of the roof, buffer spaces and solar protection.

2.1 Section I - projected performance of final house design: minimum requirements

2.1.1. Introduction

The objective of this international competition, in addition to generating new knowledge, is to create awareness among the general public on rational use of energy. And also to demonstrate that a more efficient energy use is possible and affordable, if buildings are constructed to avoid losing heat in winter and staying cool in summer, therefore using less heating and air conditioning, utilizing less consuming appliances, and getting the energy needed through renewable sources such as the sun.

Afterwards it should be brought back to Trondheim in Norway and serve as an exhibition building for zero energy technology. In this context it was important to develop an adaptation strategy that allows an optimized performance both, during the competition in Madrid and afterwards in Trondheim.

Thus it was important to investigate the different parameter influencing the zero energy balance for this new passive house. Energy calculations were done in order to define different energy efficiency measures (insulation level of different components, advanced facades, control strategies), and energy supply system (solar, heat pump, combined cooling, heat and power). This formed the basis for an adaptation strategy and optimization towards a plus energy house within the different contexts.

2.1.2. House and systems description

Proposal for a Norwegian standard that defines the terms for low energy and passive houses respectively, has been published and is in force since 2010 [1]. Requirements for maximum energy demand for heating and heat loss in combination with normative values for internal heating and ventilation values are some of the described criteria. It was decided to design the thermal envelope according to passive house criteria.

- Max. 15 kWh/(m^2 a) heat energy demand
- Air tightness of n_{50} = 0.6 ach (at 50Pa)
- Total primary energy (PE) should be max. 120 kWh_{PE}/(m^2 a)

2.1.3. House and HVAC simulation

A Norwegian energy labeling scheme for buildings has been initiated at. 01.01.2010, with effect from 01.07.2010 [2]. Adjustments of the scheme have already been notified. Today it consists of two labelling schemes:

The building's energy label scheme:

- Based on estimated total delivered (flow) energy to the building.

Heating energy label scheme:

- Based on the heating system's environmental impact, expressed as a percentage delivered non-renewable energy by the energy of hot water and heating. High percentage results in poor brand value

Requirements for maximum energy supplied to the building is based on table values and calculated for the building planned to be situated in a given climate (Oslo). Heating system's environmental impact is similarly categorized.

2.1.4. Results and discussions

The results show that with U-values as summarized in Table 2 the building provides PH criteria. In the following chapters the building design for Madrid is described, followed by the heat balance for Madrid and Norway, followed by the adaptation to the Norwegian climate. Finally, the differences in solar energy supply are described.

Tabel 1: Building geometry

Length of north and south facade:	10.0 m
Length of west and east facade:	6.4 m
Height (without roof):	3.0 m
Number of floors:	1
Deviation from south direction:	0.0 °
Ground area:	64.0 m²
Useful area (heated):	51.2 m²
Volume total:	192.0 m³
Air volume:	153.6 m³
Facade north resp. south:	30.0 m²
Facade east resp. west:	19.2 m²
Surface-to-volume value:	1.2 m^{-1}

Tabel 2: Construction details for building in Madrid climate

U values of the walls:	
north:	0.25 W/(m² K)
south:	0.25 W/(m² K)
east:	0.25 W/(m² K)
west:	0.25 W/(m² K)
Absorption coefficient of the walls:	0.5
Roof: U-value:	0.25 W/(m² K)
Floor: U-value:	0.25 W/(m² K)
Door (north facade):	
Area:	2.0 m²
U-value:	0.80 W/(m² K)
Thermal bridges:	0.05 W/(m² K)
Interior temperature:	20 °C / 23
Limit of overheating:	25.0 °C
Infiltration:	0.07 1/h
Mechanical ventilation:	0.50 1/h
Heat recovery efficiency	90 %

efficiency factor of air conditioning:	2.5 kWhcool / kWhelectricity
Internal gains:	3.2 W/m². i.e. 28.0 kWh/(m² a)
Type of indoor walls:	heavy construction
Type of outdoor walls:	heavy construction

In order to account for delivered energy, system losses due to regulation, distribution, and production have to be taken into consideration and allow to link between net energy demand and delivered energy. Annual average energy system efficiencies recommended to use are presented in Table B9 of [3]. Advanced building simulation tools can help to calculate system losses more accurately.

The only system efficiency that is required to use in TEK07 is the heat recovery system efficiency which directly reduces net energy demand of ventilation air (due to heating of ventilation air).

Results for the primary energy balance are given in Figures 1 (Madrid) and 2 (Oslo). Primary energy factors for electricity were taken to be 2.6, while fuel oil was assumed to be 1.1. Electricity form PV was multiplied with 2.6.

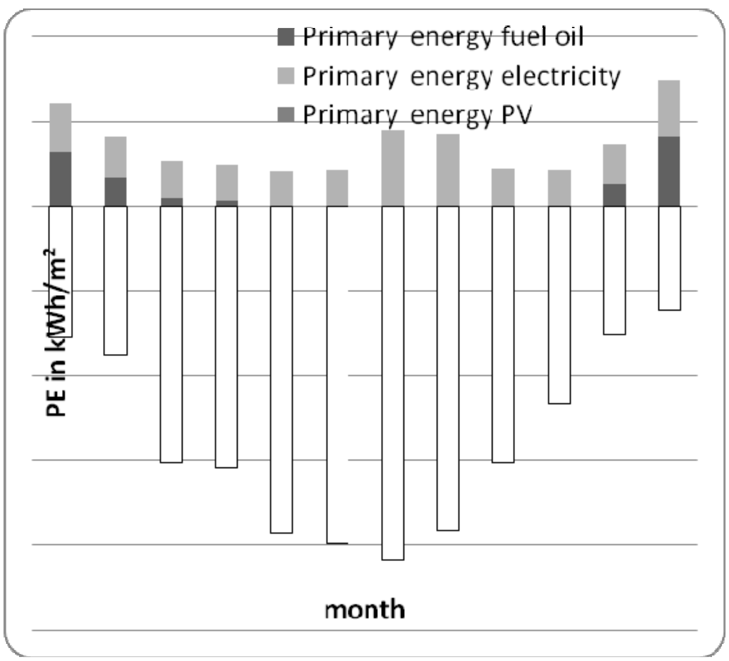


Figure 1: Primary energy balances in Madrid climate

It can be seen from Figure 1 that PE surplus form January until December as well as over the whole year occur. PE for fuel oil only occurs from November to April while PE electricity occurs the whole year with a peak in July and August due to additional cooling needs. Only in December the building requires more PE than PV can produce. However, over the year the PV system produces a surplus of PE of 247 kWh/(m² a).

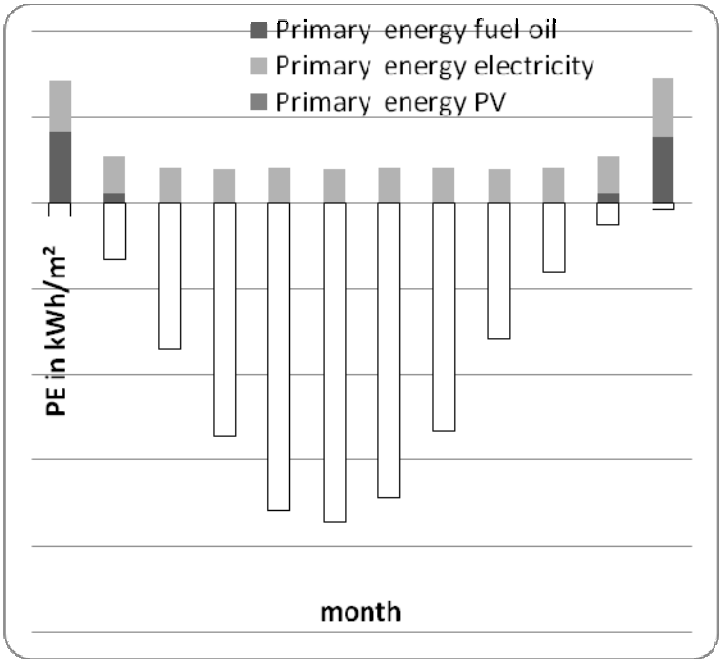


Figure 2: Primary energy balances in Oslo climate

It can be seen from Figure 2 that PE surplus form March until October as well as over the whole year occur. PE for fuel oil only occurs from November to April while PE electricity occurs the whole year with a peak in July and August due to additional cooling needs. PE from PV can balance the PE needs from March until October. That means that from November to February the building requires more PE than PV can produce. However, over the year the PV system produces a surplus of PE of 141 kWh/(m^2 a).

2.1.5. Conclusions

It was important to develop an adaptation strategy that allows an optimized performance both, during the competition in Madrid and afterwards in Trondheim.

This paper focused on the different parameter influencing the zero energy balance for this new passive house. Energy calculations were done in order to define different energy efficiency measures (insulation level of different components, advanced facades, control strategies), and energy supply system (solar, heat pump, combined cooling, heat and power). This formed the basis for an adaptation strategy and optimization towards a plus energy house within the different contexts.

The results show that due to the extreme climate differences between Madrid and Trondheim, adaptation towards a plus energy house is difficult.

The PH design for Madrid climate fulfills the PH requirements (max 120 kWh/(m^2 a)). Due to the performance of the PV system a surplus of PE can be achieved.

Moved to Norway, the building still manages to perform as a NZEB (more PE supply than demand). PH requirements are met for case 2 to case 4.

A possibility to increase floor area by adding a second floor should be further explored.

Layering the building envelope with different materials in different climates together with adjustable thermal mass provides good potential. Further, the results indicate that solar applications integrated with other energy supply technologies should be further developed for the Norwegian market until they provide cost effective solutions.

The results will be very helpful in the further development of market viable solutions for passive houses and net zero energy homes.

2.2 Section II - Influence on House Design and Competition Strategy

2.2.1. Influence on the house design

The first design proposal was looking into the design for the warm climate in Madrid. It was decided to design the thermal envelope according to passive house criteria.

- Max. 15 kWh/(m^2 a) heat energy demand
- Air tightness of n_{50} = 0.6 ach (at 50Pa)
- Total PE should be max. 120 kWh_{PE}/(m^2 a)
-

The first design goal was to create comfort conditions in the period of the SDE competition in September. The comfort criteria described in the competition are:

- Temperature band between 23 and 25 °C
- Humidity levels between 40 and 55%
- Thermal comfort

Once the building was designed the energy consumption for the whole year was calculated. Here, optimizations are possible with an adaptive building envelope that responds to the climatic conditions by regulating solar radiation through the building envelope.

Finally the building design was placed in the Norwegian climate by locating it in Oslo. The passive house criteria could then not be met. An adaptation strategy had to be found that ensures low energy consumption for heating. Here, the Kyoto pyramid was used to adapt the building in three steps:

1. Reduce heat losses through windows
2. Maximize solar heat gains
3. Reduce transmission losses through walls, roof, floor

Adaptation strategy

When the building is placed in Oslo, Norway, the building construction is not complying with the Norwegian building codes. In order to achieve PH level different changes were applied. We started with improving the window quality then the walls, roof and floor. Finally, the heating demand was reduced to below 15 kWh/(m^2 a) as required.

Tabel 3: Details of window properties in Madrid climate

	North:	South:	East:	West:
Windows area in m²:	1.8	27	1.9	1.9
Fraction of windows area at the facade	6 %	90 %	10 %	10 %
Type of windows		double glazing		
U-value glazing in W/(m² K)	3.0	3.0	3.0	3.0
U-value frame in W/(m² K)	2.8	2.8	2.8	2.8
g value glazing	0.8	0.8	0.8	0.8
Fraction of frame	20 %	20 %	20 %	20 %
Shading		Automatic, gt=0.06 (closed)		

Windows

In Madrid a double glazed window with air filling with an U-value of 3.0 W/(m2 K) and a g-value of 0.91 was sufficient to provide enough solar heat gains that compensates for heat losses during winter. The window properties were changed for the situation in Norway. First, a double glazed window with argon filling and a U-value of 1.0 W/(m2 K) was used. It also has a much better window frame so that the U_w improved to 1.0 while the g.value was reduced to 0.52. Then, a triple glazing was chosen with a Ug-value of 0.5 W/(m² K) and a Uf-value of the frame of 0.7 W/(m² K). Finally, large windows could be used that reduce the fraction of the frame to 10%.

Tabel 4: Evolution of window construction in Norway

Building data:	**base case**	**case1**	**windows case2**	**case3**	**walls, roof, floor case4**
Mean U value in W/(m² K)	0.69	0.42	0.34	0.34	0.22
Specific transmission losses in W/K	155.7	95	76.8	76.1	49.2
Specific ventilation losses in W/K	6.6	6.6	6.6	6.6	6.6
Sum specific losses in W/K	162.3	101.6	83.4	82.7	55.8
Thermal inertia in hours	46.7	74.5	90.9	91.6	135.6
Maximum heating load in kW	5.9	3.6	2.9	2.9	1.9

Maximum specific heating load in W/m²	115.1	70	56.3	55.9	37.3
Heat energy demand in kWh/m^2	129.8	65.7	40.7	35	11.5
Solar gains in kWh/m^2	191.2	121.5	107.4	112.6	88.8

Wall, roof, floor

The initial insulation thickness of the walls was increased from 150 mm to 400 mm. Thus, U-values for walls, roof and floor where reduced from 0.25 W/(m² K) to 0.1 W/(m² K).

Tabel 5: Specification of windows and wall, roof and floor construction in Norway

	base case	window case1	case2	case3
		heat protection		
Kind of windows:	double glazing		triple glazing	
U value glazing in W/(m² K):	3	1.00	0.50	0.50
U value frame in W/(m² K):	2,8	1.50	0.70	0.70
g value glazing:	0,8	0.52	0.51	0.51
Fraction of frame:	0.20	0.20	0.20	0.10

2.2.2. Influence on the HVAC system and optimization

To improve the energy performance the building is equipped with solar collectors and PV.

Solar thermal system

The size of the solar thermal system is crucial for the building design in Madrid. Here, 3m2 collector with 1000l storage tank gives a solar fraction of 60%.

The efficiency of the solar thermal collector (ST) system is 10 [3].

In Norway the solar fraction reduces drastically which is why it was decided to apply a larger collector size. This means that the building in Madrid has an oversized collector area. The vacuum collector could be adjusted by turning the absorber plates in a more vertical position.

PV system

The PV system consists of 60m^2 panels with nominal power of the PV system: 10 kW (crystalline silicon) and combined PV system losses of 23.0% (estimated losses due to temperature: 6.0% (using local ambient temperature), loss due to angular reflectance effects: 4.7%, other losses (cables, inverter etc.): 14.0%).

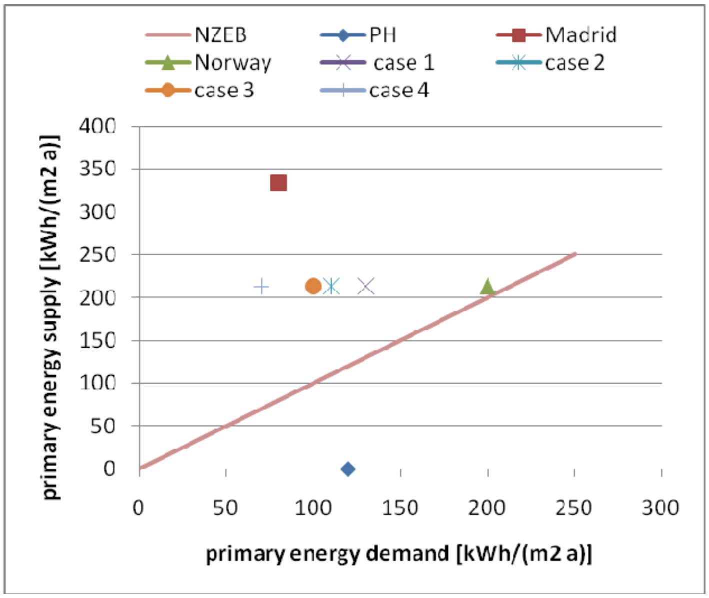


Figure 3: Net zero primary energy in Madrid and Norway with adaptation options

Figure 3 shows the results of the primary energy balance between demand and supply. It can be seen that the PH in Madrid fulfills the PH requirements (max 120 kWh/(m^2 a)). Due to the performance of the PV system a surplus of PE can be achieved. Moved to Norway, the building still manages to perform as a NZEB (more PE supply than demand). But with all changes in the building fabric (case 1 - 4; Table 4) an even better result can be reached. PH requirements are met for case 2 to case 4.

It also shows that there is possibility to increase PE demand (absolute) by increasing floor area by adding a second floor.

References

1. NS3700, *Criteria for low energy and passive houses - Residential buildings*. 2010, Standard Norge.

2. Wigenstad, T., et al., *Energimerking av næringsbygg*. 2005, SINTEF Building and Infrastructure: Trondheim.

3. NS3031, *Calculation of energy performance of buildings – Method and data*. 2007, Standard Norge.

4. TEK, *Energi – Temaveiledning*, StatensBygningstekniskeEtat, Editor. 2007, Norsk Byggtjenestes Forlag.

5. Feist, W.; Available from: www.passiv.de.

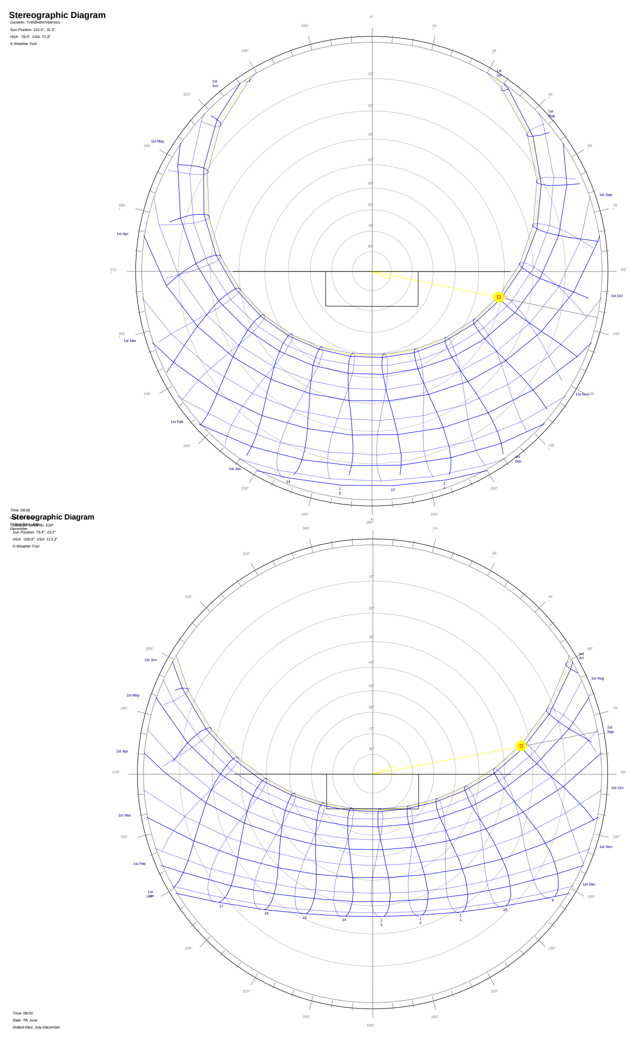
Building form, climate and energy supply system in a passive house building

1. Introduction

In Trondheim, Norway a new passive house building is now under planning. It will be exhibited in Madrid, Spain during the Solar Decathlon Europe 2012.
Solar Decathlon Europe is organized by the Secretary of State for Housing and Urban Development at the Spanish Ministry of Public Works with the collaboration of Universidad Politécnica de Madrid and the support of the US Department of Energy.
The objective of this international competition, in addition to generating new knowledge, is to create awareness among the general public on rational use of energy. And also to demonstrate that a more efficient energy use is possible and affordable, if buildings are constructed to avoid losing heat in winter and staying cool in summer, therefore using less heating and air conditioning, utilizing less consuming appliances, and getting the energy needed through renewable sources such as the sun.

Afterwards it should be brought back to Trondheim in Norway and serve as an exhibition building for zero energy technology. In this context it was important to develop an adaptation strategy that allows an optimized performance both, during the competition in Madrid and afterwards in Trondheim.

Figure 1 Solar paths for Madrid, Spain and Trondheim, Norway



This paper investigates the different parameter influencing the zero energy balance for this new passive house. Energy calculations were done in order to define different energy efficiency measures (insulation level of different components, advanced facades, control strategies), and energy supply system (solar, heat pump, combined cooling, heat and power). This formed the basis for an adaptation strategy and optimization towards a plus energy house within the different contexts.

1.1 Passive house standard

Proposal for a Norwegian standard that defines the terms for low energy and passive houses respectively, has been published and is in force since 2010 [1]. Requirements for maximum energy demand for heating and heat loss in combination with normative values for internal heating and ventilation values are some of the described criteria. It was decided to design the thermal envelope according to passive house criteria.

- Max. 15 kWh/(m2 a) heat energy demand
- Air tightness of n50 = 0.6 ach

- Total PE should be max. 120 kWhPE/(m2 a)

1.2 Energy supply system

A Norwegian energy labeling scheme for buildings has been initiated at. 01.01.2010, with effect from 01.07.2010 [2]. Adjustments of the scheme have already been notified. Today it consists of two labelling schemes:
The building's energy label scheme:

- Based on estimated total delivered (flow) energy to the building.

Heating energy label scheme:

- Based on the heating system's environmental impact, expressed as a percentage delivered non-renewable energy by the energy of hot water and heating. High percentage results in poor brand value

Requirements for maximum energy supplied to the building is based on table values and calculated for the building planned to be situated in a given climate (Oslo). Heating system's environmental impact is similarly categorized.

2. Methodology

The first design proposal was looking into the design for the warm climate in Madrid. It was decided to design the thermal envelope according to passive house criteria.

- Max. 15 kWh/(m2 a) heat energy demand
- Air tightness of n50 = 0.6 ach
- Total PE should be max. 120 kWhPE/(m2 a)
-

The first design goal was to create comfort conditions in the period of the SDE competition in September. The comfort criteria described in the competition are:

- Temperature band between 23 and 25 °C
- Humidity levels between
- Thermal comfort between

Once the building was designed the energy consumption for the whole year was calculated. Here, optimizations are possible with an adaptive building envelope that responds to the climatic conditions by regulating solar radiation through the building envelope.

Finally the building design was placed in the Norwegian climate by locating it in Oslo. The passive house criteria could then not be met. An adaptation strategy had to be found that ensures low energy consumption for heating. Here, the Kyoto pyramid was used to adapt the building in three steps:

1. Reduce heat losses through windows
2. Maximize solar heat gains
3. Reduce transmission losses through walls, roof, floor

Figure 1 South facade of single-family house with 64m^2

3. Results

The results show that with U-values as summarized in Table 2 the building provides PH criteria. In the following chapters the building design for Madrid is described, followed by the heat balance for Madrid and Norway, followed by the adaptation to the Norwegian climate. Finally, the differences in solar energy supply are described.

3.1 Building design for Madrid, Spain

The calculation of energy use are based on the Norwegian Standard for Low-energy, and passive. [1].

- The maximum energy demand for heating (space and temperature corrected annual mean temperature for on-site)
- Maximum heat loss figures for the building

The following requirements level can be established (T, TRONDHEIM, annual mean = 4.9 degrees):

Table 1 Building geometry

Length of north and south facade:	10.0 m
Length of west and east facade:	6.4 m
Height (without roof):	3.0 m
Number of floors:	1
Deviation from south direction:	0.0 °
Ground area:	64.0 m²
Useful area (heated):	51.2 m²
Volume total:	192.0 m³
Air volume:	153.6 m³
Facade north resp. south:	30.0 m²
Facade east resp. west:	19.2 m²
Surface-to-volume value:	1.2 m^{-1}

It may be worth noting that where the passive concept to date has used about 15 kWh / (m^2 y) for heating, (same value as the German Passivhaus Institut use), open NS 3700 because of land use and climate correction, for now a much higher value [1, 5].

3.2 Heat balance for Spain and Norway

Table 2 Construction details for building in Madrid climate

U values of the walls:	
north:	0.25 W/(m² K)
south:	0.25 W/(m² K)
east:	0.25 W/(m² K)
west:	0.25 W/(m² K)
Absorption coefficient of the walls:	0.5
Roof: U value:	0.25 W/(m² K)
Floor: U value:	0.25 W/(m² K)
Door (north facade):	
Area:	2.0 m²
U value:	0.80 W/(m² K)
Thermal bridges:	0.05 W/(m² K)
Interior temperature:	20 °C / 23
Limit of overheating:	25.0 °C
Infiltration:	0.07 1/h
Mechanical ventilation:	0.50 1/h
Heat recovery efficiency	90 %
efficiency factor of air conditioning:	2.5 kWhcool / kWhelectricity
Internal gains:	3.2 W/m². i.e. 28.0 kWh/(m² a)
Kind of indoor walls:	heavy construction
Kind of outdoor walls:	heavy construction

Table 3 Details of window properties in Madrid climate

	North:	South:	East:	West:
Windows area in m²:	1.8	27	1.9	1.9
Fraction of windows area at the facade	6 %	90 %	10 %	10 %
Kind of windows	double glazing			
U value glazing in W/(m² K)	3.0	3.0	3.0	3.0
U value frame in W/(m² K)	2.8	2.8	2.8	2.8
g value glazing	0.8	0.8	0.8	0.8
Fraction of frame	20 %	20 %	20 %	20 %
Shading	Automatic, gt=0.06 (closed)			

Table 4 Evolution of window construction in Norway

Table 5 Specification of windows and wall, roof and floor construction in Norway

In order to account for delivered energy, system losses due to regulation, distribution, and production have to be taken into consideration and allow to link between net energy demand and delivered energy. Annual average energy system efficiencies recommended to use are presented in Table B9 of [3]. Advanced building simulation tools can help to calculate system losses more accurately.

The only system efficiency that is required to use in TEK07 is the heat recovery system efficiency which directly reduces net energy demand of ventilation air (due to heating of ventilation air).

3.3 Adaptation strategy

When the building is placed in Oslo, Norway, the building construction is not complying with the Norwegian building codes . In order to achieve PH level different changes were applied. We started with improving the window quality then the walls, roof and floor. Finally, the heating demand was reduced to below 15 kWh/(m2 a) as required.

3.3.1 Window properties

In Madrid a double glazed window with air filling with an U-value of 3.0 W/(m2 K) and a g-value of 0.91 was sufficient to provide enough solar heat gains that compensates for heat losses during winter. The window properties were changed for the situation in Norway. First, a double glazed window with argon filling and a U-value of 1.0 W/(m2 K) was used. It also has a much better window frame so that the U_w improved to 1.0 while the g.value was reduced to 0.52. Then, a triple glazing was chosen with a Ug-value of 0.5 W/(m² K) and a Uf-value of the frame of 0.7 W/(m² K). Finally, large windows could be used that reduce the fraction of the frame to 10%.

Building data:	base	windows			walls, roof, floor
	case	case1	case2	case3	case4
Mean U value in W/(m² K)	0.69	0.42	0.34	0.34	0.22
Specific transmission losses in W/K	155.7	95	76.8	76.1	49.2
Specific ventilation losses in W/K	6.6	6.6	6.6	6.6	6.6
Sum specific losses in W/K	162.3	101.6	83.4	82.7	55.8
Thermal inertia in hours	46.7	74.5	90.9	91.6	135.6
Maximum heating load in kW	5.9	3.6	2.9	2.9	1.9
Maximum specific heating load in W/m²	115.1	70	56.3	55.9	37.3
Heat energy demand in kWh/m2	129.8	65.7	40.7	35	11.5
Solar gains in kWh/m^2	191.2	121.5	107.4	112.6	88.8

	base	window		
	case	case1	case2	case3
Kind of windows:	double glazing		heat protection triple glazing	
U value glazing in W/(m² K):	3	1.00	0.50	0.50
U value frame in W/(m² K):	2,8	1.50	0.70	0.70
g value glazing:	0,8	0.52	0.51	0.51
Fraction of frame:	0.20	0.20	0.20	0.10

3.3.2 Wall, roof, floor
The initial insulation thickness of the walls was increased from 150 mm to 400 mm. Thus, U-values for walls, roof and floor where reduced from 0.25 W/(m² K) to 0.1 W/(m² K).

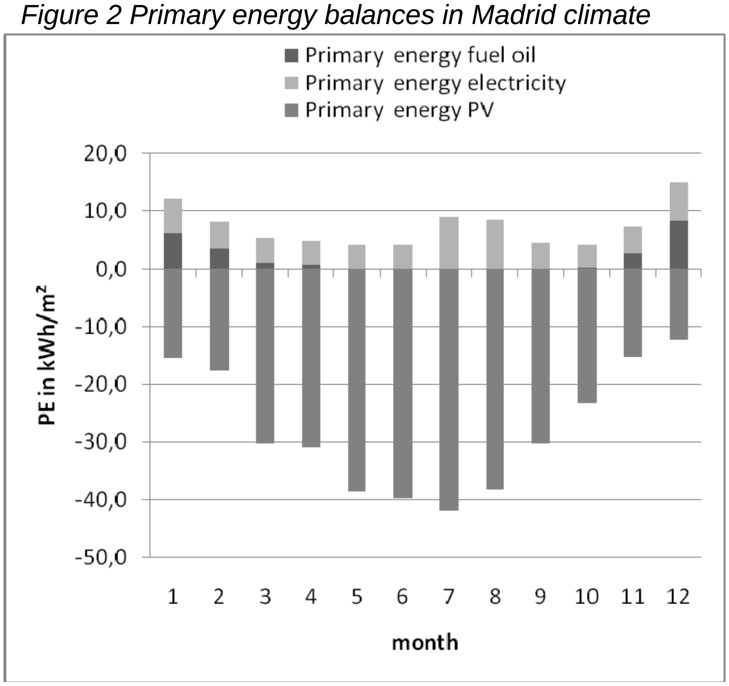
3.4 Energy supply alternatives

To improve the energy performance the building is equipped with solar collectors and PV.

3.4.1 Solar thermal system
The size of the solar thermal system is crucial for the building design in Madrid. Here, 3m2 collector with 1000l storage tank gives a solar fraction of 60%.
The efficiency of the solar thermal collector (ST) system is 10.
In Norway the solar fraction reduces drastically which is why it was decided to apply a larger collector size. This means that the building in Madrid has an oversized collector area. The vacuum collector could be adjusted by turning the absorber plates in a more vertical position.

3.4.2 PV system
The PV system consists of 60m2 panels with nominal power of the PV system: 10 kW (crystalline silicon) and combined PV system losses of 23.0% (estimated losses due to temperature: 6.0% (using local ambient temperature), loss due to angular reflectance effects: 4.7%, other losses (cables, inverter etc.): 14.0%).

Figure 2 Primary energy balances in Madrid climate

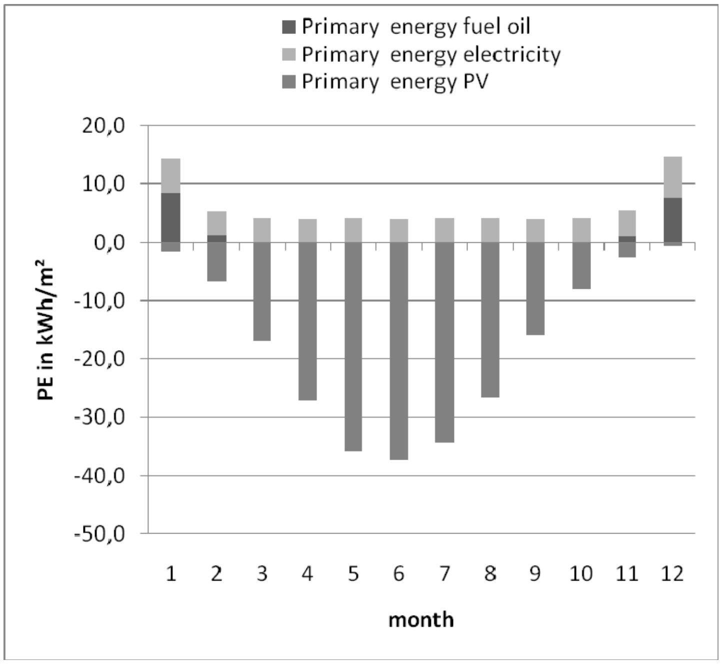


Results for the primary energy balance

are given in Figures 2 (Madrid) and 3 (Oslo). Primary energy factors for electricity were taken to be 2.6, while fuel oil was assumed to be 1.1. Electricity form PV was multiplied with 2.6.

It can be seen from Figure 2 that PE surplus form January until December as well as over the whole year occur. PE for fuel oil only occurs from November to April while PE electricity occurs the whole year with a peak in July and August due to additional cooling needs. Only in December the building requires more PE than PV can produce. However, over the year the PV system produces a surplus of PE of 247 kWh/m2.

Figure 3 Primary energy balances in Oslo climate



It can be seen from Figure 3 that PE surplus form March until October as well as over the whole year occur. PE for fuel oil only occurs from November to April while PE electricity occurs the whole year with a peak in July and August due to additional cooling needs. PE from PV can balance the PE needs from March until October. That means that from November to February the building requires more PE than PV can produce. However, over the year the PV system produces a surplus of PE of 141 kWh/m2.

Figure 4 Net zero primary energy in Madrid and Norway with adaptation options

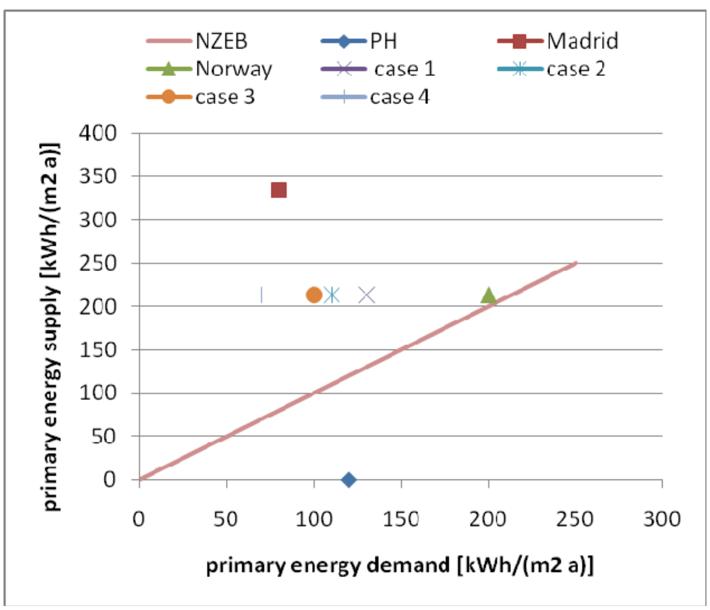


Figure 4 shows the results of the primary energy balance between demand and supply. It can be seen that the PH in Madrid fulfills the PH requirements (max 120 kWh/(m2 a)). Due to the performance of the PV system a surplus of PE can be achieved. Moved to Norway, the building still manages to perform as a NZEB (more PE supply than demand). But with all changes in the building fabric (case 1 - 4; Table 5) an even better result can be reached. PH requirements are met for case 2 to case 4.

It also shows that there is possibility to increase PE demand (absolute) by increasing floor area by adding a second floor.

4. Conclusions

It was important to develop an adaptation strategy that allows an optimized performance both, during the competition in Madrid and afterwards in Trondheim.

This paper focused on the different parameter influencing the zero energy balance for this new passive house. Energy calculations were done in order to define different energy efficiency measures (insulation level of different components, advanced facades, control strategies), and energy supply system (solar, heat pump, combined cooling, heat and power). This formed the basis for an adaptation strategy and optimization towards a plus energy house within the different contexts.

The results show that due to the extreme climate differences between Madrid and Trondheim, adaptation towards a plus energy house is difficult.
The PH design for Madrid climate fulfills the PH requirements (max 120 kWh/(m2 a)). Due to the performance of the PV system a surplus of PE can be achieved.

Moved to Norway, the building still manages to perform as a NZEB (more PE supply than demand). PH requirements are met for case 2 to case 4.
A possibility to increase floor area by adding a second floor should be further explored.
Layering the building envelope with different materials in different climates together with adjustable thermal mass provides good potential. Further, the results indicate that solar applications integrated with other energy supply technologies should be further developed for the Norwegian market until they provide cost effective solutions.

The results will be very helpful in the further development of market viable solutions for passive houses and net zero energy homes.

0. GENERAL INFORMATION

	NAME	CONTACT	OTHER RELEVANT INFORMATIONS
UNIVERSITY	**NTNU**	annemie.wyckmans@ntnu.no	
CONSTRUCTION MANAGER	Kristof Lijnen	lijnen@stud.ntnu.no	
SITE OPERATIONS COORDINATOR	Noora Alinaghizadeh Khezri	alinaghi@stud.ntnu.no	

1. GENERAL DESCRPTION OF THE SITE OPERATIONS

		PHASE	BRIEF DESCRIPTION (include assembly system, crane, trucks, other machinery, etc...)	MATERIAL AND EQUIPMENT RESOURCES	HUMAN RESOURCES	DURATION
ASSEMBLY	1	Site setting and containers discharge	discharge from trucks	cranes needed	8 students and 2 professional	6 hours
	2	Foundation placement	Manual / no cranes needed		4 students and 2 professional	4 hours
	3	Prefab Floor slabs placement	Manual / no cranes needed		6 students and 2 professional	2 hours
	4	Prefab Functional cells placement	possibly cranes needed	cranes needed	8 students and 2 professional	4 hours
	5	Transversal partitions placement	Manual / no cranes needed		6 students and 2 professional	4 hours
	6	Airtightness and waterproof	Manual / no cranes needed		2 students and 2 professional	12 hours
	7	Connecting HVAC and appliances	manual	electricity needed	2 students and 2 professional	6 hours
	8	Roof structure construction	Manual / no cranes needed		4 students and 2 professional	6 hours
	9	PV assembly	Manual / no cranes needed	electricity needed	4 students and 2 professional	6 hours
	10	External deck construction	Manual / no cranes needed		6 students and 2 professional	12 hours
	11	Testing	manual	electricity needed	4 students and 2 professional	4 hours
	i					
DISSASSEMBLY	1	External deck disassembly	Manual / no cranes needed		6 students and 2 professional	12 hours
	2	PV disassembly	Manual / no cranes needed		4 students and 1 professional	6 hours
	3	Roof structure disassembly	Manual / no cranes needed		6 students and 1 professional	4 hours
	4	Transversal partitions disassembly	Manual / no cranes needed		4 students and 1 professional	4 hours
	5	Prefab Functional cells disassembly	possibly cranes needed	possible cranes	6 students and 2 professional	4 hours
	6	Prefab Floor slabs disassembly	Manual / no cranes needed		4 students and 1 professional	2 hours
	7	Foundation disassembly	Manual / no cranes needed		8 students and 2 professionals	6 hours
	8	Organization inside containers	charging trucks	cranes needed	8 students and 2 professionals	6 hours
	i					

2. VEHICLES (Trucks, vans, ...)

	TYPE	IF TRUCKS (special or regular)	TONNAGE (total)	DIMENSION	
1	8 trucks	megatrailers	max. 25t	13.60 x 2,48 x 3,00	
i					

3. CRANE (if necessary)

	TYPE	TONNAGE	MAXIMUM LOAD	LOAD TIP	USAGE TIME
1					

4. MODULES AND MAIN COMPONENTS

		BRIEF DESCRIPTION	TONNAGE		UNLOADING DURATION	
ASSEMBLY	1					
	2					
	3					
	4					
	...					
	i					
		BRIEF DESCRIPTION	**TONNAGE**		**LOADING DURATION**	
DIASSEMBLY	1					
	2					
	3					
	4					
	...					
	i					

5. WASTE MATERIALS

	TYPE	VOLUM			
1					
2					
3					
4					
...					
i					

NOTE: For Deliverable #3, you may fill at least points: 0, 1 and 2.

2. COST ESTIMATE AND PROJECT FINANCIAL SUMMARY

2. COST ESTIMATE AND PROJECT FINANCIAL SUMMARY

2.1. Business and fund raising.

The expected budget for the construction of the ZE+hytte is of almost 700000 € (table 1), excluding consultancy, travelling etc. and 1.1 million including the rest. The team is therefore committed to raise approximately 1 million euros beyond the 100000 Euros received from the SDE organization. The fundraising strategy for the support of the ZE+hytte development is built on the base of existing efficient structures of connections aiming at stimulating the interest of both private sources and public institutions at different political levels. The design process until June 2011 – coinciding with the second phase of the SD time schedule - will be supported by small scale funding coming from the SB centre - located inside NTNU - and the Research Council. NTNU will in the meantime provide space for the design and computers for digital modeling. Research centres involved will provide numerous facilities and labs. For financial support and fundraising NTNU can rely on the technical support of the following associations:

- The Norwegian Research Council
- Green Trøndelag
- The Husbanken

The project management board responsible for the development of the project is currently trying to concretize the support of organizations that showed already a strong interest in the project. The request for funding will be augmented through new research projects and grant applications aiming at attracting the interest of private industries and research centres.

2.2. Cost estimate.

See next page (first preliminary data).

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PRICE / COST PROPOSAL FORM

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Telepone: +47-73595090

Values in EURO

SUMMERY BUDGET. DESCRIPTION OF COST ELEMENTS (page 1)

1. - DIRECT MATERIALS

		ESTIMATED BUDGET	
ROOF PROTOTYPING - CUSTOM MACHINE COMPONENTS	24000		
MASSIVE WOOD for structural walls / KLIMABLOCK	6000		
OPENINGS	38000		
METALS	18000		
THERMAL AND MOISTURE PROTECTION	36000		
FINISHES	6000		
ELECTRICAL POWER GENERATION AND BATTERY DECK	60000		
FLOOR PREFAB CONCRETE SLABS, INSULATION AND FINISHES	24000		
SOLAR PV	75000		
PURCHASED EQUIPMENTS (washing machine, kitchen, etc...)	24000		
HVAC system	20000		
PLUMBING	12400		
ELECTRICAL	12000		
SOLAR SHADING DEVICES, integrated PV	40000		
FURNISHINGS	12000		
DECK AND LANSCAPE MATERIAL	10000		
FOUNDATION	4000		
VAT 16%	84280,0		
TOTAL DIRECT MATERIALS		505680,0	40

2. - MATERIAL OVERHEAD

	% ESTIMATED RATE *TOTAL DIRECT COSTS			
FABRICATION	10 %	50568		
CONSTRUCTION	15 %	75852		
VAT 16%		20227,2		
TOTAL MATERIAL OVERHEAD			146647,2	12

3. - DIRECT LABOR

	n	HOURS /WEEK	WEEKS	HOURLY RATE	ESTIMATED COSTS		
PROFESSORS AND RESEARCHES	5	10	48	35	84000		
RESEARCH ASSISTANT	3	15	48	25	54000		
GRANTED STUDENTS	2	20	48	15	28800		
LABOURERS	2	15	24	22	15840		
ADMINISTRATIVES	1	6	36	25	5400		
TOTAL DIRECT LABORS						188040	15

4.- LABOR OVERHEAD & FRINGE BENEFITS

	n	HOURS /WEEK	WEEKS	HOURLY RATE			
ZEB centre leaders (Prof. Excluded)	3	8	24	35	6720		
GRANTED STUDENTS	2	20	36	15	10800		
LABOURERS	8	20	24	22	10560		
ADMINISTRATIVES	1	12	36	25	10800		
TOTAL LABOR OVERHEAD & FRINGE BENEFITS						38880	3

5.- LOWER - TIER SUBCONTRACTORS

PROJECT MANAGERS	HOURS /WEEK	WEEKS	HOURLY RATE			
PROTOTYPING PHASE	12	4	35	1680		
1ST CONSTRUCTION PHASE	12	4	70	3360		
2ND CONSTRUCTION PHASE	12	4	100	4800		
VAT 16%				1574,4		
TOTAL LOWER - TIER SUBCONTRACTORS					11414,4	1

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SUMMERY BUDGET. DESCRIPTION OF COST ELEMENTS (page 2)

7.- OTHER DIRECT COSTS

DIGITAL PHOTOGRAPHY for fundraising and promotional booklets		1200		
ARCHITECTURAL MODEL - material		300		
COMMUNICATION		33000		
video display component	14000			
video production	8000			
display hardware	7000			
website mantainance / podcasting	4000			
PUBBICATION AND PRODUCTION		24000		
fundraising booklet, publication and printing	6000			
promotional booklet	6000			
SPACE RENTAL IN BRØSET		donated		
FUNDRAISING PROMOTIONAL EVENT		4000		
POST COMPETITION MONITORING		12000		
TOTAL OTHER DIRECT COSTS			74500	6

8.- TRAVELS AND COSTS FOR FINAL PHASE IN MADRID

	TEAM MEMBERS	UNIT COSTS	ESTIMATED COSTS		
TRAVEL COST FOR THE TEAM	24	240	5760		
TEAM ACCOMODATION	24	840	20160		
FOOD	24	400	9600		
UNIFORMS DESIGN AND PURCHASE	48	60	6400		
SHIPPING			240		
documents		40*4			
model		80			
TOOLS AND MISCELLANEOUS EXPENSES			4800		
SITE SUPERVISION AND SECURITY			8000		
VAT 16%			8793,6		
TOTAL TRAVELS AND COSTS FOR FINAL PHASE IN MADRID				63753,6	5

9.- ASSEMBLY, TRANSPORT, DISASSEMBLY PROCESSES

DISASSEMBLY IN ORIGIN		6000		
TRANSPORT		33400		
customer broker	7400			
cranes	14000			
ASSEMBLY IN MADRID		12000		
DISASSEMBLY IN MADRID		6000		
TRANSPORT		7400		
VAT 16%		10368		
TOTAL ASSEMBLY, TRANSPORT, DISASSEMBLY PROCESSES			75168	6

10.- INSURANCES POLICIES

LIABILITY INSURANCE	4800		
TRANSPORT INSURANCE	3600		
ACCIDENT INSURANCE	12000		
MEDICAL INSURANCE	10600		
TAXES	6200		
TOTAL INSURANCE POLICIES		37200	3

TOTAL PRICE / COST ESTIMATED 1172603

Introduction

The main direction of this essay is that from the author's point of view considering the important points in cost estimate and project financial. This essay is aiming at analyzing Solar Decathlon (SD) 2012 Rule 44 [1]: *cost estimate and project financial summary.* The method of the essay is analyzing the main points from the rule and studying the previous project from SD 2010. And the goal of this essay is to get inspiration from the case. The author has been read through most of the project manuals (the English written ones) from SD 2010 [3]. And the cost estimation can be described in to two main steps:

1) Business and fundraising plan
2) Cost estimate (including project future study)

Cost estimation is one of the biggest parts in the project financing budget. For instance, material overhead, direct labor, labor overhead and fringe benefits, lower-tier subcontractors, consultants, other direct costs, travels and costs for final phase in Madrid, assembly, transports, and disassembly process and insurance, those mentioned above should be submitted with supporting documentations. Due to the limited size of the paper, only general opinion on business and fundraising plan and few suggestions about taking out quantities on direct materials which are included in cost estimation will be discussed here.

1. Business and Fund-raising Plan

Check list of business and fund raising plan according to SD 2012 Rule 44:
1) Description of overall project; 2) involved departments; 3) key sponsors

Business and fund raising plan of Team Finland is chosen as the case study. By starting the financing plan [2], Team Finland gives clear steps of approach used for collecting sponsorship. Described as follow:

1) Design and developing
2) Choose the best possible products and company
3) Project presentation by students to approach the company
4) Agreement on sponsorship

Information of the project's final budget and a list of sponsors has also been provided in the funds collection and sponsorship plan. Team Finland has integrated fundraising plan with communication actions. The process from the first day of preliminary decision to enter SD 2010 till the plan of future is all included in their business and fund-raising plan. The author thinks it is not easy to distinguish between the communication actions and fund-raising plan. Each steps of the project development are closely interacted with other departments in the university, companies, media and etc. Inspiring from the Team Finland, the author suggests that the business and fund-raising plan can be done by the following stages:

Stage A: From SD information first released to master students on 08.2010 till first design concept; it should include a very short description of first submitted report and projects from all the students' teams.

Stage B: The date of acceptance till further development of design concept, detail construction and technical solutions; it should include the media release in the newspaper and website; information about students SD workshop and the actions taken to attract the sponsors should also be given in this stage.

Stage C: Construction period till monitoring of the house; communication with sponsor, students' team work, necessary trips, open house events should be included in this stage.

Stage D: Disassembly, transportation to Madrid and assembly; short description of contractor information can be provided here.

Stage E: Transportation to Norway and assembly; this stage can be called design for future; the most interesting part of the future design is whether it will be widely accepted in the market. So this stage can be extended to another section: project future study (*it will not be developed in this essay*).

Question should be answered before proceeding to next step-cost estimate:
How sponsor pay? Per month? In one time? It is important for the cash flow!

2. Cost Estimate – Direct Materials

Check list of cost estimation according to SD 2012 Rule 44-Cost Estimation in terms of direct materials:

1) Materials quantities; 2) Materials unit prices; 3) Total price of each direct material;

No teams in SD 2010 provided a detailed cost estimate. Most of the teams gave a total construction cost figures with economic feasibility analysis. The author thinks that the main point which we should focus on currently is the materials cost in combination with construction specification since direct materials cost is one of the biggest parts in the cost estimate. The author thinks that it is a quite logical way to set up the quantity sheet according to the rough construction procedure. In the final cost estimate sheet, it might not be necessary to present according to the construction process, but it might prevent missing data during the detailed calculation. The quantity sheet can be designed as follow:

1) **Foundation:** *wooden materials, hardware;*
2) **Slabs:** *floor boards for outdoor and indoor purpose, insulation materials, hardware;*

3) **Primary layer 1:** *structural frame materials, insulation materials, hardware, excluding the service equipment;*
4) **Secondary layer:** *envelope materials, hardware;*
5) **Primary layer 2:** *structural frame materials, insulation materials, hardware, excluding the service equipment;*
6) **Windows:** *windows from all directions; skylight?;*
7) **Ceilings:** *timber materials*
8) **Structure beams:** *timber beams*
9) **Roof:** *sub roof construction should be listed one by one; excluding PV or solar thermal;*
10) **Technical installations:** *services in the primary layer (or if necessary using beams and secondary layer) including heating, water, ventilation and lighting system; PV and solar thermal collector on the roof;*
11) *Other appliances: in this category, the kitchen equipment, study equipment, living space furnishing and sleeping space furnishing should be included; it also depends on the foldable furniture such as study desk, chairs and beds are supplied together with the primary layers, or they should be installed separately during the interior construction work.*

And it should also be noted, services such as, welding; minor fabrication should also be included in the direct materials quantity sheet. Furthermore, in the direct materials calculations, despite the quantities, unit price and total cost of each construction element should be included. In combination with unit price, clearly explanation of the prices should be provided. And the explanation of the prices should be submitted with supporting documentations such as invoices, vendor quotes, catalog and etc.

3. Other Information about cost estimate

In this paper, the author shows the opinion on business and fundraising plan and cost estimation in terms of direct material cost. As it stated in introduction, cost estimation is one of the biggest parts in the project financing budget. Due to the limitation of the paper, the author provided a checklist with all the documentation that should be submitted. The author thinks that this checklist might help to avoid missing documentation according to SD 2012 Rule 44. And some comments have also been provided with the checklist. Please see the attached file for the check list.

Reference

[1] **Spain: Solar Decathlon Europe.** (June 2011). *Solar Decathlon Europe 2012 Rules.*
[2] **Team Finland.** (22.09.2010). *Project Manual.* Aalto University. Solar Decathlon Europe. (June 2011). *Solar Decathlon Europe 2012 Rules.* Spain: Solar Decathlon Europe.
[3] **Solar Decathlon Europe.** Retrieved 24.08.2011, http://www.sdeurope.org.

ELECTRIC AND PHOTOVOLTAIC CHART

NTNU UNIVERSITY — TEAM NORGE

GENERAL ELECTRICAL AND PHOTOVOLTAIC INSTALLATIONS		
Electrical supply voltage (phase-neutral) for which both installations have been designed	v	230
Electrical supply frequency for which both installations have been designed	Hz	50

ELECTRICAL INSTALLATION		
No details are required in this document about interior circuits, due to the fact that these shall adapt to the minimum requirements given by the Spanish standard REBT for a highly electrified house.		
The Organisation will supply the teams with a one-line diagram with the distribution and protections of the interior circuits, according to the Spanish REBT.		
Teams are reminded of The fact that The Electrical installations shall be designed for a single-phase supply with a maximum power of 15 kW, equivalent to 63 A (230 V / 50 Hz). For other voltages and/or frequencies the equivalent limit shall apply, by making use of the corresponding transformation relation.		
House inner surface	(m^2)	63.2
Expected maximum power	(W)	10-12 KW
Individual branch:		HO7RN-F
o Type of cable		3 x 10
o Cross-section	(mm^2)	5 x 10
General magnetothermic protection:		
o Nominal current (unit: A)		50 A
o Circuit-breaking capacity (unit: A)		6 KA
General differential protection:		
o Nominal current (unit: A)		16 A
o Sensibility / Trip value (unit: mA)		30 mA
Use of DC loads:		
o DC operating voltage (unit: V)		12 V
o Rated power of aggregated DC loads (unit: W)		

PHOTOVOLTAIC INSTALLATIONS		
[Note: Teams are reminded of the fact that the PV installations size is limited by the following rule: the maximum power of all power conditioning equipment connected to PV generation (DC/DC and/or DC/AC) is limited to 10 kW. For DC/AC power conditioning (inverters), the maximum power to be considered is the nominal power, defined as the maximum output power without time limitations/ constraints.]		
Nominal power of the inverter, or sum of the nominal power of inverters in case several inverters are used [Note: nominal power of the inverter is the maximum output power without time limitations]	*(W)*	9900
- Brand and model of inverter(s).	*6p. SMA Solar Technology AG _ Sunny boy SB 2100TL 2.0KW*	

HARD-WIRED BATTERY BANK + BATTERY INVERTER		
Nominal operation DC voltage of The battery bank (unit: V)	*none*	The +hytte will not require The use of any additional battery. The team is considering the possibility of using an electric car battery as accumulator.
Nominal capacity of The battery bank (unit: Ah)	*none*	
Nominal power of The battery inverter (unit: W)	*none*	
[maximum output power at the AC side without time limitations]	*none*	
Brand and model of The battery inverter.	*none*	

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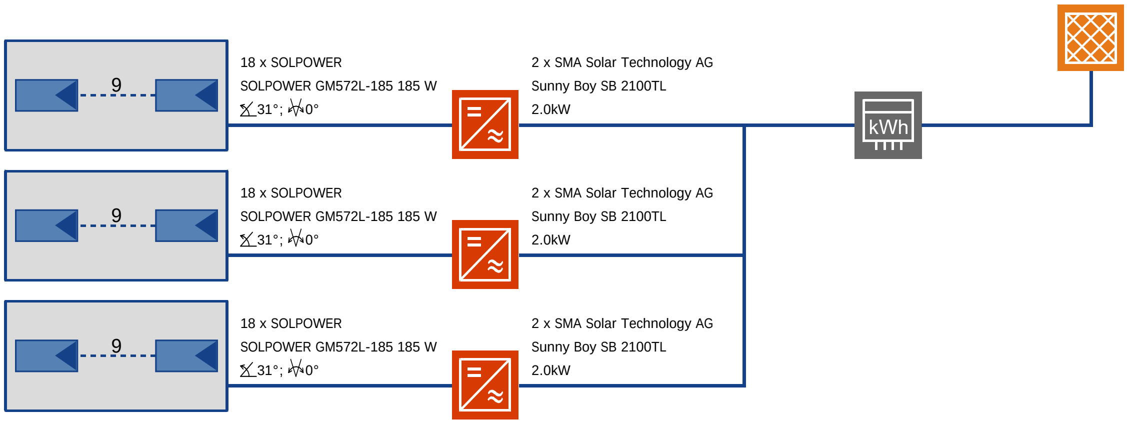
Project Name: ZEB 9/8/2011
Variant Reference: System Variant



Location:	MADRID	
Climate Data Record:	MADRID (1981-2000)	
PV Output:	9.99	kWp
Gross/Active PV Surface Area:	68.94 / 68.90	m²

PV Array Irradiation:	127,739 kWh
Energy Produced by PV Array (AC):	13,794 kWh
Grid Feed-in:	13,794 kWh

System Efficiency:	10.8	%
Performance Ratio:	74.2	%
Specific Annual Yield:	1,376	kWh/kWp
CO2 Emissions Avoided:	12,178	kg/a

The results are determined by a mathematical model calculation. The actual yields of the photovoltaic system can deviate from these values due to fluctuations in the weather, the efficiency of modules and inverters, and other factors. The System Diagram above does not represent and cannot replace a full technical drawing of the solar system..

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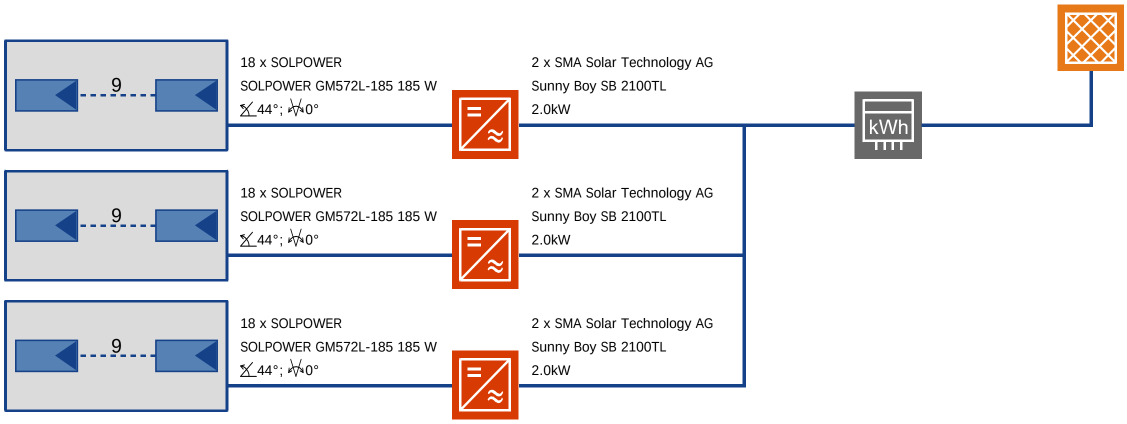
Project Name:	ZEB	9/8/2011
Variant Reference:	System Variant	



Location:	Vaernes
Climate Data Record:	Vaernes
PV Output:	9.99 kWp
Gross/Active PV Surface Area:	68.94 / 68.90 m²

PV Array Irradiation:	76,438 kWh
Energy Produced by PV Array (AC):	8,556.2 kWh
Grid Feed-in:	8,556.2 kWh

System Efficiency:	11.1 %
Performance Ratio:	76.6 %
Specific Annual Yield:	850.1 kWh/kWp
CO2 Emissions Avoided:	7,525 kg/a

The results are determined by a mathematical model calculation. The actual yields of the photovoltaic system can deviate from these values due to fluctuations in the weather, the efficiency of modules and inverters, and other factors. The System Diagram above does not represent and cannot replace a full technical drawing of the solar system..

Electric and Photovoltaic chart for the +Hytte

Elisabetta Caharija & Nigar Zeynalova

The purpose of the essay is a data collection for the Electric and Photovoltaic chart for the 3rd SDE delivery.

General description

The roof system enables the uniform distribution of daylight and air. Three skylights are distributed along the linear modules representing the hard-core of the project. Thus the surface area used for PV is reduced to 55 m^2. The inclination of the roof is 10° which was dictated by the limitations of the solar envelope.
The PV panels should have monocrystalline silicon cells in series, a mature technology on the market with higher efficiency and longer lifetime, though more expensive than other technologies.
The photovoltaic systems in the +Hytte consist of photovoltaic arrays (which consist of modules) and grid-connected inverters. The PV array can produce electrical power according to the amount of daylight it receives. The temperature of the PV array and the voltage at which it is loaded are also important factor for an efficient system. Therefore PV are back ventilated to avoid overheating of the modules.

There are two important rules or limitations that need special attention when designing the PV and electrical system of the house:

- Rule 7.3.: the sum of the maximum power of all power conditioning equipment connected to PV generation (DC/DC and/or DC/AC) is limited to 10 kW.
- Rule 51.7.: the connection interface between the house and the Villa Solar electricity grid is limited to 15 kW (equivalent to 63 A - 230 V / 50 Hz) which is limiting also the conventional electricity installation (electrical loads).

Design and specification

PV modules

Ascent Solar

The ZEB centre is promoting and supporting +Hytte in the SDE 2012. Therefore we investigated the possibility of using the product of Ascent solar company which is cooperating with ZEB through Hydro. Ascent Solar is producing light modules that capture and deliver the power of the sun through thin-film PV modules that can be easily integrated into any type of building material or application.

WaveSol Light 5- Meter 96 Voc Specification Sheet		
CIGS Thin Film Photovoltaic Modules		
Product Class	WSLE-1200-096-ST-06	WSLE-1400-096-ST-06
Electrical Specifications (Measured under Standard Test Conditions)		
Nominal Power (Pmax in Watts)	120	140
Voltage at Pmax (Vmp in Volts)	71.0	77.8
Mechanical Characteristics		
Length	4976 ±5mm	
Width	360 ±5mm	
Weight	3.4 kg	
Thickness	1.2 ± 0.5 mm (excluding junction box)	

Figure 1: WaveSol Light - 5 Meter Data Sheet (www.ascentsolar.com/bipv/)

According to the data from Figure 1 we calculated the energy production for PV surface of 55 m^2. The results were not satisfactory considering our energy goals due to the low production - only 3 kW.

Further investigation was undertaken in order to find an optimal solution for the +Hytte. We started by looking in the Norwegian market and found REC - a leading player in the solar energy industry producing all components for PV systems.

<u>REC (Renewable Energy Corporation)</u>

We chose the modules with monocrystalline silicon solar cells due to their high efficiency.

ELECTRICAL DATA @ STC	REC220PE	REC225PE	REC230PE	REC235PE	REC240PE	REC245PE	REC250PE
Maximum Power - P_{MAX} (Wp)	220	225	230	235	240	245	250
Watt Class Tolerance - P_{TOL} (W)	0/+5	0/+5	0/+5	0/+5	0/+5	0/+5	0/+5
Maximum Power Voltage - V_{MPP} (V)	28.6	28.9	29.2	29.6	29.9	30.2	30.5
Module Efficiency (%)	13.3	13.6	13.9	14.2	14.5	14.8	15.1

MECHANICAL DATA	
Dimensions	1665 x 991 x 38 mm
Area	1.65 m^2
Weight	18kg

Figure2: Rec Peak Energy series – Data Sheet (www.recgroup.com/en/products/modules/recpeakenergyseries)

According to the data from Figure 2 we calculated the energy production for PV surface of 55 m^2 using the module with Peak Power Watts-P_{max}(Wp) of 250W (the highest). For the given surface we are using 24 modules (two stripes of 12 modules each).

We got a better results – the production is two times higher than before (6 kW) but still not reaching 10kW (maximum power according to SDE rules mentioned before).

One solution can be to increase the PV surface by having only one skylight (the central one) instead of three. We need 26,4 m^2 more surface for adding 16 modules to reach the 10 kW of maximum power production (one skylight is 13 m^2). Also adding a shading device with integrated PV can be a solution.

Inclination

In Norway the optimal inclination for the PV modules is 45°. The roof has to be quite steep which is also good for the snow load in winter. In Spain the optimal inclination is lower - 35° because of the sun position. The actual roof inclination of the +Hytte is just 10° which is far from optimal (moreover in September when the competition will take place).

Inclination vs. production

Once we obtained all the necessary data (square meters of the roof, of the skylights, of the PV area, inclination and the time period) we used Ecotect to simulate changes in the main parameters which lead to a range of proposals. The point was to test and compare the results.

1st scenario: full PV (no skylights)
- 100 m^2 of PV area, inclination 10° → total energy production 2364 kWh
- 120 m^2 of PV area, inclination 35° → total energy production 2803 kWh

2nd scenario: three skylights
- 55 m^2 of PV area, inclination 10° → total energy production 1182 kWh
- 60 m^2 of PV area, inclination 35° → total energy production 1402 kWh

3rd scenario: one skylights
- 87 m^2 of PV area, inclination 10° → total energy production 2060 kWh
- 107 m^2 of PV area, inclination 35° → total energy production 2500 kWh

By increasing the inclination of the roof from 10° to 35° the energy production can be significantly improved by 16% in all scenarios.

Inverter

The inverter is used to invert the DC produced from PV panels to AC for appliances and the gird.
One of the possible supplier can be a Norwegian company - Mascot As but the AC output is only 1500 W.
A good alternative can be SMA Solar Technology. The model Sunny Boy 5000TL seems to be the most efficient with output 5000 W and designed for the maximum production from 10 to 20 kW. They are optimally suitable for use in small and mid-range systems. They are highly efficient, reliable, flexible and ensure optimum solar yield.
Two inverters are required for the +Hytte.

	Sunny Boy 3000TL	**Sunny Boy 4000TL**	**Sunny Boy 5000TL**
Input (DC)			
Max. DC power (@ cos φ=1)	3200 W	4200 W	5300 W
Max. input voltage	550 V	550 V	550 V
Output (AC)			
Rated output power (@ 230 V, 50 Hz)	3000 W	4000 W	4600 W
Max. apparent AC power	3000 VA	4000 VA	5000 VA
Efficiency			
Max. efficiency / European efficiency	97 % / 96.3 %	97 % / 96.4 %	97 % / 96.5 %

Figure 3: Sunny Boy 3000TL / 4000TL / 5000TL Data Sheet (www.sma.de/en/products/solar-inverters/sunny-boy.html)

Battery

Since in Madrid the organizers provide the village with an electric power grid (AC power) maybe there is no necessity to have a battery to store the energy, but if the +Hytte will be used as a cabin in Norway without the connection to the grid (stand alone system) there will be necessary to have a battery as a system component.

Appliances

AC power became the standard of all appliances, so nowadays is the most common solution even though it has more losses due to distribution. The DC appliances are becoming more available, they have less losses but are more expensive. If the +Hytte will have DC appliances the part of the DC loads in the Electric and Photovoltaic chart has to be filled in.

Cables, protections and electricity

Once we have decided the supplier of our PV modules, choose the optimal product and the inverter we will know which type of cable and the values of the two types of protection (magnetothermic and differential protection). And when we know the production of each model, efficiencies and losses we will have all the data necessary to calculate the monthly and annual generation of electricity in Madrid.

Possible Innovative solutions

Solar Hybrid PVT

PVT solar system combines solar electrical generation (PV) with solar thermal (T) hot water. There are many ways to combine different PV and Solar thermal technologies to a PVT collector. So far, most developments have been done on the following technologies : PVT liquid system PVT air heating (air collectors, ventilated PV with heat recovery).

<u>PVT liquid system</u> – Power Volt Panel (Hybrid PV and solar thermal panel produced by Eco Merchant – UK)
The combination increases the performance of the PV panel by running a liquid glycol behind the PV unit reducing the panel temperature which allows the panel to work at maximum efficiency whereas conventional PV panels reduce in performance as the temperature increases. The panel is also capable of producing a reasonable amount of heat production in the summer. The peak outputs of this panel are 175/460 W electrical/thermal respectively.

<u>PVT air system</u> – Hybrid Air Collector (Grammer Solar – Germany)
The sun energy penetrating is transformed within a photovoltaic module only by 25 % into electric energy. The major part of the radiant energy becomes heat which reduces the efficiency of the cell with the production of current. Therefore a good heat removal must be assured, usually by rear ventilation of the modules. With the hybrid collectors the modules are cooled actively by means of a ventilator, the heated air can be used if required.

After analyzing different technologies we came to the conclusion that PVT systems produce only 25% of electricity while generating 75% of thermal energy. As +Hytte will be highly insulated to minimize summer heat gain and preventing heat island effect, the average heat demand will therefore drop as less heat is wasted, this implies a shift of the electrical power/heat ratio towards a predominance of electricity demand. Furthermore the energy consumption will increase due to the household appliances and other sophisticated electronic devices integrated in the +Hytte, thus the technology maybe is not a suitable solution for the +Hytte.

Solutions proposed by Velux - Denmark

As a manufacturer of roof windows and skylight systems, the company's goal is to enhance and encourage the role of daylight in architecture and analyze the impact of daylight and windows on the environment and well-being. At the same time they are also working on an efficient energy concept for the projects by applying traditional solar technology, such as solar thermal collectors and PV system. If the +Hytte wants to design and install innovative photovoltaic solutions with high efficiency, Velux's technologies may not be the best source to explore further.

BIPV skylights by Onyx Solar – Spain

The skylight provides a multifunctional solution where not only energy is being generated in-situ, but also natural illumination is being provided implementing solar control by filtering effect, avoiding infrared and UV irradiation to the interior and at the same time enhancing thermal comfort. The peak power of monocrystalline photovoltaic glass used for the skylights is 120-180 W/m^2.

It can be an optimal solution since the three skylights aim at providing a homogeneous distribution of lighting and thus play an important role in the energy concept of the +Hytte.

References:

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Health and safety SD2012

Date: 06/09/2011
By: Sarah Flausse
Kristof Lijnen

HEALTH AND SAFETY SD 2012

Safety guidelines for the design process

- Are the doors and ramps wide enough (1,20m) for wheelchair users and evacuation procedure?
- Is there a level difference between the outside and the inside, this will be important for the entrance of wheelchair users into our building?
- Is the route of the house tour easy accessible?
- Are all the structural parts achieving 30min. of fire resistance (R30)? Will there be a fire alarm installed?
- Will there be special bolts integrated for the attachment of scaffolding or safety attachments for the roof work?

Health and Safety Checklist

SCAFFOLDS

- Do we need scaffolds because everything will be prefabricated and just fitting into each other?
- If we work with prefabricated parts, how will they manage to fit into each other?
- Are all the connections on a normal height or do we need to use a ladder?
- Are the connections easy accessible? Do we need electrical tools for making the connections?
- If we need scaffolds, are there points provided for attaching the scaffolds with walls if the walls are higher than 2m.
- If there is a need for scaffolds do we have to handover certificates for all work platforms and scaffolds?
- Is there safe access method (ladder) to the scaffold platform?
- Have all uprights been provided with base plates (and, where necessary, timber sole plates) or prevented in some other way from slipping?
- Is the scaffold secured to the building or structure in enough places to prevent collapse?
- Are there adequate guardrails and toe boards or an equivalent standard of protection at every edge from which a person could fall 2 m or more?
- Are intermediate guardrails fitted?

SAFE PLACES OF WORK ON OUR PROJECTS

- Can everyone on the project reach their place of work safely, e.g. are roads, gangways, passageways, passenger hoists, staircases, ladders and scaffolds in good condition?
- Are there guard rails or equivalent protection to stop falls from open edges on scaffolds, mobile elevating work platforms, buildings, gangways, excavations, etc?
- Are all holes and openings securely guard railed, provided with an equivalent standard of edge protection or provided with fixed, clearly marked covers to prevent falls?
- Are the working structures stable, adequately braced and not overloaded?

- Are all working areas and walkways level and free from trip hazards, obstructions such as stored material and waste?
- Is our site tidy?
- Is the work area and interior adequately lit? Have we sufficient additional lighting provided when work is carried on after dark or inside buildings?

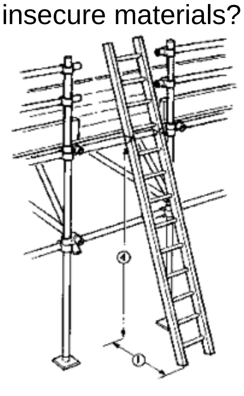
Where guard rails and toe boards or similar are used:

1. Are the toe boards at least 150 mm in height?
2. Is the upper guardrail positioned at a height of at least 910 mm above the work area?
3. Are additional precautions, e.g. intermediate guard rails in place to ensure that there is no unprotected gap of more than 470 mm between the toe board and upper guard rail?
4. Are the working platforms fully boarded and are the boards arranged to avoid tipping or tripping?

- Are there effective barriers or warning notices in place to stop people using an incomplete scaffold, e.g. where working platforms are not fully boarded?
- Does a competent person inspect the scaffold regularly?
- Are the results of inspections recorded in our company records or site diary?

LADDERS

- Do we need to use ladders in our project, if not, how will we reach the roof?
- Are ladders we have supplied the right means of access for this project or job?
- Are all of the ladders in good condition?
- Have we secured them to prevent them slipping sideways or outwards?
- Do our ladders sections raise a sufficient height above their landing place? If not, are there other hand-holds available?
- Are our ladders positioned so that users don't have to over-stretch or climb over obstacles to work?
- Does the ladder being inspected rest against a solid surface and not on fragile or insecure materials?



ROOF WORK

- Will the roof be prefabricated totally, if yes, how will they be connected with the walls?
- Are there enough barriers and is there other edge protection to stop people or materials falling from roofs?
- Are harnesses available for the workforce if required?
- Are crawling boards provided where work on fragile materials cannot be avoided?
- Are people excluded from the area below the roof work? If this is not possible, have additional precautions been taken to stop debris falling onto them?

EXCAVATIONS

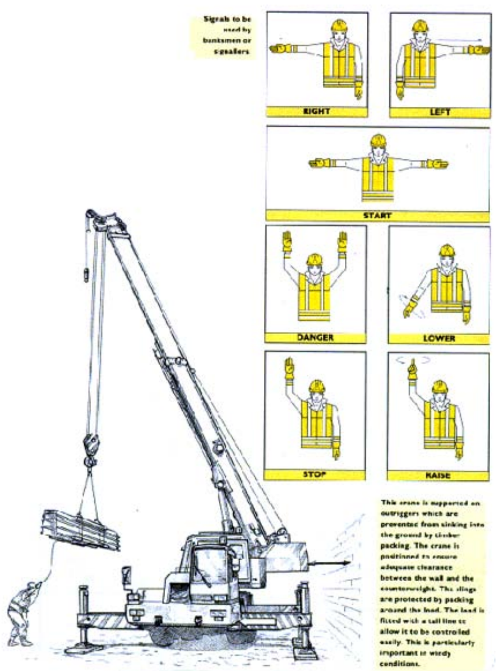
- Excavations will not be allowed under any circumstances so we don’t have to bring into account.

MANUAL HANDLING

- Has the risk of manual handling injuries been assessed?
- Are hoists, telehandlers, wheel-barrows and other plant or equipment used so that manual lifting and handling of heavy objects is kept to a minimum?
- Are materials such as cement ordered in 25 kg bags?
- Can our team avoid the handling of heavy blocks?

CRANES AND LIFTING APPLIANCES

- Is the mobile or static crane working on a firm level base?
- Are the safe working loads and corresponding radii known and considered before any lifting begins?
- If the crane has a capacity of more than 1 tonne, does it have an automatic safe load indicator that is maintained?
- Are all operators trained and competent?
- Has the banksman/slinger/signaller been trained to give signals and to attach loads correctly?
- Do the operator and signaller / banksman find out the weight and centre of gravity of the load before trying to lift it?
- Are the results of inspections and examinations recorded?
- Does the crane have a current test certificate?



PLANT AND MACHINERY

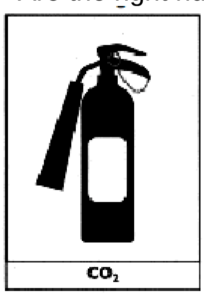
- Is the right plant and machinery being used for the job? Have the entire project team agreed on this point?
- Are guards secured and in good repair?
- Is the machinery maintained in good repair and are all safety devices operating correctly?
- Are all operators trained and competent?

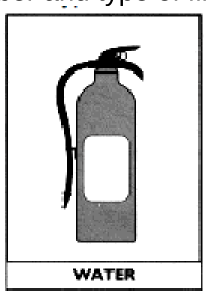
GENERAL

- Have emergency procedures been developed, e.g. evacuating the site in case of fire or rescue from a confined space?
- Are people on site aware of the procedures?
- Is there a means of raising the alarm and does it work?
- Are there adequate escape routes and are these kept clear?

FIRE

- Is the quantity of flammable material on site kept to a minimum?
- Are there provided proper storage areas for flammable liquids and gases, e.g. LPG and acetylene?
- Are containers and cylinders returned to these stores at the end of the shift?
- If liquids are transferred from their original containers are the new containers suitable for flammable materials?
- Is smoking banned in areas where gases or flammable liquids are stored and used? Are other ignition sources also prohibited?
- Are our gas cylinders and associated equipment in good condition?
- When gas cylinders are not in use, are the valves fully closed?
- Are cylinders stored outside?
- Are adequate bins or skips provided for storing waste?
- Is flammable and combustible waste removed regularly?
- Are the right number and type of fire extinguishers available and accessible?





HAZARDOUS SUBSTANCES

- Have we considered all harmful materials, e.g. asbestos, lead, solvents, paints etc and have we identified them properly?
- Have the risks to everyone who might be exposed to these substances been assessed?
- Have precautions been identified and put in place, e.g. is protective equipment provided and used; are workers and others who are not protected kept away from exposure?


NOISE

- Is suitable hearing protection provided and worn in noisy areas?

WELFARE (should be provided by the Spanish organization)

- Have suitable and sufficient numbers of toilets been provided and are they kept clean?
- Are there clean washbasins, warm water, soap and towels?
- Is suitable clothing provided for those who have to work in wet, dirty or otherwise adverse conditions?
- Are there facilities for changing, drying and storing clothes?
- Is drinking water provided?
- Is there a site hut or other accommodation where workers can sit, make tea and prepare food?
- Is there adequate first aid provision?
- Are welfare facilities easily and safely accessible to all who need to use them?

PROTECTIVE CLOTHING

- Has adequate personal protective equipment, e.g. hard hats, safety boots, gloves, goggles, and dust masks been provided?
- Is the equipment in good condition and worn by all who need it?

ELECTRICITY

- Is the supply voltage for tools and equipment the lowest necessary for the job?
- Are cables and leads protected from damage by sheathing, protective enclosures or by positioning away from causes of damage?
- Are all connections to the system properly made and are suitable plugs used?
- Is there an appropriate system of user checks, formal visual examinations by site managers and combined inspection and test by competent persons for all tools and equipment?

PROTECTING THE PUBLIC

- Are the public fenced (do we need to do this during the competition) off or otherwise protected from the work?
- When work has stopped for the day:

1. Are the gates secured?
2. Is the perimeter fencing secure and undamaged?
3. Are all ladders removed or their rungs boarded so that they cannot be used?
4. Are openings securely covered or fenced off?
5. Are flammable or dangerous substances locked away in secure storage places?

Construction specifications +Hytte Solar decathlon

Noora Alinaghizadeh and Vegard Heide

The project

The +hytte project consists of an open building able to use in many different functions. Its form results of the layout of three independent but related systems that can be combined in a wide range of solutions. The three systems are the functional cells, the roof and space in-between.

Functional cells
Three functional cells include of main static functions and environmental requirements of the building. They represent the hard-core of the project. Their construction is organized in two layers: *The primary layer* and *the secondary layer.*

The primary layer has a purely structural and technical function. It is modular, inelastic and universal. It is intended to satisfy the basic requirements of the building, like structural and technical needs (technical main roads). It is also intended to survive any functional change.

The secondary layer intends to give a spatial and sensory value to the undetermined spaces of the primary layer. This layer is based on a series of requirements related to the user and what context the house is located in. A wide range of components can be located inside or on the surface of the functional cells to achieve this: installations, insulation, surface materials and furnishing. This layer is more subject to change during the building's lifetime.

Roof
The roof has a much less clear division between the primary and secondary layer. Apart from the sensory value provided by the interior surface material and daylight inlets, it mostly has structural and technical role. So in general we can view it as related to the primary layer.

Space in-between.
There is no relation between spatial and functional layout at the primary layer: the empty space between the functional cells can host any function. The secondary layer of the functional cells with furnishing and installations makes the space into a functional program. It consists of secondary technical distribution, installations, surface finishes, transversal partitions and furnishing.
These are specific to the functional program, and therefore more likely to change.

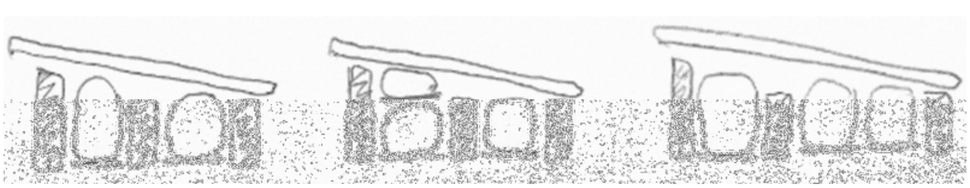


Fig1 . The functional cells, the roof and the space in-between. Each space "brings its own floor".

The main idea of having two systems (primary and secondary layer) in the functional cells is giving ability to the parts of the secondary layer to changed or interchanged without having to change the primary layer. Another advantage is that parts of the secondary layer can be designed at a later stage than the primary layer.

This will more easily allow:

- A flexible and decentralized design process, involving many independent groups and people.
- Customer-specific design of the secondary layer, with different functions, envelope details and finishes
- Changing the functions and upgrading technical installations and systems during the buildings lifetime

A structure like this is very important when we want to involve many groups with different expertise, but still cannot afford a long design period because time is short.
Different groups can work separately and independently with their specific task on their part of the layer, without too much coordination with other groups. This makes it easier to divide tasks and involve many people, and could thus allow a shorter design period.

Structure and layout of the specifications.

We think it is very important to organize the construction specification in a way that will help us focus on keeping the design modular, and keeping the secondary layer independent from the primary layer. As described above, this will make the design process more flexible, and can involve more people working independently. It may also make the design-process quicker.

Therefore we want to organize the specifications in three main parts (sheets): the functional cells, the roof and the space in between.

The functional cells are divided into the primary and the secondary layer.

All these groups are divided into sub-groups, for example the secondary layer of the functional cells are divided into “box north”, “box middle” and “box south”. These are again divided into wall structure, fillings, furniture, installations, finishes and so on.

That means there will be 5 different levels on the spreadsheet.

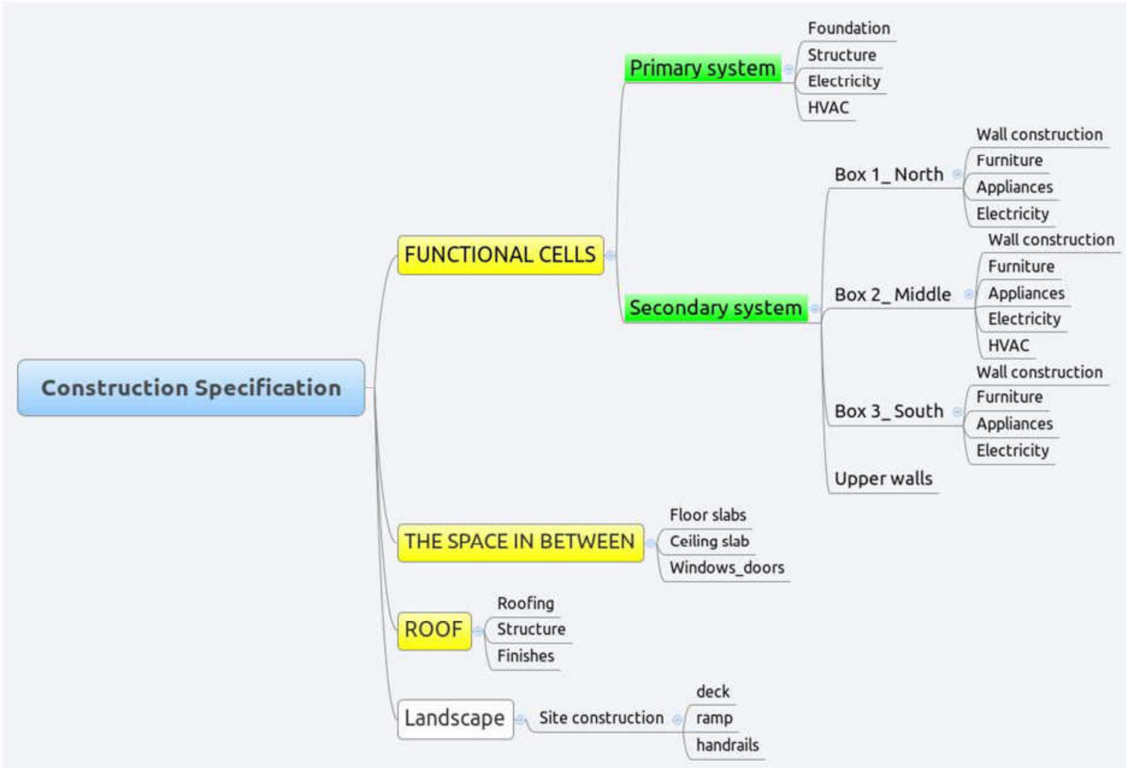


Fig 2. Spreadsheet arrangement

The different parts of the building will be prefabricated in Norway and transported to Madrid in standard containers. This determines the maximum size of the elements: 1219 m long, 2,34 m wide and 2,65 high. When using containers with an open top, the elements can easily be loaded and unloaded with a crane.

By adapting the elements to the size of standard containers we achieve flexibility in terms of transport: a great number of companies transport containers by truck, train and boat, to almost any destination (to anywhere, by anyone). Different elements can easily be fabricated at different locations also, if that is convenient.

In a sense we can say that the standard freight container is the third axis in the projects modular concept.

Organizing the specification in the three systems and two “layers” is clarifying in the design process, but when we come to the actual prefabrication phase we probably need specifications organized in a different way, for example categorizing the construction specification according to the material (metal, wood, , insulation, etc.) or components (wall, floor, roof)

When prefabricating an element, all the details and specifications have to be defined. This includes information about pipes electrical wiring and installations, surface materials, finishes and furniture. Then every piece of material that goes into the element is listed (and often pre-cut) and brought to the workstation. This, clearly, does not allow part of the detailing design to be done after work has started.

To make the element production stage simpler, an additional specification organized for each element would probably be an advantage. Experienced prefabricators must have expertise on good ways to do this in detail.

Appendix 1 includes spread sheets and detail about amount and material specification.

	Title	ref no.	no. of unit (m	specification	Area (m2)	Number	Length (m	height (m)/wi	Thickness	comments
Primary										
Foundation										
	liner foundation, adjustable		0.288	hardwood, larch		24	1.2	0.1	0.1	
	screws					24				
Structure										
	column		0.864	general timber		24	0.15	2.4	0.1	H= 3.87+0.95
	beams		0.35	general timber		4	8.75	0.1	0.1	
Secondary										
Exterior wall_ box in North										
	wall construction									
	finishes, exterior		1.2312	cladding	41.04		17.1	2.4	0.03	L=N+E+W+S
	cladding framework		0.0486	wood	1.62		54	0.03	0.03	
	vapour barrier		0.2052	Upvc film	41.04		17.1	2.4	0.005	
	insulation fraemwork		0.96	general timber	0.12	40	0.05	2.4	0.2	btw studs=500mm
	insulation		9.504	cellulose	23.76		9.9	2.4	0.4	
	non load-bearing walls/vapour barrier		0.4752	OSB	23.76		9.9	2.4	0.02	
	insulation		1.188	cellulose	23.76		9.9	2.4	0.05	
	finishes, interior		0.3564	plasterboard	23.76		9.9	2.4	0.015	
	doors and windows			wooden frame	2.7	1	1.2	2.25		
				window area	**2.7**					
	Furniture									
				Double bed						
				single bed						
	Appliances									
	Electricity									
	HVAC									
Exterior wall_ box in South					26.64					with windows
	wall construction									
	finishes, interior		1.0152	plasterboard	33.84		14.1	2.4	0.03	L=N+E+W+S
	cladding framework		0.02133	wood			23.7	0.03	0.03	
	weather proofing		0.6768	hunton asfalt vindtett	33.84		14.1	2.4	0.02	
	insulation framework		0.144	general timber		6	0.05	2.4	0.2	btw studs=500mm

insulation	5.124	cellulose	12.81		5.5	2.4	0.4
non load-bearing walls/vapour barrier	0.2562	OSB	12.81		5.5	2.4	0.02
insulation	0.6405	cellulose	12.81		5.5	2.4	0.05
finishes, interior	0.19215	plasterboard	12.81		5.5	2.4	0.015
doors and windows		wooden frame window	3.375	1	1.5	2.25	
		wooden frame window	7.2	1	3.2	2.25	
		wooden frame window	3.255	1	2.1	1.55	
		window area	**13.83**				
Furniture							
		dining table					
		chairs					
Appliances							
Electricity							
HVAC							
Internal wall_ box in middle							
finishes, exterior	0.6624	cladding	22.08		9.2	2.4	0.03
cladding framework	0.00756	wood	0.252		8.4	0.03	0.03
vapour barrier	0.288	Upvc film	5.76		2.4	2.4	0.05
insulation fraemwork	0.048	general timber	0.12	2	0.05	2.4	0.2
insulation	2.304	cellulose	5.76		2.4	2.4	0.4
non load-bearing walls	0.4416	OSB	22.08		9.2	2.4	0.02
finishes, interior	0.8832	cladding, sheeting	22.08	2	9.2	2.4	0.02
doors and windows		WC door	1.8		0.9	2	
doors and windows		WC door	3		1.5	2	
Furniture							
		desk					
Appliances		kitchen					
		refrigerator					
		freezer					
		oven					
		dishwasher					
		laundry					
		clothes washer					
		clothes dryer					
		media					
		TV	21 inch.				
		DVD player(or video player)					

		Computer(notebook,lapt 17 inch.						
	Electricity							
	HVAC							
Slabs_BOX Floors								
	finishes, interior	0.7992	hard wood with vertical g	13.32	3	11.1	1.2	0.02
	floor I beams	1.665	general pine	2.775	6	11.1	0.25	0.1
	floor construction	3.996	massive wood slab	13.32	3	11.1	1.2	0.1
	insulation	3.1968	VIP	13.32	3	11.1	1.2	0.08
	weather proofing	0.7992	vapour barrier/ huntonas	13.32	3	11.1	1.2	0.02
Slabs_BOX ceilings								
	slab	3.996	massive wood	13.32	3	11.1	1.2	0.1
Placeholder/ Upper walls								
east, west	finishes, exterior	2.3848	cladding	29.81				0.08
	weather proofing	0.5962	vapour barrier/ huntonas	29.81				0.02
	insulation	11.924	cellulose	29.81				0.4
		0.44715	vapour barrier/ huntonas	29.81				0.015
	installation layer	1.4905	insulation	29.81				0.05
	finishes, interior	0.44715	plasterboard	29.81				0.015
			north area	15.75				
			east/weast	7.03				

component	ref.no	no. unit (ı	specification	Area (m2)	Number	Length (m)	height (m)/	Thickness	comments
space floor									
finishes, interior		1.0656	hard wood with vertical grain	26.64	2	11.1	2.4	0.02	
flooring		2.664	sound insulation?	26.64	2	11.1	2.4	0.05	
floor construction		5.328	massive wood slab	26.64	2	11.1	2.4	0.1	
insulation fraemwork		1.008	general pine	0.84	12	2.4	0.35	0.1	
insulation		4.2624	VIP	26.64	2	11.1	2.4	0.08	
weather proofing		1.0656	vapour barrier/ huntonasfalt	26.64	2	11.1	2.4	0.02	
Window									
East/ west			wooden frame window	5.4	4	2.4	2.25		
			window area	**21.6**					

Title	ref.no	no. of unit (n	specification	Area (m2)	Volume (n	Numbe	Length (m)	height (m),	Thickness (	comments
Roof										
roofing		1.98912	PV integrated on roof	99.456	1.98912		11.2	8.88	0.02	
battens		0.1764		0.56	0.1764	9	11.2	0.05	0.035	
roofing felt		4.9728		99.456	4.9728		11.2	8.88	0.05	
roof sheeting		2.4864	plywood	99.456	2.4864		11.2	8.88	0.025	
rafters		1.176	wood	1.12	1.176	7	11.2	0.1	0.15	
weather proofing		1.98912	hunton asfalt vindtett	99.456	1.98912		11.2	8.88	0.02	
insulation		7.95648	VIP	99.456	7.95648		11.2	8.88	0.08	
roof slab		9.9456	massive wood	99.456	9.9456		11.2	8.88	0.1	
roof finishes		0.99456	plasterboard	99.456	0.99456		11.2	8.88	0.01	
Electricity										
			PV panels							

component	ref no.	no. of (m3)	specification	Area (ı	Number	Length (ı	height (ı	Thickness	comments
Site construction									
deck slab		2.04	wooden floo	40.8		17	2.4	0.05	
ramp		0.9	wooden floo	18		15	1.2	0.05	
handrails									

Building Services

wate water, fresh water, Gas	
	gray, black water facilities
	water facilities
	gas facilities
	prefab. sanitary objects
	plumping
Heating	
	heat facilities
	heat distribution
	local heating installation
	thermal collectors
	other
Ventilation / Air Conditioning	
	ventilation
	part air conditioning
	air conditioning
	cooling
	other
Electricity	
	PV panels
	high (> 60kV) and medium (> 1kV, < 60kV) voltage facilities
	electricity supply
	low voltage (< 1kV) switch gear
	low voltage installations
	lighting
	lightning protection and earthing
	other
Transportation	

Design issues, **popping up when studying the design.**

(Vegard: This doesn't really fit into the task but it might be useful in some way).

-Using continuous foundation beams is simpler, quicker and more precise. And it will only be necessary with 12 points.

-Solar thermal: Placed where? Maybe hybrid thermal / PV

-If using cladding of reclaimed wood, it is easier to use various width and thickness when mounted vertical.

-Joints in the outer airtight layer: If using soft wood fiber boards, those with tongue and groove make a much better joint. E.g. "Homatherm".

-If having a small upper floor suitable for sleeping ("hems"), it is necessary to have a window there that can be opened: for cross-ventilation, increased air-speed, and to prohibit claustrofobia.

-The functional cells must provide sufficient wind stability in the north / south direction. This can be achieved by making the cell stiff in itself with a cross-structure or boards. Then the cells need a strong connection to continuous foundation beams or upper gable wall parts.

-The house should definitely have a waste water heat exchanger. This can be integrated in the shower floor. The Dutch system from Bries Energietechniek called "Douchebak WTW", or from Hi-tech called "recoh-tray" is best suited in our case.
-It is only necessary with 15 -18 cm free height under the floor, and that should be no problem.

-It seems like the bottom beams in the boxes need to be bigger, in order to be stiff enough.

-The present drawings show a room height of 226 in the bathroom and 242 in the bedroom (under the second floor). Due to the sloping ceiling, the height is much greater in most areas. Such small rooms as the bathroom and bedroom can have a lower ceiling, and so it should be possible to lower the roof. By doing this, it should be possible to integrate the slabs under the boxes to be part of the boxes and still fit into the container. Technical installations (especially water and drain pipes) and assembly would then be simpler.

Detailed Water Budget

+hytte Solar Decathlon 2012

NTNU September 2011

Elisabeth Lilleby
Solveig Bergstrøm

Detailed water budget

Introduction

We want the house to contribute to a lower water usage, with appliances that are water saving and by reusing some of the water. Additionally we want to collect and use the rainwater.
The hot water tank will function as storage for the solar energy.

See the construction drawings for more detailed information about the water cycle in the house, plumbing etc.

Hot water consumption

Hot water consumption in the contest will be tested with up to three draws per day, and they might also be consecutive.
The rules say that:

- *Quality of the hot water should be $\geq$ 43^o C (full score points) and not $\leq$ 37^o C (zero points given).*
- *$\geq$ 50 liters hot water in 10 minutes must be drawn to get full score. (20.5.Subcontest 6.7)*

As we will use electricity from the solar panels and not a solar collector to heat the water, we have estimated the hot water consumption based on use of unheated water for the dish washer and the laundry machine. Details can be found in the spreadsheet that follows underneath.

The total estimated hot water consumption during the competition days is 1100 litres.

Fresh water consumption

Fresh water during the competition will be used for the dish washer, kitchen- and bath room sinks and for the laundry machine. *One of the competitions task is to vaporize 2,3 kg (= 2,3 liters) water by cooking, starting-weight at least 2,75 kg (20.5.Subcontest 6.8).* Also for the mandatory dinner there will be a fresh water consumption to take into account. See details below.

We have estimated the total fresh water consumption to 2100 litres.

Rainwater, grey water and black water

For a potential water dependent heating/cooling system, we want to collect the rain water in a separate tank.
The grey water on the other hand, can according to the rules only be used for irrigation (8.5.a), and *has to first be processed by an approved grey water reuse-system which avoids undesired organisms (see Rule 9.2).* We will therefore use a filter in connection with the grey water tank (e.g Biolan grey water filter 125, used in the Finnish team's Luukku House 2010), so that the grey water can be used for watering our vegetation. This point we have to investigate more and

then look into different solutions based on the projects collaborators.

Rules considering this: The grey water systems will be approved evaluating each particular case and considering the following criteria:
No black water source can be connected to a greywater storage or distribution system. Water coming from kitchen sinks and dishwashers is considered black water. As a reminder, the water closet will not be connected to the sewage disposal system during the event. This leaves bathtubs, showers, bath sinks and clothes washers as the only fixtures available for connection to a greywater storage/use system.
If any team pretends to use any water treatment system, they will have to send the appropriate information to the SDE Organization, indicating the fixtures connected to the greywater system, the pipes system and tanks and any other discharge points. A note must be included, indicating the safety label for any greywater reuse system. (51.8.1c)

The black water from the kitchen sink and dish washer will during the competition be collected in one separate tank.

Competition water budget

In the competition budget we have included the competition tasks and the estimated water use due to this tasks. As the number of tasks are not yet defined, we have done an estimate and the actual numbers of tasks and water use are subject to change. Everything is linked in the spreadsheet we have made, and can easily be changed there to get the correct values.

Table 1: Water consumption per use

Appliance	**Water use (in litres)**	
Hot water draws	50	According to the rules
Dish washer	6.50	Bosch eco friendly machine
Laundry Machine	56	Bosch eco friendly machine
Cooking task	2.75	According to the rules
Dinner party	20	For washing dishes and rinsing before cooking for the party, required by the rules

Table 2: Fresh water budget

Competition day	Hot water draws	Litres	Dish-washer	Litres	Laundry machine	Litres	Hot water dinner party	Litres	Cooking	Litres	
1	1	50	1	6.5	1	56			1	2.75	
2	2	100	1	6.5	1	56					
3	3	150	1	6.5	1	56					
4	1	50	1	6.5	2	112	1	20			
5	1	50	2	13	1	56					
6	3	150	1	6.5	1	56	1	20			
7	2	100	1	6.5	1	56					
8	1	50	1	6.5	1	56					
9	1	50	2	13	2	112	1	20			
10	2	50	1	6.5	1	56					
11	3	150	1	6.5	1	56					
12	3	150	1	6.5	2	112					
Total amount		1100		91		840		60		2.75	**2093.75**

Table 3: Grey water budget

Competition day	Hot water draws	Litres	Laundry machine	Litres	
1	1	50	1	56	
2	2	100	1	56	
3	3	150	1	56	
4	1	50	2	112	
5	1	50	1	56	
6	3	150	1	56	
7	2	100	1	56	
8	1	50	1	56	
9	1	50	2	112	
10	2	50	1	56	
11	3	150	1	56	
12	3	150	2	112	
Total amount		1100		840	**1940**

Table 4: Black water budget

Competition day	Dishwasher	Litres	Hot water dinner party	Litres	
1	1	6.5			
2	1	6.5			
3	1	6.5			
4	1	6.5	1	20	
5	2	13			
6	1	6.5	1	20	
7	1	6.5			
8	1	6.5			
9	2	13	1	20	
10	1	6.5			
11	1	6.5			
12	1	6.5			
Total amount		91		60	**151**

Table 5: Rainwater calculations

average precipitation in Madrid in September (mm)	roof projected surface (m^2)	precipitation volume for September (m^3)	precipitation volume to collect during competition weeks 12 days (m^3)	chosen tank dimension (l)
31	100	3100	258	300

Appliances used

All the appliances that are used in the house are energy efficient and water saving.

Dishwasher: for the estimation of water consumption per use we have used the number from Bosch eco friendly machines.

Laundry machine: for the estimation of water consumption per use we have used the number from Bosch eco friendly machines.
Here there need to be some more information on the appliances when there is decided which machines is going to be used.

Summary of tanks

We have added 20% margin of error to the total amount-numbers in the water budgets when we have estimated the sizes of the tanks. That is in case there will be some extra draws, any leakage or other unforeseen use of water.

Fresh water tank:

Location: outside the measurable area (according to the rules), fully shaded from solar radiation.

Size: 2500 litres (2093,75 litres + 20% margin of error) (result of the estimates, see tables)

Grey water tank

Location outside the measurable area.
Size: 2330 litres (1940 litres + 20% margin of error) (result of the estimates, see tables)

Black water tank

Location outside the measurable area.
Size: 180 litres (151 litres + 20% margin of error) (result of the estimates, see tables)

Rain water tank

Location outside the measurable area.
Size: 300 litres (result of the estimates, see tables)

Hot water tank

Location: inside the measurable area.
Size: Must be at least 150 litres due to the task amounts and numbers. We have concluded that for flexibility and margin of error reasons, the hot water tank will be 250 litres.

The filling of the tanks

There must be easy access for the filling and draining of the tanks. A good example from other teams is underneath the deck, with maintenance doors in the deck, or removable panels. As the SDE Organization have not yet concluded on which system they will use for filling and draining of the tanks, this has to be considered on a later occasion. (See Appendix 1)

Questions

As a lot of things in connection with water use is not yet decided upon from the organizers of the competition, there are a lot of questions. The main ones are:

1. **Heating/cooling:** Do we have a cooling system that uses (more than one filling) or needs (only one filling) water? Do we have a heating system that uses/needs water? Do we have floor heating? Do we have an evaporation cooling system?
2. **Stratified storage:** A team (Stuttgart 2010) used stratified storage within the conditioned zone and a deionized water tank outside. Is this something that is interresting for us to look into? (Does it have to do with the lime content of the water in Madrid?)
3. **Sterilize water:** Do we need to sterilize the water in some way? It seems that some of the groups from the 2010-competition has used UV-sterilization for a part of the water. But we guess it is only for specific purposes that we need to look into this.
4. **Water closet**: It is not connected to the sewerage system during the competition week anyway, so it won't be any concern with pipes on locatioin and it won't be in use. But in a norwegian Hytte, we might not want a regular water closet anyway? What will be our solution? Is that a topic we should discuss under the water-chapter?
5. **Cooking:** Shall we cook anything besides for the dinner parties and the cooking task (2,75 kg) (for example, shall anyone live in the house during the competition)? Will the cooking task be given more than one time?
6. **Water in circulation:** Should water in circulation in the heating/cooling-system be included in the fresh water budget?
7. **Irrigation:** Should irrigation be included in the water budget?

Appendix

Here we have included questions from participants and answers from the Solar Decathlon Organization, and good examples of water budgets and drawings related to the water budget from former projects.

1. Use of water for heating and cooling, delivery of water

	Question about Rule 8 Liquids by Yuichiro Tahara - Thursday, 21 July 2011, 06:32 AM
	Dear SDE Organization, We are choosing water supply & waste containers. We want to know following 2 points. 1. The water delivery & removal frequency We want to know the frequency to decide containers' size. 2. How to Deliver & Remove? What kind of equipment does the SDE organization use to deliver water to the supply container and to remove waste water from the waste container? We want to know this information to choose our containers' fittings. Yours sincerely

	Re: Question about Rule 8 Liquids by Claudio Montero - Friday, 22 July 2011, 01:35 PM
	Dear CUJ Team, 1. We have not yet finalized how the SDE Organization will supply and remove water. Therefore it is impossible for us to answer your question at this time. 2. The answer will depend on the system we will select. As soon as we have concrete information concerning the above we will notify all teams. In 2010 all the teams prepared an estimation of water usage for the competition week and design their tanks size taking into account this data. Universities had to bring their own elements for obtaining and removing water. For your information, the SDE organization constructed a general plumbing and drainage system. Sorry we are not able to give you more information at this time. Sincerely

Juan Valero
SDE Organization

2. Grey water use

Questions from Revolt House
by Ermal Kapedani - Wednesday, 8 June 2011, 02:04 PM

Hello,
We have a few questions:
1. In the rule book it is mentioned that for a certain period of time active systems would be turned off. Is the definition of an active system for that purpose alone?
2. What are the times in which the house would be monitored for comfort? would the comfort measurements include the time of the tours in the house and the dinner parties? During a tour, the house would be open very frequently and would not act as an average house.
3. Our house will be floating in a pool. Is it allowed to use the pool's water as part of the house's climatic system (ie circulate water through the house, or use the cool air on the water surface)
4. Grey water can only be re-used for irrigation: Does that mean that treated waste water from the shower or sink can't be sent to the washing machine? Kitchen, toilet and washing machine have to be serviced directly from the water supply tank?

Thanks,
Ermal Kapedani

Re: Questions from Revolt House
by María Porteros - Wednesday, 15 June 2011, 01:09 PM

Dear TUD Team,
Please find the following answers to your questions:

1.As already mentioned the SDE 2012 Organization is working to specify all the details concerning the passive evaluation of the houses' comfort systems. Therefore we are working on the specific definition of the mechanical equipment which must be disconnected during these evaluation periods. As soon as we have further information, we will include it in the SDE Rules and inform all the teams through the SDE WAT.

2.The time periods for the comfort conditions monitoring will be specified in the SDE 2012 Detailed Event Schedule. However, the comfort conditions will not be measured during the Public Tours and the Dinner Parties.

3.Yes, as you mention, you may use the pool's water as part of the house's climatic system.

4.As stated in Rule 8.5 "in the Villa Solar, teams may reuse grey water for irrigation only". Therefore, as you mention, kitchen, toilet and washing machine have to be serviced from the water supply tank.

	We hope this answers helps you continue working. Best regards, María Porteros Mañueco Competition Strategies Coordinator

3. Black water and grey water

	Question about rule 51.8 by Bruna Souza - Wednesday, 3 August 2011, 03:59 PM
	Hello! We have a doubt about rule 51.8. It states.on item "c" that "no black water source can be connected to a greywater storage or distribution system. Water coming from kitchen sinks and dishwashers is considered black water." We would like to know if water coming from kitchen sinks and dishwashers after passing through a grease interceptor may connect to our grey water treatment system. Thank you! Team Brasil

	Re: Question about rule 51.8 by María Porteros - Monday, 8 August 2011, 10:32 AM
	Dear BRA Team, As you mention, and as stated in Rule 51.8 *"This leaves the bathtubs, showers, bath sinks and clothes washer as the only fixtures available for connection to a greywater storage/ use system."*Therefore, you may not connect the kitchen sink nor the dishwasher to the greywater storage or distribution system. We are sorry for any inconvenience. Best regards, María Porteros Competition Strategies Coordinator