ENERGY AND CO_2 ANALYSIS

using the Altiflex System

DENMARK

Report	**Altiflex – Energy and CO_2 analysis**
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Resumé

Altiflex is a Danish manufacturer of a modular temporary enclosure system for the construction industry. The Altiflex System is used for new construction and renovation/refurbishment projects and offers improved working environment by effective protection against draught winds and low temperatures. For Altiflex ApS, Viegand Maagoe have carried out a desk analysis of the energy consumption and CO_2 emissions for the use of the Altiflex System compared to common methods of temporary enclosure such as plastic and plywood.

An analysis of the CO_2 emissions for heating is carried out based on a case built up of 300 m^2 enclosed by the Altiflex System (modules), plastic, or plywood in the winter months of December to March. As the total CO_2 emissions for heating mainly depends on the heating method, the analysis investigates five commonly used heating methods: electric heating, district heating, natural gas, fuel oil and diesel.

The analysis shows large energy savings for heating when the Altiflex System is used. Compared to plastic, the energy reduction is 63% and 42% for plywood. Converted to CO_2 emissions, the use of the Altiflex System instead of plastic, saves 14.0 tonnes if heated by fuel oil and 1.7 tonnes if heated by district heating. In Denmark, district heating has the lowest CO_2 impact compared to other heating sources.

In financial terms, the use of the Altiflex System saves 27-44% and 26-32% of the total cost compared to plastic and plywood respectively, based on a covered area of 300 m^2 and for 4 winter months.

An analysis of the climate effect of production and the end-of-life stage (EOL) shows that Altiflex modules in total reduces the global Warming potential through the production phase, usage phase and end- of-life cycle.

The comparable analysis of the footprint of the different setups includes the production phase of materials and the assembly of the Altiflex modules at the Altiflex facility, the energy consumption during operation for 4 months, and the end-of-life stage of the different materials used in the setups. The analysis is not to be considered as a thorough Life Cycle Assessment (LCA) but gives a comparable picture of the impact of the different setups. Data used in the analysis is from the German ÖKOBAUDAT database, which contains generic data on various building materials. This database is also the backbone of the official Danish tool for performing LCA's of entire buildings and is thus representative for Danish and European conditions.

The overall CO_2 footprint of using the Altiflex System compared to plastic and plywood in the considered setups is lower through the whole life cycle. Use of the Altiflex System reduces the global warming potential (kg CO_2-eq) by 8.6 tonnes (62%) and 4,3 tonnes (44%) compared to plastic and plywood, respectively.

300 m^2 of Altiflex modules reduces the CO_2 emissions for heating by **63%** over 4 months compared to plastic.

300 m^2 of Altiflex modules reduces the total CO_2 footprint by **8.6 tonnes** over 4 months compared to plastic.

300 m^2 of Altiflex modules reduces the emissions of particles and harmful gasses for heating by **63%** over 4 months compared to plastic.

300 m^2 of Altiflex modules reduces the overall cost of temporary enclosure by **27-44%** compared to plastic and **26-32%** compared to plywood.

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1 Introduction

For many decades there has been a large focus on reducing the energy consumption in buildings during use, mainly due to stricter requirements in the building codes and regulations.
This year (2020) a new voluntary sustainability class was introduced in the danish building regulations, which has a much larger focus on sustainability. Among the priorities are energy consumption during the construction phase, embedded energy in materials and life cycle assessments of building products.

The sustainability class is expected to be made mandatory in the coming years.

In that context Viegand Maagoe has been tasked by Altiflex to prepare a short report containing calculations on energy consumption and CO_2 emissions using the company's products, the Altiflex System, and comparing it to alternative materials, specifically plastic and plywood.

The task is divided into two sub-tasks.

Task 1
The first part calculates the CO_2 emissions and expenses for heating of a specified building. The calculations are based on a tool delivered by Altiflex,, vetted by Viegand Maagoe, that calculate the energy saving by using the Altiflex System compared to other materials. Expenses for heating and CO_2 emissions are calculated for different heating methods: electric heating, district heating, natural gas, fuel oil and diesel.

Task 2
In the second part, an analysis is performed of the overall 'footprint' using Altiflex product in relation to the alternative of plastic or plywood.
Altiflex have previously obtained comprehensive data from their suppliers regarding CO_2 footprints, but in this report the calculations are based on generic and official sources such as the ÖKOBAUDAT database and the Danish LCA Byg. The analysis will use standard factors to ensure credibility of the calculations, and includes production, use of the product and disposal. The analysis is based on the large material groups in the product, primarily plastic and aluminium. Materials that make up a few percent of the total product are not included.

2 Viegand Maagøe

Viegand Maagøe is a consulting firm that helps our customers to create added value in the green transition. Viegand Maagøe offers consultancy in the areas of energy, sustainability, resources, and climate in Denmark and abroad. Our work is based on our competencies in the areas of technology, communication, and financial matters. We have extensive experiences in analyses of the environmental impact of products and materials, mapping of CO_2-emissions and energy consumption in buildings. Our customers are public as well as private companies.
We are approximately 50 consultants working from Aarhus and Copenhagen.

3 Company- and product description

Altiflex is a Danish manufacturer of a modular temporary enclosure systems, the Altiflex System, for the construction industry. The Altiflex System is used for new construction and renovation/refurbishment projects and provides improved working environment with effective protection against draught winds and low temperatures. The modular system can be used as eg. temporary walls, hoardings, and work enclosures during the construction process, which helps to significantly reduce heat loss. With effective temporary enclosures, the challenge of excessive moisture during construction is minimized, and drying and curing of concrete happens much quicker.

The modules consist of an aluminium frame, and corner and window fittings made of composite plastic and a transparent polycarbonate sheet with enclosed air in between to improve the insulation properties. Each module can be adjusted in height and width to fit all buildings and set-ups.

Figure 1. standard Altiflex module

For large openings multiple Altiflex modules can be combined as seen in Figure 2.

Figure 2. Multiple Altiflex modules combined

4 Case setups

The case setup consists of a building 20 x 40 meters with a solid wall on one side. The height of the floor is 3,75 meters. Thus, a total of 300 m^2 of area is investigated using different materials. One wall of the installation is assumed to be an internal wall without any heat transmission through the wall. The same applies for the floor slabs. An overview of the case building is seen below in Figure 3. The arrows illustrate the surfaces where heat transfer occurs. Infiltration is not taken into account.

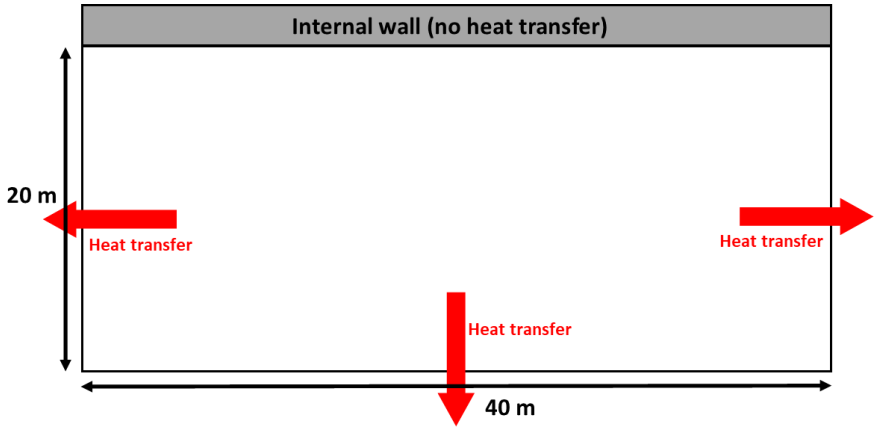


Figure 3. Case building. The red arrows show the heat transmission through the exterior walls. The calculations assume that there is no heat transfer through the internal wall.

Examples of the different setups are shown below. The plastic and plywood setups are based on the same wooden frame. Plastic and plywood are thus mounted on this frame.

Altiflex	Plastic	Plywood
		

Figure 4. Example of Altiflex modules, plastic and plywood setups. Source: Altiflex

The materials are compared for 4 winter months - December to March - a total of 120 days.
To calculate the heat loss, it is assumed that the indoor temperature is constantly held at 15 °C, according to the Danish Working Environment Authority requirements for stationary work. Outdoor temperatures are the average monthly temperature according to the Danish Meteorological Institute, as seen in Figure 5.

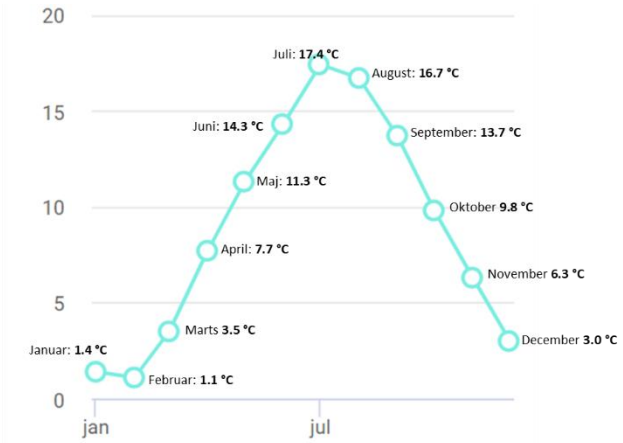


Figure 5. Monthly average temperature in Denmark 2006-2015. Source. DMI

The insulation properties of the different materials used in this analysis are shown below.
The U-values for plastic and plywood is calculated from the thermal conductivity and thickness. In practical use, air-gaps are impossible to avoid. The presence of airgaps is included in the U-value for plastic and plywood. For the Altiflex-module, airgaps have been accounted for in the U-value test carried out by Danish Technological Institute.

Material	U-value	Source
Altiflex module	2.5 W/m^2/K	Practical test by Danish Technological Institute (TI)
Plastic (2,5 mm)	6.7 W/m^2/K	Calculated based on thermal conductivity. Convection heat transfer coefficient inside and outside is included. The U-value also includes correction for air gaps.
Plywood (9 mm)	4.3 W/m^2/K	Calculated based on thermal conductivity. Convection heat transfer coefficient inside and outside is included. The U-value also includes correction for air gaps.

Figure 6. U-values for the different materials. Documentation can be seen in Appendix.

5 CO_2 emissions for heating

The heat consumption used to maintain 15 °C inside the case building in December to March is shown in the graph below.

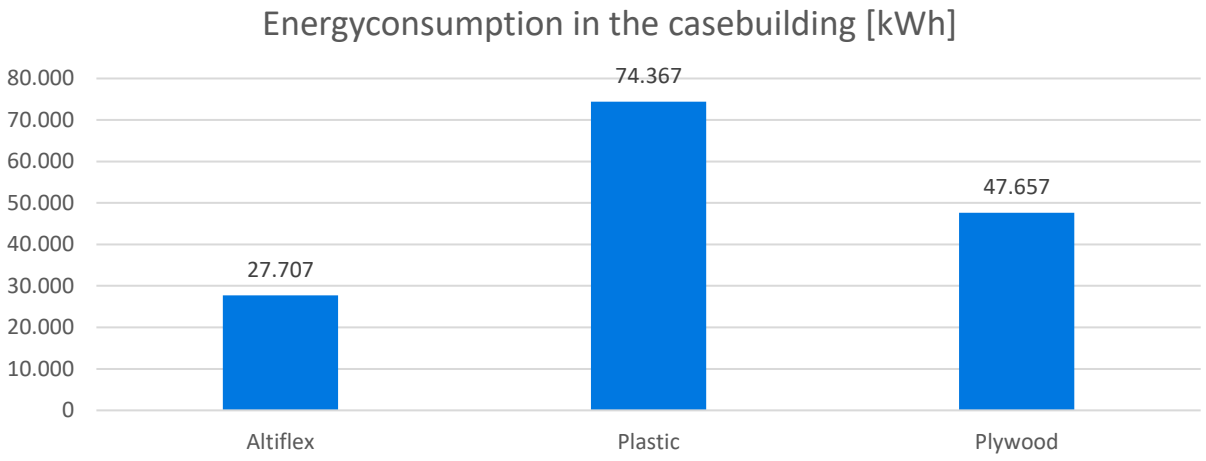


Figure 7. Energy consumption in the case building during the months of December to March.

The use of Altiflex modules reduces the energy consumption by almost 47 MWh (63%) compared to use of plastic and 20 MWh (42%) compared to plywood.

To calculate the CO_2-emissions for heating the emission factors in the Danish energy mix is used for electricity and district heating based on 2019. Data for natural gas, fuel oil and diesel are based on the Danish Energy Agencies' official datasets.

Heating method	Kg CO_2/kWh
Electricity	0.042
District heating	0.035
Natural Gas	0.206
Fuel oil	0.284
Diesel	0.267

Figure 8. CO_2 emissions for different heating methods. Sources: Energinet, Energistyrelsen and HOFOR

The CO_2 emissions for the different setups are shown in Figure 9. The lower heat consumption using the Altiflex modules is reflected in the CO_2 emissions. Across all heating methods Altiflex modules result in lower CO_2 emissions. In the section below, the CO_2 emissions for the different setups are described more thoroughly.

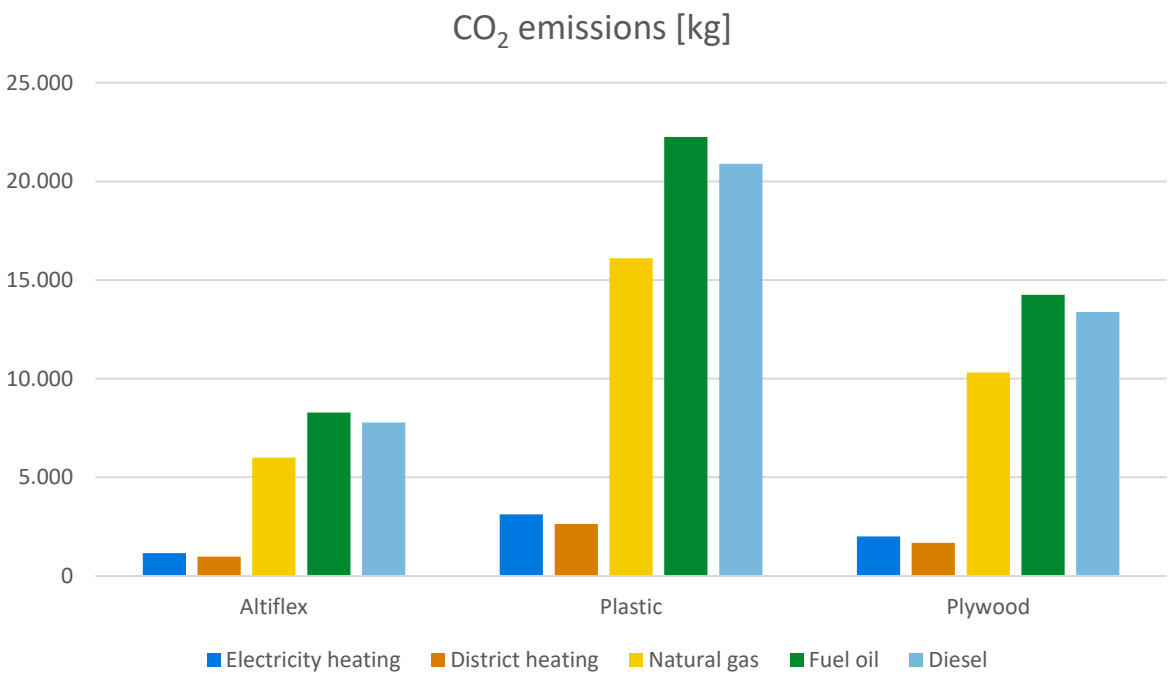


Figure 9. CO_2 emissions for the use of Altiflex modules, plastic and plywood for different heating methods.

Altiflex Modules compared to the plastic setup

Comparing Altiflex modules with plastic reduces the CO_2 emissions significantly. The CO_2 reduction depends significantly on the mode of heating. If district heating is used, the CO_2 reduction over the 4 winter months is 1.7 tonnes while the reduction is significantly higher if heated by fuel oil or diesel, 14.0 tonnes and 13.1 tonnes, respectively.

In the table below, the CO_2 reductions can be found for the different heating methods.

Altiflex modules vs. Plastic	Dec (31 days)	Jan (31 days)	Feb (28 days)	Mar (31 days)	Total
Total energy savings by using Altiflex [kWh]	11,276	12,780	11,797	10,806	**46,659 [kWh]**
CO_2 reduction by using Altiflex [kg]					
Electricity heating	474	537	495	454	**1,960 kg**
District heating	399	452	418	383	**1,652 kg**
Natural gas	2,442	2,767	2,555	2,340	**10,103 kg**
Fuel oil	3,373	3,823	3,529	3,233	**13,958 kg**
Diesel	3,166	3,588	3,313	3,034	**13,102 kg**

Figure 10. CO_2 emission reduction by use of Altiflex modules compared to plastic for different heating methods.

Altiflex Modules compared to plywood

Altiflex compared to plywood has less impact on the CO_2 emissions for heating compared to the use of plastic. Plywood has much better insulation properties than plastic and thus the CO_2 reduction is less.

Altiflex modules vs. plywood	Dec (31 days)	Jan (31 days)	Feb (28 days)	Mar (31 days)	Total
Total energy savings by using Altiflex (kWh)	4,821	5,464	5,044	4,620	**19,949 [kWh]**
CO_2 reduction by using Altiflex [kg]					
Electricity heating	202	229	212	194	**838 kg**
District heating	171	193	179	164	**706 kg**
Natural gas	1,044	1,183	1,092	1,000	**4,320 kg**
Fuel oil	1,442	1,634	1,509	1,382	**5,968 kg**
Diesel	1,354	1,534	1,416	1,297	**5,602 kg**

Figure 11. CO_2 emission reduction using Altiflex modules compared to a setup with plywood

Air pollution and particles

Reduction of energy consumption also influences the level of particles emitted while producing heat.
The emission of particles from producing electricity and district heating are available through the environmental declaration released by the energy supplier. The emission of particles from heating by natural gas, fuel oil and diesel depend on the efficiency of the combustion process and is not included in this analysis.

Use of Altiflex modules reduces the emission of particles by 0,47 kg and nitrogen oxides (NO_x) by 9.33 kg compared to plastic when heating with electricity. Altiflex compared to the combination of plywood and district heating reduces the nitrogen oxides (NO_x) by 2.18 kg and carbon monoxide (CO) by 1.88kg.

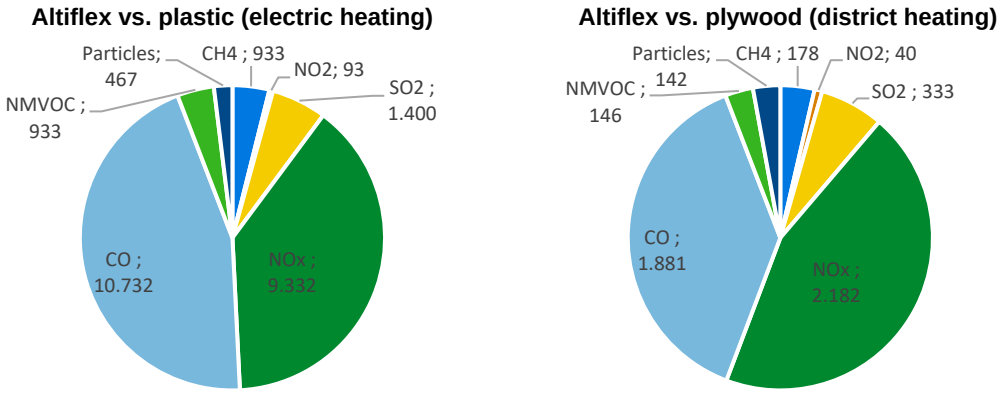


Figure 12. Reduction of particles and harmful gasses for heating. The reductions are shown in g.

6 Economy

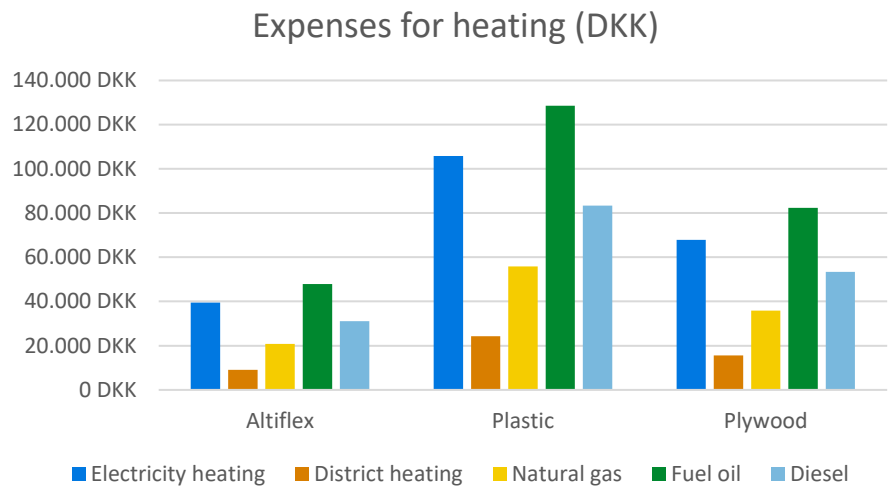
6.1 Expenses for heating

In this section, the cost of using the Altiflex modules is compared to the cost of using plastic and plywood. Expenses for heating is based on average energy prices in Denmark and is seen below.

Heating method	Price
Electricity	1.42 DKK/kWh
District heating	0.33 DKK/kWh
Natural Gas	8.26 DKK/m^3
Fuel oil	16.50 DKK/li-tre
Diesel	11.17 DKK/li-tre

Figure 13: Expenses for different energy sources. Source: Energistyrelsen, Danmarks Statistik and OK historical price overview. The prices include energy-taxes but excludes VAT.

The expenses for heating using Altiflex modules compared to plastic and plywood is shown in Figure 14.



300 m² of Altiflex modules reduces the expenses for heating by 66,000 DKK over 4 months (electricity) compared to plastic.

Figure 14. Expenses for heating of the case building during December-March

The largest financial saving can be found if the building is heated with electricity due to the relative high price of electricity compared to district heating and natural gas.

6.2 Total expenses

In this section, the total cost of using Altiflex, plastic and plywood is calculated. It includes the initial cost of installing the modules at the construction site and the expenses for heating by different heating methods for 4 months.

Expenses for the different solutions are delivered by Altiflex.

Total economy	Altiflex modules	Plastic	Plywood	Savings Altiflex modules vs. plastic	Savings Altiflex modules vs. plywood
Initial cost including installation (300 m²)	81,036 DKK	99,570 DKK	106,785 DKK		
Total expenses. Initial cost + operation cost in DKK					
Electricity heating	120,480	205,438	174,629	41,4%	31,0%
District heating	90,080	123,843	122,340	27,3%	26,4%
Natural gas	101,853	155,443	142,590	34,5%	28,6%
Fuel oil	128,940	228,145	189,181	43,5%	31,8%
Diesel	112,097	182,939	160,210	38,7%	30,0%

Figure 15. Financial overview of using Altiflex modules, plastic and plywood. The table show the total expenses including the initial cost of installation of materials and the cost of heating in DKK.

The largest saving in percent is found when Altiflex modules are compared to plastic with savings of 27-44%%. In general, the heating cost represents a large share of the total expenses for the plastic setup. When using plywood and Altiflex modules, which have much better insulating properties, the initial price represents a larger share of the total expenses. As found in the table, the use of Altiflex modules instead of plywood reduces the total cost by 26-32%.

7 Analysis of climate effect of production and end-of-life stage

In this section we investigate the CO_2 emissions from the production and end-of-life stage for the use of Altiflex modules compared to use of plastic and plywood.

This is not a thorough Life Cycle Assessment (LCA) according to EN15978, but a simpler comparative analysis based on generic data for each material to provide an indication of the climate effect of production and end-of-life stage.

Figure 16 shows the processes that are part of the five phases of a building's life cycle, as defined in the European standard EN 15978. In total there are 15 processes relating to the life cycle of the building materials and 2 processes relating to the operation (operating energy consumption and water consumption, respectively). It is very comprehensive to obtain information on all the 15 processes related to the use of materials in buildings and include them in a life cycle assessment. Thus, simplifications are usually made in the calculations performed.
In the last row, it is marked which processes that are included in this analysis.

Life phases	A 1-3			A 4-5		B1-7							C 1-4				D
	Production phase			Erection phase		Use phase							End of the life cycle				Benefits and liabilities outside of the system limits
	Raw materials procurement	Transport	Production	Transport	Erection/installation	Use 1	Maintenance 2	Repair	Replacement	Modernisation	Energy consumption during operation	Water consumption during operation	Dismantling/demolition	Transport	Waste recycling	Disposal	Potential for reuse, recovery and recycling
Modules in accordance with DIN EN15978	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Covered in this analysis	X	X	X								X				X	X	X

Figure 16. LCA diagram according to DIN EN15978.

7.1 Data sources

Material quantities (Bill of Materials) are delivered by Altiflex for all setups. Data for the Global Warming Potential (GWP) for each material is based on the German ÖKOBAUDAT database, which contains large amount of generic data on various building materials. The database is also used by the official Danish tool for calculating LCA's on buildings, LCA-Byg, and is considered to be representative for the Danish construction market.

The data for GWP for the different materials from the ÖKOBAUDAT database is compared to the European Union's Ecodesign Ecoreport tool to verify data. The EcoReport tool is the European Union's official tool to calculate product specific characteristic into environmental impact indicators and can be used as a life cycle assessment tool.

7.2 Limitations and assumptions

In the calculations certain assumptions has been made. In general, only the major materials are considered, thus minor material groups like screws and brackets are not included in the analysis. In the analysis the Altiflex modules are considered reused 60 times before disposal (3 times a year for 20 years in average), while the timber used to support the modules is reused 7 times as these are customized to be used with Altiflex modules. This information is delivered by Altiflex.

Plastic and plywood setups are not reused when dismantled and is send to an incineration facility.

The table below describes which areas that are included/excluded of the analysis.

Included in analysis	**Not included in the analysis**
Altiflex modules	
• Generic data on the large material groups for production and end-of-life stage • Assembly of the modules at Altiflex factory All processes at the Altiflex factory/warehouse is driven by electricity. The yearly electricity consumption is divided by the number of produced modules to allocate the emissions from assembly to each module • Energy consumption during operation (December to March)	• Screws and brackets • Transport of modules to and from the building site • Installation and dismantling of modules • Transport to warehouse/recycling/incineration facility • Energy consumption for storing the used modules between use • Repair and replacement during the use-phase • Water consumption
Plastic	
• Generic data on the large material groups for production and end-of-life stage • Energy consumption during operation (December to March)	• Screws and brackets • Transport of materials to and from the building site • Installation of the plastic setup • Dismantling and transport to recycling / incineration facility • Repair and replacement during the use-phase • Water consumption
Plywood	
• Generic data on the large material groups for production and end-of-life stage • Energy consumption during operation (December to March)	• Screws and brackets • Transport of materials to and from the building site • Installation of the plywood setup • Dismantling and transport to recycling / incineration facility • Repair and replacement during the use-phase • Water consumption

Materials used in Altiflex module

The table below show the materials included in one Altiflex standard module. Aluminium makes up more than half of the total weight while the minor parts are EPDM , composite plast and polycarbonate.

Parts	Unit	Item name	Weight	Unit	Material	Total weight (kg)	Weight-%
2	Pcs.	Alu-Profil V3	5.8	kg	Aluminium	10,15	38,6%
2	Pcs.	Alu-Profil V3	2.52	kg	Aluminium	5,03	19,1%
2	Pcs.	EPDM - Profil V3	0.72	kg	EPDM rubber	1,44	5,5%
2	Pcs.	EPDM - Profil V3	0.35	kg	EPDM rubber	0,69	2,6%
4	Pcs.	V3-Hjørne	1,09	kg	composite plastic (PA6)	4,34	16,5%
6	Pcs.	V3-Rudebeslag	0,25	kg	composite plastic (PA6)	1,50	5,7%
1	Pcs.	V3-Rude	3,16	kg	Polycarbonat	3,16	12,0%
Sum						**26,3**	**100 %**

7.3 Materials used in the three setups

In the tables below, the total amount of materials for the cover of 300 m^2 is shown. Only major materials are included.

Altiflex modules setup (300 m^2)

Parts	Unit	Varenavn	Weight	Unit	Material	Total weight (kg)	Weight-%
216	Pcs.	Alu-Profil V3	5.8	kg	Aluminium	1,096	32,50%
216	Pcs.	Alu-Profil V3	2.52	kg	Aluminium	543	16,1%
216	Pcs.	EPDM - Profil V3	0.72	kg	EPDM rubber	156	4,6%
216	Pcs.	EPDM - Profil V3	0.35	kg	EPDM rubber	75	2,2%
432	Pcs.	V3-Hjørne	1.09	kg	composite plastic (PA6)	469	13,9%
648	Pcs.	V3-Rudebeslag	0.25	kg	composite plastic (PA6)	162	4,8%
108	Pcs.	V3-Rude	3.16	kg	Polycarbonat	341	10,1%
127,5	m	Timber posts	4.18	Kg/m	Wood	533	15,8%
Sum						**3,374**	**100 %**

Figure 17. Total quantity of materials used in the Altiflex modules setup to cover 300 m^2. Screws and brackets are excluded.

Plastic setup (300 m^2)

Parts	Unit	Item name	Weight	Unit	Material	Total weight [kg]	Weight-%
300	m^2	Plastic cover	0.170	kg/m^2	Plastic PE	51	1,9%
522.6	m	Timber posts	4.18	kg/m	Wood	2184	81,3%
522.6	m	Wood beams	0.86	kg/m	Wood	452	16,8%
Sum						**2,687**	**100%**

Figure 18. Total quantity of materials used in the plastic setup to cover 300 m^2. Screws and brackets are excluded.

Plywood setup (300 m²)

Parts	Unit	Varenavn	Weight	Unit	Material	Total weight [kg]	Weight-%
300	m^2	Plywood cover	5.72	kg/m^2	Plywood	1,716	44,0%
522.6	m	Timber posts	4.18	kg/m	Wood	2,184	56,0%
Sum						**3,900**	**100%**

Figure 19. Total quantity of materials used in the plywood setup to cover 300 m^2. Screws and brackets are excluded.

7.4 Global Warming Potential (GWP)

In the table below, GWP for each material used in the different setups, are shown for production and the end-of-life stage. The data used is found in the database in the official Danish tool for calculating Life cycle assessments on buildings, 'LCA Byg'. The data is based on the German ÖKOBAUDAT database, that is one of the most complete databases on generic data of building materials.

Item name	Material	GWP Production	GWP End-of-life	Source
		[kg CO2-eq/kg]	[kg CO2-eq/kg]	
Alu-Profil V3	Aluminum	10,680	0,003	LCA Byg / ÖKOBAUDAT database
EPDM - Profil V3 sider	EPDM	3,214	3,161	LCA Byg / ÖKOBAUDAT database
V3-Hjørne	PA 6	10,660	2,879	LCA Byg / ÖKOBAUDAT database
V3-Rudebeslag	PA 6	10,660	2,879	LCA Byg / ÖKOBAUDAT database
V3-Rude - production	Polycarbonat PC	5,109	3,053	LCA Byg / ÖKOBAUDAT database
Plastic cover	Plastic PE	1,997	2,783	LCA Byg / ÖKOBAUDAT database
Timber posts	Wood	-1,440	1,644	LCA Byg / ÖKOBAUDAT database
Wood beams	Wood	-1,162	1,828	LCA Byg / ÖKOBAUDAT database
Plywood	Wood	-1,013	1,518	LCA Byg / ÖKOBAUDAT database

7.5 Results

Figure 20 shows the total Global Warming Potential (GWP) in the production, operation phase and the end-of-life stage.

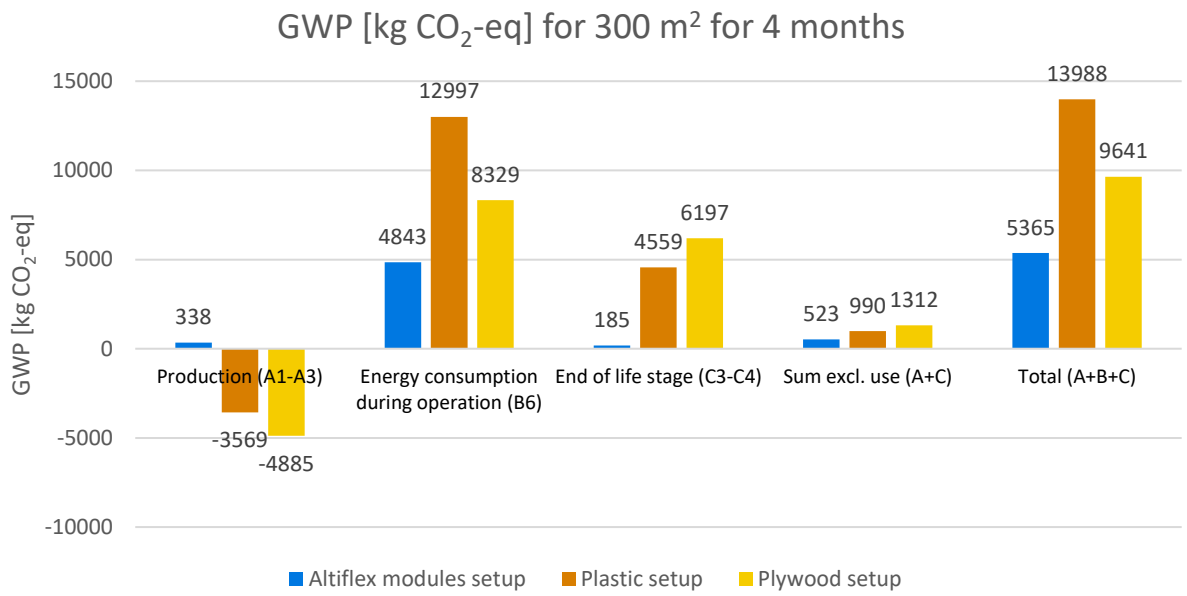


Figure 20. GWP for the use of Altiflex modules, plastic and plywood for a covered area of 300 m² and 4 months use.

Production phase

As seen, the use of Altiflex modules in the case setup of 300 m², have a GWP of 338 kg CO_2-eq in the production phase, while the plastic and plywood setups have a negative global warming potential in the production phase due to the large share of wood in these setups. Wood absorbs CO_2 during the growth phase which leads to a negative GWP in the production phase. The embedded CO_2 of wood is released during the end-of-life stage.

Energy consumption during operation

The energy consumption during the use-phase is based on the previous calculations. The average CO_2 emissions for the use of electricity, district heating, natural gas, fuel oil and diesel is used to illustrate the CO_2- emissions during operation.

End-of-life stage

In the end-of-life stage modules have a significantly lower GWP than plastic and plywood. Altiflex modules have a high content of aluminium, which is highly valuable with good reuse/recycle properties, while wood and plastic used for the plastic and plywood setups are assumed to be sent for incineration that produces district heating and electricity.

Total GWP

In total, the use of Altiflex modules in the considered setup, has a GWP that is 62% lower than the plastic setup and 44% lower than plywood. In the considered setups (300 m² and 4 months) the overall reduction in CO2-eq is 8.6 ton

for Altiflex modules compared to plastic and 4,3 ton compared to plywood. The CO_2 emissions for heating during operation represents a large share of the total global warming potential for all three cases.

Future energy supply

The CO_2 emissions from electricity and district heating are in general declining. Denmark has a goal of 100% renewable energy in the electricity and district heating sector by 2035. If heating is considered CO_2 neutral in the calculations above, Altiflex modules will still have a better performance than the plastic and plywood setup, when looking at the production phase and end-of-life stage.

8 Conclusion

The analysis show that the use of the Altiflex System reduces the energy consumption for heating compared to plastic and plywood. The reduction is significantly larger compared to plastic than to plywood due to the poor insulation properties of plastic. The energy saving is calculated to 63% compared to plastic and 42% compared to plywood.

Looking at the CO_2 emissions, these are directly proportional to the energy consumption, but depends on the heating method. Use of fossil fuels leads to higher CO_2 emissions for heating, but also leads to the largest reductions in CO_2 emissions if the Altiflex System is used.

The largest numeric reduction is seen in the comparison between the Altiflex System and plastic, when heated by fuel oil. In this case the CO_2 emission is reduced by more than 14.0 tonnes over a 4 months' period, while the reduction is 1,7 tonnes if heated by district heating.

The lower energy consumption achieved by using the Altiflex System also reduces the emissions of particles by 62,7% compared to plastic and 41,9% compared to plywood.

Use of the Altiflex System has the lowest installation cost compared to plastic and plywood. In the analysed setups of 300 m^2, Altiflex modules are 19-24% cheaper to install. These prices are based on information delivered by Altiflex.

The cost of heating is reduced by the same percentage as the energy consumption. If the initial price of installing the different solutions are combined with the expenses for heating, the Altiflex System results in savings of 27-44% compared to plastic and 26-32% compared to plywood across all heating methods and an enclosure of 300 m^2 seen over the 4 winter months.

The comparable analysis of the footprint of the different setups includes the production phase of materials and assembly of the Altiflex modules at the Altiflex facility, energy consumption during operation for 4 months, and the end-of-life stage of the different materials used in the setups.

The overall CO_2 footprint of using the Altiflex System compared to plastic and plywood is lower through the whole life cycle. Use of the Altfiflex System reduces the global warming potential (kg CO2-eq) by 62% and 44% compared to plastic and plywood, respectively.

The plastic and plywood setups have a negative GWP impact in the production phase due to the large amount of wood which has absorbed CO_2 during growth. The embedded CO_2 is released at the end-of-life stage.

As seen, the emissions from the energy consumption during operation represents a large share of the total CO_2 impact for all three setups. The insulation properties of the various materials are of great importance for the total CO_2 emissions through the life cycle of the compared materials/product.

9 References

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