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Comparison of environmental impacts of FENIX heating systems with heat pump

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1 GOAL OF THE STUDY

The aim of the calculation is to compare the environmental impacts of 3 variants of the heating system in an nZEB with a floor area of 120 m², where the annual energy consumption for heating with radiant panels and heating cables is set for 3500 kWh. The annual energy consumption for heating with a heat pump is then set at half, for 1750 kWh.

For the heating of this floor area, it is then determined to use either the heating system with 4 pieces of heating cables ADSV 71100, or 7 pieces of radiant panels ECOSUN 600, or 1 piece of heat pump.

The lifetime of the systems was determined as follows:

- 30 years for radiant panels,
- 45 years for heating cables,
- 15 years for heat pump.

The environmental impacts of the mentioned variants of heating systems were compared over the lifetime of the building, which is set by the standard for 50 years.

2 CALCULATION METHOD

Environmental assessment was done using existing standard methodologies of LCA, which is standardized by ISO 14040 and ISO 14041. The Life Cycle Assessment (LCA) is a technique for evaluating the benefits or impacts of product or process on the environment. Specific requirements for conducting an LCA study on construction products are described in EN 15 804 +A2. This standard specifies the impact categories for which environmental impacts are assessed.

All the detailed LCA calculations were performed in Simapro 9.4.0.2 software.

3 ASSUMPTIONS

This calculation includes the impacts related to the production of the assessed variants of heating systems and the consumption of operational energy used by the assessed variants of heating systems during the lifetime of the building. Specific data from the Fenix manufacturing plant was used to calculate the impacts of radiant panels and heating cables and generic data from the 'ecoinvent' v 3.9 environmental database was used to calculate the impacts of the heat pump.

A generic dataset for electricity consumption generated from the Czech energy mix was also used to calculate the impacts associated with the operation of heating systems over the lifetime of the building.

In the calculation, on the other hand, the environmental impacts of products related to the installation of heating systems, such as switchgears and PE pipes, are not included. The impacts of radiant panels and heating cables cover the impacts related to the production of the thermostat, where one thermostat is considered for each piece of product.

4 RESULTS – ENVIRONMENTAL IMPACTS

The following tables show the comparison results of LCA indicators and additional parameters for the products.

4.1 Core environmental impacts

Tab. 1. Core environmental impacts – 50 years of building reference service lifetime

Impact category	Unit	ADSV 71100	Ecosun 600	Heatpump
Climate change	kg CO2 eq	3,83E+03	5,30E+03	6,69E+03
Climate change - Fossil	kg CO2 eq	3,82E+03	5,29E+03	6,68E+03
Climate change - Biogenic	kg CO2 eq	5,69E+00	5,61E+00	5,74E+00
Climate change - Land use and LU change	kg CO2 eq	3,85E+00	6,33E+00	8,13E+00
Ozone depletion	kg CFC11 eq	6,86E-03	1,16E-04	1,80E-04
Acidification	mol H+ eq	1,54E+01	2,33E+01	3,59E+01
Eutrophication, freshwater	kg P eq	5,60E+00	8,57E+00	9,16E+00
Eutrophication, marine	kg N eq	3,57E+00	5,41E+00	6,98E+00
Eutrophication, terrestrial	mol N eq	2,66E+01	4,01E+01	7,75E+01
Photochemical ozone formation	kg NMVOC eq	7,12E+00	1,07E+01	1,58E+01
Resource use, fossils	MJ	4,93E+04	7,41E+04	9,09E+04
Resource use, minerals and metals	kg Sb eq	2,10E-02	6,38E-02	1,56E-01
Water use	m3 depriv.	7,30E+02	1,11E+03	1,54E+03

4.2 Additional environmental impacts

Tab. 2. Additional environmental impacts - 50 years of building reference service lifetime

Impact category	Unit	ADSV 71100	Ecosun 600	Heatpump
Particulate matter	disease inc.	3,36E-05	4,74E-05	1,76E-04
Ionising radiation	kBq U-235 eq	1,02E+03	1,56E+03	1,63E+03
Ecotoxicity, freshwater	CTUe	2,57E+04	5,47E+04	1,10E+05
Human toxicity, non-cancer	CTUh	-2,84E-05	-1,08E-04	8,88E-05
Human toxicity, cancer	CTUh	3,07E-07	-8,14E-07	8,40E-06
Land use	Pt	2,02E+04	3,29E+04	4,26E+04

4.3 Resource use

Tab. 3. Resource use - 50 years of building reference service lifetime

Parameter	Unit	ADSV 71100	Ecosun 600	Heatpump
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ, net calorific value	2,00E+03	3,16E+03	9,67E+03
Use of renewable primary energy resources used as raw materials	MJ, net calorific value	0,00E+00	0,00E+00	0,00E+00
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, net calorific value	2,00E+03	3,16E+03	9,67E+03
Use of non- renewable primary energy excluding nonrenewable primary energy resources used as raw materials	MJ, net calorific value	4,93E+04	7,41E+04	1,82E+05
Use of non- renewable primary energy resources used as raw materials	MJ, net calorific value	0,00E+00	0,00E+00	0,00E+00
Total use of non- renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, net calorific value	4,93E+04	7,41E+04	1,82E+05
Use of secondary material	kg	0,00E+00	0,00E+00	0,00E+00
Use of renewable secondary fuels	MJ, net calorific value	0,00E+00	0,00E+00	0,00E+00
Use of non renewable secondary fuels	MJ, net calorific value	0,00E+00	0,00E+00	0,00E+00
Use of net fresh water	m ³	7,30E+02	1,11E+03	1,54E+03

4.4 Waste categories

Tab. 4. Waste categories - 50 years reference service lifetime

Parameter	Unit	ADSV 71100	Ecosun 600	Heatpump
Hazardous waste	kg	8,82E-02	1,78E-01	1,57E-01
Non-hazardous waste disposed	kg	3,31E+02	4,27E+02	9,74E+02
Non-hazardous(excluding inert) waste disposed	kg	1,52E+01	2,33E+01	3,36E+01
Radioactive waste disposed/stored	kg	2,53E-01	3,84E-01	4,26E-01

5 RESULTS INTERPRETATION

When comparing the results in the core environmental impact categories, the heating system that uses heating cables comes out best in most of these categories. The exceptions here are the impact category

of fossil resource use, ozone depletion and climate change – biogenic, where the heating system with radiant panels performs better.

In the case of the additional environmental impact categories, the heating system with heating cables always comes out best, except for the category Human toxicity - cancer, where the use of radiant panels comes out better.

In terms of resource utilization, the heating system with heating cables again performs best.

Finally, this heating system also performs best in area of potential waste production.

The results in all evaluated impact categories speak mostly in favor of the heating system variant using ADSV 71100 heating cables. The results for the 50-year lifetime of the building reflect in many environmental impact categories the lifetime of the various heating systems. To support this conclusion, we present results for individual products with considering only their service lifetime

Tab. 5. Core environmental impacts – considering only product lifetime

Impact category	Unit	ADSV 71100 45 years life	ECOSUN 600 30 years life	Heat pump 15 years life
Climate change	kg CO2 eq	3,48E+03	3,24E+03	3,01E+03
Climate change - Fossil	kg CO2 eq	3,47E+03	3,23E+03	3,01E+03
Climate change - Biogenic	kg CO2 eq	5,35E+00	3,92E+00	3,60E+00
Climate change - Land use and LU change	kg CO2 eq	3,48E+00	4,06E+00	4,23E+00
Ozone depletion	kg CFC11 eq	6,67E-03	8,19E-05	1,22E-04
Acidification	mol H+ eq	1,39E+01	1,44E+01	2,02E+01
Eutrophication, freshwater	kg P eq	5,05E+00	5,24E+00	3,37E+00
Eutrophication, marine	kg N eq	3,23E+00	3,35E+00	3,36E+00
Eutrophication, terrestrial	mol N eq	2,41E+01	2,51E+01	5,10E+01
Photochemical ozone formation	kg NMVOC eq	6,44E+00	6,66E+00	8,56E+00
Resource use, fossils	MJ	4,45E+04	4,55E+04	3,82E+04
Resource use, minerals and metals	kg Sb eq	2,01E-02	5,64E-02	1,51E-01
Water use	m3 depriv.	6,63E+02	7,11E+02	7,73E+02

Tab. 6. Additional environmental impacts – considering only product lifetime

Impact category	Unit	ADSV 71100 45 years life	ECOSUN 600 30 years life	Heat pump 15 years life
Particulate matter	disease inc.	3,08E-05	3,10E-05	1,46E-04
Ionising radiation	kBq U-235 eq	9,20E+02	9,50E+02	5,64E+02
Ecotoxicity, freshwater	CTUe	2,80E+04	3,87E+04	8,43E+04
Human toxicity, non-cancer	CTUh	-2,92E-05	-1,09E-04	6,54E-05
Human toxicity, cancer	CTUh	2,45E-07	-1,09E-06	7,59E-06
Land use	Pt	1,83E+04	2,14E+04	2,19E+04

Tab. 7. Resource use - considering only product lifetime

Parameter	Unit	ADSV 71100 45 years life	ECOSUN 600 30 years life	Heat pump 15 years life
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ, net calorific value	1,82E+03	2,02E+03	2,78E+03
Use of renewable primary energy resources used as raw materials	MJ, net calorific value	0,00E+00	0,00E+00	0,00E+00
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, net calorific value	1,82E+03	2,02E+03	2,78E+03
Use of non- renewable primary energy excluding nonrenewable primary energy resources used as raw materials	MJ, net calorific value	4,45E+04	4,55E+04	3,82E+04
Use of non- renewable primary energy resources used as raw materials	MJ, net calorific value	0,00E+00	0,00E+00	0,00E+00
Total use of non- renewable primary energy resources (primary energy and primary energy resources used as raw materials)	MJ, net calorific value	4,45E+04	4,55E+04	3,82E+04
Use of secondary material	kg	0,00E+00	0,00E+00	0,00E+00
Use of renewable secondary fuels	MJ, net calorific value	0,00E+00	0,00E+00	0,00E+00
Use of non renewable secondary fuels	MJ, net calorific value	0,00E+00	0,00E+00	0,00E+00
Use of net fresh water	m3	6,63E+02	7,11E+02	7,73E+02

Tab. 8. Waste categories - considering only product lifetime

Parameter	Unit	ADSV 71100 45 years life	ECOSUN 600 30 years life	Heat pump 15 years life
Hazardous waste	kg	8,52E-02	1,59E-01	1,49E-01
Non-hazardous waste disposed	kg	2,86E+02	2,43E+02	6,42E+02
Non-hazardous(excluding inert) waste disposed	kg	1,29E+01	1,47E+01	1,86E+01
Radioactive waste disposed/stored	kg	2,24E-01	2,35E-01	1,64E-01

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