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How to compare energy performance requirements of Japanese & European office buildings

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Introduction

- European MS have launched NZEB requirements – each country with their own methodology
- In Japan, similar development is ongoing through ZEB Ready target
- Because of different climate, input data, primary energy factors, methodology and inclusion of energy flows, energy requirements cannot be directly compared
- EC has published official NZEB recommendations which can be used as a benchmark for comparison

Objective of this study

- To compare Estonian and French NZEB, and Japanese ZEB Ready with EC NZEB recommendation
- A reference office building with dynamic simulation and climate normalization was applied for this purpose – including some methodology development

Methods – national requirements

National requirements, energy flows, and primary energy factors

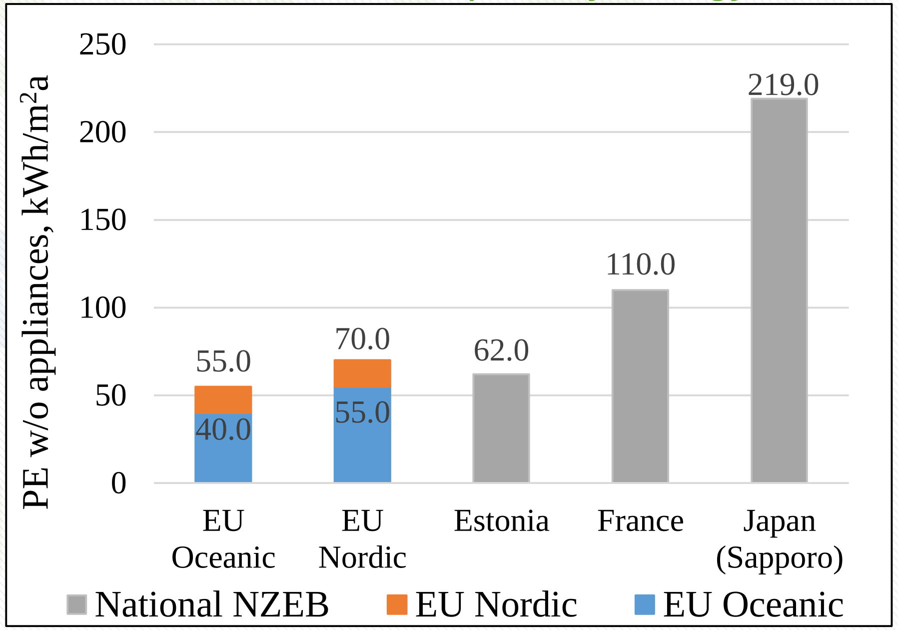
	**Energy flows excluded	Office buildings Requirement		PEF
		2016 in EU/ Present in Japan	NZEB/ ZEB Ready	
EC	appliances	-	40-55 (Oceanic) 55-70 (Nordic)	Electricity 2.3 DH1.3 Natural gas 1.1
Estonia	--	160	100	Electricity 2.0 DH0.65 Natural gas 1.0
France	appliances	$C_{ep,max} = 50\ M_{c,type}\left(M_{c,geo} + M_{c,alt} + M_{c,surf} + M_{c,ges}\right)$(1), 110 (2)		Electricity 2.58 DH 1.0 Natural gas 0.88
Sapporo, Japan	appliances	438.7 (2)	219.4 (2)	Electricity 2.71 Natural gas 1.0

** Energy flows included - HVAC, DHW, auxiliary, lighting and appliances

(1) Depending on building type and category coefficient

(2) The requirement value for the reference building used in this study.

Direct comparison of national NZEB requirements, Japanese ZEB Ready and EC recommendation of primary energy



Appliances not included

Methods – heating energy normalization

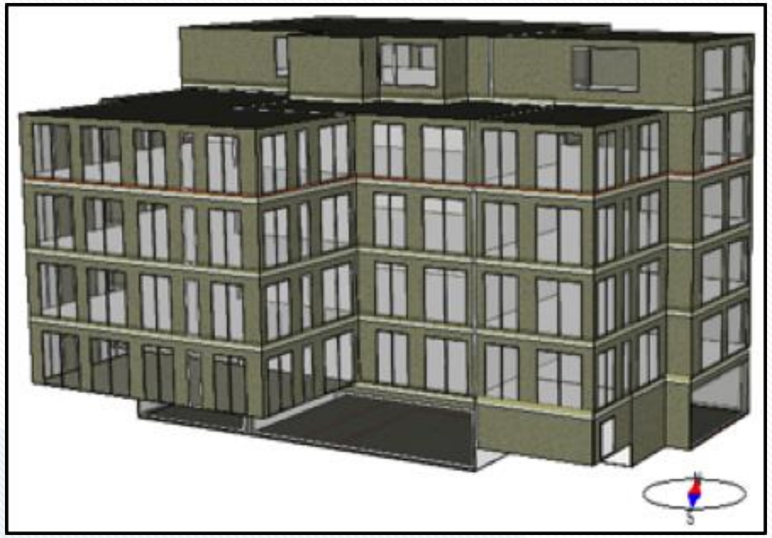
- Heating degree day (without fixed base temperature) was calculated directly from simulated heating energy need and thermal conductance:

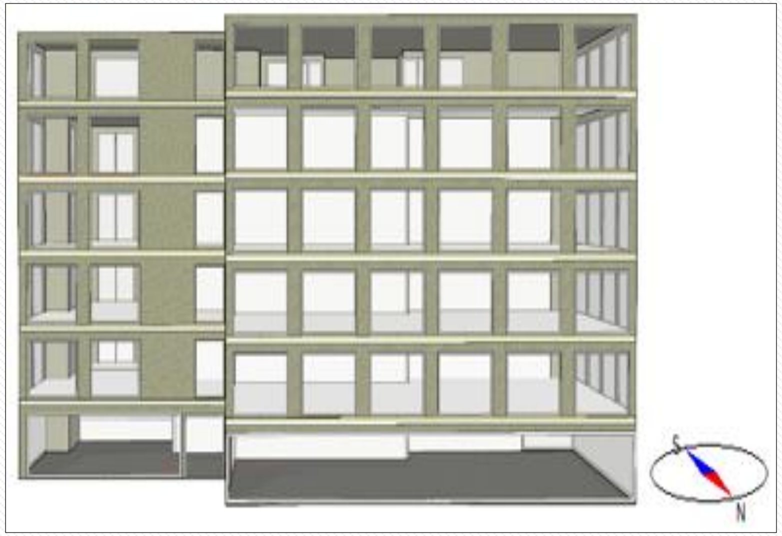
$$\frac{H_{DD^j}}{H_{DD^{ref}}} = \frac{E_{h^j}}{E_{h^{ref}}} * \frac{G_{ref}}{G_j}$$

- An economic insulation concept was applied in order to adjust the insulation thickness from one climate to another

$$U_{opt}^{ref} = U_{opt}^{j}\sqrt{\frac{H_{DD^j}}{H_{DD^{ref}}}}$$

- Cooling energy was relatively small in energy balance and was not adjusted





National and EU input data, humidification included in Japan

Input data according to EN 16798-1:2018 and national building regulations

Input data	EU	Estonia	France	[a]Japan (Sapporo)
Occupant, m^2/person	17	17	10	10
Appliances, W/m^2	12	12	5.7	12
Lighting, W/m^2	6	6	8	[b]16.3/6
Air volume flow by re-circulation, $m^3/h.\ m^2$	N/A	N/A	N/A	[c]17.1
Appliances, lighting operation hour	7:00-18:00	7:00-18:00	8:00-18:00	8:00-21:00
Usage factor	0.55	0.55	0.6	0.89
DHW, l/m^2 a	100	100	65	91.58
Fan operation hour	6:00-19:00	6:00-19:00	6:00-19:00	7:00-21:00
Ventilation rate, l/m^2 s	1.4	2.0	0.5	1.39
Heating set point, °C	21	21	20	22
Cooling set point, °C	25	25	26	26
Floor heating efficiency	0.97	0.97	0.97	0.97
Generation efficiency, GB	0.95	-	0.95	-
Generation efficiency, DH	1.0	0.9	-	-
[d] ASHP's COP for heating	2.74	2.74	2.74	2.74
[d] ASHP's EER for cooling	3.24	3.24	3.24	3.24

[a] RH during heating season should not be less than 40% and not more than 50% during cooling season;

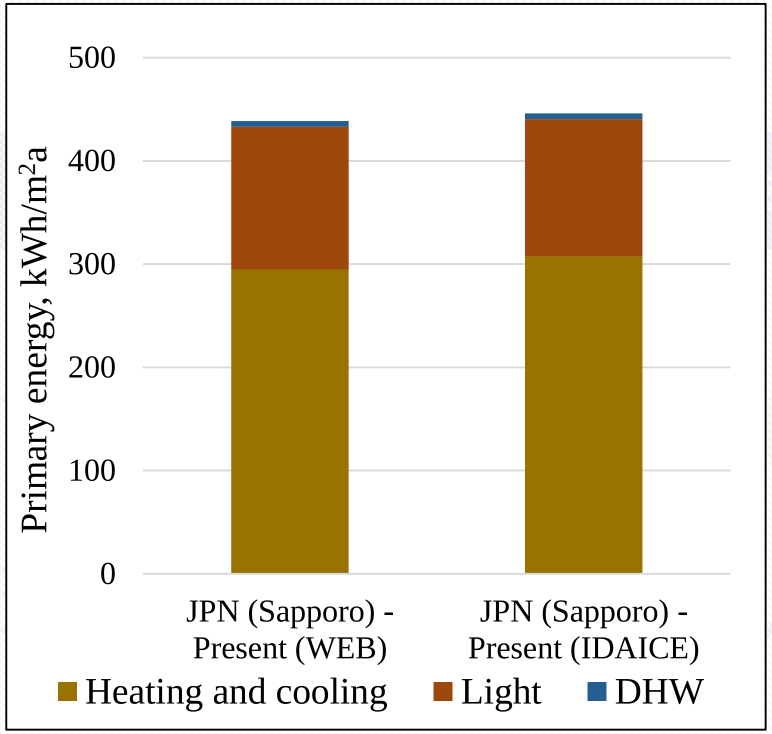
[b] Lighting power for present and NZEB are 16.3 and 6.0 W/m^2, respectively;

[c] Re-circulation was used only with present regulation and was not applied to Japanese NZEB

[d] The values of ASHP's COP & EER followed Japanese ASHP's values at rated condition. The same values were used in Estonian, French and EU cases to keep the comparison transparent

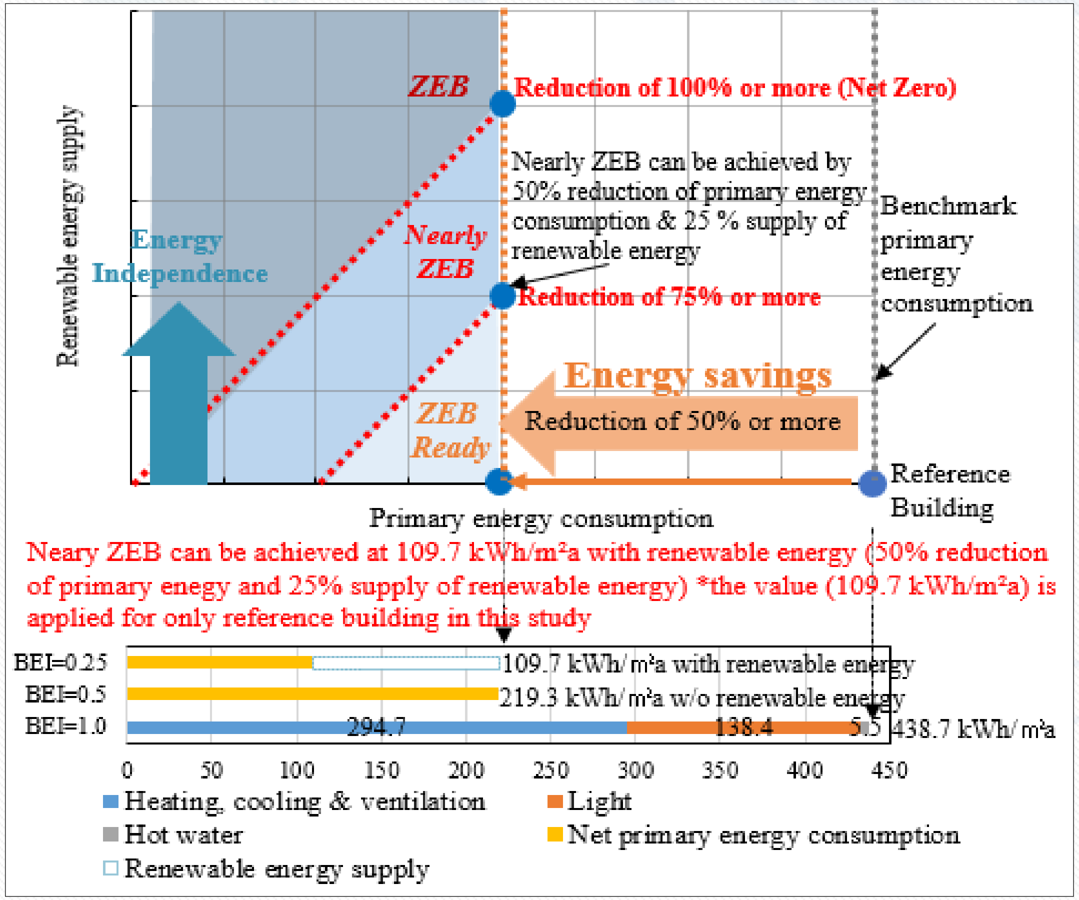
IDA-ICE simulations

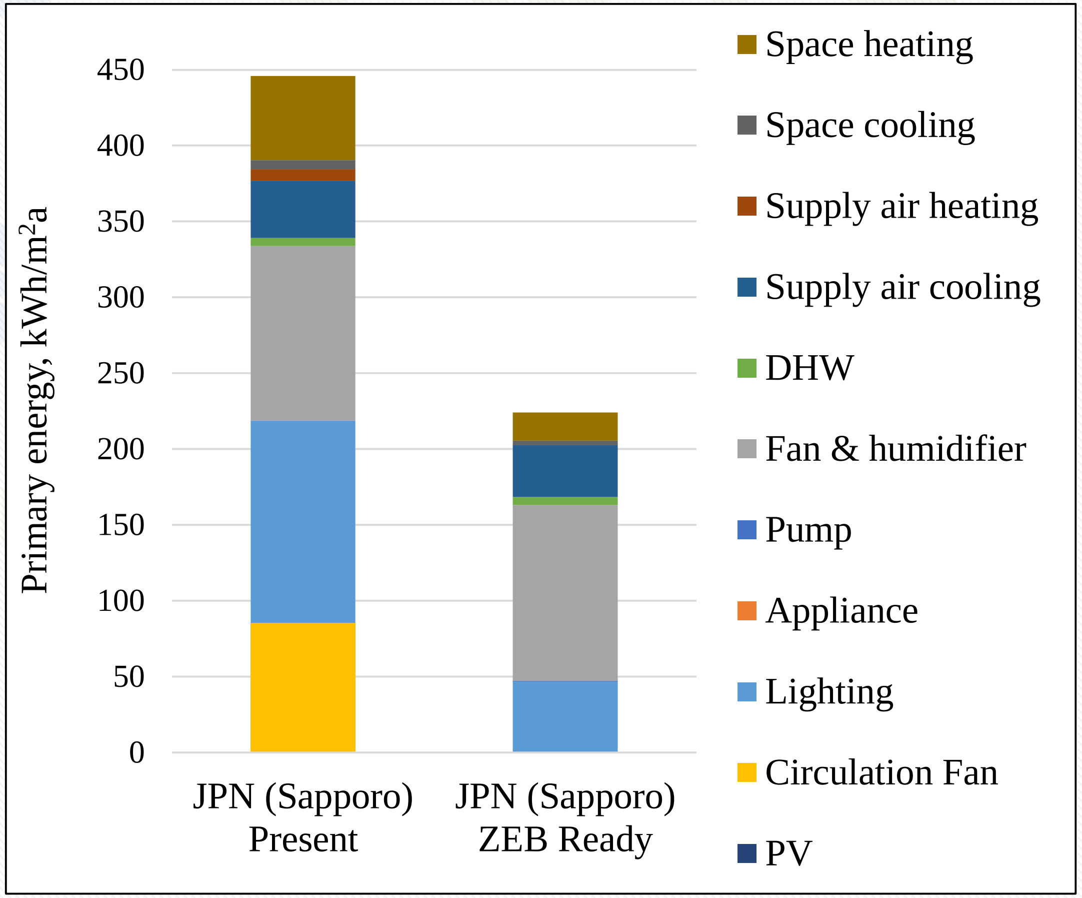
- The reference office building was simulated with Japanese WEBPRO programme with Japanese input data
- Then it was simulated with IDA-ICE simulation tool with the aim to continue analyses with this tool: 446 kWh/m^{2}a primary energy, the difference of 1.6 %
- Results of the Japanese present requirement in the figure



Results, step 1 – define Japanese ZEB Ready

- Building and system parameters were improved to reduce the primary energy compared to the present requirement by 50% (Japanese ZEB Ready reference building)
- Japanese ZEB Ready 223 kWh/m²a primary energy





Step 2&3 – JPN ZEB Ready building with national and EU input data

Japanese ZEB Ready building was moved from Sapporo climate to French & Estonian climates with considering an additional adjustment of insulation thickness & 'U value'

Step 2:

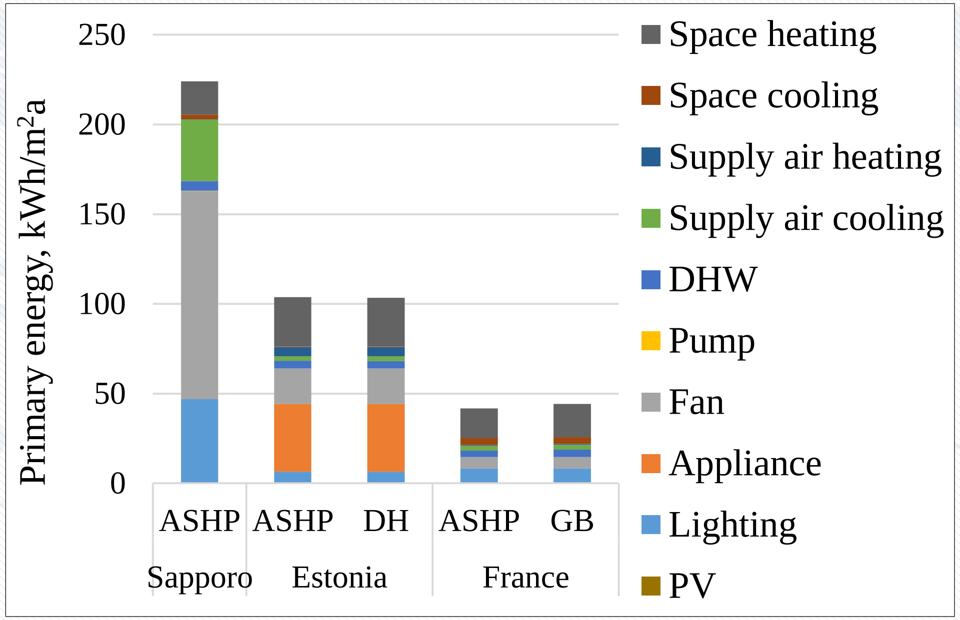
national input data & national climate files

Step 3:

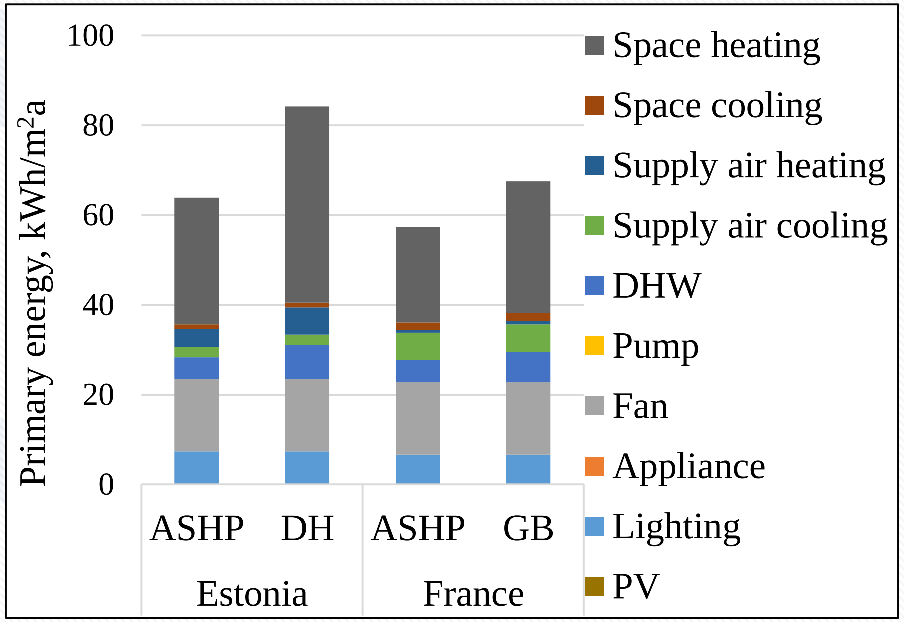
EC input data & national climate files

Adjusted insulation thickness and U value

Parameters	JPN-ZEB Ready	EST-NZEB	FR-NZEB
External wall (U value), W/m²K	0.250	0.202	0.294
Roof (U value), W/m²K	0.160	0.129	0.188
External floor (U value), W/m²K	0.180	0.145	0.212
Window glaze (U value), W/m²K	1.170	0.944	1.375



Step 2, national input data



Step 3, EU input data

Step 4, improve the building to reach EC benchmark

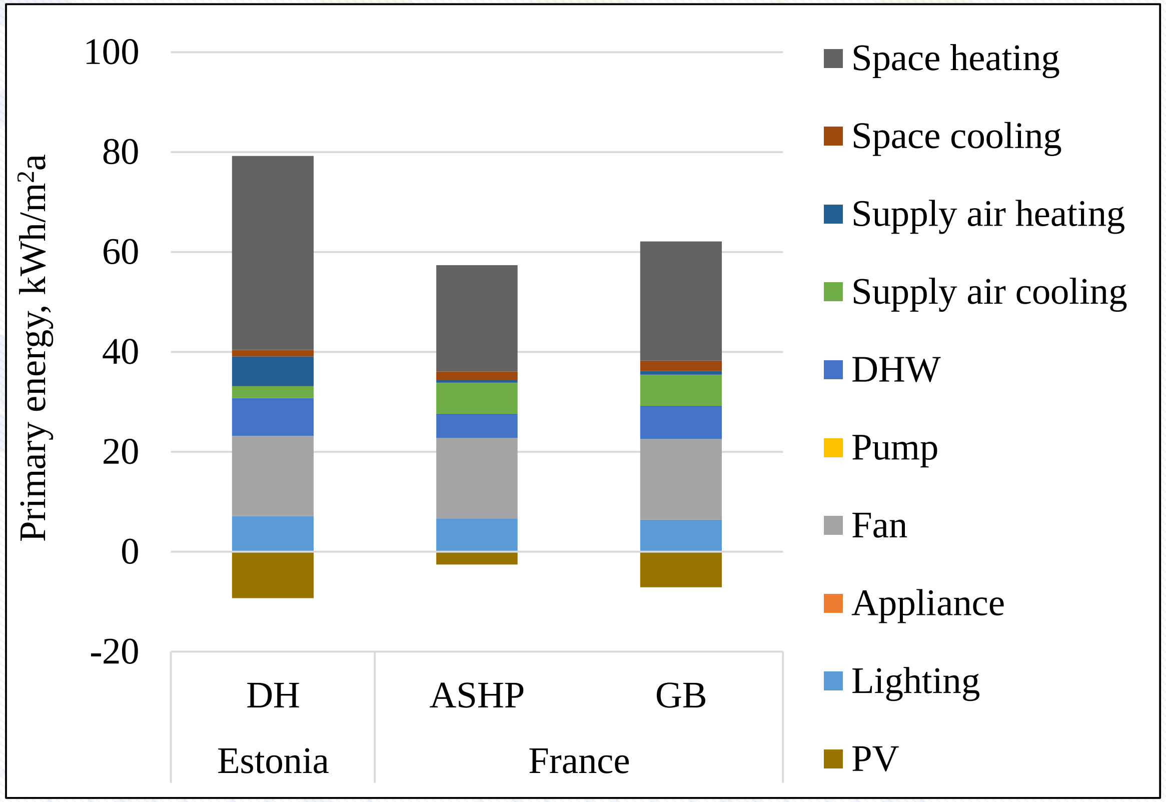
- Additional improvements were done to reach EC NZEB benchmark:

➢ Building in French climate (ASHP) - added PV panel of 0.9 kW

➢ Building in Estonian climate (DH) - external wall (0.17 W/m²K), roof (0.11 W/m²K), window (0.8 W/m²K), added PV panel of 3.93 kW

➢ Building in French climate (GB) - external wall (0.25 W/m²K), roof (0.16 W/m²K), window (1.0 W/m²K), added PV panel of 2.56 kW

➢ (Building in Estonian climate with DH did not need improvement)

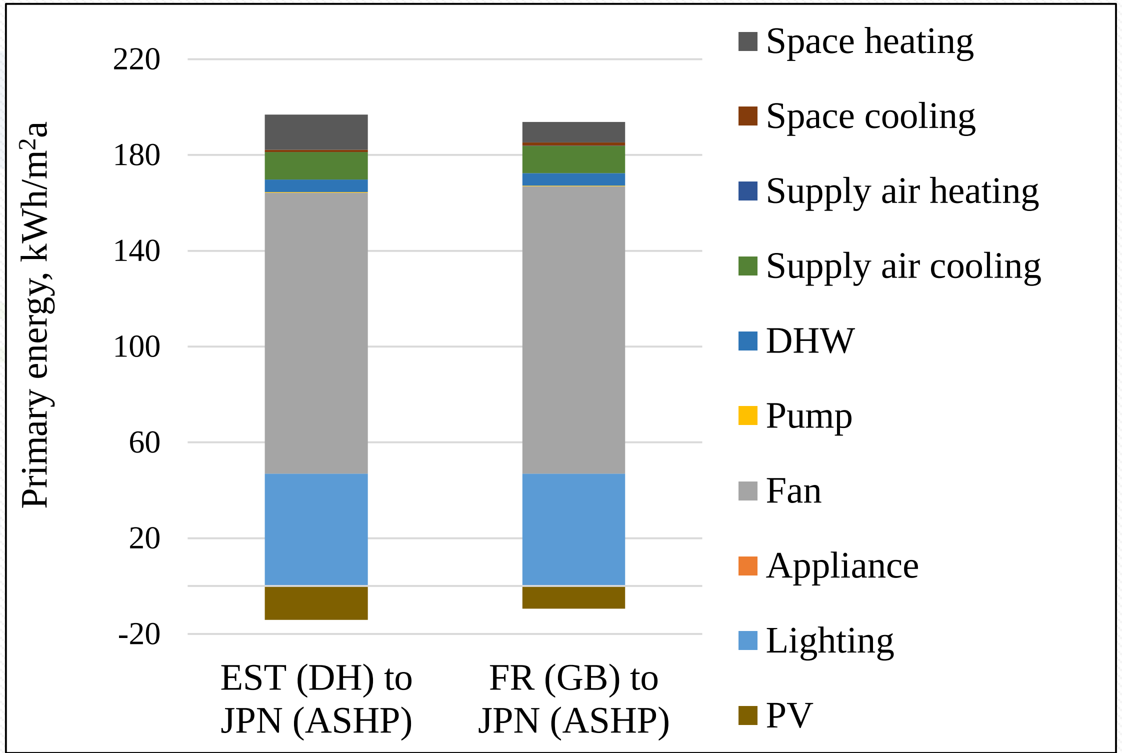


Final step, EC compliant building back to Japan

- Step 4 buildings were moved from Estonian & French climates to the Japanese (Sapporo) climate with an adjustment of insulation thickness and 'U value' of window
- Both cases were simulated with Japanese input data and climate file to show the effect of improvements of Step 4 compared to Japanese ZEB Ready: the resulting PE was by 39…40 kWh/m²a smaller than JPN ZEB Ready 223 kWh/m²a

Adjusted insulation thickness and U value.

	External wall U, W/m²K	Roof U, W/m²K	External floor U, W/m²K	Window glaze U, W/m²K
Building moved from Estonian to Japanese (Sapporo) climate				
EST	0.170	0.110	0.145	0.800
JPN	0.199	0.129	0.170	0.937
Building moved from French to Japanese (Sapporo) climate				
FR	0.250	0.160	0.180	1.000
JPN	0.174	0.111	0.125	0.695



Conclusions

- HDD was determined from the thermal conductance of the building and simulated heating energy need
- The results generated economical insulation thickness for another climate which allows to move a building from one climate to another with corresponding changes of energy needs
- Japanese ZEB Ready, 223 kWh/m^{2}a (Sapporo) resulted in 103 kWh/m^{2}a in Estonia and 44 kWh/m^{2}a in France (without humidification)
- Japanese ZEB Ready building configuration with ASHP complies well with EC NZEB benchmark, Estonian (Nordic) 63.9 vs 70 kWh/m^{2}a and French (Oceanic): 57.4 vs 55 kWh/m^{2}a
- However, with commonly used DH and GB heat sources, the result was 84.2 (vs 70.0) and 67.5 (vs 55.0) kWh/m^{2}a in Estonian & French climates respectively, thus Japanese ZEB Ready needed some improvement to meet EC benchmarks with DH & GB
- Estonian NZEB requirement fulfilled EC benchmark, & French NZEB requirement was clearly less ambitious than EC benchmark