Assessment of ecological sustainability and feasibility

Assessment criteria of the competition included:

1. **Ecological sustainability including energy performance and material efficiency**
2. Urban and architectural quality
3. Usability (functionality/quality of working environment)
4. **Feasibility (economic efficiency and quality of technical solutions)**

- These categories had to sum up with sound overall solution and it's development potential
- Referring to sustainable use of energy and material resources as well as cost efficiency , criteria 1. and 4. had transparent assessment framework:
  - quantitative criteria, described with performance based values
  - measured with kWh, tCO_2 and M€ units

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Quantitative performance based target values

- Ecological sustainability was measured with energy performance and material efficiency target values
  - Energy performance followed the target of EPBD recast for 2019-2021, nearly zero energy buildings, which is the basis for energy performance target value of 80 kWh/(m^2 a) primary energy without tenant's electricity (all other energy flows included)
  - 80 kWh/(m^2 a) per program area corresponds to significantly lower value per net area
- Material efficiency was measured in $kgCO_2/m^2$ and teams competed to achieve possibly low value without compromising with other criteria
- Primary energy factors to calculate the target of 80 kWh/(m^2 a) were:
  - Electricity 2.0
  - District heat 0.7

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Technical solutions used in competition entries (1/2)

Structural solutions:

- *Valaistus* and *Pastorale* were steel-framed, while the rest timber-framed
- of the steel-framed entries, wooden floor and facade elements have been used in *Valaistus*, while steel-concrete composite slab intermediate floor construction and steel cassette facade elements have been used in *Pastorale*
- the use of timber and steel construction achieved advantages in materials efficiencies
- concrete was used however commonly for the laboratory facilities

Energy supply:

- district heating in *Solaris* and *Valaistus*, as well as to a significant extent (40%) in *Pastorale*
- in other entries' heat pumps/boreholes were used with the peak power from the district heating, except in *191910* from electricity
- free cooling from boreholes was utilized in all entries
- waste heat of continuously cooled rooms caused some confusion and was not utilized in all entries

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Technical solutions used in competition entries (2/2)

Solar heat and electricity

- Solar cells were commonly placed on the roofs (where the generation of electrical power is more efficient), but in a few entries also on facades, facilitating also as solar protection screens
- In *Solaris*, the positioning of the solar collectors was seen exceptionally difficult for maintenance
- Similarly in *Valaistus* , the solar cells have been placed in a difficultly maintenanced location, but the solution had better development potential
- In the other competition works, the placement of solar cells, either on the roof or facades, were fairly successful

Natural light and solar protection

- In all competition entries, natural light had been utilized more or less in an exemplary fashion, and solar protection had been solved with effective external solar protection solutions.

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Assessment of ecological sustainability

- Energy performance/primary energy as specified in the competition programme:
  - E-value for a reference building solution complying with currently valid minimum code requirements
  - E-value for the design solution with conventional energy supply solutions
  - E-value for the actual design solution
- Material efficiency:
  - with the main structure's carbon footprint that is derived from the carbon dioxide emissions resulting from the building materials' manufacture and the materials' possible carbon dioxide storage
  - *Solaris* has functioned as a carbon sink because its carbon dioxide storage has been larger than the emission caused by the manufacture of its building materials

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Results of energy performance and material efficiency and construction cost estimates

Kilpailutyö	1	2	3	4	5	6
	Solaris	Valaistus	Pikkukam	Pastorale	Apila	191910
Hyötyala, hym² (ohjelma-ala 12855 ohm²)	14000	13100	14600	15800	12700	14800
Huoneala, hum²	18300	18800	18200	21500	19800	20400
Bruttoala, brm²	20600	20300	20100	23600	21800	23800
Kustannusarvio, M€	**54,9**	**54,6**	58,5	57,7	**54,1**	61,1
E-luku, vähimmäisvaatimusten mukainen vertailuratkaisu, MWh/a	5104	**4513**	4575	**4272**	4523	**4053**
E-luku, suunnitteluratkaisu tavanomaisella energiantuotolla, MWh/a	3576	3517	**3502**	3631	**3508**	**3281**
E-luku, varsinainen suunnitteluratkaisu, MWh/a	2851	**2765**	2830	2985	**2674**	**2780**
E-luku, varsinainen suunnitteluratkaisu, kWh/(ohm²,a) ilman käyttäjäsähköä	99	**92**	97	109	**85**	**93**
30 v energiankäytön hiilidioksidipäästöt, tCO_2-ekv	7589	7146	**6904**	7726	**6005**	**6102**
Päärakenteiden hiilijalanjälki, tCO_2-ekv	**-470**	**147**	1600	3269	**481**	4013
Päärakenteiden hiilijalanjälki, $kgCO_2$-ekv/ohm²	**-37**	**11**	124	254	**37**	312
30 v energiakäytön ja päärakenteiden hiilijalanjälki yhteensä, tCO_2-ekv	**7119**	**7293**	8504	10995	**6486**	10115

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Results of ecological sustainability assessment

- The best energy performance was shown by *Apila* and material efficiency by *Solaris*
- Energy performance results were fairly even, only *Pastorale* was somewhat behind the others
- In terms of material efficiency, *191910* and *Pastorale* were clearly weaker than the other entries.

- When assessing the 30-year carbon footprint (energy and materials):
  - *Apila's* 6,500-tonne emissions were the lowest
  - *Solaris* and *Valaistus* followed with 7,100 and 7,300 tonnes
  - *Pikkukampus* were midway on the scale at 8,500 tonnes, and the two remaining competition entries *191910* and *Pastorale* were clearly weaker than the others, exceeding the 10,000-tonne limit

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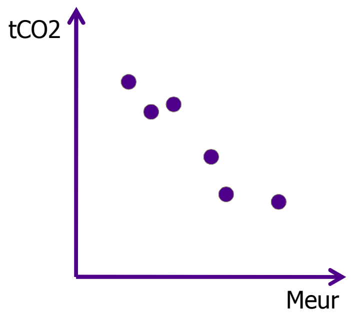
Energy performance + material efficiency = life cycle CO_2

- Energy performance and material efficiency were summed in $kgCO_2/m^2$ units in the assessment process
- Specific emission factor of 150 $kgCO_2/MWh$ was used both for electricity and district heat as an estimate for next 30 years
- Such assessment resulted in life cycle CO_2 emissions, as well as LCC in the economic efficiency assessment, including construction and energy cost, therefore the proposals were compared in the life cycle carbon (tons of CO_2) and cost (M€) scale
- (maintenance, repairs and demolition were not taken into account)



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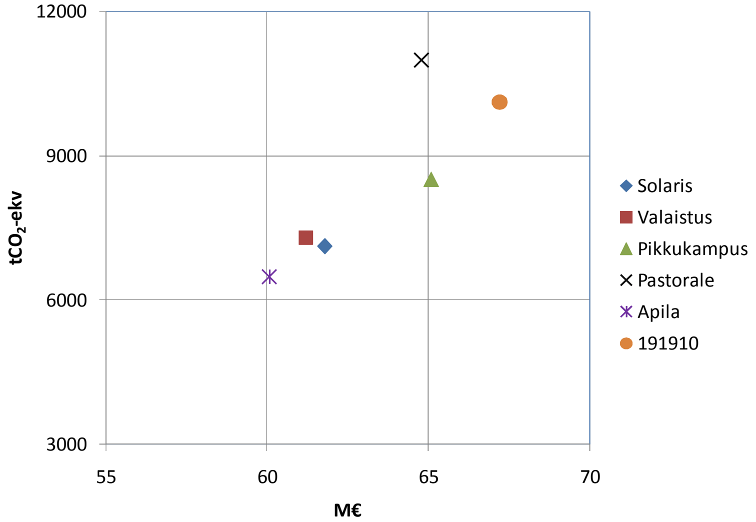
Ecological and economic efficiency results (CO_2 of materials + energy use of 30 years vs. construction + energy cost)



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Assessment of feasibility

- Ecological and economic efficiency map does not cover all aspects of assessment criteria:
  - three different E-values and carbon footprint of materials cover almost all in ecological sustainability criterion
  - feasibility criterion included the quality of technical solutions which is not covered by the map
- Quality of technical solutions and possible risks in the implementation (i.e. maintenance/durability issues, challenging technical solutions) were assessed

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Results of feasibility assessment

- For the three best in ecological sustainability(*Apila*, *Solaris* and *Valaistus*), a cost estimates demonstrated virtually identical construction costs (the cost difference within a range of 1.5%)
- Construction cost estimates for *Pastorale*, *Pikkukampus* and *191910* were significantly larger(+7-13% compared to the most economic one)
- Thus the best in terms of energy performance, *Apila*, was also the best in terms of life cycle costs, with *Valaistus* and *Solaris* following closely behind
  - this was not completely expected because compared to *Apila,* slightly less work had been done in the compact entries (*Solaris* and *Valaistus*) to achieve good energy performance
  - in *Valaistus* , the waste heat of continuously cooled spaces was not utilized, and if utilized, that would lead to best energy performance, thus demonstrating the principle advantage of compactness
  - the advantages of a compact shape were not apparent in *Valaistus*'s because the additional expenses of the complex facade and roof structure accounted for as much as 8% of the construction costs
  - likewise, significant additional costs were created in *Solaris* due to its complicated solar collector construction and weekly storage system for solar heat

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Results of feasibility assessment

Apila was best-rated at the same construction cost level:

- because it had no significant implementation-related risks
- *Apila* was designed as a pure timber building, with economical spans suiting wood construction, as well as an advantageous building's height

Solaris:

- the complicated solar solution with the curved detached solar collector structure extending from the roof to the facades was considered as major risk factor
- possible changes in the system would be critical because the building's exterior appearance has been specifically built around this system whose servicing is difficult

Valaistus :

- main risk factors were related to facades and roof
- possible changes to the shape and materials of the fabric-surfaced facades would significantly alter the building's external appearance
- roof structures were studied in sketch level and may include technical challenges regarding the shape of the roof, the placement of solar cells, and structural design
- all these factors can be solved in further design, but could alter the building's exterior and even interior character

Pikkukampus: facades implemented with hinged facade panels difficult in maintenance

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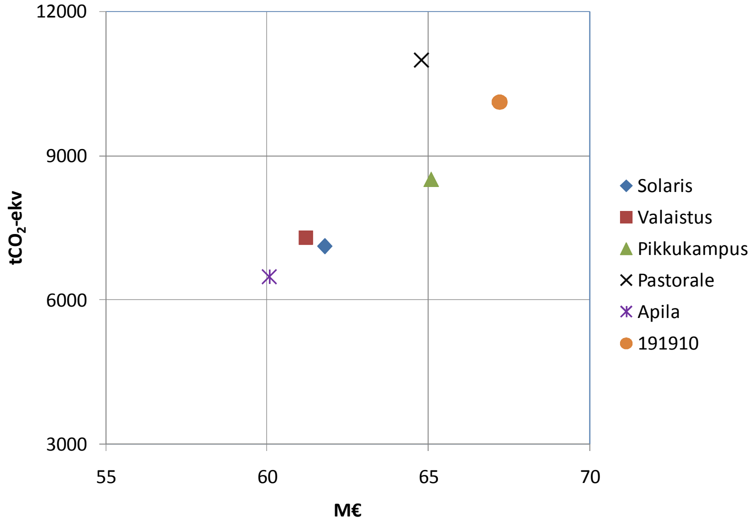

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