The Powerhouse definition

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Powerhouse Kjørbo. Photo: Chris Aadland

There exist numerous definitions on energy positive or plus-energy buildings. The Powerhouse collaboration's definition is described in this document.

1) Background

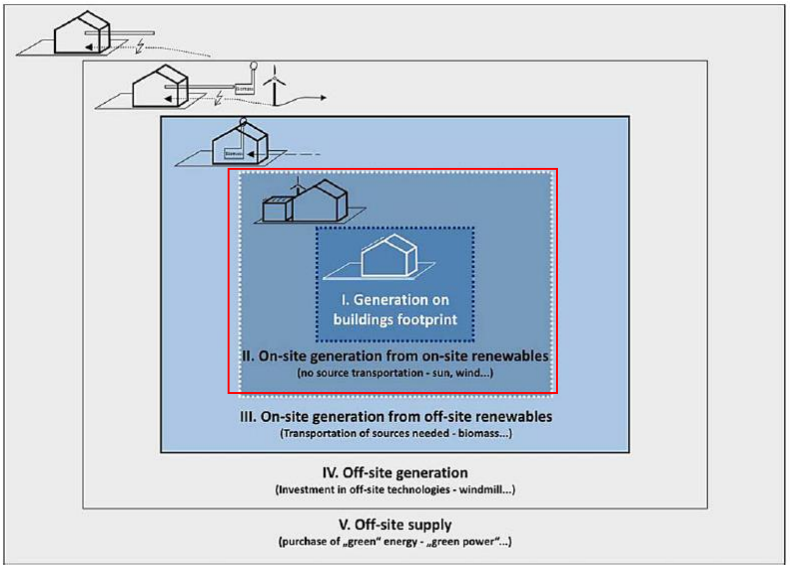
In order to fulfil the declared goal of the Powerhouse (given in a press release from the Powerhouse collaboration): The Powerhouse collaboration will "challenge existing building conventions, "develop cutting-edge concepts", "promote new national and international standards for energy efficiency and energy positive buildings", "be technological path-breaking" etc., and the declared ambition of Powerhouse: "a building, which during its lifetime produce more energy than it uses for materials, production, operation and demolition" should be based on the criteria described below.

2) The main definition of Powerhouse:

A Powerhouse shall during its lifetime produce more renewable energy than it uses for materials, production, operation, renovation and demolition.

3) Additional criteria of the main definition are given in the table below.

Additional criteria	Comments
1. The building shall be built within commercial conditions.	The lettable area and the rental rate must be competitive in the relevant market. The rental rate is partly dependent on the level of investment, including financial support for pilot projects. Increased investments compared to conventional buildings should yield the equivalent low cost of ownership in an LCC perspective. The total cost for a tenant (rent and energy, operating and maintenance costs) shall be at market level.
2. Reaching the energy goal will be combined with good architecture, good indoor climate and other key environmental qualities.	Powerhouse should demonstrate that ”plus-energy” buildings can be associated with these qualities.
3. A Powerhouse’s primary energy balance over its lifespan must be positive. The energy balance includes production of materials, construction, renovation, operation and demolition. More specifically the lifecycle stages A1-A5, B4, B6 and C1-C4 according to EN 15978 Energy production must be based on renewable energy sources on the building, on site or from the sea close to the site. See item 6 for details.	”Plus-energy” or ”energy-positive” implies that the building during its lifetime shall produce and export energy that compensates for energy used for other life cycle stages. This must be compensated with self-produced and exported energy based on renewable energy (solar, wind and heating and cooling from the sea, air or the ground via heat pump). The energy consumed to produce, process and transport materials are referred to as embodied energy. The energy balance for Powerhouse projects must be calculated in primary energy to allow for the use of LCA-based data sources such as EPDs for the calculation of embodied energy.
4. The calculation period for the lifetime is 60 years.	This is the calculation period for the life and operation phase for a Powerhouse, whether it is a new building or a renovation project.
5. The following is not included in the Powerhouse primary plus-energy balance: Energy consumption related to technical appliances (elevators, kitchen, shops, IT, infrastructure, etc.) which belong to the users of the building, or are mainly influenced by the users and are likely to be changed during 60 years lifetime of the building.	Interaction between users and the building is important in order to meet energy goals. Tenants must be encouraged to choose energy efficient equipment.
6. The system boundary of the plus-energy building/Powerhouse is the site on which the building is located.	The Powerhouse boundary is similar to the Boundary II (On site generation from on-site renewable) shown on the illustration below. Seawater nearby, as a source for heating and cooling, is accepted within the system boundary.

	 Source: A.J. Marszala,, P. Heiselberga, J.S. Bourrelleb, E. Musallc, K. Vossc, I. Sartori d, A. Napolitanoe. "Zero Energy Building – A review of definitions and calculation methodologies", Energy and Buildings 43 (2011) 971–979.
7. The energy quality of produced and exported energy shall not be lower than for bought/imported energy.	This implies that produced and exported electricity can offset corresponding amount of bought energy for both electricity and thermal purposes, while produced and exported thermal energy can only offset bought thermal energy, not bought electricity. This implies also, that export of thermal energy can balance the corresponding amount of thermal energy used for production of materials.
8. If several buildings are located on the same site, the measures for achieving plus-energy level for the Powerhouse should not exclude the same possibilities for the other buildings.	This means that each m^2 of heated floor area of all the buildings on site should be given the same access to solar exposed area or other potential renewable energy production on the site. All buildings/heated area should share advantages and disadvantages related to shading conditions on the site/buildings.
9. The building shall as a minimum fulfil the Passive House standard NS 3701. **The component requirements regarding u-value for doors and windows may be disregarded.**	A credible and path-breaking concept for "energy positive" and "energy plus" building should be based on the principle that the energy demand must be very low. This priority is also a basis for the Norwegian authorities' requirements to energy use in buildings, and should also be expected to be fundamental when EU's requirement for "nearly zero energy" becomes implemented. Low energy demand is a basic principle in projects that Powerhouse will be compared with. The passive house standard is not path breaking, and is based on well-known and tested technologies. Hence, further reduction of the energy demand should be aimed at. The component requirements in NS for windows and doors (u-value below 0.8) may cause adaptions and non beneficial optimizing.

Detailed criteria regarding operation phase calculations and embodied energy

Additional criteria	**Comments**
10. The primary energy budget for the operational phase shall be calculated according to the standard NS3031. Real operation conditions shall be used in the calculations.	The electricity produced on site for own use or export shall be calculated in accordance with NS-EN 15603 (NS 3031 do also refer to the NS-EN 15603 standard).
11. The energy balance for the operation period shall be calculated for a period of one year.	Due to variations in outdoor climate and energy production conditions over a year – there will likely be a mismatch between energy demand and energy production at a given moment during a year. The energy balance for operation shall be calculated as the sum of the annual energy use and annual energy production.
12. The primary energy factor for electricity is described in the document “Powerhouse definisjon primærenergi” (Thyholt, Fjeldheim, Buijs, Dokka: 2015).	The Powerhouse balance shall, as described above, be calculated in primary energy. Inconsistencies in sources of data required the Powerhouse alliance to establish a primary energy factor and a future development scenario consistent with LCA-methodology (“Powerhouse definisjon primærenergi” (Thyholt, Fjeldheim, Buijs, Dokka: 2015)). The system boundary of the primary energy factor for electrical energy include extraction of fuel if relevant, infrastructure, the transformation process and distribution.
13. The primary energy factor of used and exported electricity shall be equal to that of imported electricity.	The electricity that is produced and used or exported replaces production of electricity produced elsewhere and must therefore be appointed the same primary energy factor as for the imported electricity. In other words; embodied energy in the materials of the local energy production system (e.g. solar cells) do not form a basis for the primary energy factor for exported electricity. This is accounted as part of the embodied energy of the Powerhouse’s materials.
14. The primary energy factor of exported thermal energy shall be ...	*To be developed*
15. Embodied energy of materials: Areas, and their corresponding materials, to be included in the energy balance are - heated floor area (in accordance with NS 3031) - technical rooms, serving the building or parts of the building with heat, cooling, and/or electricity.	The materials necessary for the construction and maintenance of these areas comprises the embodied energy of materials in a Powerhouse. E.g. unheated parking areas will not be included in the energy balance, but a building’s supporting structure within a parking cellar is to be included. Materials for outdoor area is not included in the Powerhouse definition.

16. Embodied energy in renovation projects: - embodied energy in materials from the original building that are re-used, shall not be added to the energy account - Embodied energy related to disassembled materials which will be recycled or reused, shall not be included as a deduction in the energy account	This is to avoid double counting related to the reuse of materials. The embodied energy from materials that will be reused in other projects will be credited in those projects.
17. The embodied energy of materials shall as far as possible be calculated according to the LCA-standard NS-EN 15978.	Sources of data should be in order of priority: EPDs (Environmental Product Declarations), Database - EcoInvent, Journal articles and information from producers. Practices on electricity and energy mixes in embodied energy of materials should be in line with the practice of the relevant national EPD administrator. There is a process of international harmonisation regarding EPD framework so increased consistency across countries and hence building material producers should be expected. The system boundaries for energy used in the processing of materials is not necessarily consistent with the way the Powerhouse collaboration view primary energy use for operation. However, it is the best practical and methodological approach we have found.
18. Development scenarios for new technologies shall be well documented and scientifically founded.	Development scenarios for technologies and other aspects are necessary to establish the primary energy balance for Powerhouses. E.g.: For the development of PV it is assumed that: • the embodied energy and emissions from the production of the PV modules will be reduced with 50% by 2045 based on (Frischknecht et al. 2015), (Bergesen et al. 2014) and (Mann et al. 2014) • the efficiency of the PV modules in 2045 will have an increased efficiency by about 40 % compared to the best panels currently available from 20 % to 28% based on (NREL 2014) and (Frischknecht, 2015).
19. Replacements of building elements during the 60 year life cycle must be included in the calculation	Lifetime for input materials and components should be taken from representative product category rules (ref: the EPD system) where those are available. Where not available the SINTEF Byggforsk, Byggforskserien 700.320 intervals for maintenance and replacement should be applied. Well-documented replacement information from the building material producers may be used.
20. Feedstock energy: If the data used to describe materials include feedstock energy, the feedstock energy must be calculated and subtracted from the Powerhouse	Feedstock energy is the energy that is released of a material if it is combusted. According to the definition of a Powerhouse feedstock energy of the materials and products used in the Powerhouse projects shall not be accounted for in the primary energy balance since is it is not consumed but merely stored in the form of physical products.

energy balance for the system boundaries to be consistent.	

4) References

NS 3031 Beregning av bygningers energiytelse - Metode og data

NS 3701 Kriterier for passivhus og lavenergibygninger - Yrkesbygninger

NS-EN 15603 Bygningers energiytelse - Bestemmelse av total energibruk og energiytelse, Energy performance of buildings - Overall energy use and definition of energy ratings.

NS-EN 15978 Bærekraftige byggverk - Vurdering av bygningers miljøpåvirkning - Beregningsmetode Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method

A.J. Marszala,, P. Heiselberga, J.S. Bourrelleb, E. Musallc, K. Vossc, I. Sartori d, A. Napolitanoe. "Zero Energy Building – A review of definitions and calculation methodologies", Energy and Buildings 43 (2011) 971–979.

Thyholt, Fjeldheim, Buijs, Dokka: 2015) . Electricity produced on site for own use or export shall be calculated in accordance with NS-EN 15603

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