
Magnus Larsson¹, Alex Kaiser², Ulf Arne Girhammar³

ABSTRACT: To give future generations the ability to meet their own needs, our built environment needs to excel rather than endure. The need for continual improvement calls for fewer passive houses and more active houses — buildings that adopt a responsible and sustainable attitude as not just zero energy consumers but net energy producers, reaching a positive energy balance over time. Materiality is a fundamental element of such a discussion, and wood an obvious protagonist as a carbon store that substitutes for fossil fuel-intensive alternatives such as steel and concrete. Prefabricated timber claddings can be treated or finished or devised with different products and features that assist with turning the building into a net energy producer, and aligning the study with Rolf Disch’s concept of the PlusEnergy solar house allows for a conceptual toolbox of sustainability objectives that can be translated into our innovative wooden cladding systems. That translation process is carried out using the strategy, borrowed from evolutionary biology, of optimising design iterations within a fitness landscape using evolutionary solvers. The aim of the study is to showcase prototypical design development studies backed up with raw data in the form of simulations, tests, and analyses to begin to answer the question of how TimesEnergy timber cladding systems can be turned into a feasible and sustainable alternative in the production of multi-storey timber buildings.

KEYWORDS: WCTE 2014, Wood architecture, multi-storey timber buildings, wooden cladding systems, timber façades, Timber Age, CNC, prototype, PlusEnergy, TimesEnergy, Rolf Disch, evolutionary solvers, evolutionary algorithms, components, compost, plywood, architectural fitness

1 PLUSENERGY VS TIMESENERGY

While we appreciate the advances made by the Passivhaus and Net Zero Energy movements, we don’t agree that their goals are ambitious enough. A full implementation of the present proposal would prove that it is possible to achieve much more with a building than to simply “do no harm”.

The difference between a PlusEnergy efficiency goal and a TimesEnergy one is the difference between an additive and a multiplicative framework: a building achieving the first standard produces more energy than it consumes, while a building performing at the latter level produces several times more energy than it consumes.

There are two main unique concepts at play in this work of architecture: the power-producing façade components, and the compost towers they attach to, which not only provide lateral stability but allow for an unprecedented shift in the building’s function, from consumer to producer of energy.

1.1 BUILDING = POWER PLANT

The power-generating façade component is made from steam-bent plywood, in designs uniquely aligned with and mass-customised for each tower wall. Unique cutting patterns are generated for each wall’s components, which are then laser cut and steam-bent into a shape that allows one side to collect rain water while surfaces facing the primary sun direction are fitted with thin, transparent,

1 Magnus Larsson, Founding director, Ordinary Ltd, Unit 3A/4A, Regent Studios, 8 Andrews Road, London, E8 4QN, UK.
E-mail: magnus@ordinarystudio.com

2 Alex Kaiser, Founding director, Ordinary Ltd, Unit 3A/4A, Regent Studios, 8 Andrews Road, London, E8 4QN, UK.
E-mail: alex@ordinarystudio.com

3 Ulf Arne Girhammar, Professor, Timber Structures, Division of Structural and Construction Engineering, Luleå University of Technology, SE-971 87 Luleå, Sweden. E-mail: ulf.arne.girhammar@ltu.se
high-efficiency solar cells. In between these are fitted aeroelastic flutter windcells that produce around 7.2 kwh/month/component at average windspeed conditions of 6 m/s. The full-scale, six-tower version of Beyond Endurance shown below contains 8,688 façade components, so through wind power alone, the building would generate in the region of 62,500kwh/month, enough to sustain 70 people (in 2012, the average annual electricity consumption for a US residential utility customer was 10,837 kwh, an average of 903kwh/month). Under standard test conditions a solar cell of 20% efficiency with a 100 cm² (0.01 m²) surface area would produce 2.0 w. Used in a photovoltaic system, a solar panel with 20% efficiency and an area of 1 m² will produce 200 w at STC.

The six-tower version of the scheme features 8,688 façade components, each of which hold an approximate solar cell area of 1.3 m² (based on a tower surface area of 1,860m²/1,440 panels = 1.3 m²/panel, each façade component generates 1.2 kwh/day in solar energy). That equals 11,294 m² of solar cell area for the entire building, which under these circumstances would generate up to 4,946,772 kwh / year. Based on the average of 903kwh/month for US citizens (2012, as above), the building could sustain up to 456 people on solar power alone.

The composting scheme works as follows: 1) Soil and microorganisms are inserted into the compost, while the tower’s façade components collect water and absorb solar and wind energy. 2) Electricity and gray water is fed to the living units, surplus electricity is fed to the grid. The living units feed gray water, food waste, and humanure into the compost tower, which produces gases, manure, and gray water to the green houses. 3) Biogas (methane) is also produced, with any excess again being fed into the grid. 4) The green houses produce food both for the living units and the local community, members of which can buy fruits and vegetables in a public market within the building.

The composting towers power is tricky to calculate. Based on permaculturist inventor Jean Pain’s famous composting scheme, however – which generated enough power to heat his five-room house (100 m²) and provide 4 l/min of hot water for 18 months from a 12-ton pile of compost4 – we might assume that the part of the compost tower that feeds each living unit (with a similar floor area at roughly 114 m²/flat) would manage to produce at least that (at 3.95m x 8.4m = 33.18 m³, or 33,180 liters, for living unit and greenhouse). This might equal 5,000 kwh/year (if, conservatively, we estimate this to have been Pain’s annual energy usage). The compost energy per living unit could sustain at least an additional two people.4

The origins of evolutionary computation can be traced back to the late 1950’s. Evolutionary programming as we know it was devised by Lawrence J. Fogel (1928-2007) in 1960. Fogel focused on how simulating evolution could bring about intelligent behaviour, roughly defined as being able to predict one’s environment and respond suitably in light of a given goal. Rather than modelling the end product of evolution, the idea was to model the process of evolution itself as a vehicle for producing intelligent behaviour. Arguably, this strategy for achieving intelligent behaviour in machines could also be used to produce intelligent behaviour in “machines for living” – buildings.

Evolutionary computations essentially search for “good solutions to problems by testing large number of candidate solutions, selecting the ‘better’ ones and randomly changing them to form a new set of candidates to be tested. This process repeats until a ‘good enough’ solution is found or until the computational resources are exhausted.”

3 THE SCHEME

The project aims to disrupt the conservative attitudes so prevalent within waste management and architecture. We propose an alternative way of life in which our buildings and cities help support their inhabitants with their harvesting of energy from themselves and their immediate surroundings. That cultural change would also have a great social and economic impact, in particular as the scheme dictates that surplus food and energy be given back to the local community and/or national power grids.

4 ACKNOWLEDGMENT

The authors express sincere appreciation for the financial support from the Regional Council of Västerbotten, the County Administrative Board in Norrbotten, and The European Union's Structural Funds – The Regional Fund.

5 REFERENCES