Adaptive Building Skins

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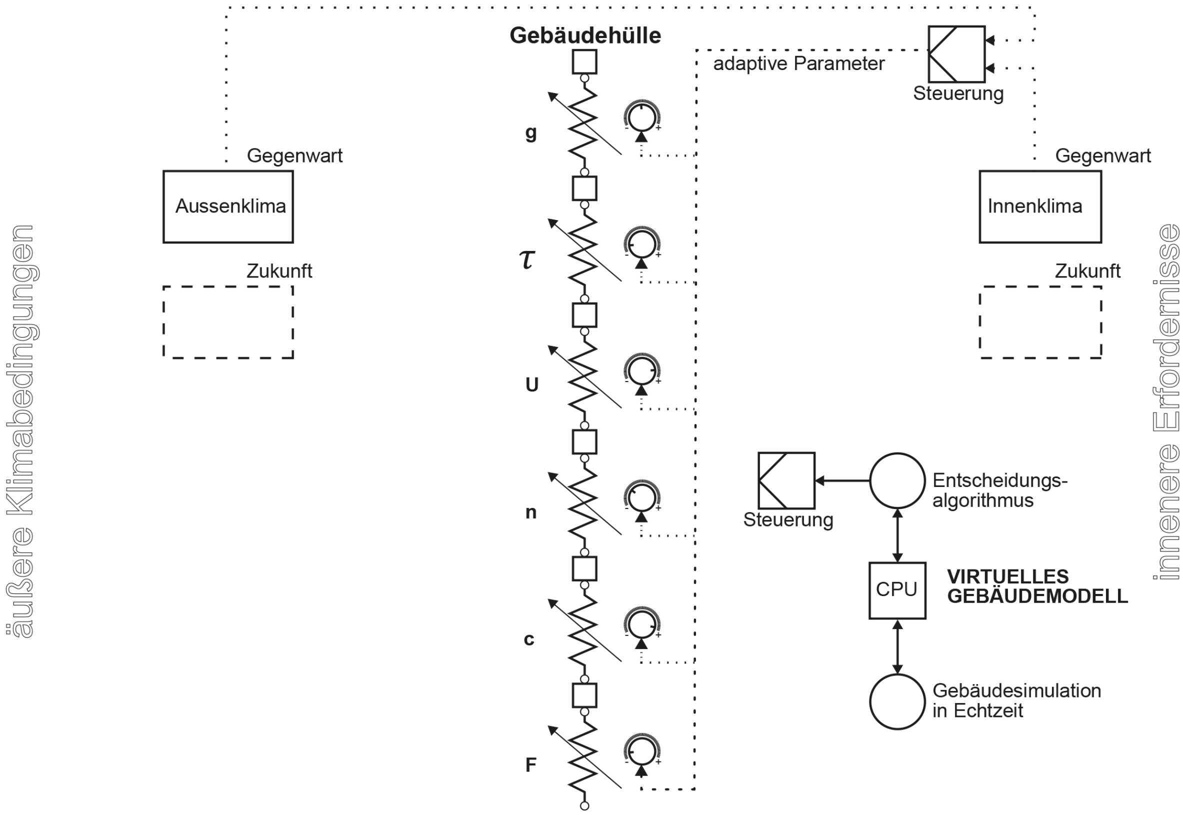
Buildings are designed and constructed to exist in an external natural environment with continuingly changing conditions (temperature, humidity, air movement, light, sound etc.) and provide more or less constant internal environmental conditions in the spaces contained within. In most cases the desired internal conditions differ greatly from the external conditions for a significant portion of the year. Two approaches can be followed in order to provide the desired internal environment; the conventional approach of sealing off the external environment as much as possible and employing mechanical systems to provide the desired internal conditions or alternatively the buildings form, construction and skin can be designed to capture and utilize energy flows in the natural external environment and support the creation of the desired internal environment. This second approach, in which, similar to the strategies employed in some Asian martial arts, the energy of the “attacking” forces are captured and utilized to achieve the desired result is for obvious reasons the more challenging but also potentially much more efficient approach with regard to the use of resources.

The building envelope is of particular importance in the design of an energy efficient building. Alongside active energy production the building’s skin can act as an adaptable filter between the external and internal environmental conditions. The physical properties of building facades in our cities at present are however unable to adapt to changing conditions in a significant manner. This applies to both the ever changing external conditions such as climate, noise, air quality and light and the fluctuating demands and needs of building occupants on the internal side of the façade interface. Their specific properties in terms of thermal conductivity, solar heat gain transmission, light transmittance, porosity etc. are static and remain essentially constant with time although the requirements for an energy efficient building skin differ significantly under the widely varying climatic conditions at different times of the day and year. Existing responsive facades are limited to one dimensional approaches such as automated shading systems.

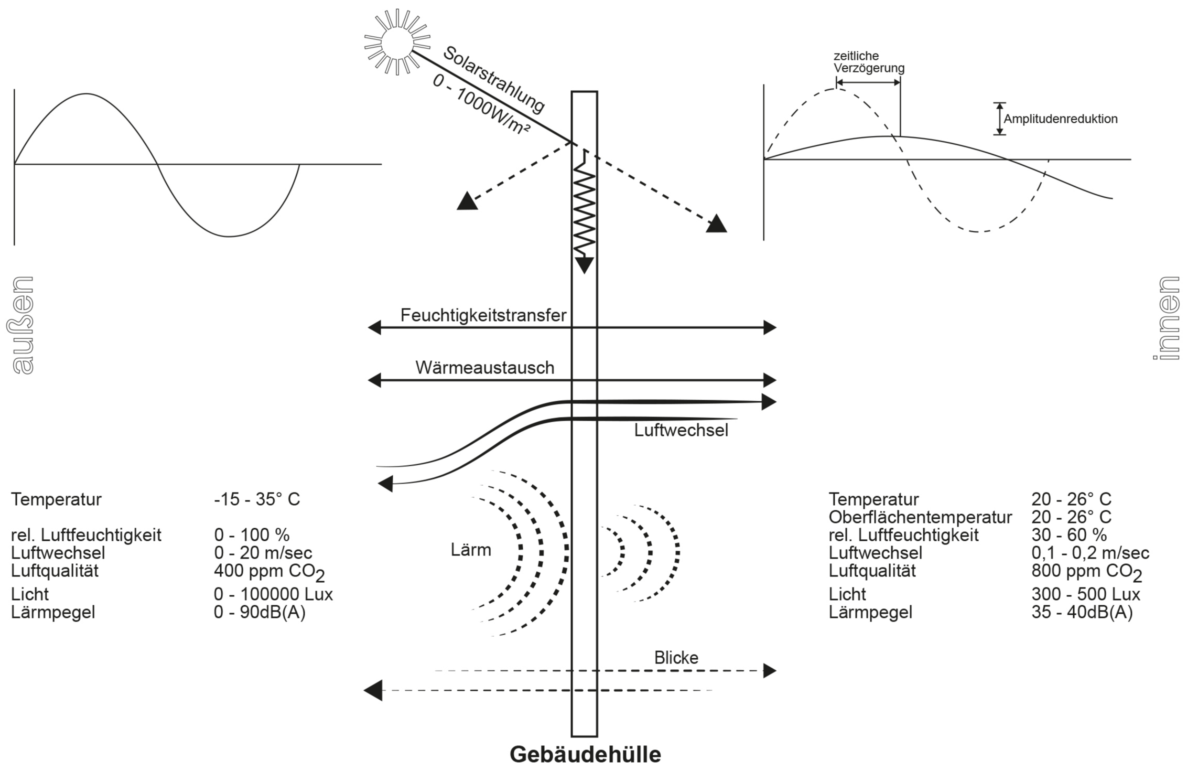
An adaptable and variable building skin could on the other hand react and adapt to both internal and external conditions, effectively creating “Space on Demand”. Furthermore, by tracking not only the present external conditions and internal desired conditions but also utilizing forecasts of the future external and internal conditions and incorporating these into a virtual model of the building which allows simulation and prediction of the buildings energy performance under varying conditions, it is possible to develop “smart skins”; building skins, which maximize energy performance by varying their physical properties to adapt to changing external and internal conditions. Such facades would constantly adapt to meet changing requirements by manipulating variable parameters for thermal insulation, solar energy transmittance, light transmission, thermal energy storage, air tightness and moisture diffusion.

We are currently undertaking research which will form the scientific basis for the development of a completely new approach to façade design by precisely determining the energy potential offered by the approach under various assumptions as well as useful insight into successful strategies for the development of suitable components. The proposed smart skin concept incorporates and uses forecast data relating to future weather and likely user behaviour (based on past experience and using an embedded artificial intelligence approach) as well as the present time data to decide the optimal configuration of physical properties and thus optimize performance. A novel and innovative dynamic simulation model, which is to be specially developed for this project, will provide meaningful insight into the potential and possibilities. This model will also serve as the virtual model to be incorporated into the completed building and so provide part of the intelligence necessary for the optimal performance of the smart skin. Smart materials, which can change their physical and/or chemical characteristics in order to accomplish the desired adaption to changing conditions, are a further possibility currently being studied.

Brian Cody, February 2015



Gebäudehülle
adaptive Parameter
Steuerung
Gegenwart
Aussenklima
Zukunft
Gegenwart
Innenklima
Zukunft
äußere Klimabedingungen
innenere Erfordernisse
g
τ
U
n
c
F
Steuerung
Entscheidungs-algorithmus
CPU
VIRTUELLES GEBÄUDEMODELL
Gebäudesimulation in Echtzeit



Solarstrahlung
0 - 1000W/m²
zeitliche Verzögerung
Amplitudenreduktion
außen
innen
Feuchtigkeitstransfer
Wärmeaustausch
Luftwechsel
Lärm
Blicke
Gebäudehülle
Temperatur -15 - 35° C
rel. Luftfeuchtigkeit 0 - 100 %
Luftwechsel 0 - 20 m/sec
Luftqualität 400 ppm CO_2
Licht 0 - 100000 Lux
Lärmpegel 0 - 90dB(A)
Temperatur 20 - 26° C
Oberflächentemperatur 20 - 26° C
rel. Luftfeuchtigkeit 30 - 60 %
Luftwechsel 0,1 - 0,2 m/sec
Luftqualität 800 ppm CO_2
Licht 300 - 500 Lux
Lärmpegel 35 - 40dB(A)

Further reading:

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