

INNOVATIVE WINDOW CONCEPTS – CHALLENGES AND OPPORTUNITIES

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Introduction

The purpose of the present paper is twofold. First it attempts to describe state-of-the-art in windows production and recognize challenges and opportunities for the industry. Second it describes and evaluates a new concept of universal window frame recently developed and introduced by Kovinoplastika Lož, Slovenia. The paper attempts to judge the potential of the concept.

State-of-the-art

Across the world there are big differences in window concepts present. Even brief analyses shows, that for example windows in the US are constructed differently as those in Europe, partially due to difference in loads that window has to withstand but also due to different approach in addressing environmental issues. On the other hand most of windows (about 50 %) are produced in Asia.

Europe offers best combination of technical properties and ecological issues. There are numerous proofs for that claim. One of most obvious is that European systems are exported to countries that can afford European quality while for example US products are rather rare in Europe.

In a study that has been done in 2002 window market has been analyzed. The study has shown, that price of a window is not the most important factor when buying new window. Instead it seems that the most important problem is client's expectations that are associated with window performance. In other words: buyers do not know what are the possibilities that windows may offer. To demonstrate the claim: the study has shown, that »classical« tilt & turn window is selected as one of most desired constructions in 90 % of all case while all other modes seem to be far less (by factor 5 or more) less desired. This means that window leaf is prime point of development. Additionally the study was analyzing what are most desired additional functions of a window. It showed that most important seems to be burglar resistance, integrated shading systems, soundproofing and self-cleaning. The study did not involve IT issues. Regarding choice of different materials expected results were yielded; PVC-U windows are more frequent in low-income households while for example wood-aluminum is more frequent in high-income households. Overall conclusion that can be obtained from the study confirms that there is a promising market for advanced windows.

Second important issue when describing state-of-the-art is description of technical parameters. There are several parameters important. Some parameters, such as thermal transmittance, g-value (solar energy transmittance) and air-tightness are directly connected to CO₂ emissions. Other parameters such as durability, water tightness and light transmittance are connected to CO₂ emissions indirectly, for example through higher energy loss due to artificial illumination. Third group of parameters are technical parameters not or only remotely connected to ecological issues, yet they are important as proven by the above mentioned study.

Thermal transmittance has most obvious impact to CO₂ emission, because lowering thermal transmittance (U-value) directly means lowering heat needed to heat houses. Over the years development of different solutions may be noticed. Typical window frame for Alpine region around 1960 comprised single glazing with

typically wooden frames. In seventies double glazing was developed. Such solutions are still present in some EU countries (e.g. Spain, Portugal). Around 1980 window frame got thicker and other solutions such as PVC windows were developed. Afterwards U value of glazing was reduced and different constructions were developed, also combinations such as wood – aluminum were developed. At the end of 20th century variety of products was high. Also improvement in reducing U-value was significant, now comprising glazing with U-value 1,1 W/m²K and 68 mm wooden frames of multi-chamber, for example 4- and 5- chamber PVC frames. In latest years market has proven need for even better products, so nowadays so called passive windows can be bought (overall U-value < 0,8 W/m²K, glazing < 0,7 W/m²K, warm edge spacer included). Overall the U-value was reduced from approx. 4,5 W/m²K down to standard 1,3 W/m²K or 0,8 W/m²K in passive houses, which is 80 % reduction in 50 years. Next generation will seek for even better frames, incorporating more insulation and better glazing (for example 0,4 W/m²K) which might reduce today's losses for 50 % (i.e. 90 % over 50 or 60 years). However since energy loss is reduced towards zero it is reasonable to predict that additional functions will be integrated into windows, making windows energy producing element.

In direct connection to the U-value is solar energy transmittance (g-value). This value depends on glazing on one hand and on portion of translucent area in window. By lowering U-value of glazing at the present also g-value is reduced which means less solar gain. Natural countermeasure is increasing of translucent part of window. One can predict that portion of translucent part of windows will grow with development. However difficulty is on the horizon; in summer effective shading is necessary in order to minimize need for cooling. It can be predicted that self dimming windows will soon be on broader market. In fact, windows and glazing, incorporating mechanical shadings are already on the market, yet less of electro trope and thermo trope solutions are used, although technically available, partly also due to price.

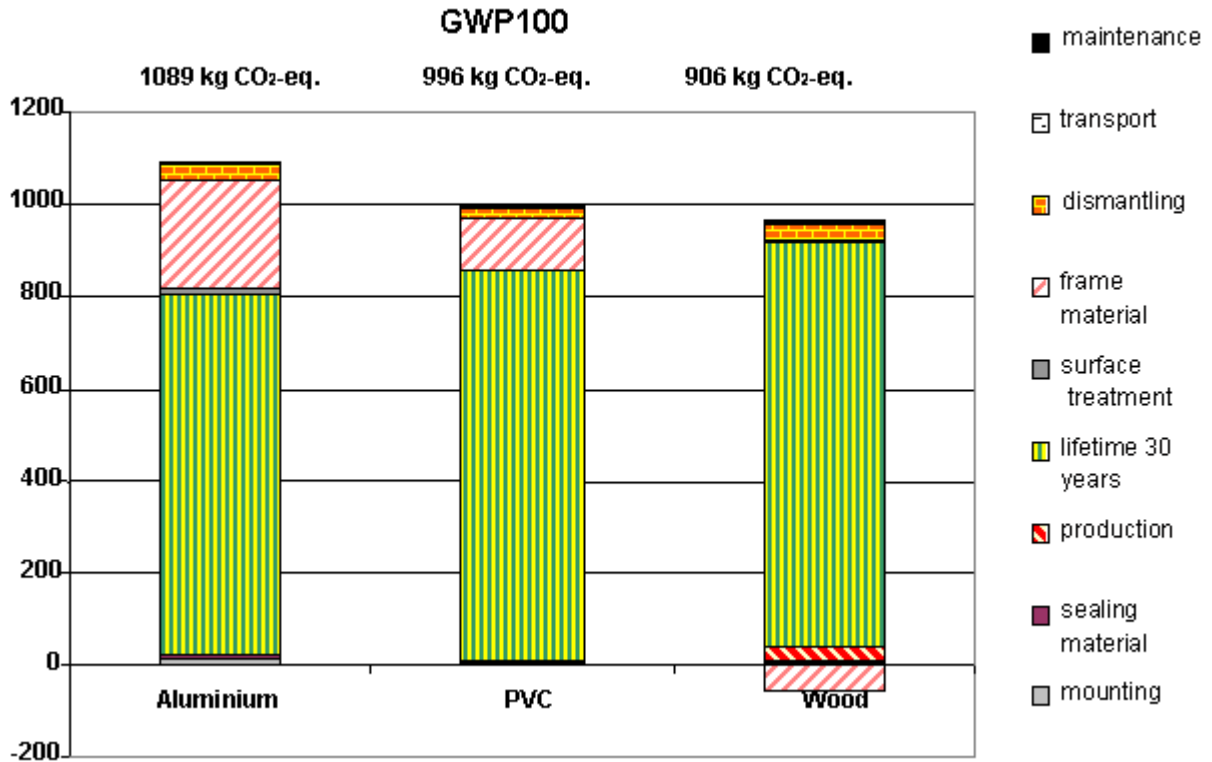
Air permeability is third characteristic that is directly connected to heat losses. In past decades there has been major reduction in ventilation heat losses caused by untight windows. At the present it seems that there is no need to develop air tightness of windows any further. A bit different issue is ventilation provided through windows. If in a certain building the ventilation principle is natural controlled ventilation there is development needed in automation and smart controls of ventilation devices. However one must not overlook the trend towards passive houses where mechanical ventilation is a must. In passive houses ideal air permeability of a window is zero, since all of the fresh air is supplied by mechanical means.

Connection of other parameters to CO₂ emission balance is more complex. Durability of thermal characteristics of modern windows is sufficient (i.e. heat losses are not increased significantly during life-time due to degradation of windows). It is however crucial that high quality processes, especially in glazing manufacturing are employed. As a consequence simplification and automation of production may have positive impact to durability in individual cases and thus reduce CO₂ emissions during life-time of a product. It is however difficult to evaluate impact properly.

Light transmittance (t) is next parameter that is important in CO₂ emission analyses. Similar principles are valid as are for g-value. Reduction of light transmittance is noticed when using selective coatings, however this reduction is less significant as is in the case of g-value. Solar protective glazings are a different story since they are meant to reduce both, g-value and light transmittance. In light transmittance again second important factor is ratio between translucent and overall size of a window. By introducing window frames with smaller height light transmittance is increased and need for artificial lighting and thus CO₂ emission may be reduced.

Third issue in state-of-the-art description with special connection to environmental issues is life cycle analyses (LCA) of windows. Although LCA methodology is well known it is not used widely across window industry. Nevertheless some results of LCA analyses are of window frames are available [2]. Analyses of mentioned studies yields two important results. First result shows that considering 30 years life-span by far the most important factor in assessment of global warming potential is actually performance or window as

whole. Second result is, that different frames have quite different results; while GWP of an analyzed wooden window is 906 kg CO₂-eq the same parameter yields 1089 kg CO₂-eq for aluminum window. The most differentiative factor is impact of production of frame in connection to energy consumption for this production. Based on mentioned conclusions it is important to improve performance of windows during service-time on the first place. Also important is to deal with integrated materials carefully. According to the study production of wooden frames requires only 73 % of the energy required in production of aluminum, while PVC is slightly worse than wood.



As written, assessment of the state-of-the-art has many aspects that have to be dealt with. Market trends on one hand and global warming on the other hand require redefinition of trend-setters in the window industry. Not only obvious aspects expressed through clear technical properties will be important in the future.

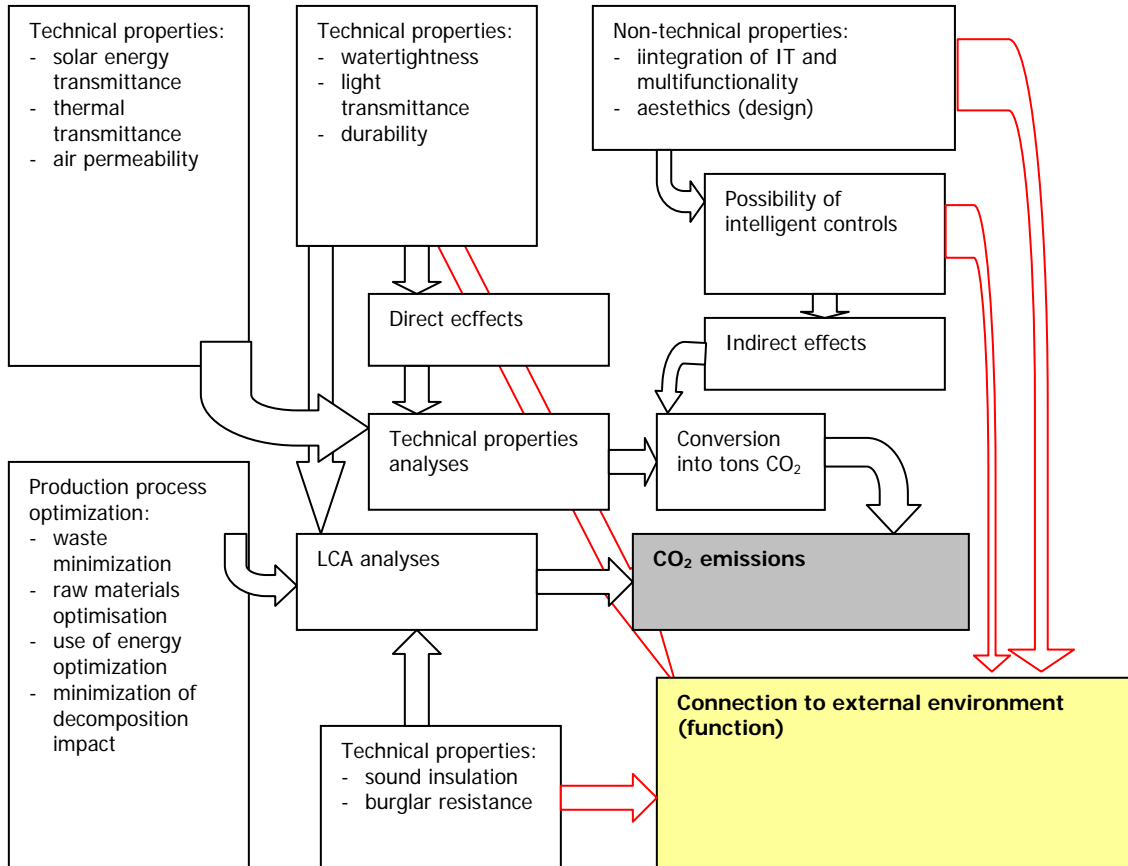
Innovative concepts and the potential

In light of analyses of current state-of-the-art it is obvious, that innovation in virtually all fields of window industry is needed. Since average size of a window producer is small, it is not easy to motivate industry in the field of research and innovation which is another obstacle in market and product development. Therefore it is especially important that attempts in searching for new added value to a window are not overlooked.

Many concepts have been developed over past years, addressing different, mainly isolated issues: self cleaning, improved weather resistance, increased insulation etc. or for example so called wood welding. Different attempts have had different success: increased insulation introducing composite frame materials is

well present on the market and is gaining its significance, while, as an example, wood welding technology is not yet implemented in industry [3].

One of the innovative concepts, introduced recently is also concept of universal window frame ARX® view. The concept is unique since it simultaneously addresses numerous issues on performance level but also on technological and ecological level. The complexity of such integrated solutions on CO₂ emission while still performing basic task of a window is shown on diagram 1. Impact, either direct or indirect of window performance and production technology to CO₂ emissions is shown. Also impact of performance and technology to provision of basic functions is shown, although connections here are less clear.



The aimed performance of the concept is rather high. In performance terms first aim is to achieve good thermal properties. Since these properties strongly depend on insulation of glazing it is more appropriate to discuss decrease of U-value of frames rather than absolute values. It is expected that U_f value (thermal transmittance of window frames) shall be reduced somewhere between 0,1 W/m²K and 0,2 W/m²K. With that reduction overall U-value would be close to passive standards.

Second goal is to increase translucent part of window by 10% to 40% and thus increase both, light transmittance and potential for solar energy utilization, without reducing basic values valid for glazing. Also in this case light transmittance and solar energy transmittance strongly depend on composition of glazing. It is however clear that bigger translucent portion of a window approximately proportionally increases light and solar energy transmittance.

Third technical goal is to improve sound insulation. Estimated improvement of 7% – 12% is expected. Due to the fact that sound insulation is not measured in % the goal needs additional quantification. It is expected, that improvement in sound insulation shall be sufficient to achieve class 4 (40 dB – 44 dB) instead of usual class 3 (35 dB – 39 dB) according to DIN 52210 which means measured value of sound insulation in laboratory ≥ 42 dB.

Fourth technical goal is improvement of burglar resistance. Again this goal strongly depends on glazing itself. Construction of the innovative concept ARX[®] view is such that enables use of glazing with high burglar resistance. It is expected that class 2 or class 3 according to ENV 1627 will be easier to achieve.

However main breakthrough is expected in technology. Unification of production is expected to lead to major savings in raw materials as well as optimization in use of energy. New technology is expected to be 10% less expensive. Use of fewer natural resources should significantly decrease environmental burden during whole production cycle. Reduction of use of raw materials is quite significant. It is claimed that potential impact to the environment under the assumption of reaching 1 % of market share in Europe (estimated 30.000.000 windows a year) alone is decrease of PVC use by 1300 tons yearly. In the case of aluminum frame production it is estimated that potential, expressed in MWh of electricity is 2.250.000 MWh yearly under the assumption of 100 % market share.

Although potentials are high it is yet another factor that is crucial in order to realize these potentials. It is competitiveness of European industry. It is essential for European window industry to address at least two key issues: to increase added value and to increase efficiency in use of energy and raw materials. Introduced innovative concept is expected to have big impact on both if the issues.

In order to assess whether above mentioned potentials are achievable the analyses of impacts has been done. General conclusion of different goals is positive, i.e. it is believed, that technical estimations are realistic. It is however impossible to predict whether market will accept the concept or not. So far studies confirm the expectation yet it is up to development to confirm the expectations.

In terms of technical performance it is estimated, that expected reduction of U_f value due to reinforcement removal is realistic. There is hidden potential in exploration of lowering linear thermal transmittance where lowering the ψ value for 0.04 W/mK would normally reduce overall thermal transmittance of window value for about 0,05 W/m²K to 0.10 W/m²K. There is however a trap in terms of durability. Production of durable frame in terms of U-value might not be very easy task. Nevertheless if durability issue is solved then it can be claimed that expectation is at least realistic. Taking into the consideration LCA analyses of windows impact of such improvement can be calculated for each individual case. Rough estimation yields approximately 10% to 20% of CO₂ emission reduction compared to usual window.

Expectations regarding solar energy transmittance and light transmittance are also realistic. Solar gains in winter in overall energy balance of a house (in Slovenia – result strongly depends on geographic conditions) may easily cover 30% or even more of total energy needed for heating. Increasing solar gains by, on average, 20% by introducing ARX[®] view concept directly means potential of 6% in heat needed for heating of buildings, which, converted to energy for an average building (calculated with 40 kWh/m² yearly) means approximately 2,4 % of heat needed for heating of buildings. However also in this area there is a trap: integrated systems must simultaneously deal also with cooling in summer, therefore automation is a big advantage.

Assessment of sound insulation improvement is in general realistic. It is impossible to estimate its impact, though. Improvement of burglar resistance is difficult to assess. Compared to average construction one

might expect higher resistance due to stronger glazing. It is however glazing that defines whether burglar resistance is improved or not.

In terms of assessment of impact of new technology one can conclude that the potential is right. It is however difficult to assess whether it will be utilized. One prediction is based on the fact of increased ecological issue and another factor is certainly competitiveness. However a lot of effort will have to be put into dissemination of the technology to change market perspective.

Conclusion

In the present paper two main objectives are dealt with; attempt to describe current state-of-the-art in window industry and an attempt to assess potential of newly introduced unified window frame system ARX[®] view, developed by Kovinoplastika Lož, d.d., Slovenia.

While the first objective is achieved through literature overview and through integration of experience, the second objective is achieved through technical analyses of the proposed construction. Derived conclusions are attempting to be as accurate as possible although it is virtually impossible to assess all of the influential factors. However in frames of development of the concept this assessment will surely be improved in order to yield more precise data.

Nevertheless the analysis strongly supports the idea especially for two good reasons; the concept truly has the potential to further reduce ecological burden of window production and, secondly, the concept is a true opportunity to change global market and to establish a new class of windows with much higher added value and thus help European industry in competitiveness. Missing this opportunity might be a crucial mistake for the future.

Literature

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