# SOLIDI JOINT CONCEPT & SOLIDIWOOD PROCESS TECHNOLOGY TO GLOBAL MARKET LEADERSHIP

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# COMBATING GLOBAL WARMING & BIODIVERSITY LOSS

An innovation story and non-fiction book on Solidiwood technology for the wood products industry and on the Solidi business entity

The Solidi development project creates lasting value

Solidi is a business ecosystem enabled by Solidiwood process technology and based on digital business platforms, as well as a global national-interest joint concept for technology and wood products companies

The integration of the digital Solidi platforms and the technological Solidiwood platforms.

Author

**Matti Kukkonen**

Chairman of the Board, Solidi Finland Oy. Wood industry technician and mechanical engineer. Visionary and innovator of Solidiwood 3D process technology & the Solidi national-interest business model.

Successor of the Solidi development project

**Heikki Kukkonen**

My son Heikki Kukkonen has been CEO of Solidi Finland since 2019. At the end of 2022 he left his position as business director for digital services at Innofactor Plc and continues as CEO of Solidi Finland. Heikki has extensive experience of working in various roles in projects developing and deploying digital services and technologies to support a range of business needs.

*The core of Solidiwood 3D process technology is that wood products are not machined in the traditional way by chip removal; instead, they are manufactured – right down to surface treatment – by hot forming green sawn timber in product-specific units.*

*Solidi Finland Oy, together with its joint-concept companies, will revolutionise the further processing of green sawn timber with its Solidiwood 3D process technology and, together with the national-interest Solidi business ecosystem that this enables, achieve global market leadership.*

*Solidiwood 3D process technology and the national-interest Solidi business ecosystem enable small Finland to become the world-leading nation in its industry, together with cost-free combating of global warming and biodiversity loss.*

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## To the reader

Looking back, the beginning of my development project in the wood products industry can be traced to the time when I was just starting my career in the field: at Koli, as a young boy, when I worked in my parents' small wood products business after finishing primary school. This background led me to sawn timber, its further-processed products and their technology, to training as a wood industry technician and a mechanical engineer, and to the large-scale sawmill industry – and later to becoming a small industrial entrepreneur in my field and, finally, an entrepreneur innovating technology and products. In this way the Solidi development project became nothing less than my life's work.

The themes of my book are the story of how a radically new business opportunity was born – the story of a big vision built up over years and decades through experience and hardship, in which, instead of maximising the returns of a single person or organisation, the aim is to solve a problem bigger than oneself for the common good.

Now, in 2026, Solidi Finland Oy has a forthcoming innovation package that has gone through successful development and research phases: the combination of Solidiwood 3D process technology and the Solidi business ecosystem. Its adoption will make the green sawn timber further-processing industry, in Finland and worldwide, considerably more resource-efficient, give it a better product range and make it more environmentally friendly in every respect.

Advancing the fight against climate change and biodiversity loss is a significant consequence of putting Solidiwood process technology into large-scale use. This large-scale opportunity lies in the national-interest Solidi joint concept & Solidiwood innovation package. My development project, which has turned out to be my life's work – my thesis (my “dissertation”) – is now available as a book, the result of my writing over the last five years.

The Solidi project was built on both my vocational studies in sawmilling and engineering and the experience of my life. It took concrete shape 27 years ago, when it was launched with the set of goal slides I prepared for an expert course at the University of Helsinki. Its starting point was the development of a radically new and profitable product range & technology. It already contained the foundations of a new business model, too.

My book describes, with its justifications, the radically new Solidiwood 3D process technology and the even more radical national-interest Solidi business ecosystem, i.e. the business model. It is also essential that the greater the profit opportunity that can be achieved, the more can be invested in both of them.

The specific target groups of my book are: 1) the management of the technology, wood products and construction industries, 2) R&D, public decision-makers and educational

organisations, 3) forest owners and 4) those who plan the use of wood products in construction and elsewhere and, above all, their end users.

The purpose of my book is to answer the question: what, why, how and with whose support the Solidi & Solidiwood development project has reached its present state – and to activate the parties in taking the project to industrial scale. With the help of the book, wood products and technology companies and those who serve them can more easily understand the radically broad and high overall result arising from the project and be motivated to study the project's present state and its foundations in depth.

Solidiwood 3D technology also creates a wood products industry that wins markets from, for example, carbon-intensive industries, offering a serious alternative to concrete, aluminium, laminate and plastic production.

Behind the present state of my development project and the results expected of it lies a process of more than half a century, which has made me the developer of a radically new kind of operating entity for the technology and wood products industries. In this book I tell the story of my development project from the basis of its innovation, its first moments and its development stages right up to its present state, and then turn my gaze to its future opportunities.

Reading the book from beginning to end will give you a thorough understanding of my project and of the people and organisations behind it. The whole will also help you understand the operating principles, results and foundations of the processes involved in my project. As a reader you are, of course, free to go straight to the part of the book that best serves your information needs right now. More detailed information on the present state of Solidiwood process technology, on the business, on their combined effects that I have already mentioned above, and on what the large-scale opportunities I present are based on, can be found in the second part of the book, II PRESENT / FUTURE.

My aim with this non-fiction book is to bring Solidi & Solidiwood closer to its potential users and partner companies in a coherent form that brings the information together. At the same time, the book is a case study of Finnish innovation which, I hope, will encourage and support – and offer something to identify with – visionaries and innovators who have experienced difficulties with their own development projects or who dream of a breakthrough for their innovations, as well as professionals working on development projects in the service of society or companies.

My book tells of a strong vision built up through even great difficulties, in which, instead of maximising the returns of a single person or organisation, the aim is to solve a problem bigger than oneself for the common good.

The better my understanding and command of my development project as a whole became while I was writing my book, the more – and the better – new results emerged. This, if anything, surprised me and spurred me on to continue. Thus the profit factors of my project improved, especially while I was finishing my book. I truly felt that my work had not been in vain.

Decades ago I read in a book by a guru of the field that *the inventor and developer should express the results as they themselves experience them.* Nor would I feel honest if I did not act in this way. At the same time, of course, I also want to say that the Solidi project has been built with the support and help of my many assistants. Our shared and difficult problem is that the overall result is incredibly large, and yet one must dare to express it despite the difficulties that follow from it, some of which seem almost insurmountable.

The overall message reflected in the core messages I set out below could not be foreseen when I started my book, nor even while I was continuing it. It emerged only in the final stages, and as a surprise – *the Solidi project is the integration of the digital Solidi platforms and the technological Solidiwood platforms.*

## The core messages of the Solidi project and of my book

1. ***The core of Solidiwood 3D process technology is that wood products are not machined in the traditional way by chip removal; instead, they are manufactured – right through to surface treatment – by hot forming green sawn timber in product-specific units.***

2. ***Solidiwood 3D process technology makes possible Solidiwood further-processed products that are by far the most cost-effective and affordable in terms of price-quality ratio compared with traditional further-processed sawn timber products. These factors alone would be enough to revolutionise the further processing of green sawn timber.***

3. ***The use of Solidiwood 3D process technology and the use of the national-interest joint concept that it makes possible – the Solidi business ecosystem, which is even more radical than the technology itself – enable exponential business growth.***

4. ***Finland has an unrivalled starting position to become the user of the market leadership of the Solidiwood 3D process technology and wood products business of Solidi Finland Oy and its joint-concept companies, and of the national-interest joint concept, the Solidi business ecosystem.***

5. ***The Solidi project can make today's small Finland the world-leading nation in its field, while also maintaining the manufacture of its technology and its future development in line with its vision.***

My book is a reference work on the future of its field and on how that future can be built into an industry – breaking the centuries-old tradition of the sawmill industry and, in particular, of its further-processing industry. It sets out the foundations and the operations, together with the visions for the future, through which its core messages also become reality.
This book

**Firstly,** this book shows as a whole how persistent and productive the development and research work that my development project has gone through so far has been. The incredibly large opportunities of the Solidi project have been built through really hard work, over a long period of as much as 65 years and with the support of numerous people.

**Secondly,** a particularly significant factor and an additional stimulus has been a work by historian and professor Markku Kuisma that I read in 2012, *Saha – Tarina Suomen modernisaatiosta ja ihmisistä, jotka sen tekivät* [Sawmill – The Story of Finland's Modernisation and the People Who Made It], which covers the period from the first half of the 19th century and the first steam sawmills to the breakthrough of the sawmill industry and the golden age of the sawmill barons. What matters most is that the end situation described in Markku's work (published in 2011) was our country's situation at that time – the foundation for the future. On this basis it was, and still is, good to continue building the Solidi project successfully.

**Thirdly,** "Finland's forests have now changed from a carbon sink into an actual source of emissions. The chair of the Climate Panel warns that Finland's climate targets will collapse unless action is taken. In the future, products with better added value should be made from less wood." This applies to much of the rest of the world as well, and thus provides perhaps the most extensive and far-reaching challenge, and justification, for the necessity of the Solidi project.

Why do I want to tell about my development project in the form of a non-fiction book as well? The main reason for starting this book project lies in the present state of my project and, in particular, in its next steps. The results expected of the Solidi & Solidiwood whole continue to broaden, as does

the group of supporters working with it. Next, those who will make use of the whole and its end users should find their way to the development project.

The Solidi & Solidiwood whole requires in-depth study before the large-scale opportunities it offers can be understood. I hope the book will help readers understand the processes and the foundations behind the results achieved in the project.

Anyone who reads my book will also come to know my values. The incredibly large opportunities and foundations of my project could not have developed and been built without them. Similar values will be needed in the future as well if Solidi & Solidiwood is to be put into use in line with my goals and to work as intended. On this basis it is safe to continue. My aim has always been that my book, too, should be made as neutral as possible. It should provide common starting points especially for all potential Solidi joint-concept companies and stakeholders. The broad publication of the complete information in my book is of truly great importance for our country and for the world.

**I have divided** the story of Solidiwood & Solidi into two parts according to its chronological phases: I RESEARCH & DEVELOPMENT and II PRESENT / FUTURE.

The chapters of Part I RESEARCH & DEVELOPMENT describe the research the project has gone through and the development work that followed from its results. This part of the book shows the critical phases that preceded the present state of my development project and that lie behind its current results and the foundations I present. It describes the journey that followed the first phase of the project as a whole – from the preliminary tests in a "garage laboratory" to the productive cooperation with Koskisen Oy and Lahti University of Applied Sciences[1], as a result of which the project matured and became ever more closely connected to a wider network of experts.

Part II PRESENT / FUTURE contains a comprehensive description of the present state of the project, as well as of the components of my development project and the properties of my technology in the forms they have reached today as a result of development work. I present the solutions that Solidiwood offers to the industry of today and of the future. A central part of this is also the effects of the technology and the business model in support of combating climate change and biodiversity loss. In addition, this part looks at ever-accelerating development, megatrends and Solidiwood's future prospects, for example through the opportunities offered by virtual models.

Truth can never be told so as to be understood, and not be believed (William Blake 1790, *The Marriage of Heaven and Hell*).

[1]Now part of LAB University of Applied Sciences.

My history in the wood products industry has given me the will to develop its operations, the ability to see where development is needed, and also knowledge of what could be done. The source of my motivation for my project therefore lies in my strong background in the field. What matters most is that for 16 years, as an industrial small entrepreneur running Ilvolankosken Puu Ky, I produced from tension-prone birch first brush handles and blanks, i.e. intermediate products for industry, and later, as my own blank product, floorboards and strip parquet for builders.

During that time I felt a need for development, especially in the production of my own products – in terms of material properties, the products themselves and the technology alike. This initial motive awakened thoughts which, combined with my other knowledge and ideas, formed the foundation on which the Solidiwood & Solidi whole began to be built and supplemented.

**From the very beginning I have been** well aware that putting the Solidiwood whole into practice at larger volume will not be easy. At the same time, as a result of increasingly diverse and continuous work, as well as cooperation and strong evidence, the broadening expectations of results and my group of supporters have kept up – and still keep up – my motivation for the project.

For example, the interest shown by representatives of industry and their actions for the benefit of my project have strengthened my faith in it and guided me to continue my work. In particular, I have had numerous meetings concerning the opportunities of my development project with the development managers of two large industrial companies – with one of them over as much as a decade. In due course, both of them also proposed to their companies that they proceed on the basis of my solutions. However, one of them moved to a company in another sector and the other's employment ended[2].

These two development managers, as well as a professor at the University of Eastern Finland (UEF) and an engineer from Savonia, to whom I have presented my development project, had already been involved with one of the starting points of my project's technology – press drying. Their interest in particular has therefore supported my goals and encouraged me, and their expertise surprised me positively already at our first meetings, which have led to longer-term and progressing joint efforts to achieve a new and better end result.

**As I see** more clearly year by year how fundamentally my development project also contributes to combating climate change and biodiversity loss – above all through its resource efficiency, while at the same time increasing carbon sinks – I cannot help gaining additional motivation to work for it.

[2]A few years later, however, he still continued working for my project while in a position in a new company corresponding to his previous job.

My project as a whole is a cleantech solution that promotes the sustainable use of natural resources, maximises resource efficiency and at the same time reduces industrial emissions. In this respect, too, these are measures of significance not only nationally but also globally.

**The most important sustainer of my motivation, faith and courage in all this** is an experience of mine that is only indirectly connected with my development project, yet at the same time part of its origins: how I came through the extremely difficult and extensive legal process, in 1985–1996, that followed the collapse of a dam and a bridge during the time of my industrial company. I alone stood accused – the opposing party being the then National Board of Roads and Waterways (TVH), assisted by the National Bureau of Investigation (KRP), the prosecutor and VTT – of the collapse of the TVH bridge and of the dam used by my company, of the damage resulting from them and of endangering human lives. In reality, the collapses I was accused of were the result of the fact that a few years earlier, when renewing the bridge, TVH had removed the well-built earth dams with their watertight tongue-and-groove plank walls and replaced them with nothing but earth fill.

When the legal process was still at the stage where the true cause of the collapse was being strongly concealed by our society's authoritative officialdom, right up to VTT, my friend Heikki Tukiainen – a profound thinker who in other ways, too, brought a great deal of wisdom into my family's life – said to me in his calm way: “Truth is the kind of thing that digs its way out.” He added to these words his reflections on how unpredictable the emergence of the truth is: it can happen quite unexpectedly and in a situation that has nothing whatsoever to do with the matter.

Heikki's thoughts about the truth coming out built in me, during that hard time, a firm belief that this is exactly what would happen in my difficult legal process, too. And so, over the course of a decade, it really did happen: the truth dug its way out. It could not be concealed forever, not even by authoritative bodies.

Heikki's meaningful words have stayed in my mind even after the legal process. The belief – and the evidence I received – that truth really is the kind of thing that digs its way out has made me grow and taught me more than anything else. This thought has also motivated me to go forward with my development project through its various stages. I know that the truth will eventually come out and become visible in its case, too. All that is needed is the effort of numerous different actors to help it along.

In addition to all of the above, what motivates me to write about my project is also my wish to encourage others who believe in the success of their own overly large projects to continue despite their perhaps considerable difficulties – and, above all, to activate our society and our industry, right

up to the highest management, to take up development ideas coming from small companies and even from private individuals.

## The seeds of the Solidiwood process technology development project begin to germinate

The basic idea of my development project had begun to germinate as early as 1988, after I read an article in the magazine *Puutekniikka* [Wood Technology][3] about the 1D press drying of beech sawn timber used by the Danish parquet giant Junckers Industrier A/S in the manufacture of solid wood parquet. This subject interested me greatly, since I had myself produced flooring products from an almost equally tension-prone hardwood, birch, and there was a need to reduce, among other things, the warping that occurs when sawn timber is dried and to improve other properties of the end product as well. What surprised me most about Junckers' technology, however, was the short drying time, only two hours. In that time the moisture content of 32 mm thick beech sawn timber falls from 80 per cent to as little as 1 per cent. The pressing temperature is 160 °C, the pressing pressure 12 bar, and the reduction in thickness, i.e. the compression, of the load-bearing parquet blanks 20%. Junckers began using the pressure drying developed by its founder, Flemming Junckers, in 1962.

A few years before my bankruptcy in 1993, I did in fact obtain a quotation from Raute for a test press for just a few boards. Fortunately, however, I did not take that request for quotation any further at the time. I got my first start in familiarising myself with heat treatment alone when a certain fire chief, a pioneer of the field in Finland, received a device he had bought from Canada.

*The potential overall result of the Solidi & Solidiwood business, as shown in Part II of this book, is incredibly large. The starting point for making it a reality is the launch of my development project on the foundation I have described above.*

## The early stage of the innovation process

All the stages of my life that I have described earlier in this book – from my entrepreneurial family background and my studies to my career in industry and as an entrepreneur in it, with all its successes and challenges – have formed the basis of my innovation work and played an important role in shaping my development project. The last chapter of this part of the book is already about the ideas taking concrete form: about how the so-called sowing began to germinate.

The period of my project described in this chapter was largely the time before email. When I started writing this book, I threw away about three quarters of the letters and other material from

[3] *see Puutekniikka* 10/1988

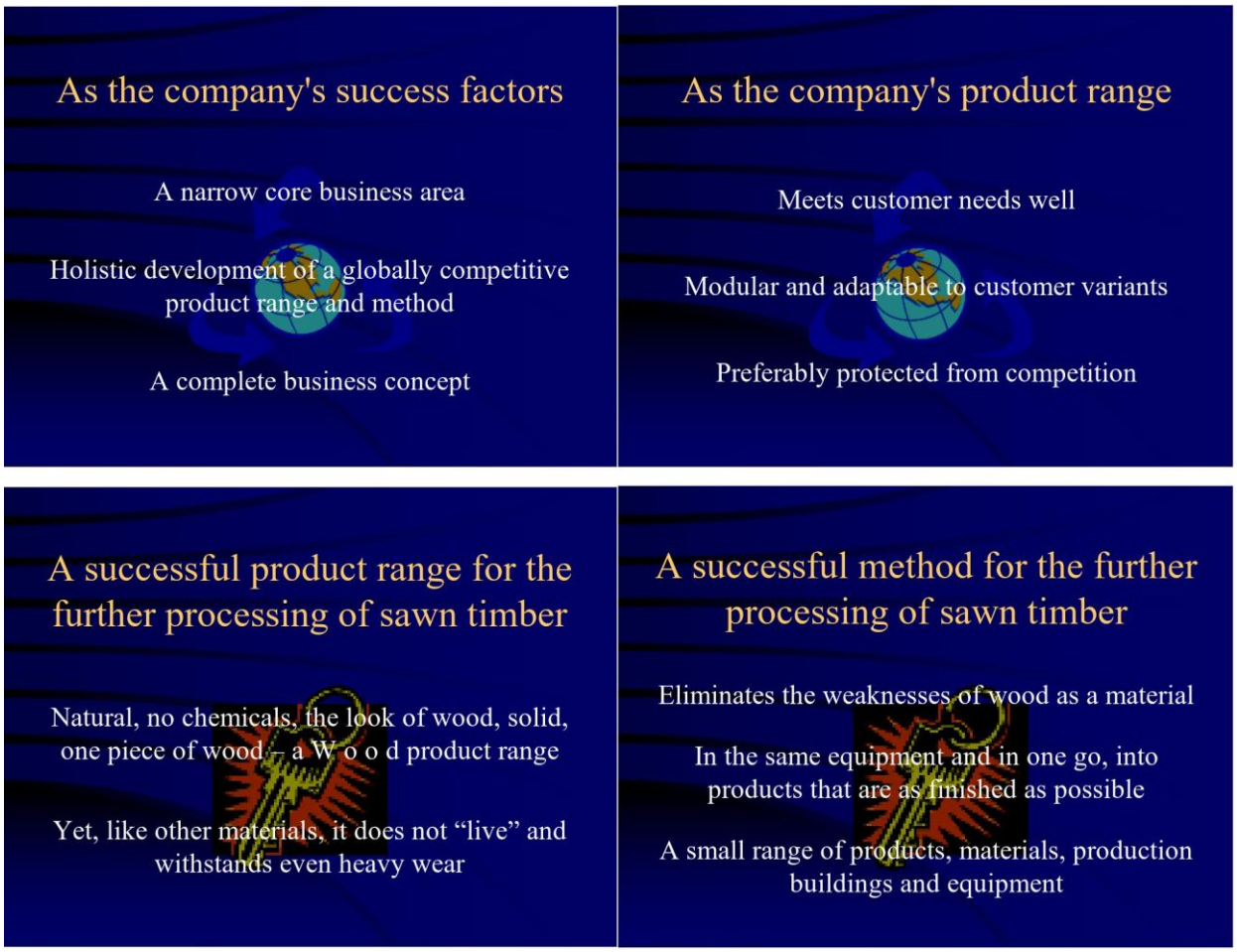
that time. However, I needed the practical work reflected in all of that material – both what I threw away and what I kept – in order to find enough productive ideas for further development. From these ideas, and from those found later, a product range – i.e. a process technology and a business concept – has been built up, especially as a result of the development work of the last couple of decades; its partial solutions complement one another and lead to a substantial overall result.

# I RESEARCH & DEVELOPMENT

## Starting points

The final project of the expert training programmes I completed at the University of Helsinki in 1997–99 laid the foundation for the subsequent stages of my project, which I describe in this part of my book. This part describes the most important development stages of the Solidiwood project from the beginning of the 2000s towards its present state and the year 2026.

As the final project of my expert training, I produced a comprehensive presentation based on the ideas from the early stage of my development project's innovation process at that time. The work presents the profit factors and goals that build Solidiwood's lasting value as a company, a technology and a product range. My central ideas at the time were a globally competitive wood product range that would be more sustainable in every respect and could be produced as close to finished as possible in a single machine, and the business opportunities created by this core idea.



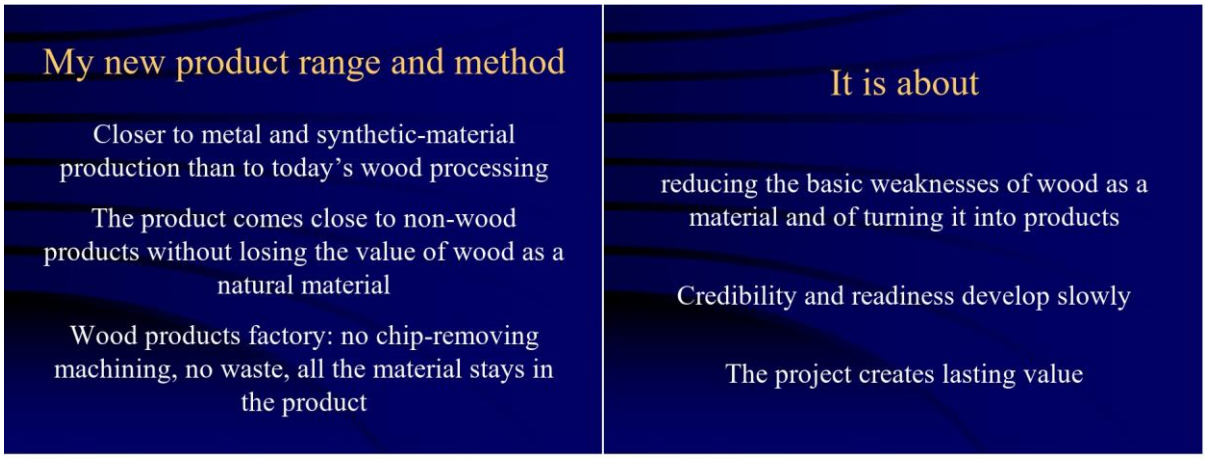



FIGURE. *Slides from my final project*

An overall picture of the state of Solidiwood in the first decade of the 2000s

By 2005 I had been carrying out development work on the Solidiwood wooden floor-covering product range and its manufacturing method for about 15 years. It was clear that the solutions I had developed would not mean small improvements to existing technology and wood products; rather, it would be a question of new technology and new wood products with new properties. In my development work I considered it a very important starting point to develop an economically advantageous overall solution, and I had already established that the total investment and production costs of a company using my pressing method would remain clearly lower than those of other methods in use. At the same time, products made with my method would be better than those made with the old one: a product dried, heat-treated and profiled with the machine made possible by my method would keep its shape better, and under more varied conditions, than one produced by normal drying followed by chip-removing machining. Other reasons for adopting the method I was developing had also already emerged. In addition, I had many development ideas in mind that would bring added value to the pressing method.

A second factor found on the basis of my development project's research and development is the hot-pressed Solidiwood 1D flooring products. Since my bankruptcy auction, i.e. from 1994 onwards, I had had birch ILVO floorboards and strip parquet manufactured and supplied them in the name of my new company, Ilvolankoski Oy. At the turn of the millennium I began having planed Solidiwood 1D floorboards and strip parquet made from birch sawn timber hot-pressed on its faces, and supplying them. My starting point and my safeguard was that Junckers had already been press drying sawn timber for over 50 years with heating plates pressing both faces. My very successful deliveries strengthened my faith in my development project for 3D pressing – on a completely different level – which had already started by then.

## Towards research and development activities

The decade changed while I was actively marketing the Solidiwood innovation, protected by industrial property rights, in the name of my company at the time, Ilvolankoski Oy – primarily to the wood products industry and secondarily to the technology industry and various public-sector actors. The aim was to start the research and development activities that were essential for advancing and productising the innovation, and starting them required obtaining external resources. The intention was to get the targets of my marketing interested in my technology and involved in a joint project needed to bring it into industrial use.

Over the years a great deal of information about my technology and the business it makes possible had already accumulated, and more kept accumulating, even though the actual research and development phase, in the full sense, had not started. I had soon been working on my project for twenty years.

In the first years of the new decade, Koskisen Oy and Lahti University of Applied Sciences (hereafter LAMK)[4] became important contacts for Solidiwood's future; I had first been in contact with both of them years earlier. Solidiwood's research and development activities started in 2011 in cooperation with LAMK and Koskisen Oy.

## Preliminary tests and manufacture of a product sample in Pekka Koivukunnas's garage lab

The purpose of the preliminary tests was to verify that the hot-pressing method works, to make observations of the phenomena occurring in the process and to manufacture at least one product sample. We carried out 20 preliminary tests in all. For the blanks we used freshly sawn (green) spruce boards, which we kept frozen to prevent them drying and took out of the freezer only just before each test. We carried out the tests with a hydraulic press that we had fitted with two heating plates and screw-operated side-pressing tools. I took part in some of the tests and paid for the additions to the equipment and other supplies. When I was not present, Pekka and I phoned each other about the results and the continuation of the tests.

The results of our tests proved true the radically new opportunities offered by the technology and products that I had already presented earlier in writing. For example, the 20th test, in which we tested whether the deformation of a product made with the method recovers under the effect of moisture, confirmed that the deformation produced with the technology I had presented is permanent.

[4]Now LAB University of Applied Sciences.

In this particular test, a piece was sawn from a blank produced by the pressing process in an earlier test phase and immersed in water for an hour. The piece was then allowed to dry freely in the air. It was observed visually that immediately after soaking, the immersed piece of blank was slightly thicker than the rest of the blank, but after drying it was practically the same thickness. This showed that a product made with the method does not return to its previous form under the effect of moisture; instead, the deformation produced by my method is retained.

We also carried out tests of pressing traditional tongue-and-groove profiles onto the edges of a board. They showed that the profiles must be pre-profiled. This is most sensibly done already in the manufacture of the sawn timber, where profile sawing makes it possible.

Finally, we made a product sample whose edges were machined with traditional tools. Compared with traditional boards, what is new about it is the use of a loose tongue strip and chamfers on both faces, which make the board's profile completely symmetrical. This allows the user to install the board with its better side facing out. The concept is suitable for exterior and interior cladding boards as well as floorboards.

When thin, short grooves are pressed into both edges without pre-profiling, the pressing force required is small and roughly equal from both surfaces. The same applies to producing the necessary chamfers. Unfortunately, these were not tested.[5]

FIGURE. *Cladding board made by hot pressing in Koivukunnas's tests (22 x 155 -> 20 x 150).*

**At the end of August** Pekka sent the final report he had written on the tests and the manufacture of the product sample to me, to the Foundation for Finnish Inventions and to Markku Mäkelä of Tekes.

[5]Koivukunnas 2009.

*Solidiwood®-teknologian esikokeiden suorittaminen ja tuotenäytteen valmistus* [Carrying out Preliminary Tests of Solidiwood® Technology and Manufacturing a Product Sample], *Pekka Koivukunnas (2009), summary*[6]:

> On the basis of the tests carried out, Solidiwood® technology appears to be a feasible and promising new technology for the manufacture of wood products.
>
> The tests showed that the technology makes it possible to dry a freshly sawn wood blank to joinery dryness quickly (about 2 hours + cooling time) and without defects (no cracking, warping, etc.). Over-drying is also possible. At the same time, the dimensions of the wood blank can be changed permanently (soaking did not reverse the deformation), i.e. the blank can, for example, be sized to dimension or compressed.
>
> It was also possible to produce a tongue-and-groove profile by pre-profiling the green wood and using a suitably shaped side-pressing tool.
>
> It was observed that the surface of the wood blank becomes considerably smoother, especially if it is wetted before pressing. At best the surface is so smooth that, as far as I know, no technology currently in use can achieve anything comparable. Likewise, a desired surface texture (relief pattern) can be copied onto the wood surface.
>
> Joining two freshly sawn wood blanks to each other by gluing during the press-drying process proved possible.

In the final stage of Pekka's lab study, I had him carry out one more, completely new test, in which we placed Chinese wood oil (tung oil) in the middle of the board's face before the pressing process. During the process the oil spread precisely to the edges of the face and there was hardly any run-off. The oil appeared to bond permanently to the wood, and the result was a protected, smooth and dense surface. This test gave me a strong impulse for surface-treatment research with different substances in the future test work on my innovation. Already then, therefore, I thought that broader research should focus not only on the surface treatment of the products but also on the profiling of their cross-section and on the manufacture of products glued together from different product parts.

## Key tests in Timo Kolmonen's mini lab

In February 2010 I began carrying out various key tests, in preparation for possible research at a university of applied sciences, together with Timo Kolmonen, who had retired from his position as Development Director of YIT's industrial maintenance business. These tests took place in Timo's "lab" in Vantaa, with equipment made from a berry press and clothes irons.

[6]Koivukunnas's (2009) final report on the preliminary tests and the sample product can be read in full here.

We wanted to carry out the tests as carefully as possible, so we acquired two square aluminium profiles, two irons, an infrared thermometer, a moisture meter and a sensor suitable for measuring the internal temperature of wood. We took the irons apart to make them suitable for manual heat control and fitted them inside the aluminium profiles. To generate the pressure in the berry press we used a 10-tonne jack.

In connection with the key tests we were able, among other things, to confirm the results of the radically new surface-treatment test carried out earlier in Koivukunnas's laboratory. There were good grounds for continuing these and other tests later in Lahti with better equipment.

The last of the significant key tests was a study in which we investigated how coating residues that may have adhered to the pressing tools can be removed. The result of this study was so clear that there was no need to continue it elsewhere.

REPORT ON TESTS TO REMOVE HARDENED COATING RESIDUES

Place and date of tests: Timo's laboratory, Vantaa, 4.11.2016. Carried out by: Timo and Matti

Coating agents: hardwood oil and undiluted oil + oil-based and water-soluble paint. Removal agents: Nitromors, 50% Nitromors and 50% thinner, thinner alone.

The coating agents had been brushed onto an aluminium surface, dried for some time at 50–70 ° and left to harden, i.e. dry, for 24 hours in a laboratory room at about 17 °C.

The first tests were carried out with the aluminium surface at about 17 °C. Both oils came off quickly and were removed with a gentle water jet. Neither of the paints, on the other hand, came off except by scraping.

The temperature was raised to and kept at about 50–70 °C, and the results were as follows:

- Both oils came off immediately and were easily removed with a gentle water jet.
- Both paints came off after a short delay and were removed with a gentle water jet.

The total time was longest with Nitromors, about 10 min, and shortest with thinner alone, about 1 min. With a mixture of the two it was almost as short, > 1 min.

Nitromors is expensive, and for other reasons too it would make sense to mix it with thinner only sparingly.

**For the other tests** there was no need to record the results or write reports. Kolmonen later received copies of my email correspondence with, for example, LAMK. We discussed these and my experiences of the research carried out there. Kolmonen's and my almost daily contact about my project still continues, now on a weekly basis.

## Koskisen Oy & Lahti University of Applied Sciences become R&D partners

In late March 2011, Kari Koskinen of Koskisen Oy unexpectedly sent me an email. During 2010 I had been in contact with him, sending Solidiwood marketing materials and other information about the project, as I mentioned in the previous chapters.

I had first been in contact with Koskisen Oy as early as the beginning of 1998, when I visited the company with Pekka Jussila of the Tampere Technology Centre to present my project to Kari Koskinen and Juha Miettinen, following a preliminary study on the patentability of my invention.[7] Already then I regarded Koskisen Oy as the most concrete option for taking my project forward and making use of it. In addition to the further processing of sawn timber, the company had hot-pressing production in its panel industry, relevant to the basis of my technology.

After this first visit I had regularly sent Koskisen Oy the latest information about my technology, and I also reported to them on, for example, the completion and results of the series of preliminary tests and the sample product.

**I had made my first contact with Lahti University of Applied Sciences** by emailing information about my project to Jari Suominen, MSc (Tech), a principal lecturer at the institution. Later I also went to present my project to him with the help of my PowerPoint presentation. LAMK came up again in 2008, when Tero Lahti of Pöyry and Pertti Viitaniemi of TKK (Helsinki University of Technology) urged me to contact Pentti Perkiömäki at LAMK and to present my technology to them for research. So I sent him an email at the time:

> I have already developed new business opportunities for the wood products industry, protected right up to a European patent. You can find preliminary information on the opportunities they offer on the website I have launched.
>
> There would be grounds for very substantial projects in marketing my technology and developing it further into business operations. I also believe that such investments would help build a strong commercial foundation, especially for the industry producing further-processed sawn timber products.

The aim of the information I sent to Kari Koskinen, especially during 2010, had been to get a significant company involved in the research on my technology that already looked possible at LAMK.

Now, in this message of March 2011, Koskinen invited Pekka Koivukunnas and me to a meeting on research into Solidiwood technology, which would be attended by LAMK principal

[7] see p. 68

lecturer Jari Suominen, Markku Mäkelä of Tekes and, from Koskisen, he himself and Timo Närvä. This meeting launched Solidiwood's research and development phase in cooperation with LAMK and Koskisen Oy.

## Research & development at LAMK

Soon after the meeting that launched the research and development work, students had been found to carry out the first Solidiwood research project at LAMK. Supervising teacher Jari Suominen appointed me as mentor to the students conducting the research. Jari Suominen played a really important role throughout the research phase; he made it possible for a good connection with LAMK to be built and to remain strong for the entire duration of the project.

Over the following years, the Solidiwood research was carried out mainly in the LAMK laboratory. Some tests were also done at Savonia University of Applied Sciences. The results of the research work were presented only to the parties involved in the research.

We obtained the timber needed for the research from Koskisen Oy, and their representatives visited LAMK to familiarise themselves with the research being carried out. I also visited Koskisen numerous times, either alone or together with the students, and we held meetings with Kari Koskinen and other representatives of the company.

In this main chapter I present, mainly in chronological order, the research carried out on Solidiwood and the other investigation and development work related to it during the period of the LAMK research in 2011–2014. What I present is largely based on surviving emails and other written material from that time.

Once the LAMK research had started, I felt that my most important task would be to motivate everyone involved in it: why, and what, it was worth achieving. I therefore kept them informed of the overall situation and, ahead of each new phase, gave them numerous business and technological justifications. In my view, the basic starting point of Solidiwood R&D was that the research should be targeted primarily at the new areas offered by Solidiwood technology, namely in particular:

1. the profiling of products
2. the manufacture of products glued from different product parts
3. the surface treatment of products.

What was essential, in my opinion, was that only with these new components is it possible to achieve a radically profitable technology. The aim of the R&D work was, in particular, to verify

through experiments the potential of the various applications of Solidiwood technology and to identify and solve their problems.

The first Solidiwood research work[8] carried out at LAMK in cooperation with Koskisen Oy and Ilvolankoski Oy, the company I represented, began in spring 2011 with a preparatory preliminary study. In it, the wood technology students who carried out the project, Leo Lähteinen and Eero Kahilaniemi, verified the basic factors of the press drying that Junckers had used for decades, and for the forthcoming main experiment they looked for the parameters with which a wood blank can be dried evenly to joinery dryness, i.e. to a moisture content of even below six per cent. The preliminary study also examined the cracking of the wood and the loosening of knots in the process. The preliminary study was successful, and it made it possible to outline the right parameters for the test press of the main study. In addition, the drying defects found in the preliminary study were minor.[9]

The actual research project began by investigating the possibility of producing a multi-part product. After the tongue-and-groove and glued joints, profiles were tested in it by pressing metal bars onto the face of the product blank. In the third stage, the treatment of the blank surface with various agents and pastes was investigated. After the individual components had been tested, a combined production process was carried out in which, in addition to press drying, these three other performance factors were also produced in the processing of the blank. At the end of the project, an end product was produced to serve as a demo product and as an example verifying the performance factors of the technology, in support of the marketing of Solidiwood.

The demo product from Lähteinen and Kahilaniemi's research demonstrates, at least indicatively, the overall functionality of Solidiwood technology, and I was satisfied with this. The central hole of the demo product was, however, too large, which caused some problems; the beam structure of the first tests tried out dimensions that were not favourable for retaining the shape of the beam. The desired shape was achieved by supporting the central hole during pressing and cooling. At the same time, however, the tests showed, just as I had thought, that the use of a hole and/or holes works, at least for removing moisture.

In the experiments carried out, I was particularly surprised by how well and how quickly the glued joint and the surface treatment – almost equivalent to the calendering of paper – succeeded. Neither result was impaired even by the fact that the raw material was freshly sawn and had sawn surfaces.

[8]Lähteinen, Kahilaniemi 2012: Puun tutkimusprojekti [Wood Research Project]
[9]Lähteinen, Kahilaniemi 2012, JOHDANTO (Introduction)

In their research report, Lähteinen and Kahilaniemi state that one of the greatest successes of the research was the quality achieved in the end product, since even with the inadequate equipment used in the experiments a very promising end result was achieved, combining all the targeted performance factors.[10]

FIGURE. *The demo product produced in the research project. The demo product is photographed from the right. On top is a white coating, which is intended primarily for treating the bottom surface of the beam.*[11]

From the start of the project it was known that the press available within its resources would only give an indication of how well Solidiwood could at least be tested and produced.

An essential limitation of the equipment was that the pressing of the edges required by the technology had to be replaced with modest special arrangements.[12] Because the edge pressing required by the technology was missing, it was not yet possible in this research, for example, to produce the column and the I-beam that I have also presented on my website[13].

In addition, the research project did not yet succeed, as targeted, in drying the beam blank to joinery dryness within the drying time of a board blank, and an exact determination of the drying time was not made because of shortcomings in the equipment. Lähteinen and Kahilaniemi nevertheless estimated that once a press closer to the optimum and better equipment for the precise

[10]Lähteinen, Kahilaniemi 2012, 18–21
[11]Lähteinen, Kahilaniemi 2012, 20 (KUVIO 14 / Figure 14)
[12]ibid. JOHDANTO (Introduction)
[13]They are highly cost-effective conceptual examples of products manufactured from sawn blanks produced by profile sawing from small-diameter sawlogs. What is also essential about them is that each of them uses the whole sawlog and the size of the product changes with the diameter class.

analysis of the various measurements and times become available in the future, it is very likely that better results will be achieved, especially in terms of speed, than were obtained now in the first project.[14]

Even taking into account these few development points presented above, the first Solidiwood research project at LAMK, carried out by Lähteinen and Kahilaniemi, was a success, since despite the inadequate resources it was possible to create a demo product and, at the same time, to verify in line with the objectives the potential of Solidiwood in industrial production.

The results obtained from the research gave strong positive indications of what the technology could achieve with better resources. Indeed, in the introduction to their research report, Lähteinen and Kahilaniemi write:

> The starting point of the project was to show that if experiments carried out with the school's "more traditional equipment" and other shortcomings produced successful indicative results, implementations with better technology and equipment would also succeed, in which case the results would only improve.[15]

In addition, even the first actual study gave clear directions for the experiments that followed it and for the further development of Solidiwood technology and products. In my opinion, it was justified to target the R&D work of autumn 2012 particularly at functions that are needed in the manufacture of as many products as possible. In this way, very versatile, high-volume production could be verified quickly and with few resources. I thought that, particularly for activating candidate companies, it would be good to obtain laboratory results as soon as possible on at least the following:

1. A beam product or products roughly corresponding to the demo product previously produced at LAMK.
2. Some product properties, such as surface treatment and gluing, tested indicatively.

It was unfortunate that, because of the lack of the edge pressing required by the technology, it was not possible to produce the column and I-beam I had envisaged. They would be very cost-effective conceptual examples of Solidiwood products manufactured from sawn blanks produced by profile sawing from small-diameter sawlogs. It is also essential that they use the whole sawlog and that the size of the product changes with the diameter class.

In the demo solution produced in the first study, however, we had to settle on a beam-like product in which moisture removal was handled by a central hole corresponding to that of a

[14]ibid. 21
[15]ibid. JOHDANTO (Introduction)

column, so in that respect it already amounted to testing a column. The central hole of this first demo product was, however, found to be too large, which caused problems – it would have to be made smaller in subsequent demo products.

In a beam corresponding to the demo product already produced, the cost advantage of producing the sawn blanks remains very small compared with the I-beam and the column. Nevertheless, once Lähteinen and Kahilaniemi's research report had been completed, I proposed to Koskisen Oy and LAMK a beam product as the next object of testing. I listed the following possible differences of the beam product compared with the preceding demo product:

- A smaller central hole and, alongside it, perforations decreasing in diameter towards the edges. At the same time, a pressing pressure so low that no support would be needed in the central hole.
- Tapered and tight tongue-and-groove joints, which, owing to the small central hole, would also be sturdier.

These could already provide joints strong enough for many applications, together with even partial gluing by the wood's own binding agents. One idea for strengthening the joints would be to test the significance of the upsetting of an over-length tongue on the blank during hot pressing. Most essential is that, as in the demo product, they are located on the centre line of the cross-section, where the bending load is zero.

- The top and bottom surfaces of the beam product must be flat.
- The height of the beam product should be greater than that of the first demo product.
- Blanks as dimensionally accurate as possible, i.e. preferably corresponding to the level of profile sawing. In my opinion, they could be made with the small tools currently available.
- Water glass, wood oil or a similar treatment even before pressing, to soften the surfaces so that they are pressed tight.
- Surface treatment of all faces and edges with a paste consisting of mineral powders and their binder, water glass.

Jari Suominen supported this proposal of mine for the manufacture of a beam product: he suggested that the development of the beam product could be carried out in a research and product development project. Engineering student Joonas Uotila took up the topic in the form of a thesis.

**The second object of the next laboratory experiments would be surface treatment and gluing.** Particularly for soft wood species, such as alder, it would be most advantageous to use the surface treatment materials that add the most hardness, such as a plastic solution. I knew that so-called

plastic wood (and very expensive end products) were still being manufactured in France. From what I had heard, plastic solution is ordinary hardware-store material. I just did not know where to get it. I assumed that at least a similar substance was used in the extruded decking board that Lunawood makes from heat-treated sawdust. I believed that with Solidiwood technology the substance could be applied to the product surface at almost no cost, without being wasted by penetrating right through the wood.[16]

I thought that paraffin was probably another surface treatment agent that would add considerable hardness but also other valuable properties. A surface treatment agent that was new at the time, seemed good and was worth testing, for example as moisture protection, was paraffin wax, which I had come across at the Finn Build fair.

Paraffin does not dissolve in water and it provides as much as 100% protection against decay. According to the decking and wood product manufacturer Dauerholz, hot-pressed paraffin increases the surface hardness of the pine they use by at least 25%.

Paraffin oil does not brown the product; instead the product retains the light colour of its wood species. For products other than decking boards, too, colour options could possibly be obtained by means of dyes.

The other water-clear liquid, water glass, browns the product strongly, and probably all the more, the hotter the product blank into which it is pressed.

Regarding coating agents, I also considered that a water-containing surface treatment agent, or even plain water, could be used to moisten a so-called over-dried blank, if the bonding is done at such a low press-plate temperature that water remains in the blank rather than simply evaporating. The lower temperature would at the same time reduce the browning (and possibly also the glazing) of the blank surface caused by the use of water glass.

A liquid surface treatment agent, even a completely water-free one, fills (moistens), just as water does, the space of the bound water removed during drying. I concluded that the surface treatment agent in particular probably cannot, and is not even worth, being taken right through the wood, but only into the surface parts to be protected.

**In September, while visiting UPM, I had become acquainted** with biofibrils, i.e. nano-scale pulp fibres. According to UPM, biofibrils can be used as a high-quality additive, for example in paints

[16]The consumer price of Dauerholz decking is approx. €130/m², that of the extruded decking of Lunawood and UPM approx. €50 and that of conventional decking approx. €25. Solidiwood could be sold very profitably at a price even lower than the latter.

and coatings. With them, a product can be made stronger, lighter or thinner, depending on the application.

I heard that nanofibres form a gel with water and, most surprisingly, that the gel would contain as much as 99% water, i.e. very few pulp fibres would be needed to form it. At one of our meetings, the student Joonas Uotila had said that 100% water glass, for its part, contains 60% water and the rest is glass. I thought that it might be good to try this "miracle substance" developed by UPM in Solidiwood's coating agents, especially as an additive in water glass.

We believed that the nanofibres in the coating might have an effect on the smoothness of the product surface, so it would be worth investigating if only we could obtain the substance for testing. A surface treatment test with a high water content at the end of the pressing process could give the product an incredibly smooth surface, corresponding to the experiment we had previously carried out with Koivukunnas.

The nano world was a rather unfamiliar area to me. The ideas I put forward were based solely on what I had heard and read a little about at that stage. The low solids content seemed almost incomprehensible to me. The topic was current and topical: for example, nano-coatings in wood products were being studied in the Nanokompo sub-project of the Puuri project[17] of Lappeenranta University of Technology.

In the materials of the Nanokompo project I did indeed find interesting arguments for the suitability of nanomaterials for Solidiwood products:

> The use of nanomaterials seeks high-quality properties for innovative wood products, for example in terms of hardness, moisture resistance and UV resistance, with which the competitiveness of wood products in various product applications can be significantly improved and their fields of application significantly extended to new uses.[18]

Lähteinen, Uotila, Suominen and I had an email discussion, in particular about the use of nanomaterials in coating. Lähteinen, for example, was also in contact with Timo Kärki of the Nanokompo project. The idea was to ask about the possibility of obtaining a coating agent produced, or at least used, by the project for preliminary tests in connection with the Solidiwood research.

It would also have been interesting to obtain substances with different dry-matter contents for testing. From them, one might have seen indicatively the effect of the fibres on the surface properties.

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[17]The Puurikastamo project was carried out in 2012–2014 by Lahden Seudun Kehitys LADEC Oy (administrator of the overall project), Lahti University of Applied Sciences, Lappeenranta University of Technology, Työtehoseura ry and Kouvola Innovation Oy. It consisted of five sub-projects. See Mäkelä, Palvi (eds.) 2014 Puumuoviliitosten tuotesovelluksia ja muita tutkimuskohteita [Product Applications of Wood–Plastic Joints and Other Research Topics]

[18]The text can be found e.g. in Kärki, Turku, Martikka, Kinnunen 2014, Nanokompo-hankkeen loppuraportti [Final Report of the Nanokompo Project]

We knew, however, that the various protections and patents of new coating products would make testing the nanofibres challenging, even though our purpose was to obtain the substance for indicative tests, and it was in no way a matter of using a protected product or method in business, which is what patents and similar protections concern. Any nano-scale fibre would also have sufficed for these tests of ours.

**By autumn 2012**, apart from other research, only one actual thesis had been written on Solidiwood, namely Jukka Ohvanainen's "Radikaalien innovaatiomahdollisuuksien markkinointi puutuote- ja teknologiateollisuudelle" [Marketing Radical Innovation Opportunities to the Wood Products and Technology Industries][19]. Joonas Uotila was therefore able to focus his own thesis almost without restriction on the radically new Solidiwood technology.

The first two topics I had named were selected as the subjects of Uotila's work: the manufacture of a beam product roughly corresponding to the demo product already made, and indicative testing of surface treatment and gluing. Thirdly, Uotila's research came to include experiments on the manufacture and surface treatment of decking boards, and the production of example products using hot forming. I wrote about this to Lähteinen and Uotila in October 2012:

> I have now added the decking board to the "Solidiwood research" appendix. We could already make a "completely" finished product sample of it.
>
> Surface grooving on both faces using a silicone mat. Both surfaces of the decking board can be used as the wearing surface. The surface treatment below acts as an additional anti-slip measure.
>
> Small grooves pressed into the edges for fastening elements. The groove should be in the middle of the product's thickness.
>
> Paraffin oil on all surfaces, especially against moisture and decay. Besides being exposed to rain, a decking board is almost in contact with the ground.

Uotila's thesis "Solidiwood-kuumamuovaus – Tuoreesta sahatavarasta lopputuotteeksi" [Solidiwood Hot Forming – From Green Sawn Timber to End Product][20], completed in May 2013, continued the experiments begun in the wood research project carried out by Lähteinen and Kahilaniemi.

This new study had three objectives: the first was to find the optimal size of the central hole for the Solidiwood beam structure. The second objective was to test the possibility of hot forming a

[19]See the chapter: *Radikaalien innovaatiomahdollisuuksien markkinointi puutuote- ja teknologiateollisuudelle* [Marketing radical innovation opportunities to the wood products and technology industries], p. 94
[20]Uotila 2013; you can read the thesis in more detail here.

decking board and to study the time taken by the drying and profiling of the product. The third purpose of the thesis was to study surface treatment carried out by hot pressing on the manufactured beam and decking pieces, and in particular the possibilities offered by water glass.[21]

Uotila's tests used freshly sawn, wetted or outdoor-stored air-dry spruce. Log-floated pine was also used in the decking board products.[22]

### Solidiwood beam structure

The main objective of Uotila's thesis was thus to design and produce a Solidiwood beam in such a way that the hole in the middle of the structure would not need support during pressing and cooling. A central hole that was too large had demonstrably caused challenges in the first Solidiwood research project carried out by Lähteinen and Kahilaniemi – a solution to this was now sought.

In the demo product produced in 2011, the size of the hole was a quarter of the beam's thickness and half of its width. Because this structure did not work without supporting the hole, the hole had to be narrowed, and Uotila tested a few different dimensional alternatives in his research. To speed up and even out the drying process, two grooves were also added to the beam components in this study, forming two additional holes in the pressed beam. The aim was to achieve efficient air exchange in the product despite the smaller central hole.[23]

In Uotila's words, the beam tests were variably successful and the end result was somewhat contradictory: "While the optimisation of the central hole and the regulation of the pressing pressures succeeded, the tests failed in terms of drying time."[24] In the tests, the optimal size of the central hole was made to work so that the central hole did not need separate support during hot pressing. Most of the beams produced, however, split along their weaker glue line – the tongue-and-groove joints – two to three weeks after pressing. Uotila states in his report that this outcome was due to the interior of the beam structure having remained moist: the beams continued to dry after the process, which resulted in considerable shrinkage of the wood substance, ultimately leading to splitting.[25]

According to Uotila, however, the solution to this problem that emerged in the tests would be simple: the insufficient drying time of 3.5 hours now used should be increased to 4.5–6 hours to ensure that the structure dries. He proposes in his work that drying could also be enhanced with compressed air so that the moist, warm air in the hole would be exchanged.[26]

[21]Uotila 2013, 12
[22]see ibid. TIIVISTELMÄ (Abstract)
[23]Uotila 2014, 19
[24]Uotila 2014, 21
[25]Uotila 2014, 21, 37
[26]ibid. 37

## Decking board product

In the decking board test part of Uotila's thesis, the aim was to manufacture a dried, profiled and surface-treated demo piece with Solidiwood technology. Uotila studied the possibility offered by hot pressing of manufacturing a decking board from a freshly sawn board into a finished product as quickly as possible.

So-called chamber kiln drying alone would take one to two weeks, in addition to which time would be spent, and costs would increase, through planing and surface treatment. Moreover, material loss would be greater owing to the wood's own defects, such as bow and spiral twist. The starting point and assumption of Uotila's experiments was that, with hot forming, the end product would be finished in just a few hours, even including surface treatment. The initial assumption was based on the board being hot formed to its final dimensions in conjunction with drying.

In this study it was also decided to add edge grooving to the sample pieces of the decking board by means of hot pressing, as this had already been found to succeed with the available equipment in the Solidiwood beam structure produced by Lähteinen and Kahilaniemi in spring 2011.[27]

As expected, Uotila's decking board tests show that the process takes only a few hours, including the dimensioning, drying, profiling and surface treatment of the piece. Problems also arose, but Uotila states:

> If the equipment were ideal, the manufacturing time would be even faster. There were also problem areas, but this was mainly due to the heat press. With greater pressing forces the results would have been much better, but this time, when the pressures remained lower, the pine boards at least were not pressed flat, as the hard heartwood part remained raised on the surface.

## Surface treatment

The second objective of Uotila's work concerned the suitability of surface treatment agents for the Solidiwood product and for hot pressing. At this stage, the emphasis was particularly on further research into water glass, which had begun in spring 2011.

In the surface treatment tested by Uotila, the number of surface treatment agents to be tested was increased on the basis of previous Solidiwood research. Previously, water glass and paper industry paste had been used. The new substances were paraffin, acrylate and fire-retardant paint, tar and water-based stain.

[27]ibid. 21–22

A prerequisite for the surface treatment tested in the research project was that it would be carried out using hot pressing. The aim was to achieve with Solidiwood technology an attractive surface with properties similar to those obtained with "traditional" drying and application techniques. The trump card of hot pressing would be speed, since normally the absorption, adhesion and drying time of the substances would stretch the process from hours to days – in hot pressing, the same would happen in a few tens of minutes.[28]

The surface treatment experiments carried out by Uotila were fairly extensive, and they provided a great deal of information with a view to the further development of the surface treatment of Solidiwood products. The summary compiled by Uotila describes the overall situation well and condenses the results obtained from the surface treatment tests carried out in the project:

> As regards surface treatment, hot pressing, despite its advantages, is still very limited at present. In most cases, heat and pressure provide good conditions for ensuring an even surface and tight adhesion of the surface agent to the wood. All materials that are absorbed into the wood work best for the time being, since once absorbed into the wood there is no risk of them burning onto the pressing surfaces. This also leaves the silicone mats used in the tests cleaner, which in turn speeds up repeating the process. Good substances of this kind also include paraffin, tried in the tests, natural oils such as linseed oil, and presumably solvent-based wood treatment oils and waxes. With the latter, however, efficient ventilation must be ensured. In the thesis tests, it was not considered wise to use solvents at all, with the exception of tar, as the test site did not have sufficiently good ventilation.
>
> In theory, hot pressing would work well with paints, but in the tests the paint tended to stick in places to the pressing surfaces of the silicone mats used. At first it was thought that the mat was dirty, but careful washing and cleaning did not eliminate the problem. Lubricating the mat with pine soap had no effect either. Some potential solutions may exist. At the very least, preventing the paint from adhering to the pressing surfaces should be investigated in future by testing, for example, Teflon, Mylar and Bates Release Coat type pressing surfaces.
>
> Regarding further research on water glass, it can be stated that it was not created to be used with any other substance, either as a mixture or on top of another substance. As the research showed, only with wood dust was it possible to darken the surface pigment slightly without the colouring becoming uneven. Wood dust, however, eliminated the glassy, glossy surface characteristic of water glass, and the result was a matt, porous surface. Water glass was also unsuitable on top of another substance. The assumption is that the glass crystals of the water glass heat up so much during the process that they either burn or soften the underlying surface agent. This results either in a surface darkened by the heat without its original colour (water-based stain) or, to put it plainly, a "hotchpotch" with none of the characteristic visual advantages of either substance (tar, paste). Water glass also sticks to the silicone mats as runs. Scraping off the stains is not in itself a demanding task, but it still takes time. Cleaning must be done after every pressing, which in mass production would require time resources to be reserved. At the same time, scraping and possible rubbing caused static electricity on the surface of the mats. This made the mat surface more prone to soiling, as small crumbs and

[28]ibid.

> dust particles stuck to it more readily. Whether static electricity has any effect on the actual surface treatment agent during pressing was not established.[29]

FIGURE. *The topographic and smooth surface of a decking board coated with paraffin in Uotila's experiments.*

**In the summary of his thesis**, Uotila concludes in general that no major problems arose during the project, but that eliminating even the minor ones would guarantee an end product better than any of the sample pieces produced during the project.[30]

According to Uotila, development should above all be targeted at the equipment. The project's tests were carried out with a press whose pressure regulation Uotila described in his report as tolerable at best: "Whereas in the ideal case the pressure regulation would provide even, 'non-pulsating' pressing, the outcome of too many tests was only indicative because of high pressure peaks."[31]

Uotila states that simultaneous edge pressing should also be made a standard part of the process: although the quality of the edges was improved towards the end of the project he carried out, it would be "more than desirable to have, for the edges too, platens that press evenly or at least hold the shape more firmly."[32] As it was, the edges of the products were left too slanted because of uneven pressing or, alternatively, bulged out because the pressing was too weak. In the experiments, the problem could be alleviated slightly by a separate edge pressing after face pressing, but this takes considerably more time than if the same result could be achieved alongside face pressing.[33] Uotila ends his written thesis on a positive note and highlights the key results demonstrated in the tests:

> With cautious optimism, one can venture to admit that Solidiwood products have commercial potential as far as the production itself and the end result are concerned. This is also proven by the Danish floor covering manufacturer Junckers, which has been a market leader on the strength of this technology. Solidiwood has a pressing technique corresponding

[29]Uotila 2013, 38–39
[30]Uotila 2013, 37
[31]Uotila 2013, 37
[32]Uotila 2013, 37
[33]ibid.

> to that of Junckers, but in Solidiwood, in addition to the faces, the edges and ends are also pressed. The tests showed that heat and moisture combined with tight pressing eliminate the wood's own defects that occur in normal drying, and press-dried spruce keeps its shape well, provided that the drying succeeds.[34]

The reports of the LAMK studies can be opened from the following links:

I https://www.solidiwood.fi/Wordpress/wp-content/uploads/Solidiwood-Raportti.pdf, and the others:

II https://www.solidiwood.fi/Wordpress/wp-content/uploads/Exportreport.pdf

III https://www.solidiwood.fi/Wordpress/wp-content/uploads/Exportreport.pdf

IV https://www.solidiwood.fi/Wordpress/wp-content/uploads/Uotila_Joonas.pdf

V https://www.solidiwood.fi/Wordpress/wp-content/uploads/OPPARI.pdf

**In my opinion, the most central element in the success of the planned R&D project** is to get the design of the pressing equipment that enables the research and use of Solidiwood technology under way as soon as possible.

Without strong investment in research and production presses, the material we have already gathered would, in my view, lead to the loss of a profit-making opportunity for the companies using my technology – an opportunity of an entirely different order of magnitude compared with the cost-efficiency and duration and, above all, the costs of the project. The factors of radically profitable production were already known. They had already been identified. Solidiwood was registered as a trademark of its own on 12 January 2015.

As regards Solidiwood technology, even before the LAMK studies of 2011–2014 came to an end I had found for the project a professional who was independent of the various parties and, from 2016 onwards, bound by a non-disclosure agreement: Teijo Ruuth. This was an important step towards producing the necessary technology. Ruuth had worked, for example, at Raute and at Makron Oy for about seven years each, largely as a development engineer and, at the latter, also as a press designer. Our plan was that, once project funding had been found, Ruuth would invite tenders from Finnish technology companies to carry out the product-specific R&D, demonstration and piloting phase of the project, i.e. to produce the technology for exploitation.

*As is evident from everything described above, much has already been attempted, but the future we are aiming for has yet to materialise, and there is no shortage of challenges either. The last part of*

[34]ibid. 38.

*my book, Part II, therefore focuses on the situation in the current year 2026 and on examining the future it makes possible.*

# II PRESENT / FUTURE

## The current situation – the foundation of the future

This chapter sets out, with their justifications, the technology and product advantages of production using Solidiwood process technology, together with its intangible rights and its role in combating global warming and biodiversity loss.

FIGURE. A Solidi coin in the collections of the National Museum of Finland.

*Solidi is a business model based on digital business platforms and made possible by Solidiwood process technology, and a global national-interest joint concept for technology and wood products companies. The foundation of Solidi & Solidiwood has been built as the result of decades of work.*

*Solidi* is a word of Latin origin that has become established as a loanword in Finnish. The meaning of solidi – firm, dense, massive, unshakeable, genuine, pure – is expressed in many languages with almost the same word.[35] In its time, the Solidi, or Solidus, was a Roman gold coin. In the Byzantine world the coin was referred to by the word solidi. The Solidi coin was pure gold, and it held its value for over a thousand years, right up to the end of the Roman Empire.

Just as the word solidification[36] – becoming solid, congealing, hardening – describes the process that the products of Solidiwood technology undergo, the meanings and history carried by the word *solidi* reflect the foundation on which Solidi Finland as a whole is built.

*Permanent values are being created in Solidi Finland Oy's Solidi development project.* The results of the project will have use and value far into the future. The Solidi business ecosystem and the Solidiwood technology and wood product range, together with their activities that support combating climate change and biodiversity loss, bring radically profitable business not only to the further processing of sawn timber but also to the technology industry and to wood construction.

[35]solid (Eng.), solide (Ger.), solidité (Fr.), solidnij (Rus.), sólido (Sp.).
[36]Finnish: solidifikaatio

The national-interest Solidi joint concept enables new business and exponential growth in combating global warming and biodiversity loss.

> Why could putting values into practice more effectively than at present not begin in the Nordic countries, which have perhaps implemented them best? (Ahtisaari, Iloniemi, Ruokanen 2016: *Miten tästä eteenpäin?* [How to Move Forward from Here?])

Bioeconomy, cleantech and digitalisation have been written into our country's government programme as the spearheads of economic growth. *Solidi, which puts these into concrete form, must be brought under the control of our society and our companies in particular*.

Today, the success of an individual company is increasingly linked to cooperation, to other companies and to ecosystems formed by companies interacting with one another[37]. Solidi Finland is now seeking primarily domestic companies exploiting Solidiwood technology, which will develop into joint-concept companies, to become part of its business ecosystem.

As its title suggests, this chapter presents the foundation on which Solidi Finland's tomorrow and future will be built. As the American futurist John Naisbitt states in his work *Ten New Directions Transforming Our Lives*: "The most reliable way to anticipate the future is by understanding the present."[38]

## Solidiwood 3D process technology

At the core of the Solidi Finland whole lies the forthcoming process technology innovation that makes it possible, and its use is well suited to large, medium-sized and small industry alike. Solidiwood process technology produces Solidiwood wood products from green sawn timber in product-specific equipment, in as little as a few hours, and these products are substantially better than conventional wood products in terms of price–quality ratio and environmental value. The central aim in developing Solidiwood process technology has been, and still is, to create a radically resource-efficient industry for the further processing of green sawn timber and, at the same time, to give the users of the processed products the product range with the best price–quality ratio, as well as a significant competitive advantage especially for wood construction and for the technology and wood products industries. There is good reason to use Solidiwood technology in the production of all further-processed sawn timber products and their intermediate products. All functions of the technology are optimised for each wood species and product, and its use is not tied to anything – for example, to a particular wood species or surface treatment.

The basic idea of Veisto Oy's method is to chip, saw and edge a log into finished sawn timber in one single sawing machine. The basic idea of Solidiwood process technology, for its part,

[37]see e.g. VTT: https://www.vttresearch.com/fi
[38]Naisbitt 1982, see Hiltunen 2019 [quoted in Finnish translation by Elina Hiltunen].

is to further process green sawn timber in product-specific equipment, all the way up to and including surface treatment, into finished Solidiwood intermediate or end products that are radically more competitive and cost-efficient than conventional ones.

Solidiwood technology is about supplementing the 1D hot pressing that has been in large-scale industrial use at Junckers for 63 years with 17 new functions that improve product properties. These functions, already tested in laboratory studies, are listed on p. 40.

The results achievable with various substances, press drying and conventional heat treatment have already been used in industrial production for decades. In general, the hot pressing of wood products and their modification with various substances have been studied very extensively and for a long time.

In Finland, for example, research professor Pertti Viitaniemi of VTT carried out tests as early as the beginning of the 1990s in which pressure and heat made pine as hard as oak. No industrial user was found for the results directly, but on the basis of the evidence obtained, Viitaniemi was already then firmly convinced that hot pressing had good commercial prospects. Viitaniemi discussed the subject over several years at that time, for example with Raute Wood.

The functionality of Solidiwood process technology can already be seen in the following research reports from 2009–2014, which reflect the research and development stages of my development project described in more detail in the previous part of this book:

1) Solidiwood -teknologian esikokeiden suorittaminen ja tuotenäytteen valmistus [Conducting preliminary tests of Solidiwood technology and producing a product sample], Innovaatiopalvelu Koivukunnas Oy[39]
2) Puun tutkimusprojekti, Solidiwood [Wood research project, Solidiwood], LAMK[40]
3) Exportplan Solidiwood, LAMK[41]
4) Solidiwood kuumamuovaus. Tuoreesta sahatavarasta lopputuotteeksi [Solidiwood hot forming: from green sawn timber to end product], LAMK[42]
5) Solidiwood Project, LAMK[43]
6) Kuumamuovausteknologialla valmistettu I-palkki [I-beam manufactured with hot-forming technology], LAMK[44]

[39]Koivukunnas 2009
[40]Kahilainen, Lähteinen 2012
[41]Lähteinen 2012, Exportplan - Solidiwood
[42]Uotila 2013
[43]Cerveny, Palfrader 2013
[44]Tapaninen 2014

In the official examinations of two separate patent applications, the technology has also been confirmed to meet the patentability criteria: novelty, inventive step and industrial applicability, the last of which means that the invention works as described and can be reproduced.[45]

As the result of long-term thinking and R&D, 17 new functions, listed below, have been built on the basic starting point of my development project, namely Junckers' 1D press drying. That process was launched as early as 1962 and has grown into large-scale industry. The fundamentally radically new and compact Solidiwood process technology hot-forms green sawn timber in 3D directions, in product-specific equipment / processes, into high-grade processed products, all the way up to and including surface treatment.

Through 3D hot pressing, Solidiwood technology enables the following for products: 1) drying, 2) heat treatment at temperatures of up to 215 degrees Celsius, 3) reduction of stresses, 4) straightening, 5) increased bending strength and 6) stiffness, 7) gluing of a product's cross-section and length from several product parts, 8) fixed lengths, 9) profiling, 10) sizing, 11) densified smooth, 12) topographic or 13) structured surfaces, as well as their 14) pressurised repair and 15) pressurised coating with various substances and/or 16) film coatings, and 17) improved fire protection and sound insulation.

Conventional techniques, even when carried out with different machines and at different times, cannot achieve the product properties produced with Solidiwood, not to mention the product-specifically optimised and cumulative total of these properties and, above all, the all-round resource efficiency of the production. The production of laminate and sandwich products, which have taken the largest market share from wood products, has also long used hot-pressing technology comparable to Solidiwood. All of this is possible in product-specific units as highly automated 24/7 production, with an average lead time of as little as a few hours. No other production equipment, by-products or intermediate storage is needed. The raw material, sawn timber, ends up in the product in its entirety. This is a wood products factory that does no chip-removing machining.

With the 17 functions mentioned above, Solidiwood technology also makes it possible to correct defects and material properties of sawn timber. Therefore only those spots that are not sufficiently corrected in the process need to be removed from the sawn timber beforehand. As stated above, gluing also allows the length of a product to be built from several product parts. At its most economical, this is done with butt-joint glue bonds. The structuring of surfaces made possible by Solidiwood also helps in gluing other surfaces together.

[45]Patenting is discussed in more detail in the chapter *Intellectual Property Rights* of this part.

All of this can also be utilised in the procurement of fixed-length sawlogs corresponding to the products. All these performance factors are of really great importance for the whole of Solidiwood production. In other words, the lengths of Solidiwood products must be matched to the standardised lengths used in construction. The same applies to the procurement of sawlogs. This also limits the number of product-specific production units in Solidiwood production.

A move by sawmill companies to green sawn timber, by technology companies to Solidiwood technology and by companies further processing sawn timber to the manufacture of Solidiwood processed products enables these companies to raise their operating profit substantially as the output of the traditional sectors declines and Solidiwood processing grows. For sawmill companies this means the opportunity to free themselves gradually from a significant share of the production stages that follow the actual sawing, and from the land, buildings, machinery and other costs they involve. This in turn gives them the opportunity to use their still-growing sawing capacity and, above all, to build the most profitable operations, i.e. Solidiwood production units, in the space that is freed up. All of the above also applies to the future operations of the technology companies mentioned and of other companies further processing sawn timber.

Thanks to their expertise in their sectors and their knowledge of their customer base, all the companies mentioned above also already have natural opportunities to offer and sell Solidiwood technology and its processed products, at the most competitive prices, in place of their conventional products. They should also note that Solidiwood processed products can be produced very profitably even from green sawn timber of the current quality grades.

Sawing large sawlogs produces the green sawn timber, with its pre-profiling, needed for the products in the chapter "Surfacing products (especially wide floorboards, interior cladding, exterior cladding and decking boards)". See pp. 52–55. The products in the chapter "Heavy-section products (small beams, hollow-core intermediate-floor and wall elements, square columns and round logs, as well as narrow glulam beams and panels)" are produced in the Solidiwood process, by gluing, largely from pre-profiled green sawn blanks of so-called small-diameter sawlogs. See pp. 55–60. Of course, both product groups also cover the corresponding Solidiwood products made from larger-diameter sawlogs.

In addition to the above, profile sawing of the outer surfaces of sawlogs on their opposite sides can economically produce 2 or 4 tongue-and-groove round-log panel blanks (cf. the figure of the version without tongue and groove on p. 59). In the Solidiwood process, their wearing surfaces can be further processed even to follow the topography of the wood, which makes them among the most striking and durable. For more on coating, see pp. 47–48. Only two different widths, i.e. wide

and narrow, are the most justified, particularly from the point of view of their production, storage and sales.

The 17 different further-processing functions of Solidiwood technology listed on p. 40 are extremely effective. One consequence is that really good further-processed products can be made even from green sawn timber of lower quality than is customary. This means that the quality level of conventional sawn timber can also be lowered. It is therefore advisable, in due course, to seek product-specific quality requirements for the sawn timber needed for Solidiwood processed products that are lower than the traditional ones. It is justified to remove from green sawn timber only those spots that will not be corrected in Solidiwood process technology. The implementation of the forthcoming small-scale equipment pilot project, pp. 68–71, will already show despite what kind of conventional defects in green sawn timber really good Solidiwood processed products can still be obtained. It should also be noted that, with butt-joint or finger-joint capability, Solidiwood processed products of the desired length can be obtained in the Solidiwood process even from shorter green sawn timber.

**The Solidiwood press** is multi-layered: in addition to the platens that press the faces of the product, it has single-part or multi-part pressing tools that press the edges and also the ends.

In the Solidiwood pressing process, the wood's own binder and the external adhesive remain in an almost molten state until the start of the last stage of the process, the cooling stage, has passed. This allows the profile and volume of the product blank, and also of its parts, to change during the production process.

At the end of the pressing process, pressing is carried out very close to the final dimensions of the product until drying or moistening of the product to the desired moisture content, equalisation of the moisture and the possibility of warping have come to an end. The products are sized as the metal tools come up against metal stops.

As a whole, the Solidiwood pressing process ends with the cooling of the products in their final pressed state. In the cooling stage, the wood's own binders and the adhesives and surface-treatment agents added to the products solidify and lock the products in their pressed state. The gluing and surface treatment of timber that was originally green or drier therefore take place at this stage, i.e. in wood that is dry to end-product moisture and compressed.

***The Solidiwood 3D process technology solution makes it possible to dry green sawn timber and to process it, all the way up to and including surface treatment, into finished Solidiwood products in about three hours on average.***

**The Solidiwood 3D process technology solution**

The illustration below shows the directions and durations of the pressing force, the heat-transfer force and the moisture transfer in different pressing methods.

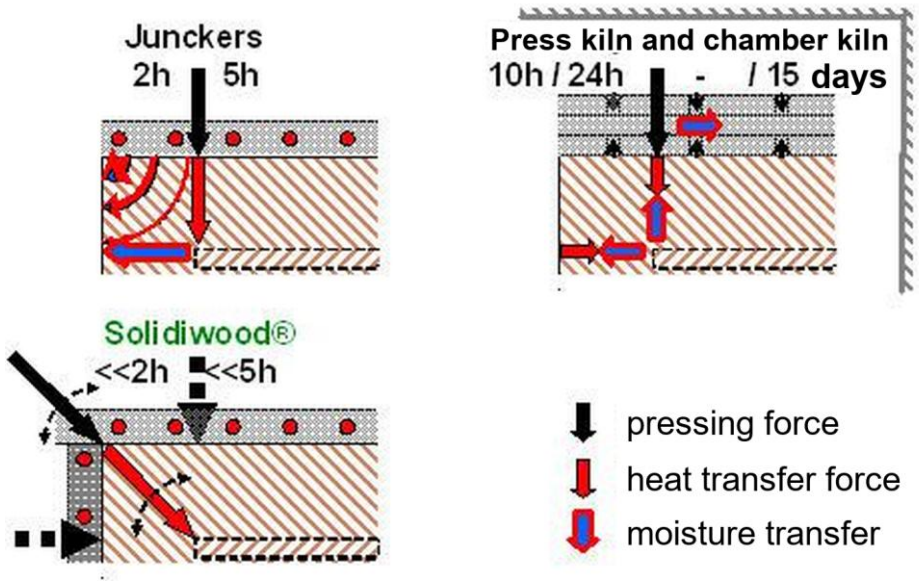


FIGURE. *Junckers and Solidiwood® vs. press kiln and chamber kiln*

In both the Junckers and the Solidiwood presses, heat is transferred into the wood through solid contact between the pressing elements and the wood and under strong pressure, and the heat transfer into the wood is very efficient.

The way the press platens are heated affects the efficiency of the process. In the conventional press kiln shown in the figure, heat is brought to the press platens by air, so that heat transfer even into the pressing elements is relatively weak. The hot oil that Junckers uses to heat its elements, and the electric cable that is also an option for Solidiwood, conduct heat 25 times more efficiently than air. Using electricity alone is already justified now that wind and solar power production has grown radically and their price has fallen.

In both the Junckers and the Solidiwood technologies, the driving force of heat and moisture transfer is high because the temperature difference between the heating element and the outside air is large. It is significant that Solidiwood process technology allows all the factors to be optimised for each product to achieve the best overall result.

***According to the second law of thermodynamics, heat always flows spontaneously from a warmer body to a colder one, and the greater the temperature difference, the greater the driving force of heat transfer.***

In other drying techniques, the heat and moisture transferred from the kiln air into the wood leave the inside of the wood back into the same, equally warm kiln air, so their driving force is radically weaker than in the Junckers and Solidiwood technologies. At the same time, in the other techniques the moisture has to leave against the direction of heat and moisture transfer and also against the pressing force. With Junckers and Solidiwood, by contrast, heat and moisture move in the same direction as the pressing force, which also applies to the movement of any resin and other extractives released from the wood.

As the figure shows, in addition to delivering its own heat capacity, the edge pressing in Solidiwood technology directs the pressing force and the transfer of heat and moisture from every point of the faces and edges towards the area that is most difficult for drying efficiency, the central part of the cross-section of the product blank. Press kilns and chamber kilns have no pressing of edges and ends at all, nor any control over the removal of moisture and heat. Other options that speed up moisture removal can also be used in Solidiwood technology and adapted to each wood species and product.

In the Solidiwood process, moisture removal can be accelerated further by means of a groove or grooves made in the edge-pressing elements and/or in both edges of the product blank. In addition, especially in heavy-section Solidiwood products such as the intermediate-floor and wall element and the square column, moisture escapes efficiently through the longitudinal central cavity that their multi-part construction makes possible. The counter-pressure on the cavity surface needed for pressing the surfaces of these products can be obtained, for example, by maintaining steam pressure in the cavity. The release of moisture, i.e. steam pressure, can be controlled from the ends of the blank.

The surface-treatment agent is under heavy pressure between the pressing tools and the densifying wood surface. Likewise, the adhesive is between two wood surfaces pressed against each other, where the hardest spots are pressed into the softer ones. Thus the surface-treatment agent and/or adhesive in each closed chamber bonds to the surfaces of the product blanks. Consequently, neither substance can escape at all with the moisture of the wood. Only some residues may end up outside the blanks, i.e. on the pressing tools. These can be removed from the tools before the next pressing batch is fed in for pressing.

**In the Solidiwood process, the pressing forces needed on opposite surfaces** should be as exactly equal as possible. Accordingly, either the opposite shapes must be almost identical, or their pressing forces must be made at least approximately equal, for example by pre-profiling, temperature or moisture. One possibility is to replace the conventional tongue-and-groove joint with thin grooves pressed into both edges and with plastic strips of product-specific widths serving as tongues.

Making the grooves and other pre-profiling in the product blanks is most economical in connection with sawing the sawn timber. The necessary pre-profiling of the product is primarily carried out by very effectively profiling the cross-section of the sawn timber almost to the final product profile with a profile-sawing machine. This is done to correspond as closely as possible to the optimal need for drying and compression and to the product profile after pressing. The need for hot-forming machining of the wood is thus kept to a minimum. At its smallest, it amounts to eliminating the minor profile and dimensional inaccuracies of sawn timber produced with today's sawing technology.

Greater hot forming is needed in the manufacture of load-bearing floorboards. Even there, however, the reduction in the thickness of the sawn timber remains below 15 per cent, which substantially increases the bending strength, stiffness and surface hardness of the product.

Solidiwood makes particular use of the sawing method, developed in its day by Veisto and so far left almost unused, that pre-profiles processed products during sawing. It is needed especially in the production of Solidiwood hollow-core elements and columns. It also has uses in board products, for example in pre-profiling grooves, log panels, V-joint tongue and groove and other shapes.

**The solutions of Solidiwood process technology** offer versatile options for each need. There is plenty to use, change and adjust. The pressure built up by edge pressing and by the steam formed, which can be optimised for each product, together with the driving force of heat and moisture transfer and the possibilities for grooving and perforating the edge-pressing tools and the product blanks, create a wide range of options that makes Solidiwood pressing and its benefits possible in all situations. The available options also make it possible to optimise, case by case, the counter-pressure against the escape of moisture and pressing pressure, which is needed especially when compressing the surface parts.

It is significant that Solidiwood process technology allows all the factors to be optimised for each product to achieve the best overall result. For the manufacture of each product, the most efficient option, the one that best enables the desired functions, must be sought. Even small-scale equipment piloting makes it possible to look for the most suitable option for each function. As a

rule, it makes most sense to design and build Solidiwood press units tailored to the area of use and the product. This guarantees maximum cost-efficiency of production and the best price–quality ratio for the products. The knowledge needed for this can be obtained above all as early as the small-scale equipment piloting stage.

The need for press units is reduced by how easily they can be converted to different sizes and products, and by the development of multi-purpose products and their manufacture. A multi-purpose product interests all the parties involved, from the suppliers of technology, sawn timber and coating agents, through storage, transport and retailers, all the way to end users. Even limited multi-purpose use of products creates added value for production as well. Above all, multi-purpose use increases the market potential of the product, and operations become simpler at every stage.

### Multi-part gluing, surface treatment and fire protection of products

The hot-pressing multi-part gluing and surface treatment of Solidiwood products is carried out both with the wood's own binders and with added treatment chemicals/materials, which can be chosen from adhesives or adhesive films/scrims, and from impregnating, filling, priming and surface-treatment agents such as plastic and fire-retardant agents. This also makes it possible to take the environmental friendliness of the substances into account when choosing them. Adhesives and surface-treatment agents can be heated before they are applied to the surfaces. This, too, helps to compress the wood at the surfaces.

The solidification of the substances during the cooling stage of the Solidiwood process locks the product in its final state, i.e. the final gluing, surface treatment and fire protection take place only in wood that is dry to end-product moisture and compressed at its treated surfaces.

Any residues are removed from the press when the pressing batch is changed and when the pressing process is interrupted.[46]

**In the pressing process, the surfaces to be glued** become structured surfaces that follow the topography of the wood. The structuring of the glue-line area can be increased in particular by high-frequency heating. Its heat is concentrated more on the wood in the glue-line area, which is moister than the rest of the wood, and on the water in the adhesive, so that the wood in the glue line is pressed more strongly into itself. In particular, the pressing of the edges of glulam products and the structuring of the lamella blanks made possible by pressing their lamellae lengthwise allow tight

[46]see Kovettuneiden pinnoitejäämien poisto [Removal of hardened coating residues], p. 20

end joints between blanks – even without glue. This applies especially when the lamella blanks are glued to each other at their faces.

Structured surfaces are of particular value on the faces (wide) of the components of load-bearing glulam products, i.e. the lamellae. Of course, value is also created on their edges and ends (narrow); for example, there is no need to produce conventional joints.

Structured surfaces substantially increase the surface area of the glue line and act as a friction or anti-slip barrier in the glue line. The adhesive bonds more evenly over the entire glued surface, and the wood at the glued surface does not tear easily in use because it is more uniform. The adhesive also improves heat transfer to the surfaces of the glue line, i.e. it softens the wood being structured by hot pressing. In addition, it lubricates the sinking of harder wood into softer wood, and structuring also helps to make use of the wood's own binders when gluing pieces of wood together.

The glue bond does not, however, need to be very strong in all products, as is the case especially with the Solidiwood hollow column, where both glue lines lie on the centre line of the cross-section, or with products in which they are closer to it. In such cases, the gluing that takes place in the process is worthwhile even with gluing that is weaker than conventional gluing. Possible damage to the bond in use is also reduced because the internal stresses of the wood die away in the hot-pressing process.

The gluing together of the surfaces of sawn timber dried to about 15 per cent, as done in conventional glued sawn timber with little pressing force and almost without heat, cannot be compared with Solidiwood gluing.[47]

**The uniform and dense surface formed in the pressing process of a Solidiwood product**, and the film of resin and extractives that forms on it, repel moisture, dirt and decay even without surface treatment. However, hot-pressing surface treatment with binders or coating agents can further densify and homogenise the product, repair defects and give the product surfaces a pressure-impregnated finish. A coating agent or water is also needed to soften the surface, for example to obtain an exceptionally smooth surface.

In Solidiwood hot pressing, the product blank heats up, and thus also compresses, quickly at its surfaces, so that mainly only the surface parts of the product densify. The colder wood inside and

[47]see "Glued sawn timber means a product made by gluing together two or more pieces of sawn timber that does not meet the standards for glulam. Such products are used as such in load-bearing structures and as blanks for various wood products, such as window frames, logs, panels, etc. Glued sawn timber products are available, among other things, strength-graded and pre-surface-treated." https://puuinfo.fi/puutieto/insinoorituotteet/liimapuu-glt/

the counter-pressure of the water vapour pushed out during pressing, for their part, slow down the compression of the inner part.

The densification of the surfaces results from the combined effect of the compression of the wood and of heated water and/or any coating agent. The liquids soften the surface parts of the product and, above all, make the heat transfer from the pressing tools into them more efficient. Liquid is needed especially when the sawn timber is not green but already dried.

Coating agents bond to wood surfaces more deeply, in greater quantity and more firmly through hot pressing than with conventional coating techniques using a pressure vessel, spray, roller or brush. In addition, pressing makes it possible to add even several layers of coating on top of each other to create a sandwich structure. The use of more paste-like substances is also possible. In this way, for example, cavities in wood surfaces, broken knots and cracks can be filled and sealed.

The Solidiwood process also allows substances to be applied, by type and quantity, to all surfaces of the product blank or only to those that need them. The coating agent can also be different for each surface.

For softwood species in particular, it would be advantageous to use surface-treatment materials that increase hardness, such as maleic acid, plastic substances (wood–plastic) and nano-scale cellulose fibrils.

According to Dauerholz, a manufacturer of decking boards and wood products, paraffin fixed in a pressure vessel increases the surface hardness of pine by at least 25%. It also provides as much as 100% protection against decay, does not dissolve in water and does not turn the product brown, but preserves the light colour typical of the wood species.

The technology also makes it possible to give a wood product a surface that follows the topography of the wood. A topographic surface is particularly well suited to decking boards, as it reduces slipperiness and increases durability and visual appeal. It also brings substantial added value, for example, to exterior and interior cladding boards.

The bonding of coating agents and the durability of the wood at the treated surfaces are particularly strong in products suited to the surfaces that follow the wood's topography made possible by the Solidiwood process.

The topographic surface formed on the blank in the Solidiwood pressing process reduces the pressing force required, as the pressing pressure it uses is the same over the entire pressing area. In conventional pressing, the greatest pressure is concentrated on the hardest spots of the wood, where the counter-force is greatest. The softer spots are then correspondingly subjected to a smaller pressing force, which weakens their resistance to pressure and wear.

Elastic pads attached to the press platens make it possible to press even a strongly pre-profiled surface. For pressing flat surfaces, an elastic plastic sheet is a better solution.

When pressing with the elastic pressing elements of the Solidiwood press, mineral matter, for example in water glass or in paper-industry paste, is pressed into the softer spots of the blank, which further strengthens their surface.

With Solidiwood, increasing the density of the wood, the cavities and their filling material substantially improve the sound insulation of the products. So do coating agents and getting them deeper into the wood.

**The industry that manufactures films for the wood-based panel industry can also manufacture sleeve films.** As an alternative to a coating applied to Solidiwood product blanks as a liquid, there is also the corresponding sleeve-film coating. In the Solidiwood process, all film coatings are drawn onto the surfaces of the product blanks from a set of rolls at the outlet or inlet end of the press. Each press layer has its own film-roll shaft, and these are at a sufficient distance from each other and from the press.

All in all, the costs of coating consist of the coating agents or films used and of the equipment needed and its operation.

**Solidiwood products can also be protected against fire.** In the Solidiwood process, a sleeve-film coating can be used to produce, for example, exterior cladding for an apartment building that requires particularly strong fire protection, even under several sleeve-film layers containing protective agents. Of course, strong protection can also be produced using only several layers of liquid protective agents. Film coating can be reinforced further with a scrim placed under the film or between two films. The films could also carry a different coating agent for each face of the board.

In addition to the Solidiwood coating and use of films described above, fire protection can be added to a solid-wood product by hot pressing in the process a paste coating consisting of non-combustible substances, i.e. minerals, and of water glass and/or, for example, plastic acting as binders. The powders can be nano-scale, which brings the additional properties offered by nanotechnology. Nano-scale powders can carry the paste deep into the wood. It is also essential that the same treatment provides the customary product properties as well.

Blown-in insulation is particularly well suited to additional fire protection of Solidiwood hollow-core elements and columns. The cavities can be filled by blowing either during the

manufacture of the products or once they are in buildings. The use of blown-in insulation brings so many additional functions that it pays for itself through their results alone.

**Fire safety of blown-in insulation.** When choosing blown-in insulation, it is also worth considering fire safety, as different fire-resistance requirements are set for structures. In public buildings and large buildings, for example, non-combustible blown-in insulation is often required. In residential buildings it is sufficient that the blown-in insulation does not promote the fire. A correctly chosen insulation is therefore also an investment in fire safety: by slowing the spread of a fire, it gives you more time to escape. Non-combustible or fire-protected blown-in insulation also protects combustible material near the insulation and slows the spread of fire, for example in roof structures. The fire resistance of blown-in insulation varies according to the raw materials used; for example, Isover glass wool, made from recycled glass, is non-combustible and belongs to the best fire class, A1.

Hunton wood-fibre insulation is made from surplus wood from the sawmill industry, so it is combustible. Ammonium sulphate is added to the wood as fire protection, so the product does not promote the progress of a fire; the wood-fibre insulation belongs to fire class E. Isocell cellulose insulation is made from recycled newsprint, so it too is combustible. Boric acid and magnesium sulphate are added to the newsprint, which slow the burning process down to smouldering and meet the requirements of fire class B. The boron chemicals can also slow down possible mould growth, which is why cellulose insulation can also be installed safely by spraying together with a binder. The binder used in sprayed cellulose insulation contains water in addition to polyvinyl alcohol. When you want to check the insulation needs of your home, or if you have noticed problems with your insulation relating, for example, to fire safety, such as blown-in insulation installed directly against a flue, it is time to call Ekoeriste.

Isocell's natural cellulose blown-in insulation is made from cellulose fibre obtained from recycled newsprint. The paper is defibred and mixed with mineral salts (magnesium sulphate, boric acid), which protect the insulation against the effects of moisture, such as decay, and also act as fire retardants.

Solidiwood hollow-core products and their filling material, together with the pressing of the surfaces of all products to a denser state, coating agents and getting them deeper into the wood, also substantially improve the sound insulation of the products compared with conventional wood products.

## Solidiwood product groups

Solidiwood wood products cover the whole of construction: frame structures, exterior and interior cladding, and joinery, yard and garden products, as well as blanks and components. There are three product groups:

1) **Surfacing products**: especially wide floorboards and decking boards, and interior and exterior cladding boards.
2) **Heavy-section glued products**: especially small beams, hollow-core intermediate-floor and wall elements, square hollow columns, round logs, and glulam beams and panels.
3) **Intermediate products**: blanks and components, e.g. for the construction, joinery and furniture industries.

Solidiwood products in groups 1 and 2 are very well suited as a second product range for manufacturers of boards, beams, columns and elements. It is also in these manufacturers' interests to get the more competitive Solidiwood production into use as soon as possible. It is also justified for **Solidiwood products** to be of fixed length, because

- Even sawlogs of fixed length or diameter are felled with computer-controlled harvesters, and the log sorters at sawmills have been extended to have more compartments. In addition, Solidiwood technology makes it possible to use green sawn timber prepared for butt or finger jointing and to repair defects in the products during the process.
- A fixed product length is in the interests of every stage, such as manufacturing, storage, sales, transport, installation and use.
- Products made from competing materials are also of fixed dimensions.
- Solid-wood products, too, have moved and are increasingly moving to fixed lengths.
- The products in product groups 2–3 must in any case be of fixed dimensions because of their intended use.
- A fixed product length enables and maximises the quality and cost-efficiency of production and of the products.

## Surfacing products (especially wide floorboards, interior cladding, exterior cladding and decking boards)

The above-mentioned Solidiwood board products can be manufactured with at least two press units that differ only slightly from each other. Ideally, it is justified to use boards as wide and as long as are sufficiently available in each country. The substantially higher price of Solidiwood board products, which rises with the wood species, width and length, does allow a price sufficient to

obtain the required sawn timber. If needed, wide and long boards can also be cut into short boards of equal length.

**A press unit / Sawn timber size 25 × e.g. 200 and 250**
22 mm floorboard and exterior cladding and decking board. The latter two moistened in the process or after it.

**B press unit / Sawn timber size 16 × e.g. 200 and 250**
14 mm floorboard and interior cladding board.

The most essential changes from unit A to unit B are thinner and more numerous face- and edge-pressing tools.

The required sawn timber is procured primarily green, in sizes 25 and 16 × 200 and 250 mm and in fixed lengths of e.g. 600 or 540 cm. A greater product width requires reducing the number of edge-pressing tools in the presses to avoid a loss of capacity.

In this solution, the cross-section of the products is a rectangle with small corner chamfers or roundings. The thin grooves of the tongue-and-groove joint are produced by pressing, and plastic strips are used as tongues. Instead of nailing from above, the decking boards produced can also be fastened to their battens from the grooves with groove fasteners.

The width of the end products is the nominal, i.e. basic, size of the sawn timber. The exterior cladding board is used together with a gap batten (see drawing). This avoids the very rapid, most common and most intense spread of fire at V-joint tongue-and-groove joints and similar points. No chamfer or rounding is needed in the exterior cladding board when a gap batten is used.

In both press units, the grooves and roundings or chamfers of the edges can be pressed with the solution presented by Teijo Ruuth.

**In the production process**, the most effective approach is for the products to move from the first press to a second one, a cooling press, in which the grooves and roundings or chamfers of the edges would be pressed first, while the face platens are only lightly in contact with the edge-pressing tools.

The cooling press could be designed and built specifically for economical cooling of the products. The second press would also save time and energy in the process, because the first press would not need to be cooled and reheated between batches; instead, it would always be ready in its hot state when processing of a new batch begins.

**In the press units for Solidiwood surfacing products**, multi-purpose products can be manufactured. Even limited multi-purpose use of board products creates added value for production. A multi-purpose product also interests all the parties involved, from the suppliers of technology, sawn timber and coating agents, through storage, transport and retailers, all the way to end users. It increases the market potential of the product, and operations become simpler at every stage.

The possibility of multi-purpose products and the product properties enabled by Solidiwood process technology, combined with growing demand, bring added value to Solidiwood surfacing products and should provide inspiration and grounds for the open-minded further development of other Solidiwood products and their technology as well.

Together with the requirements set by the conditions of use of the products, Solidiwood technology and its presses make it possible to manufacture the same product for different uses, because, for example:

- Each press can be run with a slightly different production programme when the wood species, the quality of the sawn timber, the initial/final moisture content of the product, or the coating agent and method change.
- Making exterior cladding and decking boards as the same product is already possible because they share the same conditions of use in terms of air humidity. The same applies to the use of interior cladding and floorboards.
- At best, a Solidiwood product is protected on all its surfaces by its surface treatment, including against moistening. In that case no subsequent moistening is needed at all, and simple cold storage is quite sufficient for the products.
- The thin grooves of the tongue-and-groove joint are produced by pressing, and a plastic strip is used as the tongue. This is the primary option; the second is that the tongue-and-groove elements are pre-profiled either in the profile sawing of the sawn timber or, for example, with a planing machine before the pressing unit, and they receive their final shape by pressing.
- In many end uses, the product does not need tongue and groove. A board product without tongue and groove is suitable both for decking and for exterior cladding using a gap-batten solution. The need for tongue and groove in a load-bearing floorboard can also be replaced by pressed metal fasteners that join the edges of the boards to each other midway between the battens. This can easily be done, for example, with the fastening device for Dauerholz decking boards.

**Great added value** for the marketing of Solidiwood surfacing products comes from the changes that have taken place in the floor-covering market in recent decades. Wide laminate and vinyl floor coverings, among others, have taken a large share of the market from wood – and are still doing so. It is surprising that these laminates imitate even black knots, which are regarded as defects in wood, in order to increase the market value of the products.

In addition to laminate and vinyl, thermally modified board products and wide Timberwise wood parquets have also increased their market share. This growth in demand also increases the need for Solidiwood's wide board products.

An essential part of the added value brought by Solidiwood technology is also the abandonment of battened floor structures: there is an increasing need for the thin floors made possible by Solidiwood, often glued to a concrete base, which is in fact required at least in the most demanding projects. The need for ground-source heat also continues to grow strongly, and laying its pipework increasingly requires a concrete base.

Solidiwood process technology also makes it possible to produce traditional wide "manor-house" boards with a radically more favourable price–quality ratio, and at the same time also thin boards. Thanks to the properties of Solidiwood products, the end user can also choose which surface to leave as the wearing surface: the smooth one, or the topographic surface made possible by isostatic pressing. ThermoWood, an innovation substantially older than Solidiwood that was brought from Canada and further developed in Finland, has responded to the growing demand with its own solutions. Its production focuses mainly on board products, corresponding to Solidiwood's product group 1. The largest developer and manufacturer of ThermoWood is Lunawood Oy.

"Woodura® is a patented technology that can be used to harden wood and use the whole tree as raw material. We press the surface of the wood at high temperature and harden it with wood composite powder. The result is a hardened wooden floor that is many times more durable and stronger than normal wooden floors – without compromising on the appearance and feel of wood." Accordingly, wood composite powder should also be used in the patented Solidiwood 3D process technology to harden the desired surface or surfaces before the stage in which their surface treatment agents are pressed.

### Heavy-section products (small beams, hollow-core intermediate-floor & wall elements, square columns and round logs, as well as thin glulam beams and panels)

Compared with board products, heavy-section products make it possible to operate on a larger scale in keeping with the theme of our time, i.e. to produce *ever more from ever less*. Profile sawing is

one of the essential enablers of the result. It is most profitable when sawing so-called small-diameter sawlogs, owing to their slight taper and good quality. Unfortunately, the small diameter of these logs limits the thickness of glulam beams. Of course, it is still well worth producing them from thicker sawlogs too.

*The basic idea of Veisto's method is to chip, saw and edge the log into finished sawn timber in one single sawing machine.*[48]

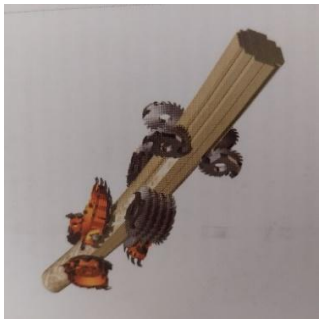

FIGURE. ©Veisto Oy: the principle of the work process of the HewSaw R200 sawing machine.[49]

The following figures illustrate three sawing blanks produced by profile sawing, which are built with Solidiwood process technology into a small beam and, from these, into hollow-core wall & intermediate-floor elements. After these figures come four sawing blanks from which a square hollow column is built and, by supplementing it, a log. The production of all these products can start from the smallest diameter class of small sawlogs, and the size of the products grows as the diameter increases. The fifth heavy-section product is the glulam beam. All the figures are schematic drawings that offer ideas for fine-tuning the products and even for new solutions.

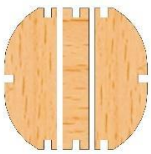

FIGURE. *For a hollow-core wall & intermediate-floor element, with its grooves.*

The sawing solution for the small beam is otherwise the same as above, but there are no grooves on its edges. The sawn blanks of the product are joined to one another with splines. Another option is a tongue profiled into the core board during sawing in place of the grooves, replacing the spline.

[48]Varis 2022, 94
[49]©Veisto Oy, Varis 2022

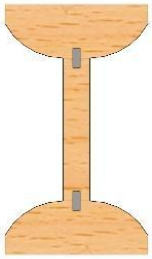

FIGURE. *Schematic drawing of a small beam*.

In the following figure, the grooved small beams have been joined together into an element with splines.

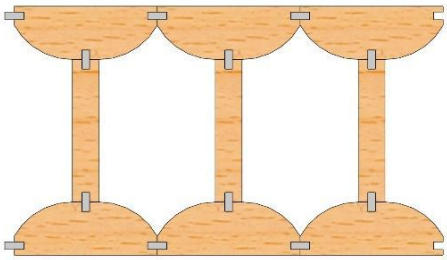

FIGURE. *Schematic drawing of a hollow-core wall & intermediate-floor element.*

When a separate, thicker board profiled with grooves is used as the core board of the small beam or element, the bottom and top parts of the small beam alone come out of the sawing heavier from the same sawlog diameter. This alone creates opportunities for new solutions too.

If desired, the required overpressure and additional heat can be brought into the core cavities from outside, e.g. by means of air or steam. The overpressure creates, on the inner surfaces of the blank, a counter-pressure to the pressure compressing its outer surfaces. This makes it possible to use a higher pressing pressure on the outer surfaces and to achieve the desired profiling and dimensioning of all parts of the product. With pressure brought in from outside the cavity, additional heat can also be delivered to the inner surfaces, and if necessary they can be protected at the end of the process with a surface-treatment or impregnation agent. The changes in moisture, pressure and temperature taking place in the cavity can then be controlled from the inner side of its surfaces, at best by regulating the amount of discharge out of the core at the ends of the product blank.

Below are illustrations of the production of a square hollow column. First, the **profile-sawing solution** for the square hollow column patented by Hammarström, supplemented with

tongue-and-groove members; in the latter figure, the grooved sawn blanks have been joined together into a column with splines:

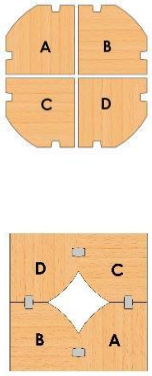


FIGURE. *Schematic drawings of a square hollow column*

Below is an illustration of how a round log is produced from a square hollow column. Boards have been added to the top and bottom surfaces of the square hollow column, and round-log panel blanks without tongue and groove, produced by profile sawing, have been added to its sides.

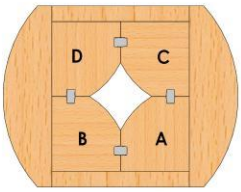


FIGURE. Schematic drawing of a round log

The round logs are fastened to one another at their top and bottom surfaces, for example with wooden glued dowels or metal fasteners.

**Next,** the grounds for producing a glulam beam. The main applications of both Solidiwood and conventional glulam beams are industrial and sports halls, large retail outlets, exhibition halls and schools, but also detached houses and agricultural buildings.[50]

The cross-section of conventional glulam beams, and of the Solidiwood glulam beams that replace them, is rectangular. Closest to their top and bottom surfaces there are most commonly 1–2 lamella blanks of a higher strength class than elsewhere. The strength class of a conventional

[50]see https://puuinfo.fi/puutieto/insinoorituotteet/liimapuu-glt/; see also Suomen Liimapuuyhdistys and Puuinfo Oy 2014 (https://puuinfo.fi/wp-content/uploads/2020/07/Liimapuuk%C3%A4sikirja-Osa-1.pdf)

glulam beam is determined by the load-bearing capacity of the top and bottom lamellae.[51] The same also applies to Solidiwood.

In the formulae, the height of the product is squared for bending strength and raised to the fourth power for stiffness. In addition, the strength of the material acts as a coefficient. Since the strength of wood increases as its density increases,[52] Solidiwood-pressed wood and structured glue lines have greater strength than ordinary wood and gluing. What matters is simply that the lamellae closest to the top and bottom surfaces of the beam, their end joints and the face-to-face glue bonds become stronger than conventional ones. Glulam beams and other heavy-section Solidiwood products can be given longitudinal holes at several points in the core area of the cross-section for efficient moisture removal.

During pressing, the harder parts of the wood are pressed into the softer ones. This should be the stronger, the closer the lamella blank lies to the top and bottom surfaces of the beam, and it should be greatest at the top and bottom surfaces themselves. It can be increased by giving the plates that press the top and bottom of the beam a greater heat-transfer capacity. With the side-pressing plates, heating remains very slight, since only the narrow edges lie against them. The width of the beam should not be reduced, so the pressing force applied to it must be sufficiently small. The pressing force directed at the height of the beam, in turn, is limited by the requirement that the height of the beam may decrease only in the above-mentioned lamella blanks that are being strengthened. The fulfilment of all the above requirements can be further enhanced by giving the side-pressing plates a higher heat-transfer capacity at the lamella blanks nearest to the top and bottom of the beam and a lower one elsewhere.

Solidiwood's green lamella blanks do not need conventional one- or two-stage drying, finger-jointing or planing of the faces. They only need the removal of defects from the blanks and cross-cutting of the beam to its set length.

The pressing tools for the edges and ends of the Solidiwood beam prevent glue from squeezing out. Together with the plates pressing the bottom and top of the beam, they also straighten the beam on all its surfaces before the Solidiwood surface treatment.

Puuinfo Oy lists the main stages of conventional glulam manufacture as drying of the timber, strength grading and finger-jointing, planing of the lamellae, glue spreading and gluing, planing and shaping of the beams, surface treatment and packaging.[53]

[51]https://puuinfo.fi/puutieto/insinoorituotteet/liimapuu-glt/
[52]see https://puuinfo.fi/puutieto/insinoorituotteet/liimapuu-glt/
[53]https://puuinfo.fi/puutieto/insinoorituotteet/liimapuu-glt/, see also Suomen Liimapuuyhdistys and Puuinfo Oy 2014, 16

Planing the faces of the lamella blanks wastes a substantial amount of dried sawn timber. Glulam is usually planed on all four sides and is available with various surface treatments and pressure-impregnated.[54] What is planed on all sides is the beam that is then awaiting only surface treatment, and the resulting waste is also substantial. It arises from straightening the beam and levelling its surfaces for surface treatment. At the same time, the edge bow of the lamella blanks caused by conventional drying and the glue squeezed out of the glue lines on the edges and ends are removed.

**Finally, a few words on the fire resistance of glulam.** The *Liimapuukäsikirja* [Glulam Handbook] (2014) of Suomen Liimapuuyhdistys [the Finnish Glulam Association] and Puuinfo Oy states that because conventional glulam structures have a large homogeneous cross-section, they offer comparatively good protection in a fire, and the larger the glulam cross-section, the better its fire resistance.[55] Glulam beams are fire-safe because, when they burn, their surface chars, which slows down the burning of the core, so the glulam beam retains its load-bearing capacity longer.[56] According to Puuinfo, the charring depth of a glulam beam after one hour of burning is ~36 mm. However, metal connectors such as screws, bolts, dowels and the like can accelerate the transfer of heat into the interior of the glulam cross-section and thus accelerate the spread of the fire.[57] The Glulam Handbook says the following about the effect of glue on fire resistance:

> Glue lines do not reduce the fire resistance of glulam if approved glue types have been used. Other glues, by contrast, both older and newer ones, can lose their strength in a fire at comparatively low temperatures and cause delamination, increased charring and additional weakening of the load-bearing capacity of the glulam cross-section.[58]

Solidiwood has the fire-load resistance of the conventional beam described above. In addition, Solidiwood's most extensive fire and other protection solution is to press glass-wool fire-protection wool, together with a glue film or glue scrim, onto all surfaces of the beam in connection with its surface treatment. This can even prevent the fire from obtaining the oxygen it needs, i.e. prevent ignition.[59] Read more about the durability of Solidiwood's structured glue lines and about fire and other protection for needs of different magnitudes on pages 153–157 of this book.

[54]https://puuinfo.fi/puutieto/insinoorituotteet/liimapuu-glt/
[55]Suomen Liimapuuyhdistys and Puuinfo Oy 2014, 24 (https://puuinfo.fi/wp-content/uploads/2020/07/Liimapuuk%C3%A4sikirja-Osa-1.pdf)
[56]Suomen Liimapuuyhdistys and Puuinfo Oy 2014, 24 (https://puuinfo.fi/wp-content/uploads/2020/07/Liimapuuk%C3%A4sikirja-Osa-1.pdf)
[57]https://puuinfo.fi/puutieto/insinoorituotteet/liimapuu-glt/
[58]ibid. 70
[59]See pp. 46–47 of this book on the durability of Solidiwood's structured glue lines and on fire and other protection for needs of different magnitudes.

**All in all,** Solidiwood process technology makes possible a glulam beam that is techno-economically superior to the conventional one. The same also applies to other glulam production.

### Intermediate products (blanks and components)

Solidiwood intermediate products are used particularly in kitchen, door and window products and in the furniture and construction industries.

Today, the manufacturing chain of wood products may comprise many short stages, each handled by a company that specialises in it. Such fragmentation of the chain creates many opportunities, particularly for small businesses.[60] Solidiwood offers operators at the various stages of the wood products industry's chains solutions tailored to their needs for blank and component production, all the way through to surface treatment.

Supplying Solidiwood blanks and components requires Solidiwood process-technology production units designed individually for the intermediate-product needs of the companies that manufacture end products. They can be operated by sawmills as well as by subcontractors or end-product manufacturers.

### Efficiency and volume

*The core of Solidiwood 3D process technology is that wood products are not worked by conventional machining; instead, they are manufactured from green sawn timber in product-specific units by hot forming, right through to surface treatment.*
*Solidiwood 3D process technology makes possible Solidiwood products that, compared with conventional further-processed sawn timber products, are by far the most cost-efficient and affordable in their price–quality ratio. These factors alone would be enough to revolutionise the further processing of green sawn timber. Solidiwood 3D process technology and the national-interest Solidi business ecosystem make it possible for small Finland to become the world-leading country in its sector, together with cost-free combating of global warming and biodiversity loss.*

[60] see e.g. http://www03.edu.fi/oppimateriaalit/puutuoteteollisuus/alkutuotteiden_jalostus/aihiot_ja_komponentit/etusivu.html

Why the average production time of Solidiwood 3D process technology can be as short as about 3 hours:

My quotation from p. 12: “The foundation of my development project had begun to germinate as early as 1988, when I read an article in the magazine *Puutekniikka*[61] about the 1D press drying of beech sawn timber used by the Danish parquet giant Junckers Industrier A/S in the manufacture of its parquet. What surprised me most about Junckers' 1D technology, however, was the short drying time, which was only two hours. In that time the moisture content of 32 mm thick beech sawn timber falls from 80 to as little as one per cent. The pressing temperature is 160 °C, the pressing pressure 12 bar and the reduction in thickness, i.e. compression, of the load-bearing parquet blanks 20%.”

*The starting point for making the incredibly large overall result of the Solidiwood business a reality is the launch of the Solidi project, on the basis I have described above, as early as 1988.*

***According to the second law of thermodynamics, heat always flows spontaneously from a warmer body to a colder one, and the greater the temperature difference, the greater the driving force of heat transfer. Consequently, moisture also moves, i.e. is removed, at a corresponding rate from the green sawn timber Solidiwood product blanks that are hot-pressed with Solidiwood 3D process technology.***

In the Solidiwood 3D process, all its other functions, right through to the absorption and adhesion of glue and surface-treatment agents, take place simultaneously with drying and partly also with cooling. The necessary drying can be carried out in substantially less time than the two hours of Junckers mentioned above, and the need for heat is also reduced, because:

1) The average moisture content of green sawn timber is only 45–60%, and not the 80% mentioned above for Junckers.

2) Drying to Junckers' one per cent moisture content mentioned above takes much more time than drying the end products of conventional present-day technologies. Their drying requirement is 6–8% for indoor use and 18–22% for outdoor use. At Junckers and in

[61] *see Puutekniikka* 10/1988

Solidiwood, the temperature can be raised from the 160 °C mentioned above to 195 °C to shorten the drying time further.

Solidiwood's main heavy-section products are built from blanks that are profiled in sawing and glued into the end product in the process, and that allow longitudinal core openings, core cavities or holes (see pp. 55–56). Even the green sawn timber blanks required for other products can be given grooves already during sawing; by exploiting these, longitudinal holes can be made at several points of the cross-section in the core area of the product blank for really efficient moisture removal. Of course there are other solutions as well, and new ones may also be found. The key point here is to achieve the most efficient possible moisture removal. It covers the entire operating time of the process and also helps with cooling. The process time can, of course, be extended as necessary. What is essential is that all of this can be tested in small-scale equipment piloting, always seeking the best overall solution for each application.

3) The heat released during cooling is transferred to a new batch of green sawn timber. That batch then enters the press already preheated.

Of course, in the Solidiwood process too, all products can be dried even to the 1 per cent mentioned above if, for some particular reason, that is better or even necessary.

Additional wetting or drying of products to their product-specific moisture content after surface treatment is possible for board products from their ends, using strong pressure or suction, and for heavy-section products simply by using their longitudinal core openings or holes. A significant reduction in cooling time is possible simply by mechanically cooling the pressing tools and the oil circulating in them. In addition, heavy-section products, with the exception of glulam beams and panels, have the above-mentioned core holes for rapid cooling by circulating cold air through them.

It makes sense for each Solidiwood production unit to further process the green sawn timber all the way to a finished, surface-treated end product. There the products are also cooled and brought to their product-specific moisture content, and they do not need a second unit or a transfer to it. All the functions of the process take place substantially better and more reliably in a single unit. Even so, using a second press for cooling, and possibly for other purposes, may prove a good solution, at least for some products. See an example of this on pp. 51–52. When cooling is done in a second press, the average total production time is already shortened substantially.

*All of the above functions, together with advance estimates of their duration, can be pre-tested in the small-scale equipment pilot project.*

**The above contributes very significantly to the fact that Solidiwood process technology enables** growing competitiveness and volume in the production of further-processed sawn timber products and their intermediate products. These stem from the completely superior price–quality ratio offered by Solidiwood technology and wood products, and from resource-efficient and environmentally friendly production. Energy produced with fossil fuels is the largest source of climate emissions, and using little of it is an important value in itself. In addition, through its energy efficiency, Solidiwood technology also responds to the current situation in which the abandonment of fossil fuels may cause a shortfall in general energy production. Solidiwood technology saves on all cost factors. The savings of Solidiwood technology are based on the efficient use of time and raw materials.

Because the throughput time of Solidiwood's production process is only a few hours, timber sawn on the same day can be dispatched to its users as surface-treated, further-processed products. In addition, all of the sawn timber remains in the product during the process, so the raw material is used efficiently. All this makes the process more efficient and saves not only material but also the person-hours spent on the process. In the same category belongs the fact that the high pressure of the hot pressing in Solidiwood process technology prevents a fire from obtaining the oxygen it needs.

The starting point for estimating the total volume of use of Solidiwood process technology is the current global production of sawn timber: 300 million cubic metres a year, of which half is produced on the American continent, one third in Europe and one thirtieth in Finland. What percentage of this potential global volume can be achieved depends primarily on the amount of intellectual and material investment by our country, and secondarily on how Solidi Finland Oy, together with its joint-concept companies, prevents the unlicensed manufacture of its products. Thus, at the maximum of the global volume, almost all green sawn timber produced in and imported into democratic countries can be further processed with Solidiwood process technology, and after that, in particular, the products of its third product group with conventional techniques.

**Sawn timber as such** has very little end use, and it is finally sold and priced only when it has been sold as further-processed products. It should be recognised that the need for sawn timber and wood construction will grow, particularly through the radically more favourable price–quality ratio of Solidiwood wood products and through cost-free combating of global warming and biodiversity loss. At the same time, Solidiwood is also taking market share from products made of other materials, such as concrete, brick, steel, aluminium, laminate and plastic. The use of sawn timber is also growing with the rise in the world's population and in the standard of living of poor countries.

The starting point for estimating the total volume of use of Solidiwood process technology is the current global production of sawn timber:

*300 million cubic metres a year, of which half is produced on the American continent, one third in Europe and one thirtieth in Finland. This has already been taken into account in Solidi Finland Oy's existing and pending IPR protection.*

Moreover, almost all sawn timber is used in further-processed form. From the magnitude of this production of processed products it can be concluded that getting Solidiwood process technology into industrial use would certainly be worth paying for – and there would hardly be an upper limit to the price.

The Solidi national-interest joint concept and Solidiwood process technology can be introduced at least in all countries of the democratic world[62]. Other countries can act as export countries for Solidiwood wood products and as suppliers of sawn timber. What percentage of this potential global volume can be achieved depends primarily on the amount of intellectual and material investment by our country, and secondarily on how Solidi Finland Oy, together with its joint-concept companies, prevents the unlicensed manufacture of its products.

Thus, at the maximum of the global volume, almost all green sawn timber produced in and imported into democratic countries can be further processed with Solidiwood process technology, and after that, in particular, the products of its third product group with conventional techniques.

*The exponential growth and global reach of the use of Solidiwood process technology and of combating global warming & biodiversity loss are made possible above all by the Solidi national-interest business ecosystem, which has grown stronger over the last five years and is even more radical than the technology.*

## Combating global warming and biodiversity loss

Large-scale climate change mitigation is possible in industry only through a radical renewal of manufacturing technology. (Ilmastorahasto – the Finnish Climate Fund[63])

*The use of Solidiwood 3D process technology, the combating of global warming & biodiversity loss that it makes possible, and the use of the Solidi business ecosystem of the national-interest joint*

[62]see Helsingin Sanomat, editorial 24.2.2023: https://www.hs.fi/paakirjoitukset/art-2000009410144.html
[63]https://www.ilmastorahasto.fi/

*concept, which is even more radical than the technology, together make exponential growth possible for climate change mitigation as well.*

The construction and real-estate sector is the world's largest industry, and its carbon footprint is also by far the largest.

The Ministry of the Environment is developing an assessment method that will make it possible to examine the carbon footprint of construction. The aim is to bring the method into use with the new Building Act as early as 2025. Indeed, the construction sector believes that a low-carbon assessment may in the near future be a condition for a building permit.[64]

According to some estimates, building with wood would reduce the consumption of natural resources by as much as 70 per cent and emissions by 60 per cent.[65] For example, Jarmo Pekkarinen, CEO of LapWall Oy, a manufacturer of wooden elements, interviewed in an article in *Puumies* magazine, considers it likely that the Ministry of the Environment's planned regulations on assessing the carbon footprint of construction will come into force. He says he believes that the use of wood in, for example, the construction of blocks of flats will increase once the carbon footprint is taken into account in building regulations.[66]

All this points to growth in the demand for, the price of and the competitiveness of sawn timber in its competition with the highly carbon-intensive materials used for construction products.

Antti Herlin, Chairman of the Board of Kone, urges in an interview with Helsingin Sanomat that Finland should stick to the line it has chosen on climate action and the green transition. According to him, the target of carbon neutrality by 2032 written into the Climate Act is a trump card that gives our country credibility in the competition for climate-friendly industry: “So far Finland has been more in the vanguard than in the rearguard, and that is good. If you are in the vanguard, you also shape the future. If you are in the rearguard, you simply have to adapt to what others do,” he says. “I myself have always preferred being in the driver's seat to sitting in the passenger seat.”[67]

[64]see e.g. *Puumies* magazine 3/2022
[65]see e.g. https://www.metsagroup.com/fi/uutiset-ja-julkaisut/muut/kampanjat/urban-carbon/puurakentaminen-on-ratkaisu/
[66]*Puumies* magazine 3/2022, Latokartano: *LapWall Oyj listautumassa pörssiin tänä vuonna* [LapWall Oyj to be listed on the stock exchange this year]
[67]HS 15.4.2023: *Antti Herlin: Suomi tekee virheen, jos ilmastotavoitteesta lipsutaan* [Antti Herlin: Finland is making a mistake if it slips on its climate target]. https://www.hs.fi/politiikka/art-2000009514901.html

**The Solidi joint concept & Solidiwood process technology** make possible significant factors in combating global warming and biodiversity loss in the areas of increasing carbon sequestration and promoting lower-carbon industry.

- The forest, together with the Solidiwood product range and especially the growth in wood construction that it brings about, sequesters ever more carbon:
- With Solidiwood process technology, the amount of forest felling, sawlogs and sawing needed to produce the same quantity of products as with current technologies is about 20% smaller than conventionally. A second, but larger, reduction comes from the 20% longer service life of the products. Throughout this time they also continue to store carbon.
- Insofar as trees do not need to be felled for sawn timber production, their roots and stumps also remain in the ground, i.e. the average carbon stock of the soil grows by more than 20%.
- The production of one of the main products, Solidiwood building elements, uses small-diameter sawlogs, which fetch a higher price than pulpwood. This increases the willingness to carry out more thinning fellings, which results in more forest growth, i.e. carbon sequestration.
- The production of the other main product, Solidiwood wide-board products, uses large sawlogs. This increases the willingness to grow trees larger, which results in more forest growth, i.e. carbon sequestration.
- Today's construction industry is the largest single source of carbon dioxide emissions. Its share is 25%.
- According to estimates, building with wood would reduce the consumption of natural resources by as much as 70%.
- The biggest problems of today's wood construction are high cost, material properties and a lack of standardisation.
- 75% of the building stock the world will need in 2050 has yet to be built.

The low-carbon transition of industry accelerates:

- Competing industries, such as concrete, brick, steel, aluminium, laminate and plastics, are highly carbon-intensive. Solidiwood increases wood construction and also takes market share from the above-mentioned industries.
- Compared with conventional processing, the further processing of green sawn timber with Solidiwood requires on average at least 70 times less land, buildings, machinery and energy for the drying stage alone.

- Solidiwood's requirement for sawlogs, sawing and transport is at least 10% smaller, and the service life of its product range correspondingly longer.
- Solidiwood hollow-core elements substantially reduce the weight of a building and save heat compared with conventional solid-wood elements.
- Compared with today's wood products, the need for glue is very small in Solidiwood elements and zero in surfacing products, apart from any end joints.

It is justified to set the price level of **Solidiwood** wood product production for large volumes, i.e. largely for use by ordinary citizens, also from the point of view of combating climate change and biodiversity loss.

The national-interest Solidi joint concept business ecosystem & Solidiwood process technology and wood product range bring radically profitable business not only to the further processing of sawn timber, but also to the technology industry and wood construction.

Increasingly exponential sales growth compensates for keeping the price level of Solidiwood wood products below the level obtainable on the market. They should therefore be given an Environmental Product Declaration (EPD).

*Solidi & Solidiwood make cost-free combating of climate change and biodiversity loss possible.*

For the forest industry, the damage resulting from a reduction in wood procurement volumes is eliminated by the really effective factors for combating global warming and biodiversity loss, and for business profit, set out earlier in this chapter.

For more information on the forest industry, see https://www.satakunnankansa.fi/maailma/art-2000010824045.html 11.11.2024:

> The volume of felling has a decisive effect on the outcome. Behind the collapse of carbon sinks are forest fellings that have remained at a high level, lower-than-expected forest growth and the accelerated decomposition of peat in drained peatland forests as a result of warming.
> The impact of felling on climate emissions is well illustrated by a comparison with traffic: three million cubic metres of forest felling causes a loss of sink equal to the emissions of all passenger cars in Finland.
> For the time being, the gap between emissions and climate action is huge, and the emission reductions announced by countries come nowhere near the Paris target.
> The chair of the Finnish Climate Change Panel, Professor Jyri Seppälä of the Finnish Environment Institute:
- the end point will be reached only when the emissions and carbon sinks of the whole world are in balance.

- emphasises strengthening carbon sinks in addition to reducing emissions.
- points out that the end point will be reached only when the emissions and carbon sinks of the whole world are in balance.
- emissions from oil, coal and gas must be brought down, but sinks must also be preserved and efforts made to strengthen them.

and https://www.hs.fi/suomi/art-2000010970147.html 8.1.2025:

> Finland's forests have turned from a carbon sink into a source of emissions. The chair of the Climate Change Panel warns that Finland's climate targets will collapse unless the situation is addressed. The forest industry should strive to put its raw material to better use in products. In future, products with higher added value should be made from less wood.

## Intellectual property rights

### Copyright

Copyright protects a work. The work must be independent and original. The author's personal contribution must be visible in it in some way, and it must be the author's own creation.

> Partial copying of this work is prohibited under the Finnish Copyright Act (404/61, with subsequent amendments) without explicit permission. Permits for partial photocopying of works are granted by Kopiosto ry, authorised by authors and publishers. For any other use, permission must be requested directly from the rights holder of each work.
>
> Solidi Finland Oy, Helsinki 2025.

### Industrial property rights

Industrial property rights comprise patents, utility models, trademarks and design rights. They have long been an essential part of companies' operations. In his book *Uudistu ketterästi* [Renew with Agility] (2008), Jyrki Kettunen states that in a growing technology company they may even be the biggest factor in determining the company's value.[68]

"Whatever you have succeeded in developing should also be protected," Kettunen states in his book, continuing: "in terms of timing, this must also be done as early as possible, because by the time commercialisation approaches, it is often too late to try to protect it."[69] Also essential here is the quality of the applications, because when the developer moves early, the application often acquires the broader character of a basic patent.[70]

[68]Kettunen 2008, 133
[69]ibid.
[70]ibid. 136

In connection with protecting significant insights, Kettunen speaks of the so-called umbrella model: the handle of the umbrella is the basic insight, and the ribs represent the applications, each built with its own patents. This creates a whole that is stronger than its parts, in which the rejection of a single application does not jeopardise the whole invention.[71]

Applying for patents and other forms of protection has not always been seen as equally valuable. Kettunen notes, first, that until the 1990s Finland's patent law favoured copying more than inventing. In addition – partly as a consequence of legislation – the benefits of protection have not previously been recognised:

> From earlier times there has been a belief in Finland that secrecy is a more effective and cheaper way for a company to protect itself than official protection. This belief is mistaken, since at the latest when jobs are cut, the means of keeping secrets also come to an end.[72]

Since then, legislation has changed in a direction more favourable to inventing, and it continues to be developed in the EU as well.

Since the turn of the millennium, Solidi Finland Oy's industrial property rights attorney has been Heikki Lahti, Patentia Oy[73].

## Patenting

Patenting is part of the business strategy of the technology and wood products industries. Its aim is to protect against imitators and to defend one's own market share – or to capture new share. Solidiwood process technology is protected by Finnish, EU, US and Canadian patents and by the Solidiwood and Solidi Finland EU trademarks. Readers interested in the technology in greater depth should study at least Finnish patent 128762B on the website of the Finnish Patent and Registration Office (PRH). There, and in other patent publications concerning Solidiwood technology, there is also information and solutions that are not included in this book.

A patent can be granted only for a new, inventive and industrially applicable solution. Solidiwood technology was protected by an FI patent applied for at the turn of the millennium and by a European patent registered in nine countries. However, the maintenance of these patents was discontinued before the end of their term.

The company later filed two FI patent applications and one European patent application containing solutions supplementing the technology. All three of these applications have been allowed to lapse.

[71]Kettunen 2008, 134
[72]Kettunen 2008, 133
[73]www.patentia.fi.

The company has also filed two FI patent applications containing solutions for raising the degree of processing achieved with the technology. Both applications have been allowed to lapse.

Trademarks

Solidiwood® is an FI trademark registered by the company at the turn of the millennium. It has also been registered as an EU trademark. Solidiwood® builds and protects the product image of the company's technology and wood products.

Solidi Finland® is an EU trademark, registered on 08.12.2020, that protects the company's name; it also serves to protect the company's business model, i.e. the national-interest Solidi joint concept.

Even before the above-mentioned trademarks, Solidi™ was being developed into a trademark to be registered as the short name for Solidi Finland Oy's operations.

The company's logo is being developed into a combined figurative and word mark covering the broadest range of service and trademark classes for Solidi Finland Oy's operations.

## The successor to the Solidi development project – Heikki Kukkonen

The further development and commercialisation of the national-interest Solidi joint concept and Solidiwood process technology are being continued by my son, Heikki Kukkonen. He stepped down as business director for digital services at Innofactor Oyj at the end of 2022 and has served as CEO of Solidi Finland since 2019. He has extensive experience of working in various roles in projects that develop and utilise digital services and technologies in support of a wide range of business needs. In a nutshell, he gives three reasons for taking the Solidi whole forward:

A. Belief in the change that the technology makes possible, a desire to make sure that it works, and the will to bring the technology to market so that the change can take place.

B. The ability to make use of the lessons I have learned in other industries and to make them collide with an industry that is entirely new to me.

C. A shared motivation to focus on doing good for the right values, so that the world might be at least a slightly better place in the future.

In my view, reason B, raised by my son Heikki, is a truly necessary perspective when a radically new kind of innovation is being introduced into the traditional sawmilling industry and the industry that further processes green sawn timber. We all need this ability to make ideas collide, and new ways of thinking, in order to find the means by which the greatest benefit can be gained from the new technology. Solidiwood process technology and the Solidi business model change existing ways of operating so that they become substantially more profitable, and that is why the whole must be examined from new perspectives. It is from this perspective of colliding ideas and open thinking that all of you would do well to continue reading and exploring the material.

### Small-scale equipment pilot project and the design of industrial production units

It is time to make Solidiwood process technology available, first and foremost, for use by our society and our industry. This should be launched through small-scale equipment piloting of the key mass products of Solidiwood product groups 1 and 2. In this connection it is also worth reading Teijo Ruuth's budget calculation for the pilot project, which includes an implementation plan.

A small-scale equipment pilot project is needed in particular to determine, through Solidiwood process technology and product trials, the best production method for each product down to the last detail, and to produce small product samples for testing and marketing. This means product-specific optimisation.

The equipment is also needed for permanent use, that is, whenever there is a need to try out a new product, function, wood species, glue or surface treatment agent, or some other better partial or overall solution.

It is also essential that even the use of the small-scale equipment makes it possible to obtain the information needed for designing and manufacturing industrial production equipment. If a particular product so requires, the small-scale equipment can of course also be built in a longer version. This makes it possible to verify the product further through trial use in its applications.

**Drawing up a concept plan** supports and enhances all of the above. This emerges, for example, from the marketing study of Solidiwood – then Ilvolankoski Oy – carried out by Jukka Ohvanainen as his thesis.[74] According to Ohvanainen's study, machinery and equipment manufacturers – like the wood industry – require “hard and concrete” facts about a new technology. For this reason, the lack of a prototype creates a credibility problem when an innovation is being sold. At the same time,

[74]Ohvanainen 2010. See also the chapter of this book: *Radikaalien innovaatiomahdollisuuksien markkinointi puutuote- ja teknologiateollisuudelle* [Marketing radical innovation opportunities to the wood products and technology industries], p. 94

however, Ohvanainen points out in his study that because machinery and equipment manufacturers work precisely in the field of engineering and technology, they are in a position to assess an innovation opportunity expertly without an actual prototype. Ohvanainen proposes that a concept plan drawn up for Solidiwood technology would demonstrate the functionality of the technology to machinery and equipment manufacturers:

> In a concept plan, the technology would be drawn, described and dimensioned, allowing an expert to assess its functionality, costs and development needs quite reliably.
>
> Concept design would not require as much investment of time and money as developing, building and testing a prototype. It would be good to have a concept plan for the wood products industry's own technology experts as well.[75]

In the design of Solidi production units, making use of virtual technologies also opens up new possibilities. In the second and third decades of the 21st century, virtuality and various simulations have become part of both our everyday lives and business in many sectors. They also offer opportunities for industry, such as technology companies.

Virtual models and digital twins, for example, have already begun to revolutionise technology and product development. They increase the possibilities of testing functionalities at earlier stages of developing innovations, even before any physical equipment exists.

With digital twins, different concepts can be tested, for example, in the actual operating environment of a future product. Digital versions of a concept can also be compared, and the right solutions found resource-efficiently before product development moves towards the final product. In this way, problems too are detected already at the design stage.

The many new possibilities offered by the digital world can be used to support the efficient development and testing of numerous different intermediate and end products and the use of different wood species. A digital twin and predictive models make it possible to model and test new products cost-effectively and quickly. In this way, the time spent on designing and testing individual new products can be reduced, even by years, compared with traditional methods.

Virtual models would naturally also make the testing and deployment of new Solidiwood technology products more efficient. They also facilitate collaboration in the product development process between experts from different fields – in the case of Solidi, for example, between technology experts and wood products experts. Digital twins can also be used to develop and optimise existing equipment that is, for example, connected to a real production line. Various simulations make it possible to investigate the effects of changes before they are put into practice. This matters, for example, when optimising production volumes, costs and energy consumption. In

[75]Ohvanainen 2010, 81.

addition, a company can present new products to its customers with a simulation built from a digital twin. A simulation can also be used, for example, to train equipment operators at a stage when the actual physical equipment does not yet exist, which speeds up putting the equipment into use once it has been completed.

**The single most important factor in the procurement of Solidiwood technology** is the basic premise of the national-interest Solidi joint concept: Solidiwood R&D, and in particular the manufacture of Solidiwood presses, must take place permanently in Finland.

Solidi Finland should therefore authorise the companies with the best design and manufacturing capacity in our country as its joint-concept companies for manufacturing its technology. Their induction and authorisation will be carried out in collaboration with Teijo Ruuth. These companies are needed to ensure a reliable and exponentially growing capacity to deliver the complete Solidiwood technology for the coming conquest of global market leadership. It is also important that their existing customer base already includes wood products companies that will take Solidiwood process technology into use.

The filling and emptying equipment for the presses and the product packaging equipment can also be manufactured. Results will start to emerge once the task is given to companies in the sector as subcontractors to the companies described above.

Veisto Oy and Ponsse Oyj have been pioneers of technological development in their industries and still are, just as Solidi Finland Oy is now. All of them also aim for global market leadership.

Google: “Ponsse's competitors include John Deere Forestry and Komatsu Forest. In addition, several smaller European and domestic manufacturers operate on the market.”

It is in the interests of Veisto Oy and its sawing machine competitors to start supplementing their existing and new sawing machines so that they also produce pre-profiled sawn timber for Solidiwood production. Veisto's competitors are found in Sweden, Germany and North America.

The basic idea of Veisto's method is to chip, saw and edge a log into finished sawn timber in one single sawing machine: the company's know-how goes back 100 years.[76]

[76]See Varis 2022

## Statement on the deployment of Solidiwood® 3D process technology

Lahti, 15 October 2023

I am convinced that, in collaboration with the technology industry, I can design and supply R&D and production equipment applying Solidiwood technology that will carry out Solidiwood's technical and production functions. I have an in-depth knowledge of Solidiwood process technology. I have been familiar with it since 1 February 2012.

I am Teijo Ruuth, a mechanical design engineer. I have more than 45 years of wide-ranging experience in designing and supplying machinery and production lines for various industries. I have worked as a designer, R&D engineer and design and project manager at, among others, Raute Oyj and Makron Oy, which manufacture presses and other woodworking machinery, and thereafter as an independent entrepreneur at Fertema Oy and Constru Oy, the companies I founded.

*What matters most is making use of the Solidi joint concept and Solidiwood process technology. This is also in the interests of all those mentioned above and of their Solidiwood customers. So one must not stand still, nor go on unknowingly bearing the greatest risk.*

## Sourcing sawn timber from sawmills, and Solidiwood sawing and process technology plants

The green sawn timber needed for Solidiwood further-processing production is sourced from sawmills under long-term contracts, under which part of the sawlogs has been sawn by profile sawing. The lengths of Solidiwood products must be matched to the standardised lengths used in construction. The same applies to the sourcing of sawlogs. This also limits the number of product-specific production units in Solidiwood production.

Solidiwood product group 1 covers wide boards sawn from large-diameter sawlogs, which are further processed into Solidiwood board products from sawn timber pre-profiled mainly for the tongue and groove, while the surface boards pre-profiled during sawing are made into log panels. The latter are mainly used in Solidiwood round logs, which are produced by adding them as the side faces of the square hollow columns mentioned below.

Solidiwood product group 2 covers in particular Solidiwood small beams, hollow-core intermediate-floor and wall elements, and square hollow columns, further processed from small-diameter sawlogs sold as pulpwood – that is, from profile-sawn green sawn timber which has been studied by Luke[77] and is well suited even to load-bearing structures. The group also covers Solidiwood glulam beams and panels produced from sawn timber conventionally sawn from small-

[77]Natural Resources Institute Finland (Luke)

diameter sawlogs. Of course, both groups also cover the corresponding Solidiwood products produced as described above from larger-diameter sawlogs.

Solidiwood product group 3 covers intermediate products, i.e. blanks and components, for example for the construction, joinery and furniture industries. Some of them also include surface treatment. Supplying them requires Solidiwood process technology production units designed individually for the intermediate-product needs of the companies that manufacture end products.
**A radically new and most profitable production option** is to build the following: after the debarking and sorting of the sawlogs, a sawing machine, e.g. one produced by Veisto for large and small sawlogs, with Solidiwood production units connected to it.

Solidiwood sawing units do not need the land, buildings and equipment that follow today's sawing machines, such as a dimension sorter, stacking machine, kiln, unstacking, packaging and storage, nor do they require much transport to further processing. At best, Solidiwood sawing is done as far as possible directly into the infeed equipment of the Solidiwood process technology units. In addition to its technology, each unit also contains packaging and storage space for the end product.

In other words, as the needs mentioned above diminish, plot space, buildings, energy, etc. are freed up at existing sawmills for Solidiwood further-processing production. Even then, it is wise to be prepared to produce conventional sawn timber as well, for example to ensure that the purchased roundwood is fully utilised. Then again, such wood lots can already be sold at the time of purchase to companies engaged in conventional sawing.

It would be particularly economical to harvest from eucalyptus plantations the sawlogs best suited to the overall production of Solidiwood further-processed products, with the rest of the wood and the resulting sawmill chips going to pulp production. Eucalyptus is really cheap compared with ordinary sawlogs. Secondly, according to an email from Jyrki Kettunen, long-time R&D director of Metsä Group, it is much easier to work with than, for example, our own tree species with their difficulties, as straight-grained and almost knot-free material is available at low cost.

As early as the beginning of the 2010s, Veisto Oy successfully piloted its sawing machine for sawing even eucalyptus with its very high growth stresses. The problem in this respect, however, is still that Solidiwood 2–3D process technology, which dries and further processes such difficult sawn timber, has not yet been brought into industrial use. Veisto's then sales manager, Kenneth Westermark, later told me that if Solidiwood technology were available, they would not need to sell their sawing machines at all – they would simply be handed out.

At its most profitable overall, the sawing of the green sawn timber required for further processing with Solidiwood process technology should be targeted at eucalyptus plantations, which

are owned by large companies. They decide how the wood harvest is used. The wood mainly goes to their pulp and paper industry, and only on very favourable terms to some extent to, for example, private large-scale sawmilling.

Other fast-growing broadleaved, coniferous and hardwood species, too, can be utilised very profitably with Solidiwood process technology.

Solidiwood process technology can be used by sawmills as well as by subcontractors or end-product companies. Some of the green sawn timber would be pre-profiled during sawing and some would not.

## Joining the business made possible by Solidi Finland

> To bring about change, technological development needs to be accompanied by a business model that links the new technology to a need identified or emerging in the market. (Tiina Valjakka, Taru Hakanen, VTT blog, January 2018)

**Jyrki Kettunen** writes about the level of ambition of a joint project: it must be set high. This gives rise to useful reflection on what the project is really aiming for. “You may have to compromise on goals that are set high, but there is nothing to compromise on in low ones,” he states.[78]

Solidi is the business model made possible by Solidiwood process technology, i.e. Solidi Finland's national-interest global joint concept for technology and wood products companies. Solidi's techno-economic solutions, IPR and standardisation, together with other key factors, offer the opportunity for a radically new and profitable innovation. The common thread in Solidi's development has been, and still is, a technology-driven perspective that unites the interests of business and of humankind globally. The joint concept enables large-scale new production, its maximum benefit and, at the same time, the best possible and cost-free combating of global warming and biodiversity loss.

As the management company, Solidi Finland Oy must maintain comprehensive R&D activities to secure the continuity of its joint-concept companies' operations. This makes it possible to maintain the price and quality competitiveness of Solidiwood wood products and to make them available to an even exponentially growing customer base.

The foundation of the Solidi joint concept's activities and operations is democracy. By this I refer, for example, to the division of the world order into democratic and undemocratic, as highlighted in the Helsingin Sanomat editorial of 24 February 2023:

[78]Kettunen 2008, 169

> The coming global order is defined by two blocs engaged in an ideological struggle. One of them is led by the democratic United States, the other by authoritarian China. Geopolitics is also forcing the economy and technology to choose sides.[79]

The Solidi joint concept and Solidiwood process technology can be deployed at least in all countries of the democratic world. Other countries can at least serve as export markets for Solidiwood wood products and as suppliers of sawn timber. These factors, together with the Solidi project's numerous other opportunities, also help in the struggle between democratic and authoritarian leadership for world domination – that is, in solving by far the greatest problem in the world.

What percentage of this potential global volume can be achieved depends primarily on the amount of intellectual and material investment our country makes, and secondarily on how Solidi Finland Oy, together with its joint-concept companies, prevents the unlicensed manufacture of its products. The export value of wood-based products from EU countries is almost 50% of the world's total export value, even though the forest area of EU countries is only about four per cent of the world's forest area. Lauri Hetemäki notes in Puumies magazine that it is precisely for this reason that EU countries are in “pole position” to bring new and more efficient bio-based products to the market.[80] It is also particularly profitable to target the deployment of Solidiwood at these countries.

**Solidi Finland Oy** owns and licenses the rights of use to its national joint concept, Solidi. Companies that produce Solidiwood process technology and use it in their own production become part of this joint concept, benefiting from its advantages and building shared value for it.

In the Solidi project in particular, it is justified to tie the licence fee, i.e. the royalty, to operating profit. This is also fair. The more profitable the foundations, i.e. the starting points, that the Solidi project has provided and continues to provide, the greater the operating profit for Solidi Finland's joint-concept companies as well. Its size is largely product-specific. Of course, if operating profit falls, the licence fee percentage must also decrease correspondingly. All this motivates Solidi Finland and its joint-concept companies to maintain effective cooperation as well as research and development.

Individual wood products companies are easily tempted to price their products according to what customers able to pay will pay for their superior properties. Unfortunately, at high prices the market for the products, and the combating of climate change, remain small. At the same time, a truly large market – that is, an overall result of an entirely different order of magnitude – is left unrealised. It is essential to make demand for the products exceed production capacity. This is

[79]See Helsingin Sanomat, editorial 24.2.2023: https://www.hs.fi/paakirjoitukset/art-2000009410144.html
[80]See Puumies magazine 2/2023

possible through advance marketing. The publication of my book should also be part of it. Then the intermediaries of the products, i.e. retailers, will not be able to extract an entirely unreasonable operating profit for themselves.

Competition in the world economy has increasingly shifted to competition between different networks or ecosystems. The Solidi business ecosystem offers the companies within it versatile support and know-how, as well as concepts that can be used jointly. Resource-consuming competitive pressure eases as competition shifts from individual companies to competition between ecosystems.

For the Solidi ecosystem to function well, it is important to make collaboration between the different actors efficient and automated, including in administrative tasks. The capabilities offered by blockchain technologies, both those under development and those still to come, could possibly be used to support efficient administration. Blockchain technologies can be used, for example, to streamline and automate contract management between the different actors in the ecosystem. In addition to contract management, automated management of all other collaboration between the actors in the ecosystem through a digital platform creates added value for them (for example, the processing and automatic settlement of licence fees).

In technology-centred business in particular, the ecosystem model has already proved to be a good way of operating, because it combines everyone playing towards the same goal with sufficient agility and freedom for individual concept companies to act independently as they see best.

In his book *Uudistu ketterästi* [Renew with Agility] (2008), Jyrki Kettunen writes that companies should form alliances “for cooperation in areas where they see strong business potential, but which at the same time would require information gathering too demanding for their own resources.” According to Kettunen, the benefit gained from such alliances relates above all to development time.[81]

**Kettunen** also writes in his book about companies' core competence and its role in a company's operations:

> Today, core competence refers to competence that a company regards as the source of its future competitive advantage and whose development it therefore wants to keep to itself. This means investing in development in selected areas and is therefore a strong driver of a company's development work.[82]

[81]Kettunen 2008, 174
[82]Kettunen 2008, 141

According to Kettunen, it is important to examine core competence specifically from the perspective of future business. Reflection on it should therefore be based on views of the company's future alternatives. “The potential of core competence lies especially in those factors that are important in all, or at least most, of the envisaged development paths,” Kettunen writes.[83]

> The technology and wood products companies within the Solidi concept specialise in Solidiwood production for one or more areas of use, or even for just one product. This is also one of the basic starting points for a really good operating profit from the use of Solidiwood process technology. For example, a narrower focus, cooperation between companies and learning from one another are in everyone's interest.

The manufacture, supply and maintenance of the necessary technology, and its primary protection against copying, are the prerogative and task of Solidi Finland's future technology joint-concept companies. Acquiring the market for the new wood products, on the other hand, is the task of the wood products joint-concept companies.

Solidi Finland's future technology and wood products joint-concept companies already have an existing customer base. As part of the concept, these companies are to offer their existing and future customers a more affordable product once its supply becomes possible.

Both the technology companies and the wood products companies in the concept benefit from each other's participation. For example, the investments of wood products companies that productise new wood products and make them known provide a ready market for the technology companies' new products. The need for technology and the ability to pay for it grow the greater the result achieved for the wood products, since all costs are ultimately paid from the revenue that comes from wood product customers. Finnish companies could therefore also go abroad to generate a larger overall operating profit by processing even the world's most expensive wood species, and even species not yet valued for traditional industrial production, into Solidiwood products. This could happen even with a lower licensing percentage than for domestic companies. Jyrki Kettunen writes in his book *Uudistu ketterästi* that

> If the programme's level of ambition is mediocre and the participants operate in the same markets, the benefit to each participant remains marginal, since the results are usually given free of charge to customers for whom they all compete. The situation changes if the programme aims at radical change and succeeds. The parties can then, by standardising the applications, create a technology cartel from which they benefit substantially more. In recent years the EU has championed this possibility.[84]

Licensing the right to use Solidi is justified when its recipients are prepared to pay adequately for it and undertake not to disclose confidential information concerning Solidi to outsiders. It is then in

[83]Ibid., 142
[84]Kettunen 2008, 173

the interests of all parties to keep the price level of wood products where it needs to be and to protect Solidi from copying.

When we think of the Solidi whole, the operations of the concept companies are not about small changes intended to respond to what competitors are doing – in which case the value they produce would also remain small – but about potentially radical innovations achieved through cooperation, which, instead of competing, can focus on serving customers, building more value and, through this, of course also a significant competitive advantage over companies outside the concept.

The services of the management company Solidi Finland Oy mean the services that come to its joint-concept companies through the national-interest Solidi joint concept and Solidiwood process technology, and their benefit to an exponentially growing customer base through the preserved price and quality competitiveness and availability of Solidiwood wood products.

**All in all, Solidi Finland has a complete solution**. It also includes the possibility of Finland becoming a pioneer, even a permanent one, and in line with its own interests. Then development results will not become available to foreign competitors without compensation, nor will the competitive advantage gained disappear. Solidi is a national-interest business model. It is so for foreign joint-concept companies as well.

Achieving the maximum national benefit means supplying Solidiwood technology exclusively from Finland. With the substantially higher licensing percentage paid by foreign companies and, above all, with a volume as much as thirty times greater, far more will flow into Finland than all the development and maintenance costs incurred so far and in the future. All this also means that what has been developed in Finland stays in Finland and continues to be developed there, i.e. Finland retains its position as a pioneer. *Thus the Solidi project may make today's small Finland the world-leading nation in its sector, while also maintaining the manufacture of its technology and its future development in line with its vision.*

**The more companies invest** in Solidiwood technology, the lower its development investment costs per company. This is also linked to the use of time. Kettunen puts it this way:

> When work is then launched as a joint effort, it can be expected to be completed faster than in a single company. This does happen, but in a dampened form. If one company completes a project in time a, the time required by a joint project is that same a divided by the square root of the number of participants; that is, a group of four completes the work in half the time.[85]

He adds, however, that the time saving in joint projects is only realised when it is taken into account in drawing up the original schedule and the programme is subjected to strict monitoring.[86]

[85]Kettunen 2008, 172–173
[86]Ibid.

**In the development of Solidiwood process technology and the administration of the Solidi business ecosystem,** a variety of new opportunities offered by the digital world can be utilised now and in the future.

The effects of using Solidiwood products on, for example, construction costs can be modelled and forecast, possibly with the help of AI-assisted modelling software. One of the biggest challenges for wood construction at present is construction costs relative to steel and concrete construction. Digital twins and cost-modelling software can be used to develop increasingly cost-effective Solidiwood end products.

Digital twins and predictive models can also be used to steer product development in an increasingly standardised direction. This further increases the cost competitiveness of wood construction, making not only the design of wood construction but also the manufacture of construction products more efficient.

It should also be noted that the availability of the national-interest Solidi business ecosystem to future Solidi joint-concept companies is assured and verified by Heikki Kukkonen, former business director for digital services at Innofactor Oyj and current CEO of Solidi Finland. Below is the task that the management of Solidi Finland and its joint-concept companies must take on themselves and carry throughout their organisations, i.e. the Mission of the Solidi project.

***The national-interest Solidi joint concept & Solidiwood process technology must become the global market leader. Here, too, it is right to act in accordance with the values set out in my book.***

Accomplishing the above mission will also make the Solidiwood wood product range the global market leader and, together with its technology, achieve a truly significant, cost-free global fight against global warming & biodiversity loss. It is therefore right to put this globally most valuable source of results first when marketing the future overall result of the Solidi project.

All of the above can be verified in the final chapters of my book, namely “Vision of market leadership” and “Solidi Finland in the more distant future”.

## A vision of market leadership

Vision is in a key position when a company wants to create a technology strategy. A company's technology strategy seeks, after all, to answer the question of what kind of technological expertise must be created within the company so that it can realise its vision.[87]

***Finland has an unrivalled starting position for harnessing the global market leadership of the Solidiwood process technology and wood products business of Solidi Finland and its joint-concept companies, and the national-interest global joint concept, S o l i d i.***

By establishing the Solidi business of Solidi Finland Oy, Finland and Finnish companies are able to lead the rest of the world and win the competition. This opportunity is built on Solidi's key factors, without competition between its domestic and foreign joint-concept companies.

It is worthwhile for Finnish forest industry companies to build Solidiwood wood product production abroad as well. Exploiting our national opportunity is also helped by the fact that our country already has forest resources larger than its size would suggest, as well as a wood products industry and a technology industry serving it, right up to international giants. The national interests of Solidi Finland's project are also united with the interests of humanity through the availability of radically more affordable technology and wood products, the resource efficiency of the technology and the growth of wood construction, and through the cost-free combating of climate change and biodiversity loss that all of these make possible.

**Wood construction** is often regarded as an expensive solution. In an interview with the magazine Puumies, Jarmo Pekkarinen, CEO of LapWall Oyj, states that there is actually nothing in wood as a material that would make it expensive; the wood products sector is simply "light years" behind others in the standardisation of its products. He believes that, in addition to developing these, the support of megatrends, for example, creates strong conditions for growing the business of wood companies.[88]

While, according to Pekkarinen for example, "the wood industry suffers from a lack of standard products and standards", the Solidiwood product range is already standardised by virtue of its production process, and standardisation is also on the agenda. Solidi's success factors have already been identified and are known. Now it is a question of putting them into use. There is no justification for delaying getting down to producing results. Compared with traditional investments,

[87]Kettunen 2008, 51
[88]Puumies magazine 3/2022: *LapWall Oy listautumassa pörssiin tänä vuonna* [LapWall Oy to be listed on the stock exchange this year]

an overall result of an entirely different order of magnitude is already being lost by dragging out the time and restricting investment.

Trends supporting and driving Solidiwood® process technology

- 75% of the building stock the world will need by 2050 has yet to be built.
- The construction and real estate sector is the largest industry in the world, and its carbon footprint is also by far the largest.
- The construction industry accounts for 25% of the world's carbon dioxide emissions.
- According to some estimates, building with wood would reduce the consumption of natural resources by as much as 70 per cent and cut emissions by 60 per cent.
- The biggest problems of wood construction are its high cost, its material properties and a lack of standardisation. Solidiwood tackles precisely these.
- Regulations that tighten the scrutiny of carbon footprints are coming into force nationally in the construction sector as early as 2025.
- Generally speaking, the other trends of our time also support the large-scale and rapid adoption of Solidiwood.

## How can the vision be made possible?

Below I have compiled the factors that make possible the vision of the future market leadership of Solidiwood technology and wood products, while at the same time maximising the fight against biodiversity loss and climate change. They also make it possible to realise national interests, at least in countries that practise democracy, and to standardise and defend Solidi Finland Oy's IPR, digital business platforms and Solidiwood technology applications.

1. The owner and leader of the Solidi project must be a management company, Solidi Finland Oy, with large Finnish wood products and technology joint-concept companies in particular as its part-owners. The operations of the management company Solidi Finland are run as far as possible with the help of IT.

2. The research and development of Solidi's digital business platforms and of Solidiwood technology, IPR and the standardisation of technology applications must remain in the hands of Solidi Finland Oy and its domestic shareholder joint-concept companies. New trademarks, patents, utility models and design protection, as well as future standardisation,

must be applied for with as worldwide coverage as possible. Suppliers of Solidiwood technology must be given support for producing the technology and must be paid, at least for the technology base and the presses, a price in proportion to the yield percentage of the wood products. The manufacture and supply of the presses in particular require that these take place only from Finland, in order to preserve the protection of the technology, R&D, IPR, etc. At the same time, the suppliers will be motivated to direct their product development and production as quickly and massively as possible towards the presses the technology requires and their loading and unloading equipment.

3. Solidi Finland Oy authorises Finnish technology companies and domestic and foreign wood products companies as its Solidi joint-concept companies. With every company to be authorised, Solidi Finland Oy concludes a Solidi joint-concept business agreement that includes the authorisation. The resulting licence fee is paid only by the wood products joint-concept companies, with the foreign ones paying a substantially larger fee, because they have not been involved at all in the research & development of the Solidi project.

4. Putting electronic services to full use, both in Solidiwood sawing and further-processing technology for sawn timber and in digital business platforms, is also one of the key opportunities for realising the vision. A generation newer than mine is able to take Solidi forward most successfully, making use of the possibilities of the digital world in an appropriate way.

5. Comprehensive information about the Solidi project, excluding its confidential information, must also be made available to the specified target groups of my book abroad: 1) management in the technology, wood products and construction industries, 2) public decision-makers and educational organisations, 3) forest owners and 4) designers and end users of wood products in construction and other uses. This will be done by translating this book of mine and the updated Solidi Finland website into several major languages as soon as possible.

### Solidi Finland in the more distant future

The key to maintaining and further increasing the volume and results of the Solidi business set out in this book is the continuous development of Solidi's digital business platforms and of Solidiwood sawing and process technology and the Solidiwood product range. Finding solutions and turning

them into results will be made possible by building a Solidi hi-tech research and development environment. It, too, is best built in the country that launched the Solidi project: Finland.

**Solidi Finland** does not intend to stop even after the next steps I have presented in this book, but to keep moving: to grow and develop along with its concept companies and with developments in the world in order to meet the needs of today and of the future.

Whatever steps the future eventually demands, taking them is possible when we combine expertise and trust in the knowledge gained through intuition, in perseverance and in believing in ourselves.

I recommend reading, among others, Perttu Pölönen's book *Tulevaisuuden lukujärjestys* [A Timetable for the Future] and moving boldly forward. It has worked so far. A second reading recommendation is Jyrki Kettunen's *Uudistu ketterästi* [Renew with Agility], aimed especially at company owners and boards, and the third is Frank Martela's book *Elämän tarkoitus – suuntana merkityksellinen elämä* [The Meaning of Life – Towards a Meaningful Life]:

> Many studies have found that people who have a strong sense of meaningfulness live longer on average. Viktor Frankl, the respected psychiatrist who survived the Holocaust, saw this with his own eyes in a concentration camp. Only those who retained their sense of meaningfulness despite unbearable conditions had any chance of survival.[89]

In my own life, retaining a sense of meaningfulness in difficult times played a decisive part in my development project seeing the light of day. I would not have dared to launch a development project that I judged to be truly difficult and unpredictable had I not had, in particular, the hard experiences of the legal process that followed the dam bridge collapse, and of surviving them too. The sense of meaningfulness helped me to keep going. The bankruptcy of my wood products company and recovering from it was another strong motivator for launching my project. A radically more productive technology and product range simply had to be achieved.

You, my esteemed successors in the project, may also encounter experiences that feel downright unbearable. They are even necessary for creating the corresponding strength to bring your project to its goal. They make it possible to maximise the end result. I would hope that you then remember how meaningful the results are that you are working for.

J. V. Snellman is said to have stated: "Every nation lives for its own interests and is right to do so. Its endeavours, however, will succeed only if its own interests are united with the interests of humanity." The national interests of the Solidi project are also united with the interests of humanity through the availability of radically more affordable technology and wood products, the resource

[89]Martela 2020, p. 8

efficiency of the technology and the growth of wood construction, and through the cost-free combating of climate change and biodiversity loss that all of these make possible.

The set of goals in my development project cannot fail to bring about radically profitable activity. Even so, it can and should also be worked on and developed further.

**The overall goal of the Solidi project** is, through Solidi Finland's superiority in process technology, business model and IT, and through the industrial operations of the Solidi joint-concept companies that utilise them, to make the **Solidi joint concept & Solidiwood process technology the global market leader**. You who toil on with Solidi have the opportunity to influence the future.

I hope this book has offered keys to that. Ahead of us now lies the phase of building up into an industry and of growth, which will make new development results possible. This is already being verified with equipment and other resources of an entirely different level and scale, starting with small-scale equipment piloting.

*The significant insights of the last years in which I wrote this book are already one clear indication that you, the future in-depth readers of my book, will have new and significant insights, especially into putting the results of the Solidi project into practice. Their key prerequisites, too, are:*

1. "High-level thinking is **the ability to handle complex and abstract ideas** and to create new perspectives and solutions."

2. Critical thinking is **a cognitive process** in which information, arguments and evidence are analysed in order to make sound decisions.

***The Solidi development project creates lasting value.***

## Acknowledgements

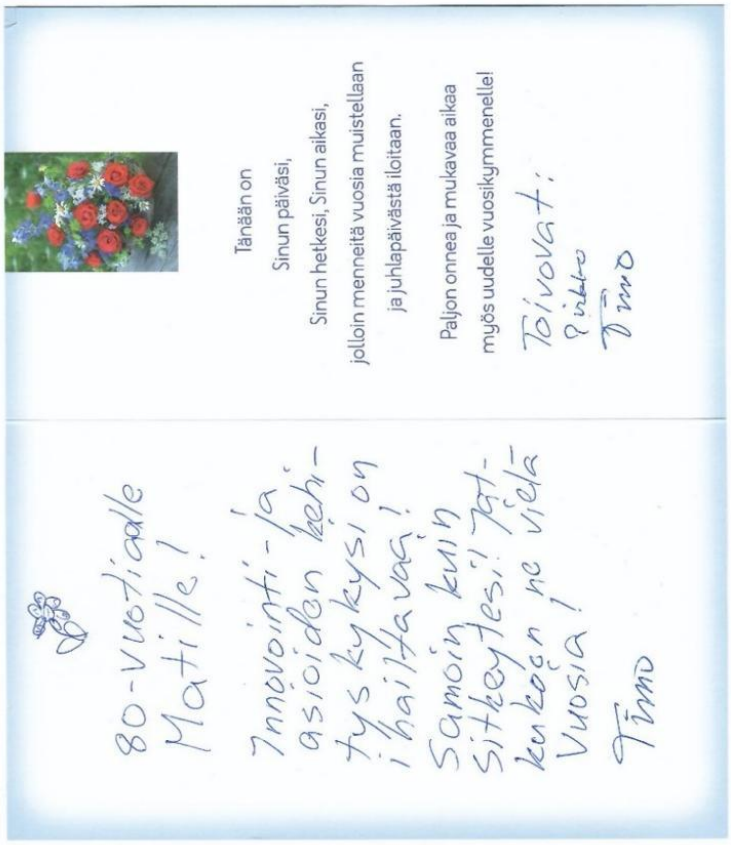


FIGURE. *Birthday card I received from Timo Kolmonen in August 2021.*

Card text: Handwritten: *"To Matti on his 80th birthday! Your ability to innovate and to develop things is admirable! As is your perseverance! May they carry on for many years yet! Timo"* – Printed verse: *"Today is your day, your moment, your time, when past years are remembered and the celebration is enjoyed. Many happy returns and a pleasant time in the new decade, too!"* – Signed: *"With best wishes, Pirkko, Timo"*

My first thanks go to the previous owner of my company Ilvolankosken Puu Ky, Heino Honkanen, and my second to the then municipal manager of Juuka, Olavi Tiittanen. Without Heino and Olavi I would not have become an entrepreneur in the wood products industry, which was extremely significant for the birth of my development project.

Thirdly, I thank Lauri Pitkäkoski, Licentiate of Technology, who helped me get through the legal process that followed the dam bridge collapse. Without Lauri's moral and expert support, my development project would hardly ever have been able to move forward.

My development project began to germinate in the previous millennium, in 1997, with the moral support of Pekka Jussila, project manager at the Tampere Technology Centre. My fourth thanks go to him. This launched my project. Through my expert courses at the University of Helsinki in 1997–1999 it took concrete shape as a set of goals whose results are now in my book. My fifth thanks for this go to the teachers on my courses and to my fellow participants.

I express my very great thanks to Professor Pertti Viitaniemi of VTT, a pioneer of R&D in the hot pressing and heat treatment of wood, for our numerous meetings, which began even before the turn of the millennium, for your valuable support for me and my project, and, among other things, for your proposal that further research on my technology be carried out at LAMK.

Since the beginning of the millennium, Heikki Lahti of Patentia Oy has acted as my IPR attorney. I express my thanks for our cooperation, which has gone and continues to go extremely well!

When I presented my development project of the time to Erkki Verkasalo, research professor at Luke, in 2006, he urged me to contact forester Jaakko Lehto at UPM's R&D. Their attitude, which built up my optimism, meant that I did not abandon my project but decided to pay for the registration of my European patent in nine different countries, which was excessively expensive and risky for me.

My deep thanks also to the active supporters of my development project in its early days: Juha Lipponen, now a seasoned innovation veteran and professor of practice, and innovator Pekka Koivukunnas, M.Sc. (Tech.). Their support led to the preliminary study of my technology in Pekka's garage laboratory in 2009. This was preceded by a presentation of my project together with Juha at the Finnish Forest Industries Federation (Metsäteollisuus ry). My special thanks for this go to Director Antro Säilä, whom I already knew from UPM through my project, for your positive attitude towards my project at the time, in 2008.

Of the strong inner circle of my development project, I would especially like to acknowledge, with the greatest thanks, engineer Timo Kolmonen, wood industry engineer and project manager Ossi Klemetti, and mechanical design engineer Teijo Ruuth.

Together with Timo Kolmonen, I carried out the significant key tests that preceded the LAMK research period, which began in 2011, in Timo's "mini laboratory" in Vantaa. There we also continued later small-scale tests related to the project. For the last couple of decades of his career, Timo worked as delivery and development director of maintenance service companies serving large-scale industry. Timo's client companies ranged from small firms right up to giant corporations, in the technology and wood products industries as well as in other sectors. Timo, if anyone, is a pioneer of outsourced industrial maintenance. The almost daily contact between Timo and me on my project, which began back in February 2010, has continued in recent years on a weekly basis.

Ossi Klemetti, who passed away in 2020, was a truly strong source of moral support in my development project from 2011 onwards.

Teijo Ruuth has an in-depth knowledge of Solidiwood process technology. He has been familiar with it since 2012 and has been closely involved in our development work. In accordance with the purpose and background of our non-disclosure agreement, Teijo, "as a professional independent of production companies and of other parties", has issued the statement required by the agreement on the adoption of the technology and has started preparations for a piloting project. The statement also reveals his long and wide-ranging background of experience.

My thanks to Tero Lahti, business consultant at Pöyry Oyj, among other things for the proposal that further research on my technology be carried out at LAMK. I extend my special thanks to Kari Koskinen of Koskisen Oy and to Markku Mäkelä, Tekes's expert on the wood products industry and head of its Lahti office, thanks to whom this Solidiwood research began in 2011 and continued successfully. My thanks to Timo Närvä of Koskisen Oy for your participation in making the research a success. My thanks also to Eero Nenonen, director of Enekos Oy, for your particularly strong activity in furthering Solidiwood's progress towards becoming an industry.

I thank those who carried out the research on my technology at LAMK in 2011–2014: principal lecturer Jari Suominen, M.Sc. (Tech.); engineering student and laboratory engineer Leo Lähteinen; engineering student Eero Kahilaniemi; and the engineering students who wrote their theses, Joonas Uotila and Lasse Tapaninen. My thanks also to Jukka Ohvanainen, then an engineering student at Kymenlaakso University of Applied Sciences, for your thesis on marketing the Solidiwood development project to the technology and wood products industries.

For our numerous meetings and, among other things, for the proposals to expand the LAMK research internationally, my thanks go to Professor Reijo Lappalainen of materials science at the University of Kuopio and to R&D expert Mauno Multamäki of Savonia, as well as to Professor Reijo Tuokko, head of the mechanical engineering unit at the University of Tampere, and Professor Markku Karjalainen, architect and Doctor of Technology, of its architecture unit.

I express my thanks to the people who have worked to advance my project in large companies. Development managers Jaakko Lehto of UPM and Jari Johansson of Metsä Wood were truly active in taking Solidiwood's solutions into their companies. Both of them had in their time also dealt with the Hottinen brothers' press drying. Jaakko was also active with regard to my development project later, when he worked as research director at FWR Oy. Jari, for his part, among other things got the company's management to decide that a more detailed study of Solidiwood would be carried out within the company. Later, Juha Kasslin worked to advance my project at Metsä Wood; my thanks to Juha as well. Finally, my thanks also to my many supporters, encouragers and sources of inspiration whose names have not been mentioned separately above.

Nor can I forget the support I have received from my family. My greatest thanks go to my wife, Kaarina. Throughout our marriage, now already 58 years, she has been a faithful spouse and an immense support to me in all the stages of our lives, the difficult ones included. My wife has also endured my spending my time and energy mainly on my development project since around 1995, which still continues now that I am 84. Kaarina has also played a significant role as the editor and proofreader of my e-mails and of my texts concerning my development work.

Thanks also to our children. Our son Markku has acted as my practical IT support and Heikki, among other things, as the IT architect of my first websites. Our other children, Leena, Leea and Mikko, have also supported me and been involved in many ways.

With the support all of you have shown, my mental resources have held out all the way up to now, and my project has not foundered at any stage.

Finally, I would like to thank my truly important assistant in writing this book, Iina Nieminen, MA. Dear reader, without Iina's versatile expertise in the most important phase – much more than just the drafting phase – my present book would never have grown into a non-fiction book about the future of this calibre.

## Afterword

On turning 80, I felt that, considering my experience and my mental resources, I was in a position to write a publishable book about my development project. My intention was thereby to help my assistants, together with Solidi Finland, to bring Solidiwood 3D process technology & the national-interest Solidi joint concept into use for the benefit both of the societies of our country and of the world and of the companies that will become Solidi joint-concept companies.

And so, with this book, I am writing myself out of the project that became my life's work. This has partly been my intention for quite some time. The difficulty of the transition process and the consequences of letting go have to some extent even surprised me. Nevertheless, I believe it is good for those who make use of the results of my development project, for my assistants, and for our children and their children to continue from here. For my part, the generational change has now taken place.

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