top engineer

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"The same chemical building blocks currently derived from oil can be produced from biomass."
– Helena Arkkola

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The new normal, what's in it for us?

In the aftermath of the financial crisis that hit global markets in 2007–2008 the term 'new normal' was coined to describe the financial and business conditions that have prevailed ever since. As with most buzzwords it has been co-opted and used in many other contexts, but generally refers to something that once was rare or abnormal, which has now become commonplace.

Premier Li Keqiang recently indicated, for example, that China is experiencing the lowest growth in 25 years and that this is the 'new normal'. Governor Jerry Brown of California warned citizens in April this year that the severe drought the state is facing 'is the new normal and that we'll have to learn to cope with it'.

I have myself used the term to describe the current challenging economic conditions we face. In our lifetimes each economic downturn has been followed by an upturn and our standard of living has continuously risen. There is widespread consensus amongst economists, however, that this predictable cycle is set to change and that a return to the strong growth of before is in all likelihood not possible. It is still unclear what development trends we can expect in the future, but a significant change appears inevitable. So what is in it for us?

If we become paralyzed by the increased uncertainty of the new normal, others will most probably overtake us. If we are able to see change as an opportunity, however, the future looks interesting to say the least. It is how we embrace change that determines what we achieve.

For those grappling with how to strategize under changed conditions it is worth remembering an old saying according to which 'the more things change the more they stay the same'. When I think of my customers' challenges and hopes, for example, it is clear to me that almost all of them still want to grow and be more profitable and successful. Many see the urgent need for industry to develop more efficient, sustainable and environmentally friendly operations. There are, as such, many constants to hang on to in changing times; our customers' core needs are still the same.

In a sense the new normal is, therefore, maybe not so different. There will always be a place for consulting engineers that understand their customers' challenges and deliver services and products that advance their goal achievement.

Material and energy audits are some of the tools we can use to help customers achieve their goals. Being at the forefront of technological developments is another. Examples include the more efficient use of fresh woodchips as fuel at biomass heating plants, a potentially revolutionary development, as well as the use of games to improve learning processes to name a few.

In the end the new normal is not so different from the old normal; the future will not be a copy of history. I hope you will enjoy reading about these topics and others in our latest edition of the Top Engineer.

Olli Manner
Editor-in-Chief
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Seeing is believing

– material audits increase profits

'Been there done that. You won't achieve anything without major investments or disturbing product quality.' These are commonly held misconceptions regarding the scope of investment and its effect on end products when discussing the merits of introducing resource savings measures. Pilot audit cases in Finland and a decade of small and medium size enterprise audits in Germany have shown, however, that real and significant savings can be achieved with relatively small investments in material audits. In short, resource efficiency pays, and does so handsomely.

Climate change has focused efficiency optimization efforts on energy savings and in Finland we have over 20 years' experience in energy auditing. Statistics show, however, that in the manufacturing sector material costs account for around 55 % to 72 % of expenses and energy costs for less than 5 % (see Diagram 1 overleaf). The potential savings to be gained from material efficiency are thus far greater than those of labour and energy combined. Material costs also account for the majority of costs in the German manufacturing industry, amounting to 45 % of total costs in 2011 (www.resource-germany.com).

This is not to say that we should not focus on reducing energy consumption, we naturally have to, just that it should not be our sole focus.

It should not be forgotten that materials savings have a significant positive environmental impact by reducing the amount of materials transported and waste produced in addition to keeping more cash in the company bank account. It is, in essence, a win-win situation for business and the environment.

Real savings have been achieved

The results of the first material audits carried out in Finland have been promising. In the audits an average of 40–100 concrete savings measures were

identified according to Motiva, the Finnish state-owned energy and material efficiency company. The calculated yearly savings potential in the material audits carried out in five medium-sized industrial enterprises was 0.3–1 million euros a year per company, of which an estimated 20–50 % was realized during the first year.

The savings potential of a single material flow is estimated to be as much as 30 %. Germany has a decade's worth of experience in material auditing. The savings potential of Germany's material efficiency projects promoted by Demea (Deutsche materialeffizienzagentur) have on average been 2.4 % of company turnover.

Implementing the material audit

In Finland material audits that are carried out within the Motiva material audit programme in line with the national resource efficiency programme published on 2.1.2014 are subsidized by the Ministry of Employment and the Economy.

Motiva's systematic and subsidized audit method makes use of the enterprise's own experts and the neutral external viewpoint of a Motiva-certified consultant. If necessary the consultant can be involved in any subsequent actions such as investment planning, feasibility studies and detailed engineering. Experience has shown, however, that many of the savings can be achieved also through operational procedural development or minor layout improvements.

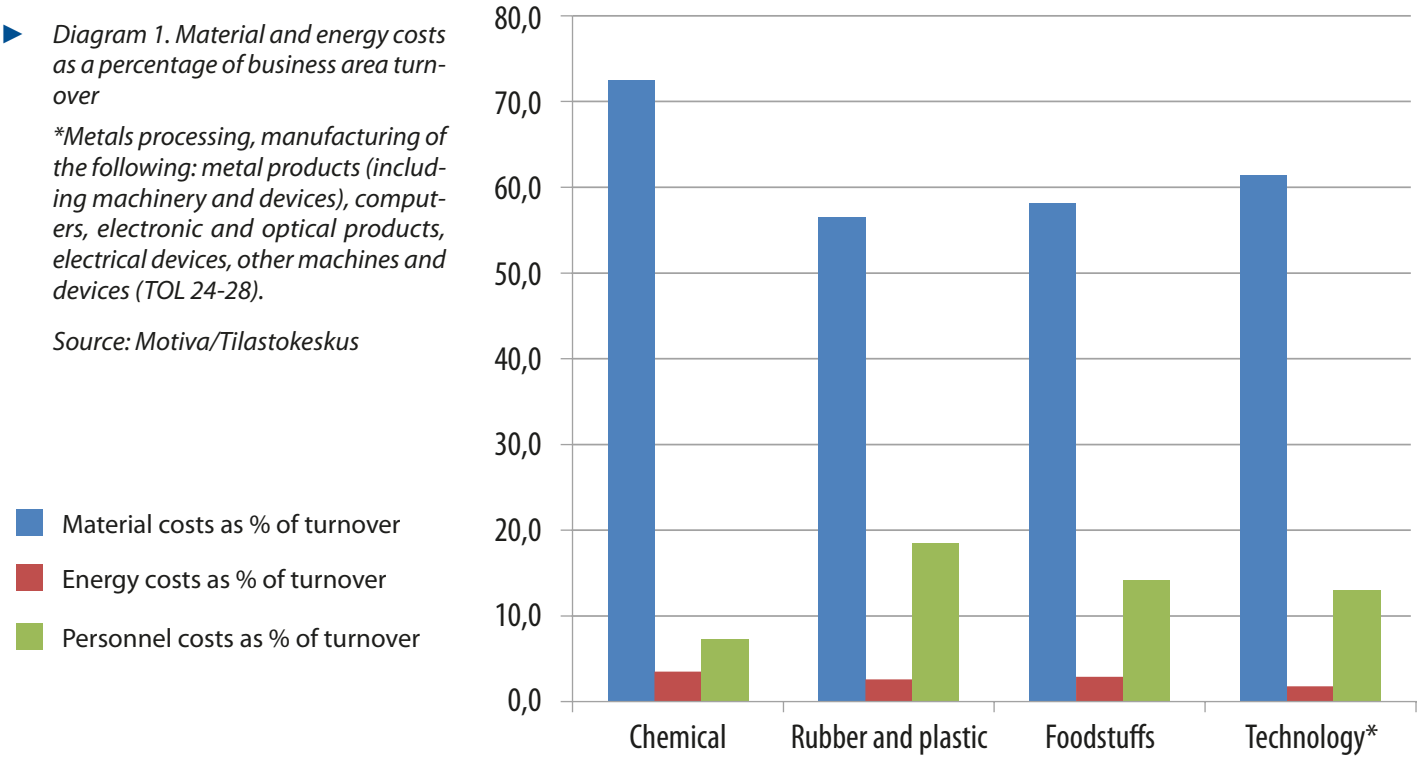
The material flow cost accounting method (MFCA ref. ISO 14051:2011) is used to calculate cost data for material flows in each step of the process, including material, energy, labour and waste management costs. The material and cost flows can be visualized with Sankey diagrams (see Diagram 2 overleaf) and with value stream mapping procedures.

Based on the material audit it is easy for companies to systematically carry out improvements step by step; starting with operational procedure updates and continuing with the shortest payback time investments.

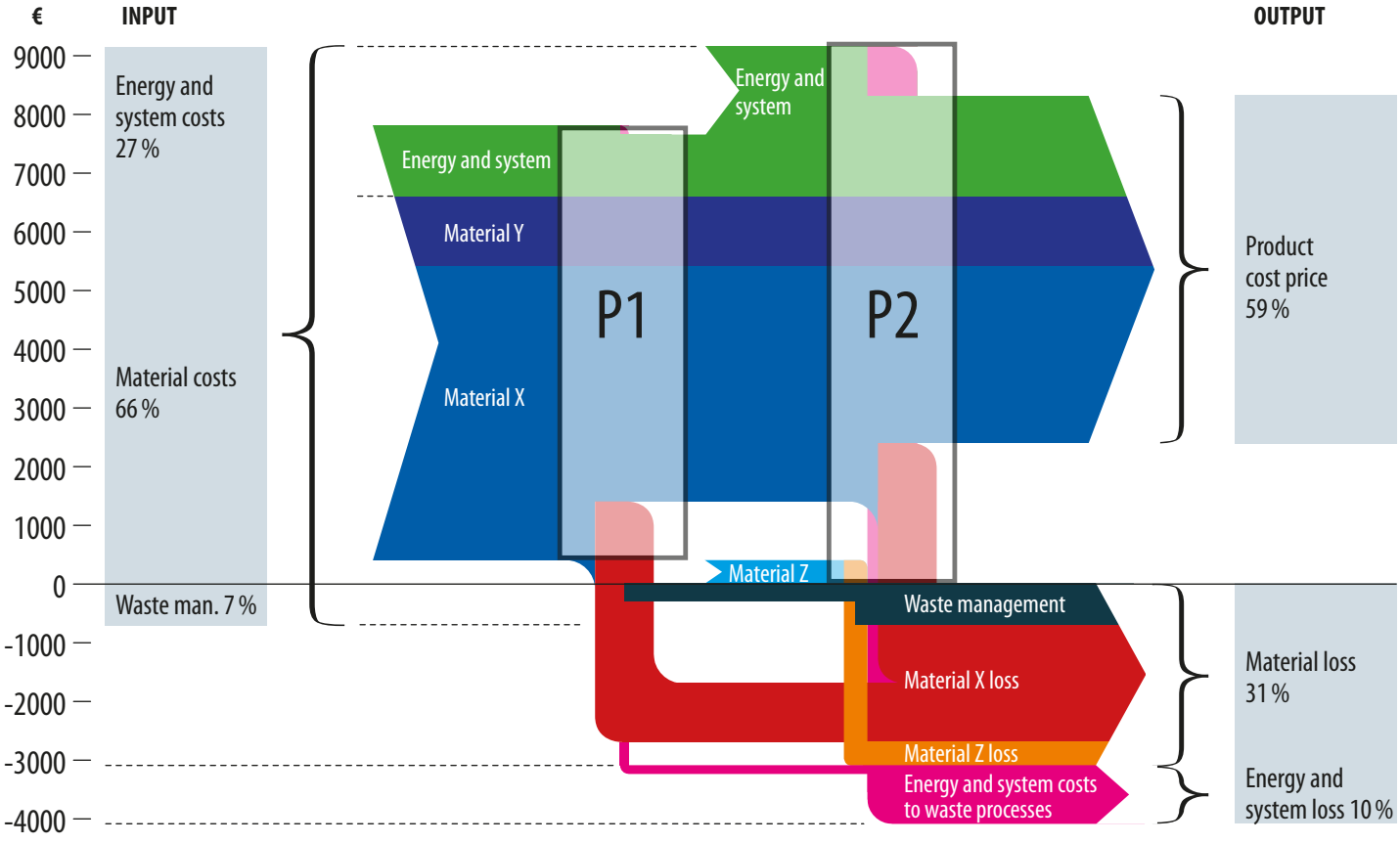
▶ *Diagram 1. Material and energy costs as a percentage of business area turnover*

**Metals processing, manufacturing of the following: metal products (including machinery and devices), computers, electronic and optical products, electrical devices, other machines and devices (TOL 24-28).*

Source: Motiva/Tilastokeskus



▼ *Diagram 2. Manufacturing process material flow model translated into costs to support material, energy and system loss optimization/minimization*



Experience has shown that large savings can be achieved through procedural developments or minor layout improvements.

Material audits should result in specific proposals regarding which measures to take to guarantee savings. This includes an estimate of the benefits, the potential for savings and possible investment needs as well as suggestions for further action.

The auditing process can last from a few months to half a year, depending on the target enterprise's size and area of operation, as well as the level of initial data and available resources for the job. The consultant's work on the audit usually requires approximately 2–3 months. The consultant main task is to act as facilitator in the project and be responsible for the work progress and reporting. The consultant also brings to the process his/her specialist experience in material balance calculations and cost accounting; a fresh and objective outsider's perspective.

A useful way to get started is to complete a simple online test on Motiva's web pages via the QR code provided here. The test provides a quick audit of the enterprise's material efficiency. If necessary an energy consultant can be brought on board to provide a more comprehensive evaluation of the savings potential.

Practice has clearly shown that materials audits identify concrete savings measures that lead to the optimized use of materials and increased profits. This is no longer debatable. Statistics indicate that there is a much larger savings potential in material related costs in the manufacturing sector than energy related costs. The discussion should shift from whether material audits bring benefits, to how the suggested savings measures can be implemented in the most cost effective and timely manner.

www.motiva.fi/toimialueet/materiaalitehokkuus/materiaalitehokkuustesti

Basics of material audits

Material audits aim to identify those stages of the production process where reductions can be made in:

- The use of materials
- The amount of waste produced
- Environmental impact (by reducing materials transportation and waste)

A material audit consists of:

- Systematic evaluation of material flows in production (material balance of factory and/or processes)
- Tracing direct and indirect costs related to material use
- Identification of improvement points
- Proposals for concrete actions to achieve these improvements
- Estimate of benefits, feasibility and savings of the suggested actions
- Possible recommendations for further examination and activities

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Agile and lean values in software development and beyond

– Case Cadmatic

For more than a decade 'agile' has been the number one buzzword associated with process improvements in software development, while Scrum has been the most popular approach used to implement agile and lean values. Implementing these values in product development is beneficial, but in order to gain the maximum benefit they should be applied to all company functions.

The Toyota Production System is the origin of many agile values and principles. Based on Toyota's approach the term lean was introduced in *The Machine That Changed the World*, a 1991 book by Womack and Jones. There have been plenty of other contributors since and the list keeps growing.

Agile and lean approaches are most beneficial when markets and user behavior cannot be fully predicted. As such it can be well applied, for example, in product development, marketing, sales, or in setting up a new business.

Instead of contemplating the ways agile and lean approaches differ from traditional approaches, I will draw here on examples from my current employment at Cadmatic Ltd to illustrate how these values can be implemented in practice.

Cadmatic software is used in plant and ship design projects and related information management. In early 2013 Cadmatic started applying the Scrum agile methodology for product development. This meant organizing software planning and development around short, time-boxed two-week increments called sprints. Each sprint delivers a potentially shippable product increment. The sprints provide fast plan-do-learn cadence, i.e. a sustainable regular iteration rhythm for product development.

At the same time the company adopted a new quarterly release model. In practice this meant releasing new software versions four times a year, compared to e.g. once a year as had been done before. The new quarterly release model called Agile Release Train (coined by Dean Leffingwell) provides slower, but quite frequent, time-boxed cadence for releasing.

A key principle of the approach is that the quality of releases and release dates are fixed, but that the scope of the releases is variable. The release trains are executed as a series of sprints.

The train refers to a metaphor where the train departs from the station on a reliable schedule. The train's cargo can be seen as the software functionalities that where ready in time to be available for the users in a software release. The train does not wait. Functionality that is not mature enough on the scheduled release date will wait for the next train, which will come quite soon.

The Agile Release Train aligns different Scrum software development teams to a common mission, schedule, and cadence. It is a spinal cord of continuous software product development flow. It also promotes internal company communication because the release name directly indicates the timing of the release.

Benefits for software users

The implementation of agile and lean values at Cadmatic has had several benefits for end user organizations. One of these is that they know exactly when new releases will be delivered and that is done according to a predictable quarterly schedule. The former traditional release approach tended to lead to somewhat unreliable slipping release schedules.

It has also maintained the high quality of releases as there are no longer major and minor releases. This is due to the fact that the software is developed in four fixed time boxes and new functionality is released as soon it is mature. There are naturally differences in the amount of functionality visible for users between releases, but the development effort for each release is equal. This approach not only mitigates bug-related risks, but also improves quality via the feedback provided by users about these frequent releases.

User organizations do not always take new releases into use, but some do and provide valuable feedback. This eventually benefits all the user organizations.

It is also worth noting that some of the most useful improvements are easy to implement, so-called low hanging fruits. Frequent releases provide a vehicle to make those improvements promptly available for end users.

At Cadmatic the Agile Release Train provides level cadence and synchronization, not only for software development, but for several other activities such as strategy follow-up and updates, product portfolio management, road mapping and marketing.

In every quarter, progress and what has changed in the understanding of customer needs is evaluated. Plans are not carved in stone. New product development is guided by a longer term vision and roadmap and reprioritized based on customer feedback. Different level plans are frequently updated to deliver the best possible value to the end users and their organizations. The whole enterprise is becoming agile and lean.

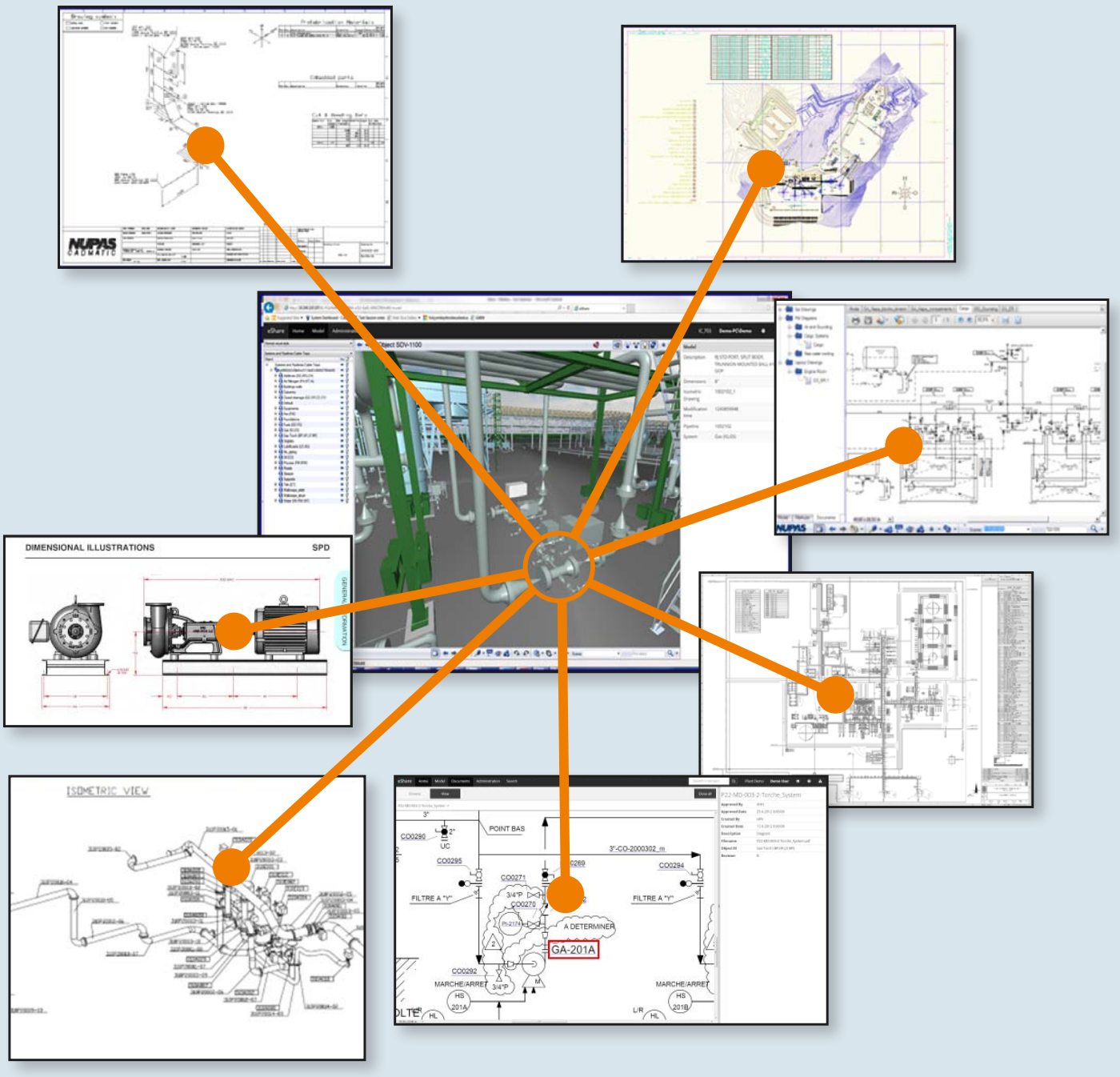
Lean startup and business model generation

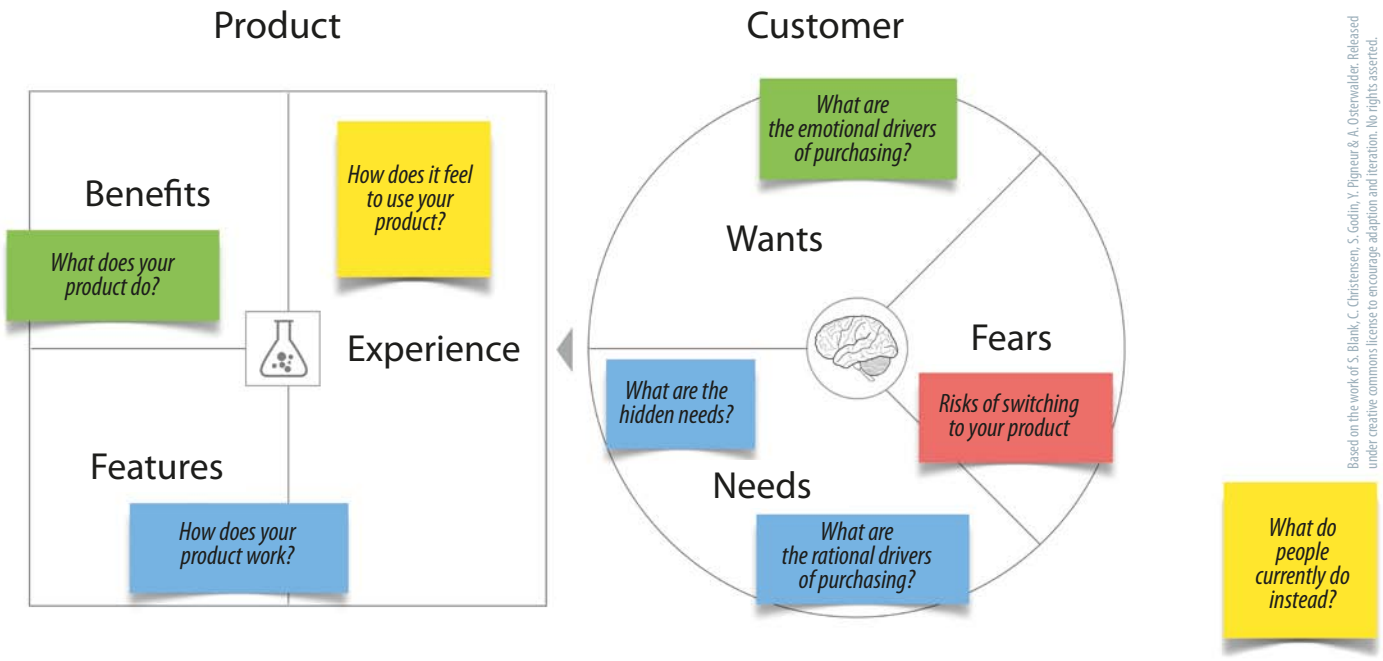
As indicated before, agile and lean values are well suited to setting up new businesses. A concrete example has been the development of Cadmatic's new eShare information management solution, which has been treated as a new startup (see the info box overleaf for more information about eShare). The approach was also suitable due to the fact that eShare is a totally new product with markets and product categories that have not yet clearly been defined. The agile and lean approach has, therefore, been especially useful. It all started when the vision of Cadmatic employees matched customer needs…

The eShare information management tool

The eShare information management tool was designed to complement design and engineering solutions. It allows different project parties to combine, find, visualize and share project and asset information via a web portal.

eShare facilitates access to information created with specialized applications for design and other business functions without needing to use each application separately. In practice it integrates information generated during the design phase of projects, as contained in 3D models and 2D drawings, with business process information such as project management, procurement, production, construction, operations and maintenance – and vice versa.





▲ *Value Proposition Canvas*

Eric Ries first proposed the lean startup as a method for developing businesses and products in 2011. Ries claims that 'startups can shorten their product development cycles by adopting a combination of business-hypothesis-driven experimentation, iterative product releases, and what he calls validated learning' (Wikipedia). He also popularized the minimum viable product (MVP) concept, which contains only those core features that allow a product to be deployed in real use to deliver enough added value for users, and no more.

In eShare's case development was started with the creation of a MVP for three different customer cases for slightly different uses. The lessons learnt from these three early adopter companies were consolidated into the productized eShare product that is now available for all customers and has replaced all earlier working prototypes.

The eShare business model was defined using a business model canvas and a value proposition canvas.

In eShare marketing and sales similar principles were applied by building a hypothesis regarding what message would make the added value of this new product stand out.

A small group of companies was targeted for marketing and sales activities in the first round. After that the approach was adjusted based on lessons learned. A key factor in applying agile and lean approaches in marketing and sales is not waiting until the product is fully developed before starting. Building the marketing message should go hand in hand with building the value proposition and developing the product.

Agile and lean values can be implemented in a wide range of organizations and enterprise functions to deliver optimized operations. While implementation methods will naturally differ the core values that drive renewal are constant. Every company has the ability to become agile and lean.

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Timo Kaltio has extensive experience in process improvement. In 2000 he published his doctoral thesis about software process improvement based on five years' experience as Nokia Mobile Phones global software process manager. After that he led global software development organizations at Nokia for 10 years. In addition to operational leadership roles, he also led agile and lean deployment activities covering software development and product and portfolio management. He joined Cadmatic in 2013 and manages Cadmatic's software development organization and has contributed to Cadmatic's transformation into an agile and lean enterprise.

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Is burning water profitable?

– simulating differences in dry and fresh woodchip use in biomass heat generation

In Finland we have seen decades of research regarding the benefits of drying woodchips for use as fuel in biomass heat generation. Drying seems reasonable, but has its use reached the end of the road? Is there a way to improve cost efficiencies even more?

In this article I will introduce a new approach to woodchip heat production by evaluating the financial implications of woodchip moisture levels on the biomass heating value chain. For the sake of a clear focus the impact of different wood types on cost structures has not been taken into consideration.

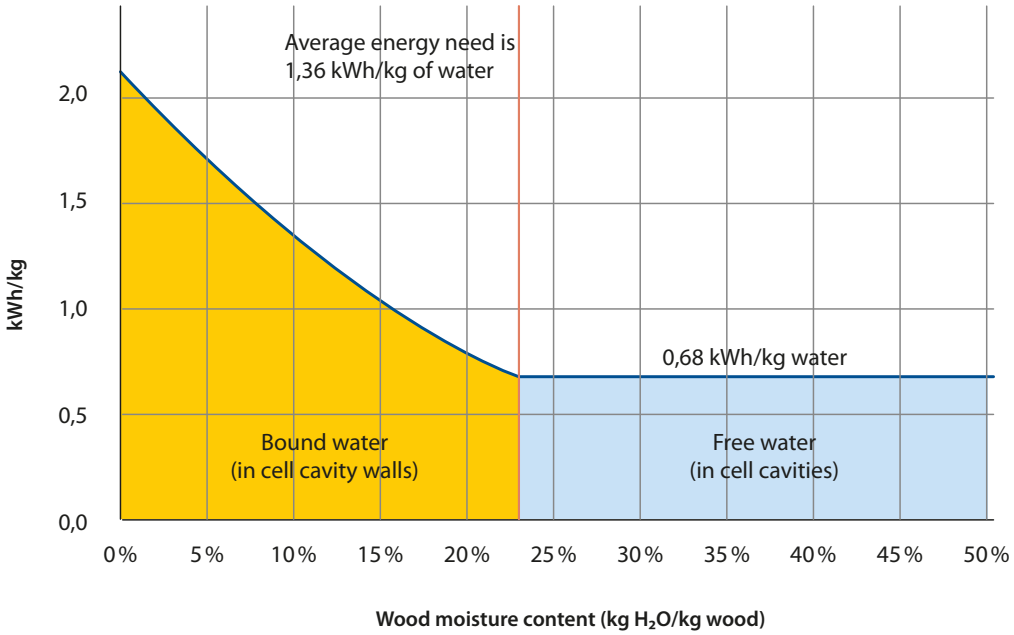
In biomass heat production there are three factors that have a particularly significant effect on cost efficiency; the moisture content of energy wood and woodchips, dry matter loss, and the energy efficiency of biomass heat production.

Moisture content in woodchip production

Water in wood is located in cell cavities (lumens) and cell cavity walls. The water in cell cavity walls is part of the chemical makeup of wood and its removal requires significantly more energy than water contained in cell cavities (see Diagram 1). When woodchip is dried to under 23 % moisture the drying energy required grows significantly, as free water in cell cavities has been removed and the energy is used to remove moisture from cell cavity walls.

The total cost of woodchip is a combination of the stumpage price, harvesting, chipping, storage and transport. These contributing cost factors vary according to the harvesting method, transport distances and storage arrangements.

Energy wood is stored as logs and woodchips to minimize chip moisture levels and maximize energy content (and sales price) upon delivery. Roadside timber stacks reduce the trans-



▲ *Diagram 1. The amount of energy required to dry woodchips as a function of woodchip moisture content (Source: www.forestpower.net)*

port weight and related transport costs of wood.

The drying process in the procurement chain aims to reduce moisture levels from about 60 % (fresh chips) to about 25–30 % (dried chips). Drying is mainly achieved thermally, i.e. by taking advantage of the combined effects of the sun and wind. A minimum level of thermal drying in Finnish conditions could be held to be about 30 % water content.

The fresh woodchip production chain does not include storage and its energy wood is burnt in the boiler immediately after harvesting. The tree is felled, brought to a pick-up point, loaded and transported via woodchip chipping to the boiler without the need for roadside wood stacking and protecting the wood from external moisture.

The transport weight of fresh woodchips is naturally higher than that of dried woodchips, but the production process is much simpler; drying woodchips can take anything from several months to years, whereas it only takes days or at most weeks for fresh woodchip to arrive at the boiler after harvesting.

Storage destroys wood

The storage of energy wood and woodchips at one or several stages in the dry woodchip production process is inevitable. A factor that is often overlooked is the dry matter loss of the fuel, i.e. the slow burning of woodchips during storage that occurs naturally as micro-organisms break down the wood fibres. As the wood is broken down the fresh woodchips give off heat.

Several field studies have been conducted regarding the amount of dry matter loss. The Technical Research Centre of Finland (VTT) conducted research in the early 2000s on the dry matter loss of woodchip stacks. It found the loss to be about 16 % over a six month storage period for initial moisture levels of 58 %. For moisture levels of 42 % the loss was about 7 %, which indicates that even for dryer woodchips the loss is still significant. It is worth noting that the greatest amount of dry matter loss is incurred in the first three months of storage.

Energy efficiency of biomass heat production

There are currently two schools of thought regarding the energy efficiency of biomass heat production. The first and traditional approach is to view heat production energy efficiency simply as a function of boiler performance where the focus is on the combustion process and its efficiency.

An alternative approach is to examine the entire heat production process from fuel production up to the recovery of residual heat. In this case the focus is on plant performance rather than boiler performance.

The fuel and its moisture content is of crucial importance in both approaches. When the goal is to optimize boiler performance dryer woodchips provide the best results. The combustion process energy is therefore not

used to evaporate moisture contained in the fuel and thereby the real performance of the boiler is maximized. Boiler performance is measured as the ratio of heat generated in relation to the energy content (qSTD) of the wood upon delivery. Typically boiler performance is between 0.89–0.91 when burning thermally dried dried woodchips (moisture about 30 %).

In the alternative approach fresh woodchips (moisture about 60 %) are combusted. A large part of the heat energy produced by the fuel is used to evaporate water contained in the woodchips. A modern boiler's performance typically decreases to 0.85–0.88 in this case. Burning fresh woodchips thus diminishes boiler performance.

Energy efficiency improvements with modern flue gas scrubbers

What happens when an efficient flue gas scrubber is coupled to heat production? The flue gas scrubber condenses the vaporized water contained in the boiler's flue gas. Vaporizing and condensing are thermodynamically opposite processes; vaporizing absorbs energy and condensation releases energy. When water contained in flue gases are condensed in the scrubber's condenser to under the dew point, heat is released and transferred to the district heating network.

The effects of heat recovery are reflected throughout the entire heat production chain including wood procurement and harvesting. It should also be remembered that the heat recovery of a condensing scrubber is reduced dramatically if dried fuel is used.

The heat recovery efficiency of a flue gas scrubber is best described as a heat recovery percentage, which is the relation between heat produced by the scrubber and heat produced by the boiler. Graph 1 outlines the relative heat recovery percentages that can be achieved by modern flue gas scrubbers (Caligo scrubber) for woodchips with different moisture levels. Other heat recovery parameters are assumed to be stable.

Sales margins in fresh and dry woodchip production

In order to concretize the financial implications of dry and fresh woodchip use a simulation model was created for analysing the woodchip delivery chain. The model includes the steps presented in Diagram 3 from wood harvesting to delivery at the boiler, as well as boiler and flue gas scrubber performance values for fuels with varying moisture levels. An initial value of 50 GWh was assigned to heat production for each simulation.

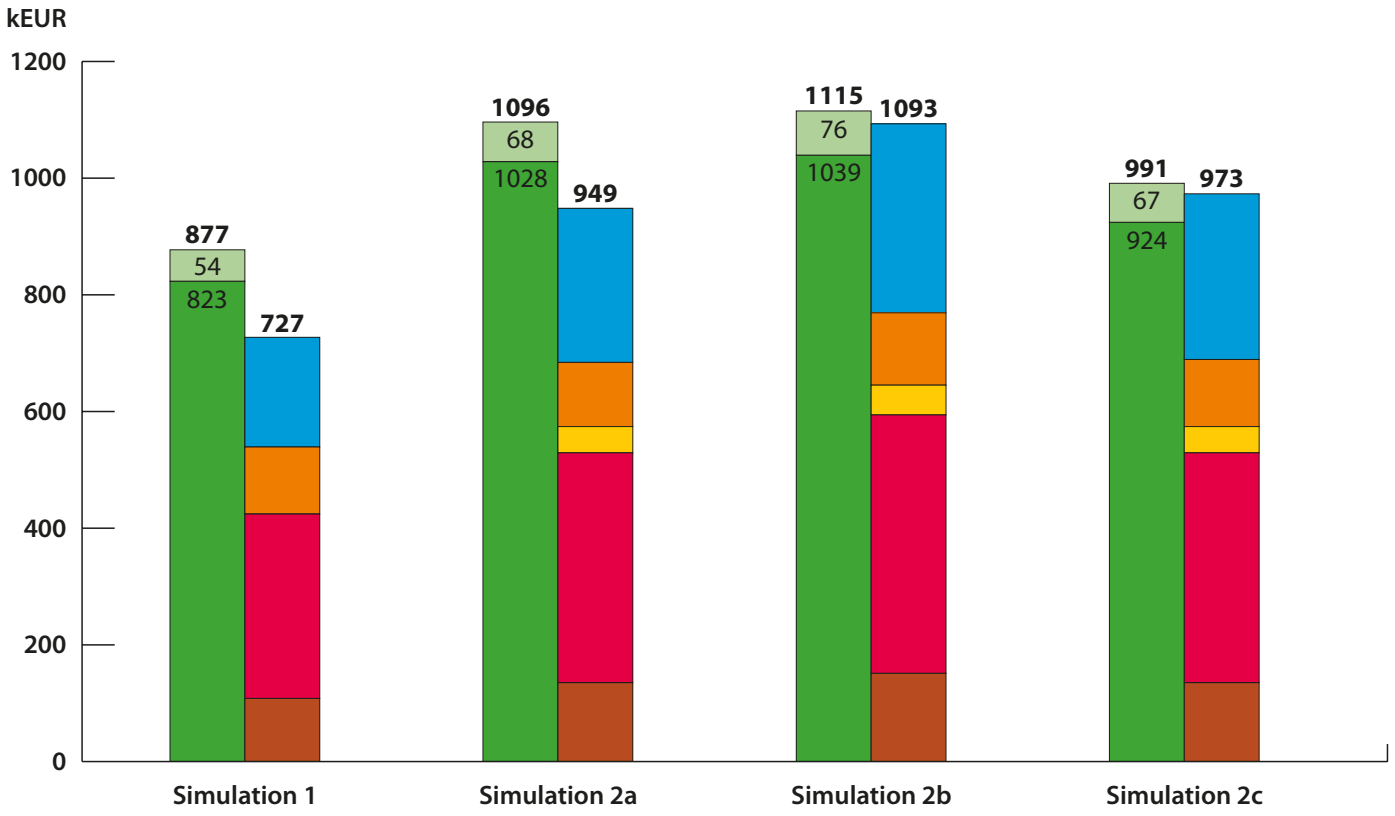
The simulation results are presented in Diagrams 2 and 4 (overleaf) according to woodchip supplier margins. The simulation includes the Kemera subsidy, which will be discontinued this year, as well as fixed costs associated with different production phases. Other woodchip supplier fixed costs are not included. It should also be noted that the simulation does not consider the net benefit of heat recovery for heating companies as the cost and income simulation was done from the perspective of woodchip suppliers.

Publically available reports and statistics were used to define the stumpage price, for which energy wood of 8 cm diameter was used that is harvested as part of forest maintenance activities. The harvesting unit costs do not include forest maintenance service compensation as this data is not available. Harvesting and forest transport costs are thus most likely overestimated in the computation. The discontinuation of the Kemera subsidy will reduce woodchip suppliers' margins and

► *Diagram 2. Dry and fresh woodchip production simulation results*

◄ *Graph 1. Heat recovery of Caligo flue gas scrubber as a function of woodchip moisture levels.*

► *Diagram 3. Stages in dry and fresh woodchip production.*



- Kemera subsidy
- Revenue
- Chipping and woodchip drying
- Transport
- Roadside stacking
- Felling and forest transport
- Timber stumpage price

Simulation parameters

Parameters used in all simulations

- Heat produced: 50 GWh
- Log size: 8 cm
- Felling as part of forest maintenance
- Fresh wood moisture level: 60 %
- Forest transporting distance: 300 m
- Long distance transport: 50 km
- Heat recovery from flue gases with a heat pump
- No terminal storage

Simulation 1: Fresh woodschip

- Fresh woodchip delivery
- No storage (< 1 month)

Simulation 2: Dry woodschip

2a:

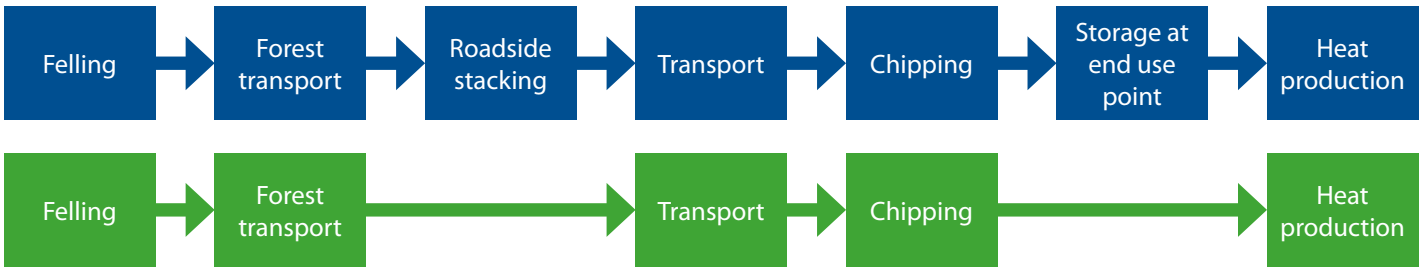
- Drying of logs to 30 %
- Roadside stacking 14 months

2b:

- Drying of logs and woodchips to 26 %
- Roadside stacking 12 months
- End use point storage 6 months

2c:

- Drying of logs and woodchips partly fails due to wet winter.
- Woodchip moisture level 50 %
- Roadside stacking 12 months
- End use point storage 6 months



- Dry woodchip production
- Fresh woodchip production

therefore downward pressure on energy wood prices is expected this year.

The greatest advantage of fresh woodchip use is that smaller amounts are required to achieve the desired heat energy levels. This benefit is visible throughout the entire woodchip production chain and reduces costs at each stage of the delivery chain starting from energy wood procurement. The reduction in woodchip use is based on the use of an efficient flue gas scrubber in the final stage of heat production, where the recovered residual heat reduces the level of direct firing and fuel required. The significance is greater in fuels with high moisture levels, as the condensing scrubber performance is optimal under such conditions. Identical flue gas scrubbers were used for each heat production simulation.

In the fresh woodchip production simulation (Simulation 1) it is assumed that roadside storage and woodchip terminal storage can be entirely avoided. Logs are thus loaded directly onto trucks after harvesting and transported to the chipping area. By eliminating the stacking and covering of timber logistical costs are reduced. The afore-mentioned dry matter loss is also avoided as no storage of woodchip is needed.

An indirect benefit of removing the need for thermal drying is that woodchip suppliers carry less risk. Drying success is highly dependent on practical conditions and the fuel moisture level can even increase during rainy periods. The woodchip supplier carries significant risk during storage as sales income is tied to the woodchip energy content upon delivery and not its real mass.

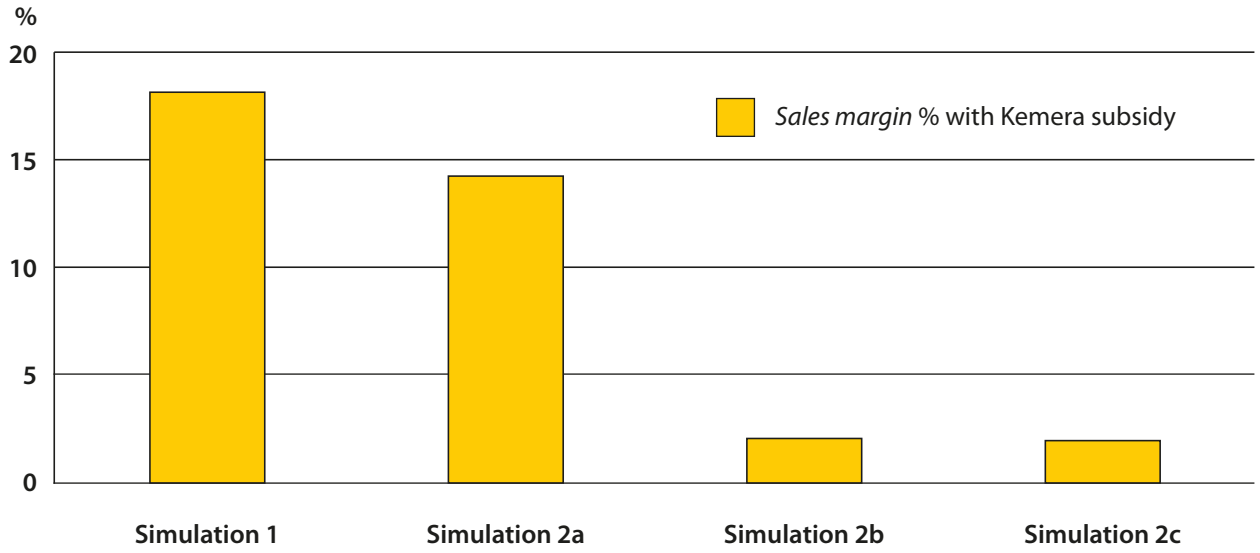
Storage at woodchip terminals is viable only when several heating plants operate in a particular area, a scenario not included in the model. As such logs are processed into woodchips at the end use point in both models.

The amount of water increases the total mass of logs and woodchips to be transported. The impact is included in the simulation and in fresh woodchip production and therefore truckload volumes are underutilized. For the simulation of both production types 60 tonne trucks are used for transport distances of 50 km. By increasing the truck size to 76 tonnes the transport cost efficiency can naturally be improved, but this solution is unlikely in Finnish conditions.

One can only imagine how much transport logistics would be simplified if fresh woodchip production were the norm. Added benefits that are difficult to quantify will most likely be achieved. It cannot be assumed that transport distances would increase in fresh woodchip production as routing directly to the end user may also shorten the distances. As such the increase in transport costs is dependent only on the higher moisture levels of logs. Load weight increases vary between 5–40 % depending how much drying has occurred during roadside stacking. The drying process is completed during woodchip storage.

A challenge in fresh woodchip production is operating a so-called hot chain. Achieving a hot chain requires precise and smooth running process arrangements and therefore there is a realistic risk of an increase in equipment stand-by periods.

▼ *Diagram 4. Sales margins (%) from the simulation models in Diagram 2.*



It can be inferred with relative confidence that fresh woodchip production is more profitable also for suppliers.

Conclusions

With the help of simulation the effect of moisture content on the cost of fresh and dried woodchip production can be ascertained with sufficient accuracy. The most significant difference is in the amount of logs required to produce the desired heat energy, the effect of which is felt in almost all the stages of woodchip production. The amount of energy wood required in fresh woodchip production is much less than for dry woodchip production. This is due to the markedly higher energy efficiency of heat generation, which in the simulation is based on a condensing flue gas scrubber with a heat pump (Caligo scrubber performance data).

Other notable differences become visible when roadside stacking and woodchip terminal storage is eliminated from the fresh woodchip production chain. Whether the production chain can in practice be simplified quite this much depends largely on how successfully the hot chain can be achieved. The transport of dry woodchip is more efficient as a result of the reduced woodchip and log weights. However, dry matter losses incurred during woodchip storage cannot be ignored. The loss is significant and therefore the cost difference in the simulation leans heavily in fresh woodchip production's favour.

Could a realistic alternative in future be a so-called hybrid production system that produces both fresh and dry woodchips in the same production chain? It is a proven fact that this production model can be applied to cases where there are several heat production plants in the same area of which some are equipped with efficient flue gas scrubbers. Dry fuel is transported to those plants that don't have flue gas scrubbers and fresh fuel to those that have.

The simulation is naturally theoretical and a relatively imprecise method of gaining knowledge of the absolute costs of different woodchip production methods. The inaccuracy is partly a result of uncertainty regarding the initial data used in the simulation as well as assumptions and simplifications. Unit costs of the different production stages were gathered from different research papers and statistical data that contained significant differences due to disparities in the real content of the various stages. In particular, unit cost data gathered from reports about the front end of woodchip production show large differences mainly due to different felling and harvesting methods and energy wood sizes. Some unit costs were averaged for use in the simulation.

Despite inaccuracies in unit cost initial data it can be inferred with relative confidence from the simulation that fresh woodchip production is more profitable for woodchip suppliers than dry woodchip production. This holds even if the current cost structure between woodchip suppliers and heating companies is maintained and the Kemera subsidy in Finland is removed. The result of the comparison is quite surprising even, as traditionally the transport of fresh energy wood and woodchips has not been considered economically viable due to the higher transport weights. Heat producers also benefit if the plant's combustion technology can handle fresh fuel without reducing performance significantly and if flue gas heat recovery works efficiently throughout the load period.

It is, therefore, profitable to burn water after all and benefits can be accrued by woodchip suppliers and heat producers alike.

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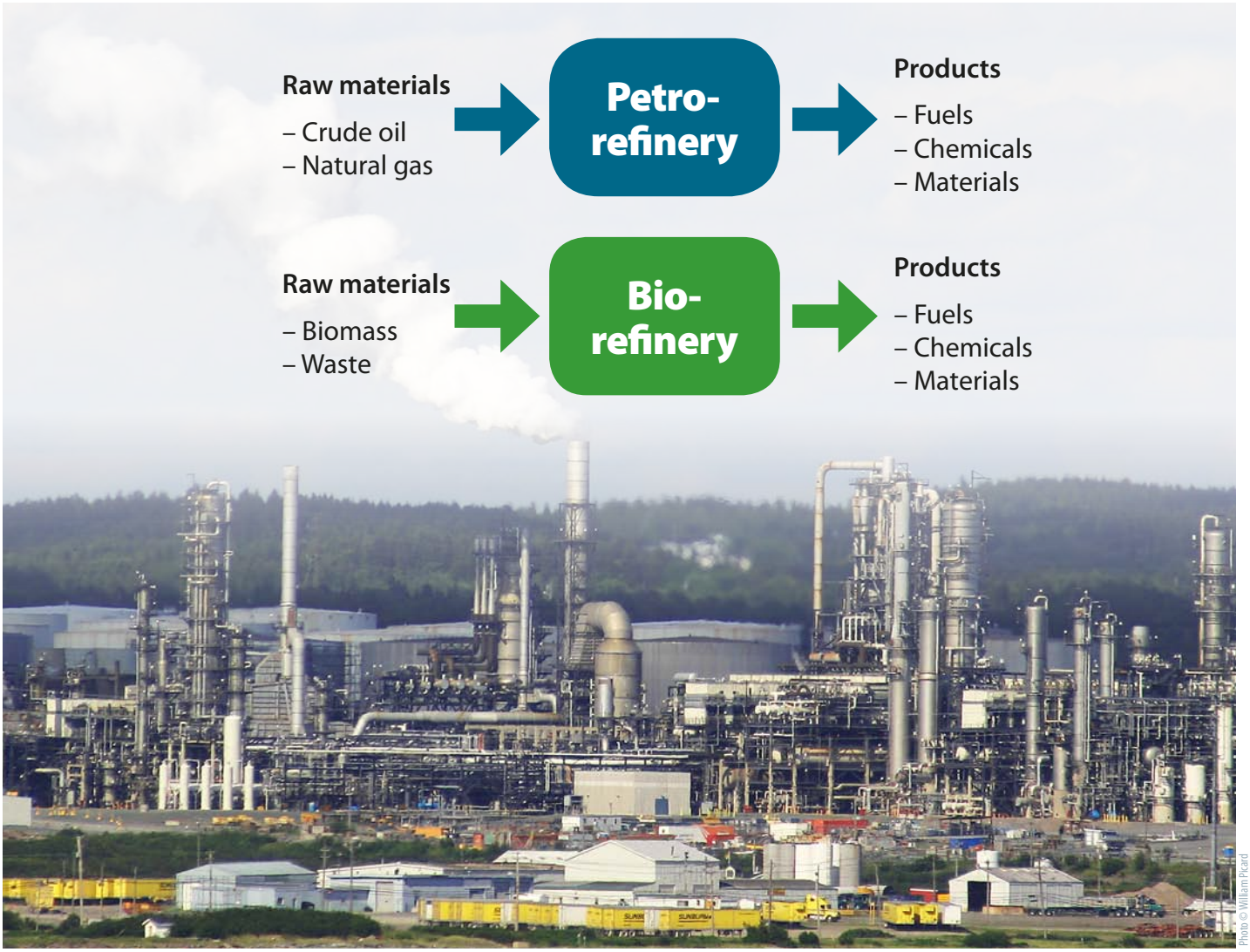
Towards a circular economy with multiple-product biorefineries

Currently 90 % of organic chemicals are produced from oil. Due to environmental concerns and fluctuating oil prices, biofuels have received much attention in recent times as alternatives to oil. Biomass can also be used for materials and chemicals production. Even if all the heat and electricity humans require could be produced from hydro, wind, solar or nuclear power, we would still need carbon mass such as oil or biomass to produce chemicals and materials we consume on a daily basis; pharmaceuticals, plastics, and detergents.



▲ *Figure 1. Similarly to an oil-based refinery, a biorefinery can produce multiple products from biomass*

A biorefinery can produce multiple products from biomass in the same way an oil-based refinery refines crude oil into fuels and chemicals. The same chemical building blocks that are currently derived from oil can be produced from biomass via chemical, biochemical or thermochemical conversion methods.

There are already biorefineries that produce energy, chemicals and materials. Pulp mills, for example, also produce heat, electricity and tall oil, which can be converted into chemicals or fuels. Biogas plants can also produce chemicals. In Finland Envor Biotech's biogas plant produces ammonium sulphate $(NH_4)_2SO_4$ for industrial and agricultural use from the biogas plant's reject water.

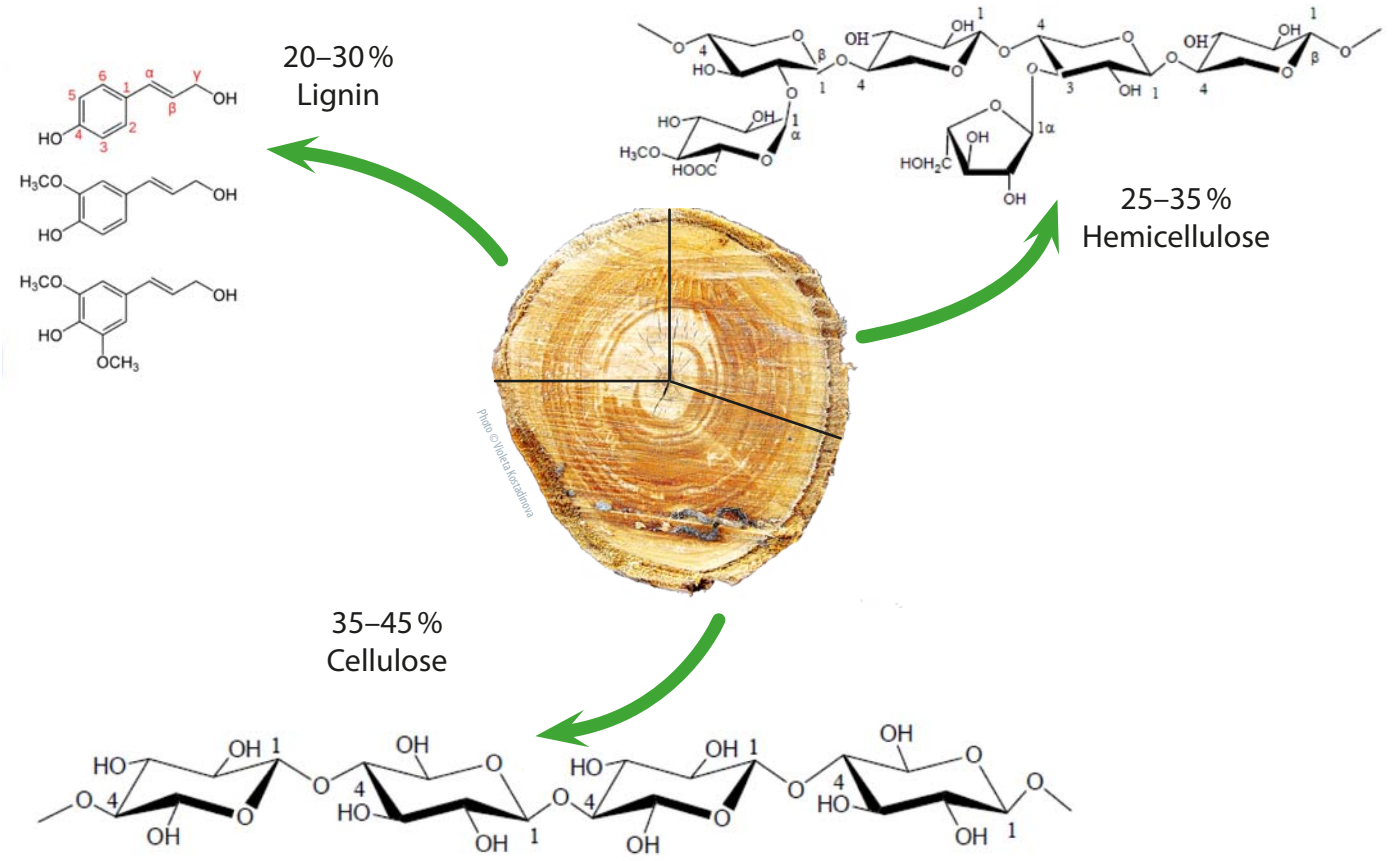
Biomass-derived products can also contain value-added properties. A good example is biopolymers in medical applications such as biodegradable implants, sutures and slow release drug delivery devises.

Finland has strong forestry tradition

Wood is an abundant raw material in Finland, where there is extensive experience in forest industry operations such as pulp, paper and saw mills. Wood is a good raw material for biorefineries as it does not compete with food production; it does not need fertilisers, pesticides or artificial irrigation and forests absorb carbon dioxide. The main drawback of wood is that it grows relatively slowly compared to other biomasses like crops. However, forests in Finland are currently growing faster than they are being harvested.

Wood and other lignocellulosic biomasses have a complex chemical structure that consists mainly of cellulose, hemicellulose and lignin. The composition depends on the biomass type.

The same chemical building blocks currently derived from oil can be produced from biomass.



For wood it is around 35–45 % cellulose, 25–35 % hemicellulose and 20–30 % lignin. Lignin makes the structure strong and works like a glue that keeps the structure together.

For pulp mills cellulose is the most desired fraction of wood. In the kraft process, wood chips are treated with sodium hydroxide (NaOH) and sodium sulphide (Na_2S), which breaks down the wood structure and separates the fractions.

After that the lignin and hemicellulose degrade in a delignification process and are washed to separate the pulp. In a traditional pulp mill the remaining material, which is called black liquor, is burnt in a recovery boiler to produce heat and electricity and the chemicals are recycled back to the cooking step.

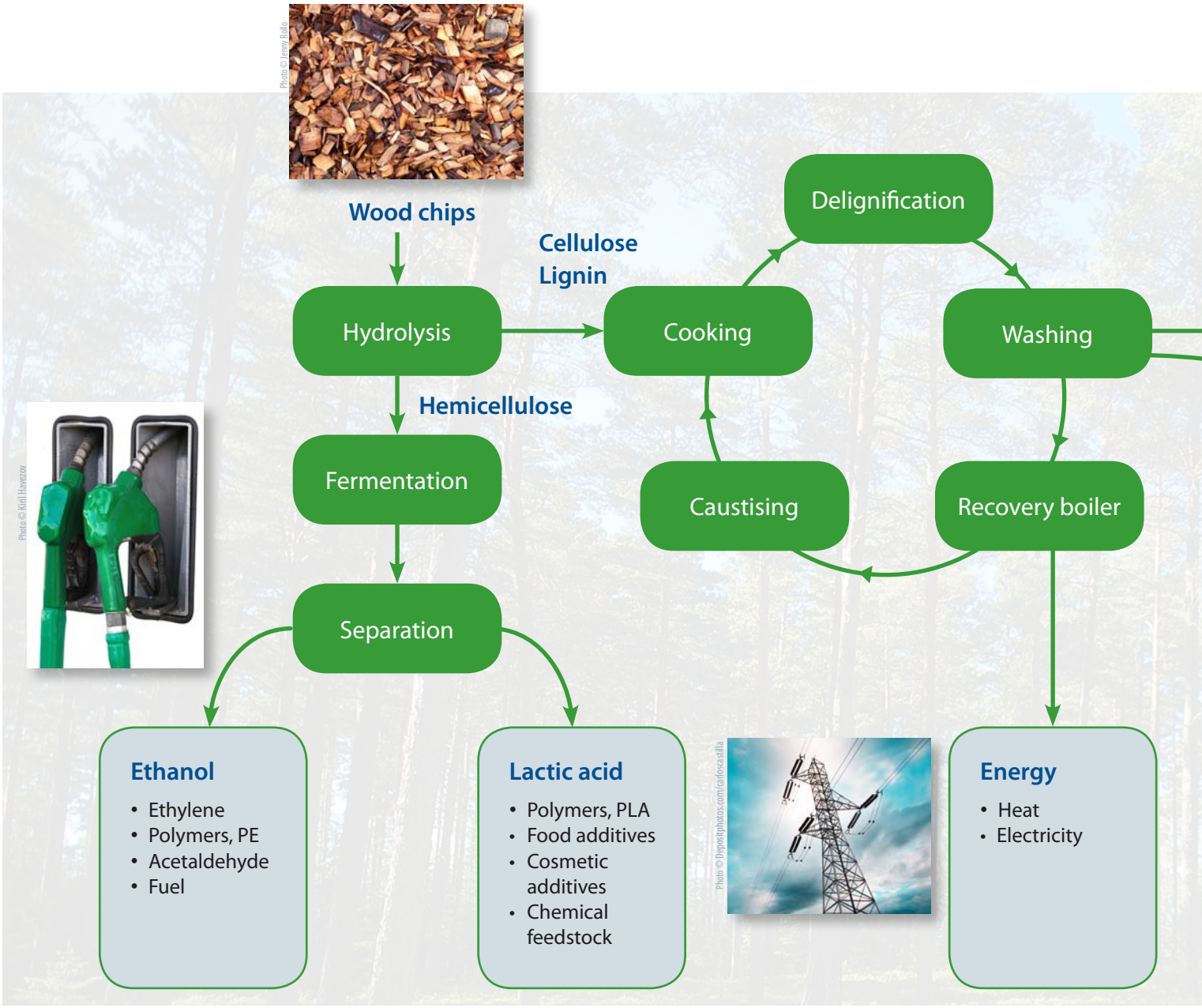
Hemicellulose and lignin have immense potential

Only the cellulose fraction of wood is used in making pulp. Hemicellulose and lignin, which are currently burnt in the kraft boiler, have the potential to be used to produce a wide variety of products that are currently made from fossil resources.

Hemicellulose is a highly branched polymer and it is easily soluble. In the kraft pulping process, it is broken down into its monomers. These monomers could be fermented into organic acids and alcohols, which could then be further processed into various chemicals and biopolymers. There is ongoing research on separating the hemicellulose fraction from wood before kraft pulping.

▲ *Figure 2. Wood and other lignocellulosic biomasses have a complex chemical structure that consists mainly of cellulose, hemicellulose and lignin. The composition depends on the biomass type. For wood it is around 35–45 % cellulose, 25–35 % hemicellulose and 20–30 % lignin.*

Lignin is a complex aromatic and amorphous polymer that consists of phenyl propane units. In the kraft pulping process, lignin ends up in the black liquor. It could be extracted via precipitation and used for production of phenol-based glues and resins, carbon fibre and chemicals such as toluene and benzene.



▲ *Figure 3. A traditional pulp mill could be converted into a future biorefinery with multiple products including heat and electricity, chemicals, textile fibres and biopolymers.*

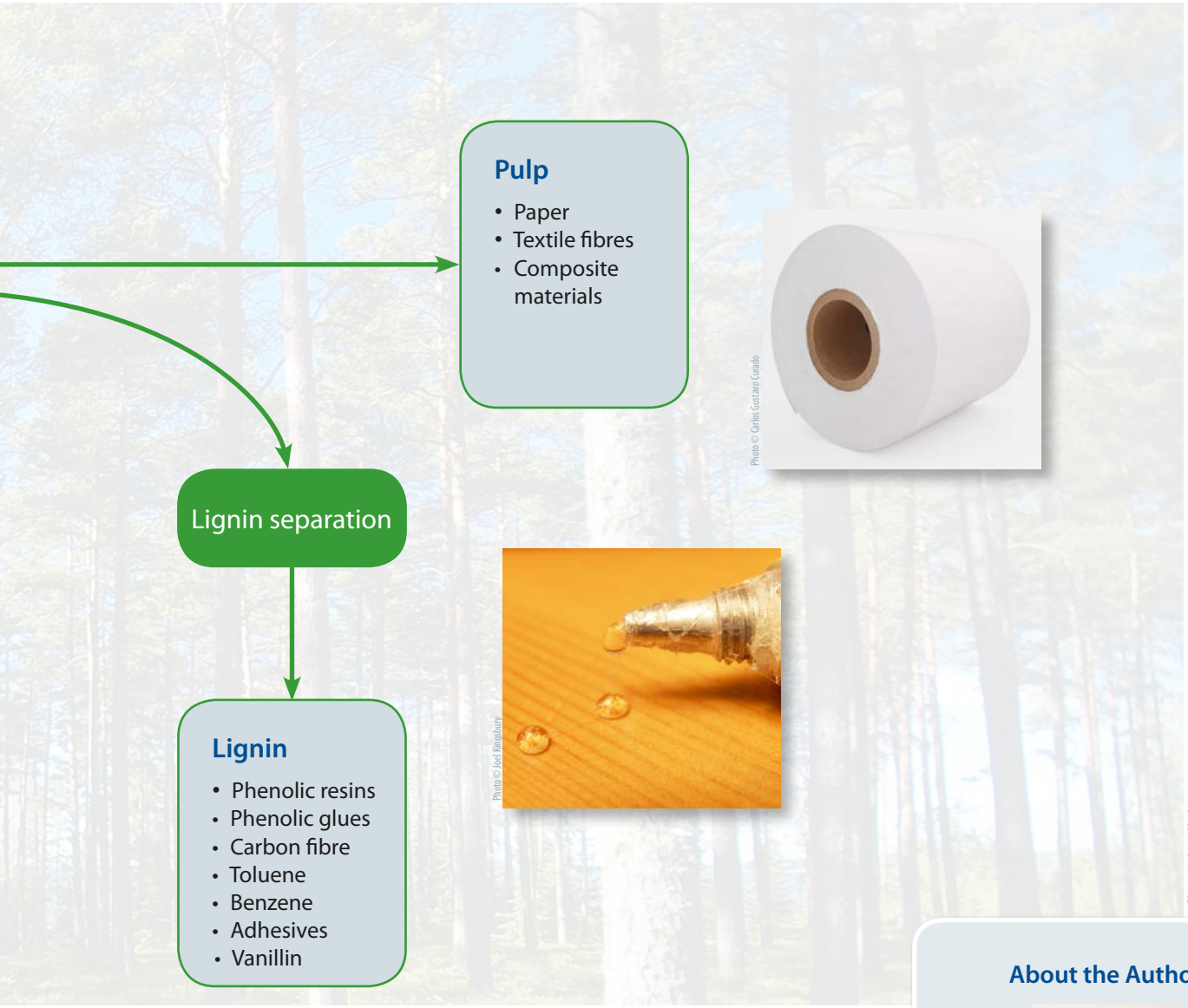
The demand for paper is decreasing because of digitalisation, but consumption of packaging materials for online stores is increasing. Additionally, there are other products that can be produced from pulp such as cellulose derived fabrics, specialty cellulose or construction materials.

High value products essential for biorefineries

The best part of the biomass should be used for high value products, such as pharmaceuticals or fine chemicals and the rest can be used for lower value products and energy production. With multiple products and processes a biorefinery can adjust its production according to market demand and prices. For example, cars are becoming more fuel efficient and, thus, less bioethanol is needed to fuel cars. There are, however, other products, such as acetaldehyde, butadiene, ethylene and propylene that can be produced from bioethanol. Ethylene can e.g. be polymerised into polyethylene (PE), which is used to manufacture plastic bottles.

In Finland a recently announced 1.1 billion euro investment by Metsä Fibre, part of Metsä Group, is a good indication of how viable the concept is. It is the biggest investment in the Finnish forestry industry ever. The main product of the planned bioproduct mill is pulp, but all the side streams will be converted into bioproducts or energy by partner companies that form an industrial ecosystem in the area. The mill will not use fossil fuels and will produce more heat and electricity than its own consumption.

Pulp mills are not the only application area for biorefinery integration. The food industry produces large



amounts of side streams, which are often used for animal feed. However, these streams contain carbohydrates, fats and proteins that could be used for higher value products.

Starch technology is another example; the side streams of starch processing could be utilised for acid and alcohol production, which can be processed into chemicals, fuels or biopolymers.

The starch can also be converted into higher value products such as modified starches, biodegradable polyesters, thermoplastics and food additives. Plant residues from the wheat or potatoes the starch is extracted from could also be used for biogas production.

In the chemical industry the waste-to-product ratio usually increases with the price of the product. In the production of fine chemicals and pharmaceuticals only a small fraction of the raw materials is used for the product and the rest is waste. This waste can and should be used more beneficially.

Upgrading an existing plant into a biorefinery that utilises side streams has several advantages. The material efficiency and the profitability of the plant can be improved by producing a new product from a waste stream that currently incurs disposal costs.

Biorefineries can, as such, maximise the value of biomass and minimise the amount of unused waste. It is difficult to come up with good reasons why this should not be done.

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Helena Arkkola has worked at Elomatic as a Process Engineer since April 2013 in projects with chemical, food and energy industry customers. The focus of her studies at the Technical University of Denmark was biofuels and biorefineries and she wrote her Master's Thesis on biogas and biohydrogen production.

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Reducing food waste a matter of urgency

Globally about 1300 million tonnes of food is discarded as waste every year. This clearly has detrimental financial, social and ecological implications. In order to preserve natural resources and live sustainable lifestyles the reduction of food waste has become a decisive battleground. A key aspect is changing consumer behaviour, which in turn requires that waste data is gathered and communicated to consumers.

The Food and Agriculture Organization of the United Nations (FAO) defines food waste as the 'masses of food lost or wasted in the part of food chains leading to edible products going to human consumption'. By this definition food that is extracted from the human food chain and reused elsewhere is also considered waste.

Food waste is created in agricultural production, the foodstuffs industry, retailing, distribution, and consumption. According to FAO 25–30 % of global food production is lost in the human food chain, while the World Food Programme indicates that the current level of food production is sufficient to cover the nutritional needs of the entire global human population.

It is interesting to note that food waste levels do not differ much between industrialised and developing nations; both lie at close to a third of the food produced. An important difference, however, is that in industrial countries households contribute significantly to waste creation while in developing nations the majority of the losses occur during storage and transportation (see Diagram 1).

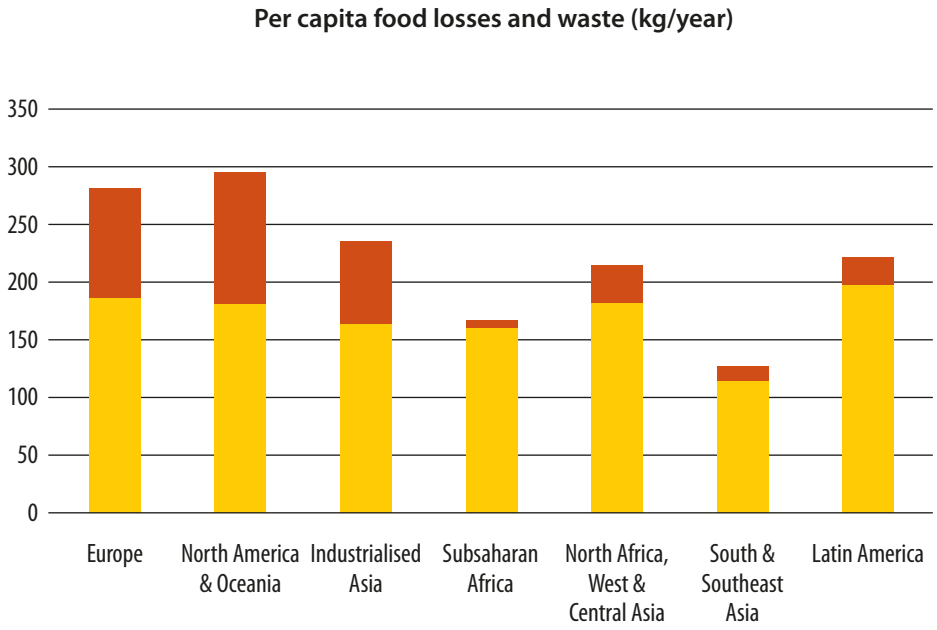


Diagram 1. Equal amounts of food waste are created in industrialised and developing nations. In industrialized nations households, however, contribute significantly to waste creation while in developing nations the majority of the losses occur during storage and transportation.

Source: FAO, Global Food Losses and Food Waste

Food waste in human food chain per year in Finland	Million kg	kg/person
Households	120–160	22–30
Catering	75–85	14–16
Food shops	65–75	12–14
Foodstuffs industry	75–140	14–26
Total	**335–460**	**62–86**

Table 1. Food waste in human food chain per year in Finland

Source: MTT Foodspill 2010–2012

The Agrifood Research Finland Institute (MTT) has conducted research on food waste and quality in Finland for the entire human food chain in its Foodspill study. The results are displayed in Table 1. It indicates that households create the most food waste with the total food waste in the human food chain being about 400 million kilograms. This translates to roughly 400 million euros a year lost as waste.

In Finland the climate effects of household waste corresponds to the carbon dioxide emissions of about 100 000 passenger vehicles. Finnish household waste predominantly consists of vegetables, potatoes, home-cooked food, dairy products, bread and fruit.

Environmental impact of food production

Food production, preparation, transport and consumption result in emissions. It follows that if edible food ends as waste the emissions were caused in vain. In addition to raw materials, other natural resources such as fresh water, energy and soil are also used in the process. As much as a quarter of all greenhouse gas emissions resulting from transport are attributed to food production.

It is clear that food production affects the environment. There are, however, large differences between different food types, with plant-based foods burdening the environment less than meat-based foods. Either way, reducing food waste has a direct positive environmental impact and also reduces food production related emissions by reducing food demand.

Photo © 2015 Olli Tuomola / Elomatic

▲ *With the ESCflow device the diner selects the food type and rates the food quality with the appropriate smiley face. ESCflow shows the amount of waste in grams. More questions can be input for broader feedback.*

The EU Commission has taken the lead in food waste reduction by encouraging EU member states to halve their food waste by 2025. It is also drawing up guidelines and best practices in this regard, which can be implemented throughout the EU. One such a measure is raising the value placed on food and food products.

In Finland there are already several organizations and digital publications that report on food waste and provide hints on how it can be minimized. The Finnish Ministry of the Environment's programs for sustainable consumption and production also aim at identifying working food waste reduction methods. Efforts as such as being made, but more needs to be done.

Consumers can bring about change

By making sustainable consumption choices consumers can directly affect how producers and markets operate. However, in order to make informed and environmentally-friendly consumption decisions they require accurate and easily understandable information regarding waste and its environmental impacts.

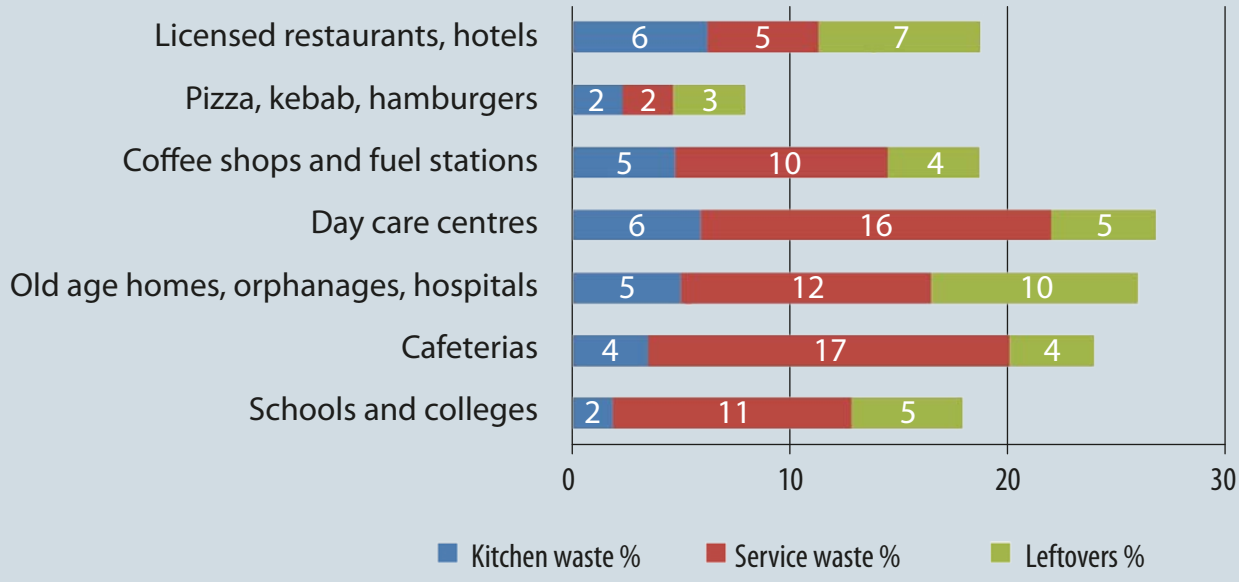
Waste is easier to understand if it can be concretised with illustrative and comparable measurement data. This data eases decision making and can be used to shape opinions and attitudes.

Corporates also need to take responsibility to inform employees of their consumption choices. Elomatic has for this purpose developed a waste measurement system called ESCflow that is used in the Elomatic cafeteria.

ESCflow measures the quantity of leftover food per employee and chosen dish and provides the employees with direct consumption feedback upon leaving the cafeteria. The diner can also provide feedback to the caterer regarding the quality of the food. This in turn allows the caterer to improve food selection and quality. The higher the food quality and the more diners appreciate the food they are served, the less likely they are to discard food as waste.

The data gathered by the device can be displayed in real time in a web browser. At Elomatic this data is gathered on a weekly basis and displayed on a wall in the cafeteria for comparison. The core idea is to make the diners aware of the amount of food waste they produce and to affect their consumption.

Waste is easier to understand if it can be concretised with illustrative and comparable measurement data.



▲ *Figure 2. Food waste distribution according to source in different restaurants and eateries in Finland. In catering the most waste in created during service and the least in the kitchen and as leftovers.*

Source: MTT Foodspill 2010–2012

In order for humans to reduce food waste and start living more sustainable lifestyles every entity in the human food chain has to play its part. Producers, logistics companies, storage providers, retailers, restaurateurs, corporates, governments and consumers all have a role to play.

Consumers have the power to affect all the other members in the chain with their choices. With the right information at their fingertips they can change the way food is produced, transported and consumed and preserve natural resources for future generations.

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Ms Nordén has worked at Elomatic in various positions during her 27 year career. Her experience covers a range of competences from process engineering and project management to process, product and procedure development and resource management. She has participated in several service and concept development projects. Ms Nordén joined Elomatic in 1988 and currently works as a Senior Design Manager at the Turku office.

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Flexibility and efficiency

in industrial automation

Automation in production and industrial environments can be interpreted as a multi-tiered structure where each level has its own specific tasks, characteristics and place. The highest level of information management concerns Enterprise Resource Planning (ERP) systems, under which there are Manufacturing Execution Systems (MES) and actual production process management systems, i.e. Distributed Control Systems (DCS). The entire structure can and should be built to be flexible so that it can be supplemented, if required, according to changing production requirements.

MES software and applications have been developed to supplement ERP systems and act in between ERP systems and process automation applications. For an automation system to operate optimally it is essential that data is able to flow smoothly and predictably from one system to another.

The development of MES-level structures for process automation was started more than 20 years ago. Since then standards have evolved and guided converging system structure architecture towards current models.

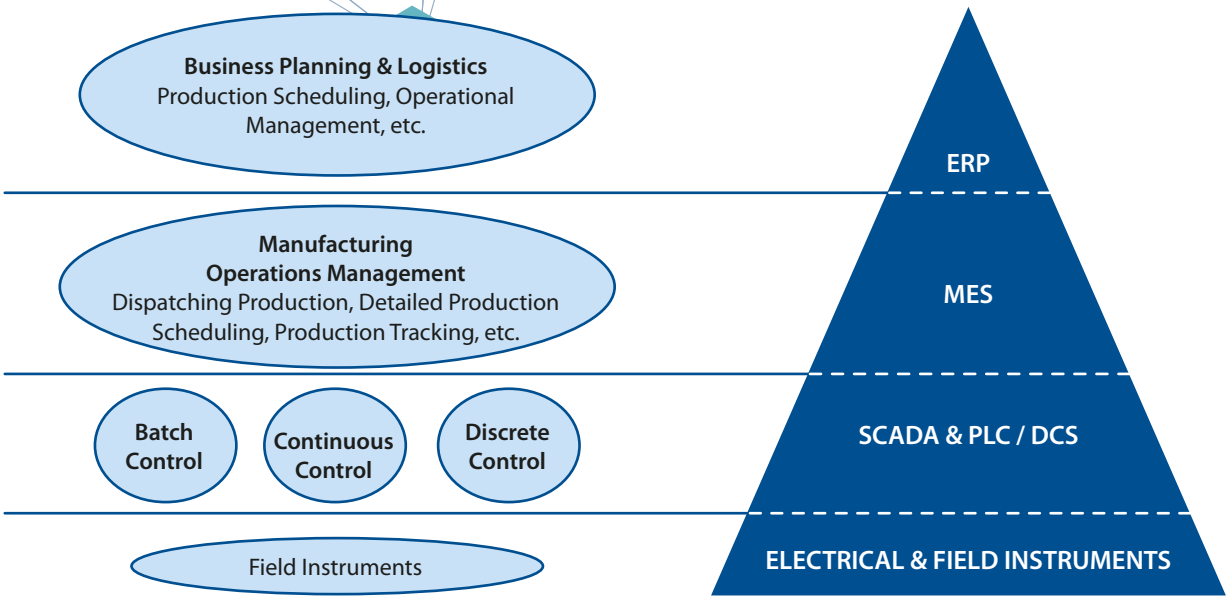
In practice, tasks are distributed in automation so that the ERP system acts at a business level in operational control, whereas MES takes care of plant-level production control. Traditional process automation focuses mainly on process and line control at a plant level. See Diagram 1.

Over the past 25 years automation has taken giant leaps of several generations forward in terms of technological development. Traditional process control systems have e.g. been furnished with MES-level functions that can be widely utilised in the design of software applications.

Internet of Things shaking up automation

The operations of modern automation systems have been strongly affected by the Internet of Things (IoT), i.e. the

▼ *Diagram 1. Industrial automation systems are multi-tiered structures with each tier taking care of specific tasks. The system needs to be sufficiently flexible to allow for different production requirements and conditions. (Based on ISA-95 model)*



Despite the sheer volume of data, we still need to be able to find the right piece of information at the right time.

Industrial Internet, which enables digital communications and data transfer between different devices, generating a system network between different systems. It can be said the IoT has already boosted the management of different kinds of plant data, and will increasingly do so in the future.

Process devices are becoming increasingly smart and produce ever growing amounts of data. This data is transferred via the IoT and used in conjunction with business operations data for further analysis. Correctly and systematically collected data enables the efficient utilisation of the industrial Internet in boosting business operations.

When building an automation system, it is important to understand what kind of production technology the end customer uses at the production plant. Production and process control applications are often designed and configured for a specific end user or production plant, even though the application platforms, development software and systems used are standard packages.

Typically an application platform consists of a SQL database, an automation interface and a user interface base, on top of which all modules are installed. In the user interface base data processing can be illustrated visually using 3D modelling and/or panoramic images and applications can be seamlessly integrated with production automation. Users can view vital production information in a readable format on control room workstations, on the office wall or on various mobile devices.

The condition of production devices must be continuously monitored and regular and preventive maintenance needs to be conducted. Plant maintenance, OEE (Overall Equipment Effectiveness) and condition monitoring are all included in a typical MES software package. Ultimately, the applications included depend on the end user and the business field. Medical applications, for example, require specific precision, thorough planning and management of the entire chain of operations; Good Automated Manufacturing Practice (GAMP).

Data storage, refining and security increasingly important

In recent years the effective storage of vast amounts of data has become a key requirement. Data pertaining to product information, for example, is particularly valuable and supports product safety and the reliable traceability of products. The overriding objective is that the system and any data therein produces benefits for business operations, improves production efficiency and allows operators to react more quickly to changes.

As the industrial Internet fast becomes commonplace the importance of information security in automation systems and their connection networks has been highlighted. Cybersecurity has received much public attention. It is a challenge in industrial networks and cannot be ignored. The industrial Internet is connected to the outside world, which necessitates the use of firewalls, bridges and information security software to prevent the system from harm.

Typical security risks include external malicious actions aimed at systems and data theft. System owners and users naturally also need to be disciplined and follow any instructions provided.

The public Internet and office networks are already infested with different kinds of computer viruses and malware and these bugs can also find their way to the Industrial Internet – either by accident or through intent.

The increase in the volume of data collected by systems and the number of devices connected is placing growing demands on the entire system, which emphasizes the need for data refining. Despite the challenges posed by the sheer volume of data, we still need to be able to find the right piece of information at the right time, every time.

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Using games to enhance learning

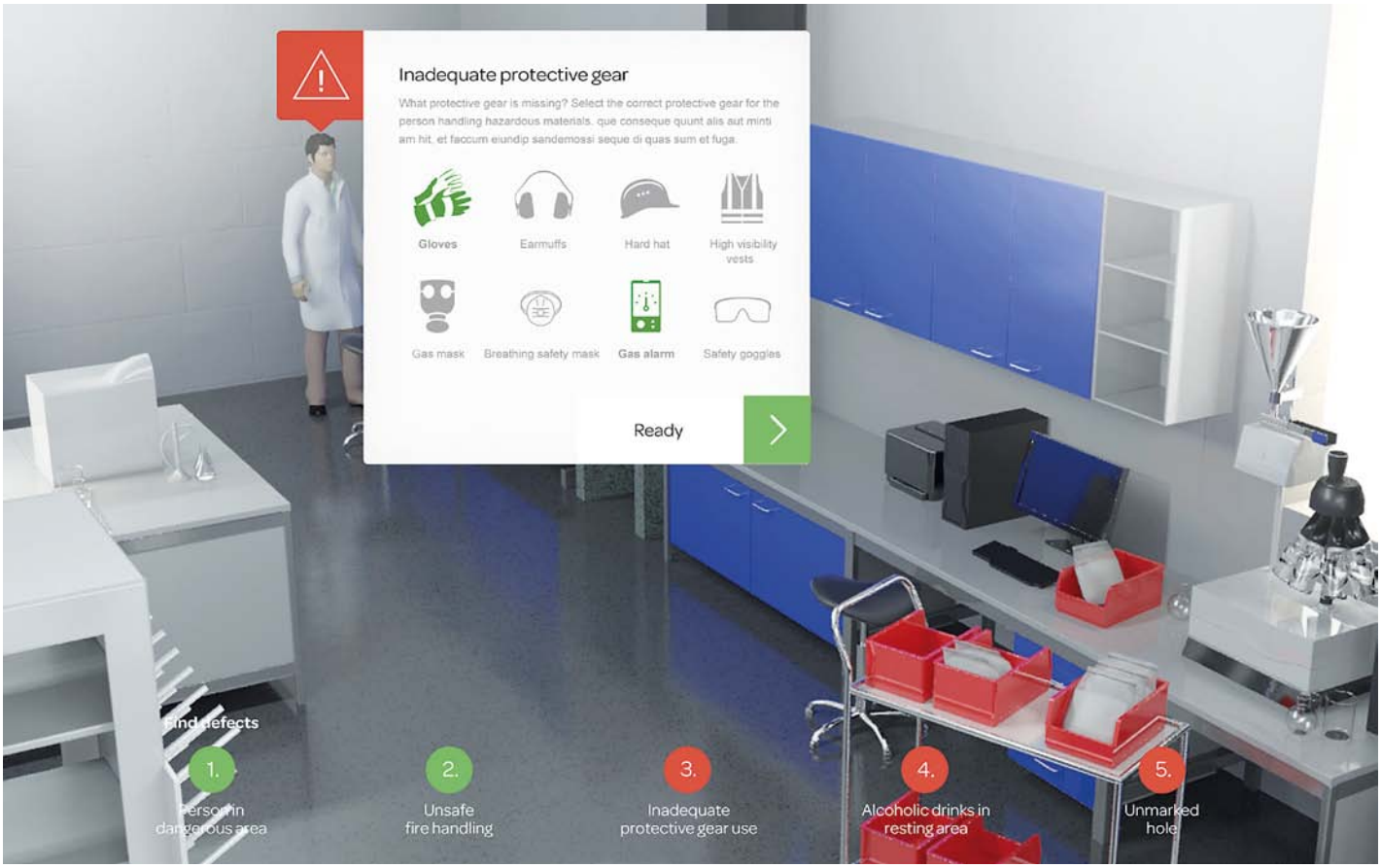
The Internet and computing technology have changed our lives forever. With them they have brought an increased awareness that traditional learning methods no longer suffice. There is strong and growing demand for new learning methods that challenge us differently. Learning games can be used effectively to motivate different kinds of learners and can even change our way of thinking and acting.

Modern pedagogical trends include learning and teaching procedures that focus on developing learners' skills instead of broadening their knowledge. According to these new approaches the teacher's or educator's mission is to guide learners instead of teaching them.

Numerous novel methods have been developed to complement traditional ways of learning. These include learning cafés, world cafés and brainstorming etc., all of which are based on acquiring knowledge via teamwork. The "flipped classroom" method represents a more independent learning strategy while process drama is very creative in its approach. Learning games have also come to the fore strongly and have the potential to revolutionize learning and teaching.

Games as teaching and learning tools

Different kinds of computer games have been part of everyday free time



▲ *A layout sketch of a safety game and a view of its user interface created by Elomatic.*

entertainment for decades. In recent times games have also gained a stronger foothold in social interaction, for example, via social media. The amount of players has grown rapidly as people of different ages, genders and professional backgrounds have jointed the gaming fold. It is an undisputed fact that people are spending more and more time online and with computing devices. Many of them play games regularly. It therefore makes sense to also use some of that time for educational purposes.

Games are very effective learning tools. They can concretely show players the consequences of their choices and also improve problem solving abilities in powerful ways. Learning games help learners to comprehend the big picture and can also improve creativity. A significant advantage of learning games is that they allow learners to try things which are impossible in real life. This is useful especially when one is interested in expensive or dangerous targets.

Another key advantage of learning games is their ability to evoke emotions; games enable different experiences. Escapism, for example, is one of the main motivators of gaming and can also be utilized for educational purposes. Positive and desirable emotions such as fun, enjoyment and pleasure can get a player hooked on a game, whereas the right balance between challenging and struggling keeps the player interested. Carefully designed rules, goals, characters and an intriguing plot motivate the player and create passion, whereas competitiveness provides that much required adrenaline rush. All these emotions can be harnessed to improve the experience and outcomes of learning.

Playfulness and gamification are becoming increasingly common notions in working environments. They can be utilized in ordinary situations that include similar procedures to games. This could, for example, be scoring workers' outcomes: a worker can be given a point after finishing a design document and two points after helping a college etc. The aim is to give clear feedback, to guide action towards achieving goals and inspire workers to increase their performance.

Challenges associated with learning games

Even though there are many benefits associated with learning games, there are also some challenges involved. Different age groups have varying abilities and enthusiasm to use computing devices. A learning game should be easy enough for inexperienced players,

A key advantage of learning games is their ability to evoke emotions.

yet sufficiently challenging for experts. Typically these requirements don't concern only computers, but mobile devices and tablets.

User skills create both technical and content challenges. Game developers run the risk of creating games that are overly simple and thus demotivating. Learning games should be sufficiently diverse as boredom tends to set in rather easily. It is therefore necessary for learning games to include thoughtful content and the optimal amount of technical learning challenges to keep learners engaged.

Learning game example – occupational safety

Occupational safety is an established part of everyday work. When educating workers about safety one has to be mindful that the same learning methods do not, however, fit everyone. Lecture-based safety courses can be remarkably awkward for learners that have difficulty in concentrating on traditional teaching and young employees or students often have little experience of industrial working environments. For such learners safety games offer an interesting and supportive alternative.

A safety learning game allows players to experience different shared workplaces such as factories, shipyards or construction sites while seated at his/her desk. In the game they practice recognizing close-call and dangerous situations – one of the most important skills related to safety.

In safety games players discover connections between causes and effects. In real life the learner cannot just try what happens if he/she pushes a compelling red button. In the game world it is possible and the consequences could very well be educational. Employees also usually do not have someone to warn them about risks in the environment and there is no time to reconsider decisions if something dangerous happens. It is better to get hurt in a game than in the real world. The player's skills can also be tested in gaming environments. This makes automatic evaluation of performance possible and guarantees fair treatment.

Safety games have unlimited opportunities. The games have been expanded continuously and can focus on different safety fields. By motivating players to learn safety issues they can be challenged in a new way, even to the extremes of their knowledge and abilities. By immersing learners in a game their knowledge of important safety issues is improved.

Learning games can provide the motivation to become familiar with new subjects and provide experience and entertainment at the same time. Anybody who has ever solved crosswords or played hangman can attest to this and has benefited from learning games.

Games have the ability improve our skills in exciting ways, provide totally new perspectives to thinking and even make our lives safer. The possibilities are infinite.

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Ms Puhjo started working at Elomatic's Tampere office at the end of 2012 in the plant engineering team. She is a member of Elomatic's HSE development group. Ms Puhjo is also a certified occupational safety card trainer and energy auditor. Before joining Elomatic Ms Puhjo worked at Vapor Finland Oy and at the Tampere University of Technology. She is currently completing her second M.Sc. degree, majoring in mathematics and minoring in pedagogy and physics.

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Mandatory energy audits in Finland

– the what, the how and the when

On the 1st January 2015 the new Energy Efficiency Act (1429/2014) in Finland came into force, It obliges large companies to conduct energy audits every four years, the first of which needs to be completed already by 5 December 2015. But what is a 'large company' and what do the audits entail? How should one go about conducting such an audit?

The new law brings Finland in line with the European Union's Energy Efficiency directive (2012/27/EU) of 2012, which aims to achieve the objective of saving 20 % of the EU's primary energy consumption by 2020 compared to projections. Finland's own national energy efficiency target, has in accordance been set as an absolute level of final energy consumption of 310 TWh (26.66 Mtoe) by 2020.

Energy intensive and large industrial and business operations have been identified as key areas where energy efficiency measures should be introduced. In the newly introduced legislation, the government has opted for a stick, rather than a carrot approach: large companies are obliged to conduct audits under the threat of financial penalties. The carrot approach previously introduced for communes and small and medium sized companies, whereby they receive subsidies for conducting energy audits of their operations, is set to continue.

For whom are energy audits obligatory?

The Act defines large companies as those that employ over 250 employees or that have a turnover in excess of €50 million and a balance sheet over €43 million. The definition takes foreign subsidiaries into account, but not foreign holding companies. Significantly the company's energy consumption is not considered at all.

In some cases companies may be exempt even if they qualify as 'large companies'. Exemptions may be grant-

Number of buildings or operational sites	Number of site audits
At most 15	1 site audit
16–100	10 % of targets
101–400	square root of target number
Over 400	5 % of targets
Sites that have energy consumption costs of under €15 000 or have floor areas under 500 m^2 do not have to be taken into consideration when determining the amount of audits required.	

Table 1. Site audits conducted on real estate. The table indicates the number of site audits required for varying building and operation site numbers.

ed if the company has an ISO 14001 system with a certified energy management system (EnMS). Also exempt are companies that are party to the energy efficiency agreement system and have EnMS systems in use.

What does the audit entail?

The obligatory audit set out by the Act includes a company energy audit and a site audit. The company energy audit reviews the energy consumption of all the group's or company's energy consuming operations: real estate, industrial operations, business operations and transport. In practice the company energy audit can be implemented fairly flexibly. It should nevertheless shed light on the energy consumption levels and its breakdown as well as completed and planned site audits.

In addition to the company energy audit a more detailed site audit needs to be completed. It should cover 10 % of the company's entire energy consumption. The site audit can be conducted on real estate targets or industrial targets. If the site audit is conducted on real estate the extent of the audit is according to Table 1. Despite some leeway in the selection of the targets the overriding principle is that targets should be chosen according to the energy consumption and savings potential levels. Audits that were conducted less than 4 years ago can also be taken into consideration.

Get started early

Due to the tight schedule set out for the first audits to be conducted it is recommended that organizations get started without delay in verifying whether they need to comply with the new Act. If the company is defined as a 'large company' it may be exempt according to the earlier specified stipulations.

If the company however is not exempt it needs to verify whether any audits have been conducted in the last four years and what they entailed. This information can be used to reduce the scope of site audits. The company will nevertheless be required to conduct a company energy audit.

If no exemptions are applicable and no audits have been conducted in the last four years then a company energy audit and site audit will have to be conducted before 5.12.2015. The company can train and register one of its own employees via the Finnish Energy Authority to conduct the audit. Alternatively it can employ the services of a registered energy auditor to consult in the matter and/or to conduct the audit.

About the author

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Jukka Summanen has worked extensively in energy engineering and consulting. His special expertise areas include energy production, feasibility studies for energy use and efficiency and consulting in project implementation. Summanen started working at Elomatic in 1999 as an energy designer. From 2004 to 2014 he headed Elomatic's energy consultation services. Currently he holds the position of Leading Expert, Energy.

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Elomatic acquires Consor Technology Oy

Elomatic has expanded its operations by acquiring the entire shareholding of Tampere-based Consor Technology Oy on 1st of April 2015. Consor supplies electrical and automation systems to industrial companies and energy production plants.

The acquisition is an important strategic step and strengthens Elomatic's position in particular in the growing sector of renewable fuel based power generation both domestically and abroad.

Consor Technology Oy was founded in 1987 and has special expertise in the field of automation and electrification of solid fuel powered heating plants. The company has six employees and a turnover of about two million euros.

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